International Scientific Conference

FORESTS IN THE FUTURE

Sustainable Use, Risks and Challenges

PROCEEDINGS

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FORESTS IN THE FU-TURE Sustainable Use, Risks and Challenges

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photo M. Veselinović, Jastrebac mountain

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SECTION I

FOREST ASSESSMENT, MODELING AND MENAGMENT, FOREST MENAGMENT PLANNING

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STRUCTURAL AND PRODUCTION CHARACTERISTICS OF MIXED FORESTS OF BEECH AND SPRUCE ON KOPAONIK

Milan MEDAREVIĆ[1], Staniša BANKOVIĆ[1], Damjan PANTIĆ[1], Biljana ŠLJUKIĆ[1*], Snežana OBRADOVIĆ[1], Dragan BOROTA[1]

Abstract: *Mixed conifer and broadleaf forests are the most valuable parts of the growing stock in Serbia, thanks to their high productivity, ecological diversity, stability and structural complexity. The subject of this study is beech and spruce mixed forests in the area of the NP "Kopaonik". The study of structural and production characteristics of these forests is based on the data of 8 (eight) permanent sample plots of average size 0.51 ha, established within the two previously defined groups of ecological units: EJ-A Fago-piceetum luzuletosum on acid brown soil and EJ-B Fago-piceetum oxalidetosum on acid brown and brown podzolic soil. The study stands are well stocked, with a pronounced domination of spruce, especially in the category of smaller-diameter trees. Multiply toothed individual and summary lines of diameter and height structure, and their great variation width imply the structural all-agedness of these forests. Small-diameter and medium-diameter trees are dominant, and the percentage of the largest-sized trees is minimal. Average volume is above 530 $m^3 \cdot ha^{-1}$, with mixture proportion about 0.6:0.4 in favour of spruce. Average value of current volume increment is about 9 $m^3 \cdot ha^{-1}$, with spruce percentage about 70% and beech about 30%. Increment percent is above 3%, in which spruce accounts for more than 2%, and beech accounts for about 1%. Taking into account the altitudinal position of these forests and the resulting site characteristics which are more favourable to shade loving species, the most productive species is spruce as a typical sciophyte. However, beech productivity is also significant, and its role in the concrete conditions is multi-dimensional, from the prevention of soil acidification, to the enhancement of multiple functionality (protection, recreation, amenity, etc). Site potential, stand characteristics and inter-relationships of tree species resulted in high productivity, ecological stability and structural complexity of these forests, therefore, in future management. radical measures and felling which could disturb the established relations and dynamic processes should be avoided.*

Key words: forests of beech and spruce, structure, productivity, Kopaonik

1. INTRODUCTION

Mixed conifer and broadleaf forests account for 2.4% of the growing stock area in Serbia, 3.2% of the volume and 3.4% of current volume increment (Banković *et al.*, 2009). They are distributed over the following mountain massifs in Serbia: Tara, Zlatibor (Murtenica), Zlatar, Čemerno, Golija, Mokra Gora, Prokletije, Šar Planina, Veliki Jastrebac, Kopaonik and Goč in the west, Stara Planina in the east, and the northernmost sites are on Rtanj and Malinik. Thanks

[1] Dr. Milan Medarević, Professor; Dr. Staniša Banković, Professor; Dr. Damjan Pantić, Associate Professor; Biljana Šljukić, M.Sc., Assistant; Snežana Obradović, M.Sc., Teaching Associate; Dragan Borota, M.Sc., Ph D student, University of Belgrade, Faculty of Forestry, Department of Forest Management Planning, Kneza Višeslava 1, 11030 Belgrade, Serbia
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to their extremely high productivity on some sites, ecological diversity (high species diversity, tree sizes and their spatial distribution), higher resistance to adverse effects of different factors of biotic and abiotic nature, and structural complexity, these forests are highly significant from the protection, social and production aspects, and thus also very interesting from the scientific aspect (Pantić *et al*., 2011).

Among foresters and ecologists worldwide, the concept of all-aged forest management in the widest sense is becoming increasingly significant in the framework of ecosystem approach to forest management (Boncina, 2000). The efforts to ensure the rational and sustainable forest utilisation by the practice of close to nature forest management requires a good and all-inclusive knowledge of the forest ecosystem dynamics, their productivity, structure, etc. (Boncina, 2000; Sagheb-Taleb, Schütz, 2002). The forest ecosystem structure can be studied at different levels, from the individuals and populations, through communities, to ecosystems (Kimmins, 1987). According to Bončina (2000), regardless of the level to which it refers, the structure is mostly defined by: 1. available elements, 2. quantitative relation between elements, 3. their distribution, and 4. interaction between elements. The selection of structural elements depends on the selected level, spatial distribution, and on the research objectives. Miletić (1951) identifies the stand structure in the widest sense with all elements which constitute the volume and are spatially distributed. According to Milojković (1958), the specific internal stand structure is the consequence of unequal development of individual trees conditioned by different factors which lead to the differentiation of trees per diameter, height, and other structural elements.

The management specificities of mixed conifer and broadleaf forests, most often of selection structure, but also of group uneven-aged structure, were reported by numerous papers by foreign (Liocourt, 1898; Schütz, 2001, 2002; Bončina *et al*., 2002; Bagnaresi *et al.*, 2002; O' Hara, Gersonde, 2004; Govedar, 2005; Čavlović *et al*., 2006) and domestic authors (Miletić, 1950, 1951; Mirković, 1959; Milin, 1961; Banković, 1981; Stojanović, Josović, 1987; Tomanić, 1996/1997; Tomanić, Jelisavčić, 1997; Vidanović *et al*., 1998; Vamović, 2005; Medarević, 2005; Medarević *et al*., 2002, 2007, 2008, 2010; Pantić *et al*,. 2011). Previous researches of mixed conifer and broadleaf forests in Serbia were mostly devoted to forests of beech and fir, and beech, fir and spruce. As for mixed forests of spruce and beech, except some modest plant community studies of this community (Mišić, 1954; Mišić, Popović, 1954; Gajić, 1966), there are almost no other researches. In the plant community sense, the beech and spruce community was described by Jovanović (1980) on Suva Planina as *Piceo-Fagetum subalpinum calcicolum*, and by Gajić (1989) on Golija, as the association *Piceo-Fagetum subalpinum silicicolum.* In the description of forest communities in the area of the National Park Tara, Obradović (2007) characterises the forest of spruce and beech (*As. Piceo-Fagetum, Gajić 92*) as a very rare plant community, one fragment of which is located between "Biljega" and "Okuka" (MU "Crni Vrh"), at the altitude of 1,100 m, on limestone. Medarević *et al*. (2007) define these forests as a special type - forest of beech and spruce (*Fago-picetum*) on rendzinas and black earths over limestone and brown soil on limestone in formations with hornfels.

In contrast to the above mentioned communities, the forests on Kopaonik are in the mountain belt. Kopaonik belongs to a group of rare mountains in Serbia on which the alternation of vegetation belts in the vertical profile is extremely regular. In the higher parts of Kopaonik, in the transition zone from beech to spruce altitudinal belt, mixed, broadleaf-conifer beech-fir, beech-fir-spruce, and spruce-beech forests occupy the area of 1,584.*05 ha* or 22.3% of forest covered area of the National Park.

Bearing in mind the more than modest previous research, and consequently insufficient knowledge on mixed spruce and beech forests in the area of Serbia, the aim of this paper was to study their structure and productivity on the concrete site, as the significant elements for the definition of silvicultural and management measures and for their implementation in the process of regular forest management.

2. MATERIAL AND METHODS

2.1. Study area

The research is performed in the Management Unit "Barska Reka", as an integral part of the National Park Kopaonik. The Management Unit is located between 18°21' and 18°31' east longitude and 43°16' and 43°23' north latitude, on the right forested side of the same name river. The lowest elevation of the Management Unit is 950 *m*, and the highest 2,017 *m*, which points to a significant difference regarding the growing conditions for tree species and to total ecological differences of submontane, montane and alpine habitats and forest sites. The general aspect of Management Unit is (south-) west, although the developed relief resulted also in south and north facing sites, as well as in numerous combinations. Management Unit area is 1,450.89 *ha*, 48.8% of which are mixed forests of spruce and beech (2004-2014). The main soil type is brown podzolic soil, formed on granodiorites in the conditions of cold and humid montane climate. In the climate zonation of Serbia, Rakičević (1980) singled out the Kopaonik special climate zone with, on the average, the coldest and the longest winters in Serbia (negative monthly temperatures from December to April), the lowest mean annual air temperature, and long average duration of snow cover. Average annual value of climate parameters in the area of Kopaonik are: air temperature 2.9 °*C*, precipitation 933.7 *mm*, relative humidity 82%, annual duration of sunny periods 1,741 hours, and the main wind directions are southwest and northeast.

The research is focused on two ecological units: forest of spruce and beech (*Fago-piceetum luzuletosum*) on acid brown soil (4 sample plots A_1-A_4) and forest of spruce and beech (*Fago-piceetum oxalidetosum*) on acid brown and brown podzolic soil (4 sample plots B_1-B_4). Sample plots are regularly managed according to their general function–landscape of exceptional features under the second degree of protection regime, except sample plot B_4, which is in the reserve "Barska Reka", under the first degree of protection regime. Sample plots are located in compartments 31, 33, 34, 35, 38 and 46, area from 0.25 *ha* to 1.3 *ha*, on the average 0.51 *ha*. They are on the forested side and on medium steep (6°-10°) and steep (10°-15°) terrains, of uniform or concave inclination, at the altitude of 1,330–1,580 *m*. The aspects are different: south, south-southeast, east, west-southwest and northwest. Parent rock consists of granite and granite-monconite, of compact structure (slightly weathered rock), and the soil is brown podzolic and acid brown.

2.2. Data collection and processing

Eight permanent sample plots, average area 0.51 *ha*, were established on representative locations on which the soil and plant communities were sampled and surveyed during the phase of ecological unit definition and which are characterised by sufficient degree of conservation, canopy closure and stand quality. The sample plot data were collected by the methods which are usually applied in such researches; diameters at breast height and height of all trees were measured.

The collected data were processed using specialised software, with additional statistical programme STATDIAGRAMICS Centurion XV-Version 15.2.11. Numerous functions were tested for the construction of height curves, and the definite selection of functions for each concrete case was based on statistical indicators of regression and correlation analyses and based on statistically significant differences between fitted and empirical heights. Volume was calculated by the volume table method, i.e. general volume tables for beech high forests in Serbia (Mirković, 1969)-for beech, and local volume tables (Banković *et al*., 2003)-for spruce. Current volume increment was calculated by the method of percentage increment using regression models which express its dependence on the number of trees per unit area, percentage of the concrete tree species in the mixture, mean stand tree diameter and height (Banković *et al.*, 2002).

3. RESULTS AND DISCUSSION

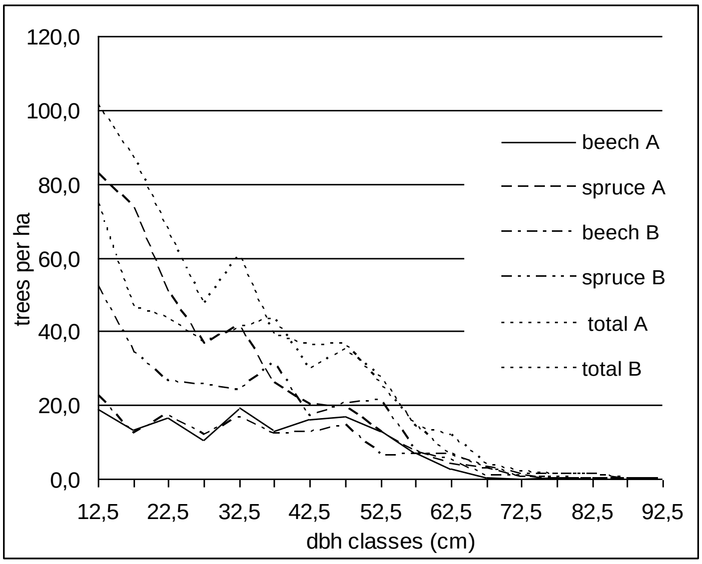
The stand structure and productivity are very significant issues from the aspect of forest science and practice. In the selection of the most favourable method of forest management, it is especially significant to have a good knowledge on the stand structural elements, their distribution and production capacities, in addition to biological-ecological characteristics of tree species.

3.1. Diameter structure

The basic element of stand structure is the number of trees. The term basic inter alia results from the fact that it participates in the formation of other structural elements, such as the stand basal area, volume, and volume increment. Miletić (1930) reports that the number of trees per unit area, and also relative relationships of diameter degrees and classes, are the basic functions in stand structure estimation. The number of trees regulates the growth space and has a crucial effect on the development of diameter, height, stand stability and productivity.

The absolute number of trees on sample plots established for this study in most cases can be considered as sufficient stocking, which is also pointed to by very high values of other elements (Tables 1 and 2). In ecological unit A (EJ-A), the number of trees varies from 179.4 $trees{\cdot}ha^{-1}$ (A_4) to 754.8 $trees{\cdot}ha^{-1}$ (A_3), average 525.8 $trees{\cdot}ha^{-1}$. The spruce dominance is evident, which accounts for 71.7% at the level of EJ-A, and the percentage of beech is 28.3% per tree number. In ecological unit B (EJ-B), the values of this element are lower and amount to 127.7 $trees{\cdot}ha^{-1}$ (B_4) to 566.7 $trees{\cdot}ha^{-1}$ (B_1), with averagely 413.4 $trees{\cdot}ha^{-1}$, with spruce dominance accounting for 64.5%. The higher relative percentage of beech in EJ-B (35.5%), with the larger sizes of mean trees (Tables 1 and 2), indicate that, in this ecological unit, the conditions for beech development are somewhat more favourable. Diameter structure of the study ecological units are characterised by (Graph 1):

- group selection all-agedness, which is in these conditions to a good extent related to group selection mixture,
- toothed curves, which points to stand storeys, layers, group selection mixture and to special inter-relationships of tree species in the growth space utilisation in the concrete conditions,
- domination of small-diameter and medium-diameter trees, with the minimal presence of large diameter sizes,
- summary distribution lines conditioned, primarily, by the spruce structure which is dominant in the total number of trees, especially in smaller diameter degrees,
- distinct two maximums in EJ-A, i.e. three maximums in EJ-B, one of which (the first one) is covered with taxation limit, and the other is 32.5 *cm* in EJ-A, i.e. in 37.5 *cm* and 47.5 *cm* in EJ-B,
- multiply and mildly toothed structure of beech up to the degree of 47.5 *cm*, with the maximum in the degree 32.5 *cm*, which, with some oscillations, ranges to the degree 47.5 *cm*, which indicates clearly the domination of medium-sized beech trees.



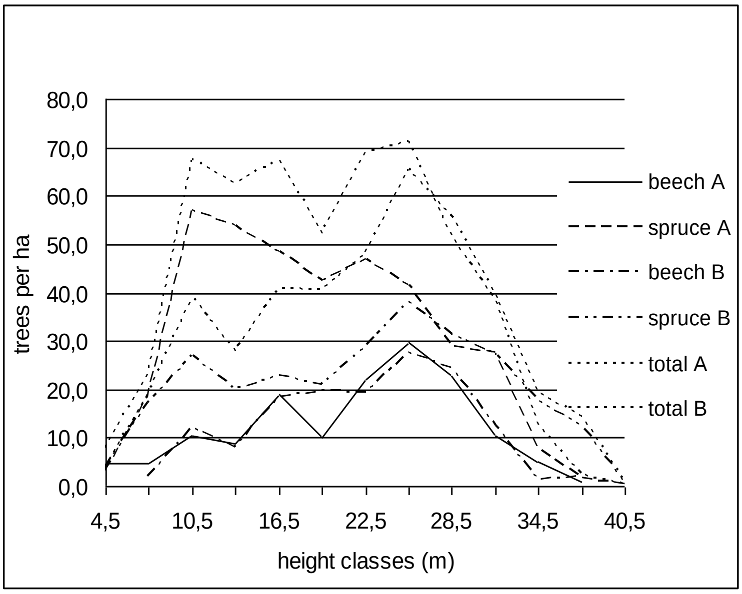
Graph 1. *Diameter structure*

The lower presence of beech in smaller-diameter degrees (and in general) compared to spruce, indicates evidently more favourable ecological conditions for spruce development, especially at the micro level. Considering the altitudinal position and the edaphotop characteristics, the conditions are more favourable for spruce as a sciophyte than to beech as a semi-heliophyte. Further, the so far performed silvicultural works and forest utilisation works in this area (in the concrete stands) should also be taken into account, as well as their impact of the current state.

3.2. Height structure and height curves

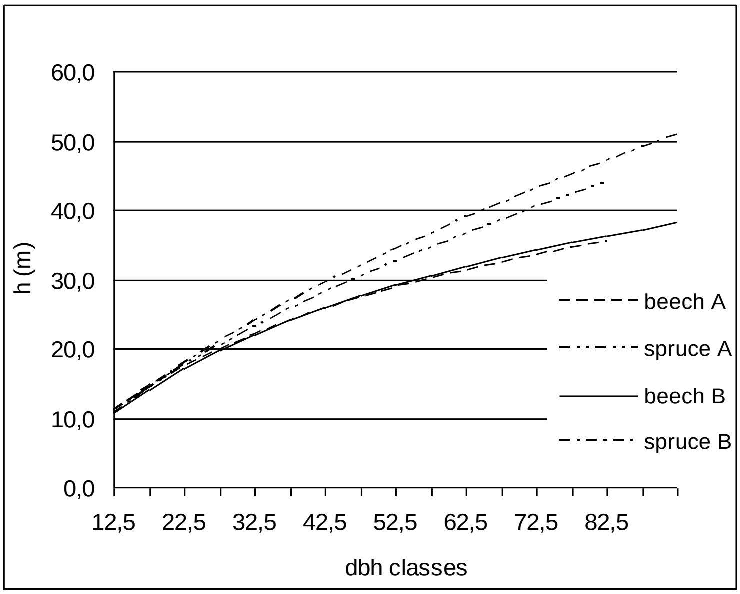
Height structure in EJ-A and EJ-B follows the concrete diameter structure and is characterised by (Graph 2):

- multiply toothed summary distribution lines of tree numbers and high variation width in both EJs, which distinguishes these forests from even-aged forests and proves their structural all-agedness,
- three maximums in height degrees 10.5 *m*, 16.5 *m* and the most prominent in 25.5 *m* in both EJs, which clearly points to the domination of low to medium high trees (correlation with diameter structure-dominance of small-diameter and medium- diameter trees),
- sharp drop in the number of trees after the mentioned maximum, to the degree of 40.5 *m*,
- spruce in EJ-A attains the first, considerably higher maximum already at 10.5 *m*, and the second one, far milder at 22.5 *m*, which is the consequence of a strong correlation with the spruce diameter structure, i.e. the dominant share of small-diameter to medium-diameter trees,
- in EJ-B, the spruce height structure is also characterised by two maximums, the first one not so high attains the degree 10.5 *m*, and the second one is higher reaching 25.5 *m*,
- maximal spruce heights are individually measured in the degree 40.5 *m*,
- analogous to diameter structure, beech height structure in both EJs is characterised by multiply toothed curves and the absolute maximum in the degree 25.5 *m*,
- individual beech trees attain the degree 37.5 *m*.



Graph 2. *Height structure*

The spruce height curves (Graph 3) are more or less straight, with a greater elevation to the highest diameter degrees, in which the EJ-A curve is somewhat lower than that in EJ-B. In beech, height curves are more curved. In beech also the EJ-A curve is lower in the coordinate system than the EJ-B curve, which to some extent indicates somewhat more favourable conditions for the development of trees in EJ-B. The positions and shapes of height curves of both species point to their differences in relation to light and social relations in mixed forests of such composition.



Graph 3. *Height curves*

3.3. Forest Productivity

Total produced volume and volume increment, as quantitative (numeric) expressions of forest productivity, result from the effects of complex site factors, internal stand relationships, realised management measures and their interaction. Average value of these and other elements in the study sample plots and ecological units are presented in Tables 1 and 2.

Table 1. *Productive characteristics in ecological units A*

Tree species	N	G	dg	hg	dgmax	hgmax	V	Iv	piv
Sample plot	*trees·ha*$^{-1}$	$m^2 \cdot ha^{-1}$	*cm*	*m*	*cm*	*m*	$m^3 \cdot ha^{-1}$	$m^3 \cdot ha^{-1}$	%
beech	152.9	18.7	39.4	24.3	56.6	31.6	257.8	2.7	1.1
spruce	505.9	41.8	32.4	22.9	53.7	34.0	551.1	11.0	2.0
A1	658.8	60.5					808.8	13.7	3.1
beech	61.2	7.4	39.1	25.0	60.5	31.2	103.3	1.2	1.2
spruce	449.0	27.9	28.2	20.5	44.7	27.5	321.2	7.6	2.4
A2	510.2	35.3					424.5	8.8	3.6
beech	351.6	34.4	35.3	22.9	51.4	26.4	414.7	4.6	1.1
spruce	403.2	21.7	26.2	18.1	41.3	26.9	238.9	5.5	2.3
A3	754.8	56.1					653.6	10.1	3.4
beech	29.4	4.0	41.5	25.9	61.6	31.7	56.3	0.7	1.2
spruce	150.0	14.6	35.2	26.4	55.0	34.8	198.7	4.4	2.2
A4	179.4	18.6					255.0	5.1	3.4
beech	148.8	16.1	38.8	24.5	57.5	30.2	208.0	2.3	1.1
spruce	377.0	26.5	30.5	22.0	48.7	30.8	327.5	7.1	2.2
Average A	525.8	42.6					535.5	9.4	3.3

Legend: N-number of trees; G-stand basal area; dg-diameter of mean stand tree per cross sectional area; dgmax-mean diameter of 20% of the largest-diameter trees in the stand; hg, hgmax-heights which correspond to the above mean diameters; V-stand volume; Iv-current volume increment; piv-volume increment percentage.

Table 2. *Productive characteristics in ecological units B*

Tree species	N	G	dg	hg	dgmax	hgmax	V	Iv	piv
Sample plot	*trees·ha*$^{-1}$	$m^2 \cdot ha^{-1}$	*cm*	*m*	*cm*	*m*	$m^3 \cdot ha^{-1}$	$m^3 \cdot ha^{-1}$	%
beech	261.5	29.2	37.7	23.6	52.9	29.1	276.8	4.1	1.1
spruce	305.1	21.0	29.6	21.8	50.5	32.6	270.8	5.7	2.1
B1	566.7	50.2					647.5	9.8	3.2
beech	87.5	13.3	44.0	26.1	59.6	31.1	192.6	1.9	1.0
spruce	415.6	50.5	39.4	28.3	56.7	35.4	713.1	12.3	1.7
B2	503.1	63.8					905.6	14.2	2.7
beech	192.0	16.3	32.9	24.0	61.6	30.8	230.8	2.9	1.3
spruce	264.0	18.6	30.0	23.1	41.9	29.3	233.8	5.1	2.2
B3	456.0	36.9					464.5	8.0	3.5
beech	45.4	10.2	53.5	30.1	75.8	35.3	163.9	1.6	1.0
spruce	82.3	7.4	33.7	23.8	54.2	37.0	103.1	2.3	2.3
B4	127.7	17.6					267.0	3.9	3.3
beech	146.6	17.3	42.0	26.0	62.5	31.6	216.0	2.6	1.1
spruce	266.8	24.4	33.2	24.3	50.8	33.6	330.2	6.4	2.1
Average B	413.4	42.1					571.2	9.0	3.2

As the consequence of good stocking and a significant percentage of medium-diameter trees, the average basal area in EJ-A is 42.6 $m^2 \cdot ha^{-1}$, with the percentage of spruce accounting for 62.2% and beech 37.8%. The higher percentage of beech in this element compared to its percentage per tree number (28.3%) indicates that this tree species in concrete conditions attains larger tree dimensions. Compared to spruce, beech mean diameter is larger by 8.3 *cm*, and mean height by 2.5 *m*. Average volume at the level of this EJ is high and amounts to 535.5 $m^3 \cdot ha^{-1}$ with mixture proportion spruce:beech=61.2%:38.8%. Volume increment is 9.4 $m^3 \cdot ha^{-1}$ and its largest part (75.5%) is spruce, whereas beech accounts for 24.5%. The absolute value of current volume increment, as well as increment percentage of 3.3%, point to ecological stability and good forest productivity of this ecological unit. With some reserve because of the abstraction of the impact of previous management treatments, it can be concluded that spruce is the carrier of productivity. Volume increment percentage of spruce is 2.2%, and that of beech accounts for 1.1%.

In EJ-B stand basal area is 42.1 $m^2 \cdot ha^{-1}$ on the average in which spruce accounts for 58%, and beech for 42%. Beech attains larger tree sizes, mean diameter by 8.8 *cm*, and height by 1.7 *m*. With the number of trees lower by 21.4% compared to EJ-A, the attained volume is larger by 6.7%, which confirms the previously stated conclusion that the conditions in EJ-B are somewhat more favourable for the development of the concrete tree species. Average volume in EJ-B amounts to 571.2 $m^3 \cdot ha^{-1}$ with mixture proportion spruce: beech=57.8%:42.2%. Volume increment is high and amounts to 9.0 $m^3 \cdot ha^{-1}$. The carrier of productivity is spruce with increment percentage of 2.1%, and that of beech is 1.1%.

In general, the stands in both EJs are characterised by ecological stability and viability, which together with the site potential, resulted in high productivity. The altitudinal position of the site (1,330–1,580 *m*) and its other characteristics described in subchapter 2.1., are more favourable to the development of spruce as a typical sciophyte, making it the carrier of productivity of these forests. However, beech productivity is also significant, as it also prevents the soil degradation (acidification), contributes to ecological stability of these forests and to the increase in their multifunctional value (landscape of exceptional features).

4. CONCLUSIONS

Mixed conifer and broadleaf forests, although with a moderate percentage in the growing stock in Serbia, thanks to their high productivity, ecological diversity and stability, structural complexity, etc., represent its most valuable part. In the past period in Serbia, the research mainly dealt with beech and fir forests, i.e. forests of beech, fir and spruce. Apart from plant community studies of mixed beech and spruce forests, there are almost no other researches. In this sense, the objective of this paper was to study the structural and production characteristics of mixed beech and spruce forests on Kopaonik. The analysis of the study results obtained in EJ-A *Fago-piceetum luzuletosum* on acid brown soil and EJ-B *Fago-piceetum oxalidetosum* on acid brown and brown podzolic soil leads to the following conclusions:

- the stocking of these forests is good, with high dominance of spruce in the total number of trees-71.7% in EJ-A and 64.5% in EJ-B,
- multiply toothed individual and summary lines of diameter and height structure and their large variation width clearly distinguish these forests from even-aged forests and confirm their structural all-agedness,
- domination of small-diameter and medium-diameter trees, with the minimal presence of large diameter sizes,
- beech attains larger tree sizes than spruce, i.e. mean diameter by about 8 *cm*, and mean height by about 2 *m*,
- average volumes are high and exceed 530 $m^3 \cdot ha^{-1}$, with mixture proportion about 0.6:0.4 in favour of spruce,
- average value of current volume increment is high and it amounts to about 9 $m^3 \cdot ha^{-1}$, with spruce percentage accounting for about 70% and beech about 30%,
- increment percentage is above 3%, i.e. spruce above 2%, and beech about 1%,

- considering the altitudinal position of these forests and the resulting site characteristics, which are more favourable to sciophytes, the production carrier is spruce as a typical sciophyte,
- beech productivity is also significant, but its role in the forests of such composition and such global function (National Park) is multi-dimensional, from the prevention of soil acidification, to the enhancement of multiple functionality (protection, recreation, amenity, etc.),
- site potential, stand characteristics and inter-relationships of tree species resulted in high productivity, ecological stability and structural complexity of these forests, consequently radical measures and fellings which could disturb the established relations and dynamic processes should be avoided in future management.

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CHARACTERISTICS OF SILVER FIR DEVELOPMENT IN EVEN-AGED FORESTS AT DIFFERENT SITES ON Mt. GOČ

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Abstract: *The study of tree and stand growth and increment laws in general is highly significant for silviculture, forest management planning, forest ecosystem monitoring, etc. In that sense, silver fir dynamic processes were studied in even-aged, mixed silver fir and beech forests at different sites on Mt. Goč. The study results point to exceptionally high silver fir adaptation capacity to different site conditions reflected in entirely opposite characteristics developed at extremely different sites. With the deterioration of site conditions, silver fir light demand increases, its dynamic processes accelerate, growth lines become curvilinear, current increment of growth elements culminates earlier, and at the poorest sites, silver fir becomes a heliophytic tree species. Conversely, as site conditions improve, silver fir shade tolerance increases, its growth dynamics decelerates, growth lines are flattened, and increment culmination shifts to older ages, so that at the best sites, silver fir becomes an extremely shade tolerant species. The application value of the study results, inter alia, is reflected in the accurate determination of silver fir rotation periods in even-aged forests at different sites, and the correct selection of structural forms of stands for silver fir cultivation. At inferior sites, it is by all means an even-aged stand, whereas selection stands should be selected only at the best sites, where silver fir can tolerate extreme shade, stagnate, and in this way contribute to a specific vertical forest structure.*

Key words: silver fir, growth, increment, site, even-aged forests

1. INTRODUCTION

Silver fir forests account for 1.1% (25,600 *ha*) of the area, 2.7% (9,838,863 m^3) of the volume and 2.5% (225,515 m^3) of current volume increment of the growing stock of Serbia. In this forest category, high natural stands are dominant with 95.3%, and the percentage of artificially established stands is 4.7%. Well-preserved stands account for 65.6%, and the percentage of insufficiently stocked stands is rather high and accounts for 34.4% of the area of silver fir forests. All-aged (in the widest sense) silver fir forests dominate with 84.4%, even-aged forests occupy 15.6% of the area. In Serbia, silver fir usually makes two- and poly-dominant communities with beech, i.e. beech and spruce, more rarely with other tree species. Along with silver fir, another 9 autochthonous tree species are identified in this forest category. Silver fir is

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an edifying species in 28 types of forests (Banković *et al.*, 2009/a). The above data, inter alia, point to two facts. On the one hand, to a great significance of silver fir forests, primarily from the ecological aspect and the aspect of growing stock diversity and stability in Serbia, and also from the aspect of productivity, because they are our most productive forests with average volume of 385 $m^3 \cdot ha^{-1}$ and current volume increment of 8.8 $m^3 \cdot ha^{-1}$. On the other hand, the percentage of silver fir forests is insufficient and largely unharmonized with the potential capacities. For this reason, one of the strategic tasks of forestry science and practice is silver fir introduction to the areas where its cultivation is possible, especially in the belt of beech forests and at places where the increase in its vertical range is already evident. The means of successful realisation of these tasks are numerous, from purely technical to scientific ones, which include in-depth studies and upgrading of the existing knowledge on silver fir biological and ecological properties. Especially significant are the studies referring to individual tree growth and increment dynamics, the dependence on site and stand characteristics, and anthropogenic impacts. If they are not reduced solely to simple comparison of numbers, such studies facilitate the understanding of forest growth dynamics in general (Magin, 1959; Pinto *et al.*, 2008). The data on development and increment are important tools in the selection of trees for felling, selection of trees for protection, calculation of rotation periods, and recommendation of silvicultural treatments (da Silva *et al.*, 2002). To be able to design the silvicultural systems which integrate ecological and economic targets, forestry professionals need wide scientific knowledge on tree and stand dynamic (development) processes in general (Franklina *et al.*, 2002). Also, the study of individual tree growth and increment enables the assessment of the effects of silvicultural measures and their timely improvement (Manetti, Cutini, 2006; Roberts, Harrington, 2008). As tree viability cannot be directly measured, tree growth and increment can be used as some of the most reliable indicators in forest ecosystem monitoring (Bigler *et al.*, 2004; Dobbertin, 2005; Elling *et al.*, 2009).

In the past period, there was a disproportion between the evident significance of the study of growth and increment laws and the scope of research devoted to this field. This refers especially to silver fir in even-aged forests, as the less represented structural form, compared to all-aged forests of this tree species. In that sense, the objective of this study was to analyse the environmental impact on individual development of silver fir trees in even-aged forests on mountain Goč, to define the possible specificities of the development, and to analyse some biological characteristics of this tree species. The study results should upgrade the existing knowledge in the above fields and thus ensure the regular management of even-aged silver fir forests, and lead to a higher percentage of silver fir forests in the growing stock of Serbia.

2. MATERIAL AND METHODS

2.1. Study area

Goč forests are located between 43° 30’ and 43° 35’ north latitude and 18° 15’ and 18° 30’ east longitude. Parent rock consists of old Palaeozoic schists of low degree of metamorphism, contact metamorphic rocks, marbles, granodiorites, andesites, dacites, and serpentinitised dunites. The soils are classified as syrozem, black soils, brown soils, leached brown soils, and podzols. A humid climate is prevailing in the region. The average annual air temperature is 7.3 °C, relative air humidity is 81%, precipitation is 1,010 mm, and duration of sunny periods is 1,938 hours (Medarević *et al.*, 2009). In addition to mixed forests of silver fir and beech which are dominant on Goč, a far smaller area is covered with sessile oak forests at higher altitudes and with subalpine beech forests.

2.2. Data collection and processing

Six sample plots of 0.5-1 *ha* were established in the belt of beech-silver fir forests, at the altitude between 650 and 1,000 m, on flat to sloped terrains up to 25^{o}. Sample plots were established at the following sites (FT), which are listed in order of decreasing potential for silver fir development – from the best to the poorest (Jović *et al*., 1999):

- FT-1: even-aged forests of silver fir and beech on acid brown soils on phyllites,
- FT-2: even-aged silver fir and beech forests on acid brown soils on granodiorite,
- FT-3: even-aged silver fir and beech forests on lessivé pseudogley on serpentine,
- FT-4: even-aged forests of silver fir and beech on brown (skeletal) soils on andesite,
- FT-5: even-aged forests of silver fir and beech on podzolised acid soils on quartzites and sericite quartzites,
- FT-6: even-aged forests of silver fir and beech on brown soils on serpentine.

The even-agedness of the above stands was confirmed using several indicators, such as height and diameter structure, the same age class, and the absence of stagnation stage observed on felled trees. (The indicators showing that the tree was not in the latent stage are: width of growth rings at breast height – above 1 mm, i.e., current diameter increment higher than 2 mm - Ferlin, 2002; and current height increment higher than 0.125 m - Banković, 1981).

The stands for this research and the trees felled for the analysis of growth and increment were selected so that the experimental error was reduced to the minimum, i.e. so that the effect of site characteristics on individual silver fir development was maximal. To this purpose, the selected stand management had to be the same in the past, and the mixture with beech ranged from 60%:40% to 65%:35% in favour of silver fir. Five trees of the dominant crown class were felled in the centre of each stand, so the effect of forest edge was eliminated. As the effect of microsite differences and genetic differences on tree development is minimal or absent in small areas, the distance between the felled trees did not exceed 20 *m* (Banković *et al.*, 2009/b; Pantić *et al*., 2011).

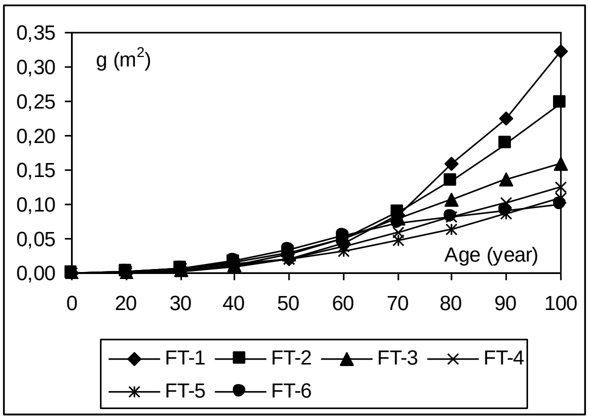
The felled trees were sectioned into stem disks on the stump (0.3 *m*), at breast height (1.3 *m*), and at 2 *m* intervals (3.3 *m*, 5.3 *m*, etc.) (Gerecke K.-L.,1988; Banković, Pantić, 2006; Bontemps *et al*., 2010). Tree age was calculated by counting growth rings on the disk taken from the stump. The data used in the construction of the lines of growth and current increment of diameter, cross sectional area, height, and volume of each felled silver fir tree are as follows: diameter at the end of the ten-year period marked on each disk from the periphery to the centre, height at which the disks are cut, and the number of growth rings on the disks (Nieuwenhuis, Barrett, 2002; Banković, Pantić, 2006; Banković *et al.*, 2009/b; Pantić *et al*., 2011). Average values of these elements at the site level (FT-1 to FT-6) are presented in Graph 1-4 and 6-9. The differences between the treatments (site classes), and their effect on tree development and increment per individual life periods were tested using one-way ANOVA, software STATGRAPHICS Centurion for Windows. As three out of six sample plots (stands) were 100 years old, the duration of the analysed period was 100 years.

3. RESULTS

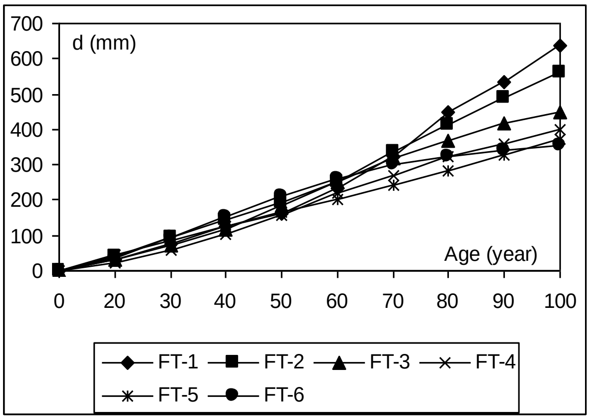
3.1. Silver fir (growth) development

The development of volume of individual trees reflects the characteristics of the development of all the volume forming elements. For this reason, the effects of site conditions on the tree species development can be followed by the analysis of volume development and increment. The increase in volume and its increment reflect the full scope of activities of individual trees. *Also, the* analyses of tree development often exclude the cross sectional area, because it is thought that it is of lower significance and that it is a category derived from diameter and its increment. The categorization of the cross sectional area development with the diameter and volume development cannot be accepted. Namely, diameter participates with its square in the value of the cross sectional area, which is just one of the elements of volume along with the height and form quotient. Taking into account the above, and to comprehend the complexity of the effects of external (site) factors on the development of individual silver fir trees in the given conditions, the analysis includes the growth of all elements – diameter, cross sectional area, height, and volume (Graph 1-4).

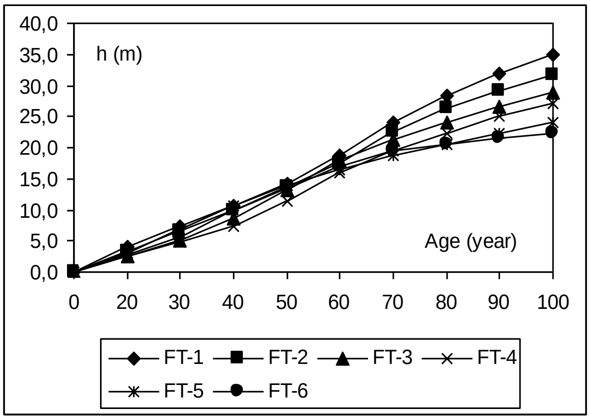
The Graph analysis shows that more intense site effects on the development (of all study elements) of individual silver fir trees are evident only after the age of 70 years. This is confirmed by the values of F ratio in ANOVA (Graph 5), which decrease between the ages of 30 and 70 years, after which their increase becomes more intense with further ages. At the age $t \leq 70$ years $F < 9$, i.e., for $t > 70$ years $F = 16\text{-}86$, $p < 0.05$; ($p = 0.000$), independent on tree sizes. Further analysis shows that it is only after the age of 70 years, that growth curves are positioned consistent with the site production potential (the curves on better-quality sites rise above those on inferior sites). Prior to the above age, this “postulate“ is not characteristic of silver fir in the given conditions. Starting from the best (FT-1) to the poorest (FT-6) sites, the curves of diameter and height development change in shape from flat, characteristic of shade tolerant species, to curvilinear, characteristic of light demanding species.



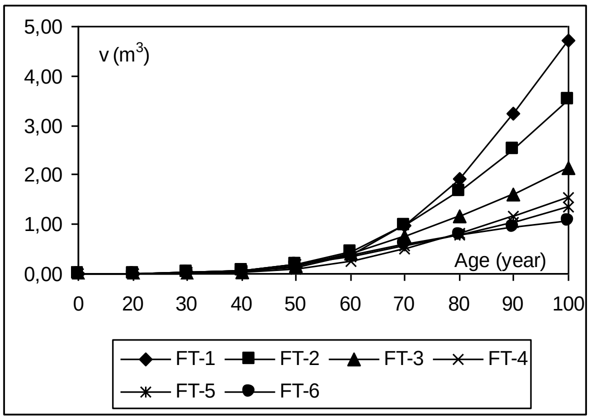
Graph 1. *Diameter development - average value by FT*



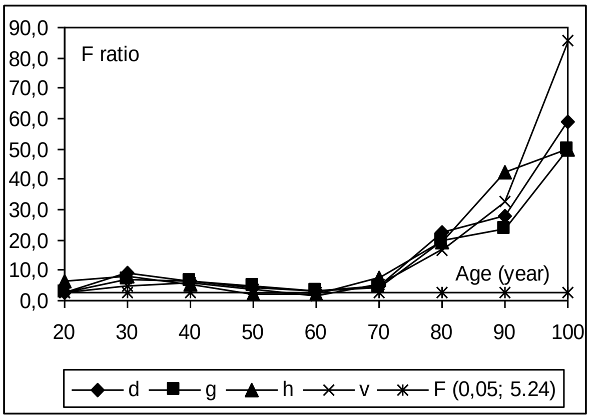
Graph 2. *Development of cross sectional area - average value by FT*



Graph 3. *Height development - average value by FT*



Graph 4. *Volume development - average value by FT*



Graph 5. *Values of F ratio depending on age*
F ratio in ANOVA
F (0.05; 5.24) – critical value of F ratio

As it has already been noted, the best conditions for silver fir development are found in FT-1 and they deteriorate towards FT-6, which can be seen based on the average tree sizes at the age of 100 years (Table 1).

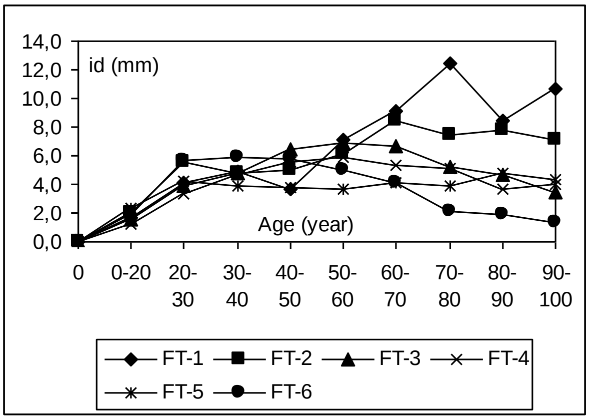
Table 1. *Average tree sizes at the age of 100 years*

FT	d		g		h		v	
	mm	%	m^2	%	m	%	m^3	%
1	638	100	0.3216	100	35.0	100	4.7299	100
2	562	88	0.2482	77	31.5	90	3.5399	75
3	450	71	0.1600	50	28.7	82	2.1299	45
4	399	63	0.1249	39	27.0	77	1.5396	33
5	373	58	0.1101	34	24.0	69	1.3540	29
6	355	56	0.0989	31	22.3	64	1.0642	22

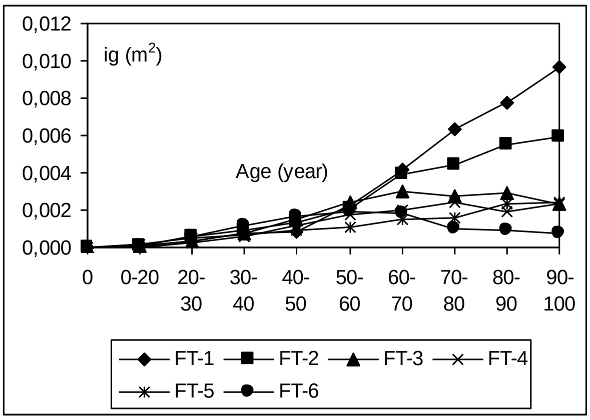
The data in Table 1 indicate that the lowest differences in tree sizes (productivity) were calculated for FT-4, FT-5 and FT-6. Also, these three sites show almost extreme differences compared to FT-1, and to some extent to FT-2. FT-3 occurs conditionally at the boundary between the extremes. The greatest differences are shown between the best and the poorest sites regarding cross sectional area and volume. Thus at FT-1, the attained cross sectional areas are by 69%, and volumes by 78% greater than those at FT-6. The differences between the above sites account for 44% - diameter, and 36% - height.

3.2. Silver fir increment

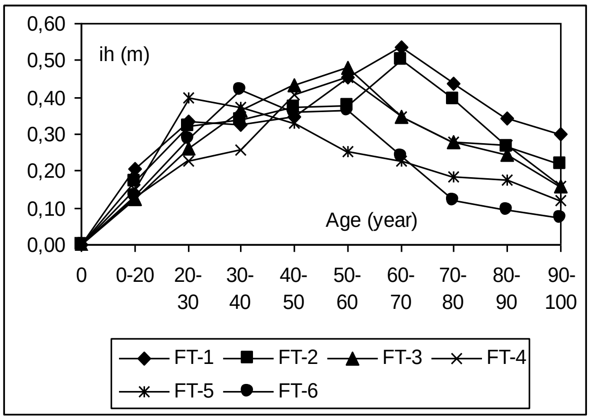
Graph 6-9 present current increment of the study silver fir elements during certain life spans at different sites. More intensive site differentiation, i.e. higher site influence on diameter and height increment occurs after the age of 65 years, and higher influence on cross sectional area and volume increment is notable afterwards – after the age of 75 years.



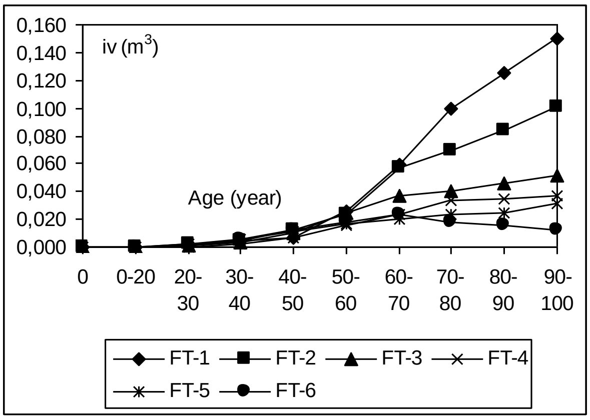
Graph 6. *Current diameter increment - average value by FT*



Graph 7. *Current increment of cross sectional area - average value by FT*



Graph 8. *Current height increment - average value by FT*



Graph 9. *Current volume increment - average value by FT*

Except for FT–5, which is characterised by total irregularity and absence of any laws in the tree development and increment, the data in Table 2 show that diameter increment culminates first at the poorest site (FT–6) and that, with better site conditions towards FT–1, culmination times shift to higher ages. The difference in culmination times of diameter increment between these two extremely different sites is 40 years. The above conclusion also refers to height increment, but the difference between culmination times at the best and the poorest sites is 30 years. At the best sites (FT-1 and FT-2), cross sectional area increment did not culminate during the study period. Volume increment attained its maximum only at the poorest site (FT–6), and it is still impossible to predict its culmination times at other sites, especially at the best sites (FT-1 and FT-2).

Table 2. *Increment culmination times*

FT	id	ig	ih	iv
	Age (year)			
1	75	○	65	○
2	65	○	65	○
3	55	65	55	○
4	55	75	55	○
5	85 (*)	○	25 (*)	○
6	35	55	35	65

id – current diameter increment; ig – current increment of cross sectional area
ih – current height increment; iv – current volume increment
(*) – irregular tree development in FT–5 to some extent disturbs the order of increment culmination
○ – increment did not culminate

The values of current diameter increment at the moment of culmination (Table 3) at the extreme sites differ by 53%, the differences in height increment account for only 21%, with substantially lower differences also between other study sites.

Table 3. Increment values at the moment of culmination

FT	id		ig	ih		iv
	mm	%	m^2	m	%	m^3
1	12.4	100	○	0.53	100	○
2	8.5	69	○	0.50	94	○
3	6.9	56	0.00296	0.48	91	○
4	5.9	48	0.00238	0.45	85	○
5	4.8 (*)	39	○	0.40 (*)	75	○
6	5.8	47	0.00188	0.42	79	0.02320

4. DISCUSSION

The information on growth and increment is highly significant for the study of the interaction between trees and their environment (site, stand) and it can be applied in different forestry disciplines, such as silviculture, forest management planning, forest ecosystem monitoring, etc. The updating and upgrading of the existing information (and knowledge) on the development of individual trees and stands in general is necessary from ecological, economic and social aspects of forest management (Spiecker, 2002). The obvious, multi-dimensional significance of the study of the above issues was the motive for the study of silver fir growth and increment in even-aged, mixed silver fir and beech forests at different sites on Mt. Goč.

A lower influence of site factors on the development of all study elements of silver fir trees is observed during the ages between 30 and 70 years, but the influence becomes significant after the age of 70. This trend of the influence of site factors on tree development is contrary to the "postulate" that the influence of site factors grows continuously with the age (Vanselov, 1948), but it coincides with the conclusion reported by Milios (2004) that stand conditions, without any interaction with the site, influence the height and volume growth of dominant beech trees in even-aged forests up to the age of 50 years.

The shapes of diameter and height growth lines change from the best (FT-1) to the poorest (FT-6) site. With the deterioration of the conditions for silver fir development, the curves of diameter and height development change in shape from flat, characteristic of shade tolerant species, to curvilinear, characteristic of light demanding species. This points to a very wide silver fir ecological range and to exceptionally high adaptation capacity to different site conditions. By adapting successfully to different site conditions and by depending on them, silver fir attains almost opposite characteristics and specificities – from an obligate shade plant at superior sites to heliophytic plant at the poorest sites. The same is reported by Šafar (1963), who concludes that on inferior soils and cold sites, sciophytes require more light, and that silver fir at the poorest sites is not a sciophytic species. Therefore, although silver fir is recognized by its shade tolerance and considered as one of the most sciophytic species (Kobe *et al*., 1995; Parent, Messier, 1996; Kobe, Coates, 1997; Stanescu *et al*., 1997; Banković *et al*., 2009/b; Pantić *et al*., 2011), it is actually a sciophyte only at the best sites. With the deterioration of site conditions, silver fir light demand increases, and by adapting to such conditions, silver fir development becomes increasingly similar to the development of heliophytic species.

The order of current diameter and height increment culmination also indicates that silver fir is successful in its adaptation to different site conditions. Namely, the culmination of these two increments is the earliest at extremely unfavourable sites. With the improved conditions, culmination times shift to higher ages, and the most delayed culmination times occur at the best sites. Such an order of silver fir current increment culmination is opposite to the conclusions that, at superior sites, tree and stand increment culminates before that at inferior site (Klepac, 1963; Stamenković, Vučković, 1988). The maximal difference in culmination times between the best and the poorest sites is 40 years for diameter increment, i.e., 30 years for height increment. Such differences and ratios in culmination times of diameter and height increment are not identified for other tree species, so they can be considered as a significant characteristic of silver fir development in even-aged stands. The differences in increment at the moment of culmination between the best and the poorest sites are significant in diameter increment and account for 53%, and in height increment they account for only 21%. The cause of such low differences in height increment is the fact that, at inferior sites, silver fir, by increasing its light demands, increases also its height increment, so it is sizeable even at inferior sites. In the given conditions, silver fir height increment at superior sites is high as the resultant of the site potential, and at inferior sites, as the consequence of greater light demand, which has a stimulating effect on height increment.

Cross sectional area increment at the best sites (FT-1, FT-2) did not culminate during the study period. Volume increment attained its maximum only at the poorest site (FT-6), and at the best sites, based on the previous trend, the time of its culmination cannot be predicted. The presented facts are also very significant for the determination of rotation periods, which should exceed 120 years, from the standpoint of the maximal wood volume production at the best sites. However, this is to some extent disputable on account of wood decay fungi (Milojković *et al.*, 1991).

The above study points to a strong interaction between the site and the silver fir development and to its high adaptation capacity to changed environmental conditions. With the deterioration of site conditions, silver fir light demand increases so that, at the poorest sites, silver fir behaves as a heliophyte, its dynamic processes accelerate, and its increment culminates earlier. Conversely, as site conditions improve, silver fir shade tolerance increases, (at the best sites silver fir behaves as a typical sciophyte), growth dynamics decelerates, and increment culmination shifts to older ages. The practical significance of these conclusions is reflected in the fact that at inferior sites, silver fir should be cultivated in even-aged stands, and that selection form is possible only at the best-quality sites, where silver fir can tolerate deep shade, stagnate, and thus contribute to a specific vertical structure of such forests.

5. CONCLUSIONS

The following conclusions can be made based on the results of the above research:

- Growth curves of the silver fir study elements change in shape depending on site characteristics, from flat shapes at the best sites which are characteristic of obligate sciophytes, to curvilinear shapes at the poorest sites characteristic of heliophytes.
- Current diameter and height increment culminate first at extremely poor sites, and with improved environmental conditions, culmination times shift to higher ages, and the most delayed culmination times occur at the best sites. The difference in culmination times between the best and the poorest sites is 40 years for diameter increment, and 30 years for height increment.
- Cross sectional area and volume increment attains its maximum only at the poorest sites. Based on the previous trend, the time of its culmination at the best sites cannot be predicted. The presented facts are very significant for the determination of rotation periods in even-aged silver fir forests.
- Silver fir has an exceptionally high adaptation capacity to site conditions and, in that sense, a large ecological range, possibly considerably larger than it has ever been presumed. At extremely different sites, its growth and increment characteristics are entirely opposite. At

the best sites, it behaves as an obligate sciophyte with decelerated dynamics. With the deterioration of site conditions, silver fir light demand increases, its growth dynamics accelerates and, at the poorest sites, it behaves as a heliophyte. The application value of the study results is reflected in the appropriate selection of the stand structure for silver fir cultivation at different sites. At inferior sites, silver fir should be grown in even-aged stand, whereas selection stands should be selected only at the best sites.

Acknowledgement

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DETERMINATION OF THE MOST APPROPRIATE METHOD OF ORIENTAL BEECH (*Fagus orientalis* Lipsky) STEM FORM COEFFICIENT IN TURKEY

Serdar CARUS[1], Yılmaz ÇATAL[1]

Abstract: *Aim of this study, is to determine the best form factor formula for Oriental beech (Fagus orientalis Lipsky) the important forest trees of Turkey. The data obtained from sample trees taken from generally even- aged, middle aged (40- 60 years), normal closed, pure and natural stands. Form factors of trees were calculated for 50 Oriental beech sample trees in Black Sea region of Turkey. As a consequent, each tree's volume was precisely calculated as the real volume. Next, the breast height form coefficient was calculated and its average was statistically compared to the averages of absolute (f_0), natural ($f_{0.1}$), artificial ($f_{0.5}$) and Hohenadl's (f_h) form coefficients using pair sample t-test. Results showed that there is significant difference between the averages of absolute, natural, artificial and Hohenadl's form coefficient. As a result, stem form coefficients are not capable to replace the breast height form coefficient of Oriental beech trees over the study area.*

Key words: Form factors, Oriental beech, pair t- test, Stem volume

1. INTRODUCTION

The wood that the main product of forest is presented to the market through being measured by the unit of volume and weight. The total wood volume of tree and forest can not be definitely determined in fact without cutting them. For this reason, various estimation methods were studied to get the volumes of standing trees and many researches were made in these subjects.

In order to determination of forest stand volume, measuring and wood sale and also many other aspects, aware of growing stock are necessary and important. Stem form of tree isn't depending on special form, therefore for determination to volume of every tree proposed different relations (Socha and Kulej, 2005). Pay attention to tree stem isn't cylinder, thus, the cylinder volume should be multiply with coefficient for near the volume to real volume of tree. This coefficient is entitled form factor in forest inventory. Form factor is the third characteristic for determine of tree volume with diameter at breast height and height. This coefficient is depended on some of factors such as tree species, habitat, situation in stand and stand density (Kalıpsız, 1984).

Oriental beech (*Fagus orientalis* Lipsky) has been considered as one broadleaved showing a successful rate of growth in natural stand in the northern Turkey. The amount of its wood production has been observed to be almost 8 m^3 ha^{-1} per year. Based on the current available statistics, about 614.000 ha of the area are currently under Oriental beech in Turkey (Anonymous, 2006). Furthermore, it is predicted that this species can be established in a narrow

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scale of plantations in the region, due to its wide scale of applications in wood industry. Regarding to the great sum of Oriental beech stands, developing accurate plans to improve the performance of forestry operations well as natural stand and the plantations seems to be essential. In forest utilization, a vast amount of investment is normally allocated to the stand and tree volume assessments. Moreover, the assessment of tree and stand volume in forest planning and harvesting are considered as one of the necessities in forest inventory.

Form factor is ratio of tree real volume to volume of one geometrical form such as cylinder, cone and or truncated cone that its diameter and height are near to tree. Diameter of geometrical from is equal to diameter at breast height and its height is equal to tree height. Form factor is different with other inventories of tree forms as form factor should be calculated afterwards calculation of tree volume. Form factor is one the method for harmony and relation between tree form and volume. Form factor is calculable for all trees (stems and branches) and or for tree stem (Zobeiry, 2000).

One speaks of the artificial form factor, based on the under-bark volume and the volume of a cylinder of equal diameter to the diameter at breast height (over bark), and of natural form factors based, for instance, on the cylinder with diameter equal to that at the middle of the tree, or at some other proportion of the total height. Hohenadl's method, used in Germany, is based on the diameter at 1/10 of the height.

Basically, the tree volume is derived from v=g.h.f equation; where "v" is tree volume (in m^3), "g" is basal area at breast height (in m^2), "h" is tree height (in m), and "f" is the tree form factor. Basal area measurement inside the forest stand can be carried out in a relatively cheap and easy way. However, measuring form factor and height is critically time-consuming and expensive work inside the stand. Although the problems associated with height measurement is somehow solved by applying different diameter and height equations and curves, measuring real form factor is still a crucial problem.

Real form factor is explained as the real volume divided by the volume of a cylinder having the basal area equivalent to the tree's basal area at breast height and the height equal to the tree's height (Kalıpsız, 1984). Therefore, if such a form factor featuring the defined height and diameter at breast height can be achieved, the tree volume assessment will be much easier. For calculating the real form factor, the tree should be cut down and its precise volume should be measured. This is considered as a time- consuming and costly work. As a result, forest researchers have proposed a variety of form factor formulas in order to replace with the real form factor. As a case in point, Kalıpsız (1984) can be noted.

To calculation of tree real volume, we need to real form factor, but for calculation of real form factor trees should be cut down and theirs real volume should be calculated with measuring of pieces volume of one and 2 m following the real form factor is calculable using real volume of trees. Pay attention to calculation of real form factor isn't possible for ever (by reason of high cost) and relations between different form factor are presented with real form factor by many researchers thus with comparison of aforementioned form factor with real form factor, it is possible for selection of it's nearest and replacement of real form factor. Mexner (2000), Socha and Kulej (2005), Khoshnava (2006) and Rahimnejad (2008) obtained the same results in relation to applicable of different form factors instead of real form factor. The aim of this study is to determine the best formula of form factor between presented form factors.

2. MATERIAL AND METHOD

The study area consists of even aged, pure and natural Oriental beech stands, which is located in the longest 100 km of Black Sea region that situated in North of Turkey. The average slope of forest field is about 20%. The area is located 700 m above sea level. Annual total precipitation of the region is almost 850 mm; average monthly temperature is about 12.9 °C. The climate of region is cool and semi humidity. Soil is relatively deep with semi heavy texture.

The data needed for the study was measured from 50 trees, which were cut as a part of the thinning operation at the tree age is changed from 40 to 60 years in the area (Fig. 1). In order to determine the best form factor formula for Oriental beech stands in Turkey, a number of 50 trees were selected based on their distribution in diameter classes, from 5 to 30 cm. Firstly, several quantitative factors including diameter at breast height and diameter at stump (0.20- 0.30 m) were measured using a diameter tape, just before the trees being felled. . After cutting the trees, the heights and diameter from breast height up to the height where diameter was measured as 5 cm using a diameter tape in a two meter interval. Finally, diameter at 0.1, 0.3, 0.5, 0.7, and 0.9 of the total height was measured respectively. As a consequent, each tree's volume was precisely calculated as the real volume. In this research tree real volume calculated for number of 50 tree using Huber formula. Also, real ($f_{r,}$), absolute (f_0), artificial ($f_{0.5}$), natural ($f_{0.1}$) and Hohenadl's (f_h) form factors calculated for these trees. Kolmogorov- Smirnov was used for normality test of data at first. Afterwards, for confidence to normality of data, pair sample t- test used for averages of calculated form factors with real form factor in order to determine the best appropriate form factor for Oriental beech by Ver 17.0 statistical package program (Kalıpsız, 1981).

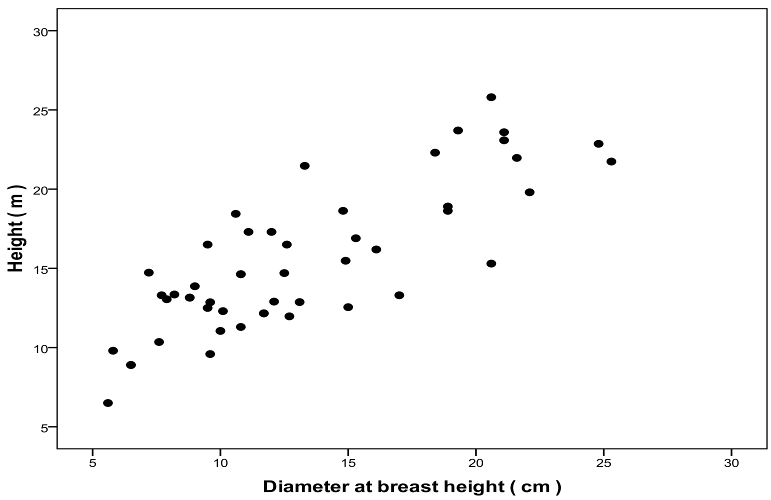


Fig. 1. *Distribution of the trees in diameter and height classes*

Table 1. *Statistical features of sample trees*

Variable	Mean	Standard deviation	Min	Max	Cv (%)
Age (year)	48.70	7.747	40	60	15.91
Diameter (cm)	13.45	5.174	5.6	25.3	38.47
Height (m)	15.71	4.401	6.5	25.8	28.01
Volume (m^3)	0.145	0.140	0.10	0.458	96.55

Following the measurement of those quantities, the below- mentioned factors were calculated in sequence.

Tree real volume

In order to calculate the tree's real volume, each log's volume was calculated from its stump to breast height using Huber's formula. Then, each log's volume was calculated from its breast height to the height where diameter becomes 5 cm, applying Huber's formula. Finally, volume of the highest part of each tree was calculated using the cone's volume equation. Then, each tree's real volume was calculated as the sum of all above mentioned log volumes.

$$v = \frac{\pi}{4} . d_{l/2}{}^{2} . l \qquad (1)$$

Where, v is log volume (m^3), $d_{l/2}$ is mean diameter of log (m) and l is length of log (m).

Form factor equation
Five different form factors were calculated as follows:

Real form factor
Real form factor for every tree is equal to ratio of tree volume to cylinder volume that its height is equal to height of tree and its basal area is equal to tree basal area in diameter at breast height that is obtained using Eq. 2.

$$f_r = \frac{v}{\frac{\pi}{4} . d_{1.3}{}^{2} h} \qquad (2)$$

Where (f_r) is the tree real form factor, (v) is the tree real volume (in m^3), ($g_{1.3}$) is each tree's basal area at breast height (in m^2) and (h) is each tree's height (in m).

Absolute form factor
This measure calculated using the equation as follows:

$$f_0 = \frac{v}{\frac{\pi}{4} d_0{}^{2} h} \qquad (3)$$

Where (f_0) is the absolute form factor, (d_0) is the diameter at the base total height, and (h) is each tree's height.

Natural form factor
This factor is derived from the ratio of the real volume to the volume of a cylinder having the same basal area as the tree's basal area at 0.1 of its height, and the same height as the tree's height. Also, natural form factor stand trees calculated using Eq. 4.

$$f_{0.1} = \frac{v}{g_{0.1}\, h} \qquad (4)$$

Where ($f_{0.1}$) is the tree's natural form factor, (v) is the tree real volume (in m^3), ($g_{0.1}$) is the tree basal area at 0.1 of its height (in m^2), and (h) is the tree height (in m).

Artificial form factor
Artificial form factor for stand tree calculated using Eq. 5.

$$f_{0.5} = \frac{(d_{0.5})^2}{(d_{1.3})^2} \qquad (5)$$

Where ($f_{0.5}$) is the artificial form factor, ($d_{0.5}$) is the diameter at the half total height, and ($d_{1.3}$) is the diameter at breast height.

Hohenadl's form factor

Hohenadl's form factor was calculated using Eq. 6. The standing trees form factor can be calculated using Hohenadl's formula as shown below:

$$f_h = 0.2\left[1 + \frac{d^2{}_{0.3}}{d^2{}_{0.1}} + \frac{d^2{}_{0.5}}{d^2{}_{0.1}} + \frac{d^2{}_{0.7}}{d^2{}_{0.1}} + \frac{d^2{}_{0.9}}{d^2{}_{0.1}}\right] \qquad (6)$$

Where (f_h) is Hohenadl's form factor and ($d_{0.1}$, $d_{0.3}$,……,$d_{0.9}$) are tree diameters at 0.1, 0.3,……,0.9 of the height from the bottom respectively.

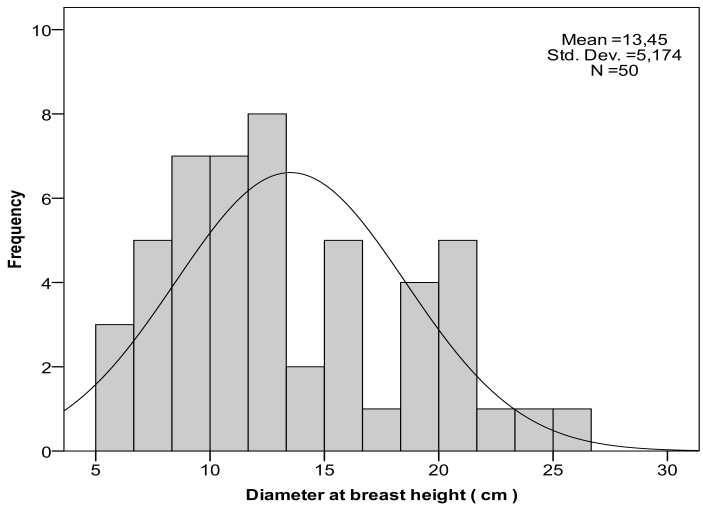
3. RESULTS

In this study, firstly, the real volumes of 50 trees were calculated as it was explained above. Next, the real form factor (f_r), the natural form factor ($f_{0.1}$), the artificial form factor ($f_{0.5}$) and the Hohenadl's form factor (f_h) were calculated respectively (Table 2 and Fig. 2).

Table 2. *Statistical features of form factors for sample trees*

Form factor	Mean	Standard deviation	Min	Max	Cv (%)
f_r	0.462	0.056	0.35	0.61	12
f_0	0.312	0.057	0.22	0.44	18
$f_{0.1}$	0.423	0.046	0.31	0.54	11
$f_{0.5}$	0.404	0.099	0.24	0.78	25
f_h	0.442	0.050	0.36	0.64	11

Following the calculation, in order to use the statistical t- test, the normal distribution of the population should be ensured. Kolmogorov- Smirnov test can be used to determine the normal/abnormal statistical distribution (Kalıpsız, 1981). Owing to the fact that the amount of calculated 0.118 (p=0.08) and the degree of freedom for 50, in 95% probability, the null hypothesis which means that there is no significant difference among the data used in the study, is not rejected. In other words, distribution of the trees in 95% probability is normal for further investigations. The distribution of the each 2- cm diameter class was given Fig. 2.



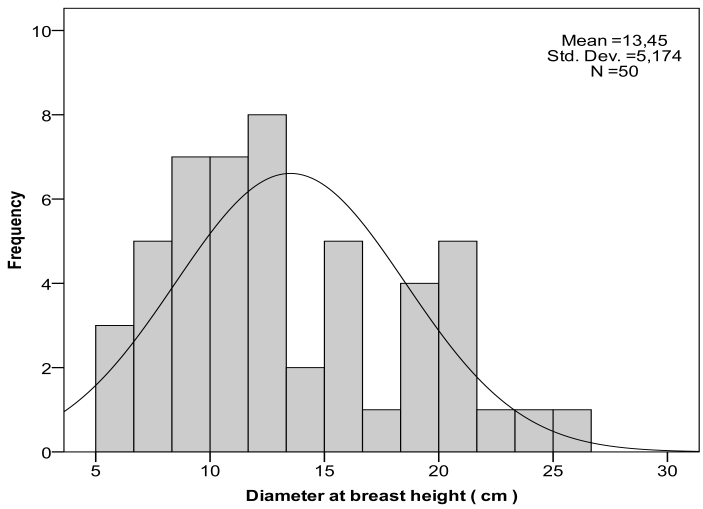


Fig. 2. *Distribution according to 2 cm diameter classes of sample trees*

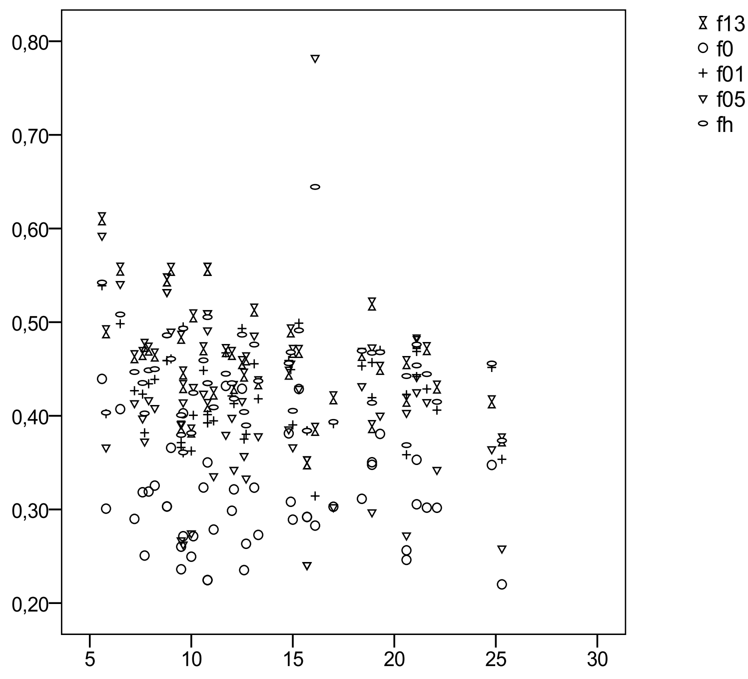


Fig. 3. *Distribution of different form factors for Oriental beech in the study*

As a consequence, pair sample t-test was implemented to the trees studied across the site. Afterwards, the average of each calculated form factor was compared to the real form factor using pair sample t-test, in order to determine the most appropriate form factor. The results of pair sample t-test were shown in Table 3.

Table 3. *Results derived from pair sample t-test for different form factors in the study*

Pairs tested	Mean difference	Standard deviation	Mean of standard error	Confidence limit (95%) Low limit	Upper limit	t	df	Sig.
$f_{1.3}$ - f_0	0.150	0.070	0.009	0.130	0.170	15.194	49	0.000
$f_{1.3}$ - $f_{0.1}$	0.039	0.049	0.007	0.026	0.053	5.719	49	0.000
$f_{1.3}$ - $f_{0.5}$	0.058	0.078	0.011	0.036	0.080	5.295	49	0.000
$f_{1.3}$ - f_h	0.020	0.060	0.008	0.003	0.037	2.339	49	0.023

The real form factor (f_r) was calculated and its average was statistically compared to the averages of absolute (f_0), natural ($f_{0.1}$), artificial ($f_{0.5}$) and Hohenadl's (f_h) form factors using pair sample t-test. According to Table 3, a significant difference can be observed between the averages of real and absolute, natural, artificial and Hohenadl' s form factors at 0.05 probability level, at the age of 40- 60 years. In other words, absolute, natural, artificial and Hohenadl's form are not capable enough to replace the real form factor (f_r) at the age of 40- 60 years for Oriental beech over the study area.

Mahinpour (2002), stated that in *Pinus elliottii* stands at the age of 27, none of the calculated form factors proved the capability to replace the real form factor. As the previous case studies, no significant difference was observed between the real and Hohenadl's form factor in the study carried out by Bonyad and Rahimnejad (2004) in Loblolly pine stands at the age of 26 years. Bonyad and Rostami (2005) reported following a form factor investigation of *Pinus elliottii* stands in 25, 27 and 30 year-ages, no significant difference was observed amongst $f_{0.1}$, $f_{0.5}$, and f_r. Thus, they proposed the application of $f_{0.5}$, instead of f_r in tree volume assessment. Khoshnava (2006) showed that between artificial and real form factor has no significant differences and it is possible for using for artificial form factor instead of real form factor. Ahmadi et al. (2008), showed that between natural and real form factor has no significant differences and it is possible for using for artificial form factor instead of real form factor for Zarbin (*Cupressus sempervirens*) plantations at the age 20 years. Fadaei et al. (2008) reported that following a form factor investigation of *Pinus taeda* L. stands at the age 18, no significant difference was observed amongst $f_{0.5}$, f_h and f_r. Rahimnejad (2008) showed that between Hohenadl and real form factors hasn't significant differences, thus it is possible for application of Hohenadl form factor instead of real form factor for *Pinus taeda* stands.

Pay attention to, inventory of tree volume is work with high cost and time, thus it is necessary to determine an form factor that is near to real form factor of tree for calculation of tree volume using simple calculations with high accuracy. Although, natural form factor is preventative more minute of stem form but artificial form factor has more application because of in common inventories, diameter at breast height are usable for performing of calculations. Determination of natural form factor is a work with high cost by reason of in non-research works if artificial form factor had no significant differences with real form factor is try to using of relations that are on basis of diameter at breast height (by reason of lower cost) and using natural form factor is relinquished.

The amount of accuracy varies based on the site, age and species. Moreover, the form factor's capability to replace the real form factor does not guarantee its preference at the tree's all growth levels and ages. Therefore, the results obtained here can hold true only in the studied stand at the age of 40- 60 years. That is mainly because the tree shape highly varies due to its growth. Even sometimes the trees belonging to a particular stand tend to turn into a cone shape from their normal cylinder shape as they grow. Fadaei (2005) reported that the real form factor in Loblolly pine stands tends to decrease as the stand's age increases. Hence, any sort of changes in the tree's shape can highly affect its form factor. It results in preference of one form factor over the others at a particular age.

In this study, reported following a form factor investigation of Oriental beech stands significant difference was observed amongst f_0, $f_{0.1}$, $f_{0.5}$, f_h and f_r. Nevertheless, the Hohenadl's form factor showed a small preference over the real form factor. Hence, it can be considered as an effective tool in terms of reducing measurement costs and time.

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ACCURACY OF NUMERICAL INTEGRATION METHODS IN TREE VOLUME ESTIMATION

Kyriaki KITIKIDOU[1*], Elias MILIOS[1], Athanasios STAMPOULIDIS[1]

Abstract: *For many integrals, none of the known integration methods can be applied. Many researchers have attempted to develop other methods of integrals calculation, the so-called numerical integration methods. The task is to calculate the volumes of solids generated by rotating a curve around the x-axis, using three methods of numerical integration (trapezium rule, Simpson's rule and Gauss squaring) and compare them to the actual volumes of trees, in order to evaluate the numerical integration's accuracy. The analysis revealed that the three integration methods do not differ significantly, while the volumes calculated by these methods of integration differ significantly from the actual tree volumes.*

Keywords: Numerical integration, *Quercus conferta*, taper equations, tree volume, volumes' comparison.

1. INTRODUCTION

One of the ways to describe tree bole shapes is by fitting taper equations to sample data. These are regression equations, linear or nonlinear, which predict the diameter d_{h_i} at any tree height h_i (Fries and Matern 1965; Max and Burkhart 1976; Goulding and Murray 1975; Kozak 1988; Bi 2000; Kitikidou 2002; Kitikidou 2010).

Taper equations can be used to derive volume equations by integration when the equation is rotated around the longitudinal axis of a tree (Bruce et al. 1968; Byrne and Reed 1986). Volumes of any specific log length can be obtained by integrating a taper function:

$$v = \frac{p}{4}\int_{h_1}^{h_2} d_h^2 dh$$

where h_1 and h_2 are the heights of the small and the large end of the log, respectively.

Ideally, the volume computed by integration of the taper equation from the ground to the top of a tree, i.e.:

$$v = \frac{p}{4}\int_{0}^{H} d_h^2 dh \text{, where } H \text{ is total tree height,}$$

should be equal to that calculated by summing the volumes of its logs (called "actual volume" of a tree from now on), on condition that the diameters d_{h_i} used in taper equation fitting and those used in the calculation of logs volumes are the same (Philip 1994). However, not all taper

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equations can be integrated; there are complicated taper equations where none of the known analytical integration methods (u-substitution, integration by parts, partial fractions, trigonometric substitution, rationalizing substitutions or other, more specialized methods) can be applied. A formula for the integrand may be known, but it may be difficult or impossible to find an antiderivative that can be written in an elementary form. In that case, we can compute a numerical approximation. Numerical integration constitutes a broad family of algorithms for calculating the numerical value of a definite integral. Thus, if $v = f(d_h)$ is a smooth well-behaved function, integrated over a small number of dimensions and the limits of integration are bounded, there are many methods of approximating the integral with arbitrary precision (Atkinson 1989). The question is if the tree volume computed by numerical integration of the taper equation approximates the actual volume.

The aim of this work is to examine if numerical integration of a taper equation approximates the actual tree volumes, in a case where the taper function cannot be integrated otherwise.

2. MATERIALS AND METHODS

We used the taper equation developed for *Quercus conferta* stands by Kitikidou (2002):

$$d_{h_i} = \sqrt[k]{\frac{H - h_i}{H - 1.3}} D, \text{ where}$$

$$k = -0.668 + 276.777\frac{D}{H} - 6087.256\frac{H - h_i}{H - 1.3}\left(\frac{D}{H}\right)^2 - 0.198\frac{1}{h_i},$$

where:

D: diameter at breast height (m)

H: total tree height (m)

d_{h_i}: diameter at tree height h_i (m)

This is a taper equation that cannot be integrated with any known analytical integration method.

Next, we calculated the volumes v (m^3) of the 500 trees used in the development of the taper equation, as follows:

From the ground to stump height (0.3 m) as a cylinder:

$$v_1 = \frac{\pi}{4} d_{0.3}^2 0.3$$

From stump height to 0.8 m by applying Smalian's formula (Hush et al. 1982):

$$v_2 = \frac{\pi}{4} \frac{d_{0.3}^2 + d_{0.8}^2}{2} 0.5$$

From 0.8 m to breast height (1.3 m) by applying Smalian's formula:

$$v_3 = \frac{\pi}{4} \frac{d_{0.8}^2 + D^2}{2} 0.5$$

From breast height up to the height where the last diameter was measured by applying Smalian's formula to each log. Diameters were measured every 2 m above breast height (that is, at i = 3.3, 5.3, … m). Each log had a volume v_i equal to:

$v_i = \frac{\pi}{4}\frac{d_0^2 + d_n^2}{2} 2$, where d_0 is the diameter of the small end of the log and d_n is the diameter of the large end of the log.

From the height where the last diameter d_c was measured till the top of the tree as a cone: $v_c = \frac{1}{3}\frac{\pi}{4} d_c^2 l_c$, where $l_c = H -$ (height where the last diameter was measured), i.e. the cone length.

The actual volume of each tree was equal to:

$$v = v_1 + v_2 + v_3 + \sum v_i + v_c$$

As regards the numerical integration of the taper equation studied, three methods were applied:

a. Trapezium rule

The trapezium rule is an approximate technique for calculating the definite integral $\int_a^b f(x)dx$. The trapezoidal rule works by approximating the region under the graph of the function *f(x)* as a trapezoid and calculating its area as follows:

$$\int_a^b f(x)dx \approx (b - a)\frac{f(a) + f(b)}{2}$$ (Atkinson 1989) (Fig. 1).

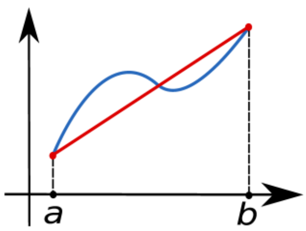

Fig. 1. *The function f(x) (in blue) is approximated by a linear function (in red).*

b. Simpson's rule

Simpson's rule is another method for the numerical approximation of definite integrals. Specifically, it is the following approximation (Süli and Mayers 2003) (Fig. 2):

$$\int_a^b f(x)dx \approx \frac{b - a}{6}\left[f(a) + 4f\left(\frac{a + b}{2}\right) + f(b)\right].$$

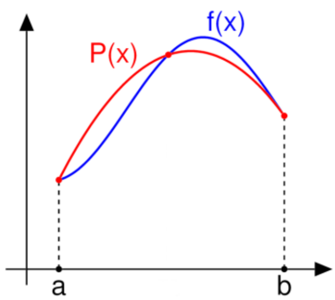

Fig. 2. *Simpson's rule can be derived by approximating the integrand f (x) (in blue) by the quadratic interpolant P(x) (in red).*

c. Gauss squaring

Gauss squaring numerical integration is based on the integral of the Gaussian function e^{-x^2}. The integral is $\int_{-\infty}^{\infty} e^{-x^2} dx = \sqrt{\pi}$ (Fig. 3). Although no elementary function exists for the error function, as can be proven by the Risch algorithm (Risch 1969), the Gaussian integral can be solved analytically through the tools of calculus. That is, there is no elementary indefinite integral for $\int e^{-x^2} dx$, but the definite integral $\int_a^b e^{-x^2} dx$ can be evaluated.

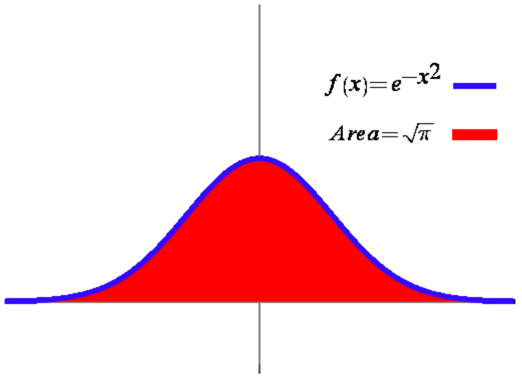

Fig. 3. *A graph of* $f(x) = e^{-x^2}$ *and the area between the function and the x-axis, which is equal to* $\sqrt{\pi}$.

For the numerical integration we used the *Mathematica* v.7 software (Wolfram Research Inc. 2008).

3. RESULTS – DISCUSSION

The volumes calculated by three different methods of numerical integration of the taper equation were identical. This could be due to the linear equation of *k* in the taper equation (Lee 2007); *k* equation has the linear form $Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3$. Summary statistics for trees volumes are given in Table 1.

Table 1. *Volumes summary statistics.*

Statistics	Actual volumes (m^3)	Numerical integration volumes (m^3)
Mean	0,0529	0,0505
Standard deviation	0,041	0,0413
Mean absolute error	0,0224	0,02034
Mean absolute error %	56,6653	49,0854

Since the distributions of the volumes weren't normal, we used Wilcoxon's test (Wilcoxon 1945) for the comparison between volumes through numerical integration and actual volumes. The test resulted in a *Z*-value of -12.111 and a *p*-value of 0.000, showing that the volumes calculation through numerical integration differs statistically significantly from the actual volumes. Moreover, there was a general underestimation of the volume; 67.8% of the volumes calculated through numerical integration were smaller than the actual volumes, while 32.2% were bigger than the actual volumes.

For years, mathematicians struggled to solve complex differential equations analytically. However, with the advent of computational modeling, many numerical integration methods, approximating the solution of a differential equation that could not be solved analytically, were created. Today the internet is littered with a lot of numerical integration schemes. Several researchers in different fields (astronomy, biomechanics) tested different schemes, and they also found that numerical integration cannot give accurate approximations of the real solution (or as accurate as desired). Won (2000) noticed significantly large variances in a comparison among different numerical integration methods on the biomechanics of the countermovement jump sport. Berry and Healy (2003), in a comparison of numerical integration techniques applied to orbit determination and space surveillance data, noticed significantly large errors and inconsistency. Clement et al. (2008), by applying numerical integration methods to celestial mechanics data, concluded that more than a few methods performed surprisingly poorly. Finally, Cviklovič et al. (2011) emphasized on the high attention and knowledge that the application of numerical integration methods requires, when they are applied to strapdown inertial navigation.

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OPTIONS FOR USING REMOTE SENSING AND ITS RELIABILITY IN STRUCTURAL AND SPATIAL DETERMINATION OF FOREST ECOSYSTEMS

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Abstract: *Researches on vegetation cover are multidisciplinary and rely on scientific achievements in biogeography, landscape and conservation ecology, physical geography, phytocenology and other scientific disciplines, and the constant development of information technologies has led to a growing importance of remote sensing technique and methodology, combined with GIS technology, in regards to identification, valuing and monitoring of forest ecosystems. Structural and phenological variations between forest communities, and tree species they are composed of, create characteristic spectral images which can be recorded by sensors. Processing and analysis of these images by specialized software offer various useful information about development and distribution of forest communities. This paper presents options for using remote sensing techniques (supervised and unsupervised classification) for preparing vegetation maps, where Landsat images were used to determine vegetation cover. The level of reliability and applicability of this methodology was tested by comparison of areas under forests and clearings, areas under individual stands, and by analysis of their spatial coincidence with standard terrestrial methods of determination thereof. A reference area used in the process was the Management Unit "Topolik" managed by the Forest Estate "Novi Sad". As for unsupervised classification, the area under forests that resulted from images is smaller by 31.52 ha, areas under clearings is larger by 38.60 ha, with lower spatial coincidence of these categories compared to terrestrial methods. Supervised classification offered better results in regards to identification of these categories – area under forests is smaller by 12.28 ha and the area under clearings is larger by 14.36 ha. When it comes to stands, identification by using the image diverts substantially compared to the situation in the field. Differences are two-way and range from 861.98 ha for poplar plantations to +3.96 ha for devastated ash forests, with significantly different spatial distribution. The use of higher quality images, hardware and software would generate more reliable and more applicable results, which is the intention when it comes to implementation of modern technologies for data collection in the forestry of Serbia.*

Key words: remote sensing, forest vegetation, structure, spatial distribution

1. INTRODUCTION

When it comes to larger areas, it can be rightfully said that remote sensing, together with aerophotogrammetry, is an inevitable method of massive spatial data collection. Remote sensing is a science (in terms of skills) of collecting information about the surface of the Earth, and

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objects on it, with no direct contact with them. This is achieved by registering and recording the energy reflected or emitted from the surface of the Earth and the structures, with subsequent processing and analyses of such obtained information. Therefore, remote sensing is a method of collecting information by using systems which are not in direct, physical contact with a phenomenon or an object of investigation (Pruit, 1960).

Due to the development of modern technologies and their practical implementation, remote sensing has found its purpose in agriculture, forestry, geology, hydrology, nature protection, prognosis of natural disasters and weather induced disasters, and many other areas of people's lives. Satellite images, if available, are a good foundation for performing analyses while working on spatial planning documents, because for most information they are more advantageous (cheaper) option compared to aerial images (Bušljeta, Vidović, 2006). An image is a picture, a photograph, or any other form which provides a two-dimensional (raster) image of objects or areas (scene). Information contained in images is presented in grey shades or colours (natural or pseudo colours). The foundation for the use of satellite images in forestry results from the fact that structural and phenological variations between forest communities and tree species they are composed of form characteristic spectral images which can be registered by sensors. Digital processing and analysis of these images by specialized software packages offer various useful information about development and distribution (fragmentation) of forest communities by areas.

Nowadays, when prices of images (digital air images, satellite images, LIDAR images) and equipment (computers, digital photogrammetric stations, photogrammetric software) are continuously dropping, and images of increasing spatial resolutions and application options are available, there are less and less reasons for avoiding the use of remote sensing methods. Consequently, in addition to earlier standard methods of collecting data on forests, it is necessary to explore an opportunity for using new methods and technologies of remote surveys in practical forestry as well, especially in forest inventory (Benko, Balenović, 2011). In those terms, the objective of this paper is to analyse options for using remote sensing techniques and methods (supervised and unsupervised classification) in preparing vegetation maps by using LANDSAT images for the area of the Management Unit "Topolik", whose bio-ecological characteristics make it an adequate subject of the research of this type.

Collection of data by remote sensing is finding its increasing practical application in forestry. Satellite images of low spatial resolution are most frequently used in Croatia for mapping of vegetation cover, assessment of health status of forests and, as of recently, National Forest Inventory. It has been confirmed that multi spectral satellite images LANDSAT (25x25 *m*), IRS (23x23 *m*), ASTER (15x15 *m*) and SPOT (10x10 *m*) can be used for the said purposes with good reliability (Seletković *et al.*, 2008). Options for using high resolution satellite images for the purpose of mapping of habitats in forestry were explored in Hungary, where it was confirmed that combination of visual and digital interpretation could be used to supplement forest thematic maps (Kristof *et al*., 2002). Mulahasić (2007) used LANDSAT images and supervised classification to prepare a map for land use for the area of Solta Island, where *Maximum Likelihood Classification* proved to be extremely appropriate method for this purpose. Pejanović (2002) compared digital and visual interpretation of LANDSAT TM satellite images for the purpose of Forest Inventory, while Kovač (2001), and then Kušan as well, Peranr (2001) used LANDSAT TM satellite images to explore applicability of regression models for assessment of stand sizes based on the data on spectral reflections.

2. MATERIALS AND METHODS

2.1. Study area

Management Unit "Topolik" is managed by the Public Company "Vojvodinasume"-Petrovaradin, Forest Estate "Novi Sad". Forests and forest land of the Management Unit are located in the Dunav littoral, both in protected and unprotected areas. According to the data contained in the current Forest Management Plan (2012-2021), areas under forests cover 79.49% of the area of this Management Unit, with cloned poplar trees being dominant with 51.17%, and shares of stands of american ash, and stands of autochthonous willow and poplar trees. In functional terms, the Management Unit is intended for production of technical wood and largely for special natural reserve under I, II and III level of protection ("Koviljsko-petrovaradinski rit"). The protected area was declared in order to preserve complexes of pond and marsh habitats, and flora and fauna typical for this region. The special reserve is characterized by the level of conservation and diversity of hydrographical forms of marshland (holms, estuaries, meanders, ponds, etc.), marshland plant communities (marshy woodland intersected by ponds, swamps, meadows and reedbeds) and diversity and richness of fauna, especially marsh bird. There are 18 stands that have been identified in the area of the MU "Topolik", which, combined with various types of forests and purposes of the area, led to the establishment of 33 Management Classes.

2.2. Digital processing of images

LANDSAT satellite images were used in the process of determination of the vegetation cover. The LANDSAT might have the longest history and widest use for monitoring the earth from space. In this paper, satellite images were the foundation for generating a thematic map for land use for the MU "Topolik". The satellite images which were used for classification contains eight bands of electro-magnetic spectrum. In order to identify areas, tree species and forest communities, a process of classification of images obtained by remote sensing techniques (LANDSAT satellite images) was performed. Due to the limitation of spatial resolution, Landsat products are usually used to map vegetation at community level. It is a challenging task to use Landsat images for mapping at species level, especially in a heterogeneous environment. However, when integrating with other ancillary data, it becomes possible to map species (Xie et al. 2008). An example of a species level of vegetation classification was implemented in the Amanos Mountains region of southern central Turkey using Landsat images, com-bined with the environmental variables and forest manage-ment maps, to produce regional scale vegetation maps with an overall high accuracy (Domac and Su¨zen 2006). The objective of the classification of images obtained by remote sensing is to assign every pixel on an image to a category from a predefined set. The result of the classification is a thematic map of the original image. Since images obtained by remote sensing contain information in a number of layers of electro-magnetic spectrum (multispectral images), the classification uses spectral information represented by values of pixels in different spectral layers. There are two methods of classification that can be used: ***unsupervised and supervised classification***. The software package ARcGIS and modules (extensions) Spatial Analyst and Image analyst were used. A digitalized map for the MU "Topolik" to the level of sub-compartment was used to control the procedure itself. The selection of bands on the satellite image established that the best way is to use a combination of bands – infra-red image R = 4, G = 3, B = 2 and also a distribution of bands which is optimum for classification of forests R = 5, G = 4, B = 3, TM 4. 3.2. because of the best noticeable differences in pixels which are used by LANDSAT satellite. Images obtained from LANDSAT 5 satellite were used for the paper.

In nature, classes being classified represent natural variations in their spectral samples, and further variations are results of mist, topographic shades, system noise and mixed pixels. As a result of this, images generated by remote surveys rarely record spectrally clear classes, and generally present a number of tones within each band. Many classification strategies do not take into account variations which may be presented within spectral categories, and do not recognize problems of overlapping of frequency distribution of values and separated categories (Mulahusić, 2007). In unsupervised classification, image processing software classified images based on natural groupings of the spectral properties of the pixels, without the user specifying how to classify any portion of the image. Conceptually, unsupervised classification is similar to cluster analysis where observations (in this case, pixels) are assigned to the same class because they have similar values. The user must specify basic information such as which spectral bands to use and how many categories to use in the classification, or the software may generate any number of classes based solely on natural groupings. This method is often used as an initial step prior to supervised classification. For the purpose of this paper, the strategy known as the Maximum Likelihood Classification also was used (supervised method). This classification uses data as a method of assessment of mean values and variances of categories, which is then used to estimate the likelihood (Campbell, 1996). Maximum Likelihood Classification is the most popular method of classification with remote sensing (Murai, 1996). Irregularities in classification (wrongly classified cells) are corrected by filtering, adjusting borders of classes and removing of small isolated regions, where a tool for clearing the data within ArcGIS software was used. Extensive field knowledge and auxiliary data may help im-prove classification accuracy. Studies have shown that classification accuracy can be greatly improved after applying expert knowledge (empirical rules) and auxiliary data to extract thematic features (e.g. vegetation groups) (Gad and Kusky, 2006). The level of reliability and applicability of this methodology was tested by comparison of areas and forest communities with standard terrestrial methods of their determination. Reference data that were used were Shape files for MU "Topolik" which were produced during regular planning of these forests. While planning the MU "Topolik", determination of compartments was performed indirectly – by visual classification on orthophoto images, and directly – by terrestrial method based on applicable criteria for determination of stands. As already mentioned, this was followed by a comparison of classifications performed in such a way.

3. RESULTS

3.1. Unsupervised classification

Based on the data provided by valid Forest Management Plan (2012-2021), the structure of the area of MU "Topolik" by stock is presented in Table 2. The total area of the Management Unit is 3,028.74 *ha* of which stocked area covers 79.5% (2,407.85 *ha*) and unstocked area cover 20.5% (620.89 *ha*). The Management Unit is dominated by cloned poplar stands (51.17% of stocked area), but there are also autochthonous willow and poplar stands, and american ash stands as well.

Table 1. *Structure of the area MU "Topolik"*

Land category	Area	
	ha	*%*
Forest	2,407.85	79.5
Clearings	620.89	20.5
Total:	**3,028.74**	**100.0**

Unsupervised classification based on grouping of values of pixels so that their spectral values meet a certain criterion of homogeneity for the same area, on a satellite image, was used to start the procedure of selection of the highest possible number of classes by using an appropriate software. The reason behind this is that a higher number of classes provides for more accurate results of unsupervised classification. Unsupervised classification resulted in too many classes, particularly because of heterogeneous land cover types, and classes had to to be combined to create a meaningful map. Once the tool *Unsupervised Iso Cluster Classification* (Figure 1) was used in this phase of unsupervised classification, out of the total of 20 previously requested classes, the software determined and classified 8 classes on the LANDSAT image for the same area of the MU "Topolik", and their areas are presented in Table 3.

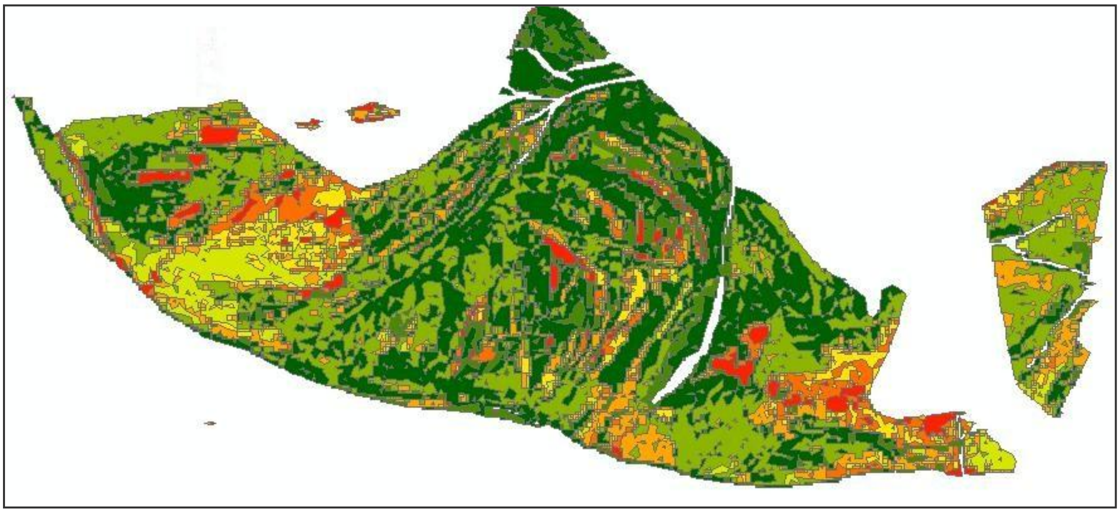


Figure 1. *Classification by using the tool Unsupervised Iso Cluster Classification*

In the next phase, manual grouping and allocation of attributes, stocked and unstocked (areas), to each of the 8 previously determined classes was performed. In terms of percentages, classes 2, 5 and 7 largely belonged to the category of unstocked land – clearings, while classes 1, 3, 4, 6 and 8 largely belonged to the category of stocked areas - forests (Table 2).

Table 2. *Grouping of classes into categories forest and clearings*

Class	Category	Area (*ha*)	Class	Category	Area (*ha*)
1	Forest	939.21	5	Clearing	137.30
2	Clearing	370.42	6	Forest	290.19
3	Forest	783.51	7	Clearing	151.77
4	Forest	142.66	8	Forest	220.76
				Total:	**3,035.82**

Results of comparisons of areas of MU "Topolik" identified by terrestrial method with areas obtained by unsupervised classification are presented in Table 3.

Table 3. *Comparison of areas determined by terrestrial method and those identified by unsupervised classification*

MU "Topolik" (terrestrial)			MU "Topolik" (LANDSAT image)			Difference		
Category	*ha*	%	Category	*ha*	%	Category	*ha*	%
Forest	2,407.85	79.5	Forest	2,376.33	78.3	Forest	-31.52	-1.3
Clearings	620.89	20.5	Clearings	659.49	21.7	Clearings	+38.60	+6.2
Total:	**3,028.74**	**100.0**	**Total:**	**3,035.82**	**100.0**	**Total:**	**+7.08**	**+0.2**

The area under forest determined by unsupervised classification from a LANDSAT image is smaller by 1.3% (31.52 *ha*), the area under clearings is larger by 6.2% (38.60 *ha*), and the total area of the MU “Topolik” is larger by 0.2% (7.08 *ha*) compared to the same categories determined by terrestrial method. Unstocked areas of this Management Unit are not clearings as such, but covered with a certain type of vegetation (ground vegetation), which resulted in their larger area on the LANDSAT image and, consequently, in substantial differences in this category (Figure 2).

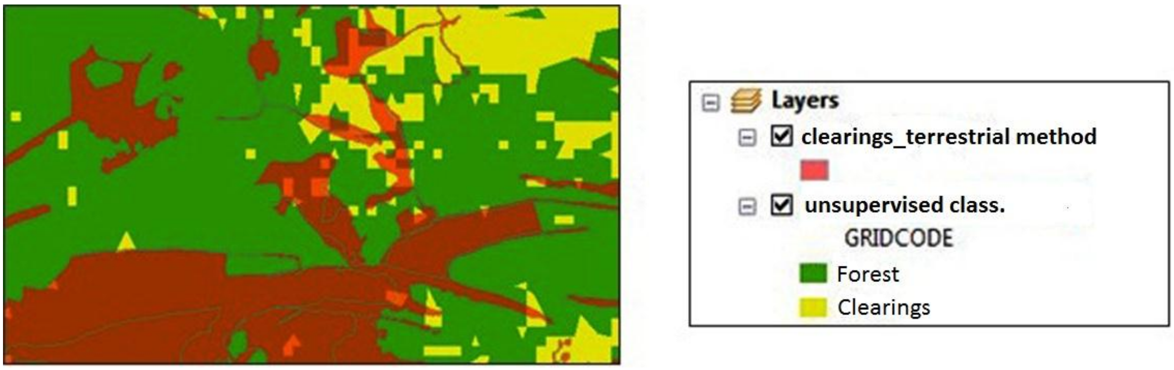


Figure 2. *Overlapping of clearings obtained with terrestrial method and clearings obtained from LANDSAT image*

3.2. Supervised classification

In supervised classification, an analyst determines classes from various pre-determined sources. The starting point used for supervised classification of MU “Topolik” were previously known classes (forests and clearings) determined by terrestrial method. In the next phase, by using the tool *Image classification*, certain training areas for stocked and unstocked areas were defined on a satellite image (Figure 3б), which essentially represent sets of pixels which are known to belong to a certain class. Once the area under forest and clearings were determined, *Training Sample Manager* tool was used to determine, group and define classes: 1–forest and 2-clearings (Figures 3a, 3б and 4).

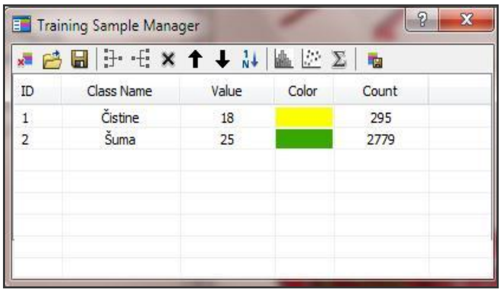


Figure 3a. *Grouping and defining of classes*

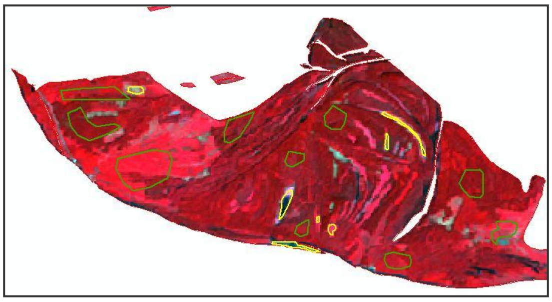


Figure 3б. *Grouping and defining of classes*

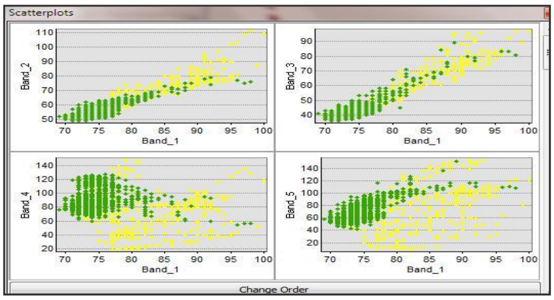


Figure 4. *Spectral characteristics of classified areas and presentation of division between classes*

Once the definition of areas of interest was completed, *Maximum Likelihood Classification* was applied. Its implementation provided areas of predefined classes (forests and clearings) and these are given in Table 4.

Table 4. *Areas of predefined classes (LANDSAT image)*

Class	Area (*ha*)
Forest	2,395.57
Clearings	635.25
Total:	**3,030.82**

Compared with areas generated by terrestrial method (Table 2), forest areas determined by the mentioned classification from LANDSAT image are smaller by 0.5% (12.28 *ha*), clearings are larger by 2.3% (14.36 *ha*), while the total area of the Management Unit is larger by 0.07% (2.08 *ha*). There are substantial differences in the spatial distribution of stocked and unstocked areas, especially in the areas noted with the ellipses (Figure 5).

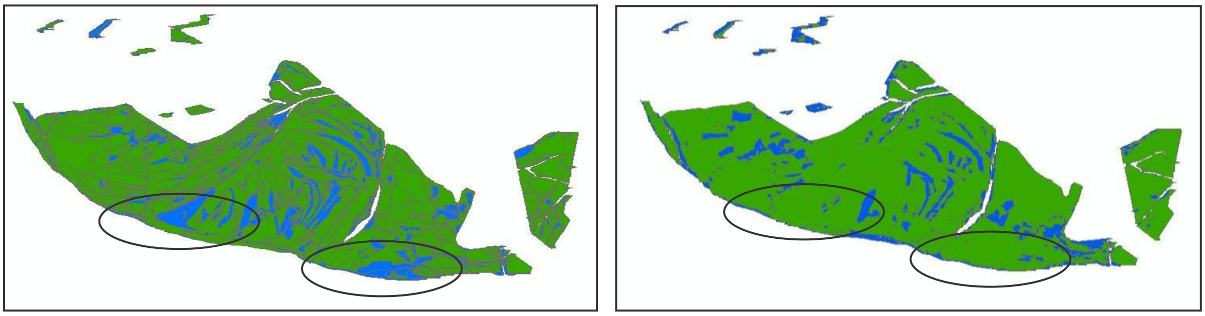
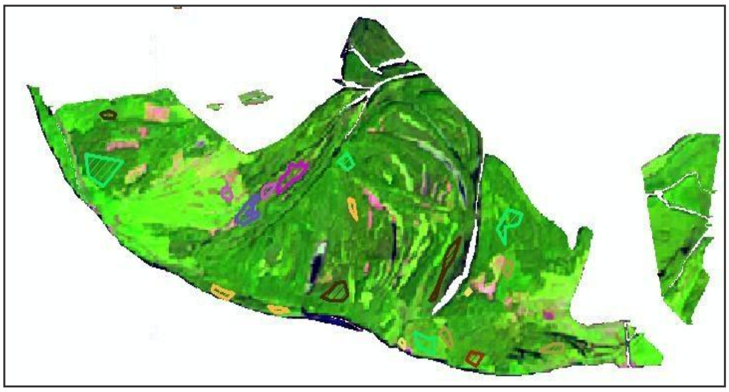
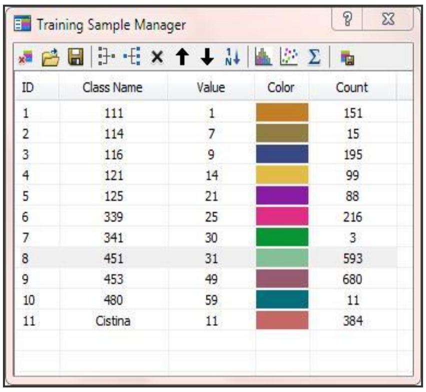


Figure 5. *Differences in spatial distribution of defined classes: left-terrestrial; right-image*

Options for using LANDSAT images in interpretation and defining a particular stand, that forest areas belong to, were explored in the next phase. *Image Classification Tool* was used to identify certain training areas on a satellite image for every stand which was previously determined by terrestrial method and which was previously known. Identified values for every stand define sets of pixels which are known to belong to a certain class. Once stands were defined, the next classes of stands were grouped and defined in the *Training Sample Manager* tool (Figures 6a and 6б)





Training Sample Manager

ID	Class Name	Value	Color	Count
1	111	1		151
2	114	7		15
3	116	9		195
4	121	14		99
5	125	21		88
6	339	25		216
7	341	30		3
8	451	31		593
9	453	49		680
10	480	59		11
11	Cistina	11		384

Figure 6a, б. *Grouping and definition of classes of stands*

The total of 10 training areas or 10 stands was identified. Spectral characteristics of classified areas (stands) and overview of separation of classes can be seen in Figure 7.

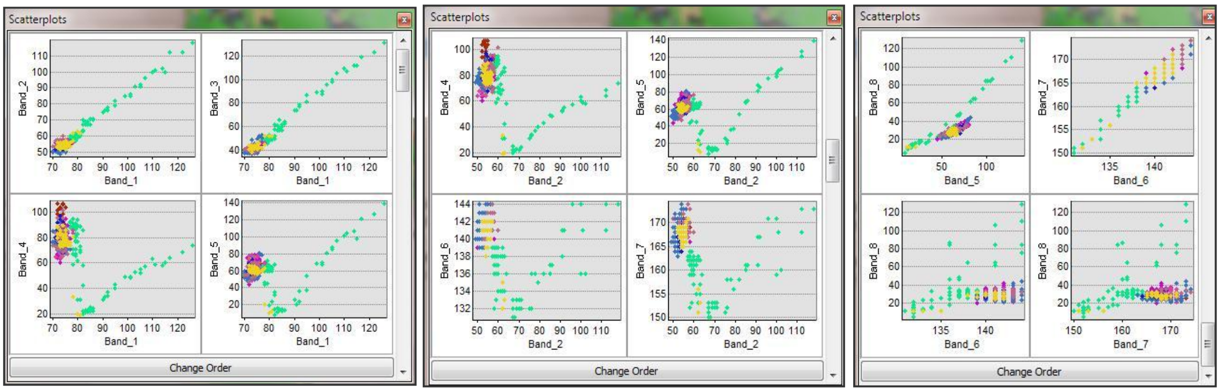


Figure 7. *Spectral characteristics of classified areas (stands)*

Comparative overview of stands determined in the MU "Topolnik" by terrestrial method and on LANDSAT image is given in Figures 8a and 8б, and Table 5 as well.

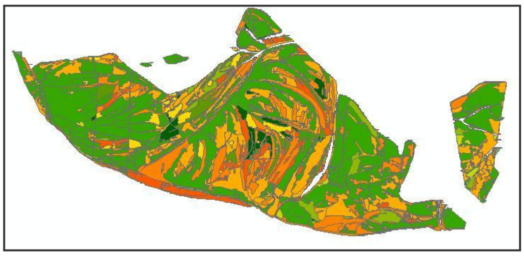


Figure 8a. *Stands – terrestrial method*

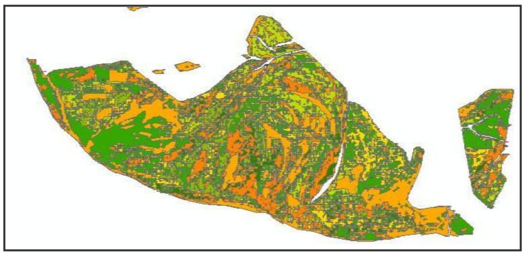


Figure 8б. *Stands – Image*

Table 5. *Comparative analysis of areas of stands determined by terrestrial model and based on LANDSAT image*

Class	Stand	Terrestrial	Image	Differences	
		Area (*ha*)		*ha*	%
1	Clearings	620.89	818.70	+197.81	+31.9
111	High willow forests	155.94	201.71	+45.77	+29.4
114	Coppice willow forests	28.07	7.32	-20.75	-73.9
116	Devastated willow forests	77.52	244.67	+167.15	+215.6
121	High poplar forests	76.14	388.91	+312.77	+410.8
125	Devastated poplar forests	64.35	185.76	+121.41	+188.7
339	High american ash forests	81.20	207.67	+126.47	+155.8
341	Devastated ash forests	0.84	4.80	+3.96	+495.0
451	Artificially established willow stands	496.89	429.09	-67.8	-13.6
453	Artificially established poplar stands	1,403.38	541.40	-861.98	-61.4
480	Artificially established devastated broadleaved stands	23.52	0.79	-22.73	-96.6
	Total:	**3,028.74**	**3,030.82**	**+2.08**	**+0.07**

4. FINAL CONSIDERATIONS

Unsupervised classification in this paper confirmed that differences in areas under forests and clearings generated from the LANDSAT image, compared to reference (terrestrial) data, are substantial (-31.52 *ha* of forests, +38.60 *ha* of clearings). The cause for these differences, and differences in spatial distribution of these categories, lays in the fact that the same values of pixels were found in both classes, they were overlapping respectively. However, it can be expected that this method of classification would provide substantially better results on areas larger than the area of the MU "Topolik" – for example, at the level of an administrative municipality or a district.

When it comes to supervised classification, it was confirmed that there are substantial differences in areas of individual stands generated from the image and by terrestrial method. The differences are two-way and range from –861.98 *ha* when it comes to poplar, to +3.96 *ha* for devastated ash forests. Spatial distribution of identified stands is substantially different. This all leads to the conclusion that based on a LANDSAT image of the given resolution (25x25 *m*) results of satisfactory accuracy cannot be achieved by the applied classification method while defining and identifying stands. On the other hand, *Maximum Likelihood Classification* for dividing (classification) of areas into two categories – stocked and unstocked (forests and clearings) - provides satisfactory results. The area under forests determined from LANDSAT image is smaller by 12.28 *ha*, and the area under clearings is larger by 14.36 *ha* compared to reference values (values in the valid Plan established by terrestrial method). However, spatial distribution of classes obtained from the image does not fully correspond to spatial distribution of stocked and unstocked land on maps of the MU "Topolnik", which somewhat makes the generated results relative and they need to be taken with reserve. It can be assumed that in case of large areas, and when information on distribution of stocked and unstocked land need to be generated in a short period of time, this method would be of satisfactory accuracy, meaningful and very much worth-while.

Exploring options and reliability of application of new technologies for collecting information in forestry (and other sectors) requires substantial funds. This is exactly one of the main reasons why exploring of application of modern methods of remote sensing in forestry of Europe is far ahead of our region (Benko *et al*., 2011). It could be said that relatively low spatial resolution of Landsat imagery might restrict its application in vegetation mapping. In those terms, more funds, and thus significantly more quality images and equipment (hardware and software) compared to the ones used for this survey, would ensure obtaining substantially more reliable and thus more applicable results.

Acknowledgement

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ASSESSING STAND DENSITY INDEX FROM NATIONAL FOREST INVENTORY DATA

Chris S. EASTAUGH[1]

Abstract: *Stand density is a key descriptive trait of forests, pertaining to the relationship between the tree size and number per hectare. In 1933 Reineke developed his Stand Density index, and postulated that the log of the quadratic mean stem diameter was linearly related to the log of the number of stems per hectare. Since that time many authors have discussed the meaning of this relationship in terms of stand self thinning, and have offered refinements, rebuttals or support for Reineke's thesis. Empirical work on stand density however is normally conducted using a relatively limited number of research plots, and often used curve fitting methods that have since been shown to be biased and inaccurate. This study applies modern statistical methods of maximum likelihood estimation to determine the self thinning line for several Austrian forest species and species mixtures, based on a large body of National forest Inventory data collected between 1981 and 2009. Besides possible species differences, the size of the dataset also allows us to study the effects of species mixtures and mixed age stands on the self thinning characteristics of forests. The work is unique in that it is the study into stand density involving a National inventory based on sampling proportional to size (angle-count sampling). Although this introduces some methodological challenges, it also has advantages over a fixed-area based inventory due to the higher probability of the larger, more influential trees being included in the sample.*

Key words: Stand Density Index, National Forest Inventory, angle-count, basal area, Austria

1. INTRODUCTION

Besides productive functions and other ecosystem services, the role of forests as sinks of atmospheric carbon is receiving increasing attention. Growing forests continuously remove carbon from the atmosphere (a function related to Net Primary Production or timber increment), and store it primarily within biomass, which is a function of standing timber volume. Both volume and increment are thus important factors in carbon accounting. Policies or management regimes that seek to maximize the value of forests for carbon mitigation purposes will thus need to balance the increased useable increment of well managed forests (Taverna et al. 2007) with the potentially higher carbon sink capacity of unmanaged stands (Luyssaert et al. 2008). The science of forestry has typically focused on maximizing the productive function of forests, which in turn maximizes the transfer of carbon to biomass but reduces the mass of carbon stored in-forest (through timber removal). In order to rationally balance these conflicting factors, more precise information is needed on the potential carbon storage capacity of forests, hence on the potential stand density of individual sites.

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Stand density

Stand density in forests is commonly assessed in terms of basal area per hectare. This measure of density does not however give any indication of how the measured density compares to its ecological potential, either in terms of what might have been possible at that stage of forest growth or as a proportion of what may be achievable in the future. Comparison of current basal area with that data from accurate yield tables can accomplish this (Zeide 2005), but appropriate tables for each site, species (or species mix) and stand age are often not available.

Reineke (1933) noticed an apparently clear relationship between the number of stems per unit area (*N*) and the quadratic mean diameter of stems in the stand (D_q), whereby in stands at their upper limit of stocking (at any diameter) showed a log-log relationship between *N* and D_q, i.e.:

$$\ln(N) = \beta - \alpha \ln(D_q) \qquad \text{Eq. 1}$$

From empirical observations Reineke suggested that α was constant over most tree species. From these observations he proposed his Stand Density Index (SDI) as a measure of density that is independent of species, age and site conditions. In a metric form, *N* is measured in terms of stems per hectare and D_q in centimeters;

$$SDI = N\left(\frac{D_q}{25}\right)^{\alpha} \qquad \text{Eq. 2}$$

The intercept parameter β in Eq. 1 is not relevant to the calculation of SDI, but is considered to be a measure relating to species-specific site conditions (Pretzsch 2002). Reineke determined a value of 1.605 for the exponent α, by ruling a line on a log-log plot of *N* against D_q in fully stocked stands. MacKinney and Chaiken (1935, cited by Zeide 2005) reanalyzed the same data with what Zeide terms ‘standard statistical methods’ and obtained an α of 1.707. Zhang et al. (2005) reviewed several modern methods of trend estimation and obtained startlingly different estimates on the same stands.

The principle of what is now known as ‘Reineke’s rule’ is that as the individuals in a stand increase in diameter, competition effects will limit stem numbers. The value of α must therefore be determined in fully stocked stands, where the number of trees is limited solely by crowding-dependent mortality. Such stands are not always easy to identify (Mohler et al. 1978), and the assessment is usually made on somewhat subjective criteria.

Angle count inventories

Studies of SDI have traditionally been conducted on long-term permanent research plots, where the management history is known, plots can be judged to be ‘fully stocked’ and many years of observations are available. This allows the trajectory of the N/D_q relationship over time to be plotted and Equation 1 parameterised against observations. Another approach is the ‘species boundary line’ of Charru et al. (2011) where a large number of measurements are assessed to determine the parameters of the most extreme (hence, presumably the most fully stocked) plots. National forest inventories (NFIs) contain a very large body of data, typically covering thousands of plots at several times. Charru et al. (2011) took advantage of this to analyse the SDI parameters of several forest species in France. Many NFIs however are conducted using the ‘sampling proportional to size’ method – the angle-count method of Bitterlich (1948). This introduces some complications into the estimation of Reineke’s parameters, but also confers some advantages. Sampling proportional to size is known to be a more efficient means of estimating basal area but less good for estimation of stem density compared to sampling proportional to area (Whyte and Tennent 1975; Motz et al. 2010). Equation 2 can however easily be rearranged to express SDI in terms of basal area per hectare rather than number of stems per hectare; besides being better suited to data derived from angle counts this also confers some statistical advantages, as will be described below.

The purpose of this work is to examine the angle-count derived Austrian NFI to determine the SDI parameters for Austrian forests. Results show that by species, statistically different β values are apparent, but species confers no significant difference in α. The effects of mixed-species forests and mixed ages are also studied but no significant impact found.

2. DATA AND METHODS

The modern 'permanent plot' Austrian National Forest Inventory made its first measurements in 1981, following two previous national inventories conducted with a temporary plot design. Inventory measurements covered the periods 1981-1985, 1986 - 1990, 1992-1996, 2000-2002 and 2007-2009. The inventory is organized into tracts each of 4 points on a 200 m square. 5600 such tracts are arranged in a square grid pattern across the country, including over areas that are not currently forested. Data for this study consists of all forested plots for the most recent 3 periods, and one plot from each tract for the entire 5 periods. In total, this gives 30518 data points. Species specifically examined in this study are Norway spruce (*Picea abies*), larch (*Larix decidua*), Scots pine (*Pinus sylvestris*), beech (*Fagus silvatica*) and oak (*Quercus robur* and *Q. petraea*).

Mathematics background

The traditional practice of plotting N against D_q has a serious flaw, in that $N = \frac{G}{kD_q^{\,2}}$ (with k being a units constant equal to π/40000). These graphs thus plot a function of D_q^{-2} against D_q, and in the Null hypothesis case that D_q has no impact on N, we would expect a slope of -2 due to the statistical non-independence of the variables, suggesting α = 2.0. Weller (1987) comprehensively demonstrated similar problems in regressing plant average mass against stocking numbers.

Equation 1 may be rearranged to show that

$$\ln(G) = \beta + \ln(k) + (2 - \alpha)\ln(D_q) \qquad \text{Eq. 3}$$

The intercept in this case will be less than that of Eq. 1 by the negative log of the units constant k, (i.e., the intercept will be β - 9.452) and the slope of the line if the Null hypothesis were true would be 0, allowing for standard statistical tests to be validly performed. SDI may be directly calculated under this formulation as:

$$SDI = \left(\frac{25^{-\alpha} G}{k}\right)\left(D_q^{\,\alpha-2}\right) \qquad \text{Eq. 4}$$

Better estimates of G

In order to get a better estimate of basal area on each angle-count plot, a new procedure is instituted whereby the original NFI data is resampled using different basal area factors (Eastaugh et al. in prep). The original data was captured using a BAF of 4m^2/ha, so given that distances to all trees from the plot centre are recorded it is possible to make new estimates of G for any BAF greater than 4. For this study, the data was resampled with BAFs from 4.0 to 8.0 in steps of 0.1, and the simple mean of the 41 estimates taken. Figure 1 shows a example of how the method provides improved estimates of basal area on an individual plot.

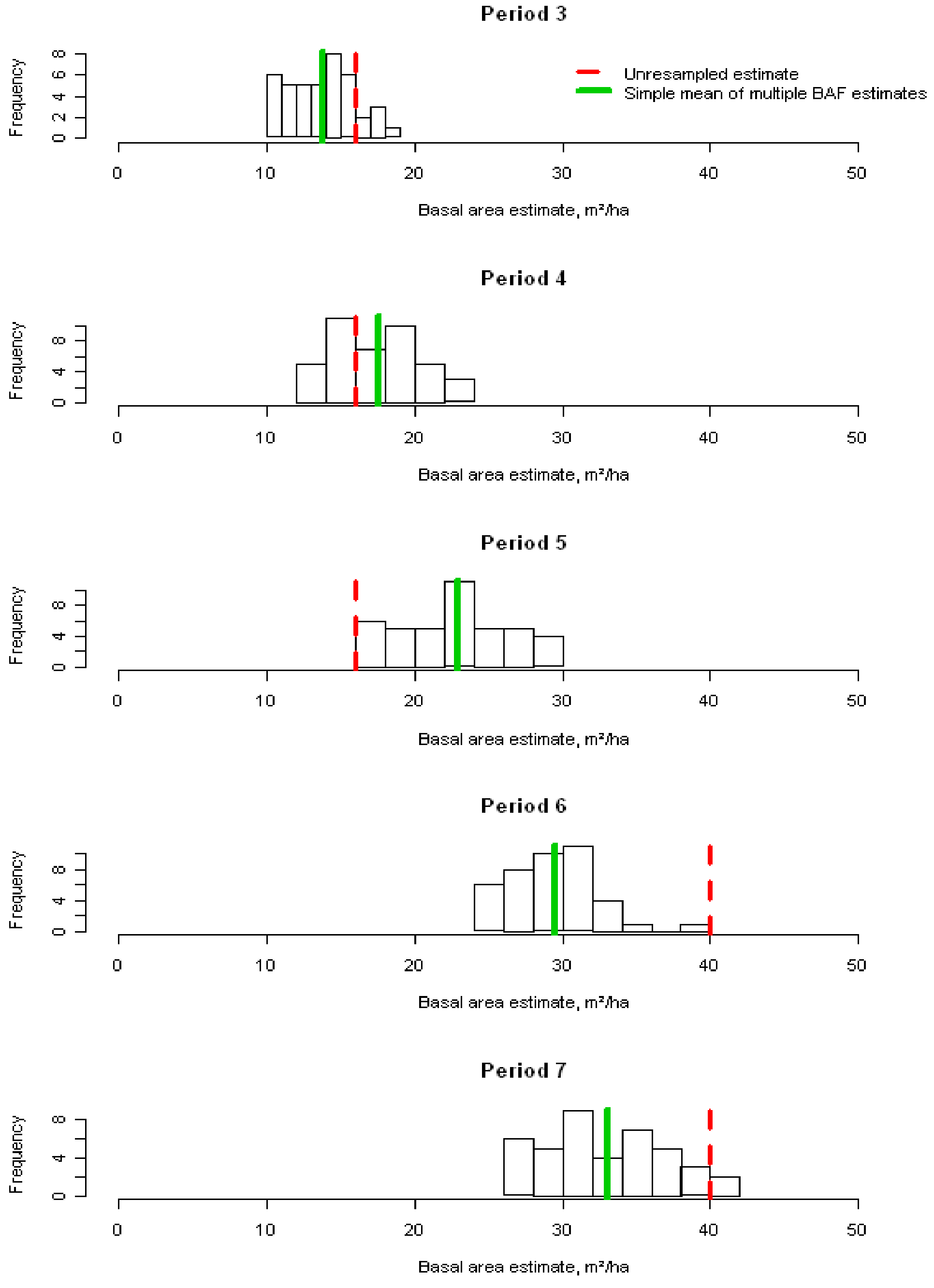

Figure 1. *Demonstration of improved basal area estimation technique. The original NFI data for each plot is resampled 41 times, with basal area factors from 4.0 to 8.0, in steps of 0.1. The histograms in each plot show the frequency distribution of the 41 estimates, dashed lines are the original estimate with BAF=4, and solid lines are the mean of the resampled estimates.*

Fitting parameters

Not all plots in an NFI dataset will be in a condition undergoing density-related mortality, and thus should not be included in the parameterisation procedure. Charru et al. (2011) selected plots based on minimum and maximum D_q criteria, and by the recorded occurrence of mortality on the plots. In this study we examine all data points for their SDI under a range of α assumptions from 1.3 to 1.9 in steps of 0.1, and select the 20 points that would have the highest SDI for each α. Parameters α and β for this set are then estimated using the stochastic frontier analysis (SFA) technique instituted in the R package '`frontier`' (R Development Core Team 2011; Coelli and Henningsen 2012), following Charru et al. (2011). The SFA technique was specifically developed to estimate boundaries of functions while recognizing that some measurement or estimation error may be present. Each major species is examined separately and tested for significant differences in both parameters using the 'dummy variable' method. Further comparisons test the significance of differences between even-ages and mixed-age forests, and between mono-species (> 90% of basal area) and mixed-species forests where one species has 50-90% of basal area. 'Even aged' is defined here as those plots with a difference of less than 20 years between the oldest and youngest trees in the sample.

3. RESULTS AND DISCUSSION

No significant differences were found between species slopes for even aged mono-species stands, but intercepts are clearly different (fig. 2). As found in other European studies, Norway spruce has a higher maximum density than other species, followed by Scots pine, beech and oak. This order of potential densities mirrors that of Pretzsch (2002) and Charru et al. (2011), but methods used in those studies suggest statistically significant differences in slope also.

Comparing forest age and species structures, no significant difference is apparent in either intercept or slope. (fig 3). Examples of all forest structures are represented among the highest recorded densities. Considering the lack of significant difference in slope according to species and the lack of significant difference in either parameter for stand structure, it is appropriate to determine a single slope for the stochastic frontier of forests represented in the Austrian NFI. Figure 4 shows that Norway spruce is the dominant species in most of the densest plots, that but maximum density does not appear to be affected either by even/mixed age structures or mono/mixed species structures.

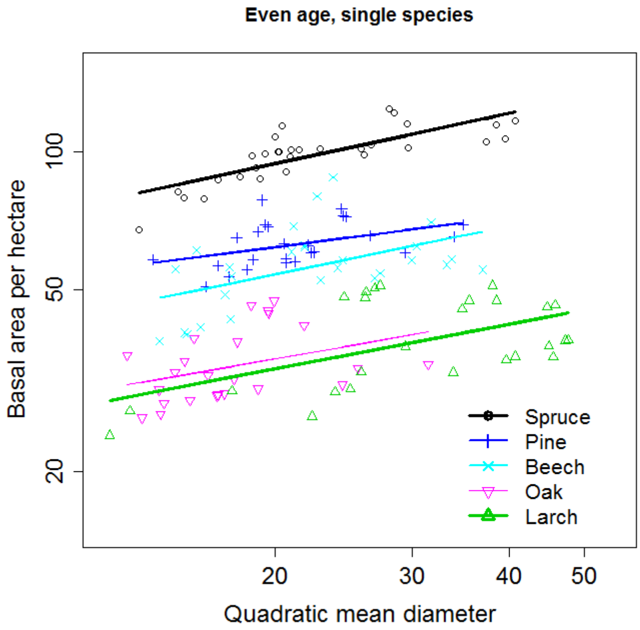

Figure 2. *Basal area plotted against quadratic mean diameter for each species, limited to even aged monospecific plots at extreme density. Thickness of lines denote significance of trends, thickest = p < .0001 (spruce and larch), mid-thickness = p < .001, thinnest = p < .01 (oak).*

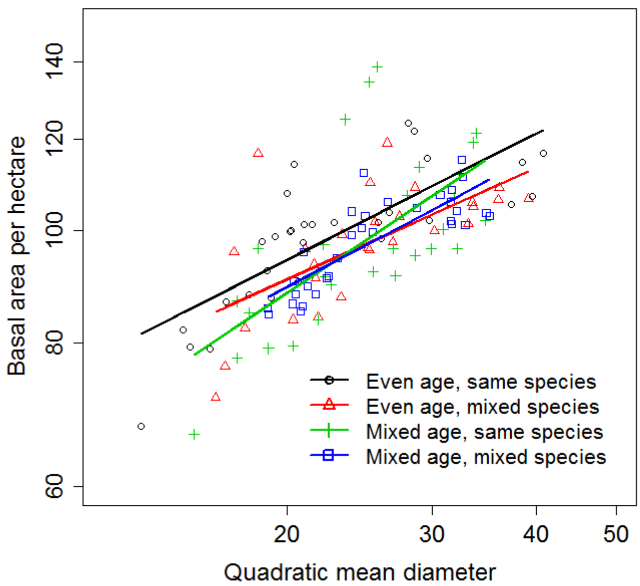

Figure 3. *Comparison of the density boundary of plots with different stand structures. All slopes are significant at p < .0001, but no significant difference is found between either slopes or intercepts.*

Overall, the results demonstrate that forest stands may maximize their use of available resources through a number of alternative strategies but that a model relating the stand basal area to the quadratic mean diameter of sampled trees is capable of capturing all structures with the same basic parameters on fully stocked stands. Determining the maximum possible SDI for every plot (not necessarily presently fully stocked) however will require further information, firstly because the intercept differs according to the dominant species, and secondly because the maximum possible SDI is dependent on site conditions (Sterba 1987).

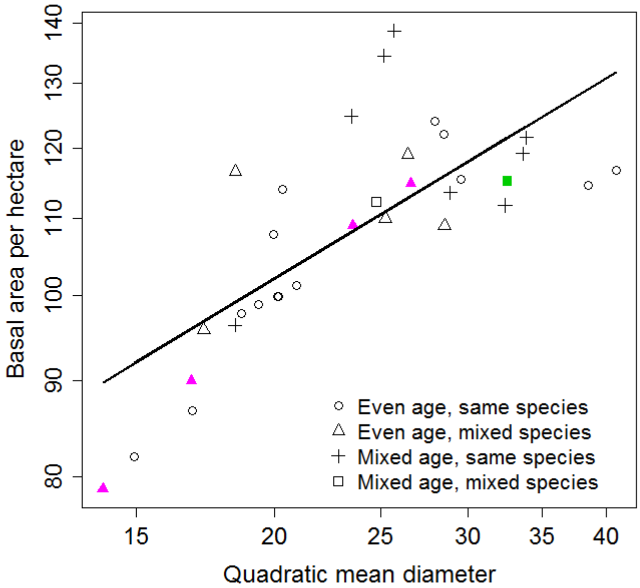

Figure 4. *Overall self thinning line for Austrian forests (α=1.643, β=13.008). All plots are spruce-dominated apart from the four solid triangles (Alnus spp.-dominated) and the one solid square (Larix spp.-dominated).*

4. CONCLUSIONS

This study provides no justification for applying different assumptions of the slope of the self-thinning line depending on stand species or forest structure, with α=1.643 found as the slope of the overall forest stochastic frontier of plots in the Austrian National Forest Inventory. Norway spruce-dominated forests generally attain the highest density, but mixtures of other species with the spruce do not appear to have any positive or negative effect on possible maximum SDI, nor does there seem to be any difference between even aged or mixed aged forest structures.

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4-5 October 2012, Institute of Forestry, Belgrade, Republic of Serbia

WORKING EFFICIENCY OF MTZ 1025 TRACTOR EQUIPPED WITH A SENSOR DISC HARROW IN THE TREATMENT OF POPLAR PLANTATIONS

Milorad DANILOVIĆ[1], Dragan GAČIĆ[1], Zoran ĐORĐEVIĆ[2]

Abstract: *This article presents the results of the research concerning operating efficiency on jobs of inter-row cultivation in poplar plantations with a sensor disc harrow. Research was conducted on the territory of the forest holding "Sremska Mitrovica" in various working conditions.*

Working conditions varied depending on the spacing of planting, soil humidity as well as the size and density of weeds. Spacing between rows and plants was 5×5 and 6×6 m.

Evaluation of the efficiency of used technology in conditions that were the subject of the research was conducted from technical, economic, ecological and energetic aspect. Data was recorded by photo-chronometric method, and the duration of working operations was measured by flowing method. Besides that, the consumption of fuel was also measured by the method of refilling the reservoir.

The share of turning time, in the total time of harrowing, depends on the length of the parcel. This time is in the correlation with the number of turns.

Relation between the number of turns and the length of parcels can be presented by linear function. The share of turning time in the effective working time is 25.8%.

Average tractor speed during mulching is 75.4 m/min.

Key words: poplar plantation, sensor disc harrow, tractor MTZ 1025, production effects

1. INTRODUCTION

Treating the young poplar plantations is very important for acquiring high yields of wood mass.

Forested area under Forest Holding „Sremska Mitrovica" is 42,495.4 ha, from which the poplar plantations take up 5,949.4 ha.

Annual plans for inter-row cultivation of the young poplar plantations in this Forest Holding vary around 3,000 ha (for instance, in 2012 it is 3,243 ha).

Disc harrows aggregated by adapted agricultural tractors are used for mechanized soil cultivation. Harrowing is conducted by classical and sensor disc harrows (Figure 1).

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Figure1: *Sensor disc harrow*

Inter-row cultivation of young poplar plantations up to 3 years of age in FH “Sremska Mitrovica” is done mechanically (by harrowing) 3 times per year – once by classical disc harrow and twice by the sensor disc harrow. Also, the area is treated once by chemicals. According to that, the same area is treated 4 times annually in order to prevent the growth of the weeds.

The direction of harrowing can differ in relation to the previous harrowing, being perpendicular or diagonal to the direction of the previous harrowing or it can be done in the same direction when the working conditions demand so.

Between 3 and 7 years of age of the plantations, the disc harrows are not used. In this period, classical disc harrow is used twice per year and chemical treatment is conducted once per year. The reason for this is the greater share of weed vegetation. In later years, the chemical treatment is conducted occasionally in order to eliminate unwanted vegetation.

Intensive poplar plantations are mostly established on the flood plains of rivers Sava, Danube, Tisza, Tamis etc. on relatively fertile lands prone to weed growth (Figure 2).

The goal of inter row cultivation is to eliminate the weed vegetation and to loosen the soil in order to provide the conditions for the maximal utilization of the soil’s potential and to provide the conditions for effective application of the treatments.

According to the previous researches, usage of sensor disc harrow is an effective solution considering its technical capacities (Nikolić and Jezdić 1993).

When using the sensor disc harrow it is possible to eliminate the weed vegetation on almost the whole surface area, while after using the classical disc harrow, some of the weed vegetation stays behind (1 m wide strips) (Danilović et all.. 2009). In the second cross-harrowing, some of the weed vegetation also stays behind in order to avoid the infliction of damages to the residual trees so, approximately 1 to 2 m^2 of weed vegetation stays around every poplar tree. These weeds are eliminated subsequently by manual labor or are treated by chemical agents which increase the costs of plantation treatments.

The goal of this article is to research the working effects of two sensor disc harrows in inter-row cultivation of poplar plantations.

2. MATERIAL AND METHOD OF RESEARCH

The research of working effects of the tractor MTZ 1025 equipped with a sensor disc harrow was conducted in the period from 2008 till 2010 in FH „Sremska Mitrovica“ on the territory of FA „Kupinovo“ in management unit „Kupinski kut“ sections 24, 37 and 38, in FA „Klenak“ in management unit „Jasensko belilo“ sections 22 and 24, in management unit „GVO“ sections 84, 88 and 90, in management unit „Senajske bare – Krstac“ sections 32, 33, 18/4, in management unit „Leget“ section 11 and management unit „Turijan – Jarak“ sections 11 and 20.

Sensor disc harrow operation was recorded on the territory of “Upper Srem” in FA “Visnjicevo” management unit “Banov Brod” section 13 and management unit “Maticni poloj” sections 22-27.

Spacing between the rows was 6×6 m. Weather conditions at the time of recording were favorable and the temperature measured at 7:00 am was between 11 and 23°C, at 10:00 am between 14 and 32°C and at 1:00 pm was between 19 and 35°C. Drivers that were operating the tractors had between 2 and 7 years of working experience.

Density of weed vegetation depended on the location and varied from low to high. Dense weed vegetation was in management unit “Senajske bare – Krstac”, section 32.

Direction of the previous harrowing was opposite to the direction of the current harrowing except in management unit „Kupinski kut“ section 24.

Figure 2: *Wood material and weed vegetation*

Beside the recording of harrowing, the consumption of fuels and lubricants was also recorded. Recording of these data was conducted by the mothod of refilling the reservoirs.

Sensor disc harrow operation was recorded by photochronometric method and the duration of working operations was measured by the flowing method (Nikolić,1993).

In the framework of the projected technological scheme, the following times were recorded: harrowing time, turning time, justified stoppages and unjustified stoppages.

Recorded data were processed by usual mathematical and statistical methods (descriptive statistic, correlation analysis, variance analysis, simple and multiple regression analysis etc.).

3. RESULTS OF THE RESEARCH AND DISCUSSION

Average length of the parcels on which the recording was conducted was 410 m; the minimal length was 90 m and the maximal was 980 m. Average width was 157 m and it varied from 66 to 465 m.

The share of turning time in the total time of harrowing depends on the length of the parcel. This time is in correlation with the number of turns. Average duration of turning on the parcels was between 0.41 and 1.07 minutes.

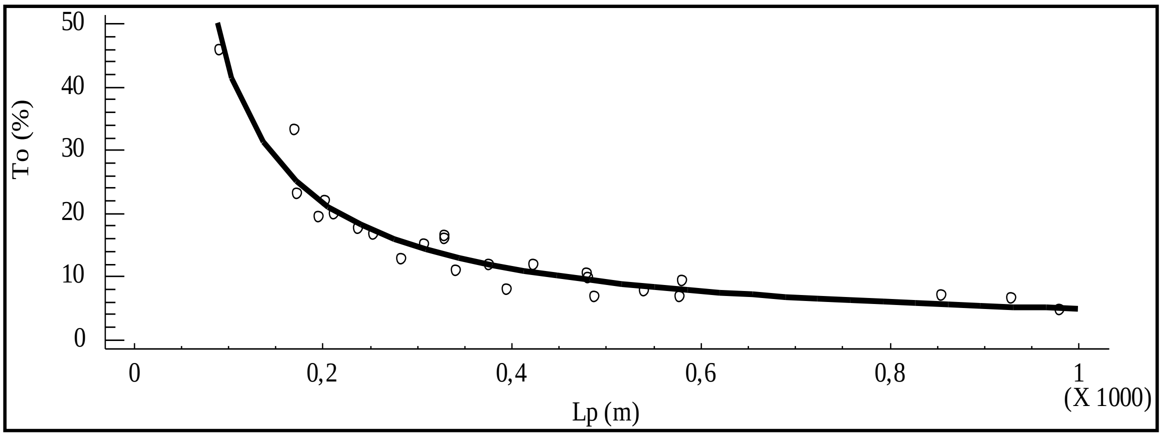

Figure 3: *Relation between the share of turning time and the length of the parcel*

The share of turning time in the total time of harrowing and turning without stoppages decreases with the increase of the length of the parcel (r^2=0.935, p=0.00). This relation can be presented by the function

$$T_o = 0,54 + \frac{4223,9}{L_p} \quad (1).$$

Relation between the number of turns and the length of the parcel can be presented by the function

$$N_o = 9,03 + 12577 \cdot L_p \quad (2).$$

Recording of the sensor disc harrow operation lasted 25 working days. The total time of harrowing during the recording was 5696 min, or 227.9 min·day^{-1} and the turning time 956.9 min or 38.6 min·day^{-1}. Stoppage time without the time for breakfast was 1075 min or 43.02 min·day^{-1}.

Width of the parcels also impacts the duration of turning time.

Relation between turning time and the width of the parcel can be presented by the function

$$N_o = 0,64 + 0,00049 \cdot W_p \quad (3).$$

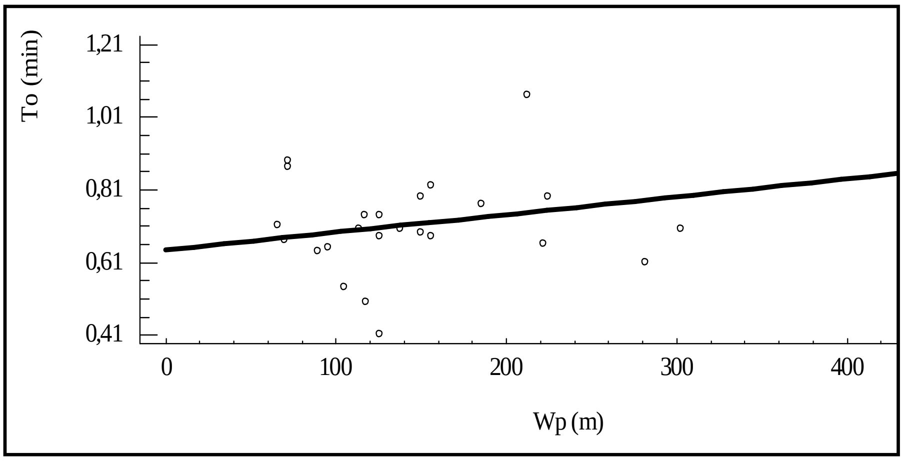

Figure 4: *Relation between the turning time and the width of the parcel*

Average speed of the tractor during harrowing in a single passing was 75.42 m·min^{-1}, and it varied from 54.1 m·min^{-1} up to 86.5 m·min^{-1}. Maximum speed of harrowing that was gained during the recording was in the management unit "Kupinski kut", section 24, where the harrowing was done in the same direction as the previous one. It can be concluded that the greater speeds are reached in cases where the harrowing is conducted in the same direction as the last one. The total surface area on which the inter-row cultivation was conducted is 126.9 ha, or 5.08 ha per day.

The share of stoppages in the effective working time is 14.5%. Consumption of fuel per an effective working hour is 5.9 L·h^{-1}.

Figure 5 presents the relation between average productivities of the sensor disc harrow and the length of the parcel which is also one of the inputs in the normative for the jobs on inter-row cultivation in poplar plantations with the disc harrow.

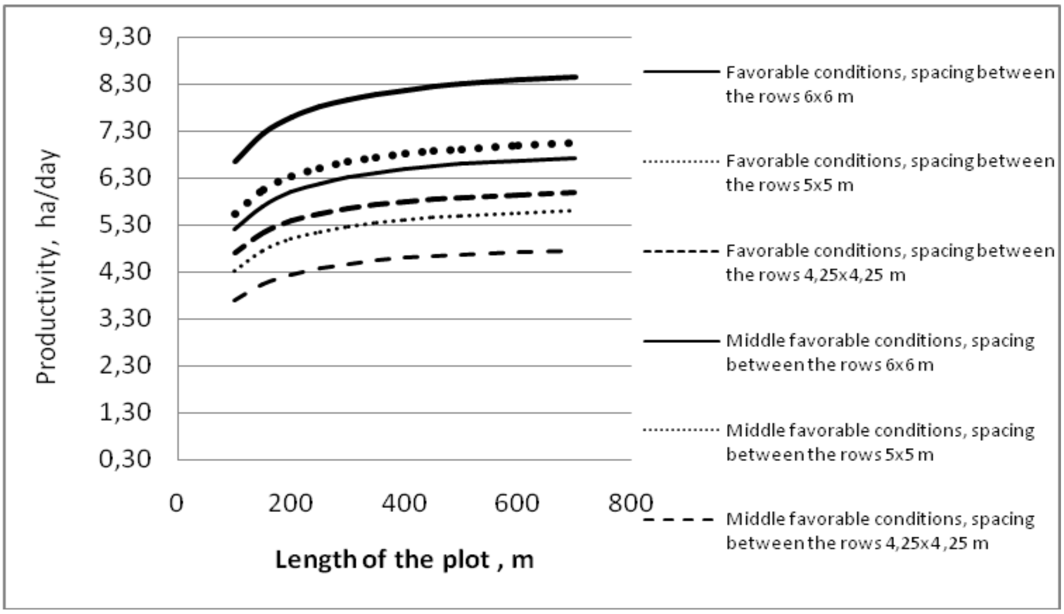

Figure 5: *Dependence of the productivity from the length of the parcel*

Normative for harrowing with a sensor disc harrow were calculated on the basis of the basic normative (Table 1).

Table 1: *Normative for the inter-row cultivation in poplar plantations*

Length of the parcel *(m)*	**100**	**150**	**200**	**250**	**300**	**350**	**400**	**450**	**500**	**600**	**700**	**Plant spacing** *(m)*
(ha/ day)												
Favorable conditions	6,39	7,08	7,49	7,75	7,94	8,08	8,19	8,28	8,35	8,46	8,54	6×6
	5,33	5,90	6,24	6,46	6,62	6,74	6,83	6,90	6,96	7,05	7,11	5×5
	4,53	5,02	5,30	5,49	5,63	5,73	5,80	5,86	5,91	5,99	6,05	4,25 ×4,25
Moderately favorable conditions	5,19	5,70	5,99	6,18	6,31	6,41	6,48	6,54	6,59	6,67	6,72	6×6
	4,33	4,75	4,99	5,15	5,26	5,34	5,40	5,45	5,49	5,56	5,60	5 × 5
	3,68	4,04	4,24	4,37	4,47	4,54	4,59	4,63	4,67	4,72	4,76	4,25 × 4,25

Favorable conditions: *dry and drained land, low density of weed vegetation, direction of harrowing same in every subsequent harrowing of the plantation.*

Moderately favorable conditions*: dry and drained land, denser weed vegetation with the presence of Amorpha fruticosa L. with larger diameter than the other weeds, direction of harrowing perpendicular or diagonal in relation to previous harrowings*

The direct operational costs were calculated using the typical calculations. The direct operational costs of the tractor MTZ 1025 with the sensor disc harrow are 182,6 EUR·day^{-1}.

Unit costs of the tractor MTZ 1025 operation with the sensor disc harrow (Figure 6).

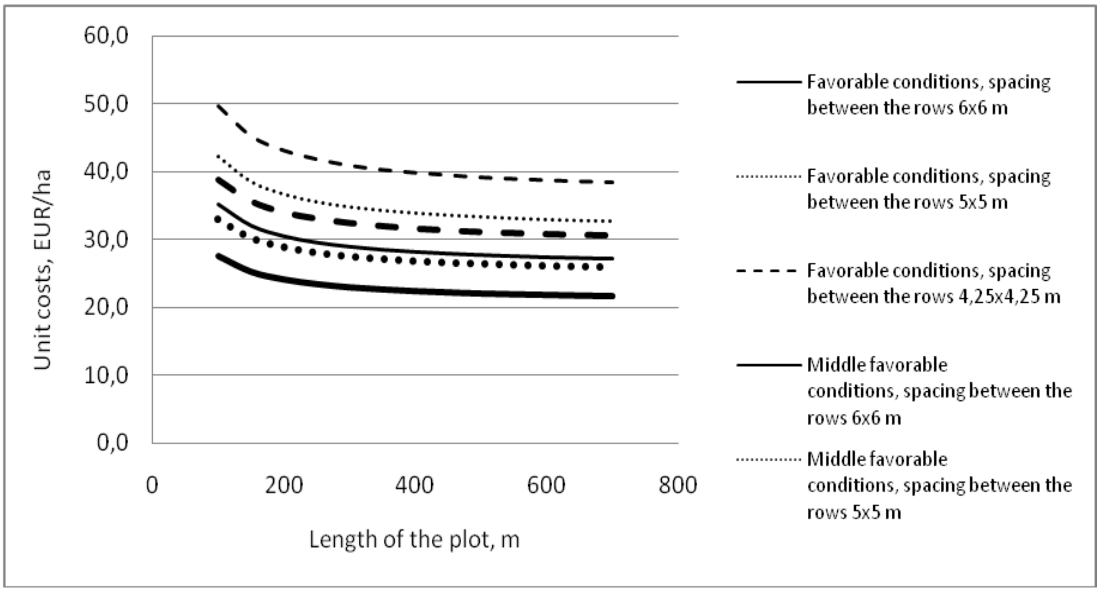

Figure 6: *Unit costs of the tractor MTZ 1025 operation with the sensor disc harrow*

4. CONCLUSIONS

These researches have dealt with the issues of working effects of the sensor disc harrow on jobs of inter-row cultivation in poplar plantations which presents an effective solution for treating poplar plantations. These issues have not been dealt with in forestry practice to an extent that provides the evaluation of effectiveness of sensor disc harrows from multiple aspects. These results contribute to a comprehensive assessment of effectiveness of sensor disc harrow utilization in poplar plantations treatment.

Based on the conducted analysis of the recorded data, the following conclusions can be drawn:

- Based on the regression analysis of the researched dependence of the share of turning time from the length of the parcel it can be concluded that a strong correlative dependence between the variables exists or, that the share of turning time in the effective working time decreases with the increase of the length of the parcel.
- Turning time increases with the increase of the width of the parcel and this increase is presented by the linear function
- The speed of harrowing depends on the direction of previous harrowing, and it increases if the harrowing is conducted in the same direction as the previous one.
- Stoppages in the effective working time account for 14.5%
- Working productivity increases with the increase of the length of the parcel and the unit costs decrease
- Damages on poplar trees caused by the operation of the sensor disc harrow are smaller in comparison to the damages caused by the operation of the classical disc harrow.
- When working with a sensor disc harrow, the harrowing should be done in the same direction, and when the conditions require the change in direction, the use of classical disc harrow is recommended.
- Normative calculated on the basis of existing data and their statistical analysis significantly differ from the aspect of working conditions in which the harrowing is

done.

- It is necessary in the future to clearly define the criteria for the working conditions for the harrowing with the sensor disc harrow.

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FOREST REGENERATION SURVEY WITH AN ANGLE-DISTANCE METHOD: STUDY CASE OF NATURALLY REGENERATED *CHAMAECYPARIS* TREES

Stanko TRIFKOVIĆ[1*], Tetsuro SAKAI[1] and Hirokazu YAMAMOTO[2]

Abstract: *Success of forest regeneration is a one of the most important prerequisites in attaining sustainability of forest management. Spatial distribution and density of juvenile trees are very important parameters to evaluate a success of forest regeneration. The mean-of-angles method is proven as a rapid approach to index spatial distribution of trees. The c-tree sampling method is known as a rapid method to estimate density of forest trees. We propose to use the combined angle-distance methodology in forest regeneration surveys. Several theoretical point populations were simulated. Also, the combined angle-distance methodology was tested in a population of naturally regenerated Chamaecyparis saplings in Kiso area of Japan. Maximum-likelihood estimator is applicable in random and the GM estimator in regular populations. The (c-1) estimator can be used in clustered populations. However, an increased degree of clustering and an increase in c-values will increase the amount of bias; the true density is overestimated in highly clustered populations and with higher c-values. Therefore, using the (c-1) estimator with small c-values, such as 2-tree or 3-tree sampling, can be more reliable to estimate density of clustered populations with unequal size and shape of clusters. Although a great variety of tree-spatial-patterns may occur in nature, the angle-distance method has proved as fast and reliable for the use in forest regeneration surveys.*

Key words: forest regeneration surveys, mean-of-angles, c-tree sampling, spatial pattern, tree density

INTRODUCTION

Success of forest regeneration is a one of the most important prerequisites in attaining sustainability of forest management. Various ecological parameters and management principles can be considered in order to regard whether forests are regenerated successfully or not. Also, in most of the cases when evaluating a success of forest regeneration foresters will need to consider spatial distribution and density of juvenile trees.

Forest regenerations surveys can be designed by using various approaches. Remote sensing can be useful in cases when it is possible to detect juvenile trees such as in forests managed by even-aged systems (Brand et al. 1991). Also, it is widely accepted opinion that the combined use of remote sensing techniques and field surveys can give the most reliable information and thus greatly improve forest management practices (Husch et al., 2002). However, in many cases remote sensing is unable to detect juvenile trees and field surveys are still the main source of information to evaluate success of forest regeneration. It is also important to underline that surveys should be designed in a cost-effective manner and methodology should be as simple as possible to be widely accepted in the practice.

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A method known as "Mean of Angles" proposed by Assunção (1994) is one of the simplest and most practical methods to indexing spatial distributions of trees. The Mean of Angles method requires measurements of angles between lines of sight from sampling points to their nearest two neighboring individual trees (Figure 1). If angles are measured in degrees – they will range from 0^o to 180^o. Frequency of angular measurements fitting to a uniform distribution would suggest a spatial randomness (Assunção 1994). A departure from a uniform frequency distribution is a straightforward approach to define a degree of clustering or regularity in distributions of trees in forests (Trifković and Yamamoto, 2008).

Many methods also can be used to assess density of trees, we have recognized potential of c-tree sampling for use in forest regeneration surveys; c-tree sampling is also referred to as n-tree distance sampling (Lessard et al. 1994; Lynch and Rusydi 1999; Lessard et al. 2002; Lynch and Wittwer 2003), density-adapted sampling (Jonsson et al. 1992) or plotless ordered distance sampling (Engeman et al. 1994). Advantage of using c-tree sampling is mostly in its simple design (Jonsson et al. 1992; Lessard et al. 1994; Lynch and Rusydi 1999; Husch et al. 2002). C-tree sampling is based on measurements of distances from sampling points to a constant number of neighboring trees, thus it is necessary to set a constant number of trees prior to a survey. For instance, 2-tree sampling requires measurement of distances from sampling points to their second nearest trees, which we can also use to draw circular sampling plots (Figure 2).

It is clear that the variable-plots or the distances correlate with a tree density; for example, an increased density of trees will induce a reduced size of plots or the distances. However, defining an unbiased estimator for c-tree sampling is not an easy task and many density estimators emerged in the past. Eberhardt (1967) assumed that "c-1 trees" exist at each sampled area, for example variable plot areas defined by radiuses from sampling points to their second nearest trees contain one tree per plot (Figure 2), and the density estimator can be written as:

$$\lambda_E = \frac{c-1}{n\pi} \sum_{i=1}^{n} \frac{1}{r_i^2} \tag{1}$$

where: n represents the number of sampling plots or sampling points, r_i are circular plot radii or distances from sampling points to the c individuals (measuring plot radii in meters and multiplying λ by 10,000 gives a density estimate per hectare).

Prodan (1968) proposed to estimating basal area of forest plantations by measuring distances to the centers of the sixth ordered tree and assumed that the variable circular plot areas contain 5.5 trees in average. Prodan's generalized estimator of density is accurate in forest plantations with regular spacing of trees (Lynch and Rusydi 1999). Also, the same assumption and averaging variable circular plot areas by a geometric mean can find a use in a wider range of regular populations (Trifković and Yamamoto, 2010) and the *GM estimator* can be written as:

$$\lambda_{GM} = \frac{c-0.5}{\pi} \left(\prod_{i=1}^{n} \frac{1}{r_i^2} \right)^{\frac{1}{n}} \tag{2}$$

Density estimators which account for variable-plot-areas are burden with a higher variance than estimators accounting for the distances which are regarded as maximum likelihood estimators (Picard et al. 2005). The *Pollard estimator* (Pollard 1971) is a one of the most studied maximum likelihood estimators and it can be written as:

$$\lambda_P = \frac{nc-1}{\pi \sum_{i=1}^{n} r_i^2} \tag{3}$$

However, maximum likelihood estimators are applicable to estimating relative density of only uniformly random populations (Pollard 1971). Also, maximum likelihood estimators can be used to estimate density of coppice forests when a spatial distribution of clumps is random (Picard et al. 2005). It is clear that c-tree sampling can yield biased density estimates with bias dependent on spatial pattern distributions exhibited by individual trees and the type of density estimator used (Payandeh and Ek 1986; Engeman et al. 1994; Lynch and Rusydi 1999; Picard et al. 2005). Therefore, indexing spatial distribution of trees is indispensible if c-tree sampling is to be used to estimating density of trees.

Although many studies in the past were investigating statistical properties and applicability of c-tree sampling in estimating relative density of trees in forests, reliability of density estimates in clustered populations was largely unknown. That largely hindered its use in forest regeneration surveys. In particular, previous studies did not sufficiently investigate the performance of the *(c-1) estimator* in estimating relative density of populations exhibiting different levels/degrees of clustering. This paper will demonstrate how different degrees of clustering influence density estimates with the *(c-1) estimator* and we will recommend appropriate *c* values for the use in forest regeneration surveys.

METHODOLOGY

In general, each individual tree in forest can be represented by a point. This allows us to map individual tree positions or to mimic real forests by simulating point spatial patterns. In this study, random populations were simulated in a Cartesian coordinate system using uniform-random numbers and scaling-up point populations to better fit into our virtual/imaginary spatial pattern distribution of trees; for example a random point population consisted of randomly distributed 100,000 points on a 100 ha area was created. Various methods can be used to simulate spatially clustered point patterns; for example the Matérn or the Gibbs-field process (Stoyan and Stoyan 1994). In this study, clustered populations were simulated by firstly creating a random population as described above and then erasing the points which fell inside randomly distributed 1,000 circular fixed-area plots: (a) setting the plot radius to 10 meters (Figure 3a), (b) setting the plot radius to 20 meters (Figure 3b) and (c) setting the plot radius to 30 meters (Figure 3c). Random c-tree sampling procedure was conducted in the simulated point populations applying *c* values ranging from 2 to 10. The angles between lines of sight from randomly distributed sampling points to the two nearest individual points in simulated populations were also measured.

Foresters can establish plantations following some regular pattern. We can simulate many different regular point patterns and in this paper a lattice-random pattern is presented which is created by randomly distributing one point inside a regular 10x10 meters lattice, so the lattice contained one point per 100 m^2.

Along with simulating theoretical point populations, we have also mapped positions of juvenile *Chamaecyparis* trees (in a Cartesian coordinate system) sized from 1.5 to 5 meters in height at 7.25 ha at the compartment 100 of the Ogawairi national forest in Japan's Kiso area (Figure 4). Later on, a simulation study measuring distances and angles was conducted. Buffer-zone of 10 meters from the border line was used in order to minimize an influence of the edge-effect and random sampling procedure with 100 points was replicated 30-times.

RESULTS

Spatial pattern indices:
A mean angle at the10mGAP point population was 79°, at the 20mGAP point population was 43°, at the 30mGAP point population was 21°, at the lattice-random population was 105° and at the saplings population was 60.4° (Figure 5). The samples of angles from each population except that of random were significantly different from the uniform distribution (Kolmogorov-Smirnov test; $p < 0.01$).

Density estimates:
Studied density estimators tend to underestimate density of the random population (Figure 6). Variances in density estimates in the random population with *Pollard estimator* were not significantly different neither with *(c-1) estimator* (p = 0.07) or *GM estimator* (p = 0.75) (exact Fisher's test).

The true density in the 10mGAP population was 736.8 points/ha, in the 20mGAP it was 293.2 points/ha and in the 30mGAP, 65.6 points/ha. The $c = 3$ sampling procedure was the most accurate in the simulated 10mGAP population, underestimating the true density by only 1.7 %. In simulated 20mGAP population $c = 2$ sampling was the most accurate, underestimating the true density by only 3.1 %, while the estimate error has tended to increase with the increase in the c value and it was higher with $c = 10$ sampling where the true density was overestimated by 21.5 %. In the simulated 30mGAP population the $c = 2$ sampling procedure was also the most accurate but here it overestimated the true density by 5.0 %. The estimate error was highest when applying the $c = 10$ sampling procedure at the simulated 30mGAP population where the true density was overestimated by 31.0 % (Figure 7).

In the lattice-random population, *GM estimator* was the most accurate. The *(c-1) estimator* tends to underestimate while *Pollard estimator* overestimates the true density (Figure 8). Variances in density estimates in the lattice-random population with *Pollard estimator* were not significantly different neither with *(c-1) estimator* (p = 0.70) or *GM estimator* (p = 0.89) (exact Fisher's test).

The true density of the mapped saplings population was 534.8 saplings/ha. Increase in c-value also tends to overestimate density of saplings with the *(c-1) estimator* as in simulated clustered populations. Increasing c-value with the *(c-1) estimator* reduce standard deviation in density estimates. Also, the reduction in standard deviation for $c \geq 4$ seems not to bring high practical gains and further increase in c-value tends to overestimate the true density (Figure 9a). The *Pollard estimator* in simulated clustered populations and at the population of *Chamaecyparis* saplings highly underestimated the true density and with increased c-values even increased a standard deviation in density estimates (Figure 9b).

DISCUSSION

Shiver and Borders (1996) have noted that we unfortunately do not have a sampling method which is “so flexible and so efficient that it could be used regardless of the forest type and inventory objective”. It is well known that the use of the fixed-area plot method requires a total count of all trees included in a sample, which often result into a choice of relatively small plots (eg. $1m^2$ plots for forest regeneration surveys) and the majority of plots often contain no counted juvenile trees whose populations exhibit clustered spatial patterns. That was also the case with the forest regeneration survey conducted at the compartment 100 at the Ogawairi national forest in Japan’s Kiso area (Mimura et al. 2004) where the use of fixed-area plots of one square meter in size have suggested that there were no *Chamaecyparis* saplings exceeding 0.7 meters in height. Here, use of c-tree sampling can be more practical.

The *(c-1) estimator* was proposed for the use in Scandinavian forest types (Jonsson et al. 1992) as well as in North-American ones (Payandeh and Ek 1986; Lessard et al. 1994). Payandeh and Ek (1986) suggested using $c \geq 10$, while Lessard et al. (1994) have suggested that the amount of the bias is not significant in North-American forest types when using $c = 5$ sampling. Different recommendations can be explained by a tradeoff between a precision and a cost. The different opinions also came as recommendations for forests with the trees exhibiting different spatial patterns.

Indexing spatial distributions of juvenile trees can suggest which density estimator to use with c-tree sampling. Our findings show that using small c-values with the *(c-1) estimator* such as 2-tree or 3-tree sampling can be more appropriate to estimating density of juvenile trees exhibiting clustered spatial patterns; to survey *Chamaecyparis* saplings we don’t need to increase c value to more than 4 (4-tree sampling). It should be emphasized that we prefer using robust estimators of density in forest regeneration surveys. The *(c-1) estimator* is recommended to estimating density of clustered populations and *GM estimator* of regular populations. Maximum likelihood estimators are appropriate to estimating density of random populations. However, our results suggest that gains of smaller variances with maximum likelihood estimators such as the *Pollard estimator* are not significant in random populations.

We recommend the angle-distance method since it is simple, it is flexible enough for the use in forest regeneration surveys and it can assist foresters in evaluating a success of forest regeneration.

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FIGURES:

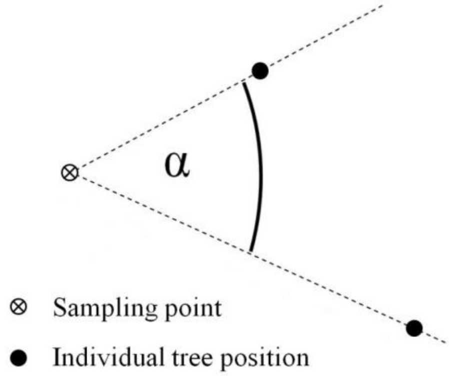


Figure 1. *Measurement of an angle α between lines of sight from sampling points to their nearest two neighboring individual trees*

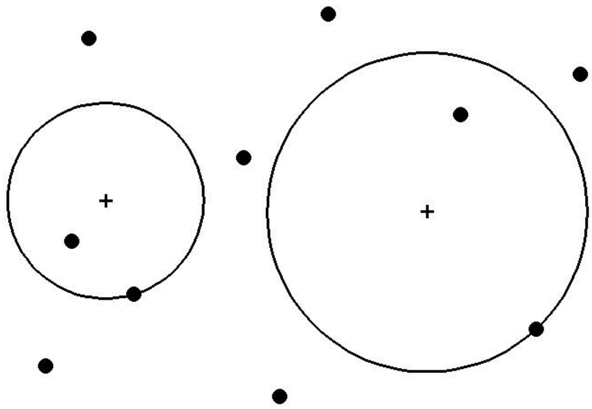
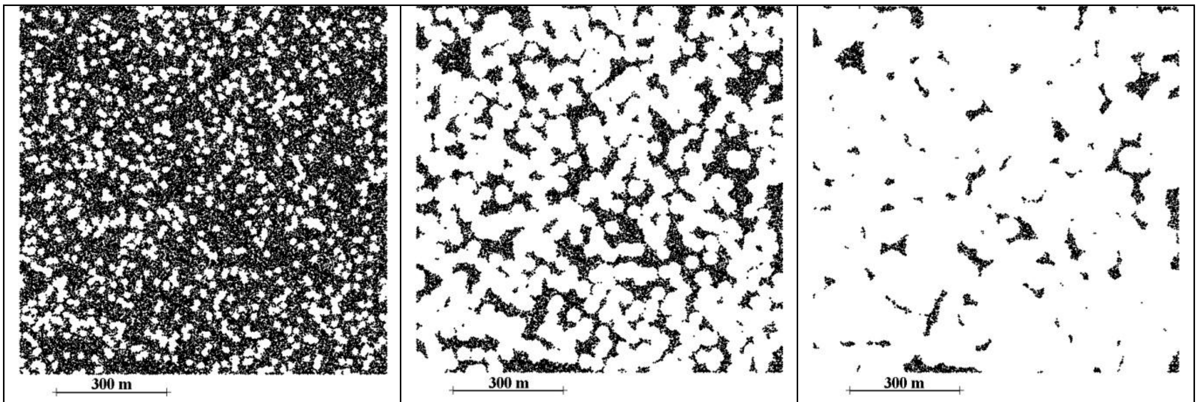


Figure 2. *Two sampling plots of a variable circular size defined by distances from sampling points (+) to second nearest individuals (black dots); c = 2 sampling*



(a) 10mGAP (b) 20mGAP (c) 30mGAP

Figure 3. *Simulated clustered point populations; black dots are simulated points representing tree positions at our virtual/imaginary spatial distributions of trees*

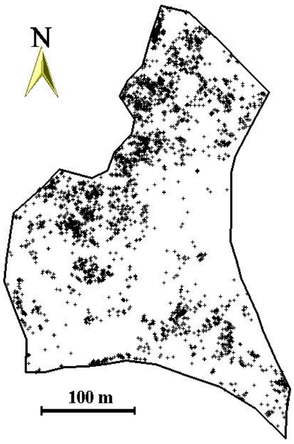


Figure 4. *Mapped Chamaecyparis saplings sized from 1.5 to 5.0 meters in height at the compartment 100 of Ogawairi national forest in Japan*

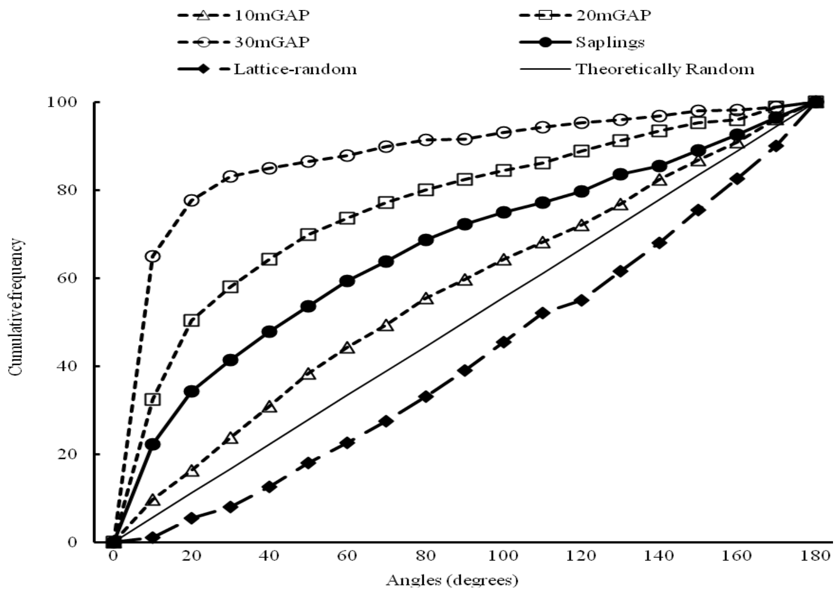
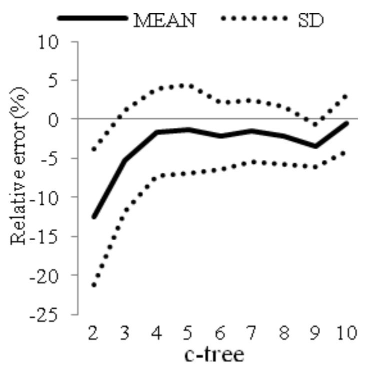
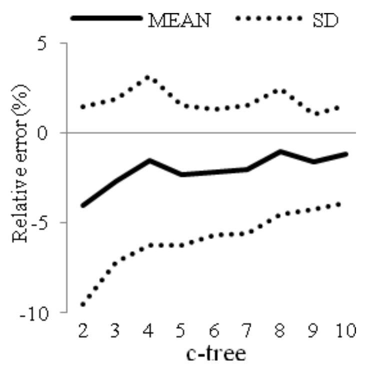


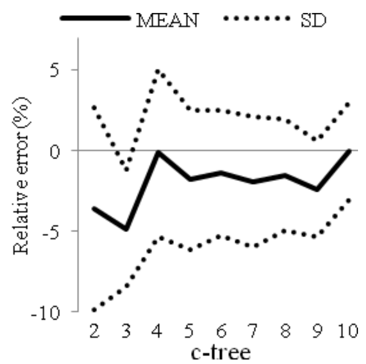
Figure 5. *Cumulative frequency distributions of measured angles in simulated clustered point populations, lattice-regular point population and population of Chamaecyparis saplings*



(a) *(c-1) estimator*



(b) *Pollard estimator*



(c) *GM estimator*

Figure 6. *Mean density estimates (MEAN) and standard deviation (SD) in random population with (c-1) estimator, Pollard estimator and GM estimator based on 30-times randomly distributing 100 sampling points; Relative Error = ((estimated density – true density) x 100) / true density*

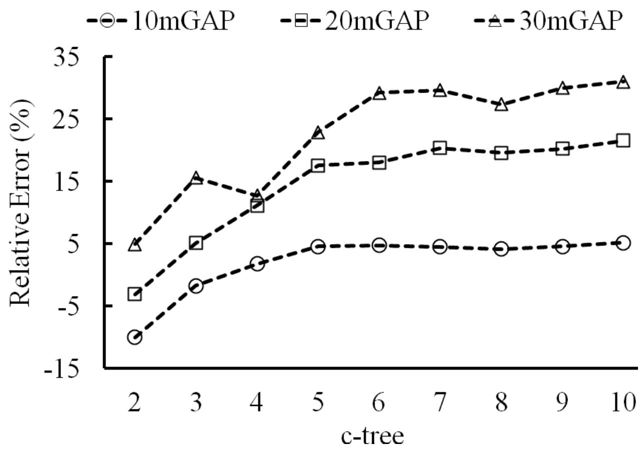
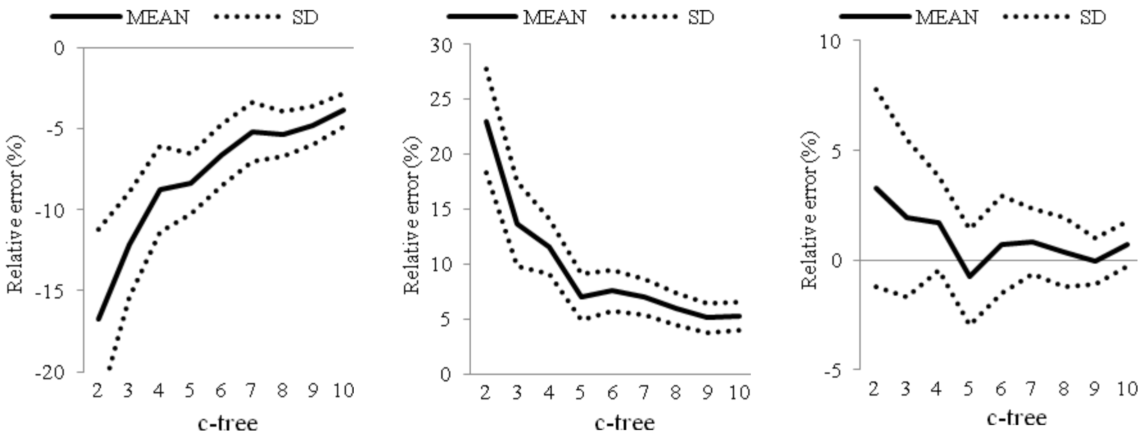
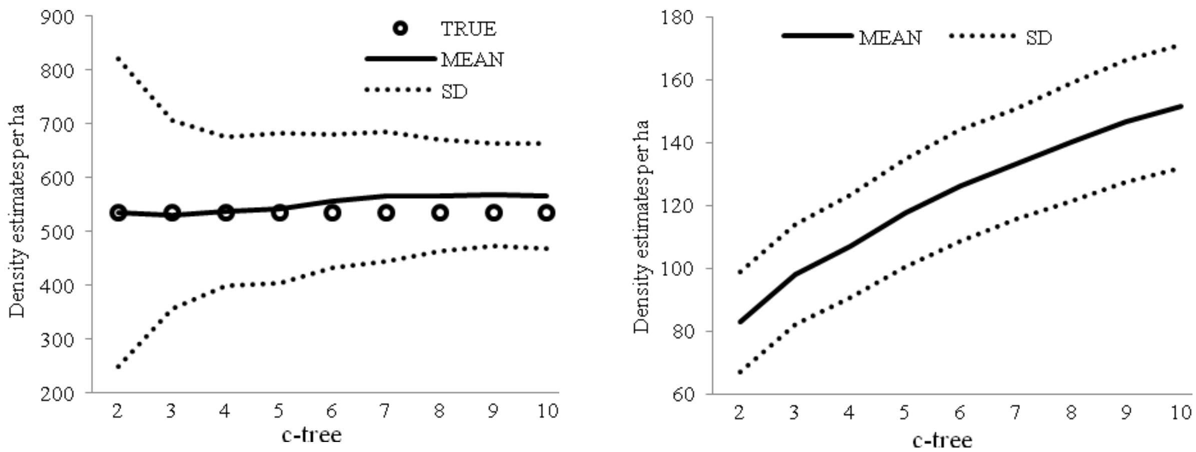


Figure 7. *Relative errors of density estimates with the (c-1) estimator based on 500 randomly distributed sampling points in simulated clustered point populations; Relative Error = ((estimated density – true density) x 100) / true density*



(a) *(c-1) estimator* (b) *Pollard estimator* (c) *GM estimator*

Figure 8. *Mean density estimates (MEAN) and standard deviation (SD) in the lattice-random population with (c-1) estimator, Pollard estimator and GM estimator based on 30-times randomly distributing 100 sampling points; Relative Error = ((estimated density – true density) x 100) / true density*



(a) *(c-1) estimator* (b) *Pollard estimator*

Figure 9. *The true density (TRUE), mean density estimates (MEAN) and standard deviation (SD) in density estimates with (a) (c-1) estimator and with (b) Pollard estimator based on 30-times randomly distributing 100 sampling points in the population of Chamaecyparis saplings*

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GROWTH MODELS OF SERBIAN SPRUCE (*Picea omorika* Pančić/Purkyně) TREES IN DIFFERENT BIOLOGICAL POSITIONSIN THE SEED CULTURE 'ZANOŽJE VITEZ'

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Danijela PETROVIĆ[1], Branislav CVJETKOVIĆ[1]

Abstract: *This work presents the growth analysis of Serbian spruce trees in different biological positions. The trees come from the thinnings in the Serbian spruce planted forest 'Zanožje Vitez' in the Management unit 'Sase Žabokvica', which is registered as an object for seed collection. In order to describe height and diameter growth in relation to age, five growth functions, commonly used for modeling tree growth, were tested. For height growth estimate Bertalanffy function proved to be the best and, for diameter growth estimate Prodan function was the best. In the studied stand. The culmination of the current annual height increment occurs before the culmination of diameter increment. In dominant trees the difference is four years, in overtopped trees only one year. Stagnation in diameter compared to height growth in overtopped trees compain in comparison to dominant trees is much more evident. Based on the obtained growth models of dominant trees height, it was optimal to start with the thinning of the studied culture at the age of about 14 years. The absence of thinning up to the age of 31 years adversely affected growth progress, especially the diameter.*

Key words: Serbian spruce, growth functions, dominant trees, overtopped trees

INTRODUCTION

Serbian spruce (*Picea omorika* Pančić / Purkyně) is an endemic and tertiary relic species, typical of the eastern part of Bosnia and Herzegovina and the Republic of Srpska and the south-western part of Serbia, which results in the significance of this species. Serbian spruce is used for the reforestation of fields, and as a species with a proper shape of the crown and resistance to air pollution in urban areas, it has significant application in landscape architecture.

According to Kotar, M. (2005) the term 'growth' can be used in an ambiguous meaning, as a process and as an amount in the quantitative change on trees at a given time interval. In the science about the growth of trees, tree growth includes the changes in the size and shape of trees. According to Stajić, B. (2003), the best and most accurate information about the growth of different stands is provided by the data obtained in a continuous study of permanent sample plots. In the absence of permanent sample plots, the necessary information can be obtained from a large number of temporary sample plots of different actual and developmental ages, or from the reconstruction of the growth of dominant trees, which are assumed to have free and unobstructed development. Without having much information about the growth and increment of

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trees or without the knowledge of biological growth principles and trends in forest ecosystems, we can't be closer to the optimal forest management.

Growth models of dominant trees are reliable indicators of the habitat production potential, as well as a reliable basis for planning the time of thinning and for planning the time of the next thinning. The time of the beginning of thinning is related to the culmination time of the current annual height increment of dominant trees because it is the most appropriate time for trees to react to possible silvicultural treatments. The relation between the height increment time and the thinning time is based on the fact that there is a strong correlation between the dynamics of tree growth in height and the ability of a crown to spread due to increased space for tree growth.

For the purpose of finding optimum silvicultural treatment of stands, it is necessary to know the growth development dynamics of the trees behind the dominant trees, and we need to know the relationship among the trees in different biological positions in the stand.

MATERIAL AND METHODS

The trees in the stand are divided into two basic categories according to their biological positions: dominant and overtopped trees (Schober, R. 1964). Dominant trees include predominant, dominant and codominant trees by Kraft classification, and overtopped trees include the categories of overtopped and distressed trees. Four trees from the categories of dominant trees and two from the categories of overtopped trees were selected for the construction of models and for the analysis of the growth of trees with a different biological position in the stand. The growth of trees was reconstructed with stem analysis, based on the stem discs which were taken at a height of 0,3 meters, 1,3 meters and two meters, and then towards the top of the tree at every two meters of height.

The trees come from the first thinning of Serbian spruce planted forest 'Zanožje Vitez' in compartment 37 of the Management unit 'Sase Žabokvica' (Figure 1), which is registered as an object for seed collection (Reg. number: S.K.035.3101.12)[1].The planted forest was established in a cambisol distric on andesite, at an altitude of 860 meters. The trees were cut down during 31^{th} years. The models were made by using the regression and correlation analysis methods and by using the statistics software package[2].

Figure 1: *Location of spruce seed culture "Zanožje Vitez"*

[1]Mataruga, M., Isajev, V., Lazarev, V., Balotić, P., Daničić, V. (2005): *Registar šumskih sjemenskih objekata RS - osnova unapređenja sjemenske proizvodnje*, Šumarski fakultet Univerziteta u Banja Luci, Banja Luka.
[2]StatSoft, Inc. (2007). *STATISTICA* (data analysis software system), version 8.0. www.statsoft.com.

In order to obtain tree growth models, height and diameter growth of trees are evaluated by growth functions. According to Wenk, G. et al. (1990), growth functions are the simplest growth models. For modeling tree growth (the age-dependence on height and diameter), different functions were tested, such as functions from Chapman-Richards (Richards, F.J. 1959), Bertalanffy (Bertalanffy, L. 1951), Levakovic-III (Levakovic, A. 1935), Prodan (Prodan, M. 1951) and Korf (Korf, V. 1939). According to a number of authors (Zeid, B. 1993, Pretzsch, H. 2009), these functions are most commonly used to model the growth of trees.

Table 1 shows the tested growth functions. Increment functions are obtained as the first derivative of growth functions. The choice of functions for modeling was performed based on the coefficient of determination, standard error of the estimate and graphical analyses representation of the obtained regression curves and empirical data. To determine the parameters of the model, iteration method (Levenberg-Marguardt) in the statistical package was used.

Table 1: *The tested growth functions*

Function	Growth	Increment
Chapman-Richards	$y = a \cdot (1-e^{-b \cdot t})^c$	$y' = abce^{-bt}(1-e^{-bt})^{c-1}$
Bertalanffy	$y = a \cdot (1-e^{-b \cdot t})^3$	$y' = 3abe^{-bt}(1-e^{-bt})^2$
Levakovic III	$y = a \cdot \left(\frac{t^2}{(b+t^2)}\right)^c$	$y' = 2bcy / t(b+t^2)$
Prodan	$y = \frac{t^2}{at^2+bt+c}$	$y' = \frac{x(bx+2c)}{(ax^2+bx+c)^2}$
Korf	$y = ae^{-bt^{-c}}$	$y' = abct^{-c-1}e^{-bt^{-c}}$

y	-	height / diameter,
y’	-	current annual height increment / current annual diameter increment,
t	-	period (years),
a,b,c	-	function parameters,
e	-	constant (2,718281828).

RESULTS AND DISCUSSION

For the evaluation of height growth, Bertalanffy function was the optimal one. The selected function is equal to Chapman-Richards function, except that the parameter ‘c’ is a constant and equals 3 (in Bertalanffy), which proved to be a better solution in this case. Table 2 gives the parameters of the derived growth model. Coefficient of determination (R^2) has a high value and shows good compatibility of the selected model with the measured growth elements. Standard error of the estimate (S_e) is higher in overtopped trees. The obtained growth models of dominant and overtopped trees are shown in 1 and the curve of the current annual increment and the mean
annual increment can be seen in charts 2 and 3.

Table 2. *Characteristics of regressions (height growth models)*

Parameters		Standard error	t	p-level	R^2	R	S_e
Dominant trees							
a	16,9053	0,7897	21,4071	0,0000	0,996	0,998	0,2665
b	0,0793	0,0035	22,6340	0,0000			
Overtopped trees							
a	16,4927	1,3616	12,1128	0,0000	0,993	0,996	0,3326
b	0,0665	0,0047	14,2269	0,0000			

According to the obtained models, the current annual increment of dominant trees culminates in the 14th year with a value of 0,60 m, and overtopped in the 17th year with a value of 0,49 m. Mean annual height increment of dominant trees culminates in the 24th year with a value of 0,43 m and overtopped trees in the 29th year with a value of 0,36 m. According to the obtained models, dominant trees reach breast height in the 7th year, overtopped trees in the 9th year. In the 31th year dominant trees reach a height of 12,9 m, and overtopped trees the height of 11,5 m.
As for the estimate of the growth in thickness Prodan function proved to be the best and most adaptable. Table 3 shows the parameters derived for growth models. As for height growth, coefficient of determination has a high value and shows the compatibility of the selected models with the measured growth elements. Standard error of the estimate is higher in dominant trees. The resulting growth models of dominant and overtopped trees are shown in chart 4 and the curve of the current annual increment and mean annual increment in charts 5 and 6.

Table 3. *Characteristics of regressions (diameter growth models)*

Parameters		Standard error	t	p-level	R^2	R	S_e
Dominant trees							
a	0,1237	0,0140	8,8656	0,0000			
b	-4,4638	0,6420	-6,9535	0,0000	0,994	0,997	0,4293
c	75,6790	7,2117	10,4939	0,0000			
Overtopped trees							
a	0,2821	0,0362	7,8041	0,0000			
b	-11,0417	1,6865	-6,5471	0,0000	0,989	0,994	0,3535
c	167,5339	1,2889	8,6855	0,0000			

According to the obtained models, current annual diameter increment of dominant trees culminates in the 18th year with a value of 10,18 mm and overtopped trees also in the 18th year, but with a value of 6,76 mm. Mean annual diameter increment of dominant trees culminates in the 25th year with a value of 6,04 mm and overtopped ones in the 24th year with a value of 3,69 mm. In the 31th year dominant trees reach breast diameter of 17,1 cm and overtopped tree of 10,0 cm. Diameter increment of trees in the last few years has an extremely small value. This points to the physiological changes in trees and the started devitalisation process, and is caused by unfavorable conditions in the stand.

In the studied stand, the culmination of height increment occurs before the culmination of the diameter increment. According to Vučković, M. (1989), *earlier culmination of height increment is typical* of *the trees that are in the early decades of life in a dense forest or which suffer after a forestation due to the intense competition of old trees shoots and various weed species, while for the trees which grew in a normal or rare density, the earlier culmination of diameter increment is typical*.

Chart 1. *Height growth*

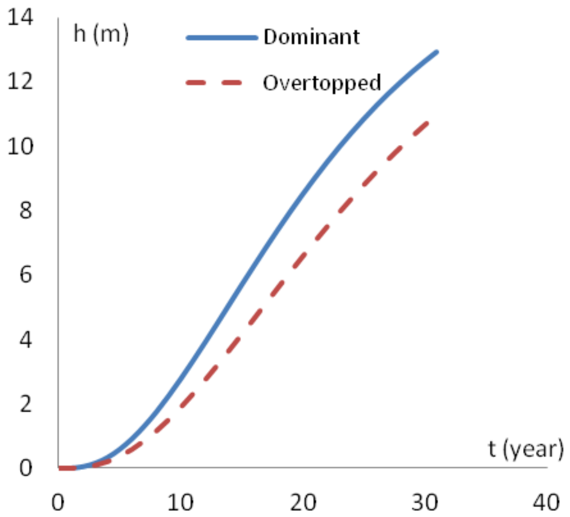


Chart 2. *Current annual height increment*

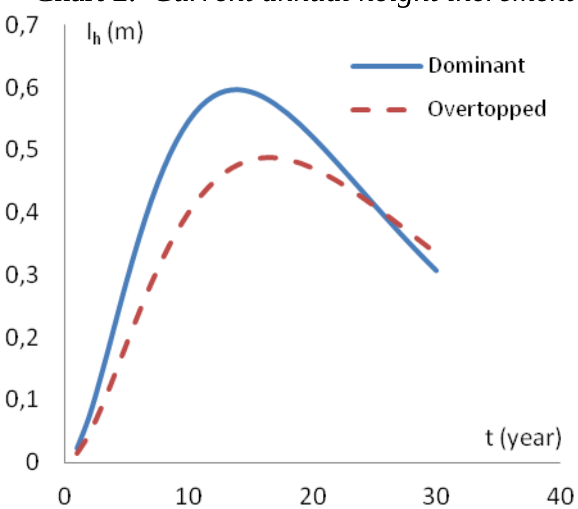


Chart 3. *Mean annual height increment*

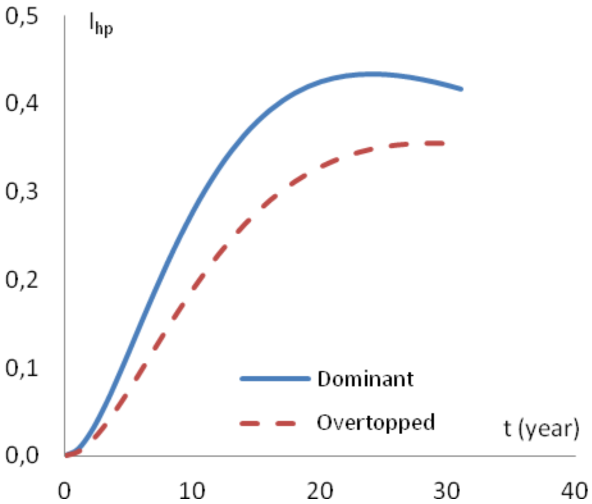


Chart 4. *Diameter growth*

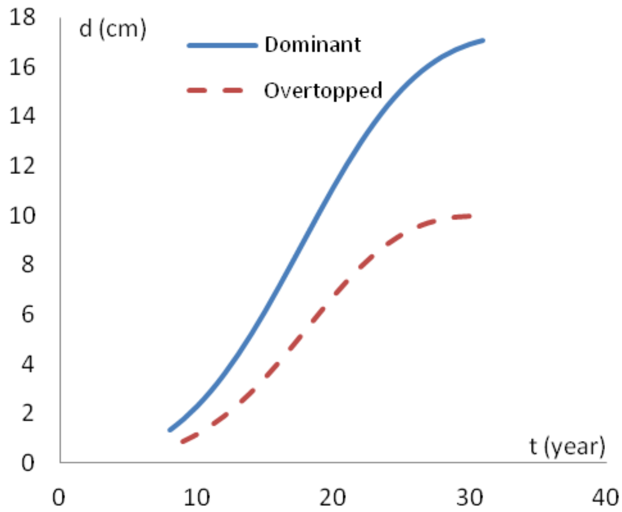


Chart 5. *Current annual diameter increment*

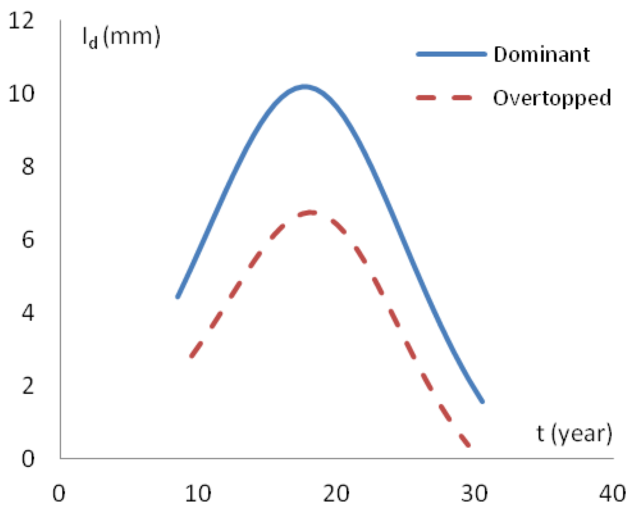
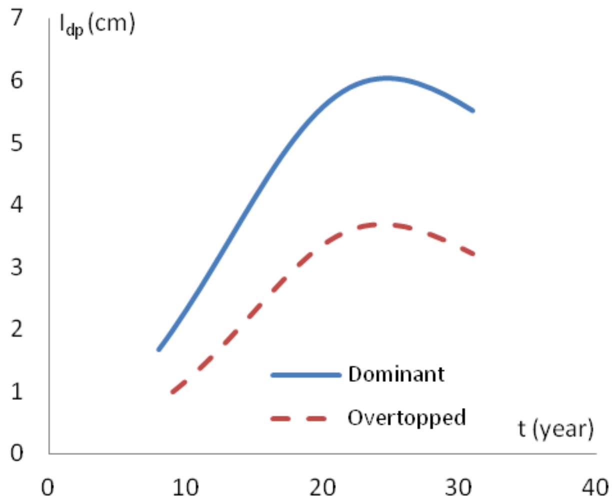


Chart 6. *Mean annual diameter increment*



Based on the obtained model for diameter and height growth, it can be concluded that the absence of thinning up to the 31st year had a negative impact on growth, especially diameter growth. According to Matić V. (1980), the position of a tree in a stand in comparison to other trees and the size of its surface are reflected on the diameter growth to a much greater extent than the growth in height.

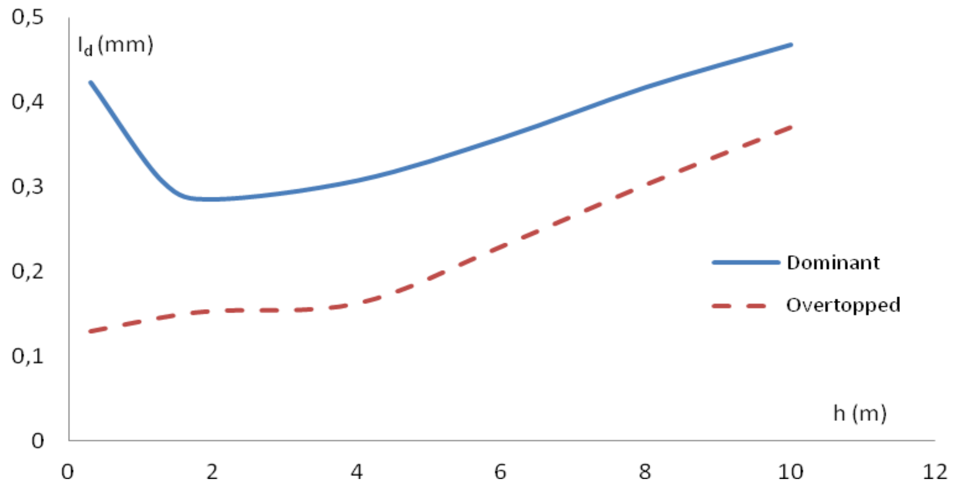
Compared to overtopped trees, dominant trees have higher lag in diameter increment than in height increment. In the last five years, both groups of trees are equated in terms of height growth. At same time, in this period, overtopped trees have an extremely small diameter increment. The share of overtopped trees height in the dominant trees height in 31st year is 89%, and the share of the diameter is only 58%. According to Matic, V. (1980), when a tree lags in height growth, in comparison to adjacent trees, the tree will die due to an overshadow, if not intensify his growth in height.

In this situation, diameter increment is not of vital importance and most of the assimilates are spent on height growth and smaller amount on diameter growth. According to Weck, J. (1955), sometimes it happens that annual ring does not show up on overtopped tree at the breast height in the years of unfavorable weather conditions, while height growth is continual.

The degree of slenderness (h / d) of trees is a measure for the assessment of stability and growth potential of a stand, and it also describes the competitive conditions prevailing in the stand. The degree of slenderness of overtopped trees was 115, and it was significantly greater than the slenderness of dominant trees, which is 75. Based on these figures, it is evident that a dominant tree possesses much greater resistance to the negative effect of snow or storms.

Chart number 7 shows the mean annual diameter increment along the stem of dominant trees and overtopped trees (the mean annual value of diameter increment over the past five years). According to Maunaga, Z. (2012), diameter increment from the ground towards the top of the tree, first decreases to approximately one fifth of tree height, and then it increases, as it is the case here, regarding dominant trees. Unlike the dominant trees in overtopped trees, from the bottom to a height of about 4 m, diameter increment is approximately equal and of a very small value and then, going to the top of the tree, it increases.

Chart 7. *Mean annual diameter increment over the past five years – along the stem*



CONCLUSION

For the construction of models and the analysis of Serbian spruce trees growth in different biological positions in the stand, stem analysis was used for the reconstructed growth of dominant trees and overtopped trees from the first thinning in the Serbain spruce seed culture ’Zanožje Vitez’, compartment 37 in the Management unit ’Sase Žabokvica’.

For modeling tree growth (the age-dependence of height and diameter), five functions were tested. Bertalanffy function was the optimal for height growth estimate and for diameter growth estimate it was Prodan function. In both cases, coefficient of determination has high values (0,99). According to the obtained models, the current height increment of dominant trees culminates in the 14th year with a value of 0,60 m and overtopped trees in the 17th year with a value of 0,49 m. The average height increment of dominant trees culminates with a value of 0,43 m in the 24th year, and overtopped in the 29th year, with a value of 0,36 m.

According to the obtained model, the current annual increment of dominant trees diameter culminates in the 18th year with a value of 10,18 mm and overtopped ones also the 18th year, but with a value of 6,76 mm. Mean annual increment of diameter of dominant trees culminates in the 25th year with a value of 6,04 mm and overtopped ones in the 24th year with a value of 3,69 mm. The current annual increment of diameter of overtopped trees in the last few years has an extremely small value, which indicates the physiological changes in trees and the started devitalisation process.

In the studied stand, the culmination of height increment occurs before the culmination of diameter increment. In the case of dominant trees, the difference is four years and in the case of overtopped trees only one year. In the category of overtopped trees, in comparison to dominant trees, the stagnation in diameter is much more evident than height increment. The share of height of overtopped trees in the height of dominant trees in the 31th year is 89%, and the share of diameter is only 58%.

Based on the obtained models of height growth of dominant trees, the thinning of the studied culture optimally starts at about 14 years of age. The absence of thinning up to the 31th year adversely affected growth, especially diameter growth.

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PRINCIPAL SCENARIOS OF BOREAL FORESTS MANAGEMENT: ESTIMATION FROM POINT OF VIEW OF SUSTAINABILITY AND THEORY OF GROWTH.

Alexander S. ALEKSEEV[1]

1. INTRODUCTION

Since Conference in Rio-de-Janeiro (1992) common six criteria and number of indicators for sustainable forest management was adopted. Following the Helsinki General Declaration, criteria and indicators for the sustainable management of forest (Loiskekoski et al., 1994) have been introduced in forestry, which concerns also the aspects of biodiversity conservation.

The Helsinki Ministerial Conference succeeded in defining the sustainable management of forests conceptually in a political context as *«the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems»* (Helsinki Resolution H1).

All stated indicators are applied mainly at regional level and must serve for the quality assessment of the current regional forest policy.

Obviously forests are affected by a number of exogenous hazards which may seriously modify management outputs towards away from sustainability due to damage from factors of risk. Risk usually defined as the expected loss due to a particular hazard for a given area and reference period (Gadow, 2000). An expected loss may be calculated as the product of the damage and its probability. So, forest management should reduce uncertainty in management outcomes by anticipating the future in a systematic way, thus reducing the probabilities of unexpected events and risks.

Generally there are two principally different strategies of forest resources use – intensive rotation forestry when development follows a succession of cutting cycles, usually define by a rotation age and characterized by thinnings, periodic clear fellings and re-plantings and continuous cover forestry which is characterized by selective harvesting of individual trees when forest remains in a state of undefined age, oscillating about a specified level of growing stock (Gadow ,2000;   Gadow K., Nagel J., Saborowski J. (eds.), 2001, Pukkala, Gadow (eds.), 2012).

The aim of this contribution is systematically, on relevant mathematical and theoretical basis of three stand model of growth, consider the advantages and limitations of above strategies of forest resources use from point of view sustainable forest management as well as minimum of risk.

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2. GENERAL MODEL OF FOREST STAND GROWTH

Growth of the forest resulted in accumulation of wood biomass is main significant process in forest ecosystem from point of view of matter-energy exchange and consist in solar energy, water, carbon dioxide and nutrition's consumption which simultaneously follows by oxygen release and water transpiration. Due to such outstanding role in forest science there is numerous publications on forest growth (Watt, 1968, 1973; Assmann, 1970; Thornley, 1976; Shugart, 1984; France, Thornley, 1984; McIntosh, 1985; Knoebel et al., 1986) review of which is out of frame of this paper.

In following analysis we will use some general model of forest stand growth very well known as *S*-shape or logistical model (Alekseev, 2003). Let *S* – amount of substance limiting growth in forest site environment, *X* - amount the same substance already fixed in forest biomass, *K* - total amount of limiting substance, then held balance equation:

$$S + X = K = const,$$

or in dimensionless variables:

$$s + x = 1,$$

where *s* and *x* equals $\frac{S}{K}$ and $\frac{X}{K}$, respectively.

If we consider the growth as autocatalytic process then

$$\frac{dx}{dt} = a * s * x$$

where *a* – growth coefficient, or using balance equation:

$$\frac{dx}{dt} = a * (1 - x) * x$$

Last equation in initial variables may be written as

$$\frac{dX}{dt} = a * \left(1 - \frac{X}{K}\right) * X$$

Growth curve derived from last differential equation may be presented as follows:

$$X = \frac{K}{1 + E * e^{-a*t}}$$

where, *a* – relative speed of growth, 1/year;

K – maximum possible growing stock of tree stand, m^3/hectare;

t – stand age, years;

$E = \frac{(K - X_0)}{X_0}$ - parameter, depending on initial growing stock, dimensionless.

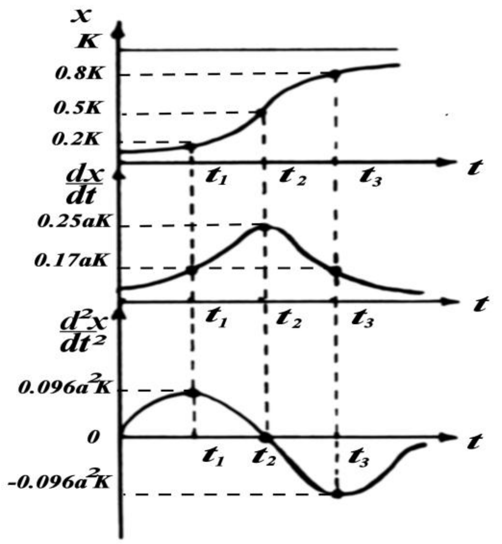
Model was verified a number of times using a lot of data from different sources on tree stand growth. Table 1 represents the variant of growth curve verification using growth and yield tables for Leningrad region. Model parameters *a*, *K* and *E* was determined by non-linear regression technique.

Table 1. *Growth curve verification on the base of growth and yield tables for Leningrad region.*

Species	Site class	Model parameters						R^2,%
		a, 1/year	*Se(a)*	*K*, m^3/hectare	*Se(K)*	*E*, dim/less	*Se(E)*	
Scots pine	I	0,053	0,007	530	11,9	18,2	7,3	98,6
	II	0,041	0,001	468	5,4	12,6	0,8	99,9
	III	0,042	0,001	376	4,4	13,2	0,9	99,8
	IV	0,050	0,001	243	2,1	13,4	0,9	99,9
	V	0,056	0,002	152	2,5	14,2	1,3	99,8
Norway spruce	I	0,039	0,002	642	13,4	12,2	1,2	99,6
	II	0,038	0,002	538	12,0	13,9	1,4	99,6
	III	0,043	0,002	383	6,2	14,9	1,5	99,7
	IV	0,052	0,003	245	3,7	16,5	2,1	99,7
	V	0,062	0,003	158	2,4	24,9	3,9	99,7
Birch	I	0,049	0,001	411	4,8	9,8	0,5	99,9
	II	0,048	0,001	360	3,1	10,0	0,3	99,9
	III	0,052	0,002	265	3,0	10,5	0,6	99,9
	IV	0,055	0,001	189	1,9	9,6	0,4	99,9
	V	0,074	0,004	94	1,5	10,5	1,3	99,9

Coefficient of determination from last column of the table 1 shows high quality of data description by *S* – shape growth model. From the table we can also learn that relative speed of growth not vary significantly between species and growth classes, the only exceptions are for site classes of low quality but for such tree stands usually exist only a few data sets on history of growth of poor reliability. Much more sharp species and site classes differs according parameter *K* which may be interpret as site capacity for wood stock..

S-shape growth curve may be used for distinguishing of special periods of time (ages) during total time of growth, on the base of growth curve characteristics such as speed and acceleration of growth. Graphs of growth curve speed and acceleration of growth represented at figure 1.



Growth curve – describes tree stand growing stock dynamics

First derivation – speed of growth

Second derivation – acceleration of growth

Fig.1. *Graphs of growth curve, speed and acceleration of tree stands growth process.*

Three special points of acceleration curve makes it possible separate four periods (or stages) during total growth period: first – stage of accumulation of growth energy, second – stage of active growth, third – stage of growth by inert ion and fours – stage of growth ending.

There is some analogy between Newton's second low in physics (*F=m*a*), where energy (power) is proportional to acceleration of moving body and forest science where we may also to consider that energy of growth is proportional to acceleration of growth process, so acceleration curve has a fundamental value for growth analysis which may be not enough admits yet.

Four stages of growing process correspond to three special points of acceleration curve and may be calculated using growth curve parameters and formulas represented in table 2.

Table 2. *Formulas for stages of growth process determination*

Special point (stage) of growth process	Age, years	Characteristics		
		Growing stock, m^3/hectare	Increment, m^3/hectare*year	Acceleration, m^3/hectare*year^2
Energy accumulation – t_1	$\frac{\ln(0.27*E)}{a}$	*0.21*K*	*0.17*a*K*	$0.096*a^2*K$
Maximum of growth speed – t_2	$\frac{\ln E}{a}$	*0.5*K*	*0.25*a*K*	*0*
Growth stop – t_3	$\frac{\ln(3.74*E)}{a}$	*0.79*K*	*0.17*a*K*	$0.096*a^2*K$

From this theory follow that the age of tree stands maturity is t_3 when all possibilities for growth including inertia are exhausted.

Table 3 represents estimations of longevity of the growth process stages.

Table 3. *Ages for different stages of growth process*

Species	Site class	Longevity of growth period stages, years			
		Energy accumulation – t_1	Maximum of growth speed – t_2	Growth stop – t_3	Period of growth, t_3– t_1
Scots pine	I	30	55	80	50
	II	30	62	94	64
	III	30	62	93	63
	IV	25	52	78	53
	V	24	47	71	47
Norway spruce	I	30	65	99	69
	II	34	69	103	69
	III	32	63	93	61
	IV	29	54	80	51
	V	30	51	72	42
Birch	I	20	47	74	54
	II	20	48	76	56
	III	20	44	70	50
	IV	17	41	65	48
	V	14	32	50	36

It follows from table 3 that period of energy accumulation is the same for Scots pine and Norway spruce tree stands (25-30 years) and is shorter for Birch tree stands (14-20). Stop of growth earlier for low quality site classes and for the same stands also as usual shorter period of growth (t_3– t_1).

There is clear relation between stages of growth period and tree stands development age classes: stage (0-t_1)-energy accumulation corresponds to young tree stands, stage (t_1-t_2) - active growth to middle aged, stage (t_2-t_3) - growth due to inertia to premature and stage after t_3 - ending of growth corresponds to mature and over mature tree stands

3. MACRO MODEL FOR GROWING STOCK USE OPTIMIZATION

The problem of optimal use of the forest growing stock excellent described by following citation: "…if we wish to extract large quantities of wood from the forest, and at the same time allow large quantities of wood to remain, we have a forest management problem. The need for forest management planning is born out of a conflict between the present and the future, i.e. the problem of sustainable development…." (Jonsson, Jacobsson, Kallur, 1993).

3.1. Basic model

Forest management problem may be stated and solved as strong mathematical task – problem of optimal control. Criteria for the problem may be presented as follows:

$$G = \int_0^T q(t)dt + X(T) \Rightarrow \max$$

here, *G* – criteria value, m3/hectare; *X(T)* – remaining part of the growing stock at the year *T*; *q(t)* – harvested volume at the year *t*, m^3/hectare*year; *T* – planning period considered as rotation age and taken equal to maturity age (t_3)

The criteria composed from two parts first reflex interests of present meanwhile second – interests of the future. Simultaneous maximization of both will result in optimal compromise.

Dynamics of tree stand growth will by modified by harvesting activity as presented below:

$$\frac{dX}{dt} = a * \left[1 - \frac{(X-q)}{K}\right] * (X-q) - q.$$

Last differential equation is a balance between harvest and increment of the tree stand growing stock, so first composed is increment of the remaining stock after withdrawal of amount *q*, second – harvested amount *q*.

Criteria of optimality, differential equation of growing stock dynamics together with conditions un negativity of variables

$$X \geq 0, q \geq 0$$

all together make the mathematical problem of optimal control which has a solution:

$$q(t)_{optimal} = X(t) - 0.5 * K.$$

Accounting for un negativity conditions we may conclude that

$$q(t)_{optimal} = 0 \quad if \quad X(t) \leq 0.5 * K,$$

that is optimal harvesting should follow for two rules, first – start after growing stock reach amount *0.5*K* at the age t_2, second – remaining stock should be no less than *0.5*K*. From above consideration it is follows that more optimal will be unclear cuttings and forestry close to continuous cover principle.

Because of optimal solution unequivocally determine not harvesting but remaining (residual) part of growing stock we may call it as "golden rule" of stock accumulation as analogy to economics where national gross product subdivided on consumed and accumulated parts in optimal way according to "golden rule" (Intriligator, 1975).

Generally optimal strategy of tree stands growing stock use may be formulated as free (or with pre-commercial thinnings) growth up to maturity age at t_3 with growing stock of *0.8*K* and subsequent harvesting of amount *0.3*K* with remaining part of *0.5*K*. Such a strategy theoretically closes to continuous cover forestry and has a number of advantages comparatively with rotation forestry based on clear cuttings with subsequent replanting of harvested area. Growing stock dynamics for these two strategies of tree stands wood stock exploitation presented on figure 2.

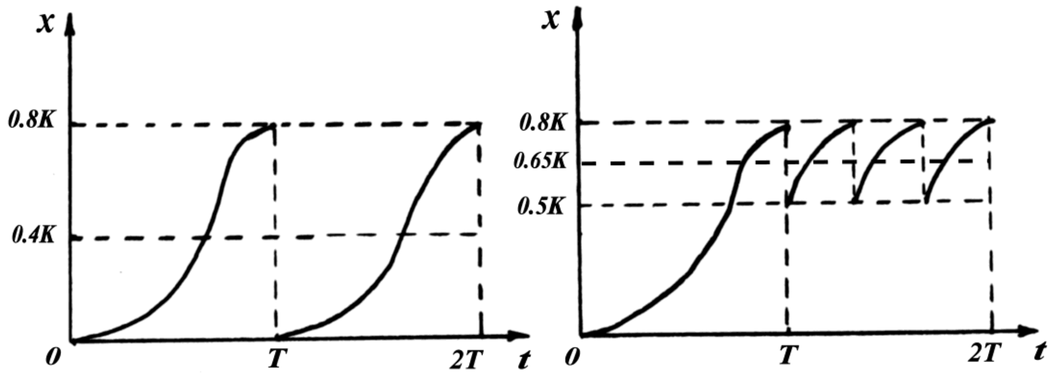


Figure 2. *Growing stock dynamics for rotation and continuous cover forestry strategies of tree stands wood stock exploitation.*

Comparison of the above strategies from point of view of present interests and interests of future presented in the table 4.

Table 4. *Comparison of rotation and continuous cover (optimal) strategies of tree stands growing stock use*

	Strategy	
	Rotation	Optimal
Interest of present (mean harvest of wood per rotation period = mean annual increment during rotation period)	$\frac{0.8*K}{T}$	$от \quad \frac{0.9*K}{T} \quad до \quad \frac{1.2*K}{T}$
Interest of future (mean remaining stock per rotation period)	$\frac{0.4*K}{T}$	$\frac{0.65*K}{T}$

From table 4 follows that advantage of optimal strategy from present interest point of view accounts for *0.1*K* up to *0.4*K* or from 12.5 up to 50% of growing stock at maturity age (*0.8*K*), and from future interest point of view - *0.25*K*. Except for it optimal strategy is much more advantageously from ecological (carbon accumulation, biodiversity, water and soil protection), forestry (natural regeneration, wood quality) and social (recreation) points of view.

3.2. Model with economics extensions

Let include in the model the following economic parameters and define how they alter the optimal decision:

α – discount rate;

$e^{-\alpha * t}$ – discount function;

f(t) – price for depersonalized cubic meter of wood in the tree stand of age *t*. Generally *f(t)* is a concave function of tree stand age increasing at the beginning because of elevation of tree stand mean diameter and decreasing later due to worsening of wood quality and increasing share of dead wood.

Criteria for optimal control problem may present as:

$$G_1 = \int_0^T e^{-\alpha * t} f(t) * q(t) dt + e^{-\alpha * T} f(T) * X(T).$$

Criteria are the present value of harvested and remained for further growth wood stock. Differential equation describing growth with harvest influence remains the same. Optimal solution will characterized as below formula:

$$q(t)_{optimal} = X(t) - 0.5 * K * \beta$$

$$\beta = \left[1 - \frac{(\alpha - \gamma)}{a}\right], \qquad \gamma = \frac{df(T)/dt}{f(T)}$$

The core of the optimal solution remains the same as in basic model but economic parameters modify it. Modifications in optimal strategy takes place due to relations between α and γ :

1. If $\alpha=\gamma$, or $\frac{df(T)}{dt} = \alpha * f(T)$, then $\beta=1$ and optimal solution remains the same as in the basic model:

$$q(t)_{optimal} = X(t) - 0.5 * K$$

2. If $\alpha>\gamma$, or $\frac{df(T)}{dt} < \alpha * f(T)$, then $\beta<1$ and optimal will be solution with more earlier and more strong harvest. Remaining part of growing stock will be less than *0.5*K*. In such a case more valuable will be present interests comparatively with interests of the future. Such case is very probable and known in the literature on natural resources management as "damnation of discounting" and leads to exhaustible use of renewable resources.
3. If $\alpha<\gamma$, or $\frac{df(T)}{dt} < \alpha * f(T)$, then $\beta>1$ and optimal will be solution with more late beginning and more soft harvest with remaining for further growth more than *0.5*K*. In such a case more valuable interests of the future.

4. RISK EVALUATION FOR TWO SCENARIOS OF FOREST MANAGEMENT PLANNING

Risk is defined as the expected loss due to a particular hazard for a given area and reference period. An expected loss (r) may be calculated as the product of the damage (s) and its probability (p): r=s*p.

Main hazard factors for trees and tree stands are such as late frost, sun burning, wind, ice and snow breakage, insects and fungi attacks as well as mainly manmade forest fires and air pollution (Otto, 1994; Gadow, 2000).

More risky are first decades of tree stand growth, at this ages more higher probability of total elimination of tree stands by usual damaging factors such as frost, exceeding precipitation, solar burn, fire, animals feeding, insects attack.

Surviving rate for young tree stands in much lower than for older ones. For first decades of tree stands living span surviving rate is extremely low because of high probability of full destruction after effect of damaging factors. Therefore less part of the tree stand area covered by young forest may be used or harvested (Kouba, 1989, Gadow, 2000).

Continuous cover forestry scenario provides absent of very sensitive for damage compact areas of young tree stands and from this point of view is more preferable because of risk minimization.

5. CONCLUSIONS

Advantages of optimal management strategy from sustainability point of view may be summarized as follows:

- More harvest of wood
- More remaining volume of wood = better carbon conservation
- Close to normal biodiversity
- Ecologically sound including more climate, water and soil control
- Prevailing of natural regeneration
- More possibilities for multi-purpose use

Advantages of optimal management strategy from minimum risk point of view are

- More control of environment by permanent forest cover
- Low level of growth related risks

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REAL FORESTS PRODUCTIVE WORTH DETERMINATION METHOD

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Abstract: *Proper determination of forest productive worth as the base for forest tax-rent establishing from forests owner to forest managers, is a problem which existing more hundreds years. This question was solved on different ways in history, depends of social-economic settlement, ownership relation in forestry area, forestry practice and knowledge about forests. In some cases this question is not solved at all, such as in B&H. Here, there is a problem of non equal validation of the same work in different state forestry region.*

In general, worth determination of some forest, because of forest tax establishing could be based only on worth of particular forest functions which foresters utilise. That is only productive function in the most cases. Productive forests worth depends of timber quality, real direct and indirect costs of forest management. Based on optimal enterprices organisation and technical capacity, adequate to planed system of management, the cost of management shoud be calculated.

Forests are different regarding volume and quality of income, current structure and accessibility for exploitation, so it could not be established only one proper tax value for all forests and different regions. There is a need for investments in forests at the same time also. How, how much, and which dynamic of the investments should be applied for economically sustainable way?

In the states with regular forestry, two ways for forest tax determination exist. First is based on market mechanism, and second is based on direct calculation of forest worth where market mechanisms are no only factors or not developed.

The concept of methodological approach, which is real for adoption in B&H, for solving this problem in short time, is presented in this paper. Its essence comes from first understanding of term normal forest, established for forest tax determination. Productive worth of forest was calculated for forest management region (FMR) "Olovsko" as the real example. FMR has four different management units (MU) regarding forest types, geomechanical properties of terrain, average slope…The results of calculated productive worth, for these MU, shows the logical and significance differences in absolute values.

Key words: productive forests worth, forest tax

1. INTRODUCTION AND THE SUBJECT

1.1. Multifunctionality of forest resources

Forests, as renewable natural resources are wealth of general interest, which deserve a special care and protection of the society. Based on this resource, the forestry as an economy activity, has been developed and has a series of specific features, which makes it different form other industries. Economic laws and economic categories are different in this industry and they have to be acknowledged in considering any matter, while by the rule they are observed, planned and achieved in forestry in a longer period of time.

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The basic specific feature of the forestry is the long-term production, which suggests a large temporal gap between the investment and the expected economic effects, as well as lack of direct economic motivation to ensure funds for the long-term investments. Moreover, significant specifics of the production in the forestry is reflected in the difference between the natural conditions related to economic activities, resulting in misbalance of the investment needs and available material resources for those purposes. Social interest and social support to such investments have to serve as a guarantee for the long-term and consistent development policy in forestry and securing the sources for financing development programs in this field.

Material interests of society as a whole and companies managing the forests are primarily divergent. Social community, in addition to the development of forest industry, is particularly interested in permanent preservation of the forests. Currently, Forest management companies in charge of forests are primarily interested in the biggest possible profit. Harmonization of wider and permanent interests of social community on the one hand and direct interest of companies supervising the forest industry (including private businesses) on the other hand, need to be ensured through the Law on forests.

Majority of the forests in FBiH are state owned, and the state entrusted this valuable and important resource to the Cantonal forest management companies. This contractual relation regulated by the Agreement on use is a sort of (specific) form of assignment. However, the state, being the owner, is not reimbursed for the use of these forests. Cantonal forest management companies are owned by Cantons; they organize business according to market rules, so that they should be profitable and thus obligated to separate part of profit for their founders (Cantonal Assembly). On the other hand, companies should be obligated to pay certain amounts to the forest owners (fee or lease) for the right to economic activity – use of forests.

This reimbursement would be the only instrument, not only for balancing the economic conditions of businesses, which mainly arise from different conditions of the forest funds resulting from different natural conditions, but would also serve as a basis for the control of development of the status of forests. This means that the introduction of lease would facilitate the transfer of some money from economically profitable to the economically non-profitable forests areas. The amount of lease would depend on economically productive value of the forest, not the profit of the company.

1.2. Differences in conditions surrounding business

The basic productive factor in forestry is the forest ground with its fertility. Production costs in forestry differ depending on fertility of the ground, climate conditions, geographical position (distance to the market), status of the forest fund, etc.

These are different natural conditions, which may slightly change by the influence of human activities in a long period, though with a lot of difficulties. The needs for the investment of the work and resources in the areas affected by poorer natural conditions are higher, and on the other hand the possibility and available reserve of the companies managing such areas are less. It is the opposite in the areas with better and more favorable economic conditions, that is, the possibilities are better and the needs for investments are smaller. It means, the companies manage the forests with different values and which make the basic resource for business. More specifically, uneven fertility of the ground, different climate conditions, and ground conditions, different conditions of forests, different distances from the market and other things are the factors which objectively affect the business results of the companies that manage the forests, independently from subjective factors and their activities (Bozalo, 2008).

By the introduction of adequate mechanisms of variable lease adjusted to the market conditions and qualitative mechanisms for the control of economic activities, the forest companies would be positioned in a proper economic position. This would facilitate that their success would depend on their business endeavors, rather than natural advantages surrounding the areas which they manage.

2. WORK METHODS IN DETERMINING FOREST LEASE

2.1. Concept in determining the lease

The idea of calculating the forest fee based on normal composition forests, elaborated in this paper is basically an old idea which originates from a regulation for determination of value of forests for the purpose of sale in Austria from 1788, adopted by the Crown Chamber of Joseph II. Of this regulation, a formula “survived” for determination of normal forest (Austrian method of Kameraltaxe), which was slightly modified by Heyer (Wagner, 1928, according to Matić 1969).

The stocks of wooden mass in the forest, a specific production resource in the forest industry, by its quality and quantity is different for individual forest managing regions (FMR). For one FMR, forest managing plan (FMP) is made which serves as a basic instrument for regulation of forest managing on principles of sustainable forest management in one managing period (usually 10 years).

So, FMR is a defined minimal area managed by a single economic entity – forest company. Thus, there is no need to identify the fee for smaller units.

To get a productive value of forests as a whole in a fair manner, the real productive value of forests should be identified for individual environmental-productive classification units of forest, managing classes (MC) and broader categories of forests within FMR. Primarily, because it is impossible to identify the optimum situation of forests and/or total necessary level of investment to forests without knowing the normal condition of forests, which is again identified for certain MC. After that, average normal situation for all forests in FMR can be calculated.

As an illustration, this paper will identify these values for individual territorial forest management units MU (parts of FMR) to show the difference in the productive value of forests, as they appear between different FMR. Along with this, the paper will show only total values for all forests per individual MU. The focus of this paper lies in FMR *Olovsko* with its significantly different 4 MU according to the orographic characteristics and composition of forests.

2.1.1. Definitions

Working on the matter of forest fee, based on identification of productive value of forests, certain notions have to be clearly defined to facilitate understanding of methods for determination of productive value of forests.

- **Total revenue (Up).** Forest companies mainly make profit on felling of parts of forest stocks which they manage. The revenues from the wooden mass (Up) will depend on rational use of wooden mass planed for cuts or assortments structure and market prices of particular assortments.
- **Real business costs (RTP).** If the area is treated as an economic facility and the conditions in the forest is maintained at the existing level of the size and quality of stock, we may conclude that this is a simple reproduction while the business costs in such conditions constitute **real business costs** (regular business costs). These costs include the costs of necessary simple biological reproduction. If the amount of costs is identified based on optimal organization and work technology within the working conditions, along with the optimal structure of the company, then we can talk about the real business costs (**RTP**).

Costs incurred by additional invested labor or resources aimed at improvement of infrastructure of FMR, increase of space under forests or improvement of the status of stock in the existing forests could be called **investments** in forests. In a long-term period, these investments result in the decreasing of **RTP**. These additional investments have the character of **expanded reproduction**. The necessary level of investments (**Uu**) in forests should be calculated.

The difference between total revenues of the company (**Up**) and real business costs (**RTP**) should serve as a basis for the calculation of fee. This difference could even be negative in case of forests with lower value, more severe orographic conditions, and low level of openness of the area by roads or other aggravating circumstances.

- **Current value of forest stocks (Tv):** That is the value of current forest stocks, expressed monetary per m^3 based structure of wooden products - assortments in the forest stocks, assumed based on rational use of raw-materials. This value directly depends on the quality and the size of current forest stocks.
- **Potential value of stock (Pv):** That is the value of forests identified based on normal composition (size and quality of stock). Also, it is necessary to identify the normal structure of forests in the entire space of forests and forest grounds (in FMR).
- **Current value of revenues (Tvp):** That is the value of revenues in the wood which may be achieved in a short period of time (one managing period) based on possible extent of felling, whose implementation does not change the status of forest stocks, their size and quality. **This extent of felling equals the value of volume increment, quality equals the quality of stock and diameter structure equal to the one obtained by normal percentage of capturing in the wooden stock per diameter classes**. As for the practice in BiH, it may be stated that the diameter structure is almost equal to the structure of wooden mass from test marking for felling (carried out by forest inventory).

Tvp is only a calculation value, that is, revenue which would be obtained by forest management without any investment to forests and/or maintenance of current situation, and as such it will definitely not be planned or implemented. It serves only as a marker in the control of quality of management and in the course of definitive determination of normal forest – for planned extent of felling in FMR.

- **Potential value of revenues (Pvp):** That is the value of revenues that could be obtained from the same forests of normal composition with the optimum infrastructure of the FMR.
- **Total necessary level of investment (Uu):** This part of investment contains two important parts:

  - investment to the improvement of the situation of stock – to normal level (Pv-Tv),
  - investment to infrastructure of FMR (Uk).

Second part of investment mainly pertains to investment aimed at achievement of optimal openness of forests to primary transport communications. Total necessary level of investments to forests (**Uu)** may be obtained as:

Uu = (Pv – Tv) + Uk

- **Dynamics of investment to forests**

Dynamics of investment to forests may differ, and we shall now provide explanation for possible options such as maximal and optimal dynamics, and investment in a regulated period.

- **The fastest investment (maximum possible):** It depends on time needed for building those forest compositions that might satisfy our needs with the size of new yield and the structure of growth, that is, on solutions which respect the principle of continuity in production. That dynamics is not simple, year by year, as it depends on specific situations in specific forest types – management classes and currently needed silviculture measures. These investments, if related only to correction of the structure, size, and quality of stock can be obtained based on the scale of felling calculated based on wooden mass of test marked trees for felling (during the inventory of forests), and the price of conversion all coppice forests to high forests, foresting of all barren lands. Of course, this dynamics is most usually impossible in reality, but yet it is necessary to know their essential elements.
- **Optimal dynamics of investment:** Defined within solution arising from the principle of continuity of revenues and continuity of managing. Basically, it is deterministic by planned felling, measures of silviculture and planned investments.
- **Investment in managing period (Uup):** Difference between the value of wooden mass based on rational use of wooden mass of the planned cutting volume and the extent of felling which maintains the existing stock is the amount of investment in corrections of the structure of forest stocks.

The plan of foresting works within expanded reproduction of forests, along with the plan of investments to permanent FMR infrastructure makes the volume of investment during a regulated period.

These investments together may be defined as investment in the following regulated period <u>These defined investments are made solely from the total revenue of the forestry company, and of course they do not include the investments from other sources.</u>

2.2. Determination of the value of forest and volume of investment to forests

- **Productive value of natural advantages for the work of forest (PRv):** It may be calculated as difference between current value of revenues and real business costs, that is:

PRv = Tvp – RTP

We are talking here about the current value of natural advantages for the work and possibility for making profit, without any investment to forests.

- **<u>Potential productive value of natural advantages for the work of the forest</u> (PRv_p):** If we calculate the difference between potential value of revenues and potential real business costs, we shall get the maximum possible or potential value of natural advantages for the work of forest.

PRv_ p = Pvp – RTPp;

where RTPp is potential value of real business costs of production. In this way, we get the potential value of natural advantages for the work or the amount, based on which we can define the size of maximum possible fee for the use of productive function of forest. It will be possible after all the investments, and/or establishment of normal composition of forest and optimal development of forest infrastructure.

RTPp are lower than **RTP**, as they are calculated based on optimal openness to the network of communications (this reduction mainly arises from short distances needed for transport of assortments), provided of course that the prices of work will not change in future.

- **FEE in a managing period (R):** In conditions of market economy or during the procedure of granting concessions for the management of forests to companies interested in use of productive function of forest, the fee may be calculated as a difference between current value of revenues and total investments in managing period.

R = PRv – Uup or, **R** = (**Tvp – RTP) – Uup**

Acknowledging the current conditions in the organization of forestry sector, connected with social problems of the society, the forest owner may at the expense of forest company, and due to possibility of making profit, define the fee (r) in the transitional period as:

r = PRv – Uup – P – S; where:

Uup – is total planned investment to forests in regulated period,
P – profit for the forestry company,
S – “payables” for the increased costs due to the surplus of workforce or insufficient technical capacities.

Profit has to be inserted in the equation above. If we calculate real business costs (**RTP**) based on optimal capacity of the forestry company with the resources of work and workforce, then we cannot count on profit, thus there is no interest for the companies managing forests or apply for the concession agreement.

Value (**S**) depends on the political decision of the forest owner, but the one which has to disappear after some time, that is, until the introduction of market mechanisms in the sector of operative forestry.

The mere distribution of fee (**r**), that is, its further use depends on the forest owner who has the right to dispose of it and use it for expanded reproduction of forests as additional investment to forests, where it is most needed, that is in those areas which potentially show the negative trend of natural advantages for work – real productive values of forests (PRv). Annual fee can be obtained by dividing the amount with the number of years in a regulated period.

3. RESULTS

The data based on which all the calculations were made were taken from the records on the status of forests, that is, the inventory (2001) and forest management plan (FMP) developed for the period: 1 January 2002 – 31 December 2011. Some financial indicators of the forestry company were also used, data on the organization of individual work stations and the sector of forestry, which implement the planned tasks of the FMP in FMR *Olovsko*.

3.1. Potential and current value of stocks and revenues from forests

Potential value of forests was calculated based on size, diameter structure, and the assumed best quality of stocks. We assumed that it is possible to reach the following quality of the wooden mass of stocks, presented in percentage of participation of the technically good quality classes of trees (Table 1).

Table 1: *Normal quality of wooden mass for high forests in FMR*

Technically quality class (T)	Class of thickness (cm)				
	5-10	10-20	20-30	30-50	50-80
	Percentage of participation in the volume of wooden mass				
I	50	70	75	85	85
II	0	0	20	12	13
III	25	20	5	3	2
IV	25	10	0	0	0

Classification of trees in terms of technical quality of tress was developed by Matić for the needs of the first inventory of forests in large areas of BiH. With some minor amendments, (Music, Lojo 2006) classification was applied in the second state inventory of forests in BiH (Lojo *et al*. 2008). Basically, value of assortments was calculated which could be produced by rational use of wooden mass, normal forest stocks, use of assortment tables (Vukmirović, 1971, Pavlič, 1973), and price list of assortments applied in Forest company of Zenica-Doboj Canton, taking the regulated period to be 10 years. The task itself was done in individual property classes, and Tables 2 and 3 showed cumulative values for individual economic units in FMR *Olovsko*.

Table 2: *Current value of forests in FMR Olovsko*

Current value of stocks (Tv)						Current value of revenues (Tvp)			
MU	Area (ha)	Stock (000 m^3)	Value of stock 000 KM	000 KM/ha	KM/m^3	10 year yield (m^3)*	Value of assortments 000 KM	KM/ha	KM/m^3
01- Gornja Stupčanica	1643	544.1	44 373.0	27.0	81.6	163 076.2	13 450.5	8 187.6	82.5
02-Donja Stupčanica	6450	1 993.5	162 763.8	25.2	81.6	550 522.8	44 627.0	6 918.8	81.1
03-Krivaja	7933	2 017.2	159 735.5	20.1	79.2	553 087.5	43 862.4	5 528.7	79.3
04-Tribija Duboštica	12214	3 554.1	285 756.9	23.4	80.4	836 326.0	68 927.4	5 643.3	82.4
FMR	28240	8 108.9	652 629.2	23,1	80.5	2,103,013	170.867	6 050.5	81.2

*m^3 – wood thickness ≥ 7 cm

Table 3: *Potential value of forests in FMR Olovsko*

Potential value of stock (Pv)						Potential value of revenues (Pvp)			
MU	P (ha)	Stock (000 m^3)	Value of stock 000 KM	000 KM/ha	KM/m^3	10 year yield (m^3)*	Value of assortments 000 KM	KM/ha	KM/m^3
Gornja Stupčanica	1643	553.1	49 479.8	30.1	89.5	135.695	12.935	7 873.5	95.3
Donja Stupčanica	6450	2056.2	182 675.1	28.3	88.8	532.264	50.131	7 772.1	94.2
Krivaja	7933	2 017.2	159 735.5	20.1	79.2	553.088	43.862	5 528.7	79.3
Tribija Duboštica	12214	3 427.6	296 610.7	24.3	86.5	938.803	85.818	7 026.2	91.4
FMR	28240	8 054.1	688 501.1	24,4	85.5	2,159,850	192,745	6.825.3	89.2

Difference between current and normal value of stock of 35.9 million KM or around 1,270 KM/ha, difference (Pv-Tv) is not big, as the current stock per quality is even bigger than normal, but it is poor in terms of quality. Thus, the current value of potential revenue for 10 years is smaller by around 22 million KM of potential normal (Pvp – Tvp).

3.2. Calculation of real business costs (RTP)

This is a very complex problem which requires a detailed analysis of working conditions, determination of optimal technology and organization of the work applied at planned management systems, a given working conditions and planned extent of tasks. At the same time, the solution of this problem affects the possibility of proper calculation of the productive value of forest, and possibility of determination of forest fee. We started from the assumption that the forest companies operate based on system of small parcels, while the number of workers is calculated as per the total extent of works, work norms and the system of management (in line with current regulations in Forest company of Zenica-Doboj Canton, 2006). The biggest expenditures arise from direct costs of the forest exploitation. To calculate them we need to define current working conditions, which depend on the orography of the terrain, possibilities and the length of roads intended for trucks in individual economic units and/or openness of the forests, mean transport distances needed for transport of wooden mass, of mean volume, intensity of felling per spatial unit, distance between the locations, provided that optimal technology is used.

First task is to determine working conditions and define measuring parameters that the costs of exploitation depend on. To determine them, we need to plot a map of technological classification of the terrain and then identify transport distance. Thus, we used the categorization of terrain according to Kulušić 1990, (Table 4).

Table 4: *Category of terrain for logs traction, depending on more important features of the terrain (Kulušić, 1990)*

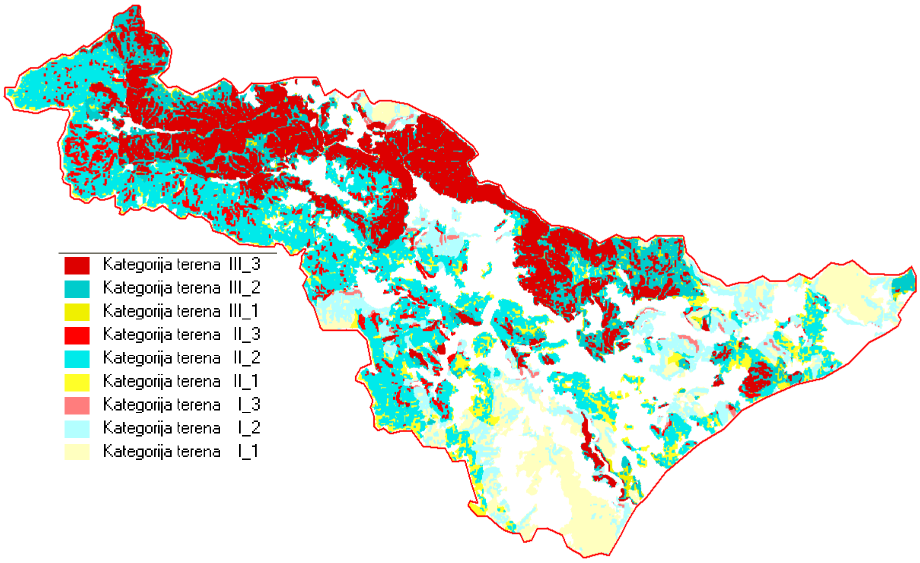
Geological-pedological unit (GPC)	Conditions and recommended tools for work	Category of terrain for traction			
		(1)	(2)	(3)	(4)
G.P.C. I – Soil on limestone and dolomites	Angle (%)	0 - 25	0 – 25	26 - 70	>70
	Distance of traction	shorter (m)	longer (v)	m/v	m/v
	Tools for work	Stand. tractor	Skidder	Skidder	Crane
G.P.C. II – Deep soils on different sand silicate an carbon rocks	Angle (%)	0 - 20	0 – 20	21 – 50	>50
	Distance of traction	shorter (m)	longer (v)	m/v	m/v
	Tools for work	Stand. tractor	Skidder	Skidder	Crane
G.P.C. III – Soil on clay silicate, peridotite-serpentine rocks and organic decomposing soil	Angle (%)	0 - 15	0 - 15	16 - 35	>35
	Distance of traction	shorter (m)	longer (v)	m/v	m/v
	Tools for work	Stand. tractor	Skidder	Skidder	Crane

To define in this specific case the geological-pedological (GPC) units in this area, and categories for attracting wooden mass, the GIS software program MapInfo was used. Having designed and used the 3-D model of terrain (DTM in GIS program, grid 50 x 50 m) the entire area of the forests and forest ground of FMR *Olovsko* was marked according to the angle of the terrain. Then, the overlapping was made with the vectored geological-pedological maps (with defined GPC) and the layer which contains information on individual forest stands in FMR.

The final result was a vectored map of the technological classification of the terrain (graph 1), with polygons which uniquely belong to GPC units, and the class of angle of the terrain. Every polygon has information about its belonging to a forest spatial units, stand, compartment, MU and MC. Individual categories of the terrain, expressed through its share of the space of individual categories of angle are given for individual MU. Table 5 illustrates one example for MU.

Table 5. *Space of GPC and class of angle for MU "Gornja Stupčanica" (01) in ha*

GPC I			GPC II			GPC III		
763,4	214,6	1,5	217,2	242,0	5,3	65,3	139,8	8,1



Graph 1: *Map of technological classification of terrain for FMR Olovsko*

Map was a basis for calculation of business costs. Towing transport distances from the center of every forest stand to the truck road were also identified by GIS program and vectored maps of forest paths (Table 6).

Table 6. *Average towing transport distance to the truck road (TD)*

MU	Gornja Stupčanica	Donja Stupčanica	Krivaja	Tribija Duboštica	FMR *OLOVSKO*
TD (m)	424	668	748	1006	802.1

Having defined orographic conditions and optimal technologies, the wooden mass in the extent of felling equal to the volume of yield, the valid norms applicable for the forest activities in the Forest company of the Zenica-Doboj Canton 2006, we identified the direct business costs for individual MU. Calculation was made for every individual working activity by the application of norms and necessary extent of duties, predominantly determined by the extent of felling or total space of the forest. These costs should usually be calculated during the design of FMP, and they should not be specially presented, as the method is well known (Matić 1977). Due to a large number of details, this cannot be presented in this paper. Table 7 presented only final results of business costs per 1 m^3 of wooden mass for felling. Calculations relate to the extent of felling which do not change the volume and quality of the current growing stocks.

Table 7. *Direct costs of current production calculated for 1 m^3 of wooden mass for felling*

MU	Construction and reconstruction of secondary road network	Felling and attracting	Silviculture works within simple reproduction of forest	Costs of preventive protection of forest	Road maintenance	Transport of workers	Costs of management plans	Total direct costs
	KM/m^3	KM/m^3	KM/m^3	KM/m^3	KM/m^3	KM/m^3	KM/m^3	KM/m^3
1	2,67	22,67	2,1	2,2	1,49	0,45	0,26	**31,86**
2	3,8	26,97	2,44	2,3	1,76	0,1	0,42	**37,82**
3	3,37	29,3	3,51	2,9	1,97	0,19	0,40	**41,67**
4	3,16	34,06	3,84	2,6	1,3	0,38	0,35	**45,72**
FMR	3,35	30,07	3,4	2,6	1,61	0,27	0,37	**41,72**

Other – indirect business costs of the company were calculated based on required number of workers, productive and nonproductive, the system of small parcels and average salaries. It was calculated for FMR that the total indirect costs and/or costs of the technological readiness for production would be 2,960,254 KM annually, which is 27% of the total structure of costs. Such structure of costs is acceptable and in line with the present researches (Delić, 2011; Delić, 2003). Calculated for MU, given the space of forest, these costs shall be (Table 8)

Table 8. *Indirect (general) costs per MU*

MU	KM/year	KM/m^3
01 – Gornja Stupčanica	175,867.1	**10.78**
02 – Donja Stupčanica	685,502.5	**12.45**
03 – Krivaja	856,990.6	**15.49**
04 – Tribija Duboštica	1,241,893.8	**14.85**
Total	2,960,254.00	**14.08**

Table 9. *Other revenues after the settlement of current costs on annual basis*

MU	Total revenue (Tvp) KM	Total current costs Real business costs **(RTP)**		Other funds (for expanded reproduction and fee including profit of the company) (**PRv**)	Company gross profit (10%)	Remaining part for the expanded reproduction and fee after the profit deduction	
		KM	KM/m^3			KM	KM/m^3
01	1,345,054	658,266	42.64	686,788	68,679	618,109	**37.90**
02	4,462,697	2,614,913	50.27	1,847,784	184,778	1,663,006	**30.21**
03	4,386,243	2,979,646	57.16	1,406,597	140,660	1,265,937	**22.89**
04	6,892,743	4,722,165	60.57	2,170,578	217,058	1,953,520	**23.36**
FMR	17,086,737	10,978,047	55.80	6,108,690	610,869	5,497,821	**26.14**

This specific example (Table 9) clearly shows the differences between individual MU, which in practice can be compared with FMR the other sources needed for investments (expanded reproduction) including the amount of fee amount on average 26.14 KM/m^3 and ranges between 22.89 and 37.90 KM/m^3. It is logical that the needs for investments are opposite proportionate to the amount of these resources. Smaller amount of these resources mean that this area has poorer conditions in which the consumption costs are higher, and revenues smaller, so that the remaining portion is smaller. It is also a signal that these areas need more investments to improve the situation. This suggests that the investment needs are bigger, and in that case the fee is smaller (it could even be negative).

Considering that based on such elaborated methods we can assume the natural forest which equals to natural yield, whereby the quality of average wooden mass has the same quality as the quality of yield, and results in maintenance of the same situation of the quality of stocks. On the other hand, the identified natural forest in FMR *Olovsko* for the period of FMP, 1 January 2002 – 31 December 2002 is smaller than the voluminous yield, it means that the achieved revenue will be smaller. As the quality structure of natural forest is worse than the quality of yield, this will take to the improvement of the quality of stocks. The above specified can be related and compare with the investment into the improvement of quality and quantity of stocks. So, if the owner agrees with the planned natural forest which is smaller than that voluminous yield (approval for FMP), it means that the deviation from the felling of part of voluminous yield aims at improvement of the condition of forest, which falls into the category of expanded reproduction. Such decision of the owner affects the reduction of total revenue of the owner, which will result in the decrease of the basis for consumption contribution. To make it clearer, we made a calculation of total revenue as per the planned natural forest based on the planner natural forest and its structure for the applicable FMP, calculating the same prices of assortments as in the previous calculation (Table 10).

Table 10. *Calculation of total annual revenue and costs per natural forest for the scheduled FMP in the period 1 January 2002 to 31 December 2011.*

MU	Volume of felling	Total revenue		Total current costs (RTP)		Remaining portion for the expanded reproduction and fee **(PRv)**	
	m^3/god	KM/year	KM/m^3	KM	KM/m^3	KM	KM/m3
01	10,024	742,153	74.04	537,261	42.64	204,892	20.44
02	37,039	2,719,171	73.41	2,226,867	50.27	492,304	13.29
03	39,642	2,746,800	69.29	2,636,095	57.16	110,706	2.79
04	67,725	4,692,395	69.29	4,450,129	60.57	242,266	3.58
FMR	154,431	10,900,518	70.59	9,850,350	55.80	1,050,168	6.80

By comparing individual economic units, we may see the differences ranging between 2.79 KM/m^3 (MU Krivaja) and 20.44 KM/m^3 (MU Gornja Stupčanica). If we observed them as forest-economic areas, it is apparent that the MU Krivaja does not have a potential for additional investments to expanded reproduction, which will endanger the possibility to pay the fee, unlike MU Gornja Stupčanica, which, for these purposes, has almost 7 times bigger amount. These differences exist in reality between individual FMR and/or forest companies. In reality, as FMR *Olovsko* is not optimally prepared given the material resources and labor force, their business costs are higher, and it is logical to ask a question if it is feasible in this case to separate any amount for the fee, without reducing the salaries along with a fair implementation of the established natural forest and getting the forest management plan.

4. CONCLUSIONS

The results of the study suggest the need for the calculation of fee at the level of individual FMR, which is the only correct solution for the determination of adequate fee for the management of forests. Determination of average fee applicable to all the areas would not facilitate the achievement of objectives and purpose of this economic category that needs to be a "corrective factor" for different conditions of business operations in individual companies. In this way, the owner (state) could achieve objectives and tasks during the implementation of a single forestry policy throughout the area. During the elaboration of these methods, only the consumption of basic product in the forestry, based on trees, was envisaged thanks to which the companies (beneficiaries) in current situation obtain total revenue. If a forestry company obtains revenue by use of other products and forest functions, this should be specially calculated within the determination of fee.

The manner of calculation and collection of fee is exclusively the matter of agreement between the forest owner and beneficiary, defined in the lease agreement. For the realistic determination of the economic value of the forest, it is necessary to know the value of natural working advantages (PRv), whose calculation is given in this example. The biggest amount of the fee per 1 m^3 of cutted tree should be obtained from the forest with the biggest economic value (the most profitable forests), while smaller amount arises from the less profitable forests (forest of poorer economic potential).

By collecting the fee, the state has to be ready to ensure the reimbursement for the costs incurred in the areas with poorer quality of forests, or at least to finance the biological reproduction of forests, completely or partially. The fee is an instrument for the improvement of the conditions of forests and creation of possibility for investment into the nonproductive forests aimed at increase of the generally useful functions of forests. This way of calculation of fee should be improved in line with the development of economic-political relations and market mechanisms.

Calculation on the value of forests was considered only for the economic (productive) value of forests was based on the use of key forest wood products. Size of the fee should be calculated separately for the use of other functions and forest products (non-wood forest products). A responsibility for their utilization should be regulated in FMP, which is in line with the needs for the development of multifunctional forestry.

The assumption for a good quality application of such calculation of the productive value of forests and/or calculation of fee are consolidated (single) norm of all operations in forestry as industry, at least in the territory of one owner. Of course, in addition to technical conditions, application of GIS computers, legislative conditions are required as well, and the political decisions relative to the introduction of such mechanism of fee, as well as introduction of adequate control of forest management in all its segments.

This method is applicable for any form of organization of forest industry in an owner wishes to determine adequate value of resources assigned to a company which wishes to manage the forest. The calculated costs are independent from the organization of works, carried out whether by public or private companies. Forest companies make decisions on the organization of their activities. Seemingly complicated calculation of the productive value of forest is in reality rather simple, as the majority of calculations were already made during the design of forest management bases.

The identified forest values: Tv, Pv, and real business costs provide basis for better planning of forest management in future, control of the management quality. The dynamics of investments was not elaborated in this paper, and this example did not illustrate this segment either, but it can easily be made based on available resources, after the deduction of real management costs – RTP, jointly expressed in value of natural working advantages (PRv, Tables 8 and 9).

During the determination of potential value of the forest, in this example relative to FMR *Olovsko*, the space of young forests and barren land were not considered, but only the space of high forests. If we consider these spaces too, the difference between the real and potential value of forest would be much higher, and the required level of investment to forests would be higher. The idea is to get the amount of funds which could be separated for the expanded reproduction (PRv), and for the purpose of fee, while the owner should define the way of its consumption.

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GEOMATICS IN FORESTRY: ANALYSIS OF SCIENTIFIC JOURNALS (2010-2011)

Małgorzata GAJOS[1]

Abstract: *The goal of this article is to identify the research problems in application of geomatics technology in forestry***,** and especially *in aspects of the state of forest ecosystems and their sustainable use in future, by reviewing international scientific journals. The selection of journals to be investigated is based upon journal profiles and their scientific prestige. Four journals of geomatics subject are studied for the 2010-2011 period: International Journal of Applied Earth Observation and Geoinformation, International Journal of Geographical Information Science, ISPRS Journal of Photogrammetry & Remote Sensing, Photogrammetric Engineering & Remote Sensing. Critical analysis and bibliometric methods have been used.*

Keywords: geomatics, forestry, journals analysis

1. INTRODUCTION

Geomatics is a scientific-technological discipline dealing with assembling, analyzing, interpreting, popularizing and practical application of geoinformation (information obtained through the interpretation of spatial data). Geomatics containing and integrating several fields, among others: geodesy, cartography, remote sensing, photogrammetry, GIS (geographical information systems) and GPS (global positioning systems) [2; 6]. Informatics tools using in these fields are applied in various fields, also in the forestry.

In this paper critical analysis and bibliometric methods has been used to analyse articles in relation to the application of geomatics in the forestry, and especially in forest ecosystems and their sustainable use in future**.** Analysis comprises the period of 2 years 2010-2011 [1].

2. ANALYSIS OF GEOMATICS JOURNALS IN ASPECTS OF FOREST ECOSYSTEMS

Base on the characteristic of the profile of a journal and its impact factor four international journals of geomatics subject are studied: International Journal of Applied Earth Observation and Geoinformation [3], International Journal of Geographical Information Science [4], ISPRS Journal of Photogrammetry & Remote Sensing [5], Photogrammetric Engineering & Remote Sensing [7].The table 1 presents number of articles related to the application of geomatics in forest ecosystems and founded in these journals.

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Table 1. *Number of articles in geomatics journals related to the forest ecosystems*

Title of journal	**IF 2010**	**Number of articles in 2010**	**Number of articles in 2011**	Total **number of articles**
International Journal of Applied Earth Observation and Geoinformation (IJAEOG)	1,557	4	11	15
International Journal of Geographical Information Science (IJGIS)	1.489	1	0	1
ISPRS Journal of Photogrammetry & Remote Sensing (JPRS)	2.158	1	6	7
Photogrammetric Engineering & Remote Sensing (PERS)	0.931	1	3	4
Total				27

Source: Own elaboration.

Characteristic of selected articles is presenting below:

1. A community-based urban forest inventory using online mapping services and consumer-grade digital images Community involvement in gathering and submitting spatially referenced data via web mapping applications has recently been gaining momentum. Urban forest inventory data analyzed by programs such as the i-Tree ECO inventory method is a good candidate for such an approach. In this research, we tested the feasibility of using spatially referenced data gathered and submitted by non-professional individuals through a web application to augment urban forest inventory data. We examined the use of close range photogrammetry solutions of images taken by consumer-grade cameras to extract quantitative metric information such as crown diameter, tree heights and trunk diameters (IJAEOG 2010, vol. 12, no 4, p. 249-260).

2. Spectral mixture analysis to monitor defoliation in mixed-aged *Eucalyptus globulus* Labill plantations in southern Australia using *Landsat 5-TM* and *EO-1 Hyperion* data Defoliation is a key parameter of forest health and is associated with reduced productivity and tree mortality. Assessing the health of forests requires regular observations over large areas. Satellite remote sensing provides a cost-effective alternative to traditional ground-based assessment of forest health, but assessing defoliation can be difficult due to mixed pixels where vegetation cover is low or fragmented (IJAEOG 2010, vol. 12, no 4, p. 270-277).

3. An improved method for estimating forest canopy height using ICESat-GLAS full waveform data over sloping terrain: A case study in Changbai mountains, China Light Detection And Ranging (LiDAR) has a unique capability for estimating forest canopy height, which has a direct relationship with, and can provide better understanding of the aboveground forest carbon storage (IJAEOG 2010, vol. 12, no 5, p. 385-392).

4. A preliminary assessment of NigeriaSat-1 for sustainable mangrove forest monitoring Mangroves constitute an area of great ecological importance and regular assessment and monitoring of this ecosystem is an integral part of environmental management plan. The difficulty of access for ground survey has often limited the frequency of assessment of mangroves and remote sensing methods therefore provide a veritable means of assessment. However, accessibility to remotely sensed data as well as the cost have been major constraints for mangrove assessment in the developing countries. The launching of small satellites by some developing countries may therefore provide a solution to this problem (IJAEOG 2010, vol. 12, Supplement 1, p. S18-S22).

5. A time-integrated MODIS burn severity assessment using the multi-temporal differenced normalized burn ratio ($dNBR_{MT}$) Burn severity is an important parameter in post-fire management. It incorporates both the direct fire impact (vegetation depletion) and

ecosystem responses (vegetation regeneration). From a remote sensing perspective, burn severity is traditionally estimated using Landsat's differenced normalized burn ratio (dNBR) (IJAEOG 2011, vol. 13, no 1, p. 52-58).

6. Exploring full-waveform LiDAR parameters for tree species classification Precise tree species classification with high density full-waveform LiDAR data is a key research topic for automated forest inventory. Most approaches constrain to geometric features and only a few consider intensity values. Since full-waveform data offers a much larger amount of deducible information this study explores a high number of parameter and feature combinations. Those variables having the highest impact on species differentiation are determined. To handle the large amount of airborne full-waveform data and to extract a comprehensive number of variable combinations an improved algorithm was developed (IJAEOG 2011, vol. 13, no 1, p. 152-160).
7. Normalized algorithm for mapping and dating forest disturbances and regrowth for the United States Forest disturbances such as harvesting, wildfire and insect infestation are critical ecosystem processes affecting the carbon cycle. Because carbon dynamics are related to time since disturbance, forest stand age that can be used as a surrogate for major clear-cut/fire disturbance information has recently been recognized as an important input to forest carbon cycle models for improving prediction accuracy. In this study, forest disturbances in the USA for the period of ~1990–2000 were mapped using 400+ pairs of re-sampled Landsat TM/ETM scenes in 500m resolution, which were provided by the Landsat Ecosystem Disturbance Adaptive Processing System project. The detected disturbances were then separated into two five-year age groups, facilitated by Forest Inventory and Analysis (FIA) data, which was used to calculate the area of forest regeneration for each county in the USA (IJAEOG 2011, vol. 13, no 2, p. 236-245).
8. Time-series analysis of multi-resolution optical imagery for quantifying forest cover loss in Sumatra and Kalimantan, Indonesia Monitoring loss of humid tropical forests via remotely sensed imagery is critical for a number of environmental monitoring objectives, including carbon accounting, biodiversity, and climate modeling science applications. Landsat imagery, provided free of charge by the U.S. Geological Survey Center for Earth Resources Observation and Science (USGS/EROS), enables consistent and timely forest cover loss updates from regional to biome scales. The Indonesian islands of Sumatra and Kalimantan are a center of significant forest cover change within the humid tropics with implications for carbon dynamics, biodiversity maintenance and local livelihoods (IJAEOG 2011, vol. 13, no 2, p. 277-291).
9. Dynamic modeling of forest conversion: Simulation of past and future scenarios of rural activities expansion in the fringes of the Xingu National Park, Brazilian Amazon The present work is committed to simulate the expansion of agricultural and cattle raising activities within a watershed located in the fringes of the Xingu National Park, Brazilian Amazon. A spatially explicit dynamic model of land cover and land use change was used to provide both past and future scenarios of forest conversion into such rural activities, aiming to identify the role of driving forces of change in the study area. The employed modeling platform – Dinamica EGO – consists in a cellular automata environment that embodies neighborhood-based transition algorithms and spatial feedback approaches in a stochastic multi-step simulation framework. Biophysical variables and legal restrictions drove this simulation model, and statistical validation tests were then conducted for the generated past simulations (from 2000 to 2005), by means of multiple resolution fitting methods. Based on optimal calibration of past simulations, future scenarios were conceived, so as to figure out

trends and spatial patterns of forest conversion in the study area for the year 2015 (IJAEOG 2011, vol. 13, no 3, p. 435-446).

10. Application of evidential reasoning to improve the mapping of regenerating forest stands This study confirmed the ability of the Dempster–Shafer theory (DST) and the Dezert–Smarandache (Free DSm model) theory to significantly improve the quality of maps of regenerating forest stands in southern Quebec, Canada compared to a classical Maximum Likelihood Algorithm (MLA). The proposed approach uses data fusion methods that allow the integration of remotely sensed imagery with conventional maps of ecophysiographic features (IJAEOG 2011, vol. 13, no 3, p. 458-467).

11. Use of multi-temporal Landsat images for analyzing forest transition in relation to socioeconomic factors and the environment Recently there have been reports of forest regrowth occurring in different regions across the world. There is also a growing recognition of the potential beneficial impact that secondary forests may have on the global environment: providing crucial ecosystem services such as soil conservation, stabilization of hydrological cycles, carbon sequestration, and support for forest dependent communities. Consequently, there is a growing awareness of the need to recognize that landscapes are complex shifting mosaics wherein forest clearing and reforestation take place. In this study, the rates of reforestation, deforestation, forest regrowth and degradation were measured using multi-temporal Landsat images of Danjiangkou, China. Landsat data from 1990, 1999 and 2007 were (1) classified as dense forest, open forest and non-forest areas and (2) compared between years to identify forest cutting, regeneration and degradation. The results showed that there was a net gain of 29,315 ha of forest area (including dense and open forest) from 1990 to 2007, showing a clear trend of reforestation in the study area. Forest modification (degradation and regrowth) and change categories (deforestation and reforestation) occurred simultaneously during the observation time period. Socioeconomic data from public statistics and environmental attributes allowed the assessment of the socioeconomic factors and the environmental conditions that caused these changes using non-metric multidimensional scaling (NMDS). The research showed that the socioeconomic factors due to different policies were major driving forces of forest transition, whereas environmental attributes of the underlying landscape constrained forest cover changes. These findings have led to a better understanding of forest transition at a local scale in our study region. Comprehensive knowledge of these relationships may be useful to reconstruct past forest transitions and predict future changes, and may help to enhance sustainable management practices aimed at preserving essential ecological functions (IJAEOG 2011, vol. 13, no 3, p. 468-476).

12. Integration of ground and satellite data to model Mediterranean forest processes The current work presents the testing of a modeling strategy that has been recently developed to simulate the gross and net carbon fluxes of Mediterranean forest ecosystems. The strategy is based on the use of a NDVI-driven parametric model, C-Fix, and of a biogeochemical model, BIOME-BGC, whose outputs are combined to simulate the behavior of forest ecosystems at different development stages. The performances of the modeling strategy are evaluated in three Italian study sites (San Rossore, Lecceto and Pianosa), where carbon fluxes are being measured through the eddy correlation technique. These sites are characterized by variable Mediterranean climates and are covered by different types of forest vegetation (pine wood, Holm oak forest and Macchia, respectively). The results of the tests indicate that the modeling strategy is generally capable of reproducing monthly GPP and NEE patterns in all three study sites (IJAEOG 2011, vol. 13, no 3, p. 504-515).

13. Predicting forest structural parameters using the image texture derived from WorldView-2 multispectral imagery in a dryland forest, Israel Estimation of forest structural parameters

by field-based data collection methods is both expensive and time consuming. Satellite remote sensing is a low-cost alternative in modeling and mapping structural parameters in large forest areas. The current study investigates the potential of using WordView-2 multispectral satellite imagery for predicting forest structural parameters in a dryland plantation forest in Israel. The relationships between image texture features and the several structural parameters such as Number of Trees (NT), Basal Area (BA), Stem Volume (SV), Clark-Evans Index (CEI), Diameter Differentiation Index (DDI), Contagion Index (CI), Gini Coefficient (GC), and Standard Deviation of Diameters at Breast Heights (SDDBH) were examined using correlation analyses. These variables were obtained from 30 m × 30 m square-shaped plots (IJAEOG 2011, vol. 13, no 5, p. 701-710).

14. Prototyping an artificial neural network for burned area mapping on a regional scale in Mediterranean areas using MODIS images Each year thousands of ha of forest land are affected by forest fires in Southern European countries such as Spain. Burned area maps are a valuable instrument for designing prevention and recovery policies. Remote sensing has increasingly become the most widely used tool for this purpose on regional and global scales, where a large variety of techniques and data has been applied. This paper proposes a semiautomatic method for burned area mapping on a regional scale in Mediterranean areas (the Iberian Peninsula has been used as a study case) (IJAEOG 2011, vol. 13, no 5, p. 741-752).
15. Development of large-area land cover and forest change indicators using multi-sensor Landsat imagery: Application to the Humber River Basin, Canada Monitoring ecological indicators is important for assessing impacts of human activities on ecosystems. A means of identifying and applying appropriate indicators is a prerequisite for: environmental assessment; better assessment and understanding of ecosystem health; elucidation of biogeochemical trends; and more accurate predictions of future responses to global change, particularly those due to anthropogenic disturbance. The challenge is to derive meaningful indicators of change that capture the complexities of ecosystems yet can be monitored consistently over large areas and across time. In this study, methods for monitoring indicators of land cover (LC) and forest change were developed using multi-sensor Landsat imagery (IJAEOG 2011, vol. 13, no 5, p. 819-829).
16. Forest Fire Alert System: a Geo Web GIS prioritization model considering land susceptibility and hotspots – a case study in the Carajás National Forest, Brazilian Amazon To increase the monitoring potential of forest fires, an alert classification methodology using satellite-mapped hotspots has been established to help forest managers in the prioritization of which hotspot to be verified in the field, thus potentially improving the distribution of fire-fighting resources. A computer application was developed based on web-distributed geographical information technology whose main function is to interact automatically generated satellite hotspots and risk areas indicated in fire-susceptibility maps and classify them into five alert levels. The location of the hotspots is available continuously every 4 h, and a susceptibility map is produced daily through map algebra algorithm, which uses static (topography, vegetation and land use) and dynamic (weather) variables. Every process runs through automated geoprocessing routines. The methodology was tested during the dry period of 2007 in the Carajás National Forest, in the Brazilian Amazon, within an area of 400,000 ha. It is a critical area constantly threatened by fires caused by invasions and deforestation owing to intense agribusiness advances and mining activities in its surroundings (IJGIS 2010, vol. 24, no 6, p. 873-901).
17. Monitoring forest areas from continental to territorial levels using a sample of medium spatial resolution satellite imagery A global systematic sampling scheme has been developed by the UN FAO and the EC TREES project to estimate rates of deforestation at global or

continental levels at intervals of 5 to 10 years. This global scheme can be intensified to produce results at the national level. In this paper, using surrogate observations, we compare the deforestation estimates derived from these two levels of sampling intensities (one, the global, for the Brazilian Amazon the other, national, for French Guiana) to estimates derived from the official inventories. We also report the precisions that are achieved due to sampling errors and, in the case of French Guiana, compare such precision with the official inventory precision. We extract nine sample data sets from the official wall-to-wall deforestation map derived from satellite interpretations produced for the Brazilian Amazon for the year 2002 to 2003 (JPRS 2010, vol. 65, no 2, p. 191-197).

18. Pre-processing of a sample of multi-scene and multi-date Landsat imagery used to monitor forest cover changes over the tropics In support to the Remote Sensing Survey of the global Forest Resource Assessment 2010, the TREES-3 project has processed more than 12,000 Landsat TM and ETM+ data subsets systematically distributed over the tropics. The project aims at deriving area estimates of tropical forest cover change for the periods 1990–2000–2005. The paper presents the pre-processing steps applied in an operational and robust manner to this large amount of multi-date and multi-scene imagery: conversion to top-of-atmosphere reflectance, cloud and cloud shadow detection, haze correction and image radiometric normalization. The results show that the haze correction algorithm has improved the visual appearance of the image and significantly corrected the digital numbers for Landsat visible bands, especially the red band. The impact of the normalization procedures (forest normalization and relative normalization) was assessed on 210 image pairs: in all cases the correlation between the spectral values of the same land cover in both images was improved. The developed automatic pre-processing chain provided a consistent multi-temporal data set across the tropics that will constitute the basis for an automatic object-based supervised classification (JPRS 2011, vol. 66, no 5, p. 555-563).

19. Prediction of L-band signal attenuation in forests using 3D vegetation structure from airborne LiDAR In this study, we propose a novel method to predict microwave attenuation in forested areas by using airborne Light Detection and Ranging (LiDAR). While propagating through a vegetative medium, microwave signals suffer from reflection, absorption, and scattering within vegetation, which cause signal attenuation and, consequently, deteriorate signal reception and information interpretation. A Fresnel zone enveloping the radio frequency line-of-sight is applied to segment vegetation structure occluding signal propagation. Return parameters and the spatial distribution of vegetation from the airborne LiDAR inside Fresnel zones are used to weight the laser points to estimate directional vegetation structure. A Directional Vegetation (JPRS 2011, vol. 66, no 5, p. 642-651).

20. Use of ETM+ images to extend stem volume estimates obtained from LiDAR data Airborne LiDAR techniques can provide accurate measurements of tree height, from which estimates of stem volume and forest woody biomass can be obtained. These techniques, however, are still expensive to apply repeatedly over large areas. The current paper presents a methodology which first transforms mean stand heights obtained from LiDAR over small strips into relevant stem volume estimates. These are then extended over an entire forest by applying two estimation methods (*k*-NN and locally calibrated regression) to Landsat ETM+ images (JPRS 2011, vol. 66, no 5, p. 662-671).

21. Potential of an ultraviolet, medium-footprint lidar prototype for retrieving forest structure The aim of the paper is to carry on methodological development for retrieving forest parameters from medium-footprint lidar signals and for assessing the performance of different sampling strategies. The 2.4 m footprint lidar prototype (a profiler instrument using an ultraviolet laser) was flown above two different maritime pine stands: a young plantation

(10 years old) and a mature, semi-natural stand (55 years old), both in the Landes forest, France. The vertical distribution of lidar measurements was studied for retrieving forest height parameters (mean total height, mean crown height and top height). The processing algorithm was based on an aggregation of successive signals followed by the correction of the signal attenuation along the travel through the vegetation. The performance of different sampling strategies was assessed by comparing the results for the full dataset (several fight lines over the stands) and for only a data subset (one flight line). In addition, the horizontal distribution of height measurements was studied for identifying the planting pattern of the stands and assessing the tree spacing of the semi-natural parcel, using geostatistics (JPRS 2011, vol. 66, no 6, Supplement, p. S92-S102).

22. <u>Use of ALS, Airborne CIR and ALOS AVNIR-2 data for estimating tropical forest attributes in Lao PDR</u> In this study, the potential of remote sensing in tropical forests is examined in relation to the diversification of sensors. We report here on the comparison of alternative methods that use multisource data from Airborne Laser Scanning (ALS), Airborne CIR and ALOS AVNIR-2 to estimate stem volume and basal area, in Laos. Multivariate linear regression analyses with stepwise selection of predictors were implemented for modelling. The predictors of ALS metrics were calculated by means of the canopy height distribution approach, while predictors from both spectral and textual features were respectively generated for Airborne CIR and ALOS AVNIR-2 data (JPRS 2011, vol. 66, no 6, p. 776-786).

23. <u>The role of ground reference data collection in the prediction of stem volume with LiDAR data in mountain areas</u> Ground reference data collection represents an important element in the prediction of stem volume with LiDAR-derived variables, and at present it is the most expensive part of such analyses. In this paper two aspects of ground reference data collection were analyzed: (1) the positioning error of the ground plots; and (2) the optimal number of training plots. A system for the prediction of stem volume at area-based level was adopted. LiDAR data were preprocessed and 13 variables describing both height and coverage were extracted (JPRS 2011, vol. 66, no 6, p. 787-797).

24. <u>Rapid Assessment of Forest Damage from Tornadoes in Mississippi</u> On april 24, 2010, mississippi was impacted by seven separate tornado events, the most notable of which was an EF4 that had a damage path up to 2.8 kilometers wide along an approximately 242 kilometer long track. Ten deaths and dozens of injuries were reported in Mississippi as a result of the storm (PERS 2010, vol. 76, no 12, p. 1298-1301).

25. <u>Automated Methods for Measuring DBH and Tree Heights with a Commercial Scanning Lidar</u> Accurate forest structural parameters are crucial to forest inventory, and modeling of the carbon cycle and wildlife habitat. Lidar (Light Detection and Ranging) is particularly suitable to the measurement of forest structural parameters. In this paper, we describe a pilot study to extract forest structural parameters, such as tree height, diameter at breast height (DBH), and position of individual tree using a terrestrial lidar (LMS-Z360i; Riegel, Inc.). The lidar was operated to acquire both vertical and horizontal scanning in the field in order to obtain a point cloud of the whole scene. An Iterative Closet Point (ICP) algorithm was introduced to obtain the transformation matrix of each range image and to mosaic multiple range images together. Based on the mosaiced data set, a variable scale and threshold filtering method was used to separate ground from the vegetation. Meanwhile, a Digital Elevation Model (DEM) and a Canopy Height Model (CHM) were generated from the classified point cloud. A stem detection algorithm was used to extract the location of individual trees (PERS 2011, vol. 77, no 3, p. 219-227).

26. Estimating Aboveground Carbon of Moso Bamboo Forests Using the k Nearest Neighbors Technique and Satellite Imagery The extensive distribution of bamboo forests in Southern and Southeast Asia plays an important role in carbon sequestration and climate change. Providing timely and accurate estimates for aboveground carbon (AGC) of Moso bamboo forests is an urgent task. Based on the integration of Landsat Thematic Mapper (TM) and field inventory data, this study explores use of the k Nearest Neighbors (KNN) technique for estimating AGC. A new distance metric named Slope, Intercept, and Correlation Distance (SICD) is introduced and compared with Euclidean Distance (ED) and Mahalanobis Distance (MD). Using leave-one-out (LOO) cross-validation, the estimation performance of KNN technique is then compared with a linear regression model. The research indicates that the SICD is slightly better than ED and MD but no significant differences were found between them in estimating AGC. For extreme AGC conditions, the KNN technique has a greater estimation performance than that of the linear regression model, and is a convenient and effective method for estimating AGC of Moso bamboo forests in a large area (PERS 2011, vol. 77, no 11, p. 1123-1131).
27. Daily MODIS Data Trends of Hurricane-induced Forest Impact and Early Recovery We studied the use of daily satellite data from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensors to assess wetland forest damage and recovery from Hurricane Katrina (29 August 2005 landfall). Processed MODIS daily vegetation index (VI) trends were consistent with previously determined impact and recovery patterns provided by the "snapshot" 25 m Landsat Thematic Mapper optical and RADARSAT-1 synthetic aperture radar satellite data. Phenological trends showed high 2004 and 2005 pre-hurricane temporal correspondence within bottomland hardwood forest communities, except during spring green-up, and temporal dissimilarity between these hardwoods and nearby cypresstupelo swamp forests (Taxodium distichum [baldcypress] and Nyssa aquatica [water tupelo]). MODIS VI trend analyses established that one year after impact, cypress-tupelo and lightly impacted hardwood forests had recovered to near prehurricane conditions. In contrast, canopy recovery lagged in the moderately and severely damaged hardwood forests, possibly reflecting regeneration of pre-hurricane species and stand-level replacement by invasive trees (PERS 2011, vol. 77, no 11, p. 1133-1143).

3. CONCLUSIONS

Analysis of 4 geomatics journals in the 2 years in aspects of forest ecosystems selected 27 articles, but most of them, 15 articles, were published in International Journal of Applied Earth Observation and Geoinformation**.**

Articles are related to application of geomatics technology in researches of forest ecosystems for: forest inventory; assessment of forest health; estimating forest canopy height, which has a direct relationship with, and can provide better understanding of the aboveground forest carbon storage; monitoring of ecosystems; post-fire management; burned area mapping; forest fire alert system; mapping and dating forest disturbances and regrowth; quantifying forest cover loss; dynamic modeling of forest conversion; improving the mapping of regenerating forest stands; analyzing forest transition in relation to socioeconomic factors and the environment; simulating the behaviour of forest ecosystems at different development stages; predicting forest structural parameters; development of large-area land cover and forest change indicators.

Development of forest change indicators and ecological indicators is important for assessing impacts of human activities on ecosystems. A means of identifying and applying appropriate indicators is a prerequisite for: environmental assessment; better assessment and understanding of ecosystem health; elucidation of biogeochemical trends; and more accurate predictions of future responses to global change, particularly those due to anthropogenic disturbance. The challenge is to derive meaningful indicators of change that capture the complexities of ecosystems yet can be monitored consistently over large areas and across time.

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HOMOGENEITY OF FIR AND SPRUCE FOREST STANDS IN THE MANAGEMENT UNIT "IGMAN"

Aida IBRAHIMSPAHIĆ[1], Besim BALIĆ[1], Ahmet LOJO[1]

Abstract: *The paper analyzes homogeneity of fir (Abies alba) and spruce (Picea abies) forest stands in the MU "Igman" using the homogeneity index (H-index) and Lorenz curve. According to established forms of Lorenz curves homogeneity level of stands deviates significantly from the homogeneous stands. The homogeneity level by values of the homogeneity index for poorer site capability corresponds with the even aged stands thinned by high thinning, but for stands of better site capability corresponds with selection stands. It was concluded that due to the "surplus" of trees in the higher and "shortage" in the lower diameter classes homogeneity level is greater in comparison to selection stands, while in cases where homogeneity level corresponds with homogeneity of selection stands that is consequence of the effects of better site capability.*

Key words: forest stand homogeneity, Lorenz curve, homogeneity index

1. INTRODUCTIONS

Productivity and stability of forest stands are closely linked to their structure, i.e. specific inter-relations of elements that build them. In relation to that, in order to set up realistic grounds for forest management, it is of utter importance to be aware of the actual state (structure) of forest stands and changes that occur. One of the forest stand structure indicators, relatively simple to define and interpret, is homogeneity (Vučković, Stajić 2006, Stajić 2010). Well structured forests and forest stands are those that give out the impression of lack of homogeneity (Füldner 1995, Stajić, Vučković 2006). In order to define forest stand homogeneity, De Camino (1976) adjusted the homogeneity index set up earlier, in 1931, by Gini for the needs of researching into the structure of agricultural and forestry management units (Kramer 1988). A forest stand is considered homogeneous if it is consisted of trees of equal volume. Forest stand homogeneity in reality stands out for the absolutely homogeneous forest stand, more or less depending on the growing model, age (for even aged stands), stage of development, treatment applied and quality of the site (Vučković, Stajić 2006.).

2. MATERIAL AND METHODOLOGY APPLIED

In order to analyze forest stand homogeneity, we used data on five permanent sample plots in fir and spruce forests in the MU "Igman" on the Igman mountain. From the syndynamic point of view, these forests may be observed as the interim stage of vegetation towards climatogenic beech, fir and spruce forests, or, due to specific conditions, represent a permanent

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vegetation stage (frost pocket), and related to that, depending on the vegetation development status sample plots are different in terms of composition of tree species. Two sample plots belong to the association *Abieti Piceetum illyricum* Stef., two to the association *Abieti Fagetum illyricum* Treg. with a small portion of beech that has just recently began integrating in the part of the stand that has been inventoried (taxation limit is 10 cm) and one to the association *Picetum montanum inversum* Fuk., frost pocket spruce forest. Besides fir and spruce as main species, the sample plots contain beech, sycamore maple, rowan, and on one sample plot (43) individual trees of goat willow, wild cherry and elm. On one sample plot (88) there are no deciduous species, but is inhabited by scots pine that is not regenerating and is slowly getting extinct. Soil in all sample plots is series of lime based types of soil.

Table 1. *General data on sample plots*

<table>
<tr><th>Sample plots</th><th>Association</th><th>Tree species</th><th>N (%)</th><th>Site class for species</th><th>Average site class for all species</th></tr>
<tr><td rowspan="3">43</td><td rowspan="3">Abieti Piceetum illyricum Stef.</td><td>Fir</td><td>62</td><td>2,8</td><td rowspan="3">2,8</td></tr>
<tr><td>Spruce</td><td>24</td><td>2,8</td></tr>
<tr><td>Broadleaved *</td><td>14</td><td>-</td></tr>
<tr><td rowspan="3">138</td><td rowspan="3">Picetum montanum inversum Fuk.</td><td>Fir</td><td>30</td><td>1,7</td><td rowspan="3">1,8</td></tr>
<tr><td>Spruce</td><td>69</td><td>1,9</td></tr>
<tr><td>Broadleaved *</td><td>1</td><td>-</td></tr>
<tr><td rowspan="3">58</td><td rowspan="3">Abieti Fagetum illyricum Treg.</td><td>Fir</td><td>36</td><td>3,0</td><td rowspan="3">3,0</td></tr>
<tr><td>Spruce</td><td>58</td><td>3,2</td></tr>
<tr><td>Beech</td><td>6</td><td>1,7</td></tr>
<tr><td rowspan="3">88</td><td rowspan="3">Abieti Piceetum illyricum Stef.</td><td>Fir</td><td>69</td><td>2,7</td><td rowspan="3">2,7</td></tr>
<tr><td>Spruce</td><td>25</td><td>2,9</td></tr>
<tr><td>Scots pine</td><td>6</td><td>2,1</td></tr>
<tr><td rowspan="4">73</td><td rowspan="4">Abieti Fagetum illyricum Treg.</td><td>Fir</td><td>60</td><td>2,3</td><td rowspan="4">2,3</td></tr>
<tr><td>Spruce</td><td>20</td><td>2,5</td></tr>
<tr><td>Beech</td><td>16</td><td>2,1</td></tr>
<tr><td>Broadleaved *</td><td>4</td><td>-</td></tr>
</table>

* Includes deciduous species whose share is below 5%

Having in mind site capability defined based on the height of the trees, two sample plots are considered to have better conditions (site class 2) than the other three (site class 3). Selection model of forest management is applied on all sample plots.

Forest stand homogeneity is presented by graph using so called Lorenz curve and by table using homogeneity index (H).

The Lorenz curve is a graphical representation of the dependence of the sum of volume percentages up to a certain diameter class (Y axe) of the sum of percentages of the number of trees of equal diameter class (X axe). Given that a homogeneous forest stand is one consisted of equal volume trees, sums of percentages of the number and of the volume of trees in that particular forest stand are equal for each diameter class ($S_{N\%} = S_{V\%}$), implying that the Lorenz curve is actually a line defined by coordinates (0.0) and (100.100). For these particular forest stands these sums are not equal which leads to the aberration of the Lorenz curve from the straight line. The bigger the aberration, the less homogeneous the stand.

Homogeneity index is calculated using the following formula (Kramer 1988):

$$H = \frac{\sum_{i=1}^{n-1} SN\%}{\sum_{i=1}^{n-1} SN\% - SV\%}$$

where:

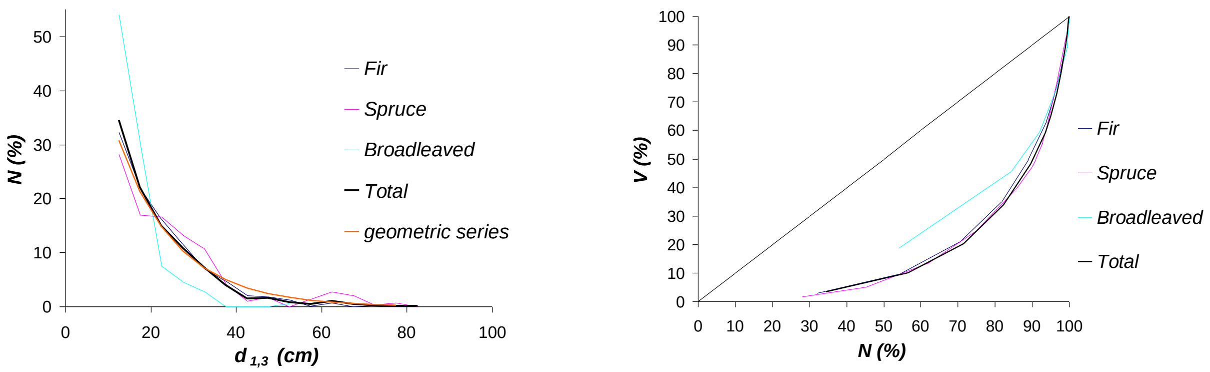
SN% – sum of percentages of the number of trees up to a certain diameter class *i*,
SV% – sum of percentages of the volume up to a certain diameter class *i*,
n – number of diameter classes.

Lower homogeneity index implies lower forest stand homogeneity (Kramer 1988). For selection stands, homogeneity index varies between 1.8 and 2.3, for high-thinned even aged stands it varies between 2.2 and 4.2, and for low-thinned even aged stands between 4.0 and 10.0. Calculation of the homogeneous index and construction of the Lorenz curves implies previously defined distribution of frequency of breast height diameters and volumes of trees. In order to define these distributions, this study used diameter classes width 5 cm.

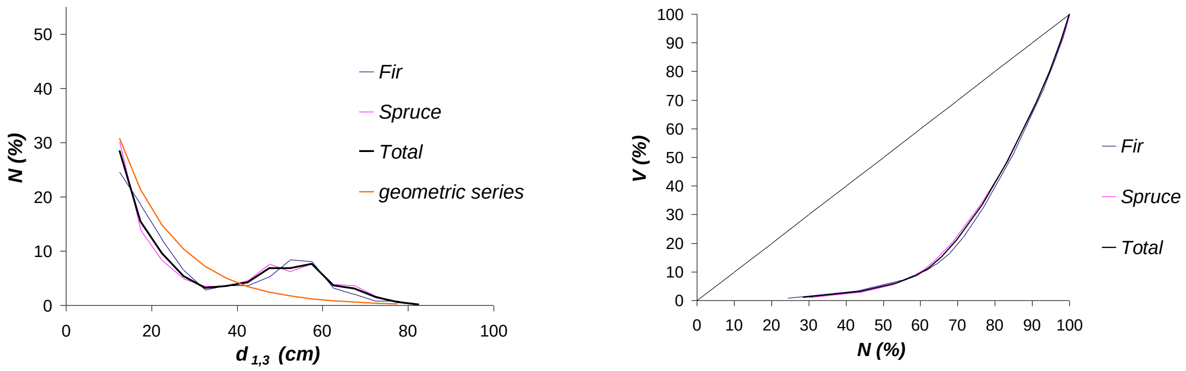
3. RESULTS AND DISCUSSION

Diameter structure of sample plots, in terms of individual species and for all species in general are in form of descending curves and point out to their selection structure, as shown by graph 1. Due to “shortage” or “surplus” of trees in some diameter classes, all diameter structures, more or less, deviate from the hypothetical “normal” form of diameter structure of selection forest stands. Exception to this is scots pine diameter structure in sample plots 88 which is unimodal – which is a characteristic of even aged stands or uneven aged stands of photophilous species of tries (scots pine). Besides diameter structures, graph 1 presents the hypothetical “normal” form of diameter structure, the Liocourt’s geometric series for coefficient q = 1.4, which corresponds with the mediocre habitat conditions on the territory of Bosnia and Herzegovina.

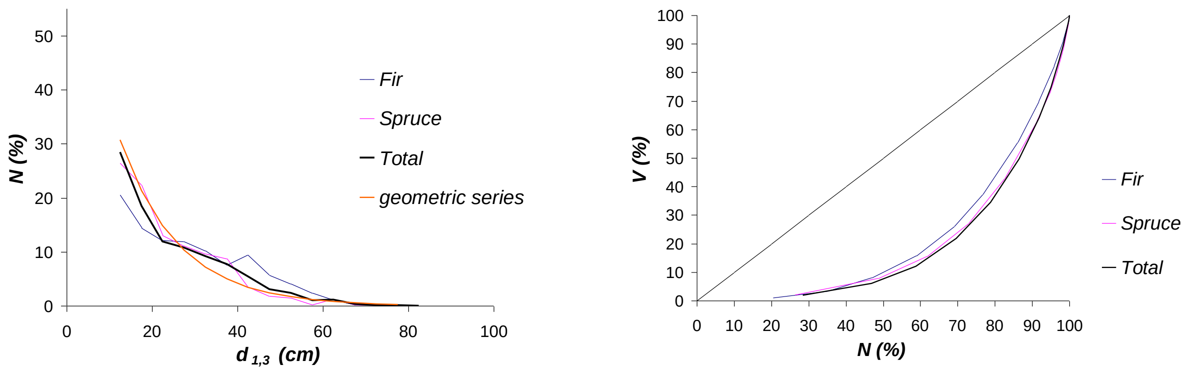
Graph 1. *Frequency distributions of breast height diameters (left) and the Lorenz curves (right)*



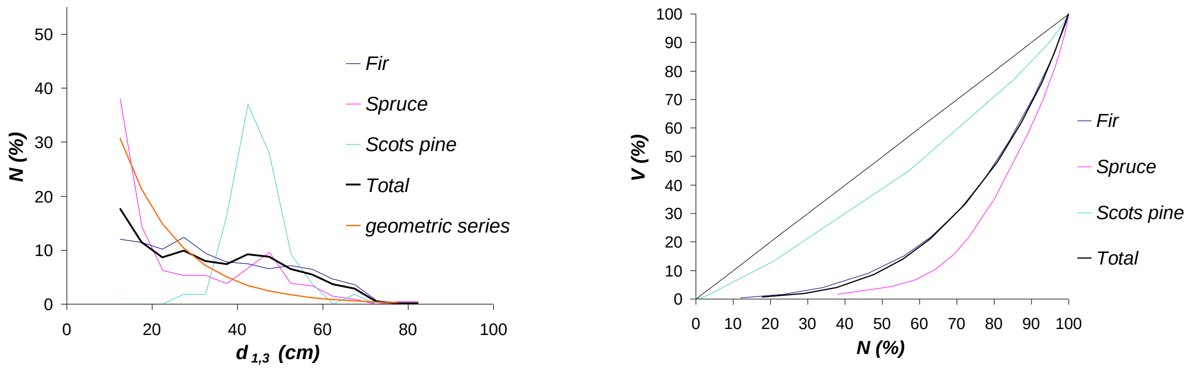
a) sample plot 43



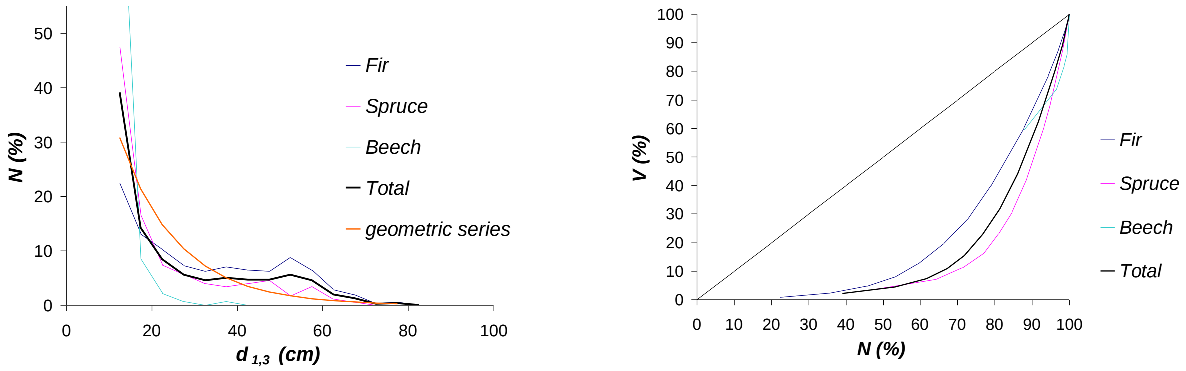
b) sample plot 138



c) sample plot 58



d) sample plot 88



e) sample plot 73

The Lorenz curves for individual species of trees and total of all species deviate from the straight line that characterizes a homogeneous stand, which points to obvious lack of homogeneity, which is in line with their diameter structure. The Lorenz curve for the scots pine on the sample plots 88 is in line with the diameter structure as well, although it is closer to a straight line, and points to a higher level of homogeneity. In sample plots 43 and 138, the Lorenz curves for fir, spruce and total are close to equal – carriers of selection structures are both fir and spruce in equal degrees. For sample plots 58, 73 and 88 the Lorenz curves are apart, with spruce being the least homogeneous. Given that spruce less shade-tolerant than fir (semi-sciophilous species) this ratio is not logical. It is caused by a relatively larger segment of spruce in lower diameter classes, and relatively smaller in higher diameter classes in comparison to fir. The same can be said for beech in sample plot 73 which is also less shade-tolerant than fir, while deciduous species in sample plot 43 are more homogeneous than fir and spruce.

According to the values of the homogeneity index (table 2), the least homogeneous, which is typical of selection stands, are sample plots 138 and 73, both in terms of individual species and in terms of total for all species.

Table 2. *Homogeneity index height in terms of individual species and in terms of total for all species*

Species	Sample plots				
	43	138	58	88	73
Fir	4.17	**2.40**	3.65	**2.70**	**2.69**
Spruce	**2.67**	**2.52**	3.74	2.82	**2.21**
Scots pine	-	-	-	13.78	-
Beech	-	-	-	-	6.18
Broadleaved	4.87	-	-	-	-
Total	3.62	**2.55**	3.61	3.28	**2.44**

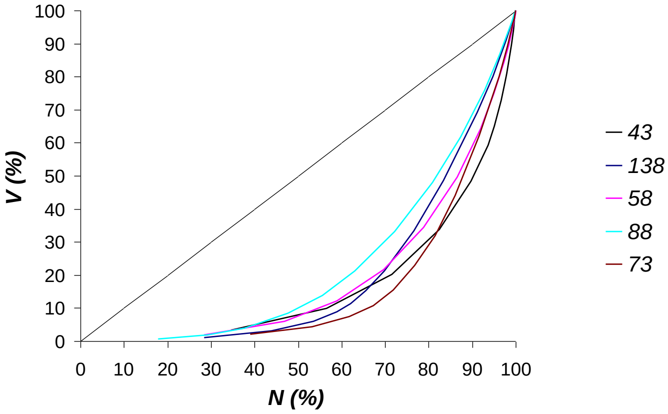
As the diameter structures in those sample plots out from the “normal” selection stand more prominently than diameter structures of other sample plots, the reason for this lack of homogeneity can be seen in the more favorable site condition, which is a characteristic of these areas in comparison to others. The stands became less homogeneous due to improved habitat conditions, which points to the possibility to use homogeneity index as an additional parameter for site capability evaluation (De Camino, 1976; according to Vučković, Stajić 2006), which often encounters difficulties for selection forest stands.

Homogeneity index value typical of selection forest stands applies to spruce in sample plot 88, while it is slightly higher for fir. However, due to apparent homogeneity of scots pine and poorer habitat conditions, homogeneity of the whole stand is larger and corresponds to the structure of even aged forest stands thinned by high thinning methods. Slightly higher homogeneity, which also corresponds to the structure of even aged forest stands thinned by high thinning methods, is observed on sample plots 43 and 58. Given that the diameter structure of these sample plots are close to “normal” selection structure, higher homogeneity level may be seen as a consequence of the poorer site conditions.

Homogeneity index for deciduous species differs, but in this case cannot be seen as reliable, as deciduous species are very scarce in the observed diameter structures, which may cause unrealistic increase of the homogeneity index (Vučković, Stajić 2006).

Comparison of sample plots and species of trees in terms of homogeneity on the base of the homogeneity index value is simple and clear, which is not the case with the comparison of the Lorenz curves, see graph 2.

Graph 2. *The Lorenz curves of sample plots, total for all species*



For the observed sample plots, based on the Lorenz curves, the only safe statement is that the sample plot 88 is more homogeneous than others. This form of the presentation of homogeneity is simple, but is not applicable for comparisons and, in this case, not linkable to the site capability. However, using these curves it is possible to simply define and compare the production contribution of some diameter classes or, in this sense, comparison of tree species and analysis of changes accompanying the development of forest stands (Vučković, Stajić 2006).

4. CONCLUSIONS

According to the graphical representation of homogeneity (the Lorenz curve) and value of the homogeneity index, homogeneity of the respective forest stand of fir and spruce is more or less low. Given that the Lorenz curves with the highest level of homogeneity are typical for stands inhabited by the scots pine (photopious species), while other stands are less homogeneous, their ranking is not possible only by comparison of the Lorenz curves. Within the same forest stand, species that are typically more homogeneous are those with “surplus” of trees in medium and higher diameter classes and “shortage” in lower diameter classes, regardless of their natural shade tolerance.

In terms of the homogeneity index, the least homogeneous, which is typical of selection stands, are the sample plots 138 and 73. For other stands defined homogeneity level corresponds with the even aged stands thinned by high thinning. Having in mind that the diameter structures of the sample plots 138 and 73 significantly deviate from the “normal” distribution of selection stand (the Liocourt’s geometric series) and that they have better site capability in comparison to other sample plots, lower homogeneity may be seen as a result of better site conditions.

Defined homogeneity indicators, as well as diameter structures, point out to certain derogations of structure of the stands from the selection structure. In the forest stands that are regularly managed, the “shortage” of trees in lower diameter classes and “surplus” in higher are consequences of applied treatments. Reduce of the homogeneity and a step towards the selection structure would be achieved by a reduction of the number of trees in higher diameter classes, which should be followed by necessary increase of the number of trees in lower diameter classes, which is only possible through professional selection and cutting of trees, primarily those trees from the higher diameter classes. In case there is no natural regeneration, or if it is insufficient, measures should be taken according to the reasons for that state (soil cultivation, repair planting and filling seedlings).

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HOMOGENEITY OF FIR AND SPRUCE FOREST STANDS IN THE MANAGEMENT UNIT "IGMAN"

Aida IBRAHIMSPAHIĆ, Besim BALIĆ, Ahmet LOJO

Summary

The paper analyzes homogeneity of fir (*Abies alba*) and spruce (*Picea abies*) forest stands in the MU "Igman" using the homogeneity index (H-index) and Lorenz curve. The study used data collected by the five permanent sample plots in fir and spruce forests in the MU "Igman" on the Igman mountain.

According to the graphical representation of homogeneity (the Lorenz curve) and value of the homogeneity index, homogeneity of the respective forest stand of fir and spruce is more or less low. Given that the Lorenz curves with the highest level of homogeneity are typical for stands inhabited by the scots pine (photopious species), while other stands are less homogeneous, their ranking is not possible only by comparison of the Lorenz curves. Within the same forest stand, species that are typically more homogeneous are those with "surplus" of trees in medium and higher diameter classes and "shortage" in lower diameter classes, regardless of their natural shade tolerance.

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MONITORING OF FOREST AREA CHANGES USING SNOW COVERED SATELLITE IMAGERY IN NORTHERN EUROPE

Urmas PETERSON[1,2] and Jaan LIIRA[3]

Abstract*:* *Boreal and northern temperate forests cover substantial parts of European land area. These forests are subjected to several kinds of tree removal disturbances, dominated by clear-cut logging. There is a need for quick and cost-efficient remote sensing methods to provide an independent means of detecting disturbances and recording the history of disturbances both at regional, national as well as at European level.*

The forests at northern latitudes are characterized by winters in which snow cover remains for some months of the year. Winter images are particularly suitable for change detection, while snow provides a uniformly bright background that accentuates tree crowns and their shadows and provides remarkable conditions for separating forested from non-forested areas.

We highlight a methodological approach of remote sensing based mapping of forest patches and forest disturbances in the Baltic region using multi-temporal winter imagery, obtained from medium resolution satellites Landsat and Spot and from scanner Aster. The mapping examples cover the areas in Eastern Europe in Estonia, Latvia and western parts of Russia. The time period covered is from 1987 to 2011.

Results show that a very simple approach using winter images is useful in mapping forest patches, canopy removal disturbances in forests and appearance of new forest patches within the context of agricultural lands in the situation of abandonment of agricultural land. We conclude that the use of snow-covered satellite images for forest change detection can be very efficient alternative to the use of summer images.

Key Words: Forest mapping, forest change detection, medium resolution satellite images, winter images

1. INTRODUCTION

The delineation of landscape patch boundaries between neighbouring vegetation communities is important for several aspects of land-use management planning and in the compilation of resource inventories. The location and accuracy of the delimited vegetation boundaries of patches however, depend on the sharpness of the boundary, the spatial and temporal resolution of the available data, as well as the subsequent statistical methods used to detect them (Fortin and Edwards 2001).

Winter in mid-latitude to boreal regions is the season with the greatest target to background contrast on predominantly two-class images composed of forest and non-forest classes offering an opportunity for accurate mapping of forests using medium-resolution satellite images. Dry snow cover causes a significant radiometric contrast between open areas and forests. Forest patches that are surrounded by open areas border on similar bright snow on all sides in

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winter. The reflectance of snow is very high in the visible and near-infrared part of the spectrum, where the Landsat Thematic Mapper (TM) spectral bands 1–4 are located.

The surface brightness of a snow-covered area is a function of the type and density of vegetation and the depth and age of the snow. If an area is devoid of vegetation, snow depth and age are primarily responsible for brightness variability over the area. Brightness increases rapidly with snow depth, irrespective of snow age. Once the depth reaches approximately 15 cm, any further increase in reflectivity with increased depth is slow, and the age and state of the snow surface become the critical variables affecting surface brightness (Robinson and Kukla 1985). The differences in spectral reflectance between different snow/ice cover types (frost, fine granular snow, medium granular snow and coarse granular snow) are relatively small in visible bands, but large in the longer wavelength bands of the mid-infrared spectral region (Xiao et al. 2002).

In an earlier study (see Peterson et al. 2004; Liira et al. 2006) we tested a method for forest mapping by the thresholding of a Landsat TM image made in late winter in plain snow cover conditions. The optimal edge threshold level can be defined by looking for a maximum radiance contrast of neighbouring pixels in a boundary area. We hypothesized that shadows cast by trees on forest edges on the bright snow of the surrounding open area make north-or north-west-facing forest edges less sharp than edges facing in other directions. If this holds true for medium-resolution Landsat TM satellite images, forest area change studies should carefully consider images taken under different atmospheric and solar elevation conditions in order to distinguish real changes at forest edges from those stemming from different conditions of solar illumination.

The results of the study showed that there were no significant differences in radiance between forest edges exposed in different azimuthal directions on the winter image. From the result, it followed that a global threshold can be applied in image classification of winter images if forest is the target class and thresholding is the classification method.

Change detection between two or more periods is one of the most important uses of satellite remote sensing data in forestry applications and in monitoring land cover change in general. Among the variety of change detection techniques, two variations are used most frequently (Coppin et al. 2004; Lawrence and Ripple, 1999; Yuan et al., 1999): (1) change detection from sequential date-pairs of images including postclassification change detection (e.g. Lunetta et al., 1999; Cohen and Fiorella, 1999; Lunetta et al., 2004) and (2) computing curves of change from multitemporal imagery (e.g. Lawrence and Ripple, 1999; Joyce and Olsson, 2000). Pairwise image comparison methods have been a more widely used technique in change detection studies (Lawrence and Ripple, 1999). Even when long time series have been used, individual date-pair images have been used to create a merged change data set (e.g. Lambin and Strahler, 1994; Olsson, 1994; Eastman and Fulk, 1993; Cohen et al., 1998, Potapov et al. 2011; Baumann et al., 2012).

Clearcutting as a major stand replacing change in forests alters the structure of forests by reducing the amount of mature forest cover, increasing edge density and isolating mature forest stands (Franklin and Forman 1987; Reed et al. 1996; Tinker et al. 1998). Political and economic changes that have resulted after the collapse of the Soviet Union have opened access to those forests that are now in private ownership and large-scale exploitation of their timber resources has started in mid 1990s. However there have been relatively few quantitative transbounbdary assessments of the extent and rate of forest fragmentation by clearcutting in Northern Europe.

In an earlier study (see Püssa et al. 2005) we tested the dependence of radiance in Landsat TM bands 1 – 5 and 7 and normalized difference vegetation index (NDVI) on forest age, gap size and forest type within the first 10 years following clear-cut logging in different seasons. This study tested the three key stages in the phenological cycle of clear-cuts of northern temperate forests that corresponded to (1) winter with snow-covered ground and leafless deciduous vegetation, (2) rapid increase in May before Betula spp. budburst, and (3) seasonal maximum in peak summer (July).The results of the study showed that late winter images with snowcovered ground are phenologically the best timed images for detecting forest clear-cut area regionally. Spring and summer images revealed to be more useful for estimation of the successional age of clear-cut areas in various soil fertility and moisture conditions.

2. MATERIAL AND METHODS

2.1. Study Area

The study region is bounded by 55° 30'N and 60°N latitude and 21° E and 32° E longitude and spans an area that extends about 500 km south from the southern shore of the Gulf of Finland in the Baltic Sea and about 600 km east from the eastern shore of the Baltic Sea. The forests in the area are boreal and boreo-nemoral forests dominated by Norway Spruce, Scots Pine, Birch and Common Alder. Clearcut timber harvesting has been a major use over the last tens of years, and has resulted in a mosaic of regenerating clearcuts within a matrix of uncut forest over most of the region. The dominant land cover in the region is forest (about half of the area is forested), pastureland, cropland and wetland.

2. 2. Satellite Data and Image Processing

The data set consisted of substantially cloudfree Landsat TM and Landsat ETM+ winter images available free of charge by the USGS Center for Earth Resources Observation and Science (EROS) and spanning a time interval from mid 1980s till 2011. The Landsat data set was supplemented with scanner ASTER winter images and SPOT HRV winter images. For change detection Landsat TM summer image pairs were used to fill the gaps in the time series of winter images.

We used digital number (DN) thresholds to assign pixels to one of the two classes 'forest' and 'nonforest'. Conversion of the Landsat TM recorded data to ground reflectances was not considered necessary in this study. The threshold value was established as the average between the 2nd and 98th percentile values in the bimodal frequency distribution of brightness of the Landsat TM bands. Figure 1 presents a bimodal frequency distribution of brightness of the Landsat TM visible red spectral band (TM 3). Other Landsat TM spectral bands have a similar frequency distribution.

Post-processing included the removal of small patches of forest, and patches classified as forest, from urban areas. Small patches, classified as forests with an area less than 0.5 ha, were removed with a minimum area restriction. Patches classified as forests in urban areas were masked out with the built-up areas map layer of the national base map.

Forest harvesting activity was mapped in a straightforward manner using an image differencing algorithm (Coppin et al. 2004) with image pairs. The images were analysed as separate date-pairs, the results of which were merged into a final harvest map. The errors in a clearcut harvest map derived from Landsat data were characterized with a comparison with a vector database containing forest stand historical information for Estonia and Latvia.

The classification of satellite images was supported by orthophotos and 1:10 000 scale national basic map in vector format for Estonia, National 1:50 000 base map for Latvia and Russian topographic maps in scale 000 and 1:50 000 for Russia. Forest was defined as area with 30 % or more tree cover with minimum patch size over 0.5 ha.

a. b.

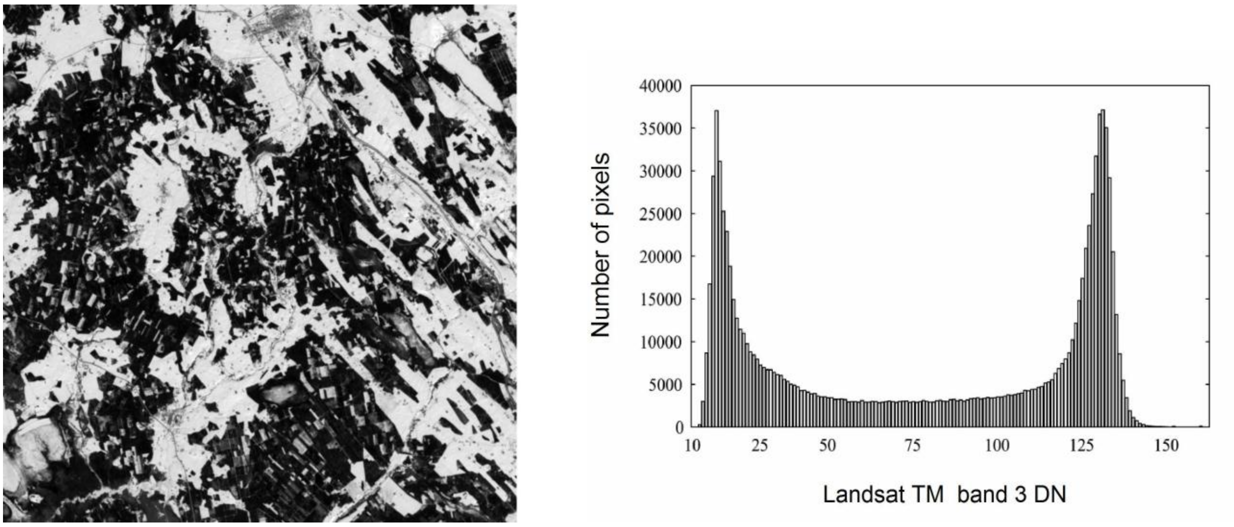

Figure 1. *Subset of a Landsat Thematic Mapper image in the visible red spectral band (TM3) (a) and the frequency distribution of pixel values (b). The image is dated10 March 1996, the subset covering an area of 25km x 25km on the ground. The frequency distribution shows image pixel brightness values in th so-called DN units The highest radiance values correspond to snow-covered bare areas or areas covered with very sparse and low vegetation. The lowest radiance values correspond to conifer dominated and mixed forests. Pixels with intermediate values are predominantly boundary pixels of forest patches.*

3. RESULTS AND DISCUSSION

The overall accuracy of the derived forest map was compared with a vector format national base map at a scale of 1 : 10 000 that was rasterized into two classes 'forest' and 'non-forest'. A set of map sheets, 5km x 5 km on the ground, was crosstabulated against the classified image. Commission and omission errors of the forest class in the forest map were from 0.02 to 0.03; Kappa index of agreement was from 0.8 to 0.9 on different map sheets. More than 80% of the discrepancies in the two datasets were located within a two-pixel-wide zone around the forest patches.

The administrative regions differed widely in forested area, the number and density of clearcuts when the area was tiled into 25 km by 25 km non-overlapping quadrangles. The overall accuracy of the forest-to-nonforest classification was better than 90%. Harvest activity was also mapped using merged differencing with greater than 90 % accuracy.

The first obvious trend is a gengerally increasing amount of temporally non-forest (clearcut) areas over time in forests in all ownership types. Approximately 15% of the forest area was disturbed overall, translating into annual disturbance rate of 0.6 %. The second trend in forest-cover patterns is the consistent difference of clearcutting between forest ownership types in the areas where it was possible to be differentiated (in Estonia and in Latvia). The general rates and patterns of clearcutting within the last twenty five years since 1985 were found to be rather similar in Latvia and in Estonia. The annual rate of cutting has increased both in private and in state-owned forests in these two countries if the yearly average rates of late 1980s and the first ten years in early 2000s are to be compared. While the rate of cutting has remained more conservative in state-owned forests, that on lands now in private possession has increased up to five times if averaged over commune areas.

Though the annual average rate of clearcutting has not exceeded 1 % of the total forest area in most of the communes, thus still supporting a hundred year long rotation period. Within these prevailing average rates of clearcutting forests from different growing conditions are harvested with different intensity. Forests in the studied areas of North-Western Russia have been cut to a lower rate than in the neighbouring Baltic States with the pattern of the clearcut area distribution dependent on the accessibility of forests i.e. on the network of roads. Forest-cover dynamics in private forests in Estonia and in Latvia during the last decade of the twentieth century was affected by a low amount of forest clearing during the preceding four decades and decline in the agricultural economy after collapse of the Soviet Union.

Disturbance rates in our study area (0.6 %) per year fall toward the lower end of the range reported for temperate forests. While the rates of disturbance are not markedly higher than those recorded from other temperate forests there has recently been a large alteration in the disturbance regime which will lead to a general transformation of forest age structure in the Eastern Baltic area if the trend continues. In general forest cover decreased throughout the region and throughout the period. Forest cover decreased across the area in all municipalities (counties) and in all forest ownership types, though there was a notable difference in rates of change.

Clearcutting is associated with predictable changes including a decrease in core area, an increase in edge density and decrease in the size of remaining forest patches. The results of these analyses reveal that fragmentation increased over the 25-year time span covered by Landsat images, but the isolation of fragments did not change substantially.

4. CONCLUSIONS

A series of medium resolution late winter satellite images covering an area of Estonia, Latvia and western regions of Russia in Northern Europe were used to classify forest from non-forest and to examine forest area changes in the region that have occurred within the last twenty years. Two processes contributing to forest area changes were clearcutting and afforestation of lands that were formerly in agricultural use respectively. The data set consisted of images from scanners Landsat Thematic Mapper (TM), Landsat Enhanced Thematic Mapper Plus (ETM+), SPOT High Resolution Visible (HRV) and Aster. The images covered a time frame from mid 1980s till 2011. Forest map was generated and forest area changes were estimated from late winter images imaged in the conditions of persistent snow cover. Forest clearcuts were mapped also from summer satellite images using forest map derived from winter images as a mask.

Approximately 15% of the forest area was disturbed overall, resulting in temporarily non-forested areas, translating into an annual disturbance rate of 0.6 %. The general rates and patterns of clearcutting within the last two decades were found to be rather similar in Estonia and in Latvia but were more modest in the territory of Russia. Clearcuting resulted in increased forest fragmentation.

Mean forest patch size and patch core area decreased, edge density increased as a result of clearcuts. The increase of forest fragmentation has accelerated since mid 1990s and particularly in private forests. While the rates of disturbance are not markedly higher than those recorded from other temperate forests there has recently been a large alteration in the disturbance regime which will lead to a general transformation of forest age structure in this part of Northern Europe if the trend continues. In general forest cover decreased throughout the region and throughout the period due to clearcut activities. The effects of land-use changes, abandonment of agriculture on forest cover throughout the region have resulted in the net increase of forested area. The increase of forested area has occurred both as the result of expansion of forest patches otwards to former agricultural lands and as appearance of new forested patches on former agricultural land. The net forest area increase is within the range of 2 % of the land that were in agricultural use in 1990 in Estonia and in Latvia. The net forested area increase in the expense of non-forested land was regionally varying in Russia, but was within 4 % of the non-forested land in 1ate 1980s.

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TREE RINGS IN THE MEDITERRANEAN

Paolo CHERUBINI[1]

Abstract: *Water is one of the most important resources for human life and human societies on the Earth. For plants, water is essential too. Without water and CO_2 no photosynthesis processes occur, and trees don't grow. Tree rings, as indicators of tree growth and physiological activity, have been used since long time ago, i.e., the beginning of the past century, for reconstructing past precipitation at local to regional scales over centuries.*

At sites where tree growth is limited by summer precipitation, such as in arid and semiarid, but also mediterranean, regions, tree-ring width is strongly affected by precipitation, and thus can be used to reconstruct past variability in precipitation patterns. At these sites, dendrochronological studies have helped in climatic reconstructions, the understanding of ecological processes, and archaeological dating. Moreover, recently, ring width has been used for reconstructing past streamflow too. Such studies are particularly critical and instrumental for water management in regions politically very sensitive, i.e. in the Middle East, where disputes on water are often a cause of war, but in the Mediterranean too.

INTRODUCTION

Analysing how forest ecosystems have reacted to changing climatic conditions in the past is of major importance to understand how they will react in the future. Tree rings provide information on the responses of forest ecosystems to environmental changes and allow their reconstruction in many regions. In the regions characterised by temperate climates, trees and shrubs stop growing during the cold season, so that annual rings are formed. These can enable the reconstruction of past climatic conditions (Fritts, 1976; Schweingruber, 1988, 1996).

For the Mediterranean region, information about past environmental conditions is scarce, although this kind of information would be very useful for understanding the effects of global change on important ecological processes such as desertification. The typical mediterranean climate at low elevations is characterized by temperature and precipitation regimes that are very different from temperate climates. Vegetative activity does not always and everywhere have a regular dormancy period, so that annual tree rings are not always formed. Although annual rings have long been reported in coastal mediterranean trees, dating tree rings in the Mediterranean is difficult because of the lack of seasonality. Tree rings are difficult to be distinguished and the application of dendrochronology in the Mediterranean is lacking (Cherubini et al. 2003).

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TREE RINGS

Tree rings in mediterranean environments can be used as a tool for dendroclimatic and dendroecological applied research. The difficulties in dating tree rings are induced by the wood-anatomical, physiological and phenological responses of trees to mediterranean climatic conditions (Cherubini et al. 2003).

CLIMATE

The Mediterranean climate consists of a temperate climate characterized by sunny, hot and dry summers, dependent on the seasonal shift of the desert regime, and by cool winters, with a pronounced rainfall maximum. Mediterranean climates grade into dry climates to the south and into cool, humid climates to the north. Mediterranean lands are therefore transitional zones with indistinct borders that may vary from year to year between moist and arid ecosystems, and between temperate and tropical regions. The types of vegetation and of tree-ring formation found at a particular site reflect the climatic conditions there as well as their biogeographical and evolutionary histories. Given the high variability of climatic conditions within the mediterranean area, a great variability in cambial activity (and in tree rings) within this region should be expected (Cherubini et al. 2003).

VEGETATION

The typical woody vegetation in mediterranean regions is characterized by the predominance of hard-leaved evergreen shrubs and dwarf and short trees, with small, stiff, leathery and thick leaves, termed sclerophyllous. The functional significance of sclerophylly commonly has been related to water conservation and to the resistance to negative turgor pressures. Mediterranean woody plants exhibit a great variety of growth forms and phenological traits. They may form proper resting buds (dormant) or not, and therefore they may grow during the winter or not. In mediterranean regions, water is usually the limiting factor. Wood anatomy, plant architecture, leaf anatomy, life history, and physiology are all related to one another, and whereas there are adaptations to aridity in each of these factors, many plants exhibit suites of co-occurring characteristics. There are various suites of xylem characteristics that commonly are found in woody plants of mediterranean regions. Most of the special characteristics associated with xylem of mediterranean plants are xeromorphic traits related to water transport and vulnerability to cavitation (Cherubini et al. 2003).

WOOD ANATOMY

The frequent appearance of numerous vessels with narrow, short elements, small intervessel pits, and helical thickenings in the vessels in arid zone species has been interpreted as a strategy for conductive safety. Many mediterranean ecosystems are dominated by shrubs or branchy wood plants. Shrubs tend to have narrower, shorter vessels than do trees, and branches have narrower, shorter vessels than main stems, so short narrow vessels will be common in the wood of mediterranean species. However, we still do not have a good functional explanation for why vessels are narrower and shorter in branches and shrubs than in trees. In conclusion, physiological adaptations may modify the cambial response to climate at the species and at the tree level, so that different responses of cambium activity between species and between individuals of the same species may be found.

DENDROCHRONOLOGY

Despite the increasing interest in dendroclimatic reconstructions for the Mediterranean region, mediterranean tree rings have seldom been used for dendroecological, dendroarchaeological or dendroclimatological purposes and the few dendroecological and -climatological studies carried out in the region mostly have been restricted to high elevation trees. The main reason for this deficiency is the inability in many cases to identify clearly and date tree annual rings. Cambial activity may stop not only when temperature becomes prohibitive (at these latitudes, during the winter), as in temperate regions, but also when periods of drought occur (during the hot, dry summer). This is the so-called characteristic Mediterranean "double stress" that triggers the formation of false or double rings. A double ring is caused by the interruption of the normal course of growth during a season. In mediterranean environments, this phenomenon happens irregularly in space (at different sites at the same time) and in time (in different years at the same site), so that it is difficult to assign a date to the formation of rings. In conclusion, mediterranean plants must face two different types of stress, winter cold and summer drought. Drought stress is the climatic factor responsible for restriction of productivity and growth of woody plants in mediterranean environments.

CONCLUSIONS

Consequently, climatic conditions, vegetation type, ecophysiological response, and phenological phase all play a key role in tree-ring formation (Cherubini et al. 2003).

(1) Dating tree rings in the Mediterranean is very difficult but possible. It is possible to cross-date unequivocally the samples for deciduous species, whereas for evergreen species dating is very difficult, and strongly depends on sampling site elevation and geographical location.

(2) Difficulties in dating are inducd by false rings triggered by climatic conditions, vegetation type (deciduous do not form false rings, but the evergreen do), ecophysiological response and phenological characteristics (laurophyllous *versus* sclerophyllous).

(3) Sampling tree cross sections is preferable to cores because of false rings, i.e., intra-annual density fluctuations. Wood anatomical observations on microsections are useful to distinguish false rings from true annual rings, although their preparation is very time-consuming.

(4) Tree-ring formation in mediterranean environments can be classified into four groups:

   (a) Trees with winter dormancy in cambial growth: a temperate mediterranean type.

   (b) Trees with a summer stop in cambial growth: found at very dry sites where summer-decidous shrubs have a drought-avoiding behaviour involving leaf desiccation or folding at the end of the growing season, i.e., the so-called malacophyllous species

   (c) Trees with a double stop, in winter and in summer: an adapted mediterranean type, typical for evergreen sclerophyllous and laurophyllous vegetation.

   (d) Trees with cambial activity characterized by no stops: a moist mediterranean type.

In the Mediterranean, site and species selection is of highest importance because of the great spatio-temporal variability in climate, vegetation types, and phenological and ecophysiological conditions.

Acknowledgements

This is a short synthesis of a paper previously published by Cherubini et al. (2003). The purpose of this paper is to stimulate tree-ring research in the Eastern Mediterranean region. The author is grateful to the Forest Research Institute in Belgrade for having invited him to attend a very stimulating conference in October 2012.

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FOREST MANAGEMENT IN PROTECTIVE WATERSHED AREA OF PALJANSKA MILJACKA ON JAHORINA MOUNTAIN

Branka RAJIĆ-BIJELIĆ[1], Azra ČABARAVDIĆ[2*]

Abstract: *Forests are one of the most complex ecosystems on Earth, which is a dynamic complex of plant and animal communities, micro-organisms and their abiotic environment. Different forest functions play important roles depending of particular forest and environmental potentials on one side and the social needs on other side. Jahorina is forested mountain in the eastern part of Bosnia and Herzegovina, near the capital – Sarajevo in Bosnia and Herzegovina. The particular importance of this area is connected with forest productivity and water resources originated from forested areas. Particular attention is paid on forest productivity on protective watershed area of Paljanska Miljacka on Jahorina. The research question is how protections of watershed zones influence forest production or are there some differences in forest production on regular economic and protective watershed areas. Survey was conducted in high forests of beech and fir with spruce on limestone soils in two departments in commercial forest of economic character and water protection forest. On the basis of field data statistical comparisons is carried out. In the characterization of production are analyzed: the growing stock, wood volume increment and felling on the basis forest plans for selected departments of the two categories of forests. For the analysis of structural characteristics were compared to the projected wood volume of the structure of wood stock.*

Key words: forest management, commercial forest, watershed

1. INTRODUCTION

Recent global climate changes and growing need for natural resources recognized forest management as a integral part in environmental utilization and protection. Particular attention is paid on forest management treatments to different environmental aspects as ecological, productive, social and others. It is known that sustainable forest management considers all forest functions trying to harmonize their interaction and contribute in natural protection and social utilization (Matić 1973). Overlapping functions as productive and protective usually open questions about rational treatments of natural resources by several users (Ollinger et al. 1998, Medarević 1991, Nikolić et al. 1998/99, Vilhar et al. 2006, Kuglerová 2010, Nikić et al. 2010, Vilhar et al. 2010).

Here is examined forest management in protective catchment's area in order to clarify were regular forest activates adapted to particular conditions aiming to preserve other forest function as protective and hydrological. Stated aims considered total wood volume distributions and wood quantities in two forested areas: in catchment's zones and in surrounding economic (productive) forest.

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2. MATERIAL AND METHOD

The study area for this research was the forested catchment's area of Paljanska Miljacka watershed in the central Bosnia. The study area covered the Forest management unit "Jahorina" Pale containing state owned productive and protective forests on 6273. 04 ha1. About 95% forests are native, multi-layres, multi-species assigned as selective forests. Here were analysed four dominant forest management classes: the high beech and fir forest with spruce on deep sylicat and silicate-carbonate soils (1201), the high beech and fir forest with spruce on carbonate soil (1202), the high fir and spruce forest or spruce forests on sylicat and silicate-carbonate soil (1203) and the high fir forest or fir and spruce forest on carbonate soil (1204).

(Figure 1.) Forest management unit contains complete catchment's zone which is divided in three zones (the first zone - without forest management activities and the second and the third zones with regular management activities). Forest stands were delineated and digitized based on the map of basic forest management units while boundaries of catchment's zones was delineated and digitized according to the elaborate for water source protection (Ćorović et al. 1987).

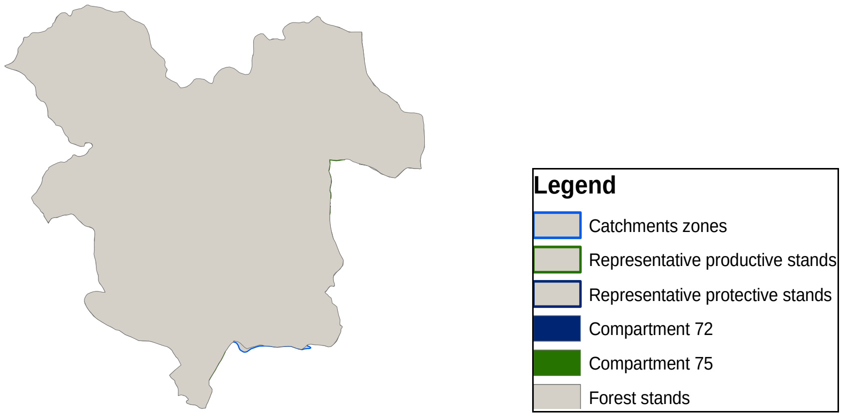
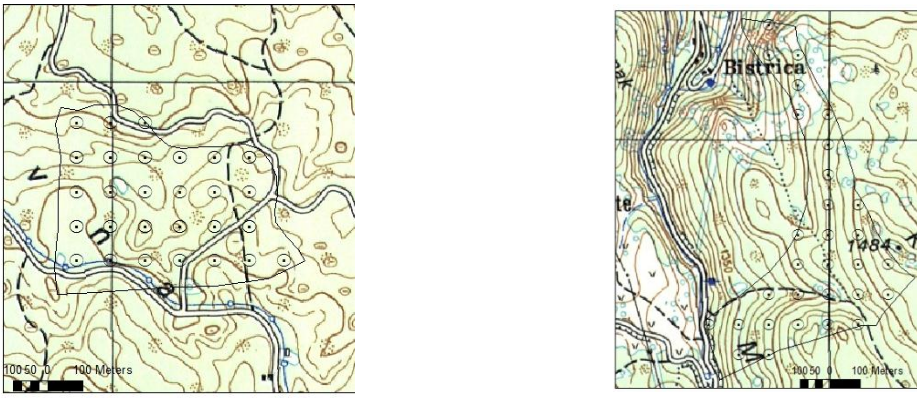


Figure 1. *Study area in GJ „Jahorina" – catchment's zones and representative stands*

In order to compare productive characteristics of forest stands in productive and protective forests, fifteen forest compartments were chosen (eight in productive and seven in protective forest). Regular planned cuttings were completed in chosen compartments for current management period and it was expected that achieved structures could indicate possible differences. Growing stock, wood volume increase and cuttings per ha based on management plan were compared.

Then two representative forest stands were selected randomly and taxative measurements on 58 sample plots in total were completed according regular rules for forest taxation (sampling plan for high forest) in year 2010 (Figure 2). Economic forest was represented by compartment 75 (Figure b) and protective forest was represented by compartment 72 (Figure a). Compartments belong to management class the high beech and fir forest with spruce on carbonate soil (1202). Here were estimated and compared the most important forest productive attributes: number stem, basal area and wood volume per ha. Then hypotheses testing about means equalities were performed using Student t-test.

[1] JPŠ „Šume Republike Srpske", Istraživačko-razvojni i projektni centar, Banja Luka (2002): Šumsko-privredna osnova za Paljansko ŠPP.



a) b)

Figure 2. *Sampling schemes in representative compartments (a. Compartment 72, b. Compartment 75)*

3. RESULTS

In the forested catchment's zones two types of activities are planned: in the first zone the sanitary cutting only while in the second and third watershed zones regular forest activities are planed. Sustainable forest management principles consider importance of protective and hydrological forest functions what could influence planned cutting.

Here are examined and compared total wood volume diameter structures in two areas: economic (surrounding determined catchment's zones) and protective (the second and third catchment's zones) forests (Diagram 1). Diameter distributions were obtained for chosen compartments where regular cutting were performed in current management period. It was found that both distributions follow approximately normal distribution with left asymmetry indicating insufficient stock in lower diameter classes (below 30 cm). In the middle diameter class total wood volume was higher in protective forest while in upper diameter classes wood volumes were similar.

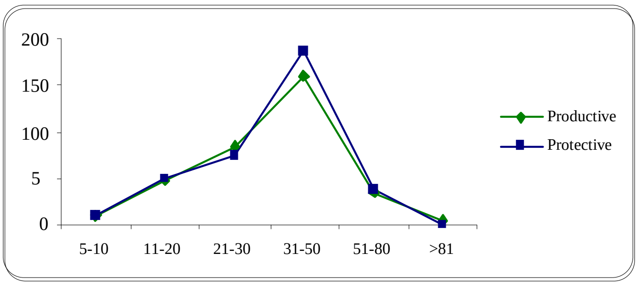


Diagram 1. *Total volume diameter distribution for representative stands*

Then total wood volume diameter distributions per management classes were obtained and compared with projected normal distributions (Diagram 2). Similar tendency of left asymmetry and higher total wood volume in middle classes in protective forests were obtained in management classes too. It is visible that total wood volume structures in productive forests were bellow projected normal distributions manly while in protective forests wood volumes were higher then projected in the middle diameter classes. In all management classes total wood volumes were lower then projected in upper diameter classes.

Obtained results pointed out that cutting were less intensive in protective forests what may be indication about respect of other forest functions here. In productive forests total wood volume distributions indicate needs for improvement aiming to follow projected wood volume distributions. According to management plan performed cuttings were less the planned and allowed (less then wood volume increment) (Bijelić-Rajić 2011).

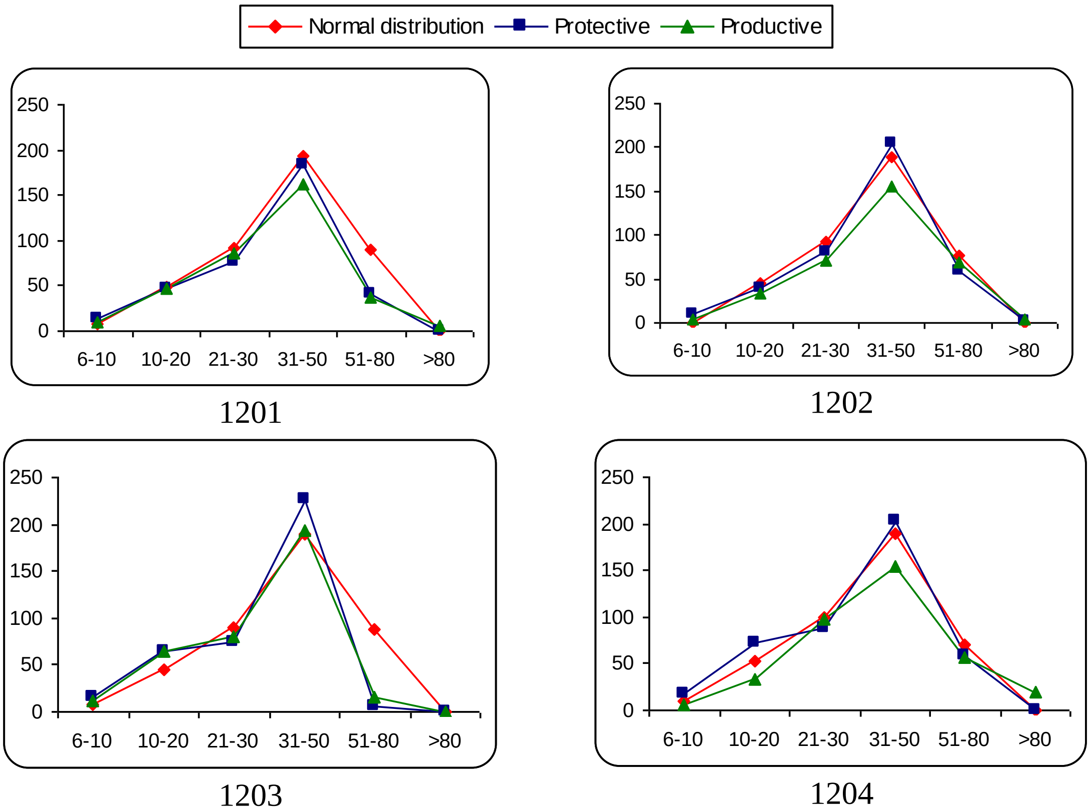


Diagram 2. *Total volume diameter distribution for representative stands per management classes*

Further, we examined estimates of taxative elements: the number stem, the basal area and the total wood volume for two representative compartments (72 and 75). Compartment 72 belongs to protective forest while compartment 75 is in productive forest. Both compartments belong to the same management classes and have similar management treatment. Terrestrial measurements, observation and estimates were used in order to compare results between compartments. The 95% confidence intervals for the number stem, the basal area and the wood volume are presented in Table 1.

Table 1. *Number stem, basal arae and total wood volume 95% confidence intervals for compartments 72 (protective forest) and 75 (productive forest)*

Species	Number stem per ha		Basal area (m^2/ha)		Total wood volume (m^3/ha)	
	72	75	72	75	72	75
Fir	373±36	346±32	11.09±0.68	7.21±0.48	139.55±8.93	82.27±6.08
Spruce	212±27	349±25	10.07±0.72	15.64±0.62	132.89±9.61	201.74±7.07
Beech	117±20	186±32	4.25±0.67	4.60±0.23	58.08±11.03	66.92±3.30
Total	670±42	733±52	25.58±0.71	24.36±0.80	330.52±10.6	308.74±7.83

Obtained estimates for totals showed better situation in protective forest: less average number stem with higher basal area and total wood volume. It is visible that fir participation in total wood volume is higher in protective area while in productive forest spruce dominates with similar beech participation in both compartments. Significant influence of fir was confirmed in testing hypotheses of the basal area and the total wood volume averages (Table 2). It is interesting that beech basal area and total wood volume were higher significantly in compartment in productive forest.

Table 2. *The t values for forest attributes per species and total ($t_{criticle}$= 2.00)*

Species	Number stem (n/ha)	Basal area (m^2/ha)	Total wood volume (m^3/ha)
Fir	0.924	3.449*	3.750*
Spruce	- 1.374	- 2.040	- 2.001
Beech	- 0.200	2.918*	2.317*
Total	-0.466	0.855	0.826

4. DISCUSSION

The findings point out differences in forest management in protective and productive forest showing that protective forest achieved higher productivity. Reasons behind could be less intensive cutting and better stand conditions. The utilization in catchment's forest was supported by animal while in economic forest tractors and animal were used so such approach contributes to decrease of potential risks of utilization damages, erosion and preserves ecosystem stability more in protective forest. Also it is noticeable that conditions in productive forests surrounding catchment's zones should be improved as in productivity so in other forest functions (protective, social, tourism) contributing in nature protection and local rural development.

Presented results related to total wood volume diameter distributions and the most important forest attributes in two representative compartments from protective and productive forest point out that forest management in catchment's zones follow planning goals and principles respecting protective forest function. This is consistent with recommendation of rational utilization of all forest potentials with identified priorities which influence forest management goals (Medarević 2006).

5. CONCLUSION

Forest management in forested protective catchment's zones is limited in the first protective zones (around water source) while in the second and the third zones regular forest activities are considered. Having in mind hydrological forest function there it was interesting to examine if regular forest utilization could achieve stated productive goals preserving other forest functions.

Here were compared total wood volume distributions in four dominate management classes in Forest management unit "Jahorina" Pale in forested protective catchment's zones and productive forest and found that distributions deviate from normal distributions in both forest categories. Better situation was found in protective forest where obtained total wood volume was higher in middle diameter classes then projected and distribution was closer to normal. In productive forest total wood volume distributions and quantities were less then planned. In both forest categories utilization were less then planned. It seems that here were prioritized other forest function as protective, hydrological and social then productive. Such approach supports integration in overall natural protection what has particular importance having in mind that study area contains forests, catchments, watershed, settlements and tourism-recreational capacities. Further research could be conducted in order to clarify values of non-productive forest function here and to identify potential economical issues non-usable today.

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SECTION II

BIODIVERSITY OF FOREST ECOSYSTEMS

CHAIRMEN – MODERATORS:

Sead Vojniković

Biljana Nikolić

INTRA-INDIVIDUAL VARIABILITY OF MORPHO-ANATOMICAL PROPERTIES OF NEEDLES OF SERBIAN SPRUCE, BOSNIAN PINE, PYRAMIDAL FIR AND SWISS PINE

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Abstract: *In investigation of variability of morpho-anatomic properties of Serbian spruce (Picea omorika /Panč./ Purkyně), Bosnian pine (Pinus heldreichii Christ.), Pyramidal fir (Abies alba var. pyramidalis Tošić) and Swiss pine (Pinus cembra L.), 13 characteristics of two-year old needles were measured: needle length, fascicle sheat length, needle width, needle thickness, cuticle + epidermis thickness, hypodermis thickness, central cylinder width, central cylinder thickness, number of vascular bundles, vascular bundle width, vascular bundle thickness, number of resin canals and resin canal diameter. The most variable properties were needle length and needle thickness as well as central cylinder width and central cylinder thickness. In Picea omorika needles the average values were 10.3 mm for needle length, 1.5 mm for needle width and 0.8 mm for needle thickness. In P. heldreichii needles the average values were 82.2 mm for needle length, 1.4 mm for needle width and 0.7 mm for needle thickness. In A. alba var. pyramidalis needles the average values were 20.0 mm for needle length, 1.95 mm for needle width and 0.5 mm for needle thickness. In P. cembra needles the average values were 77.5 mm for needle length, 1.1 mm for needle width and 0.9 mm for needle thickness. Average resin canal diameter was 33.8 µm in P. omorika needles, 41.3 µm in P. heldreichii needles, 127.9 µm in A. alba var. pyramidalis needles, and 76.8 µm in P. cembra needles. All analysed properties were compared with appropriate literature sources.*

Key words: morphology, anatomy, cuticle + epidermis, hypodermis, central cylinder, vascular bundles, resin canals

1. INTRODUCTION

Serbian spruce (*Picea omorika* /Panč./ Purkyně) is a tertiary relic conifer tree and Balkan palaeoendemite which in Serbia naturally occupies large areas of mountains Tara and Zvijezda, as well as small area in Mileševka Canyon near Prijepolje (Jovanović, 2000 and refs. cited therein). According to Vidaković (1982) it grows up to 30 (50) meters high and has pyramidal crown with whitish needles at lower sides of branches. Needles are 1 - 2 cm long and about 2 mm wide, on the cross-section flat, adaxial side is dark green, abaxial side has two rows of stomata. Cones are small and purple-red. Seeds are very small (up to 3.8 mm).

Bosnian pine (*Pinus heldreichii* Christ.) is a tertiary relic conifer tree and Balkan subendemite of south Italy, Bosnia and Herzegovina, Serbia, Montenegro, Albania, Macedonia, Bulgaria and Greece (Vidaković, 1982). This two-needle pine grows up to 20 (30) meters high and has pyramidal crown with needles on short shoots. Needles are set in bundles of two, 6 - 10 cm long, 1.5 – 2.0 mm wide. Resin ducts in needles are medial. Cones are about 8 cm long. Seeds are up to 7 mm long.

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Pyramidal fir (*Abies alba* var. *pyramidalis* Tošić) is a fir of a narrow pyramidal or conical habitus with dense branches pointed upwards, of 24 – 26 m height. It also differs from common fir in terms of other morphological properties (Rakonjac et al., 2010 and refs. cited therein).

Swiss pine (*Pinus cembra* L.) is a conifer that naturally occurs in the Alps and the Carpathian mountains (Jovanović, 2000). This five-needle pine reaches the height between 10 m and 23 m. Its crown is pyramidal in Swiss pine young age, while in the old age it assumes oval shape. Needles are 5 - 9 cm long and about 1.5 mm wide. Cones are 5 - 8 cm long. Seeds are 8 - 12 mm long.

Based on morpho-anatomical properties of conifer pines, it is possible to analyse variability of species and to resolve a dilemma with respect to the taxonomic status (of *Pinus sylvestris*, for instance, Urbaniak et al., 2009), or the position of certain genera in the systematic (genera *Keteleeria* and *Cathaya*, for instance, Wu and Hu, 1997). A number and position of resin canals perform an important role in addressing the above-mentioned dilemmas.

2. MATERIALS AND METHODS

The object of investigation were two-year old needles of four trees: Serbian spruce and Bosnian pine (both collected at Belgrade parks), pyramidal fir (gathered at the locality Ogorijevac near Sjenica in south-west Serbia), and Swiss pine (brought from Zvolen, Slovakia). Needles were collected at the end of the photosynthetic active season, around the lower third of the unshaded tree crown. Macroscopic and microscopic analyses were performed at the laboratory of the Institute of Forestry, Belgrade. Needle length and needle sheath length were measured by a portable measuring device, while other properties (needle width, needle thickness, cuticle + epidermis thickness, hypodermis thickness, central cylinder width, central cylinder thickness, number of vascular bundles, vascular bundle width, vascular bundle thickness, number of resin canals and resin canal diameter) were observed under microscope and measured in cross-section. Needle cross-sections were cut by a razorblade, in the central part of needles. Microscopic analyses and the measurement were performed by a light microscope *Carl - Zeiss Jena*. Measurements were conducted on 20 needles of each species.

3. RESULTS AND DISCUSSION

3.1. Picea omorika

The length of two-year old needles of the Serbian spruce subject to our study displays lower level of variation (9.0 mm – 11.5 mm; Tab. 1, Fig. 1a) when compared to the results disclosed by Pavlović and Matović (1994) (9.0 mm – 13.3 mm) and Milovanović et al. (2005) (12.1 mm – 19.7 mm). The needle mean length is 10.3 mm, the width is approximately 1.5 mm and the thickness amounts to approximately 0.8 mm. In the studies conducted by Milovanović et al. (2005), Serbian spruce needles are averagely longer and wider (19 mm and 1.7 mm, respectively), but of similar thickness. Serbian spruces originating from the industrial zone have a higher average thickness: 935 μm (Ilijin – Jug, 1995). *Picea glehnii* also has a similar needle length (9.5 mm), but its needles are narrower and thinner in comparison to Serbian spruce (0.65 mm and 0.5 mm, respectively) (Ishii et al., 2003). Serbian spruce needles are considerably shorter than needles of *P. sitchensis* (length: 21.8 mm, after Chandler and Dale, 1990). The hypodermis of the Serbian spruce subject to our study is single - layered. In terms of the thickness (16.44 μm – 24.66 μm), needles of Serbian spruce from our study are less variable in comparison to literature data for this species (9.5 μm – 20 μm; Vilotić, 1994).

In our investigations, the number of needle resin canals in Serbian spruce ranges from 0 - 2. Resin canals are predominantly of external type (touching epidermis). Within the *Picea* genus, *P. sitchensis* and *P. polita* (after Marco, 1939), along with *P. glehnii* and *P. jezoensis* (Ishii et al. 2003) also have external resin canals. Ilijin – Jug (1995) first noticed occurrence of the third resin canal in needles of Serbian spruce growing out of its areal (in a polluted environment). The maximum resin canal diameter of needles subject to our study (78.09 μm) is significantly higher in comparison to data on Serbian spruce disclosed by Vilotić (1994) (37 μm), but lower in comparison to data provided by Milovanović et al. (2005) (87.3 μm) and Isajev et al. (1999) (207 μm). The value of resin canal mean diameter (33.8 μm) is considerably lower when compared to literature data on both Serbian spruce (102.54 μm – 128.42 μm, Isajev et al., 1999; 70.69 μm – 87.30 μm, Milovanović et al., 2005) and other species of *Picea* genus, such as *P. likiangensis* (70 μm), *P. sitchensis* (440 μm), etc., (Marco, 1939).

Table 1. *Morpho-anatomical properties of 2-year old needles of Picea omorika*

SERBIAN SPRUCE				
Needle characteristics		**Range (min - max)**	**Mean X ± Sx**	**Standard deviation S ± Ss**
1	Needle length (mm)	9.00 - 11.50	10.30 ± 0.16	0.72 ± 0.11
2	Fascicle sheat length (mm)	-	-	-
3	Needle width (μm)	1290.00 - 1687.75	1522.20± 25.22	112.77 ± 17.83
4	Needle thickness (μm)	623.50 - 827.75	771.90 ± 10.62	47.52 ± 7.51
5	Cuticle + epidermis thickness (μm)	16.44 - 24.66	20.80 ± 0.70	3.12 ± 0.49
6	Hypodermis thickness (μm)	16.44 - 24.66	19.90 ± 0.54	2.41 ± 0.38
7	Central cylinder width (μm)	258.00 - 376.25	320.90 ± 7.73	34.58 ± 5.47
8	Central cylinder thickness (μm)	258.00 - 365.50	316.60 ± 6.95	31.09 ± 4.92
9	Number of vascular bundles	2.00	2.00 ± 0.00	0.00 ± 0.00
10	Vascular bundle width (μm)	28.77 - 41.10	37.60 ± 0.68	3.06 ± 0.48
11	Vascular bundle thickness (μm)	16.44 - 28.77	20.80 ± 0.76	3.39 ± 0.54
12	Number of resin canals	0.00 - 2.00	1.00 ± 0.20	0.89 ± 0.14
13	Resin canal diameter (μm)	0.00 - 78.09	33.80 ± 6.92	30.94 ± 4.89

3.2. Pinus heldreichii

Needles of the Bosnian pine subject to our study have a far lower range of variation in terms of length (6.5 cm – 9.9 cm; Tab. 2, Fig. 1b) in comparison to literature data on the above-mentioned species (5.1 cm – 10.2 cm, Gudeski et al., 1975; 8.5 cm – 12.4 cm, Stevanović - Janežić and Vilotić, 1998; 6.3 cm – 11.6 cm, Tošić et al., 2003), etc. In terms of needle mean length (8.2 cm), the Bosnian pine investigated in our study is most similar to Bosnian pines from Kamena Gora and Milakovići (7.8 cm; Tošić et al., 2003), while it has slightly larger needles in comparison to Bosnian pines from Šara mountain (7.1 cm, Gudeski et al., 1975) and Greece (7.1 cm – 7.7 cm, Papaioannau, 1975), but smaller needles than those of Bosnian pines from Prokletije mountain (9.7 cm, Stevanović – Janežić and Vilotić, 1998).

In terms of the needle width (1.4 mm), the Bosnian pine investigated in our study conforms to relevant literature data, while in terms of thickness (0.7 mm), needles are slightly thinner when compared to values disclosed in literature (0.9 mm – 1.0 mm). The maximum and mean value of thickness of cuticle and epidermis (24.7 μm and 21.2 μm, respectively) are higher in comparison to the data disclosed by Gudeski et al. (1975) (23.6 μm i 17.7 μm, respectively), while they are lower in comparison to same properties disclosed by Popnikola (1975) (27.3 μm on average). The Bosnian pine subject to our study has a higher mean thickness of hypodermis layer (42 μm) than Bosnian pines from mount Olympus (30.6 μm), Zlatibor (29 μm), Šara (26.1 μm), Prenj (28.8 μm) and from Bulgaria (26.6 μm and 29.2 μm), which were described by Popnikola (1975). Occasionally, the number of hypodermic cell rows is 4 - 6, similarly to Bosnian pine from mount Olympus (Popnikola, 1975). Resin canals of the Bosnian pine investigated in our study are of medial type. With its 5-6 resin canals, the Bosnian pine subject to our study is most similar to Bosnian pine from Murtenica (5 canals, Tošić et al., 2003). With respect to mean values of the resin canal diameter (41.3 µm), the Bosnian pine investigated in our study is most similar to Bosnian pines from Serbia (44 µm, Zlatibor - Pešter, Nikolić, 2008).

Table 2. *Morpho-anatomical properties of 2-year old needles of Pinus heldreichii*

BOSNIAN PINE				
Needle characteristics		**Range (min - max)**	**Mean X ± Sx**	**Standard deviation S ± Ss**
1	Needle length (mm)	65.00 - 99.00	82.15 ± 2.19	9.78 ± 1.55
2	Fascicle sheat length (mm)	9.00 - 11.00	10.05 ± 0.15	0.69 ± 0.11
3	Needle width (µm)	1182.50 - 1612.50	1389.44 ± 28.06	125.50 ± 19.85
4	Needle thickness (µm)	376.25 - 881.50	668.11± 39.54	176.82 ± 27.96
5	Cuticle + epidermis thickness (µm)	20.55 - 24.66	21.17 ± 0.34	1.51 ± 0.24
6	Hypodermis thickness (µm)	164.40 - 337.02	252.35 ± 12.69	56.74 ± 8.97
7	Central cylinder width (µm)	365.50 - 591.25	461.71 ± 14.01	62.63 ± 9.90
8	Central cylinder thickness (µm)	225.75 - 419.25	306.91 ± 12.64	56.51 ± 8.94
9	Number of vascular bundles	2.00	2.00 ± 0.00	0.00 ± 0.00
10	Vascular bundle width (µm)	82.20 - 164.40	123.09 ± 5.12	23.88 ± 3.62
11	Vascular bundle thickness (µm)	61.65 - 131.52	101.72 ± 4.81	21.50 ± 3.40
12	Number of resin canals	5 - 6	5.10 ± 0.07	0.31 ± 0.05
13	Resin canal diameter (µm)	32.06 - 49.32	41.33 ± 0.99	4.42 ± 0.70

3.3. Abies alba var. pyramidalis

The needle length of pyramidal fir (20 mm, Tab. 3, Fig. 1c) is higher than a needle length of common fir (16.8 mm, Pawlaczyk et al., 2005), while mean values of needle width (1.9 mm) and needle thickness (0.5 mm) are lower than those of common fir (2.1 mm and 1.08 mm, respectively). The hypodermis of pyramidal fir is single-layered and broken, frequently double-layered in corners. The thickness of hypodermal cells (20 µm) is similar to that of common fir. The size of the central cylinder in pyramidal fir is considerable larger than that of common fir (Robakowski et al., 2004). Like common fir, pyramidal fir has two resin canals. The average diameter of pyramidal fir resin canals (128 µm) is similar or higher than that of common fir (Pawlaczyk et al., 2005 and Robakowski et al., 2004, respectively). Resin canals of common fir are external (Robakowski et al., 2004) or medial (Pawlaczyk et al., 2005), while in pyramidal fir they nearly always touch hypodermis.

Table 3. Morpho-anatomical properties of 2-year old needles of *Abies alba* var. *pyramidalis*

PYRAMIDAL FIR				
Needle characteristics		**Range (min - max)**	**Mean X ± Sx**	**Standard deviation S ± Ss**
1	Needle length (mm)	12.00 - 27.00	20.05 ± 0.92	4.11 ± 0.65
2	Fascicle sheat length (mm)	-	-	-
3	Needle width (µm)	1682.50 - 2215.20	1950.55 ± 27.34	122.27 ± 19.33
4	Needle thickness (µm)	447.30 - 575.10	502.15 ± 8.04	35.95 ± 5.68
5	Cuticle + epidermis thickness (µm)	12.06 - 16.08	15.88 ± 0.20	0.90 ± 0.14
6	Hypodermis thickness (µm)	16.08 - 24.12	20.10 ± 0.29	1.30 ± 0.21
7	Central cylinder width (µm)	298.20 - 585.75	447.83 ± 14.79	66.15 ± 10.46
8	Central cylinder thickness (µm)	191.70 - 447.30	259.33 ± 17.67	79.04 ± 12.50
9	Number of vascular bundles	2.00	2.00 ± 0.00	0.00 ± 0.00
10	Vascular bundle width (µm)	76.38 - 116.58	95.68 ± 2.60	11.64 ± 1.84
11	Vascular bundle thickness (µm)	60.30 - 96.48	77.99 ± 2.29	10.22 ± 1.62
12	Number of resin canals	2.00	2.00 ± 0.00	0.00 ± 0.00
13	Resin canal diameter (µm)	100.50 - 148.74	127.94 ± 3.04	13.59 ± 2.15

3.4. Pinus cembra

In *P. cembra* needles the average values were 77.5 mm for needle length, 1.1 mm for needle width and 0.9 mm for needle thickness (Tab. 4, Fig. 1d). Resin canals are medial (positioned in mesoderm). The number of resin canals is between 2 and 3. Average resin canal diameter was 76.8 µm. Related pines (from subgenus Strobus, subsection Cembrae, classification after Critchfield, 1986) also have two (*P. pumila*, Wang and Hong, 2004) or three resin canals: *P. albicaulis* (one ventral and two dorsal, Kalgutkar, 1973), *P. koraiensis* and *P. sibirica* (Wang and Hong, 2004). With respect to the position of resin canals, *P. koraiensis* and *P. sibirica* are closer related to *P. cembra* (as they also have medial canals) than to *P. pumila* and *P. parvifolia*, canals of which are external (touching epidermis) (Goroshkevich et al., 2009). Additionally, needles of *P. pumila* (Gebauer et al., 2010) are narrower and thicker than *P. cembra*.

Table 4. *Morpho-anatomical properties of 2-year old needles of Pinus cembra*

SWISS PINE				
Needle characteristics		**Range (min - max)**	**Mean X ± Sx**	**Standard deviation S ± Ss**
1	Needle length (mm)	72.00 - 82.00	77.50 ± 0.74	3.32 ± 0.52
2	Fascicle sheat length (mm)	2.00	2.00 ± 0.00	0.00 ± 0.00
3	Needle width (µm)	752.50 - 1204.00	1072.31± 27.90	124.78 ±19.73
4	Needle thickness (µm)	795.50 - 1075.00	928.26 ± 17.30	77.38 ± 12.24
5	Cuticle + epidermis thickness (µm)	16.44 - 24.66	20.96 ± 0.51	2.27 ± 0.36
6	Hypodermis thickness (µm)	10.28 - 16.44	12.43 ± 0.23	1.05 ± 0.17
7	Central cylinder width (µm)	301.00 - 397.75	340.24 ± 5.25	23.47 ± 3.71
8	Central cylinder thickness (µm)	290.25 - 397.75	336.48 ± 6.62	29.62 ± 4.68
9	Number of vascular bundles	2.00	2.00 ± 0.00	0.00 ± 0.00
10	Vascular bundle width (µm)	82.20 - 246.60	155.56 ± 8.62	38.54 ± 6.09
11	Vascular bundle thickness (µm)	94.53 - 143.85	115.08 ± 3.43	15.32 ± 2.42
12	Number of resin canals	2.00 - 3.00	2.85 ± 0.08	0.37 ± 0.06
13	Resin canal diameter (µm)	36.99 - 96.59	76.82 ± 3.24	14.48 ± 2.29

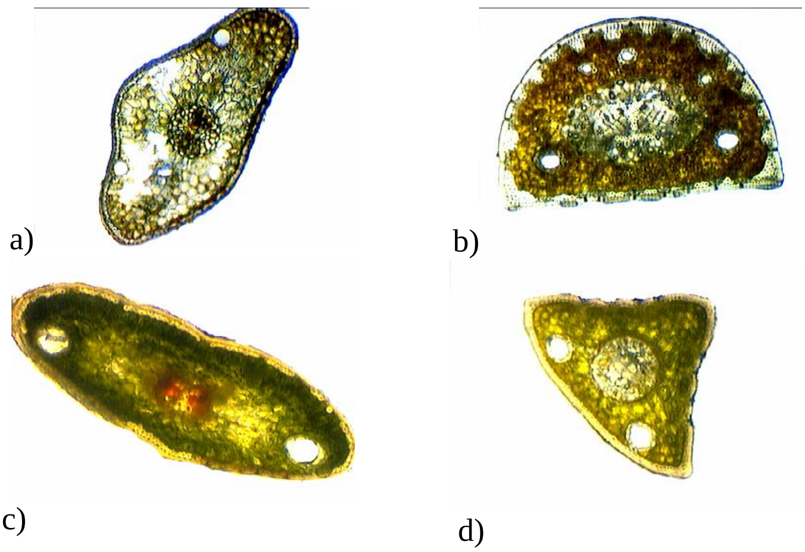

Figure 1: *Needles of: a) Picea omorika, b) Pinus heldreichii, c) Abies alba var. pyramidalis, and d) Pinus cembra (cross-section)*

4. CONCLUSIONS

This article analyzed individual variability of 13 needle traits of Serbian spruce, Bosnian pine, Pyramidal fir and Swiss pine. Investigations proved that there is a significant variability in all studied species with respect to all properties of the same tree. Sometimes our results do not correspond to the results of other authors with regard to the same species, as in Serbian spruce and Bosnian pine, for instance. Furthermore, a similarity of a higher or lower degree, with respect to morpho - anatomical properties, has been established between the studied species and their close relatives.

For the purpose of resolving dilemmas concerning taxonomy and systematisation of certain species or varieties, in particular when their areas overlap, it would be beneficial to investigate both the number and the size of stomata opening, needle serrations, etc. For that reason, current morpho-anatomical studies should be extended so as to also include the above-mentioned properties, while measurements should be performed on a higher number of specimen.

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PRELIMINARY RESULTS ON THE VARIABILITY OF WILD CHERRY (*Prunus avium* L.) IN SOME POPULATIONS IN SERBIA

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Abstract: *The variability of seven populations of wild cherry in Serbia was examined according to eight morphological leaf characteristics. All examined characteristics showed statistically significant variability among populations. The highest differences among examined populations were found in leaf blade width. The grouping of populations was described also by discriminant analysis. In spite entomophyllic crossing and zoohorial seed spreading, variability among examined populations was considerable, especially related to the recent results in Bosnia and Herzegovina. Such variability present valuable genetic resource for further work on the improvement of wild cherry in Serbia, and should be preserved by methods of in situ and ex situ conservation.*

Key words: wild cherry, genetic variability, leaf morphological characters

INTRODUCTION

Wild cherry (*Prunus avium* L.) is found in Serbia in many forest communities (Jovanović et al. 1997, Dinić et al. 2006), mostly in communities with oaks (*Quercus sp.*) and beech (*Fagus sp.*). Throughout the history the significance of wild cherry was considerable, as fruits were used as a food and the herb in pharmacy. Fruits are also important in nourishment of wild birds and animals. Considering the fact that those birds and animals are at the same time the seed vectors, wild cherry quickly disperse in long distances. This is rather an adoptable species, so it could be found from fertile to very poor soils, and from moist to dry habitats. Also, it inhabit broad spectrum of soils from riparian deposits on river bank up to the mountains on high altitudes: 1400 m.a.s.l. by Stanković (1981), 1500 m by Bojkov and Zahov (1951), 1700 m according to Šilić (2005), and 1900 m according to Russell (2003). It is abundant in the continental part but rather rare in submediteranian region of Serbia. According to the income and yield it belongs to the group of fast-growing tree species, with rotation of 40 to 60 years (Jovanović 1972, 2000). Currently, the research on wild cherry in the area of the former Yugoslavia was conducted by Ballian (2000; 2002; 2004) in Bosnia and Herzegovina. According to his research wild cherry grows rarely in pure stands or in larger groups, but mostly at the edges of forests or in restricted spots within forest. The abundance of light is of crucial importance for this species, because it is heliophilic species, with weak competitiveness related to other tree species.

The data on morphological variability of wild cherry is rather poor. Often general data could be found on certain characteristics for wild cherry in Bosnia and Herzegovina, such as morphology of seed, seldom about flower (Ballian 2000, 2002.), than leaf (Mikić 2007, Ballian 2012), as well as about fruit. The size of fruit is used for the taxonomical differentiation, so

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individuals with small black fruits belongs to the variety *Prunus avium* var. *actiana* L., or true wild cherry (Herman, 1971). Long-term development of local population in different ecological conditions resulted in numerous ecotypes and forms of wild cherry. Kolesnikova (1975) suggest five ecotypes, Vulf (1960) two forms according to the fruit color, Mijakuško and Mijakuško (1971) four forms according to several morphological characters, and Hrynkiewicz (1972) three forms of wild cherry.

Russell (2003) claim that natural populations of wild cherry range from the western part of Asia to the northern part of Africa and north of Europe. There are different data for the origin of the species. Usual opinion is that it originated from western Asia and Caucasus (Vavilov 1935), while Žukovsky (1965) suggests the origin from the Mediterranean center. However, Mišić (1987), finds that wild cherry origin from Asia Minor, and south and middle Europe, while Ninkovskom (1998) suggests it originate from Black sea region. Nevertheless, Russell (2003) found that archeological and fossil data show that wild cherry originate from north-western and central Europe.

Mišić (1987) reports that genetic analysis suggest that gametophitic incompatibility depends on the series of multiple alleles S_1, S_2, S_3, ... S_n located in one locus. Briggs and Walters (1997) report on crossing problem related to this fact. According to Pejkiću (1980) there are six alleles. Pandey (1967) suggests that genes create certain proteins in pollen and column that regulate the expression of incompatibility i.e. the enzymatic destruction of growth hormones occurs in pollen tube and column of stigma. Ascher (1966, 1970) explains the appearance of gametophitic incompatibility by hypothesis on inherited regulation mechanisms. New data gained by the analysis of proteins and DNA (Russell 2003) show the presence of 12 S alleles in domestic cherry and 25 to 30 alleles in wild cherry that control incompatibility. It should be paid attention on the incompatibility in the analysis of within and inter population variability, because it decreases differentiation by limiting intensity of gene-flow at the level of pollen and seed.

The aim of the work was to determine the degree of ecological and genetic differences among examined populations of wild cherry in Serbia by comparative and statistical analysis of morphological leaf characteristics. Also, this research could suggest the efficient way of wild cherry conservation depending on the degree of diversity, and could be used in prescription of measures for its conservation *ex situ* and *in situ*.

MATERIAL AND METHODS

Leaves of wild cherry were collected in seven natural populations in Serbia (Table 1).

Table 1. *Basic data on examined wild cherry populations*

Population	Number of trees	Basic geographical data		
		Longitude	Latitude	Altitude (m.a.s.l.)
V. Lomnica - Kruševac	15	43°29'28"	21°20'45"	231
Ivanjica - Golija	13	43°27'15"	20°14'01"	870
Brza Palanka	13	44°28'08"	22°26'06"	87
Karađorđevo	10	45°20'32"	19°14'30"	90
Jamena	10	44°52'59"	19°04'20"	77
Šid Molovin	10	45°10'45"	19°18'55"	177
Zlatibor	13	43°44'31"	19°42'53"	930

Leaves were collected according to previously recognized methodology that is applied in research on *Q. pedunculate*. According to Trinajstić (1989) and Franjić (1993, 1994a, 1994b) only leaves from short shoots represent their recent state of the species and are suitable for the taxonomical research. This technique is applied on fruits too. Thus, leaves were collected from short fertile shoots only. Only healthy, normal and fully expanded leaves were collected. The collection was done in the second part of the growing period i.e. in August, when leaves are fully expanded. Leaves were collected from trees on the edge of stand of solitary trees or individuals, usually from the sunny side of the tree crown. Those trees were selected because it is known that only solitary individuals or trees at the edge of forest area are able to present their genotype completely as it is defined (Franjić, 1993). Those trees grow without competition with other trees. This is not the case with trees within the stand. After the collection, the further selection was performed in order to dispose all the leaves that are not fully and correctly developed, such as damaged leaves and those that considerably deviate from the normal phenotypic shape.

All the leaves were herbarized for further measurements.

Every leaf was labeled, and in every normally developed and undamaged leaf following characteristics were measured: petiole length (K1), blade length (K2), the distance from leaf base to the widest part of the leaf (K3), blade width (K4), insertion angle for the first vain at the right side of leaf blade (K5), number of teeth at the right part of leaf blade at the 1 cm length of leaf edge (K6), blade width at 1 cm below the blade tip (K7) and the width at 1 cm above the blade base (K8). All characters were measured with 0.1 mm precision.

In total, 840 leaves from 84 trees were analyzed. On every leaf, eight characters were measured, that makes 6720 records in total.

Data was saved in Excel program, and statistically analyzed by SPSS 15.0 for Windows. Following statistical methods were used: descriptive statistical parameters, analysis of variance, regression analysis and discrimination analysis.

RESULTS

Analysis of variance

According to the analysis of variance for all examined characters showed highly significant differences among examined populations, as the probability in F-test was bellow 0,01 (Table 2).

Table 2. *Results of analysis of variance*

Analyzed character	Source of variation	Sum of squares	Degree of freedom	Mean square	F - test	Probability
Petiol length (K1)	Among populations	3066,35	6	511,06	21,25**	0,000
	Within populations	29664,87	1234	24,04		
	Total	32731,23	1240			
Leaf blade length (K2)	Among populations	4767,97	6	794,66	8,19**	0,000
	Within populations	119862,52	1236	96,97		
	Total	124630,50	1242			
Distance form the basis to the widthest part of blade (K3)	Among populations	1484,95	6	247,49	5,82**	0,000
	Within populations	52487,86	1236	42,46		
	Total	53972,82	1242			
Blade width (K4)	Among populations	14167,94	6	2361,32	90,66**	0,000
	Within populations	32190,30	1236	26,04		
	Total	46358,24	1242			
Insertion angle of the irst vein on the right side of blade (K5)	Among populations	6429,59	6	1071,59	27,77**	0,000
	Within populations	47687,64	1236	38,58		
	Total	54117,24	1242			
Number of teeth on 1 cm of the right edge of blade (K6)	Among populations	267,43	6	44,57	23,37**	0,000
	Within populations	2357,06	1236	1,90		
	Total	2624,50	1242			

Analyzed character	Source of variation	Sum of squares	Degree of freedom	Mean square	F - test	Probability
The width at 1 cm bellow the blade tip (K7)	Among populations	4102,95	6	683,82	16,44**	0,000
	Within populations	51394,20	1236	41,58		
	Total	55497,16	1242			
The width at 1 cm above blade basis (K8)	Among populations	3697,50	6	616,25	27,65**	0,000
	Within populations	27502,61	1234	22,28		
	Total	31200,11	1240			

** - significant F-test at $\alpha = 0.01$

The post hoc Duncan test was performed for all analyzed characters and populations. As this test reviles the significance of differences among examined populations, it allows determining the degree of variability among populations based on examined characters. In order to limit redundancy results of Duncan test for only three characters (characters that made the highest discrimination among populations) are presented (Table 3, 4 and 5).

Leaf blade length (K1) varied from 26.92 mm in Zlatibor population to 31,49 mm in population Ivanjica - Golija, while the total average value was 29,42 mm (Table 3).

The average value for petiole length (K2) varied from 82,58 mm in Šid - Moloviu population to 87,83 mm in population V. Lomnica – Krusevac. The total average value was 85,35 mm (data not shown).

The distance from basis to the widest part of leaf blade (K3) varied from 43.70 mm in Jemena population to 46,50 mm in population in V. Lomnica – Krusevac (data not shown).

For blade width (K4) the average value varied from 41,68 mm in population Zlatibor to 52,83 mm in population Jamena (Table 4).

The population average values for the insertion angle for the first lateral vein at the right half of leaf blade (K5) varied from 43,12 degree in population Brza Palanka to 49,45 degree in population Zlatibor. The total average insertion angle for examined populations was 46,27 degree (Table 5).

The population average for teeth number on 1 cm length of the right leaf blade edge (K6) varied from 9.04 teeth in population Ivanjica - Golija to 10,54 teeth in population Šid-Moloviu. The highest variation of this character was found in population Šid-Moloviu, and the lowest in population Brza Palanka. The total average value for all examined populations was 9,78 teeth (data not shown).

The analysis of leaf blade width at 1 cm beneath the blade tip (K7) showed that the population Brza Palanka had the highest average value (12,70 mm), and the population Šid-Moloviu the lowest (4,89 mm). The highest variation was found in population Brza Palanka, and the lowest in population Karađorđevo (data not shown).

The width at 1 cm above the leaf blade basis (K8) appeared to be the highest in population Karađorđevo (25,12 mm), and the lowest in population Ivanjica - Golija (21,36 mm). The total average for examined populations was 23,46 mm (data not shown).

According to Duncan test the grouping of examined populations was similar for every examined character. In four characters three homogenous groups were defined, in two characters four homogenous groups and in two characters five homogenous groups could be resolved.

According to these results it could be noticed that the highest differences occur between populations Ivanjica – Golija and Krađorđevo, as the differences are significant for every presented character. The opposite is the case of populations Šid - Moloviu and V. Lomnica – Krusevac. The results of Duncan-test confirm considerable variability described by analysis of variance.

Table 3. *Duncan test for petiole length (K1)*

Population	Number of leaves	Duncan test (α=0.05)		
		1	2	3
Zlatibor	178	26,92		
Brza Palanka	195	27,44		
Sid Moloviu	148		29,74	
V. Lomnica - Kruševac	225		29,83	
Karađorđevo	150		30,07	
Jemena	150		30,68	30,68
Ivanjica - Golija	195			31,49
Significance		0,328	0,106	0,122

According to the results of Duncan test for petiole length (Table 3) populations Zlatibor and Brza Palanka were grouped in the first homogenous group, populations Šid-Moliviu, V.Lomnica, Karađorđevo and Jemena in second and populations Jemena and Ivanjica - Golija in third homogenous group.

Table 4. *Duncan test for blade width (K4)*

Population	Number of leaves	Duncan test (α=0.05)			
		1	2	3	4
Zlatibor	178	41,6778			
Ivanjica – Golija	195	42,0097			
V. Lomnica – Kruševac	225		45,7564		
Brza Palanka	195		46,5981		
Šid - Moloviu	150		46,8000		
Karađorđevo	150			47,9530	
Jemena	150				52,8257
Significance		0,545	0,071	1,000	1,000

According to the results for blade length (K2) also three homogenous groups could be defined but the first group formed Šid – Moloviu, Zlatibor, Jemena and Brza Palanka, the second group Zlatibor, Jemena, Brza Palanka and Karađorđrvo, while in third group are populations Karađorđevo, Ivanjica – Golija and V. Lomnica – Kruševac (data not shown). The distance from the basis to the widest part of blade (K3) also allowed the formation of three homogenous groups. The first group form populations Jemena, Karađorđevo, Zlatibor, the second Zlatibor and Šid – Moloviu, and the third populations Šid – Moloviu, Brza Palanka, Ivanjica – Golija, V. Lomnica – Kruševac (data not shown). According to blade width (K4) there are four groups: populations Karađorđevo and Jemena are defined unique groups, Zlatibor and Ivanjica - Golija are together, and V. Lomnica – Kruševac, Brza Palanka and Šid – Moloviu formed another group (Table 4).

According to the insertion angle for the first vein on the right side of blade (K5) five homogenous groups were defined (Table 5).

Table 5. *Duncan test for insertion angle for the first vein on the right side of blade (K5)*

Population	Number of leaves	Duncan test (α=0.05)				
		1	2	3	4	5
Brza Palanka	195	43,1282				
Ivanjica – Golija	195	44,3231	44,3231			
V. Lomnica - Kruševac	225		45,1867	45,1867		
Šid - Moloviu	150			46,1867		
Jemena	150				47,9867	
Karađorđevo	150				49,1600	49,1600
Zlatibor	178					49,4551
Significance		0,073	0,195	0,134	0,079	0,658

Duncan test for the number of teeth on 1 cm of the right edge of blade (K6) defined four homogenous groups, where Ivanjica – Golija and Šid - Moloviu form particular groups, while the rest of populations grouped by two per group (data not shown). According to the blade width at 1 cm bellow the blade tip (K7) three homogenous groups were defined. These groups do not overlap with each other (data not shown). The Duncan test based on width at 10 cm above the blade basis (K8) showed the occurrence of five groups, where two populations formed unique groups, two groups consist of three populations and one group formed by two populations. Populations Brza Palanka appears in two homogenous groups, as well as populations V. Lomniva – Kruševac and Zlatibor (data not shown).

Grouping of populations according to similarities confirmed significant differences among examined populations reviled by analysis of variance.

Tests for the normality of distribution of frequencies

According to Kolmogoroff – Smirnoff and Shapiro – Wilk's tests for the normality of frequencies distribution it could be concluded that the distribution of frequencies is not normal for majority of examined characters and populations, as the probability of performed tests was usually over 0.05.

Petiole length has normal distribution only in the population V. Lomnica-Kruševac, where the test probability was bellow 0.01, but in all other cases the normality was not confirmed. According to the Kolmogoroff-Smirnov test, populations Brza Palanka, Karađorđevo, Jemena, Šid-Moloviu and Zlatibor showed considerable deviation from the normal distribution of frequencies as the probability reached 0,2 (p=0,2).

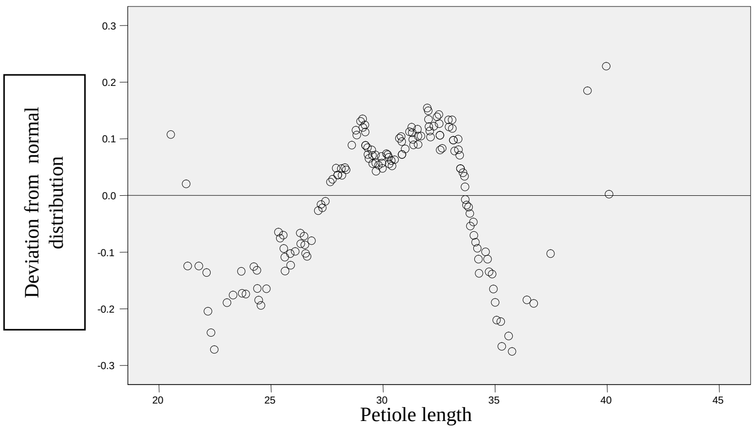

Figure 1. *Deviation from normal distribution for petiole length in population Karađorđevo*

Because of specific situation that is found the graphic distribution of deviation of petiole length is presented for the population Karađorđevo that showed significant statistical deviation (Figure 1).

Discriminant analysis

According to discriminant analysis based on all examined characters, there was no significant grouping among examined populations in clusters. That is confirmed by the fact that no function had eigenvalue higher than 1, as it is presented in table 6 and on figure 2, where the grouping of populations was presented based on canonical discriminant functions.

Table 6. *Results of discriminant analysis*

Function	Eigenvalue	% of variance	Cumulative %	Canonic correlation
1	0,687(a)	58,7	58,7	0,638
2	0,167(a)	14,3	73,0	0,378
3	0,146(a)	12,5	85,5	0,357
4	0,118(a)	10,1	95,6	0,325
5	0,043(a)	3,7	99,3	0,204
6	0,008(a)	0,7	100,0	0,090

a) the first canonic discriminant functions that were used in the analysis.

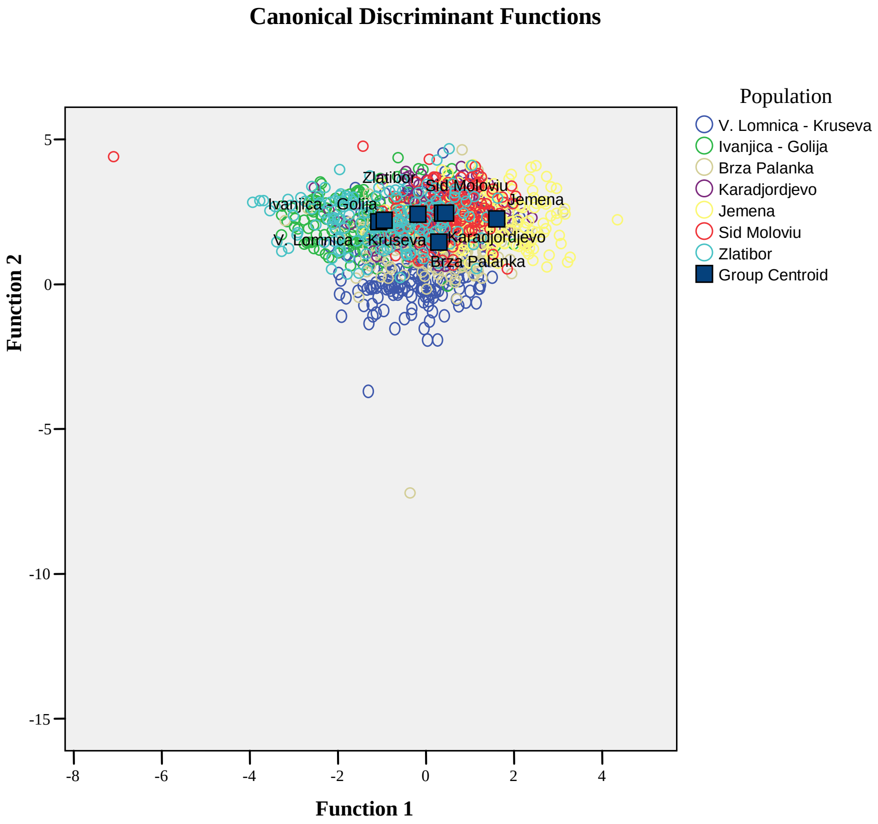

Figure 2. *Grouping of examined populations based on canonical discriminant functions*

Additional analyses where average values of examined characters were included had been included were conducted, as within numerous data differentiation among population could be lost. However, these additional analyses did not show any significant grouping among examined populations.

DISCUSSION AND SUGGESTIONS

The results gained with this research showed significant statistical differences among examined populations, even though the wild cherry is a species with very interesting and fast gene flow, and ecological plasticity and adaptability. That adoptability could be traced in modification variability. In some earlier research in wild cherry in the region, conducted by Balliana (2002) and Balliana and Bogunića (2006) insignificant differences among populations were recorded. However, in our research, that included seven populations from different ecological habitats and additional morphological characters, significant differences were found. Earlier research, considering their limited amount of data, could not explain weak differentiation of wild cherry at the interpopulation level. Analysis of those results, as well as results of other authors suggests that one of reasons could be in filogenetic juvenility of this species, and its relatively fast settling of Balkan Peninsula (Ballian et al., in print). However, some authors, at the base of fossil and archeological remains, suggest that wild cherry is present in Europe for a long time (according to Mišić (1987) and Pejkić (1980)), and in Serbia as well.

Morphological markers (characteristics) in this work allowed the differences among populations appear distinguishable, as it was successfully applied in pedunculate oak by Franjić (1993, 1994a, 1994b). However, knowing ecology and genetics of wild cherry, it could be suggested that beside ecological factors, one of the dominant influence was achieved by human activities in last 2000 years (Ducci, 1991).

As it was emphasized, wild cherry grows in very different ecological conditions, where morphological characters are considerably influenced by climatic, soil and orographic factors that directly influence and modify them in one or the other way. Thus, it could be expected that this species forms certain ecotypes. The influence of ecological conditions could be supported by our results but that should be additionally confirmed by molecular markers. Similar results were successfully explained in other species by Chiarucci et al. (1993), Johansson et al. (1997) and Kollman and Pfludshaupt (2001), as they efficiently connected differences among populations with climate conditions in examined area, which is, in present time, above our abilities.

Based on the results obtained in this research, i.e. on the analysis of variability of wild cherry in Serbia, the basic suggestions could be given for its revival and diversity preservation by methods of *in situ* and *ex situ* conservation. By further research and implementation of new morphological and molecular markers the more precise picture about wild cherry populations would be provided. Thus, in that way this research should be continued.

As wild cherry is presented with small populations, solitary trees and scattered and rare trees within stands, it is necessary to prescribe and release numerous silvicultural measures in order to improve its conditional status. According to Ballian et al. (in print) for the preservation and improvement of some population *in situ* it should be taken in consideration the fact that survival depends on basic factors of habitat as well as on particular individual tree that is carrier of genetic resource and its ability to pass this resource to the next generation (vitality, fructification, tolerance to biotic and abiotic agencies, etc.). Thus, beside the research on variability based on used markers, it is necessary to learn basic ecological factors that occur on these habitats. Nevertheless, the results from the statistical analysis should be taken with caution and criticism, as in spite the perfection of the procedure, the real results could be hidden in the forest data.

CONCLUSIONS

At the basis of results and discussion following conclusions could be made:

- Morphological characters used in this research allowed differentiation among examined populations in Serbia.
- High within-population variability could be related to the complex system of crossing, where numerous multiple S alleles suppress inbreeding, as well as to entomophyllic crossing and zoohorial seed spreading that suggest efficient and fast gene flow among populations.
- Related to the recent research in the region our results suggest the occurrence of considerable genetic resources in Serbia that should be preserved by means of *in situ* and *ex situ* conservation.

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THE TOPOGRAPHIC POSITION OF CUTTINGS AS A FACTOR IN THE SUCCESS OF DIFFERENT POPLAR CLONES ROOT STRIKING

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Abstract: *Several types of planting materials are used for the establishment of poplar plantings, whilst cuttings and roots produced within the „stool bed“ system (rooted and stool beds) are used as reproduction material for their production.*

The topographic position of sprout cuttings on the percentage of survival of cuttings is analyzed herein. The field trial was conducted in the „Ljutovo“ nursery in Bečej, operated under the PC Vojvodinašume, FH "Banat" - Pančevo, FA „Zrenjanin“. The field trial was carried out through four repetitions with the random treatment distribution. Three clones of the American black poplar Populus deltoides (cl. B-229; 665; $S_{1\text{-}5}$) were included in the field trial, as well as two clones of the Euramerican poplar, namely Populus x euramericana cl. Pannonia (M_1) and cl. I-214.

Research has demonstrated that, although there is no significant statistical difference at the 95% level of significance, there is a difference with regard to the percentage of survival of cuttings, starting from the basal to the apical part of the sprout. The topographic location of the cutting on the sprout had an effect on the percentage of survival, but not on the quality of produced seedlings.

Key words: poplar, clone, position of cuttings, rooting percentage

INTRODUCTION

Well organized nursery production of poplars accounts for the first and immensely important phase for a successful establishment of forest plantings. The entire technological process, type and kind of the seedling produced in a nursery depends on the purpose for which the seedlings are to be used.

Organized production of poplars commenced as early as in 1938 in Baranja, on the "Belje" state property, where mainly springs of the Euramerican *Serotina*, *Robusta* and *Marilandica* poplars were collected from selected trees, which were used as reproduction material for the establishment of perennial stool beds used for the production of cuttings (Marković and Rončević, 1986). Such a manner of production of cuttings is in the "stool bed" system (rooted and stool beds).

A more comprehensive nursery production began in the early 1950s, when certain issues simultaneously arose. Poplar clones used until then became most susceptible to the *Dothichiza populea* fungus (poplar bark cancer), hence the solution was to import foreign selections. The

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best results were achieved with *Populus x euramericana* (Dode) Guinier cl.I-214, which is broadly used in Serbian forestry even nowadays. This clone eventually became less resistant to the *Dothichiza populea* fungus, as well as to the new kind of fungus named *Marssonina brunea,* which causes a disease known as “brown leaf spotting”.

New circumstances led to the gradual introduction of new clones of deltoid poplars i.e. *Populus deltoids* Bartr., which demonstrated a higher degree of resistance to the aforementioned plant diseases. In addition, nursery production underwent significant changes owing to the fact that the Italian rooted bed – transplanting bed production system had been fully adopted (Rončević et al., 2002) when more intensive research pertaining to the planting material production were performed.

Reasearch has thus far demonstrated that several factors may have an impact on the success of nursery production of poplars: starting material used for making of cuttings, time of making and manner of preservation of cuttings, length of cuttings, number of buds on each cutting, treatment of cuttings before their placement in the soil, distance between cuttings, as well as any other measure implemented upon rooting of cuttings.

In addition, the habitat where a nursery is established plays an important role in production of seedlings. The most suitable habitats for the growth of poplars are located in floodplains of large rivers (the Danube, the Sava, and the Tisza) where inundation is frequent. A part of the area of all floodplains is protected by means of construction of embankments by the rivers, thus making them safe from inundation impacts. A lack of inundation accounts for one of the more relevant preconditions for the selection of nursery areas (Rončević et al., 2002). According to the same author, fluvisol and humofluvisol are the most suitable soils for the establishment of poplar nurseries.

In addition to the aforementioned, the topographic location of the cutting on the sprout is one of the major factors which may have a large impact on the success of rooting in practical terms.

Several authors have dealt with the research of the impact of the topographic position of the cutting on the sprout, as well as with the quality of sprouts used for making of cuttings. They have also given recommendations on the number of cuttings which can be obtained depending on the category of the sprout.

Mutibarić (1961) tested the quality of the sprout for obtaining cuttings. According to this author, 7-8 cuttings can be obtained from 2 meter long sprouts. He divided the obtained cuttings into three groups according to the topographic position and in the end of the vegetation period he concluded that the largest success of rooting is obtained from the base part cuttings (97.7%), followed by the medium part cuttings (82.2%), while the apical part cuttings demonstrated the weakest result (52%), whereby the position of the cutting did not have any significant impact on the quality and dimensions of seedlings.

Herpka and Marković researched the quality of rooted cuttings of the I-214 clone as reproduction material for production of cuttings. They divided sprouts into five height-related categories, the distance between which was 0.5m (1.0-1.5; 1.5-2; 2-2.5; 2.5-3; over 3.0 m), after which they made cuttings in accordance with the topographic position. Based on the two-year long research they recommended the following number of cuttings depending on the sprout category: class 1– 7 cuttings, class 2– 6 cuttings, class 3– 5 cuttings, class 4–4 cuttings and class 5–2 cuttings. The best results for obtaining reproduction materials were achieved with 2.0–2.5m high cuttings.

The purpose of this Paper is to determine the dependency of the topographic position of cuttings on sprouts on the possible percentage of rooting of cuttings of different poplar clones.

MATERIALS AND METHODS

The field trial commenced in the spring of 2012 at the "Ljutovo" nursery in Novi Bečej, which is part of the FH "Banat" – Pančevo, FA „Zrenjanin". A total of 5 different poplar clone cuttings, out of which 3 of them were American black *Populus deltoides* (cl. B-229, 665, S_{1-5}) poplar and 2 *Populus x euramericana* cl. Pannonia[1] and cl. I-214 Euramerican clones were used for the establishment of the experiment. The cuttings are 20cm long and placed in 4 repeated randomly distributed treatments. A total of 150 cuttings is placed within each repeating.

The position of the location of the cutting on the sprout was taken into consideration when making cuttings. The initial 20cm of the sprout was rejected from the selected sprouts for cuttings, whilst the remaining part of sprouts were used to cut cuttings. Five cuttings were cut from each sprout while taking care that a minimum of three buds remained on each cutting. All cuttings were gathered into beams and placed in a rooting bed.

After two days the cuttings were removed from the rooting bed and submerged in water for 24 hours. Before the very placement in the soil they were immersed in the copper lime solution for 15 minutes.

Cuttings were placed in fluvosol soil of the sandy loam type. Fertilization and nutrition of the soil was not carried out. Watering and care measures (hoeing, pruning, protection against insects and plant diseases) were conducted if necessary.

Counting of rooted cuttings was performed after 35 days. The obtained data was processed in the Microsoft Excel 2007 and Statgraphics programs. The variance analysis – ANOVA and LSD test at the level of 95% of significance (α=0.05) were used for the purpose of data processing.

RESEARCH RESULTS

Table 1 demonstrates summary statistics and variance analysis at the 95% level of significance individually for each position of the cutting on the sprout, collectively for all positions of cuttings from the sprout per clone, as well as for the total number of cuttings from the same position of the sprout regardless of the clone.

Table 1. *Summary statistics and variance analysis for observed clones*

Position of cutting	**Clone**	**Summary statistic**				**ANOVA**	
		Count	**Average (%)**	**Min**	**Max**	**F-ratio**	**P - value**
I	I-214	112	93.33	83.33	100.00	2.05	0.1389
	M-1	119	99.17	96.67	100.00		
	B-229	104	86.67	83.33	90.00		
	665	112	93.33	86.67	96.67		
	S_{1-5}	108	90.00	76.67	100.00		
	In Total:	**555**	**92.50**	**76.67**	**100.00**		
II	I-214	109	90.83	86.67	96.67	1.13	0.3782
	M-1	110	91.67	86.67	96.67		
	B-229	103	85.83	80.00	90.00		
	665	106	88.33	83.33	90.00		
	S_{1-5}	108	90.00	86.67	96.67		
	In Total:	**536**	**89.33**	**80.00**	**96.67**		

[1] Hereinafter referred to as M-1, which is a more domesticated term.

Position of cutting	Clone	Summary statistic				ANOVA	
		Count	Average (%)	Min	Max	F-ratio	P - value
III	I-214	112	93.33	83.33	100.00	3.14	0.0462
	M-1	113	94.17	90.00	100.00		
	B-229	101	84.17	76.67	90.00		
	665	103	85.83	80.00	90.00		
	$S_{1\text{-}5}$	101	84.17	80.00	90.00		
	In Total:	**530**	**88.33**	**76.67**	**100.00**		
IV	I-214	111	92.50	83.33	96.67	7.11	0.0020
	M-1	117	97.50	96.67	100.00		
	B-229	100	83.33	70.00	90.00		
	665	95	79.17	73.33	83.33		
	$S_{1\text{-}5}$	104	86.67	83.33	90.00		
	In Total:	**527**	**87.83**	**70.00**	**100.00**		
V	I-214	110	91.67	86.67	100.00	1.72	0.1983
	M-1	113	94.17	90.00	96.67		
	B-229	100	83.33	66.67	90.00		
	665	100	83.33	76.67	90.00		
	$S_{1\text{-}5}$	102	85.00	80.00	96.67		
	In Total:	**525**	**87.50**	**66.67**	**100.00**		
Sum of all the cuttings by clone	I-214	554	92.33	90.67	96.00	12.31	0.0001
	M-1	572	95.33	93.33	96.00		
	B-229	508	84.67	80.00	86.67		
	665	516	86.00	84.00	88.00		
	$S_{1\text{-}5}$	523	87.17	84.00	92.00		
	In Total:	**2673**	**89.10**	**80.00**	**96.00**		
Sum of all the cuttings by their position on a sprout	I	555	92.50			0.78	0.5494
	II	536	89.33				
	III	530	88.33				
	IV	527	87.83				
	V	525	87.50				
	In Total:	**2673**	**89.10**				

A total of 2,673 out of 3,000 placed cuttings of different poplar clones were rooted, which accounts for 89.1% of the total number of cuttings. The best percentage of rooting was observed in the M-1 (95.33%) clone, whilst the B-229 clone demonstrated the worst result in terms of rooting and it amounts to 84.67%.

If we take into consideration the total number of cuttings from the same sprout position regardless of the clone, we can conclude that the best result was obtained in the first position cuttings (92.5%), whilst the weakest was in the fifth position cuttings (87.50%). Although statistically irrelevant at the 95% level of importance based on the variance analysis, the obtained data has demonstrated that the change of the position from the basis to the apical part of the cutting on the sprout has an impact on the percentage of rooting of cuttings.

The variance analysis has not demonstrated any significant statistical differences between cuttings from the first, second and fifth position of the sprout of the observed clones, whilst in cuttings taken from the third and fourth position of the sprout such a difference is present. Furthermore, there is a significant difference in statistical terms when we compare the number of rooted cuttings per clone regardless of the position on the sprout.

Table 2 shows the LSD test results individually for each position of the cutting on the sprout and collectively for all positions of cuttings from the sprout per clone.

Table 2. *The LSD test results individually for each position of the cutting on the sprout and collectively for all positions of cuttings from the sprout per clone*

Clone	Mean	Homog. Groups	Clone	Mean	Homog. Groups
I			**II**		
B-229	86.67	X	B-229	85.83	X
S 1-5	90.00	XX	665	88.33	X
I-214	93.33	XX	S 1-5	90.00	X
665	93.33	XX	I-214	90.83	X
M-1	99.17	X	M-1	91.67	X
III			**IV**		
S 1-5	84.17	X	665	79.17	X
B-229	84.17	X	B-229	83.33	X
665	85.83	XX	S 1-5	86.67	XX
I-214	93.33	X	I-214	92.50	XX
M-1	94.17	X	M-1	97.50	X
V			**Sum of all cuttings by clone**		
665	83.33	X	B-229	84.67	X
B-229	83.33	X	665	86.00	X
S 1-5	85.00	X	S 1-5	87.17	X
I-214	91.67	X	I-214	92.33	X
M-1	94.17	X	M-1	95.33	X

LSD test results (Table 2) point to the existence of different homogenous groups within the analyzed clones between the first, third and fourth cutting, whilst such a difference does not exist in the second and fifth cutting.

The difference in the first position of the cutting appears between the M-1 and B-229 clones, whilst in the third position the differences appears between the Euramerican I-214 and M-1 poplar clones and B-229 and S_{1-5} deltoid poplar clones. There are significant differences between the I-214 and B-229 and 665 clones in the fourth position of the cutting, as well as between the M-1 and B-229, 665 and S_{1-5} clones.

Based on the results obtained by means of a comparison of summaries of all cuttings on the sprout per clone there is a clear distinction between Euramerican and deltoid poplar clones. The aforementioned difference can be explained by the difference in terms of the number of buds between these two groups of clones. Moreover, the participation of the sapped part in cuttings of the I-214 and M-1 clones is less than in the B-229, 665 and S_{1-5} clones.

Variability of the percentage of rooting of cuttings of different poplar clones taken from different topographic positions on the sprout test results is graphically shown in Chart 1.

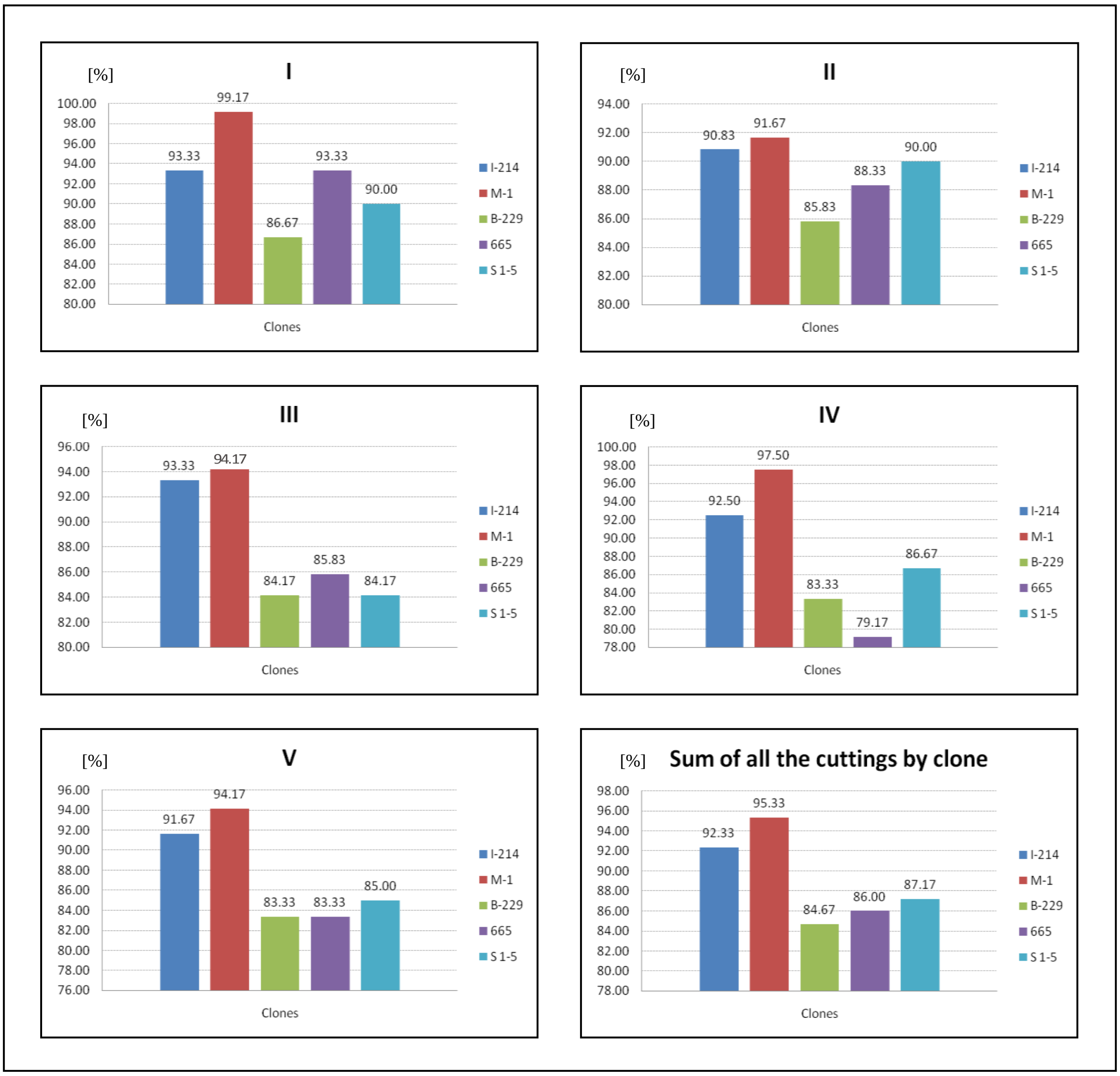

Chart 1. *Variability of the percentage of rooting of cuttings of different poplar clones taken from different topographic positions on the sprout*

CONCLUSIONS

Based on the results received from the experiment and their analyses, the following conclusions can be drawn:

1. There is a significant difference in the percentage of successfully rooted cuttings between Euramerican and *deltoides* poplar clones. The said difference is caused by greater number of buds and lesser amount of hardwood in the Euramerican poplar clones.
2. The results, although not statistically significant on the significance level of 95%, show that different topographic position of a cutting on a sprout, starting from the basal to the apical part, does have an influence on the cuttings rooting success.

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COMPARATIVE ANALYSIS OF THE FLORISTIC COMPOSITION AND DIVERSITY OF THE VASCULAR FLORA OF NEUTROPHILE BEECH AND FIR FORESTS WITH SPRUCE IN BOSNIA AND HERZEGOVINA

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Abstract: *This paper presents a study of the diversity of vascular plants within neutrophile beech and fir forest with spruce from the Illyrian area (Abieti-Fagetum illyricum Treg. 1957. nom ill.). Comparative studies using an identical method were conducted in two areas within the range of these forests in Bosnia and Herzegovina, in the central and western regions of Bosnia. Though these are the same plant communities, the starting point was the hypothesis that there are differences, both floristic and in diversity, between these forests within the sites studied, arising from their phytogeographical position as well as from the impact of management. The studies revealed that the beech and fir forest with spruce in western Bosnia (Grmeč) is floristically somewhat richer both in number of species and in diversity than that of central Bosnia (Bjelašnica). The values determined for Grmeč were as follows: average number of species 30; average Shannon index 2.64; average equality index 0.86; the values of the same indicators for Bjelašnica were: average number of species 28; average Shannon index 2.46; average equality index 0.83. Minor floristic differences were observed in the Illyrian species Cardamine trifolia, Cardamine kitaibelii (syn. Cardamine polyphylla) of Grmeč, which are not present in the Bjelašnica area.*

As regards diversity by number of tree species and the proportion of each species by number of individuals, greater diversity was observed on Grmeč, with a Shannon index value of 1.551, as against that of 1.303 for Bjelašnica. A variance analysis revealed a statistically significant difference in diversity by number of species and number of individuals on the areas studied. Diversity by basal area on Grmeč was 1.538, compared with 1.182 for Igman- Bjelašnica. Here too the differences were statistically significant, with a probability of 95%.

INTRODUCTION

Beech and fir forests (with spruce) constitute the "fundamental" and economically most valuable forest communities of Bosnia and Herzegovina. Their distribution covers a variety of geological substrates: limestone-dolomite, acid silicates, mafic and ultramafic rocks (gabbro, diabase, serpentinites and peridotites) and flysch series. The preliminary findings of the second national forest inventory of Bosnia and Herzegovina (2006-2009) are that beech and fir forests (with spruce) on a limestone-dolomite substrate cover an area of 397,200 ha.

The ecological and vegetation regionalization of Bosnia and Herzegovina (Stefanović et al. 1983) distinguishes between two types of mixed beech and fir forest, with spruce, and without. Beech and fir forest without spruce is widespread in the outer Dinarics, under the influence of the warm Mediterranean climate to the south and the hot summers of the Pannonian climate to the north, whereas beech and fir forest with spruce is widespread in the inner Dinarics.

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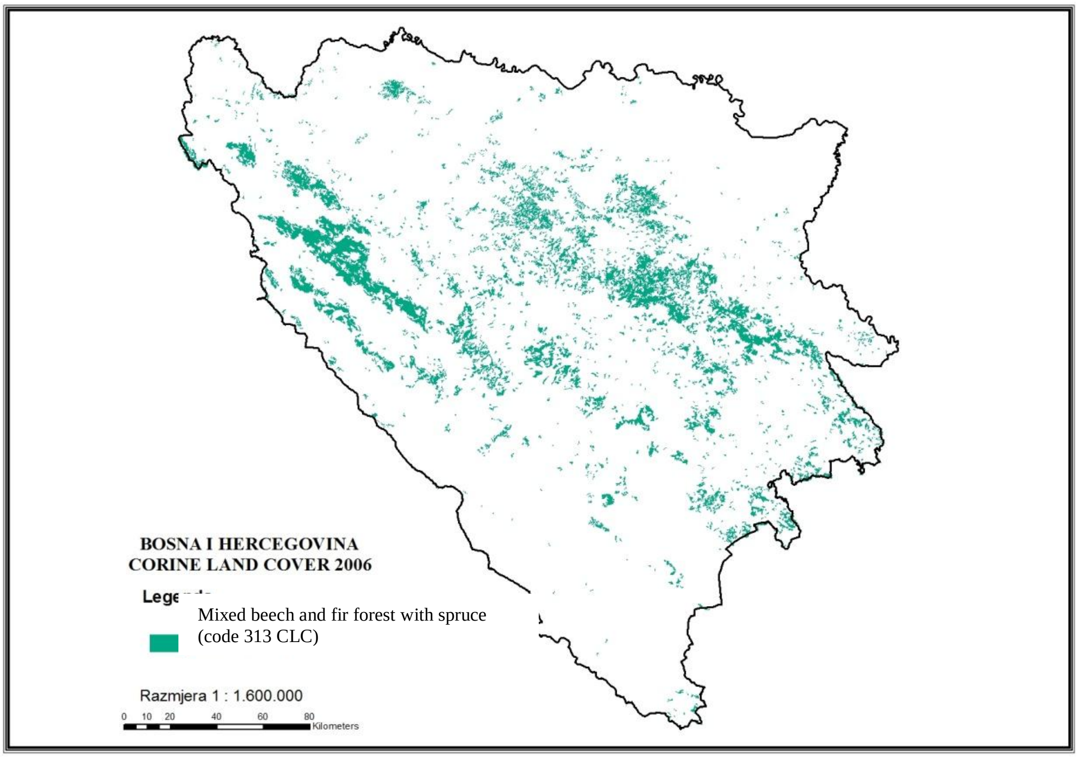

Map 1- *Range of all mixed beech and fir forest (with spruce) in Bosnia and Herzegovina, from 2008 Corini Land Cover (EEA 2008). Scale: 1:600,000*

This paper studies the floristic composition and diversity of these forests with a view to analyzing the range of typical "pure" Illyrian and meta-Illyrian species, the α diversity of vascular plants and tree diversity, so as to determine the impact of the proposed management system and the anthropogenic impact on the diversity of the vascular flora of these forests. In (semi)natural ecosystems, the diversity of a given community is a "dependent variable," the outcome of the action of evolutionary, syndynamic and ecological/environmental processes and anthropogenic impacts, which also affect ecosystem functioning. The timely observation of changes in biodiversity can help to preserve stable forest ecosystems.

RESEARCH MATERIAL AND METHODS

The studies were conducted at two sites in the range of beech and fir forest with spruce on limestone substrates in Bosnia and Herzegovina. The first is on Mt. Bjelašnica, near Sarajevo, the second on the Grmeč massif in western Bosnia. Both sites lie along the southeast-northwest orientation of the Dinarics. Fifteen experimental relevés were established on each site. These experimental relevés are circular, with a radius of 25 m. The centres of the areas were laid out on a quadrat grid 1 km x 1 km apart. Several classification elements were recorded on each relevé, including those that are relevant to determining tree diversity, such as tree species, diameter at breast height of all trees exceeding the classification threshold, and the position of each tree in the relevé using the polar method.

In addition, phytocoenlogical surveys were carried out on 14 relevés on Grmeč and 13 on Bjelašnica using the Braun-Blanquet method (1964). Diversity was analyzed for each stand at α level (Kimmins, 2004) on both research sites. Juice 7.00 software (Tichy and Holt, 2006) was used for the α diversity analysis and for the synoptic tables of the phytocoenlogical surveys of the sites. The data had previously been entered from the Turboveg database (Hennekens et

Schaminée, 2001). The measures of diversity used were number of species, the Shannon index and the Evenness equality index. The indexes obtained from the phytocoenlogical data were compared graphically using a box and whisker diagram for both sites. A T-test was used to test the significance of the tree diversity between the sites identified by number of trees and basal area.

RESULTS AND DISCUSSION

Comparison of the floristic composition of vascular plants

The comparative diagram produced results indicating that a large number of vascular species are to be found at both sites. This was to be expected as, syntaxonomically speaking, these communities belong to the same association of beech and fir forest (with spruce): *Abieti-Fagetum illyricum* Treg. 1957 (nom ill.). The following species are common to both sites, by storey: tree storey – *Abies alba, Fagus sylvatica, Acer pseudoplatanus, Picea abies, Ulmus glabra, Sorbus aucuparia...*; shrub layer – *Lonicera* sp., *Rhamnus alpinus* s. *fallax, Daphne mezereum, Corylus avellena*; herb layer – *Ajuga reptans, Anemone nemorosa, Asarum europaeum, Athyrium filix-femina, Brachypodium sylvaticum, Carex sylvatica, Epilobium montanum, Dryopteris filix-mas, Euphorbia amygdaloides, Galium odoratum, Melampyrum sylvaticum, Polygonatum verticillatum, Symphytum tuberosum, Telekia speciosa, Vaccinium myrtillus, Viola reichenbachiana*.

Table 1. *Synoptic table of the floristic composition of beech and fir forest (with spruce) of Grmeč and Bjelašnica*

GRMEČ

Synoptic table with percentage constancy and cover range

Group No.		1	
No. of relevés		14	
Abies alba	*6*	50	+-1
Abies alba	*5*	93	1-3
Abies alba	*4*	7	3
Abies alba	*1*	93	1-5
Abies alba	*2*	100	2-3
Acer pseudoplatanus	*6*	43	+
Acer pseudoplatanus	*1*	21	1-3
Acer pseudoplatanus	*2*	21	1
Acer pseudoplatanus	*5*	21	+-1
Aconitum lycoctonum	*6*	14	+
Actaea spicata	*6*	29	+
Aegopodium podagraria	*6*	7	+
Ajuga reptans	*6*	50	+
Anemone nemorosa	*6*	50	+-1
Aremonia agrimonoides	*6*	64	+
Asarum europaeum	*6*	43	+-1
Asplenium scolopendrium	*6*	21	+
Asplenium trichomanes	*6*	21	+
Asplenium trichomanes-ramosum	*6*	21	+
Athyrium filix-femina	*6*	71	+-1
Atropa bella-donna	*6*	14	+
Brachypodium sylvaticum	*6*	14	+
Cardamine bulbifera	*6*	36	+-1
Cardamine enneaphyllos	*6*	57	+-1
Cardamine kitaibelii	*6*	14	+
Cardamine trifolia	*6*	79	+-1
Cardamine waldsteinii	*6*	36	+-2
Carex digitata	*6*	7	1
Carex sylvatica	*6*	57	+-2
Circaea lutetiana	*6*	7	+
Corylus avellana	*6*	14	+
Cystopteris montana	*6*	64	+-1
Dactylorhiza maculata	*6*	7	+
Daphne laureola	*6*	14	+
Daphne mezereum	*6*	57	+
Daphne mezereum	*5*	14	+
Dryopteris filix-mas	*6*	86	+-1
Epilobium montanum	*6*	14	+
Euonymus latifolia	*6*	14	+
Eupatorium cannabinum	*6*	7	+
Euphorbia amygdaloides	*6*	29	+
Euphorbia carniolica	*6*	7	+
Fagus sylvatica	*2*	100	1-4
Fagus sylvatica	*5*	71	1-3

BJELAŠNICA

Synoptic table with percentage constancy and cover range

Group No.		1	
No. of relevés		13	
Abies alba	*2*	46	1-2
Abies alba	*5*	85	+-4
Abies alba	*1*	54	1-4
Acer pseudoplatanus	*6*	15	+-1
Acer pseudoplatanus	*5*	69	+-2
Acer pseudoplatanus	*2*	8	1
Aconitum lycoctonum	*6*	15	+-1
Actaea spicata	*6*	46	+
Adenostyles alliariae	*6*	8	+
Aegopodium podagraria	*6*	23	+
Ajuga reptans	*6*	54	+-1
Anemone nemorosa	*6*	8	+
Angelica sylvestris	*6*	8	+
Aremonia agrimonoides	*6*	77	+-1
Asarum europaeum	*6*	62	+-1
Athyrium filix-femina	*6*	46	+-1
Atropa bella-donna	*6*	8	+
Brachypodium sylvaticum	*6*	8	1
Cardamine enneaphyllos	*6*	8	+
Cardamine waldsteinii	*6*	15	+
Carduus personata	*6*	23	+
Carex digitata	*6*	15	+
Carex sylvatica	*6*	31	+
Corylus avellana	*6*	8	+
Corylus avellana	*5*	8	+
Cystopteris montana	*6*	15	+
Daphne mezereum	*6*	15	+
Daphne mezereum	*5*	15	+
Digitalis grandiflora	*6*	8	+
Doronicum columnae	*6*	31	+
Dryopteris filix-mas	*6*	85	+-4
Epilobium montanum	*6*	31	+
Euphorbia amygdaloides	*6*	62	+-1
Euphorbia carniolica	*6*	23	+
Fagus sylvatica	*5*	85	1-4
Fagus sylvatica	*2*	62	1-5
Fagus sylvatica	*1*	77	1-4
Festuca altissima	*6*	85	+-5
Festuca heterophylla	*6*	15	+-1
Fragaria vesca	*6*	31	+
Galium odoratum	*6*	85	+-2
Galium sylvaticum	*6*	31	+-1
Gentiana asclepiadea	*6*	23	+-1
Geranium phaeum	*6*	15	+

Fagus sylvatica	*1*	93 $^{1-5}$
Fagus sylvatica	*6*	14 $^{+}$
Festuca altissima	*6*	14 $^{+}$
Fragaria vesca	*6*	7 $^{+}$
Fraxinus excelsior	*6*	14 $^{+-1}$
Fraxinus excelsior	*1*	7 ^{1}
Galeopsis speciosa	*6*	7 $^{+}$
Galium odoratum	*6*	57 $^{+-1}$
Galium rotundifolium	*6*	43 $^{+-1}$
Gentiana asclepiadea	*6*	43 $^{+-1}$
Geranium robertianum	*6*	29 $^{+}$
Glechoma hederacea	*6*	7 $^{+}$
Gymnocarpium dryopteris	*6*	14 $^{+}$
Heracleum sphondylium	*6*	7 $^{+}$
Lamium galeobdolon	*6*	93 $^{+-3}$
Lathraea squamaria	*6*	7 $^{+}$
Lathyrus vernus	*6*	14 $^{+}$
Lonicera alpigena	*5*	14 $^{+-1}$
Lonicera alpigena	*6*	36 $^{+-1}$
Lonicera nigra	*5*	21 $^{+-1}$
Lonicera nigra	*6*	36 $^{+-1}$
Lonicera xylosteum	*6*	7 $^{+}$
Lonicera xylosteum	*5*	7 ^{1}
Luzula luzulina	*6*	7 ^{1}
Lycopodium annotinum	*6*	7 $^{+}$
Melampyrum sylvaticum	*6*	7 $^{+}$
Mycelis muralis	*6*	57 $^{+-1}$
Myosotis sylvatica	*6*	7 $^{+}$
Oxalis acetosella	*6*	86 $^{+-3}$
Paris quadrifolia	*6*	57 $^{+}$
Picea abies	*1*	43 $^{1-3}$
Picea abies	*4*	7 $^{+}$
Picea abies	*5*	71 $^{+-1}$
Picea abies	*2*	43 ^{1}
Picea abies	*6*	29 $^{+}$
Platanthera bifolia	*6*	7 $^{+}$
Poa pratensis	*6*	7 $^{+}$
Polygala vulgaris	*6*	7 $^{+}$
Polygonatum multiflorum	*6*	21 $^{+}$
Polygonatum verticillatum	*6*	29 $^{+}$
Polypodium vulgare	*6*	29 $^{+}$
Polystichum lonchitis	*6*	21 $^{+}$
Polystichum setiferum	*6*	50 $^{+-1}$
Populus tremula	*5*	7 $^{+}$
Prenanthes purpurea	*6*	57 $^{+}$
Rhamnus alpinus s. fallax	*6*	7 $^{+}$
Rhamnus alpinus s. fallax	*5*	21 $^{+-1}$
Rubus hirtus	*6*	100 $^{+-5}$
Rubus idaeus	*6*	14 $^{+}$
Ruscus hypoglossum	*6*	14 $^{+}$
Salix caprea	*5*	7 $^{+}$
Salvia glutinosa	*6*	21 $^{+}$
Salvia pratensis	*6*	7 $^{+}$
Sambucus nigra	*6*	7 $^{+}$
Sambucus racemosa	*5*	7 $^{+}$
Sambucus racemosa	*6*	14 $^{+}$
Sanicula europaea	*6*	43 $^{+-1}$
Scrophularia nodosa	*6*	7 $^{+}$
Senecio germanicus	*6*	64 $^{+}$
Sorbus aucuparia	*5*	29 $^{+-1}$
Sorbus aucuparia	*2*	7 $^{+}$
Sorbus aucuparia	*6*	43 $^{+-1}$
Symphytum tuberosum	*6*	7 $^{+}$
Telekia speciosa	*6*	7 $^{+}$
Ulmus glabra	*5*	7 ^{1}
Ulmus glabra	*1*	7 ^{1}
Ulmus glabra	*6*	21 $^{+}$
Ulmus glabra	*2*	14 $^{1-2}$
Vaccinium myrtillus	*6*	14 ^{1}
Viola reichenbachiana	*6*	57 $^{+}$
Geranium robertianum	*6*	31 $^{+}$
Heracleum sphondylium	*6*	23 $^{+}$
Hordelymus europaeus	*6*	38 $^{+}$
Hypericum montanum	*6*	15 $^{+}$
Knautia dinarica	*6*	23 $^{+}$
Lamium galeobdolon	*6*	85 $^{+-2}$
Lamium maculatum	*6*	8 ^{1}
Laserpitium krapfii	*6*	38 $^{+}$
Lathyrus vernus	*6*	8 $^{+}$
Lilium martagon	*6*	15 $^{+}$
Lonicera alpigena	*5*	8 ^{1}
Lonicera alpigena	*6*	46 $^{+-1}$
Lonicera nigra	*5*	15 $^{+-1}$
Lonicera nigra	*6*	8 $^{+}$
Lonicera xylosteum	*5*	15 $^{+-1}$
Lunaria rediviva	*6*	8 ^{1}
Luzula sylvatica	*6*	31 $^{+-1}$
Melampyrum sylvaticum	*6*	15 $^{+}$
Milium effusum	*6*	15 $^{+}$
Mycelis muralis	*6*	38 $^{+-1}$
Myosotis sylvatica	*6*	15 $^{+}$
Oxalis acetosella	*6*	62 $^{+-2}$
Paris quadrifolia	*6*	31 $^{+}$
Phyteuma spicatum	*6*	8 $^{+}$
Picea abies	*2*	69 $^{1-2}$
Picea abies	*1*	85 $^{1-3}$
Picea abies	*5*	69 $^{+-2}$
Picea abies	*6*	8 $^{+}$
Picea abies	*4*	8 $^{+}$
Polygonatum verticillatum	*6*	38 $^{+}$
Polystichum setiferum	*6*	54 $^{+}$
Populus tremula	*5*	8 $^{+}$
Prenanthes purpurea	*6*	69 $^{+}$
Pulmonaria officinalis	*6*	8 $^{+}$
Ranunculus platanifolius	*6*	8 $^{+}$
Rhamnus alpinus s. fallax	*6*	8 $^{+}$
Rhamnus alpinus s. fallax	*5*	62 $^{1-3}$
Rosa pendulina	*6*	46 $^{+}$
Rubus hirtus	*6*	15 $^{+}$
Rubus idaeus	*5*	23 $^{+-1}$
Rubus idaeus	*6*	38 $^{+-2}$
Salix caprea	*2*	8 ^{1}
Sambucus ebulus	*5*	8 $^{+}$
Sambucus racemosa	*5*	8 $^{+}$
Sambucus racemosa	*6*	8 $^{+}$
Sanicula europaea	*6*	46 $^{+}$
Saxifraga rotundifolia	*6*	23 $^{+}$
Scrophularia nodosa	*6*	15 $^{+}$
Senecio germanicus	*6*	31 $^{+}$
Sorbus aucuparia	*5*	54 $^{+-2}$
Sorbus aucuparia	*2*	8 ^{2}
Stellaria nemorum	*6*	8 ^{1}
Symphytum tuberosum	*6*	31 $^{+}$
Telekia speciosa	*6*	8 $^{+}$
Thalictrum aquilegifolium	*6*	8 $^{+}$
Ulmus glabra	*2*	8 ^{1}
Urtica dioica	*6*	23 $^{+-4}$
Vaccinium myrtillus	*6*	38 $^{+-3}$
Veronica chamaedrys	*6*	23 $^{+}$
Veronica urticifolia	*6*	23 $^{+}$
Viola reichenbachiana	*6*	85 $^{+-1}$

Some species, however – *Cardamine trifolia* (R), *Cardamine kitaibelii* (syn. *Cardamine polyphylla*) (V) – are present on Grmeč but absent on Bjelašnica, which is associated with the range of these species, classified as protected rare (R) and vulnerable (V) species (Šilić, 1996). As well as differences arising from the range of species, there are also floristic differences resulting from sampling times and the corresponding phenophases when the surveys were conducted. Further species found on Grmeč were *Fraxinus excelsior*, *Daphne laureola, Cardamine bulbifera, Circaea lutetiana, Eupatorium cannabinum, Lathraea squamaria, Platanthera bifolia, Poa pratensis, Polygonatum multiflorum, Ruscus hypoglossum, Salvia glutinosa, Salvia pratensis, Sambucus nigra*, which were not observed on Bjelašnica during the course of this study, though this does not mean they are absent. During the study conducted by Beus and Vojniković (2002) in the virgin forest area of Ravna Vala – Bjelašnica (department 106), *Cardamine bulbifera, Polygonatum multiflorum* and *Salvia glutinosa*, or *Circaea lutetiana* were recorded, but were not observed during the present study. Some of these species, such as *Sambucus nigra, Eupatorium cannabinum, Poa pratensis* and *Salvia pratensis*, are not typical forest species but are associated with human activity in forest ecosystems. A few of these species are vulnerable or rare: *Platanthera bifolia* is classified as rare (R), *Ruscus hypoglossum* as endangered (E), and *Daphne laureola* as rare (R) (Šilić, 1996).

Species recorded on Bjelašnica but not on Grmeč include *Adenostyles alliariae, Angelica sylvestris, Carduus personata, Dactylorhiza maculata, Doronicum columnae, Digitalis grandiflora, Hordelymus europaeus, Hypericum montanum, Phyteuma spicatum, Stellaria nemorum, Veronica chamaedrys* and *Veronica urticifolia.* Among the tall herbaceous species (class *Adenostyletea*) that feature within this forest phytocoenosis are *Adenostyles alliaria, Angelica sylvestris, Digitalis grandiflora, Veronica urticifolia, Stellaria nemorum* and *Phyteuma spicatum*, which appear infrequently, in small numbers and over limited areas. None of these species is classified as rare or vulnerable. However, their presence on Bjelašnica in beech and fir forest is an indication that the habitat has been somewhat disturbed in places, since they were found where trees had been felled, in clearings, along forest roads and log tracks on fresh, friable, nutritious soil with fully decomposed humus. Still more significant is the presence of *Rhamus alpinus* s. *fallax* and *Festuca altissima* in significantly greater abundance and percentage cover as well as frequency in beech and fir forest on Bjelašnica by comparison with Grmeč. These species are associated with forest habitats on limestones of which the structure has broken down, where there is sufficient light for them to develop at shrub or herbaceous level respectively. The presence of these species may also indicate a somewhat higher level of xerothermalization of the habitat. Though not recorded during the surveys, the forest species *Vicia oroboiedes* is also present on Bjelašnica (personal observation), which Šilić (1996) classifies as rare (R).

Analysis of the diversity and equality indexes of vascular plant flora

In all, 115 species of vascular plants were recorded on fourteen of the relevés in the beech and fir forest on Grmeč, an average of 30 per relevé. The largest number of species on a relevé was 52, compared with 17 on the relevé with the fewest species. It was found, however, that the relevé with the largest number of species did not have the highest Shannon diversity index. The highest Shannon diversity index was 3.42, and the lowest was 2.12, on a relevé which also had almost the lowest equality index value (0.69). In the studies conducted by Višnjić et al (2009) in the virgin forest reserve of beech and fir with spruce at Plješevica in western Bosnia, the Shannon diversity index was similar in value, at 2.89.

On Bjelašnica, a total of 105 species of vascular plants were recorded on thirteen of the relevés in beech and fir forest on limestone substrate. The average number of species per relevé was 28; the numbers ranged from the maximum number of 39 species on one relevé to 21 on the relevé with the fewest species. The average Shannon diversity index was 2.46. The relevé with the most species and the highest equality index (0.83) also had the highest Shannon diversity index (3.14). The lowest Shannon index (1.93) was on the relevé with the lowest equality index (0.63), which was also the relevé with the fewest species. The average equality index value on Bjelašnica was 0.71.

The box and whisker diagrams below – species numbers (Diag. 1), Shannon index (Diag. 2) and equality index (Diag. 3) reveal that there are no significant differences in the diversity indexes for herbaceous plants for the beech-fir forest stands on Grmeč and Bjelašnica. The quantitative results suggest that the selective cuting management system of the beech-fir forests on Grmeč and Bjelašnica has had roughly the same effect on herbaceous flora diversity, including species number, diversity and species equality.

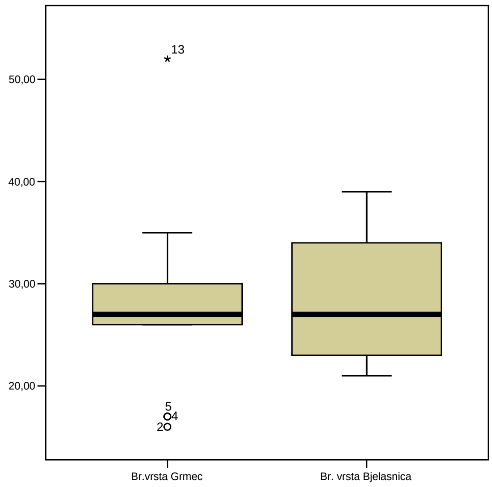

Diagram 1: *Box and whisker diagram of species numbers for stands of beech-fir forest on Grmeč and Bjelašnica.*

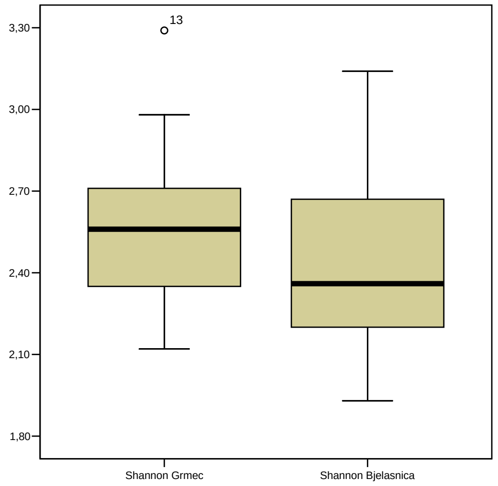

Diagram 2: *Box and whisker diagram of herbaceous flora diversity (Shannon index) for stands of beech-fir forest on Grmeč and Bjelašnica.*

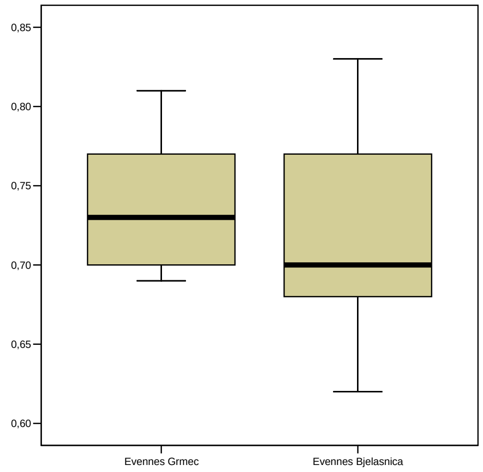

Diagram 3. *Comparison of tree species diversity on Bjelašnica and Grmeč*

The findings of the studies on Bjelašnica and Grmeč were used to compare the diversity of the recorded tree species by number of trees of each species and the ratio of the basal area of each tree to the basal area as a whole. The results of the study revealed that there are differences in tree species diversity between Bjelašnica and Grmeč.

The average number of tree species on Bjelašnica on the fifteen relevés in beech and fir forest with spruce on limestone substrate was four, compared with an average of six tree species on the fifteen relevés in western Bosnia (Grmeč). In terms of diversity by number of species and abundance of each species, greater tree species diversity was observed on Grmeč, where the Shannon index had a value of 1.551, compared with 1.303 on Bjelašnica. Variance analysis identified a statistically significant difference in diversity by number of species and number of trees per species at the two sites. Similar results were obtained by Solaković (2011), who studied tree diversity in western Bosnia, where the diversity index by number of trees was 1.78.

Table 2: *Average tree species diversity on Bjelašnica and Grmeč calculated on the basis of the number of tree species and the number of individual trees per species*

Site	N	Number of species	Diversity by number of individuals	T-test
Bjelašnica	15	4	1.303	+
Grmeč	15	6	1.551	*
Probability level 0.95		F = 4.89		

Still greater differences in tree diversity were revealed from an analysis of diversity by ratio of the basal area of the various trees on the relevés to the total basal area. Diversity by basal area on Grmeč was 1.538, compared with 1.182 for Bjelašnica. The conclusion is that tree species diversity by basal area is greater on Grmeč, with a statistically significant difference compared with that on Bjelašnica, with a probability level of 95%. The ratio of species by basal area on Grmeč is significantly more evenly distributed than on Bjelašnica, with no single species dominant in the distribution of basal areas, which cannot be said of Bjelašnica.

Table 2: *Average tree species diversity on Bjelašnica and Grmeč calculated on the basis of the number of tree species and ratio of their basal area*

Site	N	Number of species	Diversity by basal area	T-test
Bjelašnica	15	3.8	1.182	+
Grmeč	15	5.6	1.538	*
Probability level 0.95		F = 7.32		

Differences in tree species diversity by species abundance at these sites are the result of the local climate, the prevailing habitat-related orographic and edaphic conditions, and human activity over the centuries, with latitude and altitude, along with the interaction between animals and plants within these forests, playing a decisive part. However, as regards tree species diversity by basal area, the main impact is anthropogenic. Different management systems are applied at various sites in these forests, with different objectives. The projected composition ratio has a marked impact on the basal area, so that the state of the basal area is closely tied to management. It would thus appear that the management system applied on Grmeč encourages dendrological diversity to a markedly greater extent than is the case on Bjelašnica.

CONCLUSIONS

The analysis of the floral elements present at the sites suggests that there are differences between the areas studied as regards individual species of vascular plants. A greater number of species on the potential Red List for the flora of Bosnia and Herzegovina were recorded on Grmeč than on Bjelašnica, which can be explained by the proximity of centres of Illyrian provenance (north-western Bosnia, north-western Croatia and part of Dinaric Slovenia). On the other hand, the presence of tall herbaceous plants (class *Adenostyletea*) in forest stands suggests that there are greater felled areas, log tracks or open habitats on parts of Bjelašnica, allowing tall herbaceous plants to establish. Typical Illyrian species found in Slovenia and Croatia, such as: *Lamium orvala, Omphalodes verna, Haquetia epipactis, Scopolia carniolica* and *Calamintha grandiflora*, were not recorded during this study. However, certain distinctive and characteristic species associations give these forests their particular appearance, distinguishing them from central European beech-fir forests: *Aremonio-Fagion* (Syn. *Fagion illyricum*), and species such as *Euonymus latifolius, Rhamnus fallax, Daphne blagayana, Aremonia agrimonoides, Euphorbia carniolica, Cardamine polyphylla* and *Dentaria trifolia.* Given their location in relation to the centre of species of Illyrian provenance, these species may be described as meta-Illyrian (from the Greek *meta*, with, after, between – Oxford English Dictionary on-line, 27 July 2012; Klaić, 1958). Beech and fir forests (with spruce) in Bosnia on a limestone-dolomite geological substrate have not been clearly classified syntaxonomically according to current phytocoenlogical nomenclature. In Slovenian and Croatian reference works, these forests are referred to as *Omphalodo-Fagetum* Marinček et al. 1992, in line with the current code of phytocoenlogical nomenclature. Studies in Bosnia and Herzegovina (Višnjić et al. 2009) have not confirmed the presence of *Omphalodes verna,* which is regarded as the differential species of the communities of these forest, making the use of this term questionable in the case of Bosnia and Herzegovina. The question of nomenclature or syntaxonomical definition should be resolved at a future date.

Differences have been observed in the number of species of vascular plants between beech and fir forests (with spruce) on various geological substrates (Beus et Vojniković, 2010). Previous diversity studies have demonstrated that there are no significant differences in the diversity indexes and number of species of vascular flora between managed forests and virgin beech and fir forest (with spruce) on limestones-dolomites (Beus et Vojniković 2002, Sebastia et al. 2003, Beus et Vojniković 2006). The analysis also shows that there are no significant differences in the number of species, diversity index and equality index between the forests studied in western and central Bosnia where the same management systems are applied. The quantitative results suggest that the selective cuting management systems applied to beech-fir forests on Grmeč and Bjelašnica have approximately the same impact on herbaceous plant diversity, including number of species, diversity and species equality.

Differences in tree species diversity are potentially caused by the local climate, habitat-related orographic and edaphic conditions, syndynamic moments and human activity over the centuries. This statement is valid if tree species diversity is compared by number of species and abundance of each species.

However, in the case of tree species diversity by basal area, the impact of management is of greatest significance in preserving tree diversity in beech and fir forests with spruce. One of the indicators of forest management quality is the preservation of indigenous tree species and their even distribution within a community. The present study has revealed that the management system applied on Grmeč helps to conserve and enhance the state of diversity of beech and fir forest with spruce.

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COMPARATIVE RESEARCH OF SIZE AND NUMBER OF STOMATA OF DIFFERENT BEECH CULTIVARS

Marina NONIĆ[1]*, Dušan JOKANOVIĆ[1], Radmila KNEŽEVIĆ[1]

Abstarct: *This paper presents the results of the variability of stomatal parameters (stomatal dimensions and number) of the leaves of ornamental cultivars of beech: red-leaf Fagus sylvatica L. 'Purpurea' and variegated-leaf Fagus sylvatica L. 'Roseomarginata' (= F. Sylvatica L. 'Purpurea Tricolor'), as well as the leaves of Fagus moesiaca (Domin, Maly) Czeczott. - control. These trees, from which the leaves are collected, were selected at the site Beli Dvor and two private gardens in Belgrade. Ten leaves were taken from each tree for the research of size (width and length) and number of stomata per unit area. The number and size of stomata were measured on the lower epidermis of the leaf. The characteristics of stomata were determined by the method "collodion process", stomata were taken between the third and fifth leaf vein. Analysis was performed using the computer system and a microscope with a camera. The values obtained for stomatal sizes were processed by computer program "Statistica". There are differences between the ornamental cultivars and the Moesian beech. The research results are shown in the paper.*

Key words: stomata, red-leaf beech, variegated-leaf beech

INTRODUCTION

European beech (*Fagus sylvatica* L.) is a significant forest tree species, also renowned by numerous ornamental cultivars. These representing spontaneous mutants in leaf colour and shape are very rare and insufficiently researched in Belgrade. European beech is a drought-sensitive species, and drought stress is one of the most important limiting factors for photosynthesis, as it induces stomata closing. Stomatal density, apertures and their regulation are of key interest in the study of drought-adaptation in forest trees (Čaňová, *et al*., 2008). Stomatal characteristics vary widely among beech species and genotypes (Fei *et al*., 1999; Denk, 2003; Čaňová, *et al*., 2008).

The results of the study of anatomical characters of the leaves from selected beech test trees are presented. The research object were 5 test trees – 4 ornamental beech cultivars: *Fagus sylvatica* L. 'Purpurea' and *Fagus sylvatica* L. 'Purpurea Tricolor' and one Moesian beech - *Fagus moesiaca* (Domin, Maly) Czeczott. Test trees were selected from 3 different locations in Belgrade.

The aim of this research was to study the variability of the stomatal characteristics of selected ornamental beech cultivars and compare it with Moesian beech.

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MATERIALS AND METHODS

Test trees of ornamental beech cultivars - *Fagus sylvatica* L. 'Purpurea' (trees number 1 and 2) and *Fagus sylvatica* L. 'Purpurea Tricolor' (trees number 4 and 5) and one Moesian beech - *Fagus moesiaca* (Domin, Maly) Czeczott (tree number 3), were selected in Belgrade. At the site Beli Dvor were selected 3 test trees (*Fagus sylvatica* L. 'Purpurea' and *Fagus moesiaca* (Domin, Maly) Czeczott.), another 2 test trees (*Fagus sylvatica* L. 'Purpurea Tricolor') were selected in private courtyards on Banovo Brdo and Žarkovo. Ten fully expanded leaves were collected from each tree. Stomatal imprints from leaves were prepared in a laboratory under identical conditions, a sudden or extended dark or a high temperature and strong wind can close the stomata or influence their degree of openness (Brewer, 1992; Batos *et al*., 2010).

Stomatal imprints were taken by applying colourless nail polish over the midrib on the abaxial leaf side in the direction from the petiole to the leaf top. All imprints were fixed onto glass microscope slides (Figure 1). Stomatal density and dimensions were measured by analyzing the imprints with a light microscope with a camera (*Magnum*), at a magnification of 40 x 10 and 100 x 10.

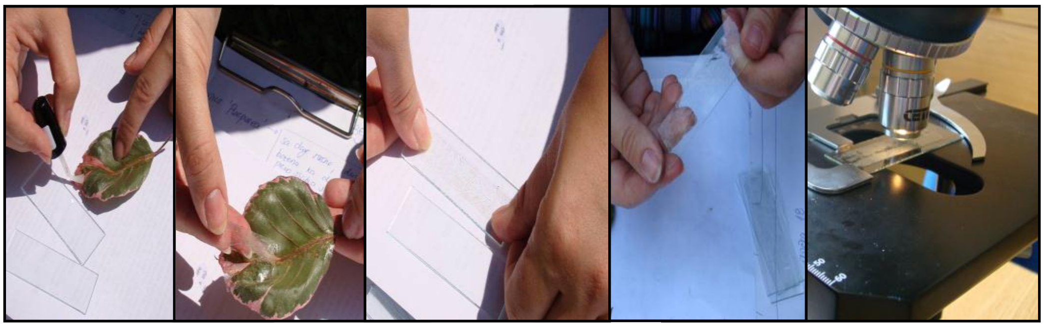

Figure 1. *Method for making stomatal imprints*

Three stomatal parameters were analyzed: stomatal density (*SD*), stomatal length (S_L) and stomatal width (S_W), and one derived parameter - stomatal shape coefficient (*SSC*). Stomatal density was defined as the number of stomata per mm^2, while stomatal size was defined as the length and width of the stomatal aperature (5 sampled stomata were measured per imprint using calibration factors for the microscope). The data were processed by the software package „Statistica“. Following results were presented: descriptive statistics (minimum and maximum values, average value, standard deviation), LSD-test, one-way analysis of variance and cluster analysis.

RESULTS AND DISCUSSION

In Serbia, the leaf stomatal traits of beech cultivars have been studied by a small number of researchers. Vilotić *et al.* (2006) were analyzed the morpho-anatomical characteristics of leaves of cultivars *Fagus sylvatica* 'Luteofolia' and *Fagus sylvatica* 'Atropunicea', but no detailed research has been done so far on stomatal characteristics of *Fagus sylvatica* 'Purpurea Tricolor' cultivar. In Slovakia, Čaňová, *et al*. (2008) were analyzed changes in stomatal characteristics in European beech cultivars: 'Aurea Pendula', 'Cristata', 'Rohanii', 'Rotundifolia' and 'Viridivariegata', during leaf development.

Results of descriptive statistics for measured anatomical characteristics are presented in Table 1.

Table 1: *Results of descriptive statistics for size and number of stomata*

Trait	Tree	1	2	3	4	5
S_L (μm)	X_{min} - X_{max}	15.00-24.20	13.10-24.80	15.70-27.50	13.30-22.20	18.30-26.10
	$\overline{X}$	18.70	17.88	20.14	19.37	21.29
	Sd	2.00	2.65	2.54	1.91	1.94
S_W (μm)	X_{min} - X_{max}	7.20-19.00	9.80-19.60	11.80-22.90	12.10-22.20	9.80-20.90
	$\overline{X}$	12.87	15.05	17.97	16.62	16.83
	Sd	3.03	2.44	2.34	2.03	2.78
SSC **(%)**	X_{min} - X_{max}	40.91-107.65	53.57-126.67	60.15-128.22	61.73-121.02	47.23-100.00
	$\overline{X}$	68.77	85.54	90.29	86.72	79.31
	Sd	13.78	16.53	14.54	14.02	12.84
SD (mm^{-2})	X_{min} - X_{max}	56.00-88.00	72.00-104.0	56.00-92.00	44.00-88.00	52.00-80.00
	$\overline{X}$	75.55	85.78	74.22	64.44	70.67
	Sd	9.59	10.29	11.82	14.45	9.50

Legend: S_L - stomatal length; S_W - stomatal width; ***SSC*** - stomatal shape coefficient; ***SD*** - stomatal density; X_{min} - X_{max} - minimum and maximum values; $\overline{X}$ - average value; ***Sd*** - Standard deviation

The values show statistically significant differences in the size and density of stomata. Values for stomatal length range from 13.10 μm to 27.50 μm, and for stomatal width from 7.20 μm to 22.90 μm. The smallest mean stomatal length and width were measured in leaves of red beech cultivar (*Fagus sylvatica* 'Purpurea') - tree number 2 for smallest stomatal length (17.88 μm) and number 1 for smallest mean stomatal width (12.87 μm), Figure 2. The highest mean stomatal length was observed in cultivar *Fagus sylvatica* 'Purpurea Tricolor' (tree number 5 - 21.29 μm), while the highest stomatal width was measured in *Fagus moesiaca* (Domin, Maly) Czeczott. leaves (tree number 3 - 17.97 μm), Figure 3 and Figure 4.

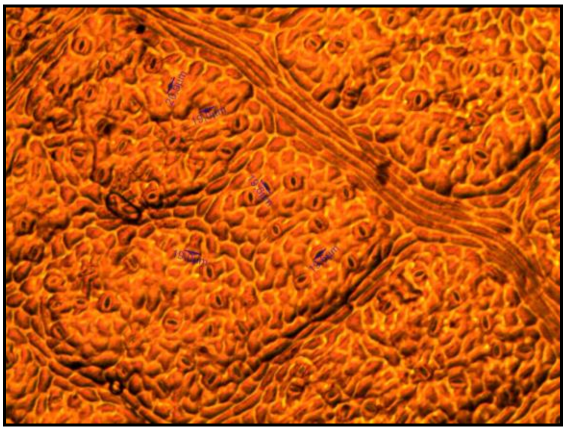

Figure 2. *Stomata of F. sylvatica L. 'Purpurea'*

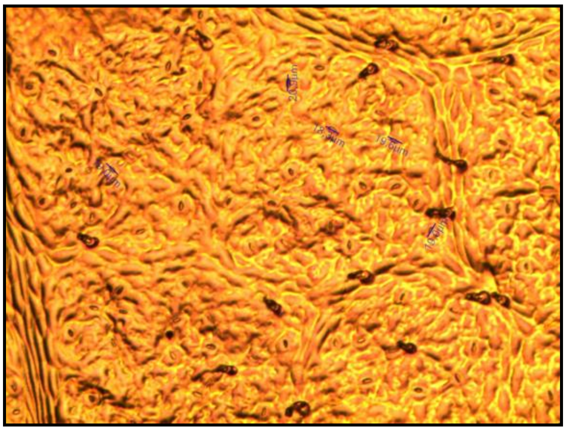

Figure 3. *Stomata of F. sylvatica L. 'Purpurea Tricolor'*

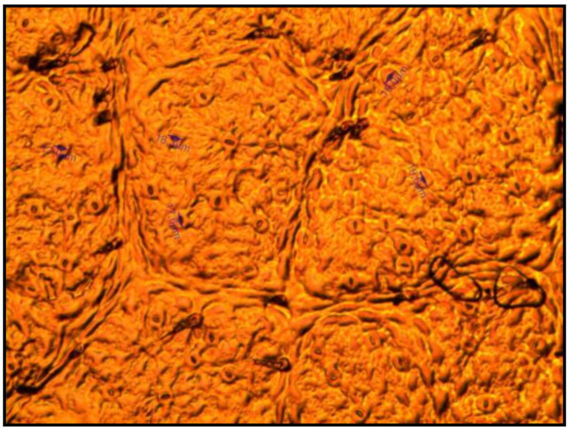

Figure 4. *Stomata of F. moesiaca (Domin, Maly) Czeczott.*

These results are similar with results of research where Vilotić *et al.* (2006), were analyzed the morpho-anatomical characteristics of leaves of red beech, yellow beech and European beech. Results of their analysis also showed that the smallest stomatal length and width were measured on red beech cultivars.

Stomatal shape coefficient (*SSC*) was defined as the ratio of the stomatal width (S_W) and stomatal length (S_L), in percentages (Batos *et al*., 2010):

$$SSC = \left(\frac{Sw}{Sl}\right) \cdot 100$$

Test trees were grouped into three categories, according to the stomatal shapes:

1) *SSC* = < 80% - more elongated stomata
2) *SSC* = 80-90% - less elongated stomata
3) *SSC* = > 90% - flattened stomata

The mean values for stomatal shape coefficient show that ornamental beech cultivars are characterized with different shape of stomata, in comparison with Moesian beech. Stomata of *Fagus sylvatica* 'Purpurea' and *Fagus sylvatica* 'Purpurea Tricolor' belong to first and second category, with more or less elongated stomata, while stomata of *Fagus moesiaca* (Domin, Maly) Czeczott. belong to third category, because mean value for *SSC* is >90% (90.29 %) and the shape is different - flattened stomata. The most elongated stomata are observed in leaves of red beech cultivar – tree number 1 (68.77 %).

The values for the number of stomata per mm² show that the red beech cultivar is statistically different, with a greater number of stomata on the abaxial leaf side (85.78 and 75.55 stomata per mm²), while the smallest number was obtained in variegated-leaf beech (64.44 and 70.67 stomata per mm²). This result confirms that the leaves with smaller stomata (the smallest mean stomatal length and width were measured in leaves of red beech cultivar) have higher stomatal density and larger transpiration area. A large stomatal opening that induces transpiration is a necessary consequence of the plant's need to maintain gas exchange in leaves for photosynthesis (Lemoine *et al*., 2002). On the other side, values for Moesian beech are between red beech and variegated-leaf beech cultivars (74.22 stomata per mm²). These results are very similar with results of Vilotić *et al.*, where: „*the red beech cultivar is statistically significantly different, it has a greater number of stomata (85.33) on the leaf underside, compared to the yellow beech cultivar and common beech*" (Vilotić *et al*., 2006).

Results of Analysis of variance (Table 3) showed that the obtained differences between average values of beech cultivars and Moesian beech were statistically significant (P-value <0.05) for all analyzed characteristics of stomata.

Table 2: *Results of analysis of variance (ANOVA)*

Between trees			
Trait	**Mean Square**	**F-ratio**	**P-Value**
Stomatal length	155.25	31.24	0.00
Stomatal width	350.16	53.90	0.00
Stomatal shape coefficient	6427.04	31.02	0.00
Stomatal density	1095.82	8.61	0.00

Table 2 presents the results of LSD test for analyzed characteristics of stomata.

Table 2: *LSD-test for analyzed characteristics of stomata*

LSD-test					
Tree	Average value	Homogenous groups	Tree	Average value	Homogenous groups
Stomatal length (μm)			**Stomatal width** (μm)		
2	17.88	X	1	12.87	X
1	18.70	X	2	15.05	X
4	19.37	X	4	16.62	X
3	20.14	X	5	16.83	X
5	21.29	X	3	17.97	X
Stomatal shape coefficient (%)			**Stomatal density** (mm^{-2})		
1	68.77	X	4	64.44	X
5	79.31	X	5	70.67	XX
2	85.54	X	3	74.22	X
4	86.72	XX	1	75.55	X
3	90.29	X	2	85.78	X

The test trees were grouped to identify similarities and differences between the average values. Values for the stomatal length are very different and trees were not grouped, while values for stomatal width of trees number 4 and 5 are similar (16.62 and 16.83 μm), and make one homogenous group. For stomatal density, trees number 4 and 2 are very different, and trees number 1 and 3 are in one homogenous group.

According to the diagram of Cluster analysis (Diagram 1), it can be concluded that the shortest linkage distance is recorded between trees 3, 5 and 4 (*Fagus moesiaca* (Domin, Maly) Czeczott. and *Fagus sylvatica* 'Purpurea Tricolor'), on the other side are linked trees number 1 and 2 (*Fagus sylvatica* 'Purpurea') on longer distance.

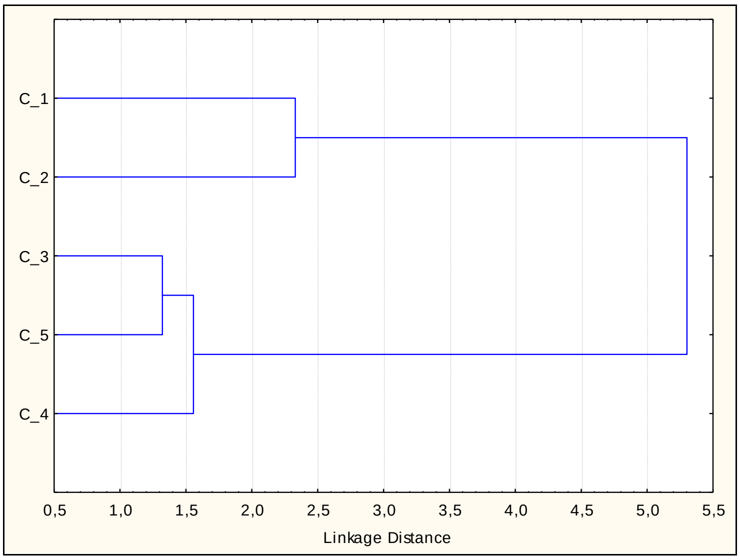

Diagram 1. *Cluster analysis diagram based on stomatal length, width and stomatal shape coefficient*

CONCLUSIONS

Based on the results of the study of anatomical characteristics of the leaves (size and number of stomata), which are undoubtedly under genetic control, it was concluded that beech cultivars with red leaves (*Fagus sylvatica* 'Purpurea') are significantly different from variagated-leaf beech cultivars (*Fagus sylvatica* 'Purpurea Tricolor'), as well as from the Moesian beech (*Fagus moesiaca* (Domin, Maly) Czeczott.).

It can be concluded that the red-leaf beech showed the smallest mean stomatal length and width and highest stomatal density. This means that leaves of red beech have larger transpiration area, and this cultivar can be planted on the moister sites, compared to both variagated-leaf and Moesian beech.

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4-5 October 2012, Institute of Forestry, Belgrade, Republic of Serbia

DIVERSITY OF ECTOMYCORRHIZA IN BEECH STANDS FROM DIFFERENT LOCALITIES IN SERBIA

Marina KATANIĆ[1], Bratislav MATOVIĆ[1], Saša PEKEČ[1],
Tine GREBENC[2], Hojka KRAIGHER[2]

Abstract: *Beech forests that make almost one half of forestry fond in Serbia have important function in biomass production and influence on environmental status. Valuable information about functioning of forest ecosystems can be provided by investigating the structure of mycorrhizal community. The aim of this study was to preliminarily describe and identify ectomycorrhizal types in natural managed beech (Fagus sylvatica L.) stands from four different sites in Serbia: Homolje Mountains, Čemernik-Ostrozub, East Boranja and Fruška gora. Samples were collected in December 2011 with soil corer of 274 ml volume at a distance of about 1m from the tree trunk. The total number of samples was 12 i. e. 3 samples per locality. Identification of fungal partner in ectomycorrhiza was obtained with morphological and anatomical characterization according to published descriptions. Different types of ectomycorrhiza were observed, described and identified. Shannon-Weaver diversity index and Species richness index were calculated. Total number of ectomycorrhizal types found in examined beech stands was 26 (8 types of ectomycorrhiza were found in the locality Fruška gora and East Boranja, 9 types in Čemernik-Ostrozub and 10 ectomycorrhizal types were observed in Homolje mountains). The preliminary results indicated high ectomycorrhiza diversity which is at the level of diversity published for other comparable beech stands in central and SE Europe. However, seasonal dynamics of ectomycorrhizal community structure should be investigated and identification of ectomycorrhizal types should be supplemented with molecular methods.*

Key words: ECM, *Fagus sylvatica* L., morphological-anatomical characterization, Serbia

1. INTRODUCTION

Establishment, growth and survival of trees in most temperate and boreal forests depend on colonization with ectomycorrhizal (ECM) fungi. Mycelium of ECM fungi represents the main component of forest ecosystems which link biotic with abiotic factors. ECM fungi successfully take water, organic and inorganic nutrients from soil and translocate them to fine roots of plants from which they obtain carbohydrates in return (Smith and Read, 2008). Since the functional compatibility and stress tolerance of ectomycorrhizal types is species specific, the information on the ectomycorrhizal community structure can provide valuable information about physiology of forest trees and functioning of forest ecosystems (Kraigher et al., 2007).

Beech (*Fagus sylvatica* L.) is the most common tree species in Europe and it has important economical and ecological function in forestry ecosistems (Jazbec, et al., 2007). In Serbia beech forests make almost one half of forestry fond. They have important function in biomass production and significant influence on environmental status as well (Vučićević, 2004).

In spite of the importance of this species, data about community structure of ECM fungi on beech in Serbia are scarce (Katanić et al., 2011). The aim of this study was to preliminary describe and identify types of ectomycorrhizae in natural managed beech (*Fagus sylvatica* L.)

stands from four different sites in Serbia: Homolje mountains, Čemernik-Ostrozub, East Boranja and Fruška gora.

2. MATERIAL AND METHODS

ECM was analysed at four sites in Serbia representing pure or mixed natural uneven-aged managed beech (*Fagus sylvatica* L.): Homolje Mountains, Čemernik-Ostrozub, East Boranja and Fruška gora.

Locality at Homolje Mountains is situated 20 km from town Kučevo in Eastern Serbia. Coordinates of locality are N44°24’12’’ E21°36’35’’, altitude is 480 m a.s.l. and climate is continental. The average annual precipitation is 653 mm, average annual temperature is 11,3 ºC (data for Veliko gradište according to RHMZ) and soil type is illimeric soil (Škorić et al., 1985).

In Čemernik-Ostrozub samples were taken 15 km from town Predejane in South-eastern Serbia (N42°50’13’’ E22°12’47’’). Altitude of locality is 936 m a.s.l. and climate is temperate continental. The average annual precipitation is 625,4 mm, average annual temperature is 11,1 ºC (data for Leskovac according to RHMZ) and soil type is acid brown soil (Škorić et al., 1985).

Locality in East Boranja is placed 20 km from town Krupanj in Western Serbia (N44°21’24’’ E19°16’41’’). Altitude of locality is 801 m a.s.l. and climate is continental. The average annual precipitation is 868 mm, average annual temperature 11,6 ºC (data for Loznica according to RHMZ) and soil type is acid brown soil (Škorić et al., 1985).

Iriški venac locality is situated at Fruška gora, 20 km from Novi Sad in North-western Serbia. Coordinates of locality are N 45° 09’ 25’’ E 19°48’26’’, altitude is 480 m a.s.l. and climate is temperate continental. The average annual precipitation is 647,3 mm and average anual temperature is 11,4 ºC (data for Novi Sad according to RHMZ) and soil type is gray brown podzolic soil (Škorić et al., 1985).

Map of Serbia with studied sites

Beech was main and dominant woody species on all localities. However, on locality Krupanj was found *Sambucus nigra* L., while at Iriški vanac there were *Sambucus nigra L.*, *Acer platanoides L.*, *Tilia* sp. and *Rubus sp.* as well.

Soil samples at all localities were collected in December 2011. A soil corer of 274 ml volume was used for taking standardized samples (Kraigher, 1999) at a distance of about 1m from the tree trunk. The total number of samples was 12. Three samples were taken per each locality. Roots were carefully washed from soil and vital ECM root tips were separated from old, nonturgescent and nonmycorrhizal (ONN) roots in water under a dissecting microscope. Types of ECM were analyzed and ECM fungi identified after morphological and anatomical characteristics with a binocular (light sourse Olympus Highlight 3100, daylight filter) and microscope Olympus BX 51 (enlargement 100-2000x) according to published descriptions (Agerer, 1987-2002; Agerer et Rambold, 2004–2011) and methodology described by Agerer (1991) and Kraigher (1996). Divesity indices (Shannon Weaver index, Species richness index, Evenness, Equitability and Berger-Parker index) were calculated after formulas given by Atlas at Bartha (1981).

3. RESULTS AND DISSCUSION

The total number of ECM types at all sites was 26 (Table 1). Eleven types of ECM were identified to the species level: *Cenococcum geophilum* Fr., *Cortinarius bolaris* (Pers.:Fr.), *Fagirhiza cystidiophora*, *Fagirhiza tubulosa*, *Geastrum fimbriatum* Fr., *Genea hispidula* Berk. &Br., *Lactarius blennius* Fr., *Lactarius subdulcis* Bul: Fr, *Piloderma croceum* Erikss.& Hjortst, *Russula illota* Romagn., *Russula ochroleuca* (Pers.) Fr.; five types were determined to the genus level: *Lactarius* sp., *Russula* sp. 1, *Russula* sp. 2, *Russula* sp. 3 and *Tuber* sp., while ten ECM types remained unidentified.

It should be kept in mind that ECM types in this study were identified only according to morphological and anatomical characteristics, so identifications to the species level are only "closest to characteristics of these types". In order to support the identification, molecular methods should be applied. In that case it is assumed that results could differ to some extent from obtained ones (Štraus et al., 2011).

In the localities Iriški venac and Krupanj were separated 8 types of ECM, in Predejane 9 types and in Kučevo 10 ECM types (Table 2). Number of vital ECM in investigated samples was in range from 517 (Iriški venac) to 2288 (Predejane) and the total number of fine roots ranged from 2027 (Krupanj) to 9013 (Predejane). However, the highest percentage of vital ECM roots was found in Krupanj. The highest value of the species richness index was recorded in Kučevo (2,99) and Shanon Weaver index was highest at Iriški venac (1,64). The lowest values for both indices were found in Krupanj (2,35 and 1,15 respectivelly). For samples from Iriški venac were observed highest values of evenness, equitability and Berger-Parker index, while in Krupanj those values were the lowest among analysed localitites.

Diversity indices of ECM fungi recorded on investigated sites were comparable to diversity indices of ECM fungi on beech published in other papers (Al Sayegh Petkovšek, 2004; Grebenc, 2005; Grebenc et al. 2009; Mašek et Grebenc, 2011). Preliminarily results indicate high ECM diversity on investigated localities.

The ECM community structure differed among investigated localities (Figure 1). In all sites one dominant ECM type has made about a half of all ECM roots. In Kučevo the dominant ECM was *Lactarius subdulcis* with 51%, in Predejane *Cenococcum geophilum* (55%), in Krupanj *Lactarius blennius* (61%), and in Iriški venac *Cortinarius bolaris* with 46%. There was no ECM type in common for all investigated sites, yet *Russula illota* and *Lactarius blennius* were found at three sites. *Cenococcum geophilum* was recorded only in Predejane and Iriški venac. *Lactarius subdulcis*, *Cortinarius bolaris* and *Tuber* sp. were also found on two localities, while other ECM types occurred only on one of studied localities.

Recorded types of ECM are commonly found on beech (Brand, 1991; Grebenc et Kraigher, 2007; Kraigher et al., 2007). *Lactarius* and *Russula*, with three and five species/types of ectomycorrhizae were the most abundant genera in investigated samples which is in accordance with previous research (Grebenc, 2005; Grebenc et al., 2009). *Cenococcum geophilum* has a World-wide distribution with a wide range of plant partners (Smith et Read, 2008). Its mycorrhizae is very common on seedlings and mature trees but it rarely dominated root system (Ingleby et al., 1990). However, *Cenococcum geophilum* is known to be frequent and abundant on sites under the influence of stress factors (LoBuglio, 1999). At locality Predejane this species made 55% of all found vital ECM could indicate stress conditions. On the other hand it has been shown previously that *C. geophilum* may include several types and therefore should be considered as a „group type" (Al Sayegh Petkovšek et Kraigher, 1999). In order to confirm our finding, molecular analyses are needed and number of soil samples should be increased as well.

Expected global climate changes, especially decrease of precipitation and temperature increase, could result in increse thread to beech forests within their present areal (von Wuehlisch, 2004). Information about ECM community structure and abundance of ECM fungi on beech is helpful in estimating site condition of particular stands and monitoring their potential changes in future. In order to reveal potential disturbance of ECM fungal diversity on analysed localities, the ECM monitoring should be continued. In addition, the started monitoring should be supplemented with molecular methods for ECM identification and special attention should be paid on the seasonal dynamics of ECM community structure.

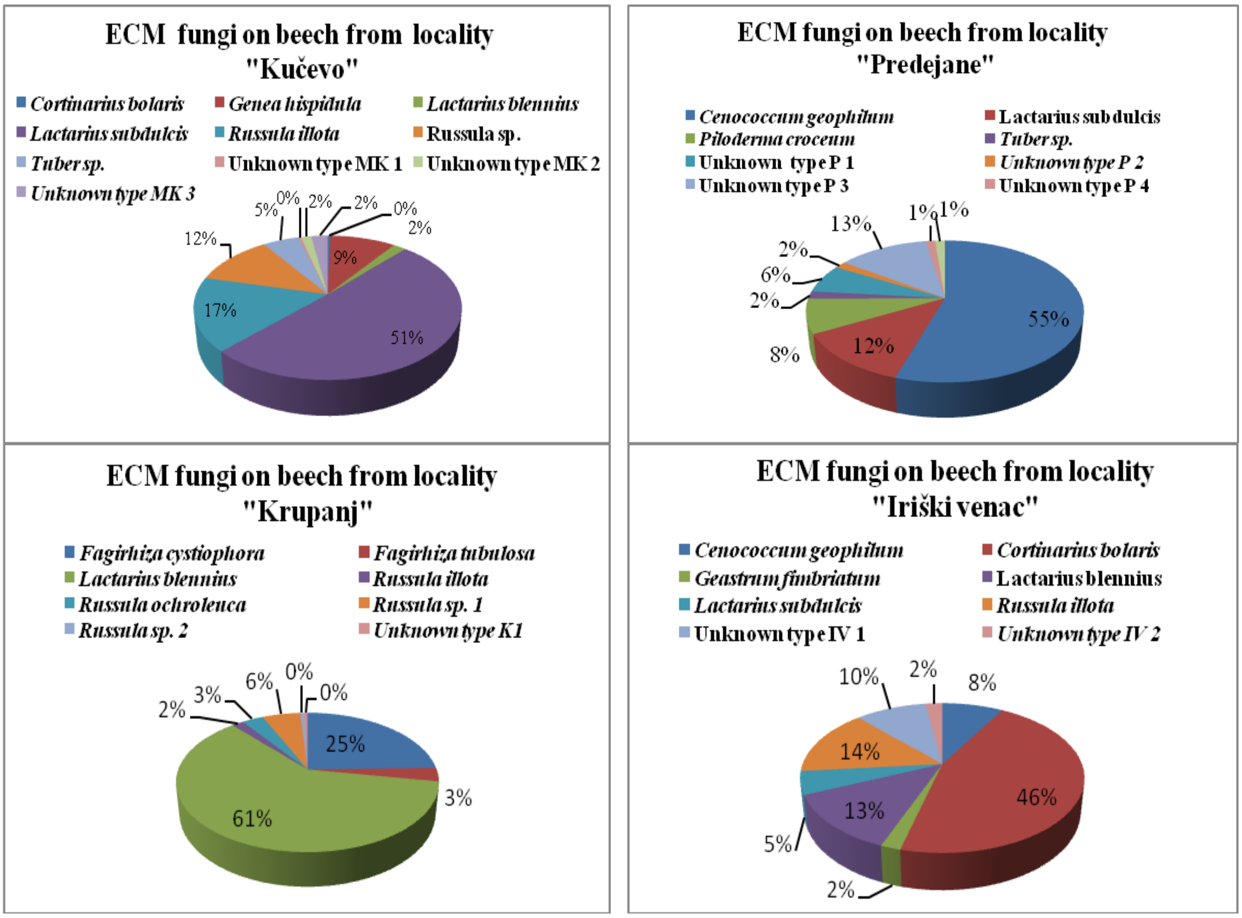

Figure 1. *ECM community structure of different sites in Serbia*

Table 1. *Description of ECM types found in beech stands from different localities in Serbia*

Designated identity code of ECM type	**Ramification and shape**	**Surface and color**	**Hyphae and cystidia**	**Rhizomorph, anastomoses**	**Anatomy of mantle**	**Locality** (IV=Iriški venac; MK=Kučevo; K=Krupanj; PR=Predejane)
***Cenococcum geophilum* Fr.**	simple, monopodial-pinnate, straight or bent	loosely woolly or long spiny, black	melanized hyphae without clamps, cystidia not observed	not observed	outer mantle hyphae star-like arranged and tightly glued together, G type according to Agerer (1987-2002), inner mantle plectenchymatous	PR, IV
***Cortinarius bolaris* Pers.:Fr.**	irregularly pinnate, bent	densely stringy, white silvery, brown	hyphae with clamps, cystidia not observed	rhizomorphs D type according to Agerer (1987-2002), anastomoses opened with short bridge	outer mantle plectenchymatous hyphae irregularly arranged with no special pattern, B type inner mantle plectenchymatous ring-like, A type according to Agerer (1987-2002)	MK, IV
Fagirhiza cystidiophora	monopodial-pyramidal, straight	short spinny, golden-yellow, cream	hyphae are not observed, cystidia A type according to Agerer (1987-2002)	not observed	outer mantle epidermoid cells bearing a hyphal net Q type according to Agerer (1987-2002), inner mantle plectenchymatous	K
Fagirhiza tubulosa	irregul., pinnate, bent	woolly-cottony, bright brown , silvery	hyphae without clamps, cystidia not observed	not observed	outer mantle P type according to Agerer (1987-2002), inner mantle plectenchymatous	K
***Geastrum fimbriatum* Fr.**	simpe, monopodial-pinnate, bent	densely woolly, white, silvery, brown	hyphae without clamps, cystidia P type according to Agerer (1987-2002)	rhizomorphs slightly differentiated C type according to Agerer (1987-2002) , anastomoses not observed	outer mantle hyphae irregularly arranged with no special pattern, B type according to Agerer (1987-2002), inner mantle plectenchymatous	IV
***Genea hispidula* Berk. &Br.**	monopodial pyramidal, bent	grainy with emanating hyphae or loosely woolly, dark brown	hyphae thick walled, without clamps, cystidia G type according to Agerer (1987-2002)	not observed	outer mantle angular cells, bearing mounds of roundish cells, K type according to Agerer (1987-2002), inner mantle plectenchymatous	MK
***Lactarius blennius* Fr.**	simple, mon. pinnate-pyramida, straight	shiny, smooth, light brown, golden, cream	hyphae without clamps, cystidia not observed	not observed	outer mantle epidermoid, puzzle-like, jig-saw-shaped, M type according to Agerer (1987-2002), inner mantle plectenchymatous with laticifers	MK, K, IV
***Lactarius* sp. PR8 005**	mon. pinnate-pyramidal, straight	smooth, golden-brown with veins	not observed	not observed	outer mantle Q type according to Agerer (1987-2002), inner mantle plectenchymatous with laticifers	PR
***Lactarius subdulcis* Bul: Fr**	monopodial – pinnate, pyramidal, bent	shiny, smooth, shiny, orange-brown, golden	hyphae without clamps, cystidia not observed	not observed	outer mantle angular cells bearing a hyphal net , P type according to Agerer (1987-2002), inner mantle plectenchymatous with laticifers	MK, PR
***Piloderma croceum* Erikss.&Hjortst.**	simple, monopodial pinnate or irregularly pinnate, bent	wooly-cottony, lemon yellow, white, silvery	hyphae without clamps, cystidia not observed	rhizomorphs A type according to Agerer (1987-2002), anastomoses closed by a simple septum, with bridge	outer mantle hyphae irregularly arranged with no special pattern , B type according to Agerer (1987-2002), inner mantle plectenchymatous	PR
***Russula illota* Romagn.**	monopodial pyramidal, straight, bent	densely short-spiny, with sand, cream, brown	hyphae not observed, cystidia D type according to Agerer (1987-2002)	not observed	outer mantle plectenchymatous hyphae arranged net-like, with prominent cystidia , D type according to Agerer (1987-2002) inner mantle plectenchymatous	MK, K, IV
***Russula ochroleuca* (Pers.) Fr**	monopodial pinnate, monopodial pyramidal,straight	densely grainy or warty, yellow with yellowish or greenish dots	not observed	not observed	outer mantle angular cells and mounds of flattened cells , O type according to Agerer (1987-2002), inner mantle plectenchymatous	K

Russula sp. K1 (K1 001)	simple, straight	grainy, light brown	hyphae are not observed, cystidia D type according to Agerer (1987-2002)	not observed	outer mantle K type according to Agerer (1987-2002), inner mantle plectenchymatous	K
Russula sp. K2 (K1 005)	pinnate, straight	smooth-grainy, golden-brown	hyphae are not observed, cystidia B type according to Agerer (1987-2002)	not observed	outer mantle M and in some parts Q type, inner mantle H type according to Agerer (1987-2002); structures that look like laticifers in inner mantle	K
***Russula* sp. MK1 MK 2 008**	irregularly pinnate, straight	grainy, dark brown	hyphae are not observed, cystidia B type according to Agerer (1987-2002)	not observed	outer mantle K type, inner mantle L type according to Agerer (1987-2002)	MK
***Tuber* sp.**	pinnate, bent	smooth with emanating hyphae, brown, younger parts are brighter	hyphae without clamps, cystidia A type according to Agerer (1987-2002)	not observed	outer mantle Q type according to Agerer (1987-2002), middle M type and inner mantle plectenchymatous	MK, PR
Unknown type IV 3 (FG 3 004)	irreg. pinnate-pyramidal, simple, straight-bent	loosely woolly, brown with white (silvery)	hyphae without clamps, cystidia not observed	not observed	outer mantle L and in some parts P type, inner mantle L type according to Agerer (1987-2002	IV
Unknown type IV 1 (FG 2 003)	irregularly pinnate, bent	loosely woolly, brown, younger parts are brighter	hyphae with clamps, cystidia not observed	not observed	outer mantle L and in some parts P type, inner mantle H type according to Agerer (1987-2002	IV
Unknown type K1 (K1 004)	pinnate, straight, bent	smooth with emen. hyphae, gray-brown	hyphae with clamps, cystidia not observed	not observed	outer mantle Q type according to Agerer (1987-2002), inner mantle plectenchymatous	K
Unknown type MK 1 (MK4 001)	simple, straight	smooth with emanating hyphae and sand, white	hyphae with clamps, cystidia not observed	rhizomorphs A type according to Agerer (1987-2002), anastomoses not observed	outer mantle plectenchymatous, B inner mantle H type according to Agerer (1987-2002)	MK
Unknown type MK 2 (MK 2 004)	pyramidal, bent	smooth with emen. hyphae and sand, white-cream	hyphae without clamps, cystidia not observed	not observed	outer mantle L type according to Agerer (1987-2002), inner mantle plectenchymatous	MK
Unknown type MK 3 (MK 3 004)	pinnate, straight	smooth, dark brown, young parts are golden-brown	not observed	not observed	outer mantle Q type, middle mantle M type and inner mantle plectenchymatous according to Agerer (1987-2002)	MK
Unknown type PR 1 (PR10 005)	pinnate, bent-torturous	smooth, gray-cream	not observed	not observed	outer mantle M type according to Agerer (1987-2002), inner mantle plectenchymatous	PR
Unknown type PR 2 (PR8 002)	pinnate, bent	woolly-cottony, cream-brown	hyphae with clamps, cystidia not observed	not observed	outer mantle hyphae arranged net-like, repeatedly and squarrosely branched , E type according to Agerer (1987-2002), inner mantle plectenchymatous	PR
Unknown type PR 3 (PR8 004)	simple, straight-bent	smooth with emen. hyphae, with sand, cream, gray	hyphae without clamps clamps not observed, cystidia not observed	not observed	outer mantle M type according to Agerer (1987-2002), inner mantle plectenchymatous	PR
Unknown type PR 4 (PR15 004)	simple, pinnate, bent	cottony, dark brown, younger parts are brighter	hyphae without clamps, cystidia N type according to Agerer (1987-2002)	not observed	outer mantle gelatinous matrix between the hyphae, C type according to Agerer (1987-2002), inner mantle plectenchymatous	PR

Table 2. *Number of ECM, fine roots and diversity indices on different localities from Serbia*

Locality	Number of ECM types	Number of vital ECM	Number of ONN roots	Total number of fine roots	% of vital ECM roots	Species richness index (d)	Shanon Weaver index (H)	Evennes s (e)	Equitabi lity (J)	Berger-Parker index
Kučevo (Homolje Mountains)	10	1032	7005	8037	12,8	2,99	1,46	1,46	0,21	0,48
Predejane (Čemernik-Ostrozub)	9	2288	6725	9013	25,4	2,38	1,42	1,49	0,18	0,44
Krupanj (East Boranja)	8	947	1080	2027	46,7	2,35	1,15	1,27	0,17	0,39
Iriški venac (Fruška gora)	8	517	1811	2328	22,2	2,58	1,64	1,82	0,26	0,54

4. CONCLUSIONS

- Total number of ECM types found in samples taken in investigated beech stands was 26
- Eleven types of ECM were identified to the species level, five were determined to the genus level, while ten types remained unidentified
- ECM community structure differed among investigated localities
- *Russula illota* and *Lactarius blennius* were found on three sites, *Cenococcum geophilum*, *Lactarius subdulcis*, *Cortinarius bolaris* and *Tuber* sp. were observed on two localities, while other ECM types occurred only on one of studied localities
- Preliminary results indicated a high ECM diversity on all investigated localities

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SURVEY OF MACROFUNGAL DIVERSITY IN THE FOREST ECOSYSTEMS OF VIDLIČ (STARA PLANINA), KOPAONIK AND TARA

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Abstract: *Forests represent one of the ecosystems with exceptional biodiversity and yet they are among the most threatened ones nowadays, due to unsustainable management, pollution, climate change. Fungal diversity is one of the most important indicators of overall forest biodiversity and its health. However, scarce information exists on the macrofungal diversity of mountain forests in Serbia.*

Survey conducted during four months in 2011, on three sites (Vzganica - Vidlič, Metođe – National Park Kopaonik, Mitrovac – National Park Tara), yielded in 119 species of macrofungi. They were recorded from the five selected permanent plots, each with the size of 1000m^2. Plots no.1 and 2 are situated on Vidlič (beech stand and stand of Douglas fir and spruce, respectively), plot no. 3 on Kopaonik (stand of beech and spruce), while plots no. 4 and 5 are located on Tara (stands of spruce, beech and fir). Fifteen species were collected from more than one plot, while 104 were collected from only one plot. Twenty species were reported during more than one investigated month and 99 were reported only once during investigated year. Forty-four species couldn't be identified. Among the identified species only 5 belong to division Ascomycota and 70 to division Basidiomycota. Determined fungal species were members of following ecological trophic groups: 38 identified species were lignicolous (wood-decaying), 20 were terricolous saprotrophs and 17 mycorrhizal. This survey gave only a slight insight into the fungal diversity of investigated forests. Further ivestigations will give us more accurate picture and enable us to monitor the well-being of selected forest ecosystems.

Key words: diversity, forest, macrofungi, mountain, ecosystem

INTRODUCTION

Forests are ecosystems with exceptional biodiversity. Nowadays, they are also among the most threatened ecosystems due to unsustainable management, pollution and climate change. Fungi play very important role in the ecological balance of forest ecosystems. They represent crucial decomposers of organic matter, members of mycorrhizal communities necessary for the normal development of trees, accumulators and degraders of harmful materials. Due to this, fungal diversity is one of the most important indicators of forests health (Karaman et al., 2012). However, studies on fungal ecology and their presence in the specific forest habitats are still neglected and rare in the region of Serbia. This paper represents results of one year survey dealing with macrofungal diversity in 5 different habitats on the following mountains: Vidlič (Stara Planina), Kopaonik and Tara. Research was carried out as part of an integrative project "Biosensing technologies and global system for continuous research and integrated management

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of ecosystems", supported by the Ministry of Science of the Republic of Serbia. Only few papers dealing with fungal diversity and distribution in the investigated areas were published so far, mostly concerning fungi of Mt. Kopaonik (Tortić, 1979; Karadžić, 1989; Ivančević, 1996). Fungal diversity of Stara Planina-Vidlič and Tara are even less explored - first and the only records are represented by Ivančević, Beronja (2004) and Čolić (1968).

Vidlič Mountain is predominantly located in the southeastern part of Serbia, between a city of Pirot and Stara Planina (Balkan Mountain range), while its smaller part is situated in Bulgaria. The highest peak is Basarski kamen (1377 m). Vidlič is often considered part of a Stara Planina Mts, and yet it is far less studied. In contrast to Stara Planina, Vidlič has lower altitude, limestone as geological basis and is poor in water (Anđelković, 1980).

Kopaonik represents the largest mountain range in the central part of Serbia, with Pančićev vrh as the highest peak (2017m). Kopaonik has a very diverse geological composition, as a result of tectonic movements and volcano activities responsible for its formation in the past. Rocks of different origin and age are present: granites, serpentinites, slates, marble, andesite, limestone (Anđelković, 1980, http://www.npkopaonik.com/). Kopaonik is located on the border between mediterranean and continental air currents, which is why its subalpine climate has specific characteristics (heavy snowfall, large number of sunny days, relatively high winter temperatures). The forest vegetation has a typical height alternation, with deciduous forests in the lower parts to coniferous forests at higher altitudes.

Tara Mountain represents a part of Dinaric Alps, located in western Serbia. The highest point is Kozji rid (1591m). Tara is mostly made of limestone and characterized by mountain peaks, gorges, karst caves, pits and springs. Climate is moderate-continental, with a high level of humidity (http://www.nptara.rs/). Most part of this national park is covered with forest ecosystems dominated by spruce, fir and beech. Tara represents one of the very important refugial habitats in Europe, with many rare, relict and endemic species.

MATHERIAL AND METHODS

Mycological investigation was conducted on three sites: Vzganica - Vidlič, Metođe – National Park Kopaonik, Mitrovac – National Park Tara. Five selected permanent plots, each with the size of $1000m^2$, were established. Plots 1 and 2 are situated on Vzganica. Plot 1 is located in the beech stand and plot 2 in the stand of Douglas fir and spruce, planted in the natural habitat of beech. Plot 3 is established in the Nature Reserve Metođe, protected area of 1. degree, in the stand of beech and spruce. Last two plots are located on Mitrovac. Plot 4 is situated within the protected area of 2. degree, in the stand of spruce, fir and beech. Plot 5 was set up in the wider range of the Nature Reserve "Crveni potok", in the stand of spruce, fir and beech.

Macrofungal sporocarps were collected in April, June, July and September of 2011. During four days of each expedition all of the investigated sites were visited. Established permanent plots were carefully searched for the fungal fruiting bodies. Each fungus was photographed in the field, using Nikon Coolpix P90 camera. Collected material was transported to the lab within solid boxes in the handy fridge. Long period of transport and often unfavorable conditions (high outside temperatures, carpophores damaged before collecting) resulted in the loss of one portion of collected samples. Laboratory examination implied analysis of macromorphological and anatomical characteristics, microscopic characteristics of spores and other relevant structures (Olympus BX51, Japan) and the specific chemical reactions. Literature of Department's Library as well as on-line books, keys and specialized mycological sites were consulted during determination: Dennis, 1968; Moser, 1978; Courtecuisse & Duhem, 1995; Bon, 2000; Jordan, 2004; Uzelac, 2009; Kuo, 2011; Rogers, 2012. Classification and nomenclature follow "Species 2000 & ITIS Catalogue of Life: 2011 Annual Checklist" (Bisby et al., 2011) and "*Index Fungorum*" (Kirk, 2012). Each fungal species was assigned to a specific ecological group (lignicolous/terricolous saprotroph/mycorrhizal) depending on substratum they were found on. Dried material, spore prints and microscope slides are kept in BUNS Herbarium (Department for biology and ecology, Faculty of sciences, University of Novi Sad).

RESULTS AND DISCUSSION

Survey conducted during four months in 2011, on three sites, within five permanent plots, yielded 119 species of macrofungi, among which 75 were identified to the species level. Among the identified species only 5 belong to division Ascomycota and 70 to division Basidiomycota. Forty-four species could not be determined, mostly due to the poor condition of the carpophores. Nevertheless, they represent an important part of registered diversity and thus were included in the analysis of each investigated site. Following table (Tab.1) shows the list of recorded fungal species with information on their distribution, monthly occurrence and ecological trophic group they belong to.

Table 1. Fungal species recorded during 2011 on selected permanent plots

	Species	***Plot***					***Month***				**ETG***
		P1	**P2**	**P3**	**P4**	**P5**	**IV**	**VI**	**VII**	**IX**	
	ASCOMYCOTA										
1	*Hypoxylon fragiforme* (Pers.)J.Kickx f.				x				x		L
2	*Kretzschmaria deusta* (Hoffm.)P.M.D.Martin	x					x				L
3	*Peziza phyllogena* Cooke	x						x			TS
4	*Vibrissea truncorum* (Alb. & Schwein.)Fr.				x			x			L
5	*Xylaria hypoxylon* (L.) Grev.				x	x			x		L
	BASIDIOMYCOTA										
6	*Amanita battarae* (Boud.) Bon			x					x		M
7	*Amanita rubescens* Pers.		x					x			M
8	*Bjerkandera adusta* (Willd.) P. Karst.			x	x			x	x		L
9	*Boletus badius* (Fr.) Fr.				x					x	M
10	*Boletus calopus* Pers.				x				x		M
11	*Calocera cornea* (Batsch) Fr.				x				x		L
12	*Calocera furcata* (Fr.) Fr.		x						x		L
13	*Calocera viscosa* (Pers.) Fr.				x				x		L
14	*Cantharellus cibarius* Fr.					x			x		M
15	*Craterellus tubaeformis* (Fr.) Quel.				x					x	M
16	*Clavulina coralloides* (L.) J. Schröt.			x						x	M
17	*Cortinarius collinitus* (Pers.) Fr.			x						x	M
18	*Cortinarius evernius* (Fr.) Fr.				x				x	x	M
19	*Cortinarius flexipes* (Pers.) Fr.				x					x	M
20	*Cortinarius sanguineus* (Wulfen) Fr.				x					x	M
21	*Daedaleopsis tricolor* (Bull.)Bondartsev&Singer				x			x			L
22	*Entoloma vernum* S. Lundell		x				x				TS
23	*Flammulaster carpophilus* (Fr.) Earle ex Vellinga	x						x			TS
24	*Flammulaster erinaceellus* (Peck)Watling	x						x			L
25	*Flammulina velutipes* (Curtis) Singer			x						x	L
26	*Fomitopsis pinicola* (Swartz ex Fr.) Karsten.				x	x		x	x	x	L
27	*Ganoderma applanatum* (Pers. ex Wallr.) Pat.				x	x		x	x	x	L
28	*Geastrum quadrifidum* DC. ex Pers.		x				x				TS
29	*Gymnopus androsaceus* (L.) J.L. Mata & R.H. Petersen		x	x		x		x	x		TS
30	*Gymnopus dryophilus* (Bull.) Murrill	x		x		x	x	x	x		TS
31	*Gymnopus foetidus* (Sowerby) J.L. Mata & R.H. Petersen	x						x			TS
32	*Gymnopus perforans* (Hoffm.)				x	x			x		TS
33	*Hericium clathroides* (Pall.) Pers					x				x	L
34	*Hydnum repandum* L.					x				x	M

35	*Hypholoma fasciculare* (Huds.) P. Kumm.			x						x	L
36	*Laccaria laccata* (Scop.) Cooke			x						x	TS
37	*Lactarius vellereus* (Fr.) Fr.		x						x		M
38	*Lycoperdon perlatum* Pers.		x				x				TS
39	*Lycoperdon pyriforme* Schaeff.					x		x			L
40	*Marasmius bulliardii* Quél.	x				x		x			TS
41	*Marasmius rotula* (Scop.) Fr.	x	x			x		x	x		TS
42	*Megacollybia platyphylla* (Pers.) Kotl. & Pouzar	x					x				TS(L)
43	*Mycena galericulata* (Scop.) Gray			x				x			L
44	*Mycena galopusI* (Pers.) P. Kumm.				x				x		L
45	*Mycena maculata* P. Karst.				x					x	L
46	*Mycena pura* (Pers.) P. Kumm.			x				x			TS
47	*Mycena rosea* Gramberg	x						x			TS
48	*Mycena rubromarginata* (Fr.) P. Kumm.		x		x			x	x		L
49	*Mycena sanguinolenta* (Alb. & Schwein.) P. Kumm.				x				x		TS
50	*Mycetinis alliaceus* (Jacq.) Earle ex A.W.Wilson & Desjardin			x	x			x	x		TS
51	*Mycetinis scorodonius* (Fr.) A.W. Wilson & Desjardin		x			x		x	x	x	TS
52	*Oudemansiella mucida* (Schrad.) Höhn.					x				x	L
53	*Oxyporus populinus* (Schumach.) Donk					x	x				L
54	*Phallus impudicus* L		x					x	x		TS
55	*Phellinus pomaceus* (Pers.) Maire	x					x				L
56	*Pleurocybella porrigens* (Pers.) Singer					x				x	L
57	*Pluteus cervinus* (Schaeff.) P. Kumm.				x	x				x	L
58	*Pluteus leoninus* (Schaeff.) P. Kumm.		x					x			L
59	*Polyporus varius* Pers. ex Fr.	x		x				x	x	x	L
60	*Psathyrella candolleana* (Fr.) Maire	x							x		TS
61	*Pseudohydnum gelatinosum* (Scop.) P. Karst.					x			x		L
62	*Russula cyanoxantha* (Schaeff.) Fr.				x				x		M
63	*Russula foetens* Pers.		x						x		M
64	*Russula fuscorubroides* Bon				x					x	M
65	*Russula nigricans* Fr.				x					x	M
66	*Schizophyllum commune*	x					x				L
67	*Sparassis crispa*				x	x				x	L
68	*Strobilurus tenacellus*(Pers.) Singer		x				x				TS
69	*Trametes gibbosa* (Pers.) Fr.	x					x				L
70	*Trametes hirsuta* (Wulfen) Lloyd	x					x			x	L
71	*Trametes pubescens* (Schumach.) Pilat	x						x			L
72	*Trametes versicolor* (L.) Lloyd	x				x	x			x	L
73	*Trichaptum abientinum* (Dicks.) Ryvarden					x		x			L
74	*Tricholomopsis rutilans* (Schaeff.) Singer				x					x	L
75	*Xerula radicata* (Relhan) Dörfelt	x						x	x	x	TS(L)
	UNIDENTIFIED	8	9	7	13	7	2	16	15	11	
	Total	27	23	20	40	27	15	43	44	37	

* EG- ecological trophic group (L - lignicolous, TS - terricolous saprotrophs, M - mycorrhizal)
* hatched fields – species already recorded on the same site/mountain in the work of other authors

Out of 75 determined fungal species, 15 were collected from more than one plot (Tab. 1), which could indicate to their higher distribution ability. *Gymnopus androsaceus* and *Gymnopus dryophilus* were the only species reported from all of the investigated mountains. Majority of 104 taxa (including unidentified species) were collected from only one plot. Twenty species were reported during more than one investigated month and 99 were reported only once during investigated year. In order to better estimate species prevalence and the frequency of their occurrence in studied sites, more detailed investigation is needed (more than one year of research and more visits per year).

The most favorable months for fructification were Jun and July (Tab. 1). It is not usual to collect high number of fungi during summer period. This could be due to frequent weather changes in 2011, with the shift of rainy and warm, dry periods.

Determined fungal species were members of following ecological trophic groups: 38 identified species (51%) were lignicolous (wood-decaying), 20 (27%) were terricolous saprotrophs and 17 (22%) mycorrhizal (Fig. 1).

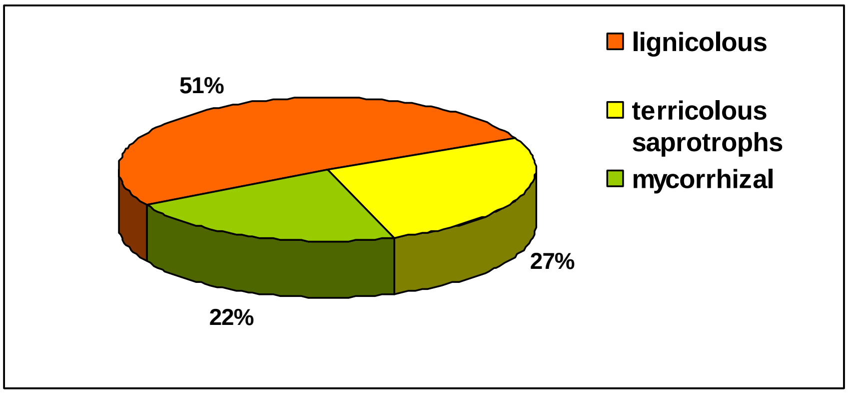

Figure1. *Proportion of the identified fungal species classified into three ecological trophic groups*

From 119 fungal taxa collected during this research, the highest number (62; 20 of which remained unidentified) was recorded from Mitrovac, Tara Mt. (Fig 2.). Investigation of site Vzganica, located on Vidlič Mt., yielded in 32 registered species (17 were unidentified), while the lowest number of species, 20 (7 unidentified), was recorded from site Metođe on Kopaonik Mt.

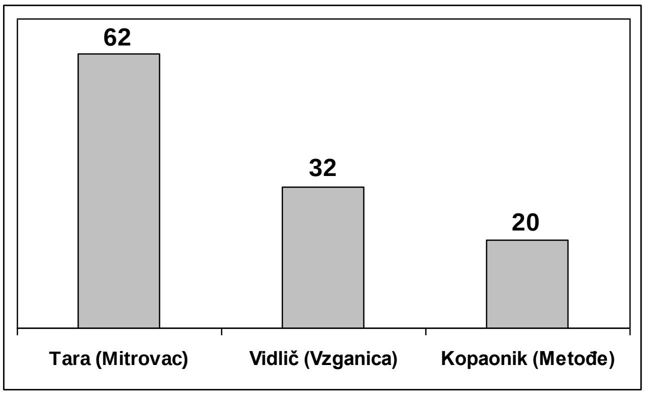

Figure 2. *Number of fungal taxa recorded from investigated sites*

Among investigated plots, plot 4 (spruce, beech and fir association) stands out with the highest number of findings (Fig. 3). Such a result was expected, considering that in this locality water is often retained in the surface layers of soil, due to poorly permeable substrate. Within twenty-seven fungal species identified from plot 4, lignicolous species were dominant (15 species comparing to 9 mycorrhizal and 3 terricolous saprotrophs). Similar situation was observed on plot 5 – 13 lignicolous species, 5 terricolous saprotrophs and 3 mycorrhizal (Tab. 1). Both plot 4 and 5 are situated in protected parts of forest where human disturbance is minimal, which resulted in significant amount of coarse woody debris suitable for development of lignicolous fungi. Lignicolous species whose carpophores were recorded in high quantities on both plots are *Ganoderma applanatum* (present mostly as a saprotroph) and *Fomitopsis pinicola* (present mainly as a parasite but also as a saprotroph). These species are known as usual residents of beech and spruce forests (Edman & Jonsson, 2001; Piltaver et al., 2002; Bernicchia et al., 2007a; Bernicchia et al., 2007b; Küffer et al., 2008). Another important taxon recorded on plot 5 is *Hericium coralloides*, listed as rare species, as well as important indicator of conservation value for old growth forests (Christensen et al., 2004; Adamčik et al., 2007).

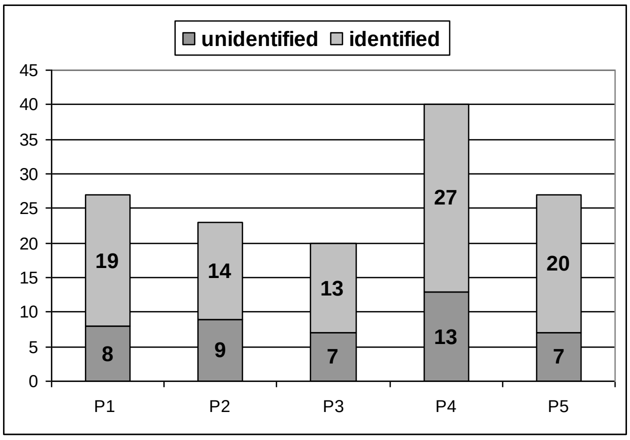

Figure 3. *Number of fungal taxa recorded from investigated plots*

Results of survey conducted on plots 1 and 2 from Vidlič Mt. show similar number of fungal species. Among all other plots, plot 1 (beech stand) had the highest number of recorded terricolous saprotrophs, but no mycorrhizal fungi were found (Tab. 1). This may be due to rich litter layer. As reported by several authors, the litter thickness and humus form can promote fructification of saprophytic fungi and decrease development of mycorrhizal species (Tyler 1991, Holec, 1994, Mihal & Bučinova, 2005). Dominant species on plot 1 was *Xerula radicata*, detected during 3 of 4 visits, mainly with more than one developed carpophor. On plot 2 (stand of Douglas fir and spruce, planted on the natural habitat of beech) all trophical groups of fungi have been reported, showing that ecological balance might be established.

Investigation of plot 3 (association of spruce and beech) yielded lowest number of fungal species. This might be due to significant steepness of terrain (30-40º) resulting in water and nutrient draining. *Polyporus varius* showed extraordinary abundance on this plot, being the only species present during every month of research, except April, and always with high number (>5) of fruiting bodies. Similar situation was observed on plot 1, but with less abundance of carpophores. In studies of other authors, *Polyporus varius* was recognized as one of the most frequent and typical species in beech stands (Andersson, 1995; Mihal & Bučinova, 2005).

Only a few published papers exist for the fungal diversity of mountains Stara Planina, Kopaonik and Tara. If we consider Vidlič as an independent geological structure, apart from Stara Planina mountain range, mycological data given in this paper represent a complete novelty for this area. In comparison to the list of fungi of Kopaonik Mt., summarized by Ivančević (1996), results of our investigation yielded 6 new species for this mountain (*Amanita battarae*, *Bjerkandera adusta*, *Cortinarius collinitus*, *Flammulina velutipes*, *Gymnopus dryophilus*, *Mycena galericulata*). Furthermore, these data are significant since investigated site, Metođe, represents one of the most important Nature Reserves on Kopaonik Mt., with the presence of relict forest communities. The only previously published mycological study on Tara Mt. was conducted by Čolić (1968), on the same locality where plot 5 is situated. In comparison with these data (251 recorded fungal species), among 42 species of fungi presented for Tara Mt. in our research, 21 represent new records (Tab 1.).

CONCLUSION

Research of fungal diversity on mountains Vidlič, Kopaonik and Tara, conducted during four visits in 2011, has yielded 119 records and 75 identified species. These results are even more important considering the fact that only scarce information on macrofungal diversity in Serbia exist so far. Future investigations of established plots will give us more complete picture on fungal diversity and enable us to monitor the condition of fungal populations. Results of such studies are beneficial for better understanding of important natural processes and monitoring of ecosystems health.

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COMPARATION OF FLORISTIC COMPOSITION OF BLACK PINE- CINQUEFOIL (*Potentillo heptaphyllae-Pinetum gocensis* B. Jovanović 1959) AND BLACK PINE-WINTER HEATH FOREST (*Erico-Pinetum gocensis* Krause 1957) ON CRNI VRH MT. NEAR PRIBOJ, SERBIA

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Abstract: *Crni vrh near Priboj is a part of serpentine-peridotite massif of Balkan peninsula, which is located on the border between Ilirian and Moesian floristic provinces and it possesses high vegetation diversity. Black pine forests are the most widespread vegetation segment of this area. The comparation of floristic composition of black pine plant communities Potentillo heptaphyllae-Pinetum gocensis B. Jovanović 1959 and Erico-Pinetum gocensis Krause 1957 is presented in this paper with the aim to ascertain what is the difference in the floristic composition between these two communities, considering they are located in immediate vicinity of each other. Testing with t-test showed there are no significant differences between researched communities considering canopy and elevation. There are significant differences in the coverage of herbacious layer and aspects in which these communities grow. Total number of recorded plant species in communities is 97, of which 39 occur in both communities. Jaccard similarity index is 0.39. Community Potentillo heptaphyllae-Pinetum gocensis B. Jovanović 1959 is more xerophilous and intolerant than community Erico-Pinetum gocensis Krause 1957, and contains more xerophilous elements in the spectrum of distribution types also. Apart from similarities, which are the consequence of the same geologic bedrock, these two communities show also significant dissimilarities which differ them clearly.*

Key words: black pine, Pinus nigra, Crni vrh, plant community, floristic composition

1. INTRODUCTION

Forest management unit „Crni vrh-Ljeskovac“ is located in southweastern Serbia, near Priboj. It is positioned on the border between Bosnia and Herzegovina and Serbia, where both illirian and moesian floristic influences occur. That causes heterogenous vegetation, making this area interesting for multidisciplinary research. Geological bedrock of researched area is serpentine. Forest vegetation is very diverse. The most widespread species in this management unit is black pine (*Pinus nigra* Arn.) Forests are degraded due to the vicinity of settlements, and since black pine suffers from fires, this presents a big problem in a process of reclamation of these degraded areas. One of the most important plant communities in this area is *Erico-Pinetum gocensis*, which used to be widely present in ofiollite massifs of eastern Bosnia and western Serbia (Pavlović 1951; Jovanović 1972; Tatić 1969 etc). Plant community *Potentillo heptaphyllae-Pinetum gocensis* is much more scarce in Serbia, it is recorded only in Goč Mt. (Jovanović 1959) and Pešter highland (Ozren Mt. and Dubočica river valley) (Rakonjac 2002). It is mostly of secundary origin, developed on former beech, beech-fir or sessile oak sites (Tomić 2006). Comparation of floristical composition of black pine forest with cinquefoil (*Potentillo*

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heptaphyllae-Pinetum gocensis B. Jovanović 1959) and black pine forest with snow heath (*Erico-Pinetum gocensis* Krause 1957) on Crni Vrh Mt. near Priboj, with the aim to ascertain if there is a difference between floristic composition of these communities, considering they are placed next to each other and to ascertain if it is justified to set aside these two forests as separate communities.

Figure 1: *Geographic position of researched area*

2. MATERIAL AND METHODS

Ten phytocoenological releves in community *Erico-Pinetum gocensis* Krause 1957 and nine in community *Potentillo heptaphyllae-Pinetum gocensis* B. Jovanović 1959 were collected in Crni vrh near Priboj using classique Braun-Blanquet (1964) method (Novaković 2008). They were sorted in phytocoenological tables. Ecological spectra as well as spectrum of distribution types were made according to Stevanović (1992, unpublished). Ecological species characterisation (relation of plants towards moisture and light) were provided according to Kojić *et al* (1997). Forest vegetation taxonimic units were named according to Tomić (2006). Jaccard similarity index is calculated (Magurran 2004). Correlation analysis between the communities and *t*-test were made in software package SPSS Statistics 17.0 (IBM Inc. 2008).

3. RESULTS AND DISCUSSION

There is no statisticaly significant difference between researched communities considering elevation, although community *Potentillo heptaphyllae-Pinetum gocensis* grows on somewhat higher ground, while community *Erico-Pinetum gocensis* has higher amplitude of elevations. Also, there is no statisticaly significant difference between communities considering inclinations, although community *Potentillo heptaphyllae-Pinetum gocensis* usually occurs on steeper slopes, while community *Erico-Pinetum gocensis* can be found on almost flat terrains. There is no significant difference considering characteristics of tree layer also.

Table 1: *Average elevation, inclination, canopy and coverage of herbacious layer in researched communities*

	Potentillo heptaphyllae-Pinetum	*Erico-Pinetum*
Elevation (m a.s.l.)	956.7	772
Inclination (º)	17.7	16.4
Canopy (%)	0.49	0.51
Coverage of herbaceous layer (%)	0.71	0.88

Results of *t* test analysis showed no statistically significant difference between researched communities considering coverage of herbacious layer. Mean total coverage in community *Erico-Pinetum gocensis* is 0.88, and in community *Potentillo heptaphyllae-Pinetum gocensis* 0.71. The explanation could be in the different presence of *Erica carnea* in communities, which is very frequent in community *Erico-Pinetum gocensis*, while it occurs only in one releve in community *Potentillo heptaphyllae-Pinetum gocensis*.

Light conditions dont influence coverage level of herbacious layer. That is expected since both researched stands are standards, which have open canopy, and there were no recent forest openings which would allow the entrance of species dependent on additional light influx.

Significant difference exists considering aspects on which researched communities develop. While community *Potentillo heptaphyllae-Pinetum gocensis* occurs mostly on sunny, southern and southwestern aspects, the community *Erico-Pinetum gocensis* more frequently grows on sheltered aspects-northern, northeastern, northwestern. It is usual that both communities grow on sunny areas, however on Crni vrh community *Erico-Pinetum gocensis* well preserved itself on northern, inaccesible part of river Uvac valley, while the stands on more accesible terrain are highly degraded or replaced with black pine plantations.

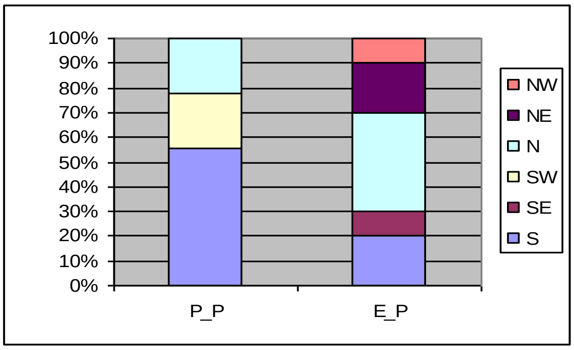

Figure 2: *Aspect ratio on which researched stands grow (E_P (Erico-Pinetum gocensis); P_P (Potentillo heptaphyllae-Pinetum gocensis)*

Total number of all recorded plant species in both communities is 97, 39 of which were found in both communities, making 40% of species. The high number of joint species is expected, considering same dominant species, same geological bedrock and small spatial distance. However, the number of different species is high also, which indicates that these are two different plant communities. Jaccard similarity index for researched communities is 0.39.

Table 2: *Floristic characteristics of researched communities*

Family	**Species**	**Community**		**Distribution type**	**Life form**
		E_P	P_P		
Aceraceae	*Acer campestre* L.	+	-	Middleeuropean	P
	Acer tataricum L.	-	+	Pontic	P
Anacardiaceae	*Cotinus coggygria* Scop.	+	+	Mediteranean-Pontic	P
Apiaceae	*Danaa cornubiensis* (Torn.) Burn.	-	+	Middleeuropean	H
Asteraceae	*Cirsium lanceolatum* (L.) Scop.	+	-	Euroasian	H
	Hieracium bauhini Schult.	-	+	Middleeuropean	H
	Mycelis muralis (L.) Rchb.	-	+	Middleeuropean	H
	Tanacetum corymbosum (L.) Sch.	+	-	Euroasian	T
Betulaceae	*Betula pendula* Roth.	+	+	Eurosiberian	P
	Carpinus betulus L.	-	+	Middleeuropean	P
	Ostrya carpinifolia Scop.	+	+	Mediteranean-Submediteranean	P
Boraginaceae	*Pulmonaria officinalis* L.	-	+	Middleeuropean	H

Family	Species	Community		Distribution type	Life form
Brassicaceae	*Alyssum markgraffi* Schulz.	-	+	Mediteraean-Submediteranean	Ch
Campanulaceae	*Campanula patula* L.	+	+	Middleeuropean	H
	Campanula persicifolia L.	+	+	Middleeuropean	H
Caryophyllaceae	*Silene vulgaris* (Mnch.) Gar.	-	+	Euroasian	H
Cistaceae	*Helianthemum nummularium* (L.) Mill.	-	+	Middleeuropean	H
Cupressaceae	*Juniperus communis* L.	+	+	Holarctic	P
Dipsacaceae	*Knautia arvensis* (L.) Coult.	+	-	Middleeuropean	H
	Scabiosa columbaria L.	+	+	Mediteranean-Pontic	H
Ericaceae	*Erica carnea* L.	+	+	Middeleuropean montane	Ch
	Vaccinium myrtillus L.	+	+	Cirkumboreal	Ch
Euphorbiaceae	*Euphorbia amygdaloides* L.	+	+	Middleeuropean	Ch
	Euphorbia cyparissias L.	-	-	Middleeuropean	H
	Mercurialis ovata St. et Hoppe	+	-	Mediteranean-Submediteranean	H
Fabaceae	*Coronilla varia* L.	-	+	Middleeuropean	H
	Dorycnium germanicum (Gr.) Rouy.	+	+	Mediteranean-Pontic	Ch
	Genista ovata W.et K.	+	-	Mediteranean-Pontic	Ch
	Lathyrus pratensis L.	+	-	Euroasian	H
	Lotus corniculatus L.	+	+	Euroasian	H
	Medicago falcata L.	-	+	Mediteranean-Pontic	H
	Trifolium alpestre L.	+	+	Middleeuropean	H
	Trifolium pretense L.	+	+	Euroasian	H
	Vicia incana Vil.	+	+	Mediteranean-Pontic	H
Fagaceae	*Fagus moesiaca* K. Maly) Czecz	+	+	Middleeuropean	P
	Quercus cerris L.	+	-	Middleeuropean	P
	Quercus dalechampii Ten.	+	-	Middleeuropean	P
Geraniaceae	*Geranium sanguineum* L.	+	-	Middleeuropean	H
Hypericacae	*Hypericum montanum* L.	+	+	Middleeuropean	H
	Hypericum perforatum L.	-	+	Euroasian	H
Hypolepidaceae	*Pteridium aquilinum*(L.) Kuhn.	+	+	Cosmopoliten	G
Lamiaceae	*Calamintha vulgaris* (L.) Druce	-	+	Middleeuropean	H
	Melittis melissophyllum L.	-	+	Middleeuropean	H
	Prunella laciniata L.	-	+	Mediteranean-Pontic	H
	Prunella vulgaris L.	-	+	Holarctic	H
	Stachys recta L.	-	+	Mediteranean-Submediteranean	H
	Stachys scardica Gris.	+	+	Mediteransko-Submediteranski	H
	Thymus pulegioides ssp.montanus L.	+	+	Middleeuropean	Ch
Liliaceae	*Allium pulchellum* Don.	+	-	Mediteranean-Pontic	G
	Ornithogalum umbellatum L.	-	+	Mediteranean-Submediteranean	G
Oleaceae	*Fraxinus ornus* L.	+	+	Mediteranean-Submediteranean	P
Onagraceae	*Chamaenerion angustifolium* L.	+	+	Cirkumboreal	H
	Epilobium montanum L.	-	+	Euroasian	H
Orchidaceae	*Cephalanthera rubra* (L.) Rich.	-	+	Middleeuropean	G
Pinaceae	*Pinus nigra* Arn.	+	+	Southeuropean montane	P
Poaceae	*Anthoxantum odoratum* L.	-	+	Euroasian	H
	Arrhenantherum elatius (L.) Mert. et Koch.	+	-	Middleeuropean	H
	Brachypodium pinnatum (L.) P.B.	+	+	Euroasian	H

Family	Species	Community		Distribution type	Life form
	Brachypodium sylvaticum Huds. P.B.	+	+	Euroasian	H
	Bromus mollis L.	+	-	Euroasian	T
	Dactylus glomerata L.	+	-	Euroasian	H
	Deschampsia flexuosa (L.) Tr.	+	-	Cirkumboreal	H
	Festuca heterophylla Lam.	+	+	Middleeuropean	H
	Poa pratensis L.	+	-	Holarctic	H
	Poa trivialis L.	-	+	Euroasian	H
	Sesleria serbica Adamovic	+	+	Southeauropean montane	H
Polygalaceae	*Polygala comosa* Schk.	-	+	Pontic	H
Polygonaceae	*Rumex acetosella* L.	-	+	Holarctic	H
Ranunculaceae	*Aquilegia vulgaris* L.	+	-	Middleeuropean	H
	Clematis vitalba L.	+	-	Middleeuropean	S
Rosaceae	*Aremonia agrimonioides* (L.) DC	+	+	Middleeuropean	H
	Crataegus monogyna Jacq.	+	+	Middleeuropean	P
	Filipendula hexapetala L.	-	+	Euroasian	H
	Fragaria vesca L.	+	+	Euroasian	H
	Potentilla heptaphylla Jusl.	+	+	Middleeuropean	H
	Cerasus avium Mnch.	+	+	Middleeuropean	P
	Pyrus pyraster Burg.	+	+	Middleeuropean	P
	Rosa pendulina L.	+	-	Middleeuropean montane	Np
	Rosa spinosissisima L.	+	+	Middleeuropean	Np
	Rubus hirtus Wald.&Kif.	-	+	Middleeuropean	Np
	Rubus idaeus L.	+	+	Cirkumboreal	Np
	Sangiusorba minor Scop.	-	+	Euroasian	H
	Sorbus aucuparia L.	+	-	Eurosiberian	P
	Sorbus domestica L.	+	+	Mediteranean-Submediteranean	P
	Sorbus torminalis (L.) CR	+	+	Middleeuropean	P
Rubiaceae	*Galium cruciata* (L.) Scop.	+	-	Middleeuropean	H
	Galium purpureum L.	+	-	Southeuropean montane	Ch
	Galium sylvaticum L.	-	+	Middleeuropean	H
	Galium tenuissimum	+	+	Pontic	H
	Galium vernum Scop.	+	-	Euroasian	H
	Galium verum L.	+	-	Euroasian	H
Salicaceae	*Populus tremula* L.	-	+	Euroasian	P
Salicaceae	*Salix caprea* L.	+	-	Euroasian	P
Scrophulariaceae	*Veronica officinalis* L.	+	+	Middleeuropean	H
Violaceae	*Viola alba* Bess.	-	+	Mediteranean-Submediteranean	H
	Viola silvestris Lam.	+	+	Middleeuropean	H
∑		68	72		
Total species number		97			
Joint species		39			

Black pine (*Pinus nigra*) is almost the only species in tree layer in both communities. In community *Potentillo heptaphyllae-Pinetum gocensis*, apart from black pine, occurs *Quercus dalechampii* only in one releve, and in community *Erico-Pinetum gocensis Fagus moesiaca* and *Quercus dalechampii* occur in one releve each. Significant differences exist in shrub layer. While in community *Erico-Pinetum gocensis* 16 species are recorded in shrub layer, in community *Potentillo heptaphyllae-Pinetum gocensis* only 9 occur. Rejuvenation of Balkan sessile oak (*Quercus dalechampii*) is abundant in shrub and herbacious layer, which indicates sindynamic correlation of black pine forests with more mesophilous basiphilous Balkan sessile oak forests.

The highest coverage in community *Potentillo heptaphyllae-Pinetum gocensis* posses *Rosa spinosissima*, *Rubus idaeus* and *Brachypodium silvaticum* apart from dense rejuvenation of *Pinus nigra,* while the highest coverage in community *Erico-Pinetum gocensis* has *Erica carnea*, and all other species occur single or in smal groups. *Erica carnea* is the main differential species between these two communities, since it dominates in community *Erico-Pinetum gocensis*, while in community *Potentillo heptaphyllae-Pinetum gocensis* it occurs only in one phytocoenological releve.

Community *Potentillo heptaphyllae-Pinetum gocensis* is more diverse (it contains 31 family, 59 genera and 72 species) than community *Erico-Pinetum gocensis* (it contains 26 families, 54 genera and 68 species). The most species rich families in community *Erico-Pinetum gocensis* are *Rosaceae*, *Poaceae* and *Fabaceae*, while in community *Potentillo heptaphyllae-Pinetum gocensis* the most species rich are *Rosaceae*, *Lamiaceae* and *Fabaceae*. The family representation in researched communities is mostly in concordance with other communities on serpentine. It is worth to stress families *Fabaceae, Asteraceae, Poaceae* and *Ericaceae,* which are especially significant in serpentine vegetation of southern Europe (Marin, Tatić, 2001).

Hemycryptophytes are the most numerous life form in both communities, which is usual in communities in this climatic area, but they are more frequent in community *Potentillo-Pinetum nigrae* (59.7%) than in community *Erico-Pinetum gocensis* (51.5%). However, in comparison with this community on Pešter (Rakonjac, 2002), where hemycryptophytes count for 52% of species number, community *Potentillo-Pinetum nigrae* on Crni vrh is richer in this life form. It may be caused by high presence of families *Fabaceae* and *Lamiaceae*, which mostly belong to this life form. Phanerophytes have high presence in both communities, but they are more numerous in *Erico-Pinetum gocensis* (30.9%:25.0%), due to more diverse shrub layer. Chamaephyte share is nearly equal in both communities, while terophytes and climbers are rare in *Erico-Pinetum gocensis* and they are not recorded in *Potentillo-Pinetum nigrae*.

Middleeuropen group of distribution types is dominant in both communities, but it is more numerous in community *Potentillo heptaphyllae-Pinetum gocensis* (43.0%:38.2%). This community has high share of species belonging to xerophilous distribution types (mediteranean-pontic, mediteranean-submediteranean and pontic), totally 25%, while the patricipation of these species in community *Erico-Pinetum gocensis* is 17.6%. On the other side, community *Erico-Pinetum gocensis* has significantly higher share of species belonging to euroasian distribution types (23.5%:15.3%). It can be concluded from the spectrum of distribution types that both communities develop under strong submediteranean influence, which is a characteristics of their coenological relations, but this influence is higher in community *Potentillo heptaphyllae-Pinetum gocensis*. Species from northern and colder areas are more widespread in community *Erico-Pinetum gocensis.* It can be explained in aspects on which these communities occur; while community *Potentillo heptaphyllae-Pinetum gocensis* grows on sunny slopes, with natural presence of xerophilous floristic elements, community *Erico-Pinetum gocensis* grows on sheltered aspects, more suitable for the development of more cold resistant species.

Considering relations to light, semitolerant species dominate in community *Erico-Pinetum gocensis* (50.0%), while semitolerant-tolerant species are most widespread (43.1%) in community *Potentillo heptaphyllae-Pinetum gocensis*. Generaly speaking, community *Potentillo heptaphyllae-Pinetum gocensis* has more intolerant species, but all comunities have high representation of semitolerant species.

In commnity *Erico-Pinetum gocensis* xerophilous and mesophilous species are equaly represented, 50% each, which is not usual for these forests, but it is the consequence of significant presence of species characteristic for beech forest, which are mesophilous. Considering moisture, xerophilous species are more prevalent to mesophilous in community *Potentillo heptaphyllae-Pinetum gocensis* (56.0%:44.4%). It indicates that community *Potentillo heptaphyllae-Pinetum gocensis* is more xerophilous than community *Erico-Pinetum gocensis.*

4. COCLUSIONS

Comparation of floristical composition between plant communities *Potentillo heptaphyllae-Pinetum gocensis* and *Erico-Pinetum gocensis* on Crni vrh Mt. near Priboj is done in this paper. Analysis of floristic composition showed significant differences between two communities. Plant community *Potentillo heptaphyllae-Pinetum gocensis* contains 72 species, and community *Erico-Pinetum gocensis* 68; 39 species occur in both communities. Community *Potentillo heptaphyllae-Pinetum gocensis* contains more genera and families also. There are no statisticaly significant differences between researched communities considering elevation, inclination, or canopy, but there are significant difference in herbacious layer coverage. Community *Potentillo heptaphyllae-Pinetum gocensis* has higher herbacious layer coverage, which is a consequence, on the first place, of great coverage of *Erica carnea*, which absolutely dominates in shrub layer of community *Erico-Pinetum gocensis*. Great differences exist in aspect on which communities develop. While community *Potentillo heptaphyllae-Pinetum gocensis* occurs mostly on sunny, southern and southwestern aspects, community *Erico-Pinetum gocensis* grows mostly on sheltered aspects-northern, northeastern or northwestern.

Spectrum of life forms has hemycryptophyte-phanerophyte character in both communities, but the community *Potentillo heptaphyllae-Pinetum gocensis* contains somewhat more hemycryptophytes (59.72%:51.47%), and community *Erico-Pinetum gocensis* more phanerophytes (30.88%:25%). In the spectrum of distribution types in community *Potentillo heptaphyllae-Pinetum gocensis*, highly represented are species who belong to xerophilous distribution types (mediteranean-pontic, mediteranean-submediteranean and pontic), totally 25%, while community *Erico-Pinetum gocensis* has much more species of euroasian distribution type (23.52%:15.27%). Speaking about relation of species to light, community *Potentillo heptaphyllae-Pinetum gocensis* contains more intolerant species, but both communities have high presence of semitolerant species. Considering the light, community *Potentillo heptaphyllae-Pinetum gocensis* is more xerophilous than community *Erico-Pinetum gocensis* .

Floristical composition shows that both communities have a lot of similarities, but also a lot of differences, which reflects in the coverage of herbacious layer, aspects on which they develop, present species, genera and families. Community *Potentillo heptaphyllae-Pinetum gocensis* is more xerophilous and intolerant than community *Erico-Pinetum gocensis.* According to analysis of floristic composition it can be concluded that it is justified separation of these two forests in different plant communities.

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NATURAL FOREST DYNAMICS FOLLOWING BARK BEETLE CALAMITIES IN THE ALPINE NATIONAL PARK BERCHTESGADEN (GERMANY)

Maria-Barbara WINTER[1,2], Roland BAIER[13], Jörg MÜLLER[3], Christian AMMER[14]

Abstract: *Forest management has been aiming to eliminate natural disturbance dynamics in forest ecosystems over the last centuries. Since the last decades, however, the changes of structural and microclimatic conditions for example by storms or bark beetle infestations have been detected by science as valuable hotspots of forest biodiversity. Protected areas enable a monitoring of the natural processes following large-scale disturbances and their consequences for biodiversity.*

In the Berchtesgaden National Park winter storms in 1990 and 2007 led to subsequent bark beetle calamities, without interference by management on approximately 6,000 ha of forest land in the core zone of the park. To assess the impact of the large-scale disturbances on the unmanaged forest ecosystem we investigate how the site conditions are altered by the disturbances, how vegetation and deadwood develops and how this processes influence the diversity and abundance of selected groups of species. The study plots are located in three different types, namely, undisturbed spruce stands potentially susceptible to bark beetle infestation (reference), stands affected by bark beetles within the last 5 years (new disturbance) and stands being infested in the 1990th (old disturbance). Stand structure, regeneration, vascular plants and arthropods diversity were surveyed during the vegetation period 2012. Preliminary results show that nitrophyllous and light demanding species as Rubus idaeus, Rubus fructicosus s.l., Urtica dioica and fern species were more abundant in bark beetle gaps. No significant differences in species numbers between the different levels of forest succession could be detected yet. An increase in sample size in the next year may provide a clearer picture in further analysis.

Keywords: forest succession, biodiversity, vascular plants, disturbance, conservation

INTRODUCTION

The European spruce bark beetle *Ips typographus* L. (Coleoptera, Scolytinae) is an important element of every spruce forest ecosystem and one of the most destructive pests of Norway spruce (*Picea abies* Karst)(Schwerdtfeger 1995, Wermelinger 2004). The typical r-strategist profits from the availability of large amounts of dying spruce trees, commonly after storm events, and reacts with an explosive increase of its population size (Wermelinger and Seifert 1998). Under these conditions large areas of previously vital forests can be infested (Kautz et al. 2011). Between 1950 and 2000 about 2.9 million m³ of timber are estimated to be damaged per year in European forests by bark beetles (Schelhaas et al. 2003).

Forest management has been aiming to eliminate natural disturbance dynamics in anthropogenically shaped forest ecosystems over the last centuries (Schelhaas et al. 2003). However, natural disturbances as storm, fire and biotic impacts as bark beetle calamities shape

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the ecosystem processes of European forests. The majority of present forest species developed by adaptation to past natural disturbance regimes (Bengtsson et al. 2000). Protected areas enable a monitoring of the natural processes following large-scale disturbances and their consequences for biodiversity.

Bark beetle calamities create spatial patterns in forests that alter microclimate and nutrient conditions. In addition large amounts of deadwood are produced. Changes in habitat structures are closely related to the occurrence and abundance of forest species (Bouget and Duelli 2004). Particularly light demanding species or species which rely on deadwood availability are favored. Müller et al. (2008) characterized *I. typographus* as driving factor for Norway spruce forest succession and as a keystone species for biodiversity in unmanaged spruce forests.

The Alpine National Park Berchtesgaden was founded in 1978. In contrast to managed forests where most often active control, salvage logging and regeneration measures are conducted, no manipulation of natural forest dynamics takes place on approximately 6,000 ha of forest land in the core zone of the National Park. Although already in the 1990s several bark beetle outbreaks occurred in the Parks forest, spruce bark beetles caused a significant die-off of spruce stands not before the winter storm *Kyrill* in 2007.

To assess the impact of large-scale disturbances on the unmanaged mountain forest ecosystems and their further development, this project addresses the following questions:

- Which site characteristics are influenced by the disturbances through spruce bark beetles?
- How do the altered site conditions influence further forest dynamics? And how does the forest development proceed?
- How is the diversity of selected species groups (vascular plants, wood-decaying fungi, arthropods, mollusks) influenced by the development of the forest ecosystems?

MATERIALS AND METHODS

Study area

The Berchtesgaden National Park is located in South-Eastern Germany in the Northern Limestone Alps and covers an area of 20,800 ha (Fig. 1). With an altitudinal gradient from 603 m a.s.l. in the *Königssee* valley to 2,713 m a.s.l. at the top of the *Watzmann* massif the mean annual temperature ranges from +7°C to -2°C. Annual precipitation values vary between 1,500 - 2,600 mm. The mean duration of snow cover increases from approximately 110 days in the valleys to 200 days in 1,500 m a.s.l. and 2,700 days in 2,000 m a.s.l. (Spandau 1988). The main soil types are rendzic leptosol of intermediate and shallow soil depth and eutric leptosol (humus layer > 15cm - 35 cm) at the steep slopes and chromic cambisol at less steep slopes and in the valleys.

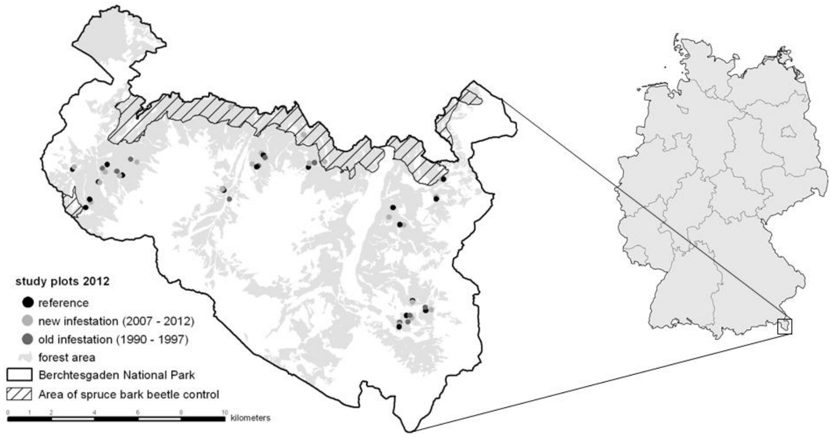

Fig. 1 *The study area Berchtesgaden National Park in South-Eastern Germany with the location of the forest area and the 51 study plots.*

Mixed mountain forest sites with beech, spruce and fir and mostly high growing stocks composed the natural vegetation at the montane and high montane slopes of the area till the middle ages. Spruce-larch and Swiss stone pine stands characterized the subalpine regions (Köstler and Mayer 1974). The foundation of the monastery in Berchtesgaden in the 12th century and the settlement of the surrounding valleys started the shift of the natural forests towards pure spruce stands at assessable sites. This development increased drastically with the rise of the salt mining industry in the 16th century (Knott et al. 1988).

Nowadays 44% of the National Park area is covered by forest (Nationalpark Berchtesgaden 2001) (Fig. 1). Norway spruce (*Picea abies* (L.) Karst) holds the highest share of the species composition with 50%, followed by European larch *(Larix decidua* Mill.) 28%, European beech (*Fagus sylvatica* L.) 8%, Swiss stone pine (*Pinus cembra* L.) 4%, sycamore maple (*Acer pseudoplatanus* L.) 4%, dwarf pine (*Pinus mugo* Turra) 2% and silver fir (*Abies alba* Mill.) 1% (Konnert and Siegrist 2000).

Induced by the winter storms *Vivian* and *Wiebke* in 1990 around 100 ha of spruce stands were affected by spruce bark beetles between 1990 and 1997. Dead trees were removed only within the control zone of 1,200 ha at the border of the National Park (Fig. 1). The calamity ceased naturally at the end of the 1990s (Nationalpark Berchtesgaden 2001). Contrary to the preceding events the winter storms *Kyrill* in 2007 and *Emma* in 2008 caused most disturbances in the core zone where no management takes place. Since then, approximately 500 ha of spruce stands have been infested by bark beetles (Fig. 2).

Fig. 2 *Unmanaged forest development influenced by storm and spruce bark beetle southeast of the Königssee in May 2012* (Photo: M.B. Winter).

Study design

Unfortunately, no investigations of forest dynamics have been conducted in the National Park following the calamities in the 1990s. Therefore no "true" time series analyses can be performed. Instead, study plots were established which are located in three different types of forests characterizing a "false" time series of unmanaged forest dynamics following spruce bark beetle attack. The three types are: undisturbed spruce stands potentially susceptible to bark beetle infestation (*reference*), stands affected by bark beetles within the last five years (*new disturbance*) and those being infested in the 1990th (*old disturbance*) (Fig. 3). Each category could by found on three altitudinal zones (montane, high montane, subalpine) and on south- and north-facing sites with each three replicates. The only exceptions are old disturbed stands in the subalpine region which could, due to a missing number of replicates, not be included into the study.

For assessing the impact of salvage logging, three additional plots have been installed on north-facing slopes in the montane region inside the bark beetle control zone, where all infested trees have been removed by clear-cutting.

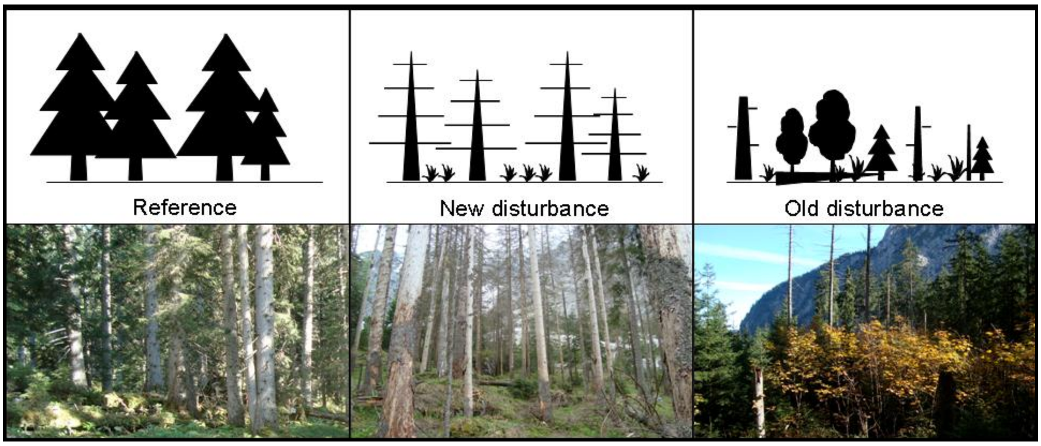

Fig. 3 *False-time series of forest development following bark beetle calamities with the example of study plots in the Wimbach valley (Photos: M.B. Winter).*

The *reference* plots are measuring points of the National Park forest inventory grid (Konnert and Siegrist 2000). The *old* and *new* plots have been established specifically for this study in the centre of bark beetle disturbances. As the size of the old bark beetle gaps did rarely exceed one hectare, gaps were chosen with dimensions of 1,000-10,000 m² to keep them comparable. The selection of potential plots was carried out with the help of aerial photographs of 1990, 1997, 2001, 2003 and 2009 and verified in the field. Each of the 51 circular study plots (17 variants x 3 replicates), is 500 m² in size and permanently marked by magnet in its center. For detailed measurements of seedlings, small saplings (0-20 cm height) and vascular plants 8 subplots (1 m² circle) are surveyed on each plot. Saplings with a height of 20-50 cm are measured on a 50 m² small incircle; 50-200 cm high saplings are surveyed on a 150 m² large incircle (Fig. 4).

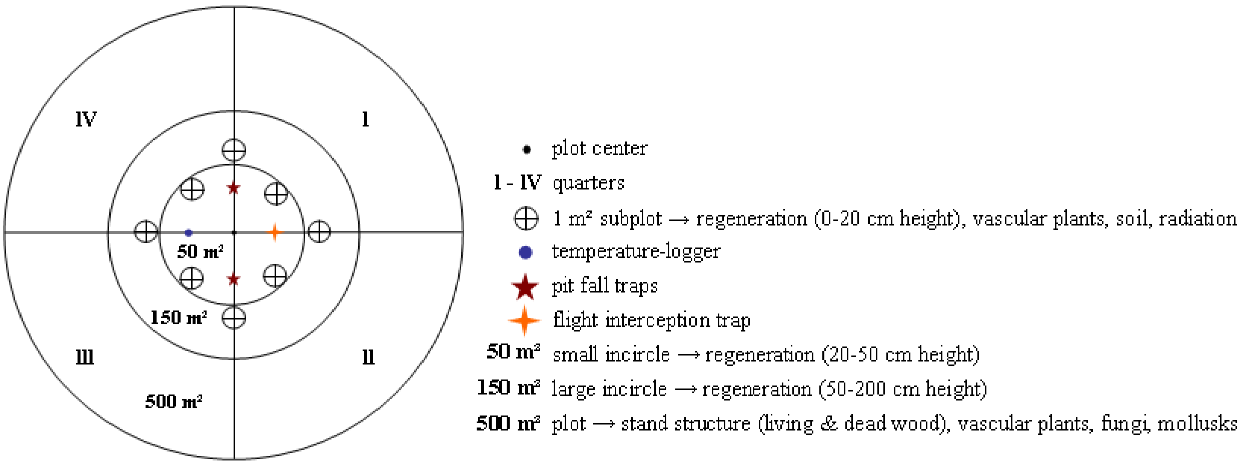

Fig. 4 *Sampling design of the study plots.*

Data sampling and analyses

Data-loggers storing half-hourly measurements of air temperature (1 m above ground) and soil temperature (5 cm below ground) were established in May on 34 of the 51 of the study plots. A first read out of the loggers and analysis of the temperature measurements was carried out in September.

To characterize the changes in radiation caused by the disturbances hemispherical photos are taken on each subplot.

Arthropods were sampled during 2012 (May-September) using two pitfall traps and one flight interception trap per plot. Additionally light traps were used to sample moths, operating during warm and dark nights in June and August. The specimens of the following species groups are currently determined to species level and will later be evaluated: Beetles (Coleoptera), spiders (Arachnida), true bugs (Heteroptera), springtails (Collembola), snails (Mollusca) and moths (Lepidoptera).

Stand structure of living and deadwood, regeneration and vascular plants have been and will be recorded on all plots during the vegetation periods of 2012 and 2013.

Field mapping of vascular plants was conducted on the 500 m² plots following Braun-Blanquet (Braun-Blanquet 1964). The abundance was later coded as mean of the cover class. The total share of vascular plants on the 500 m² was estimated in 5%-steps. SPSS was used for statistical analyses (SPSS 13.0 for Windows 2004). For comparison of species diversity of vascular plants between the different plots and plot types the *true Shannon-diversity-index* was calculated (Jost 2006). The level of significance for all statistical readings is defined with $\alpha \leq 0.05$.

PRELIMINARY RESULTS: DEVELOPMENT OF VASCULAR PLANTS IN THE UNMANAGED MONTANE ZONE

Soil and air temperature showed no significant differences in mean values from June to September. Mean air temperatures vary between 15.7 °C and 16.7 °C, mean soil temperatures ranged from 14.1 °C to 16.0 °C (Tab. 1).

The mean total cover of the herb layer was highest on the study plots with old disturbances (81%), medium on the recently disturbed plots (75%) and lowest in reference stands (61%), however without significant differences yet.

A total of 235 vascular plant species were found on the 18 plots in the montane zone of which five are listed as endangered species (*Coeloglossum viride*, *Cotoneaster integerrimus*, *Laserpitum siler*, *Taxus baccata*, *Trollius europaeus*) (Scheuerer and Ahlmer 2003).

Six species showed a maximum degree of presence and could be found on each study plot (*Acer pseudoplatanus*, *Adenostyles alpina*, *Brachypodium sylvaticum*, *Fragaria vesca*, *Picea abies* and *Senecio fuchsii*).

Tab. 1: *Site characteristics of montane plots concerning temperature and plant diversity. Standard deviation (mean temperature) respectively range (mean diversity) in parenthesis.*

		montane zone (700-1.200 m a.s.l.)					
		reference		**new disturbance**		**old disturbance**	
		north	**south**	**north**	**south**	**north**	**south**
air temperature [°C]	mean	15.8 (4.2)	16.7 (4.5)	15.8 (4.3)	15.7 (4.5)	15.7 (4.2)	16.3 (5.2)
	minimum	5.6	4.8	5.3	4.4	5.7	4.7
	maximum	28.9	31.7	30.6	30.3	31.7	33.8
soil temperature [°C]	mean	14.8 (2.1)	16.0 (1.9)	14.4 (1.5)	14.5 (1.6)	14.1 (1.4)	15.8 (2.0)
	minimum	8.7	10.1	9.2	8.6	9.1	8.7
	maximum	22.6	21.8	18.3	18.4	17.3	20.4
vascular plants	mean species no.	71 (63 - 79)	74 (71 - 81)	73 (70 - 78)	74 (60 - 91)	72 (70 - 78)	81 56 - 93)
	mean species diversity	14.93 (9.29-23.28)	15.79 (14.78-16.47)	17.28 (15.25-19.73)	15.68 (9.25-23.59)	17.98 (16.86-20.04)	15.34 (11.98-22.07)

The total number of species did not differ significantly among plot types (Tab. 1). The highest numbers of species were found on south-facing sites with old or new disturbances. Species that profited most from the disturbance of the tree canopy and reacted with higher cover rates were nitrophyllous and light demanding species as *Rubus idaeus, Rubus fructicosus* s.l., *Urtica dioica* and fern species.

OUTLOOK

Additionally to the completion of the study plot set (10 study plots/plot type = 170 study plots) during the vegetation period 2013, nutrient measurements (soil and leaves) will be conducted to improve the understanding of the altered site conditions. Moreover the occurrence and abundance of mollusks and wood-decaying fungi as important deadwood composers will be surveyed in August/September 2013.

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FLORISTIC AND EDAPHIC CHARACTERISTICS OF BALKAN BEECH AND TURKISH HAZEL PLANT COMMUNITY (*Corylo colurnae-Fagetum* Jov. 1979) IN NATIONAL PARK "ĐERDAP" IN SERBIA

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Abstract: *Floristic and edaphic characteristics of Balkan beech and Turkish hazel plant community* **(***Corylo colurnae-Fagetum B. Jovanović (55) 1979) are researched in national park "Đerdap" in eastern Serbia. This plant community, in national park "Đerdap", occupies cold aspects-northern, northwestern and northeastern. Inclinations are very different, from flat terrains to very steep slopes.*

Balkan beech and Turkish hazel plant community in national park "Đerdap"is distributed mainly on limestone parent material. Soils are very different and next soil units interchange on very small area: Rendzic Leptosol (sceletic, brunic), Molic Leptosol (eutric), Leptic Cambisol (eutric, clayic), Vertic cambisol (eutric) and Colluvic Regosol (eutric).

Seventeen tree species are recorded in tree layer. Dominant species are Balkan beech (Fagus moesiaca K. Maly) Czecz) and Turkish hazel (Corylus colurna L.), but beech has greater abundance. Other tree species with high presence level in this layer are: Acer platanoides L., Fraxinus excelsior L., Fraxinus ornus L., Acer campestre L., Carpinus betulus L. and Acer pseudoplatanus L. Seventeen species are recorded in the shrub layer also. The highest abundance has beech regeneration, while high presence level have also Sambucus nigra L. and Cornus mas L. High presense level in herbacious layer have: Asperula odorata L., Rubus hirtus W. et K., Mercurialis perennis L., Prunus avium L., Viola sylvestris Lam., Pulmonaria officinalis L., Fagus moesiaca K. Maly) Czecz., Festuca drymeia M. et K and Lamium galeobdolon (L.) Crantz.

Phanaerophytes are most numerous in the life forms spectrum (39.5%), which indicates polidominant and relic character of these forests. Increased number of geophytes (16%), confirms that this community belongs to the alliance of beech forests Fagion moesiacae Bleč et Lakš 1970.

The Balkan beech and Turkish hazel plant community excels in flora richness and ecological diversity, which ensures joint life to various ecologically different plant species.

Key words: *Corylo colurnae-Fagetum*, floristic composition, edaphic conditions, life forms, distribution types, Đerdap

INTRODUCTION

Tree hazel (*Corylus colurna* L.) is distributed in the southeastern Europe (southwestern Romania, Serbia, southeastern Bosnia and Herzegovina, Montenegro, FYR Macedonia, Bulgaria, Greece and Albania) and western Asia (Turkey, Iran and Caucasus region) (http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl?11645). Tree hazel occurs in Serbia at elevations below 1200 m, as a dominant species in various plant communities, but mostly with beech, usually on limestone (Cvjetićanin, Perović 2010; Jovanović 2007). Tree hazel grows in Serbia in the following plant communities: polidominant community of common lilac, tree hazel and other

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species (*Syringo-Coryletum colurnae* Mišić 1967), polidominant community of oaks, tree hazel and other species (*Querco-Coryletum colurnae* var. geogr. *Acer intermedium* Mišić et Dinić 1971), polidominant community of ash, tree hazel and other species (*Fraxino excelsioris-Coryletum colurnae* var. geogr. *Acer intermedium* Mišić et Dinić 1972), polidominant community of balkan maple, tree hazel, beech and other species (*Aceri intermedii-Coryletum colurnae* B. Jov. 1953), relic pauperized forest of beech and tree hazel (*Corylo colurnae-Fagetum moesiacae* B. Jov. (55)1979), polidominant forest of beech, tree hazel and other species (*Fago moesiacae-Coryletum colurnae* Mišić 1967) (Tomić 2006). All these plant communities, with the exception of *Aceri intermedii-Coryletum colurnae* B. Jov. 1953, are recorded in Đerdap area (Mišić 1997). Considering that tree hazel plant communities in Serbia are not satisfactorily researched, the aim of this work is to present new data on floristic characteristics of beech-tree hazel community and to define soils on which this community grows.

OBJECT OF RESEARCH

Research was done in the National park „Đerdap", which is located in eastern Serbia, on the border with Romania. It comprises the biggest part of Đerdap gorge, the longest gorge in Europe, located on the right bank of Danube river, with total lenght of 98 km. The area of National park is 63680 ha, and buffer zone 93967 ha, which makes „Đedap" the biggest national park in Serbia. The lowest elevation in park is 80 m, and the highest 803 m a.s.l. (Vučićević, 1999). The climat in this area is temperate continental. Mean annual precipitation level is 784 mm, and mean annual temperature 11.3°C, which indicates that this area is considebarly warmer in comparison with the most of the territory of Serbia. Geological composition is very diverse, siliceous and limestone rocks are approximately equaly distributed (Medarević 2001, 2005). Over 1100 vascular plant species and over 50 tree and shrub plant communities occur in the National park (Amidžić et al. 2005; Amidžić *et al*. 2007). Total volume of tree hazel stams in National park area is 45998 m³, i.e. 0.5% of the total volume of Đerdap forest sands and it counts over 120000 stems (Medarević, 2001). The research was done in the area of Forest management units „Štrbačko korito" and „Kožice".

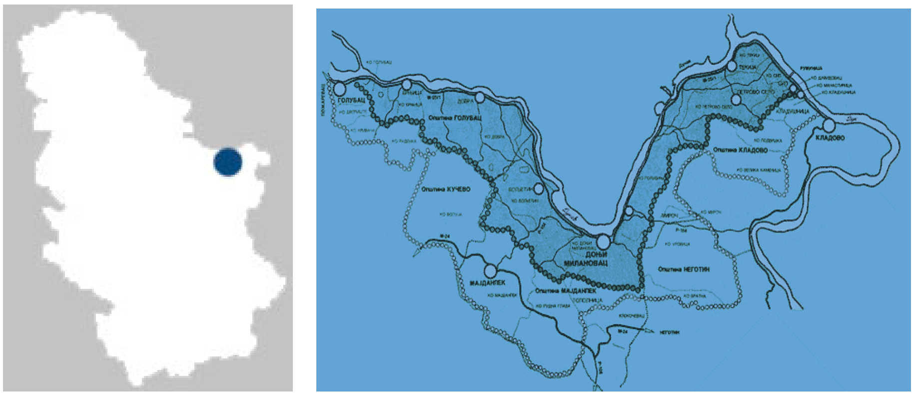

Figure 1: *The position of the Đerdap national park in Serbia*

MATERIAL AND METHODS

Eighteen phytocoenological releves were collected in the field using classique Braun-Blanquet (1964) method. Releves are afterfards sorted in phytocoenological table. Plant species are determined according to „Flora Srbije I-X" (Josifović et al. 1970-1977, Sarić, Diklić et al. 1986, Sarić et al. 1992) and „Ikonographie der flora des südöstlichen Mitteleuropa" (Jávorka, Csapody, 1979). The names of syntaxons are given according to Tomić (2006). The spectrum of floristic elements are made according to systematisation of biogeographical elements by Gajić (1980, 1984), and biological elements and life forms spectra according to Kojić *et al*. (1997).

Soil research was done based on the 11 dug soil profiles. Field research was done according to the standard methodology described in „Guide for field soil research" (Priručnik za ispitivanje zemljišta, book IV, 1967). Morphogenetical research of soil profiles were done, and samples were collected for the laboratory research. Laboratory research comprised physical and chemical soil properties. Among physical properties the content of hygroscopic water was estimated by drying in kiln at the temperature of 105°C during 6 to 8 hours; granulometric composition was estimated by treating the samples with sodium-pyrophosphate, and soil fractioning was done by the combination of piphete methode and elutration methode using sieve, according to Atterberg, by estimating percentage of next fractions: 2-0.2*mm*, 0.2-0.06*mm*, 0.06-0.02*mm*, 0.02-0.006*mm*, 0.006-0.002*mm* and fractions smaller than 0.002*mm*. The triangle of American pedological society was employed for estimating of texture classes.

The following chemical properties are investigated: active acidity (pH in H_2O) estimated electrometrically by using of pehameter, supstitucional acidity (pH in 0,01*M* $CaCl_2$) estimated electrometrically using pehameter, hydrolitical acidity estimated by *Kappen* methode, the sum of adsorbed alkali cations (S in $cmol*kg^{-1}$) estimated by *Kappen* methode, total adsorption capacity for cations (T in $cmol*kg^{-1}$), total sum of acid cations (T - S u $cmol*kg^{-1}$) calculated indirectly using hyrdrolitical acidity, level of alkali soil saturation calculated by *Hissink* (*%*), total nitrate level in soil calculated by *Kjeldahl* (*%*) method, proportional relationship of carbonate to nitrate (C:N), accesible P_2O_5 and K_2O (*mg*/100 *soil grams*) calculated by Al method.

Analytical methods used for laboratory soil research are described in JDZP guides for soil research (***1966, ***1997). The soils were classified according to the Classification of soils of Yugoslavia (Škorić et al, 1985), and afterwards, based on the proposition of the new version of national classification (Knežević et al, 2011), these soils were described according to the principes of the WRB classification.

RESULTS

On the basis of phytocoenological research it was established that researched plant communities belong to the beech-tree hazel community (*Corylo colurnae-Fagetum moesiacae* B. Jovanović (55) 1979). This community in Đerdap occurs mostly on sheltered aspects-northern, northwestern, northeastern. Inclinations are very different: it occurs on flat areas, than on mild, steep and very steep slopes. Total number of 81 vascular plant species is recorded in releves. The species numbers in a single releve varies from 11 and 34, averagely 24. Balkan beech (*Fagus moesiaca* Domin/Maly/Czeczott) and tree hazel (*Corylus colurna* L.) are recorded in all releves, while 15 plant species are recorded in more than 50% phytocoenological releves, which makes 18.5% of total species number.

The canopy in tree layer varies between 0.6 and 0.9. Tree layer counts 17 species, dominant species is always *Fagus moesiaca* Domin/Maly/Czecz.($V^{1.1\text{-}5.5}$), while *Corylus colurna* L.($V^{+\text{-}2.2}$) is codominant. In this layer, with high presence level (IV), are recorded also Norway maple (*Acer platanoides* L.) and common ash (*Fraxinus excelsior* L). Shrub layer also counts 17 species, and most frequent is rejuvenation of *Fagus moesiaca* which has presence level $IV^{+\text{-}2.2}$. *Corylus colurna* is sparsely represented with presence level I^{+}. Characteristic species assemblage in herbacious layer comprise: *Asperula odorata* L.($V^{+.2\text{-}3.4}$), *Rubus hirtus* W. et K.($IV^{+\text{-}1.2}$), *Mercurialis perennis* L.($IV^{+.2\text{-}4.4}$), *Prunus avium* L.(IV^{+}), *Viola sylvestris* Lam.(IV^{+}), *Pulmonaria officinalis* L.($IV^{+\text{-}+.2}$), *Fagus moesiaca* Domin/Maly/Czecz.($IV^{+\text{-}+.2}$), *Festuca drymeia* M. et K($IV^{+\text{-}3.3}$) and *Lamium galeobdolon* (L.) Nath($IV^{+.2\text{-}1.2}$).

In Đerdap area, tree hazel plant communities grow on soils formed on limestone and basic and neutral siliceous rocks. Significant areas are occupied by beech-tree hazel forests

(*Corylo colurnae-Fagetum moesiacae* B. Jovanović (55) 1979) on limestone parent material. Soil forming conditions on limestone are very specific. The alteraton of soil types occurs on very small area (Knežević 2001; Košanin, Knežević 2005; Košanin, Knežević 2007).

In *Corylo colurnae-Fagetum moesiacae* B. Jovanović (55) 1979 community, next soil types are researched in Đerdap area (Škorić et al, 1985): colluvium, rendzic on limestone, kalkocambisol and eutric cambisol. On the basis of established soil properties and using the proposal of new version of national soil classification (Knežević et al, 2011), researched soils are presented according to the principles of WRB classification (2006). Next classification units are recorded in researched beech-tree hazel stands in Đerdap: Rendzic Leptosol (sceletic), Rendzic Leptosol (brunic), Molic Leptosol (eutric), Leptic Cambisol (eutric, clayic), Vertic Cambisol (eutric) and Colluvic Regosol (eutric).

Rendzic Leptosol (Sceletic); Rendzic Leptosol (Brunic); Molic Leptosol (Eutric)- Leptosols are shallow, azonal soils, very frequent in mountain areas, sceletic. In many classifications leptosols on limestones belong to rendzic soils, and those on other rocks to rankers. Researched rendzic soils are distributed on the rims of the funnel-shaped holes and on the steeper slopes of researched area. Soils are usually highly sceletic-Rendzic Leptosol (Sceletic). This deteriorates physical soil properties. Sceletic soils are also very shallow. Typical rendzic soils-Molic Leptosol (Eutric), have mollic A horizon, up to 25 cm (40 cm) thick, colour is brown to dark grey, structure is granular. AC horizon is incoherent which deepens physiologically active layer to about 45cm. The texture of researched renzic soils is silty-loam.

Chemical properties of rendzinas are characterised by neutral or slightly acidic reaction, and adsorptive complex shows high alkali saturation (V=95,51%). Rendzic soils are moderately rich in humus, as well as in sodium. Relation C:N shows the formation of *mul* humus. The soils are poorly supplied with accessible phosphorous, while they are moderately to well supplied with accessible potassium. Deeper rendzinas are brownized in the lower part of the A horizon-Rendzic Leptosol (Brunic). In these soils a subsurface cambic horizon can be separated, at the dephts below 50 cm, which shows signs of differentiation considering A horizon. Differentiation is consisted in higher content of clay and colloid fraction. Primary and secondary soil particles are connected in bigger structural aggregates, and the manifestation of the characteristic brown color occurs also. Formed layer has all characteristics of cambic horizon, with the depht lower than 15 cm-Rendzic Leptosol (Brunic). Typical rendzinas in Đerdap frequently occur in soil combination with brownized rendzinas and cambic soils on limestone.

Leptic Cambisol (eutric, clayic) **-** in researched area these soils are on limestones, they mostly form on flatter relief forms (bottoms of funnel-shape holes and slopes with lower than 5° inclination), although this soil can be formed also on much steeper slopes, with the inclination of 20°, and even 35° (slopes of funnel-shaped holes). The surface is rocky (15-20%), but that characteristics does not occur in all profiles. Profile depth is up to 60-80 cm.

A horizon is 4.0-10.0 cm deep, its colour is brown, structure is usually granular. (B) horizon is much better developed, its depth is between 20 and 70 cm. Its color is characteristically brown to reddish-brown, the structure is poliedric to nut. Shallower soils are more sceletic, while deeper soils do not contain scelet at all. According to the texture, researched soils are loam to clay-loam in A horizon, and loam-clay in (B) horizon. Humus content in A horizon is 2.14-11.77%, and 1.05-5.45% in (B) horizon. Soil is without carbonates, its reaction is slightly acidic in all layers. Soils have high adsorption capacity and alkali saturation level is more than 50%. Soils are poorly supplied with accessible phosporous, while they are moderately supplied with accessible potassium.

Vertic Cambisol (eutric) **-** this soil in Đerdap forms on neutral or basic igneous rocks: amphiboles, andesites, sandstones etc. Depth of these soils in Đerdap is between 50 to 70 cm. A horizon is tawny gray, with stable granular or nut structural aggregates, with loamy texture. (B) horizon is brown, it has very favourable mechanical composition, mostly with nut structure.

Mechanical composition is mostly loamy. Soils are usually more or less sceletic. Reaction of these soils is slighty acidic to neutral, and humus content is moderate. This type has high level of alkali saturation (V>63,10%).

Colluvic Regosol (Eutric) **-** they are very poorly developed mineral soils on incoherent substratum, and they are not differentiated on soil horizons. Colluvic Regosols (Eutric) are very frequent in Đerdap. They are formed by leaching of soil material which was represented by sandy clays and fragmented parent rock material. This material forms as a consequence of intense rock weathering, and is leached from higher ground downslope. These soils are up to 80 cm deep. Mechanical composition is very diverse and depends on the parent material. Their texture is usually silty loams to silty clays and silty clay-loams. Humus content is the highest in the uper layer and reduced with the depth, its values are from 6.99 to 1.09%. Upper soil layers are well supplied with nitrogen, so the C:N relation shows very favourable humification and mineralisation processes. Their reaction is moderately to weakly acidic. High saturation of adsorptive complexes with alkali (54.26-92.11%) indicates that soil was formed by sedimentation of weathering particles from neutral or basic siliceous rocks and soil material formed from these substrata. Soils are poorly supplied with accessible phosphorous, while they are usually moderately supplied with potassium.

Dominant lifeform in *Corylo colurnae-Fagetum* Jov. 1979 biological spectrum are phanerophytes (40.7%), on the second place are hemycryptophytes (33.3%). Significantly represented are also geophytes (16%). The most frequent group in the spectrum of distribution types is the group of middeleuropean floral elements, which counts for 39.5% of all plant species. Next most abundant group are eurasian group of floral elements (19.8%), and submediteranean group (11.1%).

Table 1. *Spectrum od distribution types of Corylo colurnae-Fagetum Jov. 1979 community in Đerdap*

Group of floristic elements	Plant number	Presence	Floristic element	Plant number
MIDDLEEUROPAEAN	32	39.5%	Middleeuropean	11
			Submiddleeuropean	21
SUBATLANTIC	7	8.6%	Subatlantic-submediteranean	7
SUBMEDITERANEAN	9	11.1%	Submediteranean	6
			Eastern-submediternean	1
			Subeuksinsian	1
			Subiranian-eastsubmediteranean	1
BALKAN AND BALKAN-APENINE	2	2.5%	Moesic	1
			Subbalkanic	1
PONTIC-MIDDLEASIAN	5	6.2%	Pontic-submediteranean	2
			Pontic-eastsubmediteranean	2
			Subpanonian	1
EUROASIAN	16	19.8%	Subsouthsibirian	2
			Euroasian	11
			Subeuroasian	3
CIRKUMPOLAR AND COSMOPOLITE	8	9.9%	Cirkumpolar	3
			Subcirkumpolar	2
			Cosmopolitan	3
TURANIC	1	1.2%	Iranian-euksinian	1
ADVENTIVE	1	1.2%		1
TOTAL	81	100%		81

DISCUSSION

Beech-tree hazel plant communities belong to the alliance of beech forests (*Fagion moesiacae* Bleč. et Lakš. 1970) and suballiance of beech-tree hazel forests (*Corylo colurnae-Fagenion* Jov. 1979). It comprises xeromesophilous communities on hilly and montane areas on limestones in eastern and southeastern Serbia. They very rarely occur on other parent material, for example on andesite on Mrkonjski vis near Medveđa. These comunities are vicarious to those in suballiance *Ostryo-Fagenion* from western Serbia, with the difference than here *Ostrya carpinifolia* doesnt occur, and is replaced with *Corylus colurna*. Floristic composition of beech-tree hazel community shows, apart from mesophilous species of beech forests, significant number of xerophilous, and calciphilous species (Tomić 2004).

Two similar beeck-tree hazel communities are recorded in Đerdap area: polidominant community of beech, tree hazel and other species (*Fago moesiacae-Coryletum colurnae* Mišić 1967) and relic pauperised forest of beech and tree hazel (*Corylo colurnae-Fagetum moesiacae* B. Jov. (55)1979). Mišić (1997) quotes that community *Corylo colurnae-Fagetum moesiacae* B. Jov. (55)1979 formed during the process of pauperisation of more complex and diverse community *Fago moesiacae-Coryletum colurnae* Mišić 1967, and that there are transitions between them which indicate their common origin. Community *Corylo colurnae-Fagetum moesiacae* B. Jov. (55)1979 contains lower number of woody species than *Fago moesiacae-Coryletum colurnae* Mišić 1967, and is characterized with the absence of *Acer intermedium* Panč. as well as with the domination of beech in tree layer (Tomić 2004). Analysis of floristical composition of researched forest stands revealed that Balkan beech (*Fagus moesiaca* Domin, Maly/ Czecz) is the most frequent species in all phytocoenological releves, in contrast to the other dominant species *Corylus colurna* L., which is also represented in all releves, but with much lower frequency. Besides that, the presence of *Acer intermedium* has not been recorded at all. Thus, we consider that researched forest stands belong to the plant community *Corylo colurnae-Fagetum moesiacae* B. Jov. (55)1979. This community occurs out of refugia, on limestone areas of hilly and montane belts in biger part of eastern Serbia. It often forms on tablelands or flat ravines. Elevations are 700 to 1100 m, inclinations are lower than in community *Fago moesiacae-Coryletum colurnae* Mišić 1967. Soils are without rock blocks on the surface (Tomić 2004).

Biological spectrum of *Corylo colurnae-Fagetum moesiacae* B. Jov. (55)1979 community in researched area has phanerophyte-hemycryptophyte-geophyte character. Indicative is high representtion of phanerophytes (40,7%) comparing with biological spectrum of Serbia, where phanerophytes are represented with 8% (Jovanović 2007). This fenomena clearly speaks of relic character of this community. Overrepresentation of geophytes (16%), comparing with 10%, which is averege representation of geophyites in Serbian flora (Diklić 1984), confirms affliation of this community to the allliance *Fagion moesiacae* Bleč. et Lakš. 1970.

Middleeuropean group of floral elements is the most frequent group in the spectrum of distribution types, which indicates temperate-continental climate conditions in this community. Significant occurence of submediteranean group (11,1%) indicates xerothermic influence (Gajić 1984).

Vast number of species recorded in this community are characteristic for the class *Querco-Fagetea*, i.e. order *Fagetalia*: *Fagus moesiaca* Domin/Maly/Czeczott, *Asarum europaeum* L., *Arum maculatum* L., *Dryopteris filix-mas* (L.) Schot., *Festuca drymeia* M. et K, *Geranium robertianum* L, *Circaea lutetiana* L., *Dentaria bulbifera* L., *Sanicula europaea* L. etc.

CONCLUSIONS

Beech-tree hazel plant community (*Corylo colurnae-Fagetum* B. Jovanović (55) 1979) is researched in National park "Đerdap". This community grows on colder aspects, on very different inclinations, from flat to very steep terrains. Geologic parent material is mostly limestone, although it was recorded also on other rock types. *Corylo colurnae-Fagetum* B. Jovanović (55) 1979 in Đerdap occurs on different soil types: Colluvic Regosol (eutric), Rendzic Leptosol (sceletic), Rendzic Leptosol (brunic), Mollic Leptosol (eutric), Leptic Cambisol (eutric, clayic) and Vertic Cambisol (eutric).

The community is floristically very diverse. In 18 phytocoenological releves, 81 vascular plant species is recorded. Most frequent are phanerophytes (40,7%), which clearly indicates relic character of this community. Overrepresentation of geophytes (16%) indicates affliation of this community to the alliance *Fagion moesiacae*. Characteristic species assemblage comprise following species: *Fagus moesiaca* Domin, Maly/ Czecz, *Corylus colurna* L, *Asperula odorata* L, *Rubus hirtus* W. et K, *Mercurialis perennis* L, *Prunus avium* L, *Viola sylvestris, Pulmonaria officinalis* L, *Festuca drymeia* M. et K. and *Lamium galeobdolon* (L.) Nath.

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Corylo colurnae-Fagetum B. Jov. 1979																			
Releve number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Presence
Aspect	NE	NE	NNE	N	N	N	N	WNW	NW	NW	WNW	_	NE	NE	N	W	WNW	NE	
Inclination (°)	20	19	20	20	20	18	15	35	37	30	30	_	15	7	15-25	27	10-15	35	
Parent material	Limestone																		
Species number	33	21	24	32	31	25	25	28	33	30	34	18	23	20	18	13	11	17	
TREE LAYER																			
Canopy	0.8	0.7	0.9	0.9	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.7	0.9	0.9	0.9	0.6	0.9	0.8	
Fagus moesiaca Domin/Maly/Czecz	4.4	3.4	4.4	4.5	4.4	4.5	5.5	3.3	2.2	3.3	3.2	1.1	2.2	1.1	3.3	1.2	1.2	2.2	V
Corylus colurna L.	1.1	1.2	1.2	1.2	1.1	1.2	1.1	2.2	1.2	2.2	2.2	1.1	+	+	+	1.1	1.1	1.1	V
Acer platanoides L.	.	.	.	1.2	1.1	1.2	1.2	1.2	1.1	1.2	1.2	.	+	.	.	.	+	+	IV
Fraxinus excelsior L.	1.1	2.2	2.2	1.1	1.1	1.2	.	.	1.2	.	1.1	.	+	+	1.1	1.1	2.1	.	IV
Fraxinus ornus L.	+	.	.	+	1.1	+	.	1.1	1.1	1.1	1.1	1.1	+	.	.	.	.	.	III
Acer campestre L.	+	.	.	.	+	.	.	.	.	+	.	1.1	+	2.2	+	+	+	.	III
Carpinus betulus L.	.	.	+	+	.	.	+	.	.	.	.	3.2	1.2	2.2	1.1	.	.	+	III
Acer pseudoplatanus L.	.	.	.	.	+	+	1.1	+	1.1	+	+	.	.	+	.	+	+	.	III
Tilia tomentosa Mnch.	+	1.1	+	.	.	.	.	1.1	1.1	2.2	2.2	.	.	.	.	.	.	.	II
Juglans regia L.	+	+	.	.	.	.	.	+	.	+	1.1	.	.	.	.	.	.	.	II
Prunus avium L.	.	+	+	1.1	.	+	1.1	.	+	.	.	.	.	.	.	.	1.1	.	II
Sorbus torminalis (L.) Cr.	.	.	.	1.1	+	.	.		.	+	.	.	+	.	.	+	.	+	II
Tilia platyphyllos Scop.	.	.	.	+	+	.	.	1.1	.	.	.	.	.	.	.	.	+	.	II
Quercus petraea (Matt.) Lirb.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Populus tremula L.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Pyrus pyraster Burg.	.	.	.	+	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	I
Ulmus glabra Huds.	.	.	.	.	.	.	.	1.1	.	.	1.1	.	.	.	.	.	.		I
SHRUB LAYER																			
Canopy	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.3	0.2	0.1	0.3	0.1	0.2	0.2	0.3	0.4	0	0.4	
Fagus moesiaca K. Maly) Czecz	+	2.2	1.2	1.2	1.1	1.1	+	1.2	1.1	1.2	1.2	.	.	.	1.2	.	.	1.2	IV
Sambucus nigra L.	+	+	+	1.2	+	2.2	1.2	.	.	.	.	.	.	.	+	3.3	.	.	III
Cornus mas L.	+.2	.	.	.	+	.	.	1.2	1.2	.	+	1.1	1.2	1.2	.	.	.	.	III
Tilia tomentosa Mnch.	+	1.1	+	.	.	.	.	1.2	+	1.2	1.2	.	.	.	.	.	.	.	II
Acer platanoides L.	.	1.1	.	+	+	.	.	.	+	.	+	.	.	.	.	.	.	.	II
Daphne laureola L.	.	.	.	1.2	+	+.2	+.2	.	.	.	.	.	.	.	.	.	.	.	II
Tilia platyphyllos Scop.	.	.	.	+	+	.	.	+.2	.	.	.	.	.	.	.	.	.	.	I
Fraxinus excelsior L.	1.2	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	I
Carpinus betulus L.	.	.	.	+	.	.	.	+	.	.	.	+	.	.	.	.	.	.	I
Acer campestre L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I
Cornus sanguineus L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Corylus colurna L.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	I
Sorbus torminalis (L.) Cr.	.	.	+	.		.	.	.	.	.	.	.	.	.	.	.	.	.	I
Prunus avium L.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	I
Fraxinus ornus L.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1.2	I
Clematis vitalba L.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	I
Crataegus monogyna Jacq.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	I

Corylo colurnae-Fagetum **B. Jov. 1979**																			
HERBACIOUS LAYER																			
Coverage	0.7	0.8	0.5	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.9	0.6	1	0.5	0.6	0.2	0.7	
Asperula odorata L.	3.3	3.3	2.3	3.3	3.4	3.3	2.3	1.2	+.2	+.2	1.2	.	2.3	1.2	2.2	+.2	.	.	V
Rubus hirtus W. et K.	1.2	1.2	+.2	+.2	+	+	+.2	+	+	+	+	.	1.2	+.2	.	.	+.2	.	IV
Mercurialis perennis L.	+.2	2.2	1.2	1.2	2.2	1.2	1.2	3.4	4.4	3.3	3.3	.	+.2	+.2	.	.	.	.	IV
Prunus avium L.	+	+	+	+	+	+	+	+	+	+	+	.	.	.	+	.	.	.	IV
Viola sylvestris Lam.	+	+	+	+	+	.	+	+	+	+	+	+	.	.	+	.	.	.	IV
Pulmonaria officinalis L.	+.2	+.2	.	+	+	+.2	+.2	.	+	+	+	.	+	+	+	.	.	+	IV
Fagus moesiaca K. Maly) Czecz	+.2	1.2	+.2	+	.	+	.	1.2	+.2	.	1.2	.	+.2	1.2	+	.	.	+.2	IV
Festuca drymeia M. et K	.	.	.	+.2	+.2	+	+	+	+	+.2	1.2	3.2	2.2	3.3	2.2	.	.	2.2	IV
Lamium galeobdolon (L.) Nath	.	.	.	+.2	+.2	1.2	+.2	1.2	+.2	1.2	1.2	.	1.2	1.2	1.2	+.2	.	+.2	IV
Circaea lutetiana L.	.	1.2	+.2	1.2	+.2	2.2	1.2	.	.	+.2	.	.	.	.	.	+.2	.	.	III
Daphne laureola L.	.	.	.	+.2	+	+	+.2	+	+	+	+	.	.	.	.	.	.	.	III
Melica uniflora Retz.	.	.	.	+.2	1.2	.	+.2	.	+	+.2	+.2	1.2	1.2	1.2	.	.	.	.	III
Acer platanoides L.	.	.	.	+.2	.	+	+	+	+	+	+.2		+		.	.	+	+	III
Corylus colurna L.	+	+	+	+	.	.	.	.	.	+	.	.	.	+	.	.	.	.	II
Salvia glutinosa L.	+	+	.	.	.	.	.	+.2	.	+	+	.	.	.	.	+	.	+	II
Acer campestre L.	+	.	+	.	+	.	+	.	.	+	.	.	+	.	.	.	.	.	II
Juglans regia L.	+	+	+	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	II
Dryopteris filix-mas (L.) Schot.	.	.	+	.	.	+.2	+	.	+	+	.	.	.	.	+.2	.	.	+	II
Polystichum setiferum (Forsk.) Moore	.	.	+	.	.	.	+.2	+.2	+.2	.	+	.	.	.	.	.	.	.	II
Ruscus hypoglossum L.	.	.	.	+.2	.	R	+	+	.	+	.	.	.	.	+.2	.	.	.	II
Acer pseudoplatanus L.	.	.	.	+	+	+	.	+	.	.	+	.	.	.	.	.	.	.	II
Lathyrus venetus (Mill.) Wohlf.	.	.	.	+	+	.	.	+	+	+	+	.	.	.	.	.	.	+	II
Mycelis muralis (L.) Rchb.	+	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	II
Sanicula europaea L.	+.2	.	.	.	.	+	+	.	.	.	+	.	.	.	.	.	.	+	II
Sorbus torminalis (L.) Cr.	.	+	+	.	.	.	.	.	+	.	.	.	+	+	.	.	.	.	II
Tilia tomentosa Mnch.	.	.	+	.	.	.	.	.	+	+	+.2	.	.	.	+	.	.	.	II
Clematis vitalba L.	+	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	II
Dentaria bulbifera L.	.	.	.	+	+	+	.	.	.	.	+	.	.	.	.	+	.	.	II
Alliaria officinalis Andr.	.	.	.	+	+	+	+	.	+	.	+	.	.	.	.	.	.	.	II
Hedera helix L.	.	.	.	+	.	.	.	+	.	+	+	.	.	.	.	.	.	1.2	II
Melittis melissophyllum L.	.	.	.	+	.	.	.	+	+	.	+	.	.	.	.	.	.	.	II
Ulmus glabra Huds.	.	.	.	.	+	.	.	+	.	+	+	.	+	+	.	.	.	.	II
Carex pilosa Scop.	1.2	.	.	.	+.2	.	.	.	.	.	.	1.2	2.2	.	.	.	.	.	II
Asarum europaeum L.	.	.	.	.	.	.	.	+.2	+.2	+.2	+.2	.	.	.	.	.	.	.	II
Euphorbia amygdaloides L.	.	.	.	.	.	.	.	.	+	+	+	.	+	+	.	.	.	.	II
Stachys sylvatica L.	+.2	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Geranium robertianum L.	+.2	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Calystegia sepium (L.) Br	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Arum maculatum L.	.	.	R	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	I
Atropa belladonna L.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	I
Rosa pendulina L.	+.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Brachypodium sylvaticum (Huds.) P.B.	+.2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I

Corylo colurnae-Fagetum B. Jov. 1979																		
Stenactis annua (L.) Ness.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Fraxinus ornus L.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	I
Epilobium montanum L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Cornus mas L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Fragaria vesca L.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I
Carex sylvatica Huds.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Geum urbanum L.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Fraxinus excelsior L.	.	2.2	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	I
Moechringia trinervia (L.) Clairv.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Quercus petraea (Matt.) Lirb.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Dactylis glomerata L.	.	.	+	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	+.2	I
Populus tremula L.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Heracleum sphondylium L.	.	.	+	.	.	.	.	.	.	.	+.2	.	.	.	.	.	.	.	I
Sambucus nigra L.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	I
Lunaria rediviva L.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	I
Urtica dioica L.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Galeopsis speciosa Mill.	.	.	.	.	+	.	.	.	.	.	.	.		.	.	.	.	.	I
Asperula taurina L.	.	.	.	.	.	+.2	.	.	.	+	.	.	.	.	.	.	.	.	I
Tilia platyphyllos Scop.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	I
Lithospermum purpureo-coeruleum L.	.	.	.	.	.	.	.	+.2	+	.	.	.	.	.	.	.	.	.	I
Lilium martagon L.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	I
Carpinus betulus L.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	I
Ruscus aculeatus L.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	I
Evonymus latifolius (L.) Mill.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	I
Staphyllea pinnata L.	.	.	.	.	.	.	.	.	+	.	+.2	.	.	.	.	.	.	.	I
Phyllitis scolopendrium (L.) New.	.	.	.	.	.	.	.	.	+	.	+.2	.	.	+	.	.	.	.	I
Carex digitata L.	.	.	.	.	.	.	.	.	.	.	+.2	.	+	.	.	.	.	.	I
Aremonia agrimonioides (L.) DC	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	I
Rosa arvensis Huds.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+.2	I
Brachypodium pinnatum (L.) P.B.	.	.	.	.	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	I
Crataegus monogyna Jacq.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I
Ligustrum vulgare L.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	I
Glechoma hirsuta W. et K.	.	.	.	.	.	.	.	.	.	.	.	.	+.2	1.2	+	.	.	.	I
Viburnum lantana L.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	I
Polystichum aculeatum (L.) Roth.	.	.	.	.	.	.	.	.	.	.	.	.		.	+	.	+	.	I
Parietaria officinalis L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5.5	.	.	I
Hepatica nobilis Mill.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	+.2	I

SECTION III

CLIMATE CHANGES

CHAIRMEN – MODERATORS:

Michal Bosela

Mihailo Ratknić

FORESTS – THE CRUCIAL PLAYER OF THE GLOBAL CARBON CYCLE – ENVIRONMENTAL SENSITIVITY AND SEASONAL COURSE OF THE

Michal V. MAREK[1], Dalibor JANOUŠ

Abstract: *Carbon fluxes between the stands of plants and atmosphere could be regarded as the key process of the global mass and energy exchange. Especially forest stand plays crucial role, because their surface area and longevity. Huge amount of the atmospheric carbon is absorbed by vegetation via the process of photosynthesis, i.e. biological pump of the carbon. Final carbon exchange of a real plants stand is a manifestation of a permanent balance between assimilatory activity and respiratory losses of the carbon. The respiration carbon efflux is a result of both autotrophic (mainly plants roots) and heterotrophic (soil bacteria) activity strongly dependent on the temperature and soil moisture, respectively. The process of plants carbon pumping is extremely sensitive to the impact of environmental factors, primarily the effects of microclimatic factors of the real plant stand and external synoptic events, and by the seasonal ontogeny of assimilatory apparatus and soil biota. Carbon pumping in the real world of plants stand is characterised by the distinctive seasonal course of the carbon fluxes because of the seasonal ontogeny of assimilatory apparatus. The sensitivity of plant carbon pumping can be demonstrated on the sequence of spring days, i.e. the situation of the start of the vegetation season. Principles of carbon pumping are mainly connected to the potential of photosynthetic activity of plants, rep. trees and carbon sources form the forest soil, respectively. Very interesting for the evaluation of the potential of concrete region, country, point of view brings a comparison of different ecosystems types. To be able to evaluate the importance of different ecosystem in the carbon sequestration the comparison for different ecosystems of the Czech Republic is presented. It is still evident that the importance of forest ecosystem in the carbon deposition is without any doubts.*

Keywords: carbon cycle, sensitivity of carbon deposition, ecosystems comparison

EXPERIMENTAL SITES AND METHODS

The eddy-covariance technique (Aubinet et al. 2000) was used for the carbon exchange measurement in different ecosystem types (Tab.1). Unified eddy-covariance systems were applied for the fluxes measurements in all types of investigated ecosystems. Fluxes of carbon dioxide and water vapor and subsequently latent and sensible heat exchange between stand and atmosphere were measured using closed-path eddy-covariance system InSituFlux (InSituFlux, Sweden, IRGA: LI-7000, Li-Cor USA) sonic anemometer (Gill R3, Gill Instruments UK) and the data were processed by special EcoFlux software (InSituFlux, Sweden,). At present, the current network of eddy-covariance towers in the Czech Republic is composed of a set of five observation sites representing the basic types of terrestrial ecosystems (Table 1). The measurement of carbon fluxes started gradually from 1997 (Bilý Kříž mountain spruce z forest) to 2008 (Štítná beech forest).

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RESULTS AND DISCUSSION

Ecosystem final carbon storage is a result of the balance between photosynthetic assimilation and ecosystem carbon efflux, which is product of both autotrophic (mainly plant roots, stems, branches and foliage) and heterotrophic (soil fauna, fungi, bacteria etc.) activities strongly dependent on temperature and soil moisture, respectively.

A comparison of the individual basic types of ecosystems of the Czech Republic (example of the year 2009) brings evidences on their different carbon storage potential. Concrete annual the dynamics of the carbon storage makes this differentiation more evident (Fig. 1). Because of the length of the growing season, the Norway spruce forest was identified as the significant landscape carbon sink. The same importance was found for the mountain adult beech forest. Of course the pattern of the seasonal dynamics of the carbon storage is little bit different because of the seasonality of the assimilatory tissue. The mountain non-managed grassland showed massive respiration and secondly a part of the grassland carbon is annually lost by the biomass harvest (up to 1.1 t of carbon) resulting in the negative final annual carbon balance. Important carbon storage was observed in the agro-system (up to 65% of the forest – spruce and beech stands carbon storage). However this carbon storage was achieved because of the combination of an intensive crop management (nitrogen fertilization up to 130 kg N ha^{-1}) and a combination of the crops system (wheat and maize) resulting in a prolongation of the intensive growth and biomass accumulation phase. Wetland ecosystem carbon sink amounted medium value in comparison to other ecosystems type (up to 3 t C $year^{-1}$). The flowage is the main limitation of the carbon uptake in wetland.

Ecosystem carbon sink is strongly related to the course of individual growing season (Fig.2). The occurrence of some microclimatological events (hot and dry days, drought, temperature turn of events) are crucial for the final, on seasonal base, carbon storage.

Deeper analysis of the seasonal course of carbon uptake by the spruce forest and the application Savitzky - Golay Spline fitting makes possible to determine the most productive part of the season from the carbon storage point of view (Fig. 3).

Observed “between-season” differences in the amount of seasonal storage carbon in Norway spruce stand are affected by the prevailing form of incident solar radiation (Fig. 5). Because of the nature of diffusive solar radiation penetration into stand crown layer, the photosynthetic assimilation responses to diffusive light and generally moderated respiration under cooler conditions of cloudy days, the final spruce stand carbon storage is positively related to the number of cloudy days during the season.

Realized analysis shows the undisputable role of forests in Czech Republic terrestrial ecosystems for the carbon sequestration. This role of forest is generally accepted (Kauppi et al. 1992, Janssens et al. 2003, Marek et al. 2011). The duration of an active growing season, i.e. time of active photosynthetic carbon uptake can be regarded as the crucial factor determining the ecosystems carbon sink strength. Especially sequences of zero-plus days with active carbon storage at the start and lower temperature – related slow respiration activity at the end of the season are of great importance. The carbon storage is strongly related to the physiological background, i.e. photosynthesis. Thus, all factors related to the feed-back limitation of assimilation are responsible for the whole-stand scale carbon capture dynamics. Moreover, the final balance between the captured and released carbon is very tight mainly because of the strong link to the microclimatic factors, external synoptic events, soil temperature and moisture and to the seasonal ontogeny of assimilatory apparatus (Law et al. 2002).

The current mosaic of ecosystem types which is presented in the Czech landscape is manifested by their different ability to act as important and stable carbon sink. However, the sustainability of this situation in future is questionable (Nabuurs at al. 2003) because of predicted increase of temperature, carbon dioxide atmospheric content, increased occurrence of extreme climatic events, air pollution and pests.

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Tab.1: *Basic description of investigated ecosystems*

Experimental site	**Latitude**	**Longitude**	**Elevation (m.a.s.l.)**	**Ecosystem type**	**Main species**	**Age (years)**	**Height (m)**
Bílý Kříž Beskydy Mts.	N 49^0 30′	E 17^o 58′	930	spruce forest	Picea abies	32	17
Bílý Kříž Beskydy Mts.	N 49^0 30′	E 18^o 32′	855	grassland	Festuca rubra		
Štítná White Carpathians Mts	N 49^o20′	E 17^o58′	560	beech forest	Fagus sylvatica	150	32
Žabčice	N 49^o00′	E 16^o36′	179	agrosystem	barley, maize		
Mokré louky Třeboň	N 49^o01′	E 14^o46′	426	wetland	saedge grass		

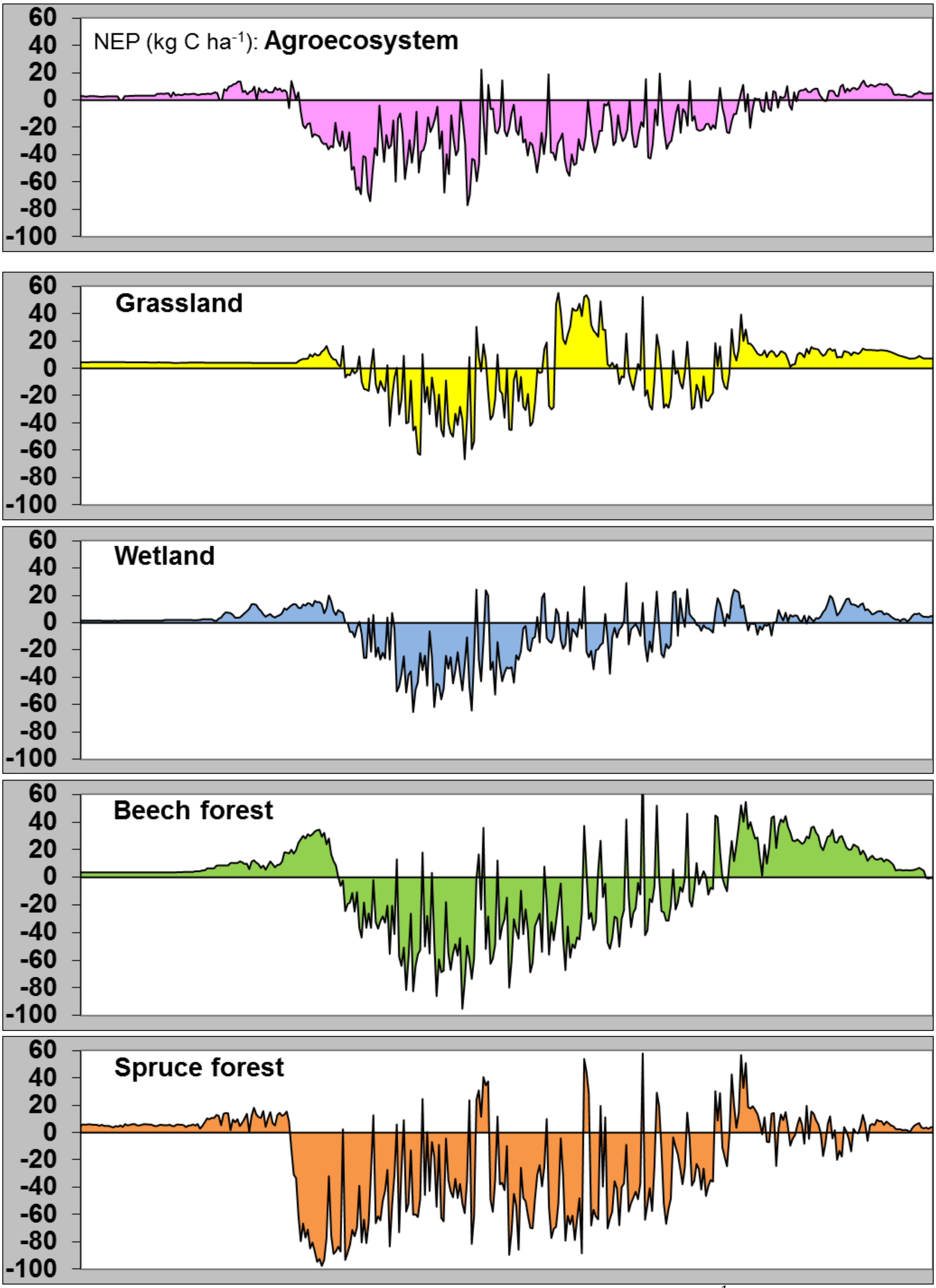

Fig. 1: *Seasonal course of the Net Ecosystem Production (NE: kgC ha^{-1}) of the investigated ecosystems types – season 2010 (the area above the x-axis – carbon efflux, area below x-axis – carbon gain)*

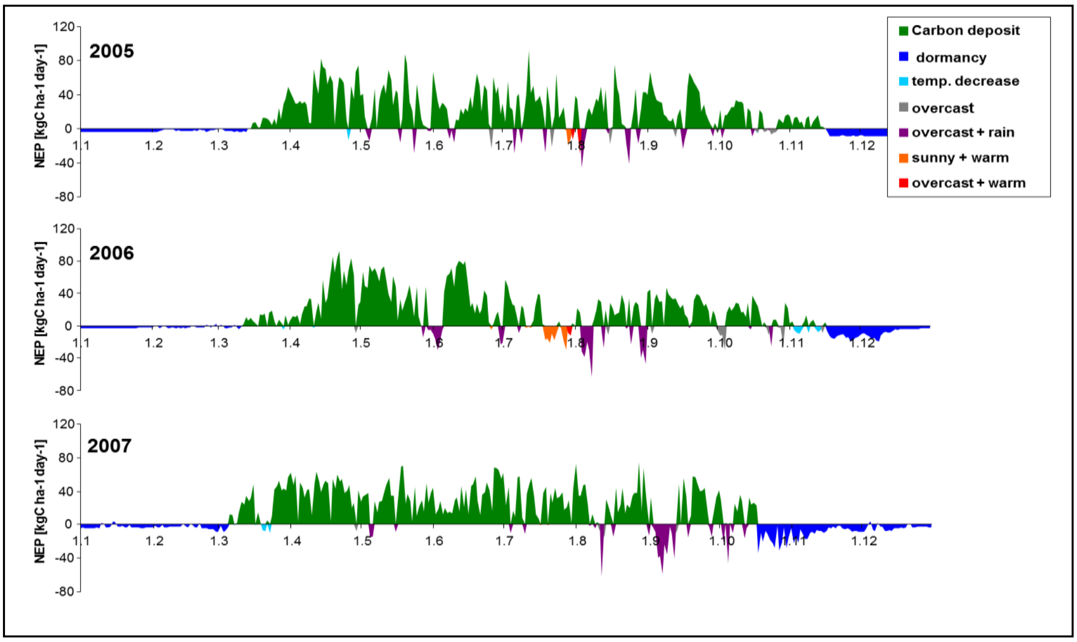

Fig. 2: *Detailed analysis of seasonal course of NEP, comparison of 3 seasons, Norway spruce. Different microclimatic and phenological situations are identified.*

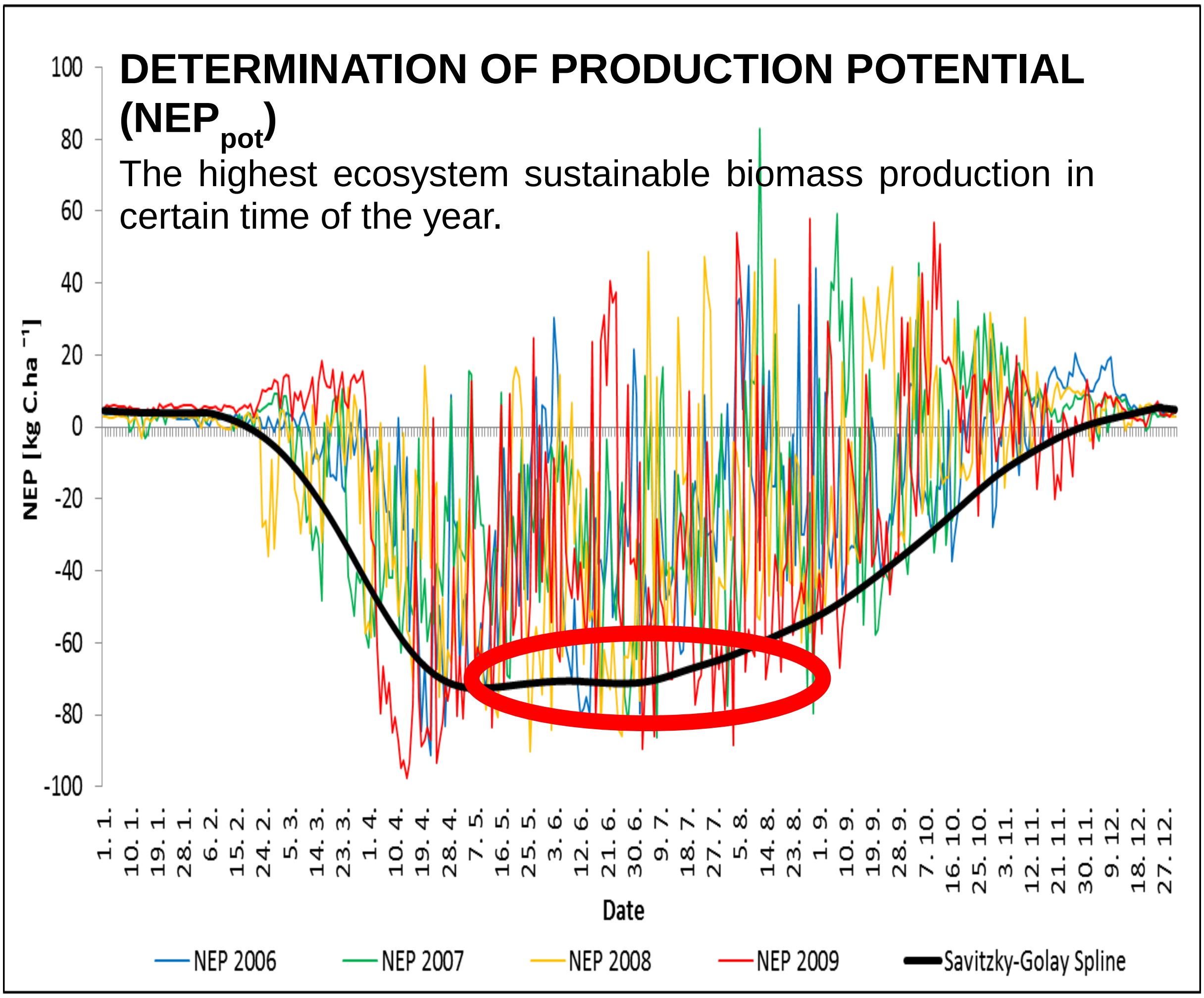

Fig. 3: *Determination of the seasonal most carbon storage section – Norway spruce, estimation based on the 5 years data set of NEP.*

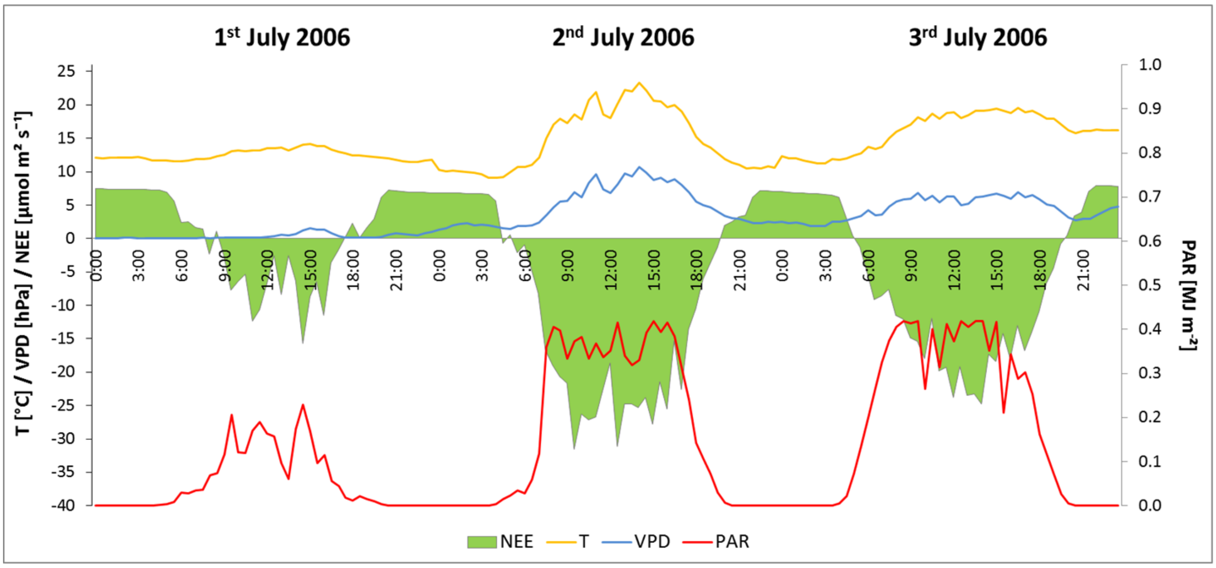

Fig. 4: *The identification of the "high carbon storage capacity deplete phenomenon" the Norway spruces during selected sequence of summer days of the growing season 2006.*

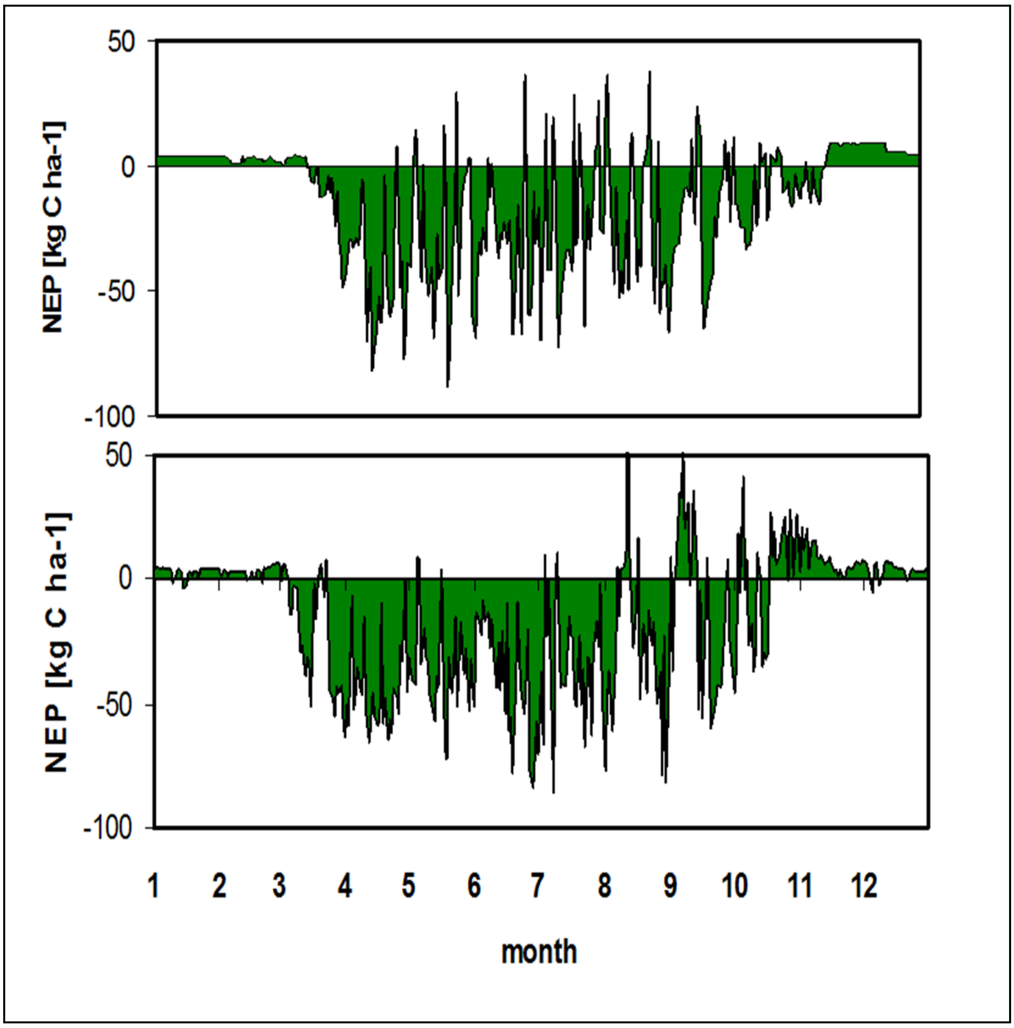

Fig. 5: *Observed "between-season" differences in the amount of seasonal storage carbon in Norway spruce stand related to prevailing form of incident solar radiation.*

International Scientific Conference
FORESTS IN THE FUTURE – SUSTAINABLE USE, RISKS AND CHALLENGES
4-5 October 2012, Institute of Forestry, Belgrade, Republic of Serbia

CLIMATE CHANGE IN SERBIA AND ITS IMPACT ON FOREST ECOSYSTEMS

Milun KRSTIĆ[1], Zoran GOVEDAR[2], Ivan BJELANOVIĆ[1], Srdjan KEREN[2]

1. INTRODUCTION

It is known that climatic factors determine habitat conditions that influence regeneration and survival of forests and other plant formations in a given area, and that the distribution of specific types of forest vegetation is adapted to existing climatic conditions. According to the Intergovernmental Panel on Climate Change (IPCC), the current changes in global and regional climate in the future will be, among other things, manifested by increasing the temperature and temperature extremes, and reducing the amount of rainfall. This would seem particularly stressful to trees (forest), particularly through reduction of biodiversity, reduction of vitality of trees, drying (extinction) of some tree species, etc. Forests will be difficult to adapt to sudden changes, which may lead to their demise. Therefore, forest management has to be adapted to altered environmental conditions, and one of the solutions is through application of nature-based silviculture.

It is known that a key component in the hydrologic cycle is evapotranspiration - the conversion of liquid water at the earth-atmosphere boundary, and a number of approaches have been used to assess evapotranspiration and runoff changes within the context of an altered climate.

The evaluation of evapotranspiration is important in the study of the impact of climate change on water resources as evapotranspiration can be considered a key "link" between the atmosphere and the soil matrix within the hydrologic cycle (Hagan, et. al; 1967, acc. to Yates D., Strzepek K. 1994).

The paper presents the results of analyzes of climate change in Serbia based on data for two typical meteorological stations: one lowland in urban conditions (Belgrade) and other typical altitude meteorological station in the forest area (Zlatibor). The data relate to the measurement period from 1991 to 2010., and they were compared with reference data for the period 1961-1990. We analyzed the basic elements of climate – air temperature and precipitation regime. In particular, the analysis of climatic parameters important for the development of forest vegetation (such as evapotranspiration and soil water regime) has been performed. Comparative values of evapotranspiration are presented by applying methods of Penman-Monteith, Thorntrhwaite, and Thornthwaite-Mather as different parameters are used in different methods for determination of evapotranspiration. Also, annual variation for this period is shown along with determined differences between methods, and there is a recommendation for the use in our conditions.

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The data are particularly important from the point of forestry, especially for the purpose of defining, selecting and applying specific needs of silvicultural treatments in terms of current and expected future climate change.

2. GENERAL NOTES ON CLIMATE CHANGE

In the fourth report of the work group I of the Intergovernmental Panel on Climate Change (IPCC, WG1 IPCC) 2007 (www.hidmet.sr.gov.yu, 2010) the following facts are stated:

- In many world regions the changes in the intensity and frequency of the occurrence of the climate extremes, such as drought, floods, tropical cyclones, storm weather, followed by hail, snow blizzards and avalanches, the waves of the extremely high air temperatures, frost, strong rain of short duration, wildfires, were registered;
- Furthermore, the projections of the climate change for Europe show the decrease of the quantity of precipitation in south-eastern Europe by 1% per decade;
- Even in the case of the radical reduction of the emission of the gases with the greenhouse effect, the average global air temperature will increase by 0.6^{o}C by the end of the century;
- The different increase of the air temperature in some regions would be followed by the different regional changes in the precipitation regime, variability of the local climate, changes in the intensity and frequency of the climate extremes, the shift of the climate zones towards the poles and greater altitude;
- In south-eastern Europe, the region to which Serbia belongs, along with the further trend of the increase of the air temperature in the next period, the further decrease of precipitation followed by the reduction of the number of the days with snow and snow layer, the decrease of the water drainage, soil humidity, and the availability of the water resources, is anticipated.

According to Jovanovic (1954), Wagner states that in Europe from the beginning of the XIX century the temperature has increased by 1^{o}C per century. Over the past 100 years the average global increase of the temperature was 0.6^{o} C, and the further increase of it is anticipated (Root et al., 2003).

The current climate change has been registered in Serbia. The Republic Hydrometeorological Service of Serbia (www.hidmet.sr.gov.yu, 2010) presents the following basic climate characteristics in Serbia in regard to the climate change: in most parts of Serbia June is extremely warm, July is warm, and August is very warm. The number of the tropical days was above average for summer, and in August this number was even double the average. The heat wave, as the extreme climate event, was registered in most parts of Serbia, from June 21st to June 27th.

The Figure 1 presents the average annual temperature for GMS Belgrade, by the deviation of the temperature from normal range for the standard period 1961–1990. The solid line presents the 5-year moving average for the period 1886-2005, and the columns present the deviations from the normal range for every year. The global trend of the increase of temperature, which is particularly expressed in the last decade of the last century and continued by 2005, is clearly visible. By the mid 20th century the temperature was below the normal range, and since then until 1990 it varied within the normal range, and later it varied considerably above the normal range. The post-2000 period has been warmest since the beginning of the temperature measurement in Serbia (Krstić et al, 2010).

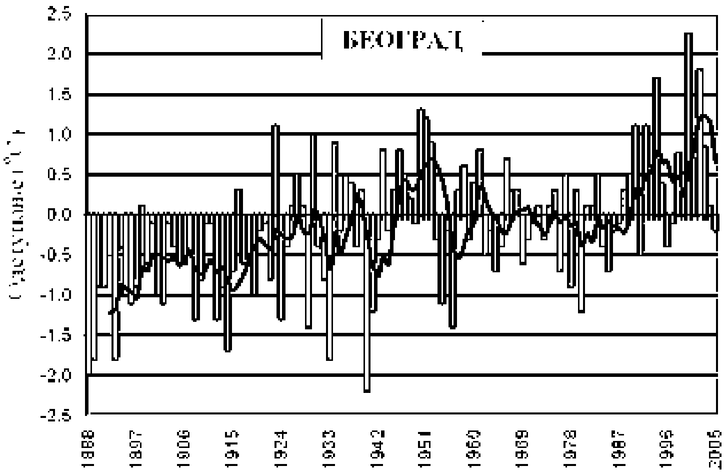

Figure 1. *The deviation of the average annual temperature from the normal range for the standard period 1961–1990. for GMS Belgrade*

3. COMPARATIVE CLIMATE CHARACTERISTICS FOR BELGRADE AND ZLATIBOR

An analysis of basic climate change elements (air temperature and precipitation) for the last 20 years (in the period 1991-2010.) was performed and the results were compared to the reference period 1961-1990. The analysis inter alia involved some specific years: eir changes for each characteristic in this period: the coldest 1991., the warmest 2000., max precipitation 1999., and the the driest (with a minimum rainfall) the year 2000.

Table 1. *Basic climate data*

Period	Air temperature (°C)				Precipitation (mm)					
	Belgrade		Zlatibor		Belgrade			Zlatibor		
	An	GS	An	GS	An	GS	%	An	GS	%
1961-1990	11.9	18.4	7.1	13.0	684	389	56.9	964	545	56.5
1991-2010	12.8	19.6	8.0	14.1	714	404	56.6	1040	567	54.5
1991	11.4	18.1	6.6	12.6	728	435	59.8	996	553	55.5
1999	12.4	19.2	8.1	14.4	1051	637	60.6	1282	715	55.8
2000	14.2	21.0	9.2	15.6	368	203	55.2	849	456	53.7

3.1. Change of air temperature

Compared to the reference period 1961-1990., in the last 20 years (1991-2010.) mean annual air temperatures in Belgrade and Zlatibor has increased by 0.9 °C (Table 1). At the same time in the growing season the increase is 1.2 °C in Belgrade, and 1.1 °C on Zlatibor. The data clearly indicate that there was a significant xerothermisation of climate, which is tuoched upon for the last 100 years.

During the coldest year in the analyzed period (1991.) mean annual air temperature in Belgrade and Zlatibor is lower compared to the period 1961-1991. by 0.5 °C, and compared to the period 1991-2010. by 1.4 °C. During the warmest year (2000.) mean annual air temperature in Belgrade and Zlatibor is higher compared to the period 1961-1991. for more than 2 °C, and in relation to the period 1991-2010. by 1.4 °C in Belgrade, and 1.2 ° C on Zlatibor. Comparing both the warmest and the coldest year, it is found that the temperature difference in the mean annual temperature was slightly less than 3 °C, and for the growing season exactly 3 °C.

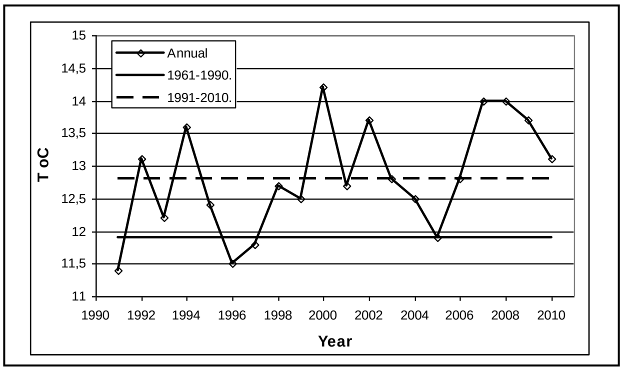

Figure 2. *Air temperature in Belgrade*

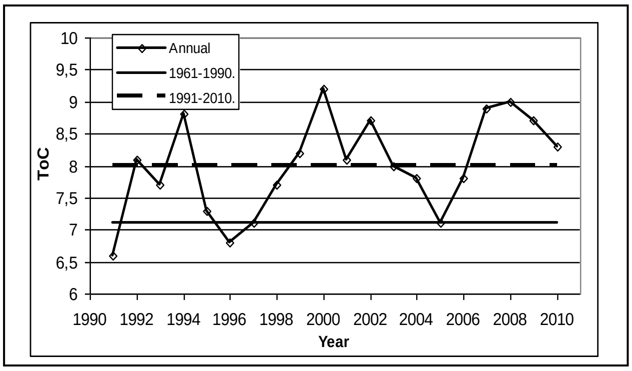

Figure 3. *Air temperature on Zlatibor*

The analysis of annual changes in air temperature values shows that in relation to the period 1961-1991. only years 1991., 1996. and 1997., had lower temperatures, while in relation to the average for the period 1991-2010 variation is very pronounced. At the same time the cyclic alternating warm and cold periods is indicated. Except the hottest year 2000., significantly warmer were also the years 1994. and 2007. (2008) (Figure 2 and 3).

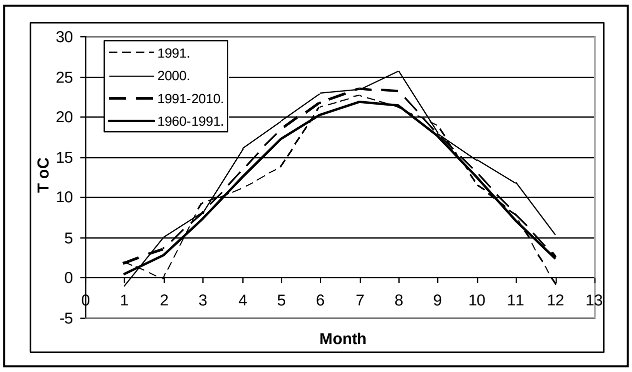

Figure 4. *Air temperature in Belgrade*

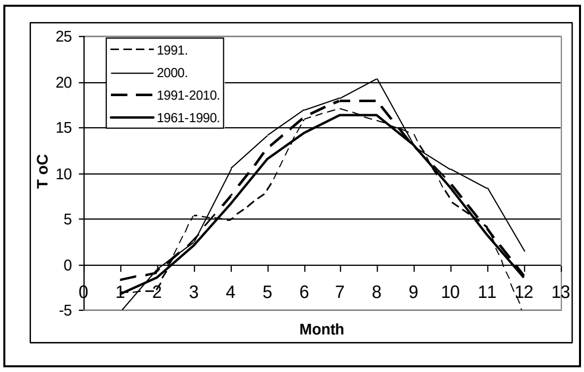

Figure 5. *Air temperature on Zlatibor*

Comparing the occurence of monthly values of temperature, it can be concluded that in the warmest 2000. the warmest month was August and the coldest month was January (Figure 4 and 5).

3.2. Precipitation changes

Similar to air temperature, average annual precipitation in Belgrade and Zlatibor has increased in the last 20 years (1991-2010.) relative to the reference 1961-1990. period. Increase in Belgrade was for about 4% and on Zlatibor around 8%. (Table 1). At the same time in the growing season this increase is not so high.

During the driest year in the analyzed period (year 2000), compared to the period 1961-1991., the annual sum of precipitation in Belgrade decreased by about 86%, and on Zlatibor for about 14%. In relation to the period 1991-2010 Belgrade it was almost two times smaller and on Zlatibor for about a quarter less. Comparing the wettest year 1999. and the driest 2000. for the period 1991-2010., it can be noticed that the annual sum of precipitation was lower in Belgrade for more than 2.5 times, and on Zlatibor about 50% less. This difference is even more pronounced during the growing seasons.

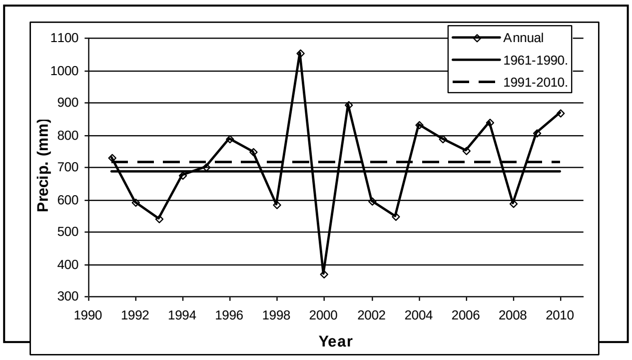

Figure 6. *Yearly precipitations in Belgrade*

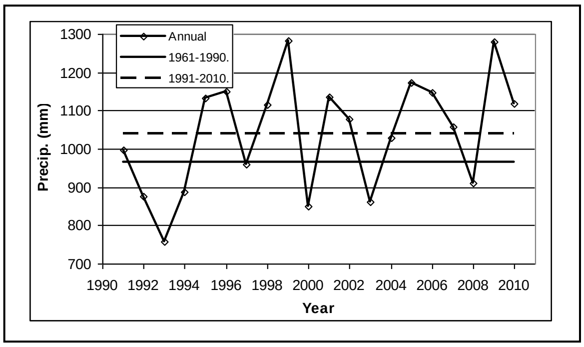

Figure 7. *Yearly precipitations on Zlatibor*

Analysis of changes in monthly values of annual precipitation sum, it can be concluded that in the wettest year 1999. the most extreme rainfall was in July (262 mm in Belgrade and Zlatibor 210 mm) and lowest in August (Figure 8 and 9). In the driest year 2000. least rainfall was in August with only 8 mm in Belgrade and 22 mm on Zlatibor. These data show the enormous differences in the amount of rainfall during the vegetation period, which reflects the stress on vegetation.

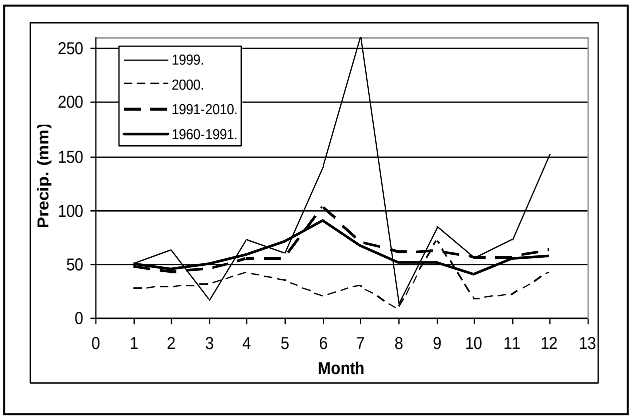

Figure 8. *Monthly precipitations in Belgrade*

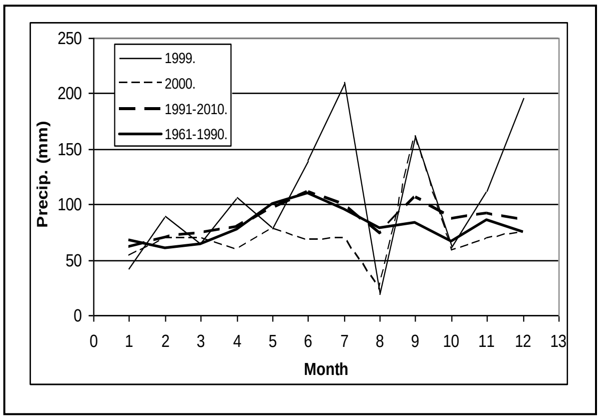

Figure 9. *Monthly precipitations on Zlatibor*

3.3. Potential evapotranspiration

Runoff changes within the context of an altered climate Thornthwaite (1944) defines potential evaporation as “the water loss which will occur if at no time there is a deficiency of water in the soil for use of vegetation” — assuming soil storage is not depleted. According to Thornthwaite (1948) the rate of evapotranspiraton depends on four things: climate, soil-moisture, plant cover an land management. First two prove to be far the most important. Precipitation and evapotranspiration are equaly important climatic factors.

There are a number of methods for estimating reference evapotranspiration (ETo), which is widely used in many fields of economy and science. In the framework of the UN Food and Agriculture Organization (FAO), after testing many known methods, Penman-Monteith model-is accepted as a standard for determining ETo and labeled as FAO56-AM. www.hidmet.gov.rs/ciril/meteorologija/agro_evapotranspiracija.php. The Penman-Monteith equation is regarded as one of the most accurate equations to estimate evapotranspiration (Yates D., Strzepek K. 1994). The Penman-Monteith method refers to the use of an equation for computing water evaporation from vegetated surfaces. Standardized ET equation for a tall reference crop would be viewed as successful under this short period test but extreme environment (Howwel and Evett).

The Thornthwaite water balance (Thornthwaite, 1948) uses an accounting procedure to analyze the allocation of water among various components of the hydrologic system. Computations of monthly water-balance components of the hydrologic cycle are made for a specified location. Inputs to the model are monthly temperature and precipitation. Outputs include monthly potential and actual evapotranspiration, soil moisture storage, snow storage, surplus, and runoff. (www.javaforge.com/wiki/80890). The modfied Thornthwaite-Mather water balance model described below, hereafter referred to as the soil‑waterbalance (SWB) model, was developed by the WGNHS to estimate the spatial and temporal distribution of natural groundwater recharge for watersheds in humid and temperate humid regions. The model accounts for the processes of precipitation, evapotranspiration, interception, surface runoff, soil-moisture storage, and snowmelt through (Dripps and Bradbury, 2007).

Comparative characteristics of the implementation of the budget evapotranspiration by different methods were given by D. Yates, Strzepek K. (1994).

This contribution is an analysis of climatic parameters important for the development of forest trees – evapotranspiration and water balance in the soil. Among other things, the evapotranspiration can be used for assessing the situation and assess the need for irrigation. This article shows the comparative values calculated by methods of Penman-Monteith, Thorntrhwaite and Thornthwaite-Mather because the calculations use different parameters for determination of evapotranspiration (Table 2).

The presented data suggest that the Penman-Monteith method gives the highest values of potential evapotranspiration in all years. The calculation is based on a large number of parameters that influence PE, air temperature, air humidity, wind speed, and length of daylight during the year for a given locality. During the reference period 1961-1990. by the method of Penman-Monteith the annual value (An) of potential evapotranspiration (PE) is 905 mm, and in the growing season (GS) is 698 mm. Similar values were in the period 1971-2000. (901 and 691 mm), which gives the Republican hidrometerorološki Service of Serbia (www.hidmet.gov.rs / ciril / meteorology / pros_pet.php)

Table 2. *Potential evapotranspiration (PE mm) by different methods*

Used method	Season	Year and meteorological station									
		1961-1990.		1991-2010.		1991.		1999.		2000.	
		Bel.	Zlat.	Bel.	Zlat.	Bel.	Zlat.	Bel.	Zlat.	Bel.	Zlat.
Thornthwaite	An	736	573	776	599	725	570	759	602	837	645
	GS	632	504	670	528	620	486	655	534	713	555
Thornthwaite -Mather	An	658	503	701	528	649	500	682	529	757	572
	GS	557	437	596	458	548	421	581	464	637	487
Penman-Monteith	An	905	695	771	727	877	636	825	709	1168	858
	GS	698	541	568	572	673	498	637	547	904	664

Methods by Thornthwaite and Thornthwaite-Mather use the energy-temperature conditions and duration of sunshine, except that the method of Thornthwaite-Mather calculates evapotranspiration separately for decades in a month. He also gives a minimum value of PE. The values of PE, regardless of the applied calculation method, change proportionally in accordance with the changes in air temperature. The biggest, expectedly, in the hottest year 2000. and compared to the coldest year 1991., the annual values of PE are higher by one third.

According to Yates D., Strzepek K. (1994), several of the more common methods for estimating potential evapotranspiration were detailed and used within a hydrologic model to determine how these various methods impact a climate change assessment. It was generally shown that by simply using a different estimator of Etp, dramatically different impact results can be found. Empirical methods, which are often only temperature based, give significantly different marginal changes to temperature fluctuations when compared with the physically (or micrometeorological) based methods such as the modified Penman equations.

As is known, the method of Thornthwaite and Mather-Thornthwaite allow calculation of actual evapotranspiration, which depends also on the amount of precipitation and soil water reserves. The calculated values are shown in Table 3 according to the method of Thornthwaite, at higher altitudes it is equal to the potential (as is the case in Zlatibor), or less. In Belgrade, the annual value is less than potential for the reference period 1961-1990. about 20%, and the like in the 1991-period of 2010. In the warmest and driest year 2000, the annual value of actaul evapotranspiration (AE) is lower for more than twice, and in the wettest year 1999 is lower for about 10%.

Table 3. *Actual evapotranspiration (AE mm)*

Used method	Season	Year and meteorological station									
		1961-1990.		1991-2010.		1991.		1999.		2000.	
		Bel.	Zlat.	Bel.	Zlat.	Bel.	Zlat.	Bel.	Zlat.	Bel.	Zlat.
Thornthwaite	An	582	573	610	599	618	570	727	602	368	645
	GS	487	504	504	528	513	486	623	534	290	555
Thornthwaite-Mather	An	486	442	298	288	484	436	504	435	313	443
	GS	401	380	238	244	400	362	412	373	227	362

Since the decadal values of climatic elements necessary for the calculation of PE and AE by the method of Thornthwaite-Mather were not available, they were calculated according to the monthly values, and a comparative view of the relationship of the amount of PE and AE in analyzed periods is shown on the basis of their values by the method of Thornthwaite (Figure 10).

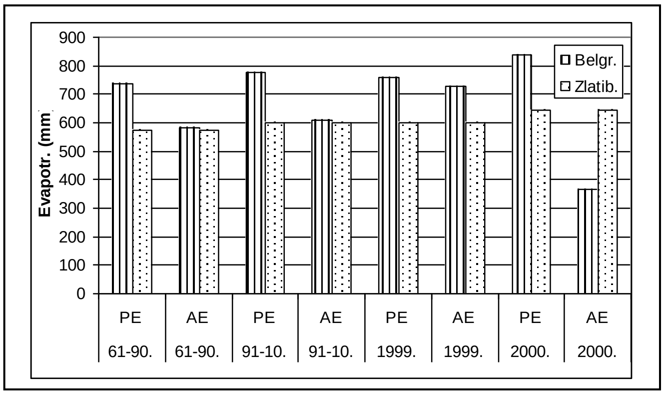

Figure 10. *Comparative view of the relationship of the amount of PE and AE in analyzed periods*

3.4. Climate classification

For the purposes of forestry, especially the method of choice for silviculture and reforestation, are of great importance, and most are in the application of climate classification by Lang and Thornthwaite (Kolić, 1988). D. Yates, Strzepek K. (1994) concluded that the strength of regional calibrated empirical methods is shown in the Mulbeny Basin, where the calibration and validation statistics performed best using the Thornthwaite method.

Thornthwaite climate classification divides climates into groups according to the vegetation characteristic of them, the vegetation being determined by precipitation effectiveness (*P/E*, where *P* is the total monthly precipitation and *E* is the total monthly evaporation). The sum of the monthly *P/E* values gives the *P/E* index, which is used to define five humidity provinces, with associated vegetation (www.encyclopedia. com/topic/Thornthwaite_climate_classification.)

According to Thornthwaite (1948) precipitation and evapotranspiration are equaly important climatic factor. In some places more rain falls month after month than evaporates or than the vegetation uses. Where precipitation is in excess of water need, the climate is moist, where the wather deficiency is large in comparision with the need, the climate is dry.

Table 4. *The climate changes determined by using Thornwhite's and Thornthwaite-Mather's methods*

Method	Period	Belgrade			Zlatibor		
		Im	Sym.	Climate type	Im	Sym.	Climate type
Thornthwaite	1961-1990.	1.4	C_2	Moist subhumid	68.2	B_3	Intensely humid
Thornthwaite-Mather		17.6	C_2	Moist subhumid	96.7	B_4	Extremely humid
Thornthwaite	1991-2010.	0.2	C_2	Moist subhumid	73.7	B_3	Intensely humid
Thornthwaite-Mather		17.1	C_2	Moist subhumid	73.1	B_3	Intensely humid
Thornthwaite	1991.	37.4	B_1	Mildly humid	74.6	B_3	Intensely humid
Thornthwaite-Mather		74.5	B_3	Intensely humid	107.0	A	Perhumid
Thornthwaite	1999.	37.4	B_1	Mildly humid	113.0	A	Perhumid
Thornthwaite-Mather		74.5	B_3	Intensely humid	157.7	A	Perhumid
Thornthwaite	2000.	-47.6	E	Arid	37.9	B_1	Mildly humid
Thornthwaite-Mather		-20.7	D	Semiarid	65.9	B_3	Intensely humid

In the analyzed reference periods, in Belgrade climate was moist subhumid (C2), and on Zlatibor increased to a very humid. In the driest year 2000. the climate is a semi-arid or arid, in Belgrade, and on Zlatibor mildly or very humid. In the wettest year 1999. climate in Belgrade was mildly and very humid, and on Zlatibor per-humid.

And this research has shown that the Thornthwaite method is very acceptable for research in forestry because it provides reliable data about how many actual evapotranspiration there is, and whether and when during the year there is a surplus or shortage of water in the soil.

4. THE NECESSARY SILVICULTURAL MEASURES IN THE CONDITIONS OF ALTERED CLIMATE

The Work Group III of the Intergovernmental Panel on Climate Change (WGIII IPCC, 2007) presented the key technologies and activities for the alleviation of the climate change in some sectors, stating that the changes in the way of life and model of behavior can contribute to the alleviation of the climate change in all sectors. The following conclusions are made (www.hidmet.gov.rs/podaci/meteorologija, 2010):

1. Many natural ecosystems are affected by the climate change, particularly by the increase of air temperature, due to the global warming: the shift of the zones with certain plant and animal species to the north and to the greater altitudes; from the early 1980s, the trend of the leaf formation of the vegetation and the prolongation of the duration of the growing season; the important changes in many physical and biological systems – above 89% is consistent with the direction of the anticipated changes of the reaction to the global warming.

2. Many ecosystems which are able to naturally adapt to the climate change will lose this capacity owning to the unprecedented combination of the climate change, followed by the disturbances (such as floods, drought, wildfires, insects, ocean acidification), and other factors of the global changes (changes in the ways in which soil is used, pollution).

The intensifying of the achieving of the targeted goals of the multi-functional forest management can also be achieved by the application of the **close to nature silviculture**, which implies the permanently sustainable and economically justified silvicultural activities limited by and conditioned by the natural processes (Krstić et al, 2006; Govedar et al, 2006).

According to Krstić et al. (2010) the significance and role of the future forest growing refers to the sustainable forest management. The modern concept of the sustainable forest management implies the harmony between the preservation, use and improvement of the condition, i.e. harmony between the use of natural resources in the forest, productive potential of site, and genetic potential of forest tree species, by the preservation of productivity, stability and vitality of forests, protection of forest ecosystems and natural biodiversity, as well as the preservation of the current natural rarities – relict and endemic species and forest communities. The basic silvicultural methods would imply the increase of the areas covered by forests, improvement of the forest condition, application of the silvicultural form, and the conversion of the degraded forests, which would mean the application of the suitable silvicultural methods depending on the concrete site conditions and stand characteristics. In this way their stability and vitality would be preserved, and, at the same time, the anticipated forest functions would be performed in the best way, the impact on the alleviation of the climate change would intensify, and the forests would adapt to the altered climate conditions much faster.

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NORWAY SPRUCE MONOCULTURE VERSUS NEAR-NATURAL FOREST MANAGEMENT: COMPARISON OF ENERGY, CARBON AND ECONOMIC BALANCE

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Abstract: *According to forest land area, the most tree species is Norway spruce in the Czech Republic. Climate change will probably be mediated through changes in disturbance regimes (storm, insect, pathogens). Decreased susceptibility of trees to abiotic stress impacts in combination with favorable conditions for pests' gradation can lead to declination and disintegration of spruce stands. Nevertheless, most of the forest owners still justify spruce monocultures on these unsuitable sites.*

We analysed all main inputs and outputs in the forest with norway spruce monoculture and compared it with altered tree species composition corresponding to the potential vegetation. For comparison were used methods of energy balance, amount of carbon in aboveground, belowground and total forest biomass and economic balance.

Forests with Norway spruce monoculture have benefit with economic profit (70,679 EUR), but energy efficiency (262.6 GJ:1GJ from calculation of aboveground biomass; 317.5 GJ:1 GJ from calculation of total biomass) and amount of carbon in biomass (433 t of carbon/ 1ha) are lower by comparing with altered trees species composition.

Key words: **N**orway spruce (*Picea abies)*, forest management, energy-carbon-economic balances

1. INTRODUCTION

In the Czech Republic, total area of forest is 2,657,376 ha (33.7% from total land area) (CSO, 2011). Current forest composition consists of 73.9% of coniferous forest and 25.1% of broadleaf forest (51.9% of coniferous forest area is formed by Norway spruce). Natural composition of forest consisted of 34.7% coniferous forest and 65.3% broadleaf forest (coniferous forest area was formed by 11.2% of Norway spruce) (Ministry of Agriculture of the CR, 2011).

Forests in Middle Europe are particularly sensitive to climate change. Lindner et al. (2010) projected temperature increase 2.5-3.5 ºC, but water limitation due to the increased evapotranspiration is especially risky. The most important effects of climate change will probably be mediated through changes in disturbance regimes (storm, insect, pathogens). Prolonged and warmer vegetation period will especially enhance the development of bark beetles.

From these reasons we can expect that the cultural Norway spruce stands in the middle and lower altitudes in the Czech Republic would become fragile. Nevertheless, most of the forest owners still justify spruce monocultures on these unsuitable sites by its economic potential.

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The contribution aim is to analyze the current state of costs (inputs) and benefits (outputs) of energy balance, amounts of carbon in forest biomass (aboveground, belowground, total) and economic balance to compare forest stands with different management in region of Novohradské hory Mts. (Czech Republic). For these points of view several management types of Norway spruce monoculture with model alternatives with altered tree species composition in forest stands were compared.

2. MATERIALS AND METHODS

The research area is located in the Novohradské hory Mts. (Czech Republic), upper part of the Stropnice river watershed (Fig. 1). The total area is 99 km^2 (49% forests, 23% meadows and pasture, 18% arable land and 4% ponds).

Fig. 1. *Research Area in the Novohradské hory Mts.*

For comparison of forest management of Norway spruce monocultures with forest stands with altered tree species composition, energy balance, quantification of aboveground and belowground carbon and economic balance were used. Forest management was divided into following stages: seedling production, planting, silviculture, and logging. Transport of wood and next timber processing were not evaluated in this contribution. It was accounted with one life cycle of forest from seedling to logging.

The energy balance method, applied to forest stands, consists of comparison of the quantified inputs (fossil fuels, electricity, used machinery, fertilizers, etc., converted into energy units in Joules) with quantified outputs (biomass production in Joules).

For quantification of outputs data about amount of timber in m^3 (tree diameter higher than 7 cm) from the Growth and mensurational tables of the main species were used (Cerny M. et al., 1996). On the basis of calculation using, biomass expansion factors (BEF), total amount of aboveground and belowground biomass were assessed (Marek M.V. et al., 2011). Amount of energy and carbon outputs were accounted from dry-weight of biomass.

Accordingly, the economic analysis of expenses and benefits were carried out. Amount cost of overhead was 25% from total direct costs. Price of materials, fuels and wages are in average values for year 2012. For quantification of the forest yields price timber assortments on the basis on table of assortments was assessed (Simanov, 2006).

Function unit, for which all data collected were related, was 1 ha. Main framework of the approach is demonstrated in Figure 2.

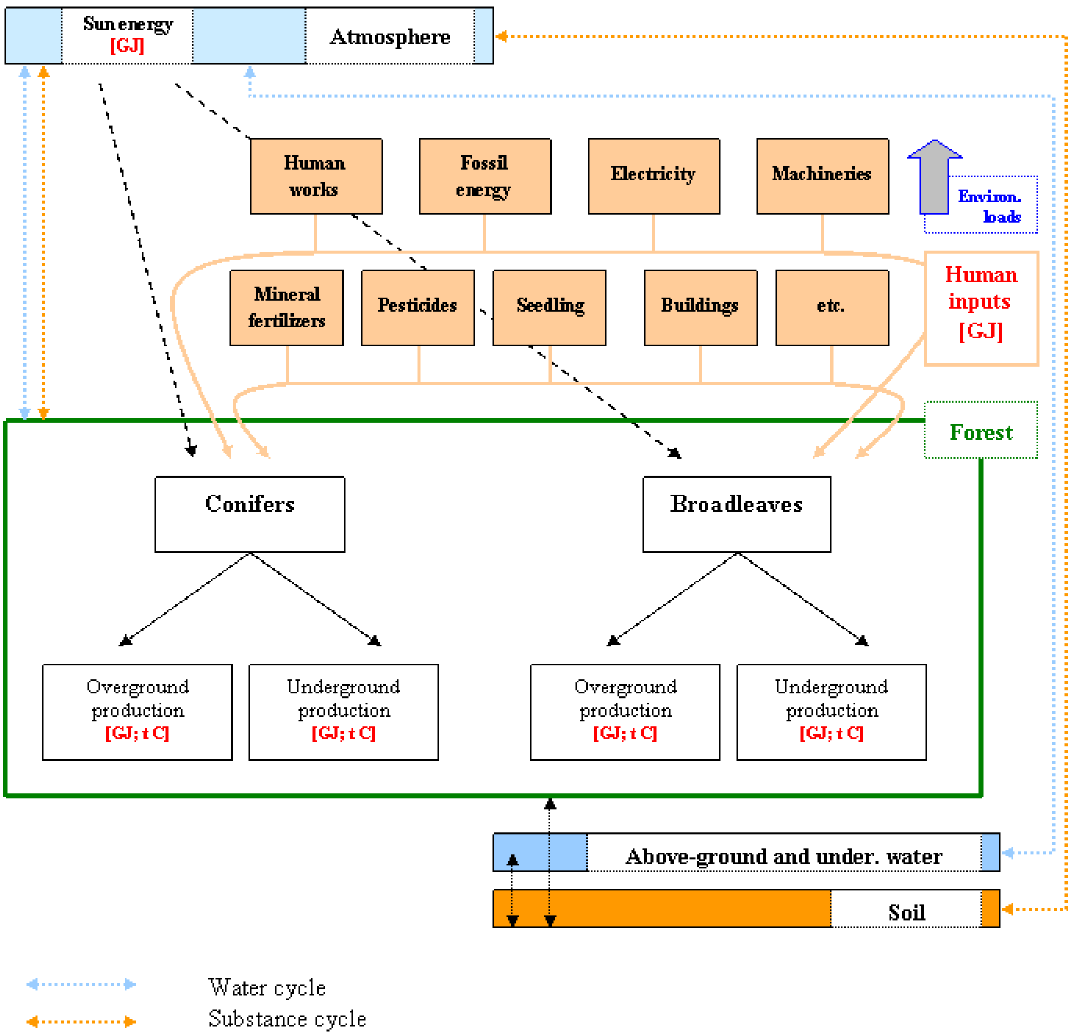


Figure 2. *Main framework for forest ecosystem.*

Cienciala E. et al. (2011) published Framework Directions for Adaptation Management in Norway spruce stands. For selected 5th vegetation zone with altitude range 600-900 m a.s.l. (expressing natural condition potential), model tree composition, connected with the imagination of forest stand structure, as a long-term aim of forestry was defined. The description of individual tree species combinations is given in Table 1.

Tab. 1. *Tree species composition (%).*

Alternatives	Norway Spruce	Pine	Fir	Beech and others broadleaves
	NS	P	F	B
Norway Spruce	100%			
Alternative 1	50%		10%	40%
Alternative 2	10%	40%		50%
Alternative 3	50%		20%	30%
Alternative 4	40%		20%	40%

Energy efficiency was counted according to formula 1.

$$\mathbf{EEF_{ENERGY} = EP_{ENERGY} / \sum Input_{i\text{-}energy}} \qquad (1)$$

where EEF_{ENERGY} is the energy efficiency, EP_{ENERGY} is the amount of energy in biomass (aboveground, belowground, total), $Input_{i\text{-}energy}$ is the sum of all inputs expressed in energy in relations to framework **(fig. 2).**
Economic efficiency was counted according to formula 2.

$$\mathbf{EEF_{ECONOMY} = EP_{ECONOMY} / \sum Input_{i\text{-}economy}} \qquad (2)$$

where $EEF_{ECONOMY}$ is the economic efficiency, $EP_{ECONOMY}$ is the amount of economic yields expressed in EUR, $Input_{i\text{-}economy}$ is the sum of all economic costs in EUR in relations to framework **(fig. 2).**

3. RESULTS

Energy inputs for production of Norway spruce was 53.7 GJ/ ha, other tree species alternatives had energy inputs higher (57.7-59.1 GJ/ ha). Of the total amount of energy used, silviculture and logging accounted for the largest energy inputs, with 42.3 GJ/ ha (78.9%) for Norway spruce. Other alternatives had 43.1-44.5 GJ/ ha. Energy outputs for Norway spruce were lowest from all alternatives (17,042.8 GJ/ha; approximately 170.4 GJ/ ha/ 1 year). Energy balances for all alternatives were positive (Table 2).

Table 2. *Energy balance of energy inputs and outputs (GJ/ ha).*

Energy balance (inputs, outputs, profit)	Norway Spruce monoculture		Alternative 1 NS5, F1, B4		Alternative 2 P4, NS1, B5		Alternative 3 NS5, F2, B3		Alternative 4 NS4, F2, B4	
	GJ/ ha	%	GJ/ ha	%	GJ/ ha	%	GJ/ ha	%	GJ/ ha	%
Seedling production	4.8	8.9%	5.0	8.6%	4.9	8.3%	5.1	8.8%	5.1	8.7%
Planting	6.6	12.2%	8.8	15.1%	11.1	18.8%	8.7	15.0%	9.2	15.7%
Silviculture	20.4	38.1%	20.5	35.2%	17.4	29.5%	20.8	36.0%	20.8	35.3%
Logging	21.9	40.8%	23.9	41.1%	25.6	43.4%	23.2	40.2%	23.8	40.3%
Total energy inputs	53.7	100.0%	58.3	100.0%	59.1	100.0%	57.7	100.0%	58.9	100.0%
Energy in aboveground biomass	14095.9	82.7%	16679.0	82.5%	16146.7	82.4%	16277.7	82.6%	16874.6	82.6%
Energy in belowground biomass	2946.9	17.3%	3529.3	17.5%	3456.7	17.6%	3426.9	17.4%	3563.9	17.4%
Total amount of energy in biomass	17042.8	100.0%	20208.3	100.0%	19603.4	100.0%	19704.6	100.0%	20438.5	100.0%
Energy profit (from abovegr. biomass)	14042.2		16620.7		16087.7		16220.0		16815.7	

Note: e.g. NS5, F1, B4 = Norway spruce 50%, Fir 10%, Beech 40% = total 100%

Total amount of carbon (aboveground + belowground forest biomass) was lowest in Norway spruce monoculture (433 t of carbon/ 1ha). Highest amount of total carbon had the alternative 4 (519.2 t of carbon/ 1 ha) with tree species composition Norway spruce 40%, fir 20%, beech 40% (Table 3).

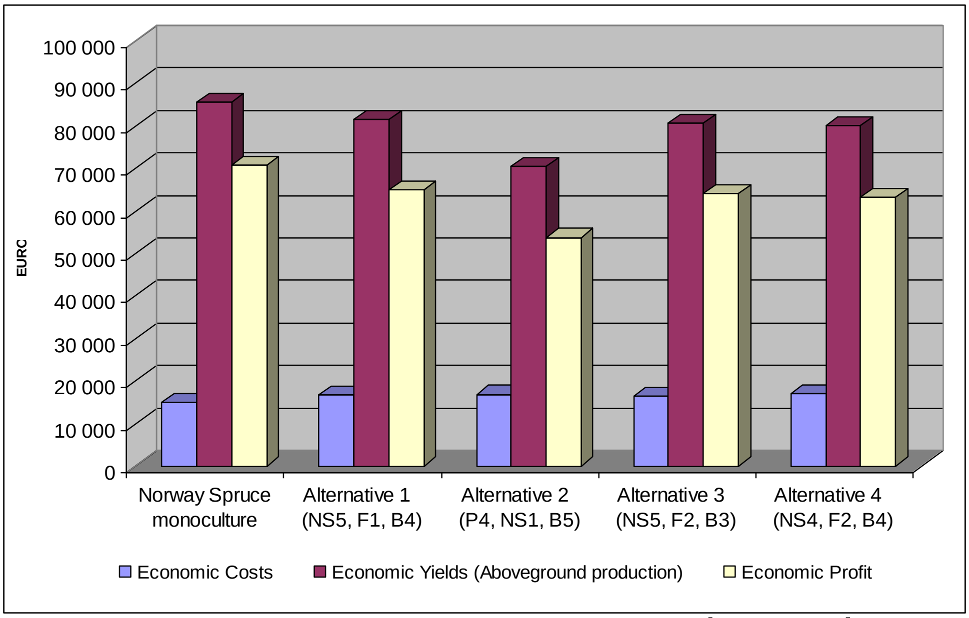
Table 3. *Forest production of carbon (t/ ha).*

Amount of carbon in biomass (abovegroung, belowground, total)	Norway Spruce monoculture		Alternative 1 NS5, F1, B4		Alternative 2 P4, NS1, B5		Alternative 3 NS5, F2, B3		Alternative 4 NS4, F2, B4	
	t/ ha	%	t/ ha	%	t/ ha	%	t/ ha	%	t/ ha	%
Aboveground biomass in carbon	358.1	0.8	423.7	0.8	410.2	0.8	413.5	0.8	428.7	0.8
Belowground biomass in carbon	74.9	0.2	89.7	0.2	87.8	0.2	87.1	0.2	90.5	0.2
Total amount of carbon in biomass	433.0	1.0	513.4	1.0	498.0	1.0	500.6	1.0	519.2	1.0
Aboveground biomass in carbon per 1 year	3.6	0.0	3.8	0.0	3.5	0.0	3.8	0.0	3.8	0.0
Belowground biomass in carbon per 1 year	0.7	0.0	0.8	0.0	0.8	0.0	0.8	0.0	0.8	0.0
Total amount of carbon in biomass per 1 year	4.3	0.0	4.6	0.0	4.3	0.0	4.6	0.0	4.6	0.0

Note: e.g. NS5, F1, B4 = Norway spruce 50%, Fir 10%, Beech 40% = total 100%

Norway spruce monoculture had lowest economic costs (14,897 EUR), highest yields (85,577 EUR) per 1 ha and highest profit (70,679 EUR). The lowest profit (53,751 EUR) was computed for the alternative 2 with tree species composition Norway spruce 10%, pine 40%, beech 50% (Fig. 3).

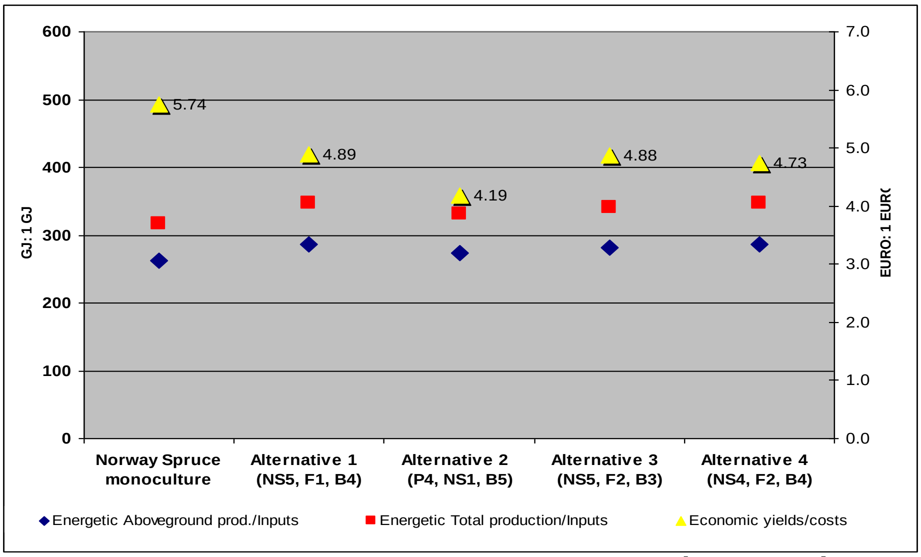
Fig. 3. *Economic costs, yields and profit (EUR).*



Note: e.g. NS5, F1, B4 = Norway spruce 50%, Fir 10%, Beech 40% = total 100%

For more comprehensive comparison, the indicators of energy and economic efficiency were computed. By comparing all alternatives, Norway spruce had lowest energy efficiency (262.6 GJ:1GJ from account of aboveground biomass, 317.5 GJ:1 GJ from account of total biomass). Highest energy efficiency were 286.6 GJ:1 GJ and 347.2 GJ:1 GJ by the alternative 4. From economic point of view, alternatives with lower abundance of Norway spruce had lower economic efficiency compared to Norway spruce monoculture (Fig. 4).

Fig. 4. *Energy and economic efficiency.*



Note: e.g. NS5, F1, B4 = Norway spruce 50%, Fir 10%, Beech 40% = total 100%

4. DISCUSSION

Berg et al. (2005) published energy use in forest operations in Sweden. In this study energy use required to produce 1 m^3 s.u.b. (m^3 solid under bark) of timber wood was 200 MJ in northern Sweden, 187 MJ in the central Sweden and 147 MJ in southern Sweden. Of the total amount of energy used, transporting timber to the industrial sector was accounted for the largest energy requirement (56%, 113 MJ in the north; 53%, 99 MJ in the central region and 53%, 77 MJ in the south). It means that for seedling production, silviculture and logging, 87 MJ/m^3 in northern Sweden; 88 MJ/m^3 in central Sweden and 70 MJ/m^3 in southern Sweden were assessed. According to our results, energy inputs for production of Norway spruce were 53.7 GJ/ ha, other tree species alternatives had energy inputs higher (57.7-59.1 GJ/ ha). We accounted that average inputs per 1 m^3 were 40-45 GJ for main tree species (norway spruce, pine, fir, beech).

For near-natural forest management we can find in literatures a lot of criteria. Near-natural forests should be mixed from different trees species, to choose suitable tree species in relation to forest stand, maximum support of a natural regeneration etc. (Kosulic M., 2010). We suppose that in production forests natural regeneration will be used minimally, while in near-natural mixed forests it will be used with maximally emphasis. Using natural regeneration can contributes to decrease energy inputs and economic costs and from this reason to increase energy and economic efficiency.

In term of carbon sequestration, Jandl R. et al (2007) concluded, that mixture of beech and Norway spruce is a better forest management option than pure Norway spruce stand. Species that occupy different ecological niches can complement each other. For the productivity of a forest over the entire rotation period, its stability against disturbance is important.

5. CONCLUSIONS

Preliminary results in our study indicate that Norway spruce monocultures have benefit with economic profit, but energy efficiency and amount of carbon in aboveground and belowground biomass is lower by comparing with altered trees species compositions. More research is needed. In this time we are planning to add also next method – LCA (life cycle assessment).

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CLIMATE CHANGES IN REPUBLIKA SRPSKA AND THE POTENTIAL IMPACT ON FOREST ECOSYSTEMS

Goran TRBIĆ[1], Zoran GOVEDAR[2], Milun KRSTIĆ[3], Ivan BJELANOVIĆ[3], Srđan KEREN[2]

Abstract: *The paper presents alterations of air temperature and precipitation that result in climate changes in Republika Srpska. The assessment of variability and climate changes is provided based on the analisys of climate data that originated from 22 meteorological stations. The alterations of air temperature and precipitation are provided on the basis of comparative results for 1981-2010 and 1961-1990 periods consecutively. The potential impact is determined according to the regional climate model devised for the purpose of Second National Conference of Bosnia and Herzegovina with reference to the United Nations Framework Convention on Climate Change (SNC BiH UNFCCC). The potential climate changes were analized in compliance with A1B and A2 scenarios along with their potential impact on forest ecosystems in Republika Srpska. A1B scenario was characterised as "medium" and A2 as a "high" scenario. The results indicated the evident climate changes on Republika Srpska territory but the fact remains that those alterations are mostly regional. The changes in air temperature and pluviometric regime caused the increase of draught intenisty and frequency, which should further be the basis of any plan or strategy for forest ecosystem adaptation to climate changes in Republika Srpska.*

Key words: climate changes, forest ecosystems, climate models

INTRODUCTION

Global climate changes are one of the most popular scientific, ecological, economic, and political issues in present times. The most pertinent elements and consequences of climate changes are as follows: air temperature increase, fluctuation of pluviometric regime, precipitation decrease during the vegetative period, increase of intensity and frequency of draught periods, floods, and increase in number of days accompanied by tropic temperature (over 30ºC). The 4th Assessment Report of IPCC infered that most major climate change impacts on ecosystems and humans should be manifested through Earth's water cycles alterations (*IPCC, AR4, 2007*). Climate changes also have huge impact on Republika Srpska environment, especially when it comes to water resources, agriculture, forestry, ecosystems, and human health. These premises define the starting point and major issues of our research. According to IPCC and its climate models (e.g. SRES) by the end of 2100, the global temperature of the atmosphere surface should increase per 1,4-5,8^{o}C, which may further lead towards numerous changes of the environment, ecosystems, and sustainable development. Temperature regime alterations, the impact of extreme values, and more, are the key factors of the overall atmosphere surface condition. The IPCC reports point out the interdependance of the adaptive opportunities and developent processes, above all the economic ones, as well as the necessity of fundamental

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researches that define this type of interdependance. The developing countries, including Republika Srpska, belong to those countries that are sensitive to any undesirable impact of global climate changes, which has been confirmed by many recent studies. The estimation is that Republika Srpska area should be susceptible to the impacts that might affect the whole society. Any potential protection from these impacts is small on a local level but there are many options of adaptation to climate changes.

The key issue about the global climate changes and and their impact is to define new environment models and development strategies at all levels (local, regional, and entity levels) that would fit the sustainable development (*Trbić, 2010*).

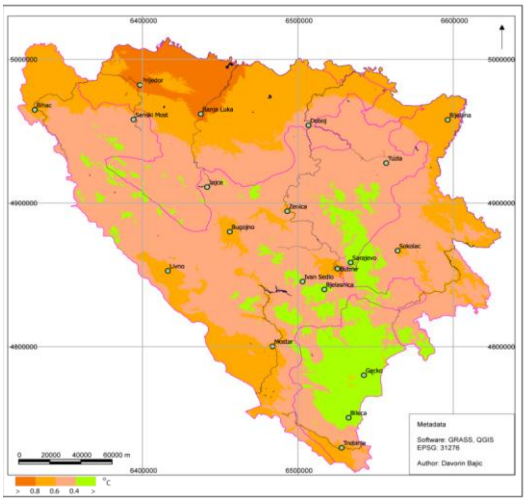
The international contracts on climate changes set forth the principles, institutional mechanisms, and rules to deal with the causes and consequences of climate changes. The UN Framework Convention and the Kyoto Protocol bind all the singnatory countries (including BiH, i.e. Republika Srpska) to devise strategies that would mitigate the climate changes and help adapt to altered climate conditions, to cooperate within the processes of climate research, observations and technology transfer, and to improve the programs of public education and awareness. With reference to this, all European Union candidate countries took the committments from the Framework Convention on Climate Changes and Kyoto Protocol. Bearing in mind the actual and potential consequences that climate changes impose on long-term development goals and the aforementioned ratified agreements, there is a strong need for defining the development strategies with the elements of action plans.

METHODS AND AIM OF THE RESEARCH

The estimation of climate variability is provided based on the analyses of hystorical meteorological data from the State Weather Bureau of Republika Srpska and the data from the State Weather Bureau of BiH Federation. In order to assess the trends of climate changes and calibration of regional climate models we shall use the current normal period of World Meteorological Organization (1961–1990) and the last 30-year-period 1981-2010. Based on the meteorological data from weather stations in towns of Banja Luka, Novi Grad, Prijedor, Doboj, Bijeljina, Sokolac, Cemerno, Gacko, and Bileca (Republika Srpska) and towns of Sarajevo, Mostar, Tuzla, Zenica, Jajce, Bugojno, Livno, Bihac, Sanski Most and Ivan Sedlo (BiH Federation) the GIS theme climate maps were devised for the periods of 1961-1990 and 1981-2010. The most relevant methods used for our research were interpolation, reduction, and regression analisys. The mean values of air temperature and precipitation for the total area observed were calculated by using the digital elevation model (DEM), the regression equation, and Kriging model of spatial interpolation in MapInfo GIS software application (*Bajić, Trbić, 2010*).

Temperature changes

The research on air temperature changes for the 1961-2010 period clearly shows there aws the temperature increase in all parts of the country. Based on the comparative analisys for the 1961-1990 and 1981-2010 periods, the highest average increase in air temperature for the summer period was in south part of the country (Mostar, Herzegovina 1,2°C) and in central parts of the country (Sarajevo 0,8°C), whereas the highest increase in spring and winter periods was in north-central part of Republika Srpska (Banja Luka 0,7°C). The smallest autumn increase of air temperature was between 0,1 and 0,3°C (Map 1).



Map 1. *Changes of annual air temperatures in Bosnia and Herzegovina (comparison for the 1981-2010 and 1961-1990 periods)*

The increase of the air temperature at annual level was between 0,4 and 1,0°C, whereas the increase during the vegetation period was up to 1,0°C. Nevertheless, the air temperature increase over the last decade was even more evident (Table 1). It is crucial to say that the temperature increase, apart from the larger emission of Greenhouse gas, was also due to larger insolation and bigger urbanheatislandeffect (Trbić, 2012).

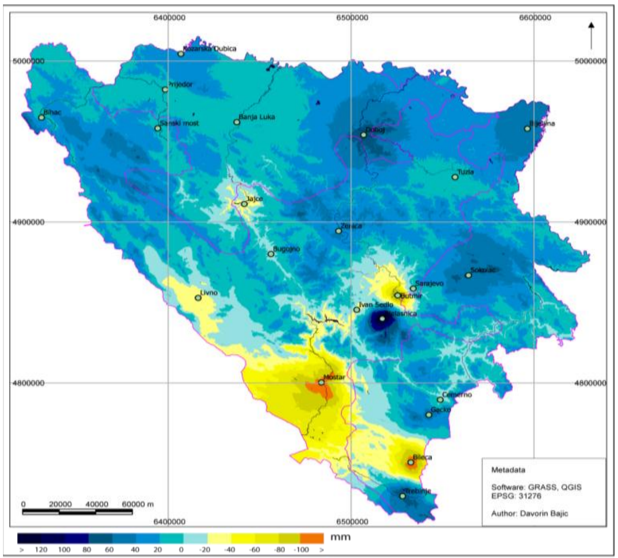
Table 1.*Changes of air temperature* (°C) *in towns of Banjaluka, Sarajevo, and Mostar1961-2010*

		Year	Vegetation period	Spring	Summer	Autumn	Winter
Banja Luka	1961-1990	10,6	16,9	10,9	19,7	10.9	0,8
	1981-2010	11,4	17,9	11,6	21,0	11,5	1,5
	deviation	0,8	1,0	0,7	0,3	0,6	0,7
	2001-2010	11,9	18,4	12,3	21,7	11,8	2,2
Sarajevo	1961-1990	9,7	15,7	9,7	18,3	10,4	0,4
	1981-2010	10,1	16,2	10,0	19,1	10,5	0,7
	deviation	0,4	0,5	0,3	0,8	0,1	0,3
	2001-2010	10,4	16,5	10,5	19,6	10,6	1,1
Mostar	1961-1990	14,6	20,3	13,6	23,5	15,3	5,9
	1981-2010	15,2	21,2	14,3	24,7	15,5	6,2
	deviation	0,6	0,9	0,7	1,2	0,2	0,3
	2001-2010	15,5	21,8	14,9	25,3	15,5	6,5

Changes of precipitation

During the1961–2010 period, most Republika Srpska territory was characterized by little increase in annual precipitation. Largest positive annual precipitation shift was typical of central mountain areas (Bjelasnica, Sokolac) and Doboj vicinity, whereas the largest deficit was in southern part of the country (Mostar, Bileca).

The biggest decrease in precipitation was in spring and summer and it was mot emphasized in the region of Herzegovina (up to 20%). In autumn, we measured the largest precipitation increase when it comes to seasons and the largest suficit was in northern and central parts of BiH. Even though there were no significant changes of precipitation, the pluviometric regime, i.e. the annual distribution, was in disbalance. The number of days with precipitation larger than 1mm decreased almost all over the territory, and the percentage of annual precipitation increased due to precipitation 95 percent larger than in 1961-2010 period. In other words, though there were no significant changes at the annual level, the decrease in number of days with more than 1,0 mm precipitation and the increase of days with intensive precipitation both strongly abused the pluviometric regime. The huge alteration of annual precipitation distribution accompanied with temperature increase is one of the major factors that cause more frequent and intensive draughts and floods on both Republika Srpska and Bosnia and Herzegovina territory.



Map 2. *Changes of annual precipitation in Bosnia and Herzegovina (comparison between the periods of 1981-2010 and 1961-1990)*

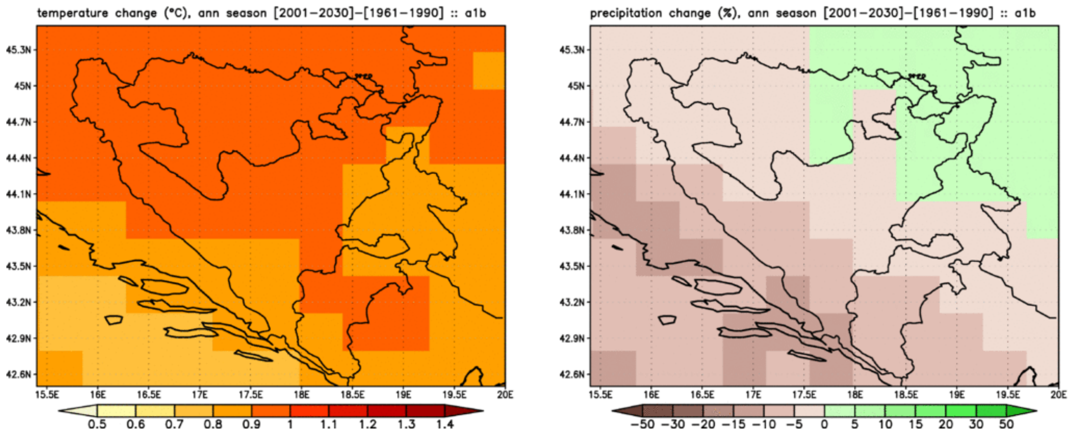
Table 2. *Changes of precipitation (mm) in towns of Banjaluka, Sarajevo, and Mostar 1961-2010*

		Year	Vegetation period	Spring	Summer	Autumn	Winter
Banja Luka	1961-1990	1027	562	262	298	246	221
	1981-2010	1034	540	258	270	278	227
	deviation	+7,0	-22,0	-4,0	-28,0	+32,0	+6,0
	2001-2010	1078	546	263	271	280	221
Sarajevo	1961-1990	932	468	226	242	241	223
	1981-2010	936	472	221	236	266	213
	deviation	+4,0	+4,0	-5,0	-6,0	+25,0	-10,0
	2001-2010	1014	514	226	252	304	226
Mostar	1961-1990	1523	522	379	196	450	497
	1981-2010	1405	502	335	173	458	439
	deviation	-78,0	-20,0	-39,0	-23,0	+8,0	-58,0
	2001-2010	1514	534	339	188	472	506

Climate models and scenarios

Climate scenarios for Republika Srpska, i.e. Bosnia and Heregovina, were devised by using EBU-POM regional climate model. Its atmosphere component is the ETA model, devised at the University of Belgrade, with a horizontal resolution of 0,25° and 32 vertica levels. The ocean component of EBU-POM model is the Princeton Ocean Model (POM) with the horizontal resolution of 0,20°, with 21 levels vertically distributed. The results of integration of the global SINTEX-G model were used for scaling at the regional level as follows: results of integration for three periods (1961–1990, 2001–2030, and 2071–2100). For the 2001-2030 period, only A1B, IPCC/SRES scenario was used since the results of various scenarios for the same period only displayed slight difference. Along with the A1B scenario, the A2 scenario was also used for scaling the global model results for 2071–2100 period (Đurđević, 2012).

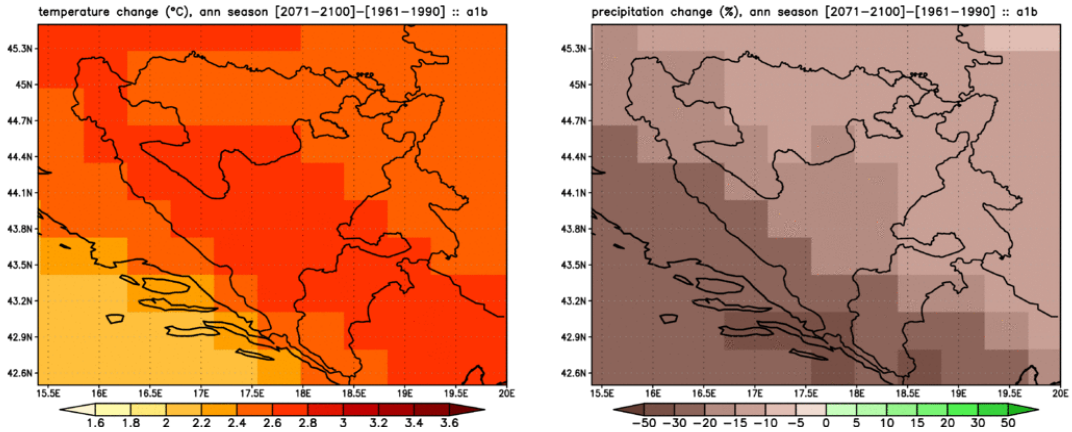
A1B scenario, 2001-2030: According to the results of the changes model, mean seasonal air temperature during the observed 30-year period varied from +0.6°C up to +1.4°C, depending on the season and BiH area. The largest changes were determined during the June-July-August season, i.e. +1.4°C in north and +1.1°C in south. For December-January-February season, the changes were about +0.7°C, and reached the maximum in central parts of BiH. For the March-April-May season, the changes were somewhat larger in comparison with December-January-February period, with figures varying from +0.8 up to +0.9. September-October-November season displayed the +0.6 to +0.8 alterations in east-west direction over the country. The precipitation changes picture shows that the results of the model displayed both negative and positive alterations. Positive precipitation changes, i.e. the increase, is evident for March-April-May season (+5% for north and north-east parts) and June-July-April season (maximum +15% at the whole territory except from south-east parts). Largest deficit was evident along the south-west BiH borderline with 20% maximum.



Picture 1. *Changes of mean annual air temperature in ℃ (left) and precipitation in % (right)*

At the annual level, the air temperature changes were within the 0.8 up to 1°C, the values being larger in the north and west parts of the country (Picture 4). Changes of annual precipitation were negative in the whole territory, ranging from 0 % up to -10 %, except from the north-east parts where the changes were positive (up to +5 %).

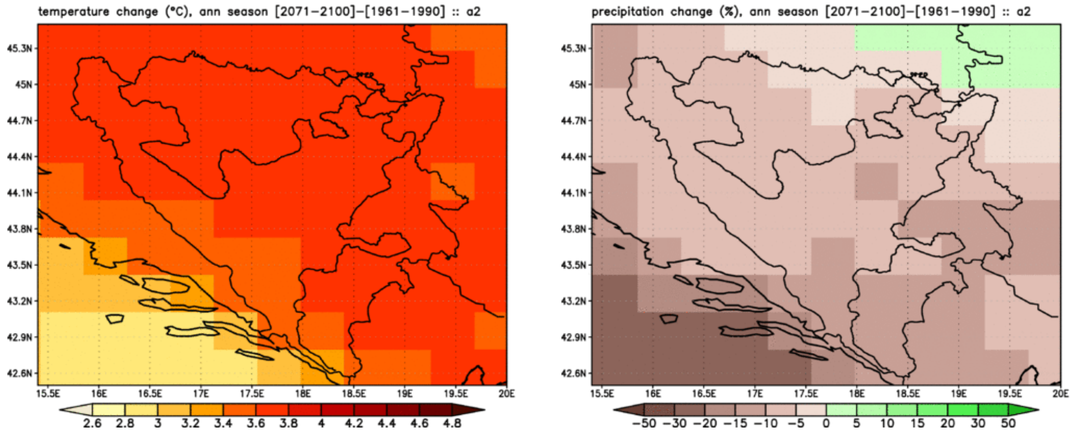
A1B scenario, 2071-2100: Results for A1B scenario and 2071-2100 period showed that the spatial structure of parameter changes, especially the temperature, was similar to the 2001-2030 period but only with larger magnitude of changes. This time the temperature changes ranged from +1.8°C up to +3.6°C. Largest alterations (+3.6°C) were again typical of June-July-August season. During the winter season (December-January-February) the maximum was reached in central regions and it was up to 2.4°C. During March-April-May season, the changes in the whole territory ranged from 2.4°C to 2.6°C. And finally, September-October-November changes were within the limits of 2.0°C to 2.4°C. There was almost no season or area during this period that was characterized by positive precipitation anomaly. Large negative anomalies were typical of December-January-February and September-October-November seasons with changes ranging from -15 to -50 %. March-April-May season had the values close to -10% in the whole territory. The deficit during the June-July-August season was bigger in southern parts (-30 do 0%) in comparison with the northern parts of the country.



Picture 2. *Changes of mean annual air temperature in ℃ (left) and precipitation in % (right).*

The annual air temperature changes ranged from 2.4 to 2.8°C, the values being larger in south and west (Picture 2). Annual precipitation changes were negative in the whole territory (-30 % to -10 %).

<u>A2 scenario, 2071-2100</u>: Based on the A2 scenario for the 2071-2100 period, the temperature is expected to increase in the whole BiH territory per 2.4 to 4.8°C. Largest increase during June-July-August season was in north with values over 4.8°C. The December-January-February season had the maximum chnge around 3.6°C. The March-April-May season had the values ranging from 3.4°C to 3.6°C. The September-October-November season changes larger in west ranging from 2.8°C to 3°C. For A2 scenario, all the seasons, except December-January-February, had the negative anomaly in the field of accumulated precipitation in all of the country. The December-January-February season had the positive anomaly in nearly whole territory ranging from 0% to +30%, except south-east parts. This scenario displayed largest changes for the June-July-August season wth values of -50%. During the March-April-May and September-October-November seasons anomalies ranged from -30% to 0%. The annual air temperature changes ranged from 3.4 to 3.8°C (Picture 3). The annual precipitation changes were negative in the whole territory ranging from -15 % to 0 %.



Picture 3. *Changes of mean annual air temperature in ℃ (left) and precipitation in % (right)*

Vulnerability of forest ecosistems in BiH to climate changes

Forests and forest soil in BiH cover the surface of 2.700.770 ha i.e. 53 % of total BiH territory (BiH preparation project for Johanesburgh Summit, 2002). According to the preliminary results of the 2nd BiH forest inventory (2006-2009) the surface of forests was larger and occupied 63 % of BiH territory. Forest ecosystems produce a biomass that „storages“ CO_2 twice as more as the atmosphere does (Eamus & Jarvis, 1989). Namely, in the process of photosynthesis, forest trees bind each gram of CO_2 and release 0,75 grams of oxigen. The increase of CO_2 participation in the air stimulates the biomass by accumulating so-called C3 in plants, with which the atmospheric CO_2 assimilation occurs directly in the mesophyll cells of the asimilation organs. Forest ecosystems on Earth bind around 65 billion tonnes of CO_2 in which process some 51 billion tonnes of oxigen is released. In average environment conditions, trees and other plants in a 1 ha forest annually consume around 4 tonnes of CO_2, which they extract from approximately 18 million cube meters of air (Jones & Curtis, 2000). Consequences that climate melting has on forest ecosystems are as follows (Medarevic, 2007; Govedar, 2011):

- Increase of intensity and frequency of dangerous atmosphere phenomena and spreading of areas of certain diseases and pests,
- In the regions of temperate and larger latitudes, the vegetation period is expected to increase,
- Decrease of biological potential to adapt and limitation of forest biodiversity, limitation shift of certain forest types regarding the latitude and altitude,
- Different natural redistribution of forest types and their interrelations,
- Different content of some plant communities accompanied by disappearance of one and appearance of another sort of plants, with reference to levels and social position,
- Changes of relations tha certain types have with reference to daylight,
- Increase of risk for preservation of relic, rare, and endangered forest communities and tree sorts that are typical of those communities.

Besides, the aggravating circumstances that might affect the forest ecosystems and to which more attention should be paid (with reference to breeding and preservation) are as follows (Govedar, 2011):

- the productive period with regular forests of generative origin lasts, with most hardwoods and conifer woods, more than a hundred years and during that period the climate change trends inevitably affect the forest conditions
- the increase of air temperature and soil aridity causes the slow and hard decomposition of dead forest soil, which negatively affects the process of natural forest regeneration,
- the sorts of trees in a forest can only be randomly predicted due to the complexity of ecological factors that refer to climate changes as well as due to the lack of exact data on interrelation between trees and those changes over the long production period.

The last decade of 20th century marked the fluctuation of the condition of forest tree crowns (Karadzic, et al., 2011). That was directly connected with chains of negative climate effects, entomological and phytopatological diseases, especially the indicative ones that were typical of oak, beech, spuca, and fir tree forests. Most affected were *Quercetum farnetto – cerris* and *Quercetum montanum* forests as well as the groups of *Abieti – Picetum* and *Abieti – Fagetum*. The reasons were many but were mostly connected with physiological decay of trees primarily caused by melting. Furthermore, due to arid and warm springs there was the gradation of insects, whereas severe phytopatological diseases were the result of complete physiological decay. Polifag is a consequence of punk gradation (*Lymantria dispar*) and the beech trees were mostly defoliated by *Orchestes fagi,* which was a direct consequence of negative effects of atmosphere polutants. Conifer forests, especially spuca trees, have been lately exposed to negative wind impacts in mountain areas due to irrational felling. Furthermore, there were evident negative impacts of snow in spuca woods, especially the young unattended beech trees (snowbursts and snow disruption), that were typical of small altitudes in BiH. Spuca trees in the whole BiH territory displayed the gradation of Ips sexdentatus caused by anthropogenic factors and suitable climate for this insect's overbreeding. Climate changes according to the devised scenarios would certainly affect both horiozontal and vertical zones of forest vegetationa and the forest structure. That would affect all ecological, economic, and social functions of the forests with the consequences no one could predict. Namely, changes of basic climate parameters do not have the same trends or intensity and do not occur simultaneoulsy at the all of BiH territory. Thus, we cannot expect equal changes of the aforementioned functions of forest ecosystems. We may only assume that the melting of climates according to the A2 scenario might cause severe damage to the hygrophyle and mesophyle forest communities. The result would be the domination of beech trees in the Dinarides and most area would be occupied by Mediterrenean and sub-Mediterranean communities. Sudden climate changes due to thermal impact along with the alteration of precipitation shape, time, and amount (e.g. snow compared with rain, draught compared with floods, etc.) may bring about the hypersensitivity of forest ecosystems with reference to harmful pathogenes (Schlyter et al., 2006.). The production period duration is also closely connected with the forest productivity. If the production period lasted longer, it would affect the forest production over the year, which would further have a strong impact on the forest yield increase. The abundant biodiverity reflects in the number of flora and fauna species in BiH (NATURA 2000 in BiH). Most endangered would be the species less immune to negative impacts of high temperatures. The melting might lead to bigger fire threats, and the forest fire are the constant danger for the forest ecosystems. The damages that result from fires depend on the type of fire, the surface it affects, the type of trees, etc. and the fire threats differ depending on the forest type and area. Namely, the sub-Mediterranean areas in BiH with limestone geologic bottom and limestone soils are most sensitive to forest fires in BiH. This problem is tightly connected with the regional climate and global warming tendencies, which imposes the necessity to create the antifire protection and measure programs. The karst regions in BiH over the past decades have been intensively afforested in compliance with the afforestation programs. Nevertheless, the current issues of forest fires spreading, which are additionally conditioned by climate melting, urge us to assess the climate typical of afforested areas, preserve the forest hotbeds specialised in karst afforestation in BiH, and better choose the trees with reference to biotopes. Bearing in mind the forest planning in BiH, it is crucial to analise and characterize the climate of an area on the basis of 10-year movable chains (Burlica and Govedar, 2003). Namely, the commercial and forest features for the purpose of forestry in BiH are devised on the basis of a 10-year plan and the planned endurance for most our hard foliage conifers is more than a hundred years (generative-originated forests with clearly defined technical goals) so during their growth and development these trees are under the influence of large climate changes. The impact of these changes is typical of artificial sorts. Because of that, breeding forests should aim at right choices that may easily adapt to new climate conditions and melting. The increase of number of trees would probably help alleviate the global warming effects. Namely, the increase of forest areas affects the process of photosynthesis in which CO_2 is assimilated (a gas which, among others, largely affects the Green House effects). Therefore, the solutions should be searched for through practical increase of trees and local studies of space and time dyamics of climate changes in BiH forests.

CONCLUSION

Based on the results obtained, the following may be inferred:

1. The air temperature increase in 1961-2010 period was typical of all BiH territory. Largest increase during spring and winter was evident for northern and central parts of the country. Largest mean increase was measured in southern BiH parts (Herzegovina) in summer. The annual air temperature increase ranged from 0,4 to 1,0°C, whereas the increase during the vegetation period was up to 1,0°C.
2. Over the 1961–2010 period, most Republika Srpska territory was characterized by little annual precipitation increase. Largest precipitation decrease was during spring and summer, especially in Herzegovina region (up to 20%). The precipitation amounts did not largely decrease but the pluviometric regime was strongly disturbed (i.e. the annual precipitation distribution).
3. The key factors of more intensive and frequent draughts and floods in Bosnia and Herzegovina geospace were the change of annual precipitation distribution and air temperature increase.
4. According to the A1B scenario (2001-2030 period) the annual air temperatute change ranged from 0.8 to 1°C, the values being larger in north and west. The annual precipitation change was negative all over the country (0 % to -10 %) except north-east where the change was positive up to +5 %.
5. According to A1B scenario (2071-2100 period) the annual air temperature change rangd from 2.4 to 2.8°C, the values being larger in south and west (Picture 2). The annual precipitation change was negative all over the country (-30 % to -10 %).
6. According to A2 scenario (2071-2100 period) the expected air temperature increase in all BiH ranges from 2.4 to 4.8°C. The annual temperature changes range from 3.4 to 3.8°C (Picture 3). The annual precipitation change was negative all over the country (-15 % to 0 %).
7. Possible impacts of BiH climate changes on forest ecosystems are as follows:
   - Larger damage due to negative impacts of abiotic factors, especially in artificial communities and biotic factors (beech and oak);
   - Longer vegetation periods,
   - Poorer adaption ability of forest species and decrease of biodiversity;
   - Climate melting according to A2 scenario would strongly affect hygrophile and mesophile forest communities;
   - Shift of horizontal and vertical limits of certain forest types and alteration of forest content;
   - Strong impact on forest productivity and natural regeneration;
   - Larger forest fire threats, especially in sub-Mediterrenean parts of BiH;
8. Afforestation and studies of space and time dynamics of climate changes in forest ecosystems in BiH would affect the preventive measures when it comes to alleviating negative effects of climate changes.

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CLIMATE CHANGES IN REPUBLIKA SRPSKA AND THE POTENTIAL IMPACT ON FOREST ECOSYSTEMS

Goran TRBIĆ, Zoran GOVEDAR, Milun KRSTIĆ, Ivan BJELANOVIĆ, Srđan KEREN

Summary

Global climate change is one of the most pressing scientific, environmental, economic, and political problems of our time. The fourth IPCC report (Intergovernmental Panel on Climate Change) indicated that biggest impact of climate change on ecosystems and the people is manifested through changes in the water cycle on Earth (IPCC AR4, 2007). According to the IPCC and its climate models by the end of the year 2100, the global temperature of aboveground atmosphere could rise by 1.4 to 5.8 ° C. Estimates from previous studies indicate that the Republic of Srpska (BiH) will be exposed to influences that may have consequences for the entire society. For assessment of climatic variability the analysis based on historical data from meteorological stations of the Republic of Srpska and Federation of BiH was conducted. Based on meteorological data from stations in Banja Luka, Novi Grad, Prijedor, Doboj, Bijeljina, Sokolac, Čemerno, Gacko and Bileća (Republic of Srpska), and data from stations in Sarajevo, Mostar, Tuzla, Zenica, Jajce, Bugojno Livno , Bihać, Bosanska Krupa and Ivan Sedlo (Federation of BiH), thematic maps in GIS are made two periods: 1961-1990 and 1981-2010. Comparative analysis of two periods (1961-1990 and 1981-2010) showed that the largest increase in average air temperature during the summer months was recorded in Herzegovina (Mostar 1.2 ° C) and in the central parts (Sarajevo 0.8 ° C), while the largest increase in the spring and winter was recorded in Banja Luka 0.7 ° C. Smallest increase was in the fall and it ranges from 0.1 to 0.3 ° C. The increase of annual air temperature ranges from 0.4 to 1.0 ° C, while the temperature rise in the vegetation period is about 1.0 ° C. Increase of air temperature has been more pronounced over the last decade. In the period of 1961-2010. years, most of the territory of the Republic of Srpska was characterized by a slight increase in rainfall annually. However, due to reduced number of precipitation days over 1.0 mm and increase in number of days with intense rainfall, pluviometric regime is severely disturbed. Significant changes in annual distribution of rainfall followed by air temperature increase, represent one of the key factors that caused frequent and intense droughts and floods in the Republic of Srpska (BiH). Climate scenarios for the Republic of Srpska and Bosnia and Herzegovina are made using a regional climate model EBU-POM. For the purpose of scaling the results of global model two scenarios were used: A1B "medium" scenario and A2 "high" scenario. According to A1B scenario for period 2001 – 2030 at annual level rise of temperature is expected in the range of 0.8 to 1 °C with higher values in the north and west of the country. Change in annual rainfall is negative for the whole territory up to -10%, except the northeast, where the change is positive up to +5%. A1B scenario for period 2071 – 2100 indicates annual level rise of temperature in range from 2.4 to 2.8 °C with higher values in the south and west of the country. Change in annual rainfall is negative for the whole country and the interval of these negative values is from -30% to -10%. On the other hand, according to A2 scenario for period 2071 – 2100 it is to expect that the annual rise of temperature will be 3.4 to 3.8 °C. Change in annual rainfall is negative for the whole country up to –15%. In conclusion, based on the analysis of climate models for BiH, climate change model A1B (''medium scenario'') is expected. Trend of increasing temperature on the whole territory of Bosnia and Herzegovina. Precipitation distribution has already changed throughout the year, which caused significant changes in pluviometric regime leading to intensive droughts and floods (2010. and 2011). Preliminary analyses indicate necessity for greater use of research results on climate change. Possible impacts on forest ecosystems are: moving boundaries of forest types in the horizontal and vertical direction; change in habitats of individual species of flora and fauna; increasing the frequency and extent of forest fires; increasing the degree of risk for rare, relict and endangered forest communities; changes in the qualitative and quantitative composition of biocenosis; increased grade bark beetles and gypsy moths (NAO index); there is a possibility that climate change in the long run (scenario A2) lead to a transformation of the entire forest ecosystem, shifting distribution and composition of forests. Proposed adaptation measures are: mapping of forest vegetation in GIS technology; detailed analysis of climate change impacts on forest ecosystems by decades; to improve research and monitoring (more permanent plots in different forest types); create stand structures that will help in protecting forests from detrimental insect and fungi species; afforestation with appropriate species selection; strengthen the capacity of relevant institutions, local communities and the public; and finnally, developing strategies and effective operational plans for adapting forest ecosystems to expected climate changes.

EROSION PROCESSES IN THE ĐORĐEVAČKA RIVER DRAINAGE BASIN (SOUTH-EAST SERBIA) IN THE PERIOD 1953-2011

Sonja BRAUNOVIĆ, Milan KABILJO[1]

Abstract: *The Đorđevačka (Davidovačka, Vrtogoška) River is a left tributary of the Južna Morava River, into which it flows at approximately 5 km north-east from Bujanovac. The paper presents the results of a study of change of intensity of erosion processes in 1953, 1970 and 2011. The erosion process intensity in 1953 and 1970 was established on the basis of available erosion maps, whereas in 2011 it was determined by means of satellite images and field mapping. A calculation of the Z erosion coefficient for all three reference periods was performed based on Prof Gavrilović's methodology, which enabled conducting a comparative analysis of the obtained data.*

Key terms: erosion intensity, socio-demographic factor, land use

1. INTRODUCTION

The Đorđevačka River is a left tributary of the Južna Morava River in the Vranje valley. It flows into the Južna Morava River at approximately 5 km north-east from Bujanovac. The drainage basin area amounts to 25,85 km^2, it is of an elongated shape and its mean width is 2,01 km. Length of the main stream is 14,8 km. The direction of flow is northwest – southeast, elevation of the source is 1170 m above sea level and 390 meters above sea level elevation of the confluence. The drainage basin elevation difference is 780 m.

2. WORK METHOD

The existing documentation on land use and erosion process intensity, type and scope of performed erosion control works and measures, was collected and analysed. The condition of drainage basin erosion, its distribution and intensity were determined on the basis of erosion maps drawn up for all three observed periods based on the method by Prof Gavrilović (1972). The Z erosion coefficient [1] was used for quantification of erosion intensity. By means of field research conducted during 2011 and use of satellite images of the area, the condition of basin erosion and a land use were established. The objective of such methodological approach was a comparison of results from 1953, 1970 and 2011.

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3. RESULTS

3.1. Orographic-hydrographic characteristics of the drainage basin

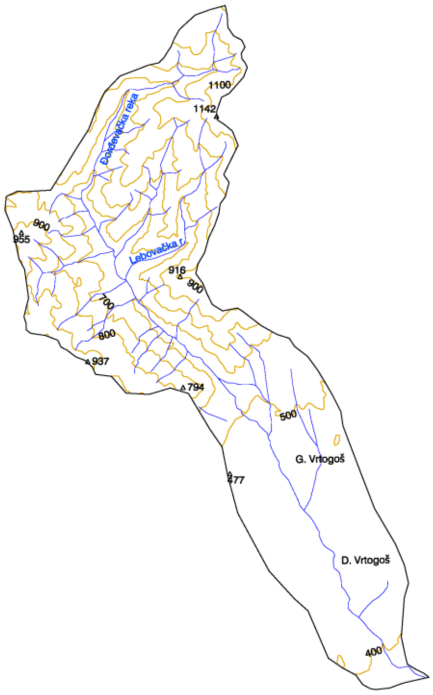
The Đorđevačka River's drainage basin has a well-developed hydrographic network. The main stream length is 14,80 km. In the upper and middle part of the drainage basin there are 11 mainly smaller tributaries on the right. The left side of the lower part of drainage basin has two tributaries while in the middle and upper part has 11 tributaries, of which the largest is Lebovačka river.

8,73 km^2 (33,77%) of its drainage basin area is located in a 300-500 m elevation zone, 4,94 km^2 (19,11%) is in a 500-700 m elevation zone, 10,13 km^2 (39,19%) is in a 700-1000m elevation zone and 2,05 km^2 (7,93%) is located in the elevation zone above 700-1000m. The elevation distribution is presented in the chart (picture 2).

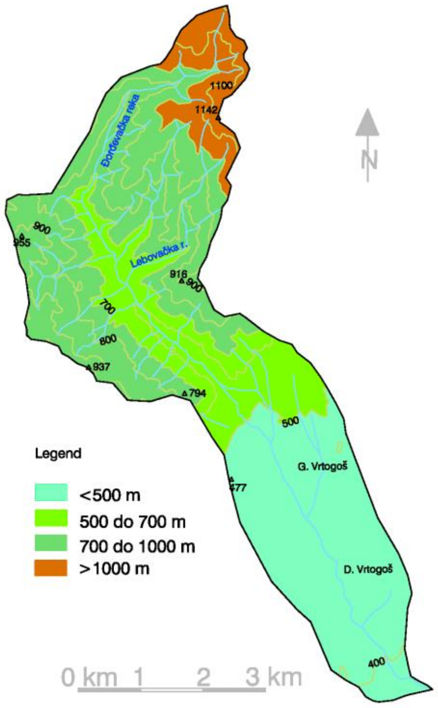
The impact of a terrain relief and its configuration on development of erosion processes is presented through most important orographic and hydrographic parameters of the drainage basin (Table 1).

Table 1. *Orographic-hydrographic parameters of the drainage basin*

Parameter	Symbol	Value
Orographic characteristics of the drainage basin		
Drainage basin area	F (km^2)	25,85
Drainage basin perimeter	O (km)	30,58
Drainage basin length	L (km)	12,80
Highest point in the drainage basin	K_v (m)	1270
Elevation of the source (confluence)	K_{izv} (m)	1170
Elevation of the mouth	K_u (m)	390
Mean elevation of the drainage basin	N_{sr} (m.n.m)	841,30
Mean elevation difference	D (m)	451,30
Mean slope of the drainage basin	I_{sr} (%)	2,78
Flood potential during the torrential rains	P_{sl}	478,42
Local erosion base	B_e (m)	880
Coefficient of the erosion energy of relief	E_r (m km^{-2})	123,51
Geomorphological erosion coefficient	M ($mkm^{-3/2}$)	0,03
Hydrographic characteristics of the drainage basin		
Module of the watershed development	E	1,68
Morphological coefficient	n	0,12
Coefficient of the drainage basin form	A	0,40
Main course length	L_{gl} (km)	14,80
Total length of all tributaries	L_{pr} (km)	35,20
Density of the hydrographic network	G (km/ km^2)	1,93
Mean slope of the drainage basin	I_s (%)	5,95



Picture 1. *Topographic map*



Picture 2. *Elevation distribution map*

3.2. Geological and pedological characteristics of the drainage basin

Tertiary sediments, well-represented in this region, are of different composition and age. The younger Tertiary sediments, which are very widespread, cover the lowest parts of the drainage basin. They are represented by loosely connected or non-connected pond sediments, gravels, sands and clays, whereas claystone and marl are comparatively rare [2].

Table 2. *Parent rock of the drainage basin*

Parent rock	Area (km^2)	Distribution %
Metamorphic rocks		
Amphibole schists	0,32	1,24
Quartzite	0,04	0,15
Fine grained biotite and muscovite gneiss biotite	7,61	29,44
Leptinolith and micaschists	0,56	2,17
Total metamorphic rocks	8,53	33,00
Igneous rocks		
Leucogranites; granitoids (Bujanovac pluton)	6,71	25,95
Total igneous rocks	6,71	25,95
Central part of the series limestone with hornstones, sandstones and marl	1,09	4,22
Sands, clays, marls, bentonite clay, lignite	3,36	13,00
Prolluvium – facies of subaerial delta sediments	3,49	13,50
Alluvium	1,97	7,62
Delluvium	0,7	2,71
Total sedimentary rocks	10,61	41,05
Total	25,85	100,00

Quarternary formations are represented by alluvial and delluvial deposits. Alluvial river deposits occupy, in topographic terms, lowest parts of the terrain – river and stream beds. Based on a digitalised geological map of the Đurđevačka River’s drainage basin, a classification of its structure into igneous, sedimentary and metamorphic rocks was performed and their percentage representation was calculated (Table 2).

Table 3. *Types of soil in the drainage basin*

Class	Profile structure	Soil type	Area (km^2)	Distribution %
AUTOMORPHIC SOILS				
I Undeveloped	(A) - C	Colluvial soil (Colluvium)	1,26	4,87
II Humus accumulative	A - C	Smonitza (Vertisol)	6,78	26,23
III Cambic soils	A-(B)-C	Brown acid (Distric cambisol)	14,97	57,91
HYDROMORPHIC SOILS				
I (A)-G (undeveloped)	(A)-G	Fluvial or Alluvial (Fluvisol)	2,84	10,99
		Total	25,85	100,00

Most represented soils in the Đurđevačka River's drainage basin are district cambisol (58 %), followed by smonitza (vertisol) (26%), alluvium (11%) and colluvium (5 %) (Table 3). District cambisol on schists is represented in a 600-1100 m elevation zone. It is characterised by a good-water absorption, along with a presence of numerous fragments created by degradation of schists. On acount of its pronounced brittleness, it is easily susceptible to erosion processes, the intensity of which is particularly determined by the absence of protective vegetation cover. Smonitzas, due to a large content of clay, permeate absorbed water very slowly, and, as a result, even low intensity rains can cause surface run-offs, whereas in drought periods deep cracks are created. They lie in a 420-550 m elevation zone.

3.3. Land use

State in 1953. Forests of interrupted canopy were mainly represented in the upper part of the drainage basin and accounted for 55,55 % of the total surface area. It is well-known that expansion of agricultural land was performed unreasonably at the expense of forests, which resulted in an occurrence of intensive erosion and washing away on steep terrains. Creation of ploughland on forest terrains, which took place in this basin as well, represented the most important precondition for occurence of the above-mentioned torrents.

Plouhland constituted a large part of the drainage basin (28,38%) and it was characterised by being located at steep slopes, which, along with an inadequate treatment, additionally contributed to development of erosion processes (Table 4).

Table 4. *Land use in the drainage basin (1953)*

Culture	Area (ha)	%
Degraded forests	1436	55,55
Ploughland	734	28,38
Meadows and pastures	14	0,54
House adjacent gardens	25	0,98
Total productive areas	2209	85,45
Barren land	301	11,64
Settlements	75	2,91
Total non-productive areas	376	14,55
Total	2585	100,00

Table 5. *Land use in the drainage basin (2011)*

Culture	Area (ha)	%
Forests	1359	52,57
Degraded forests	14	0,54
Ploughland	766	29,63
Meadows and pastures	61	2,36
Degraded pastures	22	0,85
Orchards	45	1,74
Vineyards	69	2,67
House adjacent gardens	46	1,78
Total productive areas	2382	92,15
Gullies	1	0,04
Stone fields	74	2,86
Settlements	128	4,95
Total non-productive areas	203	7,85
Total	2585	100,00

Condition in 2011 [3]**.** Based on a drawn up land use map**,** it can be observed that there had been no drastic changes in comparison to 1953. Most significant changes occured in the category of forests, as the area occupied by degraded forest was reduced from 55,55 % to only 0,5%, primarily as a result of applicaton of administrative measures, and a population decrease in the period 1961-1991. Ploughland, meadow and pasture areas slightly increased, whereas barren land had been reduced from 11,64 % to 2,90% (gullies and stone fields). Small orchard and vineyard areas were observed, scattered within the drainage basin. Non-productive areas accounted for 14,55 % in 1953 whereas in 2011 they constituted 7,85% of the surface area of Đorđevačka River's drainage basin (Table 5).

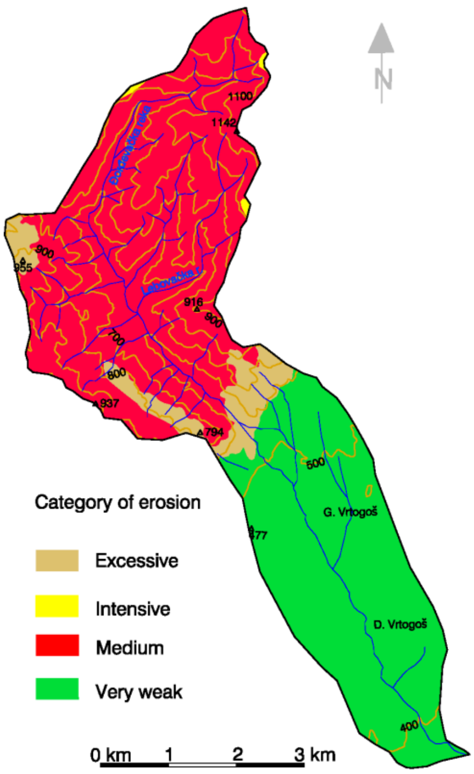
3.4. Erosion processes

The intensity of erosion processes in 1953 and 1970 was established on the basis of available digitalised erosion maps (Table 6, Pictures 3 and 4), whereas the erosion intensity in 2011 was determined by means of satellite images and field research (Table 7, Picture 5).

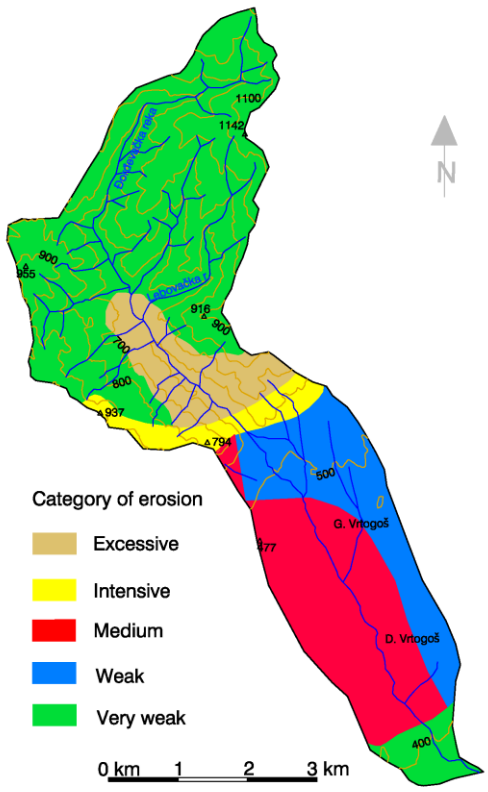
Table 6. *Mean erosion coefficient (Z_{mean}) in the drainage basin (1955 and 1970)*

Category	Zsr	Area (ha)	%	Zsr	Area (ha)	%
	1955			1970		
Excessive	1,25	154,00	5,96	1,25	244,00	9,44
Strong	0,85	8,00	0,31	0,85	117,00	4,53
Medium	0,55	1411,00	54,58	0,55	534,00	20,66
Weak	0,30	266,00	10,29	0,30	390,00	15,09
Very weak	0,10	746,00	28,86	0,10	1300,00	50,28
Total	Z_{mean} = 0,42	2585,00	100,00	Z_{mean} = 0,37	2585,00	100,00

The value of the erosion coefficient in 1970 amounted to 0,37 (low erosion), 11,9 % lower than the Z value in 1953 (0,42 – medium intensity erosion), whereas the value of Z erosion coefficient in 2011 was reduced by 35,7% in comparison to 1953 (0,27 – low erosion). The 1970 erosion coefficient value was reduced by 27,0% when compared to the Z value for 2011 (Table 7).



Picture 3. *Drainage basin erosion map – condition in 1955*

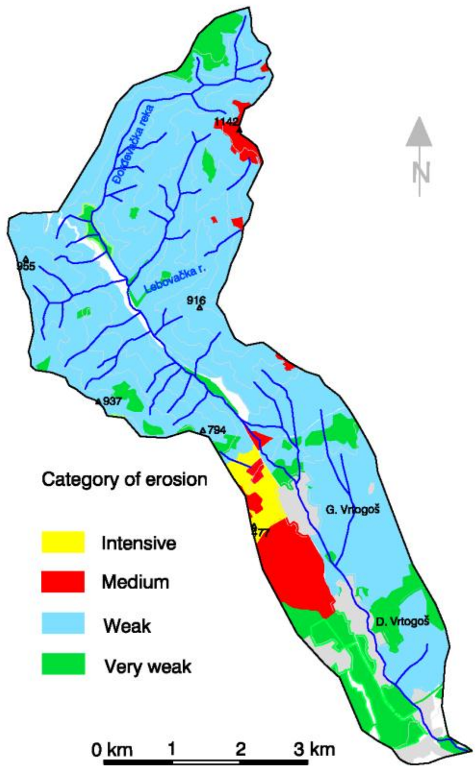


Picture 4. *Drainage basin erosion map – condition in 1970*

Table 7. *Mean erosion coefficient (Z_{mean}) in the drainage basin (2011)*

Category	Zsr	Area (ha)	%
Strong	0,85	47,00	1,82
Medium	0,55	140,00	5,42
Weak	0,30	1874,00	72,50
Very weak	0,10	331,00	12,80
Total		2392,00	92,53
No erosion[1]		193,00	7,47
Z_{mean} = 0,27			

[1] Areas not endganered by erosion include settlement construction zones, asphalt roads



Picture 5. *Drainage basin erosion map – condition in 2011*

3.5. Demographic characteristics

The investigated drainage basin is located on the territory of the cadastral municipality of Karadnik and Vrtogoš. There was a steady decline in the number of inhabitants (Table 8), average number of household members and population density in the period from 1948 to 2002.

Given the low altitude levels, a slight increase in population figures occurred in the period 1991-2002 [4]. An increase of population figures taking place until 1953 and a decrease of population figures in the period 1961-1991 (Table 8) are of importance from the aspect of erosion processes.

Table 8. *Number of inhabitants in the drainage basin*

Cadastral municipality	Elevation	Number of inhabitants per census year						
		1948	1953	1961	1971	1981	1991	2002
Karadnik	396	431	449	438	396	384	379	455
Vrtogoš	453	1535	1570	1576	1425	1387	1340	1369

Picture 6. *An abandoned house in the Đorđevačka River's drainage basin -2011*

In the Register of performed erosion control works on direct tributaries of the Južna Morava River in the Vranje valley area (1947-1977), there are no data on performed technical works. The only information is that 4,1 hectares were afforested in that period [5].

CONCLUSION

By conducting a comparative analysis of the obtained data, it was established that the intensity of erosion in the Đorđevačka River's drainage basin has decreased. Given the fact that erosion control works have not been registered in the drainage basin (exept for 4,1 ha afforestation), lessening of an adverse impact of anthropogenic factor, as a result of demographic decrease, represented a decisive factor that determined lower intensity of erosion processes in the drainage basin.

In order to maintain such state of erosion in the drainage basin, it is necessary to perform erosion control works (technical works in the riverbed and biological works on the slopes of the drainage basin).

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PLANTING METHOD INFLUENCE SPRUCE ON NURSERY STOCK GROWTH ON FORESTED AREA ON Mt KOPAONIK AND IMPACT ON MICROCLIMATE

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Abstract: *For reforestation, especially in the reclamation of degraded areas, it is very important way of site preparation, seedling selection, proper type, size, age, type of production, techniques of planting and care measures after planting. The aim of this research was to propose the more successful technique for afforestation and reforestation activities. Reforested area at the locality "Rendara" on the Mt. Kopaonik is exposed to unfavourable microclimate with strong winds and snow drifts, the coldest and longest winters in Serbia with the lowest average annual temperature and duration of snow cover is about 160 days a year.*

This area used to be under spruce forest, remain without woody vegetation and was reforested 1996 with spruce nursery stock (Picea abies Karst.), age of 2+2 years, provenance Mt Tara. Planting was done by two methods: in pits and furrows ("by ripping"). It was planted with a total of 3.000 plants per hectare on the total area of 20 hectares.

After 20 years it was recorded a very good success of nursery stock survival and physiological vitality in both planting methods (about 80%) which can be considered very good success. Analysis of growth and physiological vitality done in 2012 show that there was a significant difference between two planting techniques in plant height, mean value of plant height planted in pits and furrows was 4.14 m and 4.95m.

According to this research with spruce nursery stock, it is possible to recommend afforestation with planting method in furrows in order to mitigate unfavourable microclimate.Reforested area on the site of a former meadow, now with spruce trees height over 4 m, more substantively retains large amounts of water from snow and rain, which returns to the atmosphere by evapotranspiration, increases the relative humidity of the air and thus affects the microclimate of this site influencing the temperature of air and soil. A large number of trees also lower the intensity of the strong winds and thus cause decreased snow on the road during the winter. Further growth and development of spruce seedlings will certainly improve this favourable trend.

Key words: spruce, afforestation, planting method, microclimate.

1. INTRODUCTION

Multiannual disturbance of traffic by snow and wind at some sections of the road Brzeće – Kopaonik, especially at the locality "Rendara" (Photo1) were extremely endangered (Veljković et al. 1990) and this was the reason why the afforestation of this area was proposed. This area, used to be under spruce forest much earlier, remain without woody vegetation. The new reforested site at "Rendara" locality, was established in the year 1997 by the Forest service of the National Park Kopaonik as a forest shelterbelt and represents a supplement to the previous established spruce snow and wind shelterbelt.

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Spruce is the most common conifer forest species of the North hemisphere. It is very common in Serbia in the higher parts of mountainous region. It can be high about 40 m and in about 1 m in diameter. Root is not deep, develops in surface area of the soil and has a good formatted lateral roots. It is one of the most used species for afforestation in the region.
As an ornamental plant it is used for the mountains region regulation. It is also used in for grafting methods in various conifer cultivars of genus *Picea* production, pendulous, globosa, fastigiata etc. as well as Christmas tree.

On the investigated area spruce seedlings were planted by two methods: in pits and furrows. In the year 1998, the success of seedling survival, growth parameters and development of spontaneous vegetation in the afforested area was analyzed (Dožić et al 1998). The results of the research show a very good success of seedling survival in both planting methods. The physiological vitality of seedlings in first 2 years was not optimal, namely, the chlorosis of higher or lower intensity was observed numerous of seedlings, according to the content of biogenous mineral elements in needles, probably was the consequence of transplantation stress and damage of the root system (Dožić et al, 1998).

The aim of research was to find out which of the planting method can be recommended as rather better after a 16 year period of monitoring.

2. MATERIAL AND METHODS

2.1. Environmental conditions in the investigated area

The site "Rendara" on which was done the analysis of spruce seedlings that were used for afforestation, is located within the National Park Kopaonik, GJ "Brzećka Reka", SO Brus territory. It is near road from Brzeće to the peaks of Mount Kopaonik (43^{o} 19' 42.28″ N; 20^{o} 51' 04.02″ E), the total area of 20 hectares. The elevation is from 1492 m to 1540 m and a slope of about 10% to 22%. At the bottom of the slope along the road there is earlier established protective forest shelter belt of spruce trees 40 years old. On all this area it used to be a dense spruce forest. On Mt Kopaonik it is represented very proper altitudinal arrangement of vegetation. Spruce forests dominate from 1550 to 1750 meters above sea level (Mišić et al, 1985).

Mt.Kopaonik is the area with special climatic characteristics by the coldest and longest winters in Serbia (negative monthly temperature from December to April) with the lowest mean annual temperature. The mean annual air temperature is about $3.0^{o}C$. The coldest month is January with - $6.0^{o}C$ and the warmest August from $11.9^{o}C$. Absolute daily maximum rainfall is 76.5 mm. Average numbers of days with snow cover is 163.6, the maximum height of snow cover is about 2 m. The most frequent winds of an average year are blowing from the southwest direction and from the northeast (Smailagić J. 1995). At the locality was found decomposing bedrock where it formed brown podzolic soil depth of 40-80 cm, with the skeleton (about 30%).

2.2. Plant material and planting method

Spruce nursery stock age of 2+2 years, were produced from seed provenance of Mt.Tara in local forest nursery at the altitude which is similar to "Rendara" locality on Mt Kopaonik. Afforestation has been done with two methods, by planting in pits depth of 30 cm and in the furrows ("by ripping") on the second part of the investigated area. It was planted with a total of 3.000 plants per hectare. Spacing between plants in pits and furrows was 2.5 m. It was also done some floristic analysis on the afforested site.

2.3. Seedling analysis

Morphometric properties were analyzed in September 2012 at the end of vegetative season. It was measured tree height, diameter at breast height, needle length, and mass of 100 needles. Analysis was carried out on 3 experimental plots 5x5 m with 25 tree plants on each plot, selected by the method of randomized blocks and on both areas with different types of planting.
2.4. Statistic

All data were processed in the statistical analysis of data STATGRAPHIC. The conclusions were made on the basis of analysis of variance (ANOVA) and LSD test was used to determine significant differences among mean values of the treatments (p<0.05).

Photo 1. *Snow cover at the locality „Rendara"*

Photo 2. *Spruce seedlings on the afforested area in 2004.*

3. RESULTS AND DISCUSSION

According to the observed data on the temperature and winds, it can be concluded that in this part of Mt.Kopaonik there are extremely unfavourable microclimatic conditions.

Analysis of 19 years old spruce tree plants on the locality "Rendara"(Photo 3,4), conducted in September 2012, included the assessment of survival rates, physiological vitality, height, stem diameter, length and weight of needles.

It was recorded a very good success of spruce plants survival in both planting methods (over 80%) which can be considered very good success.
The earlier analysis of physiological vitality of plants, 2 years after planting and 8 years after planting (Photo 2), show also very good survival (over 85%), although chlorosis of various intensity was observed in some plants. Evaluation of chlorosis degree (1-5), needle macronutrients N, P, K, Mg content, needle mass and length, was than conducted on 600 spruce plants from six selected experimental plots. Lower physiological vitality, greater percentage of plants with chlorosis (64.29%) was observed on plants planted in pits than on those planted in the furrows (48.49%), reflecting the size, average weight and length of needles. According to sufficient content of biogenous mineral elements in needles, it probably was the consequence of transplantation stress and damage of the root system due to transplanting (Dožić et al, 1986).A few years later there was no chlorosis any more until nowadays.

Our current analysis of growth and physiological vitality was done in September 2012. Spruce plant vitality was very good with average mark 4.9 on the furrows plot and 4.8 on the plot with planting in pits (grade 1 to 5) (Photo 3 and 4).

Analyzed data show that height and diameter growth of spruce plants were very good. It was observed that height mean value was significantly less in plants planted in pits (4.136 ± 0.125 m) than in plants from furrows (4.954 ± 0.115 m) at the level 95% (Figure 1).

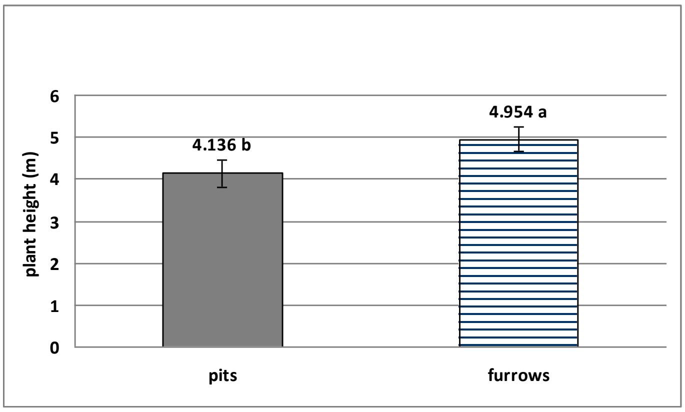

Figure 1. *Average spruce plant height (m) on forested plots with planting in pits and furrows. Different letters indicate significant difference between means at 95%.*

Average stem diameter at 1.5 m at breast height was also smaller in plants from pits (7.569± 0.323 cm) than in those from furrows (8.015± 0.287 cm), but there was no significant differences at the level 95% (Figure 2).

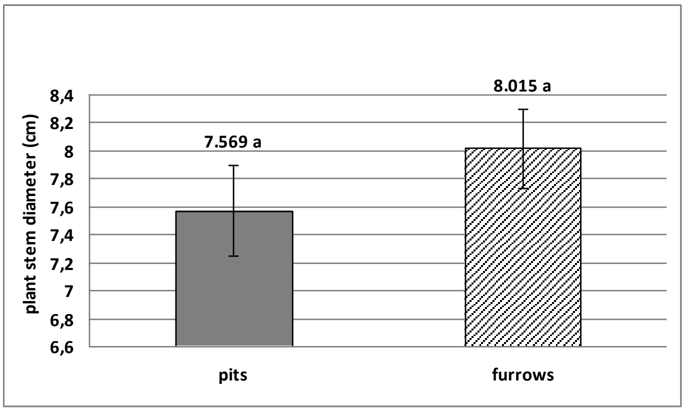

Figure 2. *Average spruce plant stem diameter (cm) on aforested plots with planting in pits and furrows. Different letters indicate significant difference between means at 95%.*

Two years old needles had significantly higher average length in plants from pits (1.853 ± 0.015 cm) than those form furrows (1.614 ± 0.014 cm), but needles from current vegetation were significantly longer in plants from furrows (1.59 ±0.0187 cm) than in plants from pits (1.405 ± 0.0131 cm) at the level 95% (Figure 3).

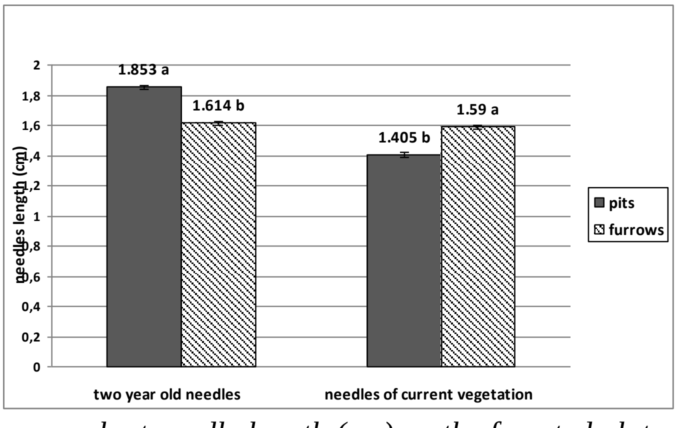

Figure 3. *Average spruce plant needle length (cm) on the forested plots with planting in pits and furrows. Different letters indicate significant difference between means at 95%.*

Two years old needles had significantly higher average fresh mass in plants from both plots. In plants from pits average values of fresh mass of 100 needles was 0.73 ± 0.0228 g and from furrows 525 ± 0.0068 g. In younger plants, needles from current vegetation from furrows had lower average values, 0.43 ±0,011g, than in plants from pits with average values off 0.49 ± 0.007g , at the level 95% (Figure 4).

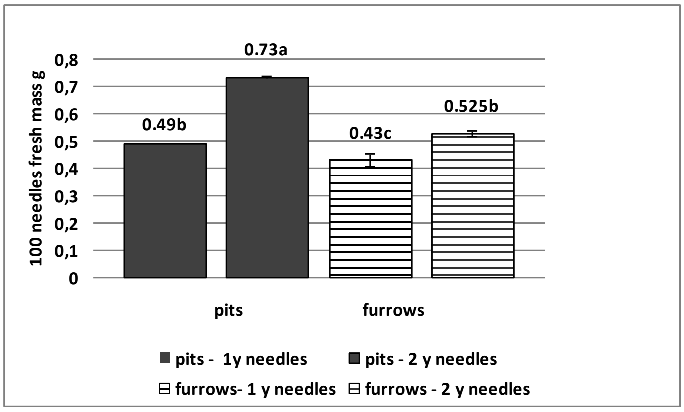

Figure 4. *Average spruce plant needle fresh mass (g) on the aforested plots with planting in pits and furrows. Different letters indicate significant difference between means at 95%.*

Although there was a various soil moisture in several parts of forested area, it was considered that the entire surface has enough water because of the great amount of snow cover and abundant rains, so the soil contains a sufficient supply of moisture during the growing season. A balanced water regime of spruce plants is of the great importance for the supply and utilization of mineral elements and for the growth and development (Djukić et al 1996, 98; George and Marschner, 1996).

Based on the obtained data it can be observed that the spruce nursery stock planted in furrows achieved a significant better overall vitality and height growth.

Previous studies show that the average height and root collar diameter of plants planted in furrows have higher values than those planted in pits (Dožić et al.1998).This can probably be explained by the greater vitality (less chlorosis) during the first 2 years of development, after planting. Chlorosis could be caused by less content of macronutrients and Mg as the result of transplanting stress, and therefore less photosynthetic production and growth rate.

However, afforestation affected the less floristic diversity of this area. According to earlier research it was observed that in floristic and vegetation terms this area had mosaic character where in the lower part of the area dominated communities with *Festuca ovina* as edificator. In addition to these types numerous were also *Hypericum perforatum, Rubus caesius, Dactylis glomerata, Rhinanthus rumelicus* et al. At the lower part of the area there is wetter facies dominating the species *Juncus inflexsus* (Dožić et al.1998).

Now, because of the development of spruce seedlings, presence of ground flora has been substantially reduced, and appears much smaller number of species. The dominant presence of *Epilobium salicifolium,* with a small number there are also *Rubus caesius, Dactylis glomerata,* and with a very low abundance occur *Verbascum longifolium, Gentiana lutea, Trifolium campestre, etc.*

The second reason is probably lower soil pH that is unfavourable for the most herbaceous plant species that were previous present on this area. It was observed in many cases such as in New Zealand where it was found that the soil pH in the 0-5 cm soil was significantly lower under pine forest compared with grassland after 15 years (Alfredsson et al, 1998).

So it is necessary to observe also soil changes (pH and base saturation level) under conifer afforestated area (Alriksson and Olsson, 1995).

In aforestation activities it is very important make adequate seedling selection, provenance, seedling quality (proper type, size, age, type of production), techniques of planting and also care measures after planting. In this case it this conditions was fulfilled, proper size and age of seedlings, adequate provenance and planting methods. Care measures after planting should be improved by fertilization because experience with fertilization of spruce seedlings showed that the addition of basic macro elements can significantly affect the growth and physiological vitality (Đukić et al, 2004).

In Ireland it was investigated the effect of site preparation on below and above ground biomass production by young Sitka spruce (*Picea sitchensis* (Bong.) Carr.) trees. Site preparation techniques studied included different mounding- and drainage methods and combinations of these. The results showed that mound planted trees had greater total biomass production, greater stem biomass and DBH, as well as greater foliage biomass compared to trees planted on the flat. This was probably due to improved weed control and more favourable soil temperature- and moisture condition within the planting mounds (Wills et al, 1999).

Photo 3. *Spruce trees in September 2012.*

Photo 4. *Spruce trees height and good physiological vitality*

4. CONCLUSIONS

The aim of research was to propose the more successful technique for afforestation and reforestation activities.

The results of the analysis showed a very good success of seedling survival and physiological vitality at the locality “Rendara“ on the Mt. Kopaonik which is exposed to unfavourable microclimate with strong winds and snow drifts, the coldest and longest winters in Serbia with the lowest average annual temperature and duration of snow cover over 150 days a year.

The presented data of the analysis of 19 years old spruce seedlings show that there was a significant difference in spruce tree height between two planting techniques with mean values of plant height planted in pits and furrows of 4.14 m and 4.95 m. It was also recorded a very good success of seedling survival (about 80%) and physiological vitality which can be considered very good success. Planting method in furrows could be recommended for further afforestation with spruce nursery stock.

Reforestated area at about 20 hectares on the site of a former meadow, now with a large number of spruce trees height over 4 m, more substantively retains large amounts of water from snow and rain, which returns to the atmosphere by transpiration, increases the relative humidity of the air, especially during the growing season and thus affects the microclimate of this site influencing the temperature of air and soil. It also lowers the intensity of the strong winds and thus cause decreased snow on the road during the winter.

Further growth and development of spruce seedlings will certainly improve this favourable trend.

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THE ANTIOXIDATIVE CAPACITY OF FOUR BASIDIOMYCETOUS FUNGAL SPECIES FROM FRUŠKA GORA PROVENANCE AS A POTENTIAL BIOCHEMICAL INDICATORS OF ENVIRONMENTAL DISTURBANCE

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Abstract*: In the last decades, basidiomycetous fungal species became of great importance as sources of natural bioactive molecules. Moreover, macrofungal species have been also used as a good bioecological indicator of contamination of ecosystem in biodiversity monitoring examinations, determining conditions of soil, wood species and air. Biochemical parameters of oxidative stress in four macrofungal species were analyzed for their antioxidative capacity referring of possibility of disturbance of Fruška Gora Provenance and its forest ecosystem by environmental (e.g. climate) changes above Vojvodina region. Organic extracts (70% methanol and 100% chloroform), made of four lignicolus fungal species (Panus tigrinus, Fomes fomentarius, Agrocybe aegerita, Omphalotus olearius) from natural Fruška Gora Provenance were examined directly for their antioxidative capacity by 3 tests in vitro: DPPH•assay, FRAP assay and total phenol content determination.*

The highest radical scavenging capacity (RSC) and the lowest IC 50 value (129,22 µg/ml) in DPPH• assay was noticed in the extract of F. fomentarius, while the extract of A. aegerita showed ≈ 13 times higher value (1746,38 µg/ml) indicating lower antioxidant potential. O. olearius extract showed the highest antioxidative capacity in all tests obtained. However, F. fomentarius species showed higher value in FRAP test (69,1 mg equivalent of ascorbic acid/g dw) and total phenol content (240,55 mg equivalent of galic acid/g dw) then P. tigrinus and A. aegerita species in the same tests, showing its stronger antioxidative defense against oxidative stress. Positive correlation (r=0.98) between total phenol content and ferric reducing power of fungal extractst indicated the possibility that phenols are major active constituents in obtained antioxidative activity. According to results for DPPH• assay, two fungal species, P. tigrinus and A. aegerita indicate possibility that different, non-phenolic secondary metabolites can be responsible for high IC 50 value and strong anitoxidative reaction.

The obtained results suggest that all analyzed fungi from natural Fruška Gora Provenance are of potential interest as a good bioecological indicator for Fruška Gora Provenance which ecosystem is in balance, as opposed to the obvious climate changes.

Key words: antioxidative capacity, basidiomycetous fungi, climate change, in vitro assays, ROS

INTRODUCTION

Reactive oxygen species (ROS) such as superoxide (O_2^-) and hydrogen peroxide (H_2O_2) are by products in normal metabolism of all aerobic organisms, produced mainly by partial reduction of oxygen during process of respiration. In the presence of traces of metal ions, O_2^- can react with H_2O_2 and generate the more reactive singlet oxygen ($^1O_2$). Furthermore, H_2O_2 can

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oxidize sulfur centers of iron and cysteines in certain proteins or react with transition metals and produce the most toxic hydroxyl radical ($OH^{\cdot}$), which cause an oxidation of any cell molecule resulting in DNA damage, protein inactivation, protein cross-linking and fragmentation or lipid peroxidation. Cells have a number of mechanisms to maintain low intracellular ROS levels, which constitute the antioxidant response (Aguirre et al., 2006).

Phenolic compounds are the major naturally occurring antioxidant components found in medicinal mushrooms (Mau et al., 2002; Ribeiro et al., 2007) and most of those identified in commercial mushrooms are phenolic acids (Dubost et al., 2007; Kim et al., 2008). Non-phenolic compounds including terpenoids (Leon et al., 2004) and polysaccharides (Tseng et al., 2008) have also been recognized as mushroom antioxidants. Some of previous studies of fungal antioxidants have been oriented towards commercial mushrooms used as food (Dubost et al., 2007), but the recent scientific literature shows an even higher antioxidative potential for wild-growing mushrooms (Barros et al., 2007, 2008; Elmastas et al., 2007).

Moreover, macrofungal species have been also used as a good bioecological indicator of contamination of ecosystem in biodiversity monitoring examinations, determining conditions of soil, wood species and air. For example**,** *Fomes fomentarius* is a common and economically important wood-rotting fungus in deciduous forests of Central Europe (Gabriel et al., 1997). It is a whiterot fungus causing heart rot of wood of several tree species including *Fagus sylvatica* and *Betula pendula* (Crockatt et al., 2008). Enzyme activities measured in wood closely located to fungal fruit bodies of *Fomes fomentarius* and other basidiomicetous fungal species are likely to reflect the activity of the single species. Understanding of the decay process in fungus-colonized wood and the factors affecting fruit body formation are essential for the understanding of the physiology of fungi causing biodeterioration of wood and may help both to develop preventive measures to reduce fungus-induced wood losses and to undertake measures for the conservation of endangered wood associated fungi (Dahlberg et al., 2010).

Lignicolus fungal antioxidative answer due to climate changes may indicate possible changes on (micro) ecosystem level, since the temperature and moisture variation in Fruška Gora provenance is evidential and crucial for forest biodiversity sustainability.

The aim of study

Biochemical parameters of oxidative stress in four macrofungal species were analyzed for their antioxidative capacity referring of possibility of disturbance of Fruška Gora Provenance and its forest ecosystem by environmental (e.g. climate) changes above Vojvodina region.

MATERIALS AND METHODS

Fungal material. Wild-growing fungi of *Fomes fomenatrius* ((L.) J.J. Kickx t.) (Figure 1.), *Agrocybe aegerita* ((Brig.) Fayod) (Figure 2.), *Omphalotus olearius* (Wulf. Ex Fr.) (Figure 3.) and *Panus tigrinus* ((Bull.) Fr., (1825)), and Quel.) (Figure 4.) were collected from the Fruška Gora low mountain chain (northern Serbia). Voucher specimens have been deposited in Herbarium Laboratory of the Department of Microbiology, University of Novi Sad.

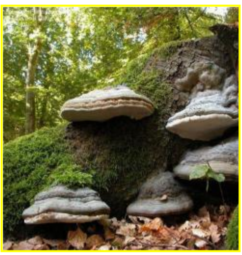

Figure 1. *Fomes fomentarius*

Figure 2. *Agrocybe aegerita*

Figure 3. *Omphalotus olearius*

Figure 4. *Panus tigrinus*

Extraction of fungal material. Mature fruiting bodies were brush cleaned, air-dried in the oven at 50°C to constant mass and pulverized. The powder was stored in the dark, at room temperature, in desiccators over $CaSO_4$ prior to analysis. For each sample, 10 g of powder was macerated with 350 mL of 70% aqueous MeOH or 100% $CHCl_3$, at 25°C, stirred using a rotary shaker (120 rpm) for 72 h and filtered twice. The filtrates were evaporated to dryness at 40°C *in vacuo* and the dried extracts redissolved in 70% MeOH (or 100% $CHCl_3$) and stored at <+4°C for further use (Karaman et al., 2010).

Scavenging effect on the DPPH radical. The radical scavenging activity of fungal extracts was determined by the $DPPH^{\bullet}$ radical scavenging method (Soler-Rivas et al., 2000). The samples (6.25–700 μg/mL for MeOH and 6.25–1400 μg/mL for $CHCl_3$ of stock solution) were mixed with 1 mL of 90 μm DPPH solution and made up with 95% MeOH to a final volume of 4 mL. The reactions were performed in triplicate and recorded against two positive controls i.e. BHT (0.25 mol/dm_3) and BHA (0.32 mol/dm^3). The percentage (%) of radical scavenging capacity (RSC) was calculated by the following equation:

$$RSC\ (\%) = 100 \times (A_{blank} - A_{sample} / A_{blank})$$

The scavenging activity of the samples was expressed as IC 50, representing the concentration of extracts that express 50% inhibitory effect of DPPH radical.

Ferric Reducing Antioxidant Power Assay (hereinafter: FRAP)**.** This procedure involves the reduction of Fe III-TPTZ to a blue-colored Fe II-TPTZ by biological antioxidants and chemical reductants, some of which might have no antioxidant activity in a sample. The FRAP assay compares the change in absorbance at 600 nm of a sample with the change in absorbance of a known standard ($FeSO_4 \times 7H_2O$) to determine antioxidant levels (Griffin and Bhagooli, 2004). Each reaction was repeated three times. Ascorbic acid was used to calculate the standard curve.

Total phenol determination. The concentrations of total phenols (TP) in fungal samples (expressed as galic acid equivalents) were determined using Folin-Ciolcateu reagent (Taga et al., 1984). Absorbance was read at 760 nm after 2 h and galic acid was used to calculate the calibration curve. The estimation of the phenolic compounds was carried out in triplicate. Galic acid equivalents reflected the phenolic content as the amount of galic acid (mg) per g of dry extract (d.w.).

All statistical analyses were performed in the Statistica 7.1. Software, using Duncan's multiple arrange test and results are finalized in Microsoft Excel Programme as histograms.

RESULTS AND DISCUSSION

The highest radical scavenging capacity (RSC) and the lowest IC 50 value (129,22 μg/ml) in $DPPH^{\bullet}$ assay was noticed in the extract of *F. fomentarius,* while the extract of *A. aegerita* showed ≈ 13 times higher value (1746,38 μg/ml) indicating lower antioxidant potential (Figure 5.). *O. olearius* extract showed the highest antioxidative capacity in all tests obtained. However, *F. fomentarius* species showed higher value in FRAP test (69,1 mg equivalent of ascorbic acid/g dw) (Figure 6.) and total phenol content (240,55 mg equivalent of galic acid/g dw) (Figure 7.), then *P. tigrinus* and *A. aegerita* species in the same tests, showing its stronger antioxidative defense against oxidative stress.

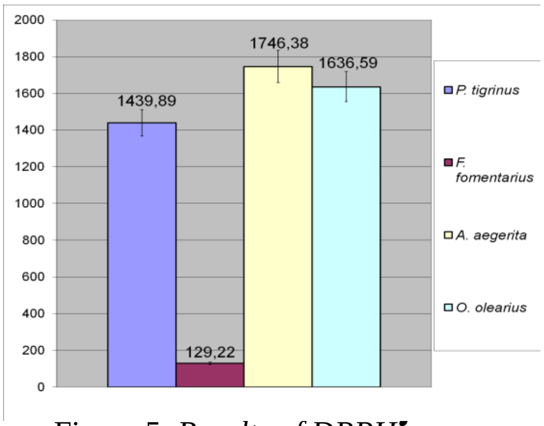

Figure 5. *Results of DPPH• assay*

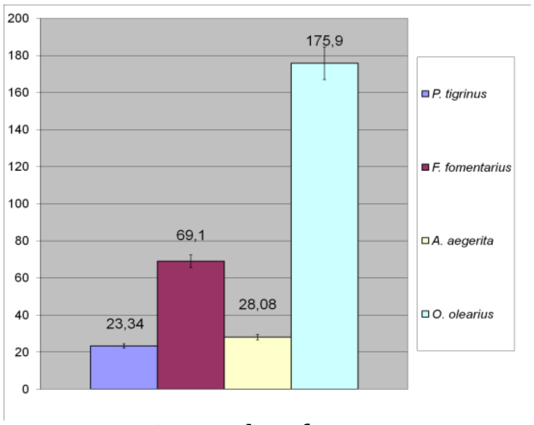

Figure 6. *Results of FRAP assay*

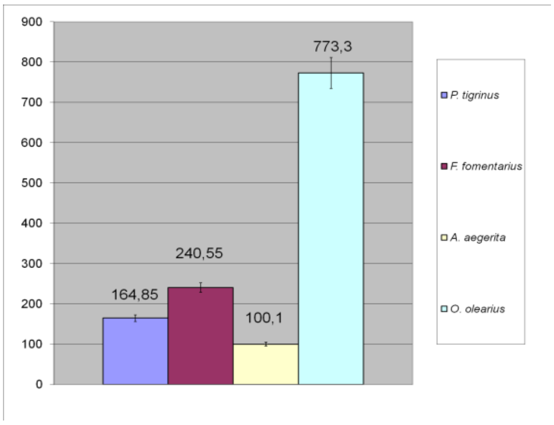

Figure 7. *Results of total phenol content*

Antioxidant activity was in correlation with the total phenol content (eq. galic acid mg/g dried extract), ranging from 164 to 773 eq ga mg/g dw. Total phenol content was in direct positive correlation (r= 0.98) to ferric reducing capacity of extracts (eq. ascorbic acid mg/g dried extract) (Figure 8.). Positive correlation between total phenol content and ferric reducing power of fungal extarcts indicated the possibility that phenols are major active constituents in obtained antioxidative activity.

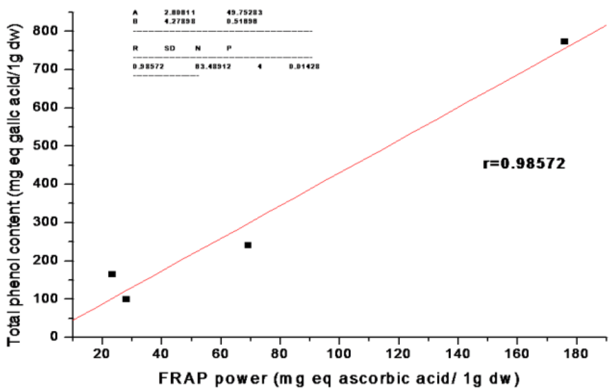

Figure 8. *Correlation between total phenol content and ferric reducing power of analyzed extracts (mg equivalent of galic acid/g dw)*

According to results obtained for DPPH• assay, two fungal species, *P. tigrinus* and *A. aegerita* indicate possibility that different, non-phenolic secondary metabolites can be responsible for high IC 50 value and strong anitoxidative reaction. *A. aegerita* is wealthy in antibacterial peptides such as agrocybin and agrocybolacton and saccharide, 1,3-α-D-glucan (Rosa et al., 2003). *Agrocybe aegerita* is relatively understudied for its cultivation and biotechnological applications when compared to other mushrooms species of similar organoleptic properties. Ullrich and Hofrichter (2005) reported that during vegetative growth, *A. aegerita* produces a peroxidase which catalyzes the oxidation of 2,6-dimethoxyphenol or 2,20-azinobis-(3-ethylbenzothiazoline- 6-sulfonate). Laccase, peroxidase and carboxylmethyl cellulase enzymes were also detected at different stages of fruit body development, during cultivation on cotton seed and sawdust substrate (Wang et al., 2000). Biochemical composition of fruiting body of the species *P. tigrinus* is still unknown.

CONCLUSION

The results of this study suggest that tested fungal extracts contain constituents that are good radical scavengers. Obtained results indicate also that all analyzed fungi from natural Fruška Gora Provenance are potentially good biochemical indicators for Fruška Gora Provenance which ecosystem is in balance, as opposed to the obvious climate changes. Further *in vitro* tests should be performed to gain in-depth picture of potential use of these four species as eco-biochemical indicators of forest environmental changes. Also, the important fact is that evaluation of oxidative stress level combined with analysis of possible changes in the chemical composition of wood may allows differentiation between the different ecophysiological groups of lignocelluloses degrading fungi and may be useful to identify fungal key species.

Acknowledgement
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4-5 October 2012, Institute of Forestry, Belgrade, Republic of Serbia

THE IMPACT OF CLIMATE CHANGE ON REPRODUCTIVE POTENTIAL OF INVASIVE SPECIES *Aster lanceolatus* Willd.

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Dragana SKOČAJIĆ, Danijela ĐUNISIJEVIĆ-BOJOVIĆ, Slađana SAMUILOV[1]

Abstract: *Understanding and predicting changes in community composition, plant distributions and ecosystem functions in the era of climate change has become a central issue of invasive plant ecology. There is a large volume of published studies suggesting that traits related to reproduction, such as timing of flowering, high seed production, good seed viability and long-distance dispersal ability can promote species invasion potential. This paper presents results of the research conducted on several locations in Belgrade where Aster lanceolatus Willd. spread rapidly, forming dense patches over large areas. Late flowering period, high seed production, long-distance dispersal ability and rapid vegetative spread were noticed. This results suggest that Aster lanceolatus Willd. have high reproductive potential. This characteristic will be even more significant with the climate change driving extreme weather conditions, which are likely to support the spread of this invasive perennial.*

Keywords: *Aster lanceolatus* Willd., invasive plants, reproductive potential, climate change

INTRODUCTION

With human populations and average consumption raises, human impact on natural resources is increasing and natural ecosystems are being degraded, converted and destroyed to meet human needs. Climate models predict that the temperature will rise and that precipitation regime will be changed. These changes will affect the plants and the ones that will survive will be those that are able to evolve or to quickly adapt to changes, migrate and colonize areas that suit them better. Invasive plants have these abilities and it is reasonable to expect that they will pose an even greater threat to biodiversity and economy than they are today. These changes will be most pronounced in urban and suburban areas.

Numerous studies analyzed features of invasive plants, the characteristics of communities that are prone to invasion and the consequences of invasion to ecosystem and its functions. However, in recent years, an increasing number of studies have examined how climate change affects the indigenous and non-indigenous plants, which traits are particularly important in terms of climate change and invasion and try to predict how invasive species will behave in new conditions. However, it is difficult to say which features of plants and habitat will have decisive role for plant growth in the future. Various experiments were conducted, but the general pattern is not observed. To predict how particular genus or species will respond to future climate change, specific case studies are needed (Miller-Rushing and Inouye, 2009).

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Based on 79 independent comparisons of native and invasive plants, Daehler (2003) reported that the invasive plants were not having higher growth rates, competitive ability or fecundity, but the success of invasive and co-occurring native plants depend on growing conditions. Element of global change that could have effect on invasive plants are increased atmospheric CO_2 concentration, climate change, increased nitrogen deposition, altered disturbance regimes and increased habitat fragmentation (Dukes and Mooney, 1999). It is important to identify functional traits that are related to tolerance of different climates (Dukes and Mooney, 1999).

Aster lanceolatus Willd. inhabits moist soils along lakes, riverbed and bogs, or roadsides and disturbed ground (Obratov-Petković *et al*., 2009; Jones, 1987) and all these sites behave as migration and dispersal corridors. The primary reproductive characteristics of riparian plants are tradeoffs between generative and vegetative reproduction, seed size, timing of dormancy, timing of seed dispersal, seed dispersal mechanisms, and longevity (Naiman and Décamps, 1997). Characteristics which favor *A. lanceolatus* over indigenous plants could be related to the reproductive potential.

The aim of this study was to begin the evaluation of reproductive potential of *A. lanceolatus* and to make predictions how unremitting climate change will affect the further spread of this highly invasive species. Germination rates and potential for vegetative propagation of *A. lanceolatus* were investigated.

MATERIAL AND METHOD

Study species Aster lanceolatus Willd.

The studied species was identified as *Aster lanceolatus* Willd. based on standard floristic methods, using relevant literature Javorka and Csapody (1934), Josifović (1970-1977), Tutin *et al*. (1964-1980), Sarić and Diklić (1986), Sarić (1992) and Online data base of Flora Europaea. *A. lanceolatus* is common invasive species in Serbia (Obratov-Petković *et al*., 2011). This species is edificator in the *Asteretum lanceolati* community, which is a new type of invasive community in wet and degraded habitats (Obratov-Petković *et al*., 2011). All material was collected during the fall 2011.

Study sites

To investigate the generative reproductive potential of *A. lanceolatus*, seeds were collected at 9 locations: two river islands, Ada Međica and Veliko Ratno Ostrvo; Kumodraž area in the valley of the creek of Kumodraški potok; Makiš, Živača, Jakovo, Veliko Blato and Krnjača on the alluvial plain and Košutnjak hill close to Sava River. Rhizomes of *A. lanceolatus*, were gathered from Veliko Ratno Ostrvo.

Laboratory studies

Visually mature flower heads from the entire inflorescent were collected from *A. lanceolatus*. Collected seeds were stored at room temperature for 6 months until the germination test. Before the germination test, 7 day prechill treatments were applied. The control was tested without pretreatment. A germination test was carried out in a growth chamber, Type 1291/TPC-1/LP-113, on filter paper (3×30 seeds per treatment) at 20ºC (±2), 16 h photoperiod was applied (Grbić *et al*., 2011). Germinative capacity (GC) was determent after 14 days, while germinative energy (GE) was calculated on the seventh day (ISTA, 2003).

To asses potential for vegetative reproduction 4 parameters were measured: number of shoots, total leaf number per plant, number of primary roots and length of primary roots. 46 rhizomes cuttings of *A. lanceolatus* were prepared for growing in hydroculture. All cuttings were approximately the same length with the same number of bulbs. Modified Hoagland solution was used (Džamić *et al*., 1999). After one week, the solution was changed with new one, and during the second week solution was filled up. Pots with plants were placed in the growing chamber at 20ºC (±2). The relative humidity of air was 70%. Photoperiod was 16/8 (light / dark) and the photon flux densities at a height just above the plants were approximately 20μM/cm. The plants development was monitored for 3 weeks. After the end of the third week, the plants were removed from the solution and defined parameters were measured.

RESULTS AND DISCUSSION

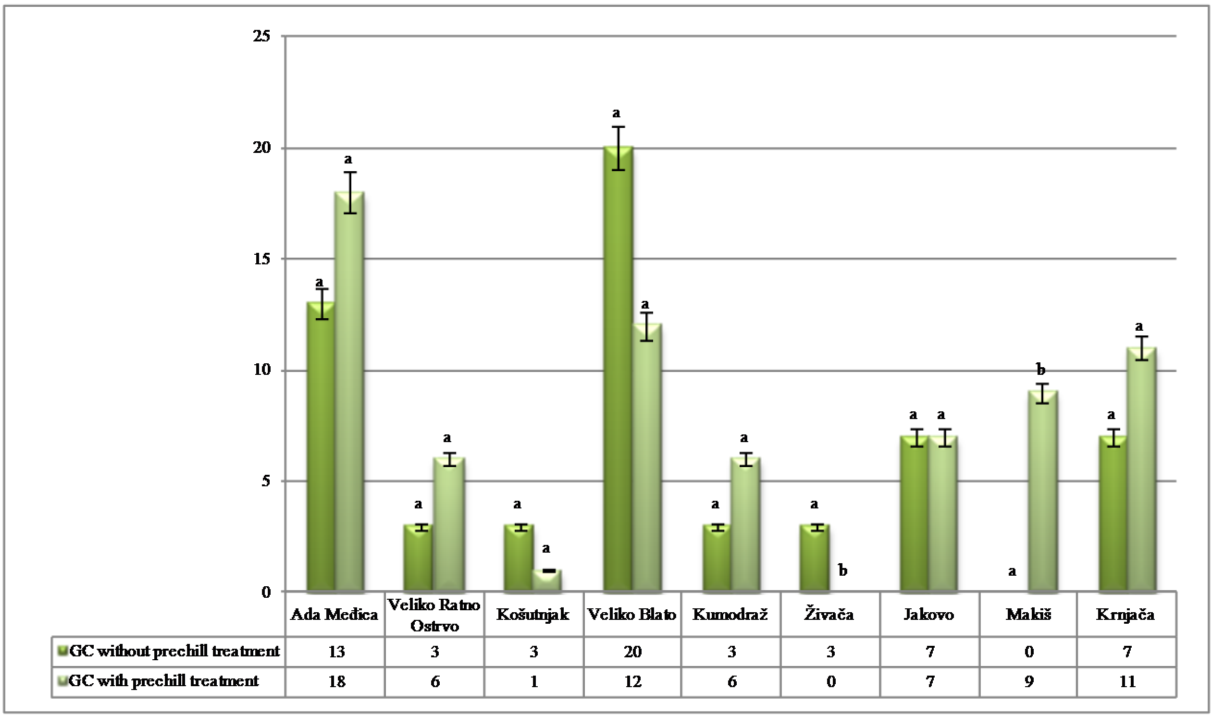
Reproduction is particularly important trait for invasive species, because the number and genetic quality of propagules produced by plants are important for successful colonization and spread in new environments (Barrett, 2001). Most successful non-indigenous species have traits that promote effective reproduction and dispersal, superior competitive ability, and the ability to occupy vacant niches (Elton, 1958).

Generative reproduction

Propagule pressure is a term that describes the number or rate at which propagules enter a region (Duncan, 2011). However, it is important to consider quality as well as quantity of propagules when assessing the impact of propagule pressure on the likelihood of an invasion (Davis, 2009). Flowering of *A. lanceolatus* does not appear to be controlled by plant size since all ramets within a clone, regardless of cytotype, year of study, size, or position within a clone, flower by the end of the growing season (Chmielewski and Semple, 2001). In all investigated localities *A. lanceolatus* flowered from late August to early November and clones were with highly branched inflorescences. Some plants consisted of more than 200 flower heads. Jones (1987) noticed that plants of *A. lanceolatus* that were pruned, flowered and that the flowering time lasted long after the end of flowering of plants that were not pruned. Late flowering period is important for the spread of *A. lanceolatus*, especially since climate change leads to the extension of the growing season and reduces winter and low temperatures (Obratov-Petković *et al*., 2011). Species *A. lanceolatus* is pollinated by a variety of insect species and has adaptive mechanism to preserve and to protect pollen by sleep movements when the ligules tend to close around the disk florets at night (Jones, 1978). This adaptation could favor *A. lanceolatus* over native plants that are pollinated by insects and do not have night movements.

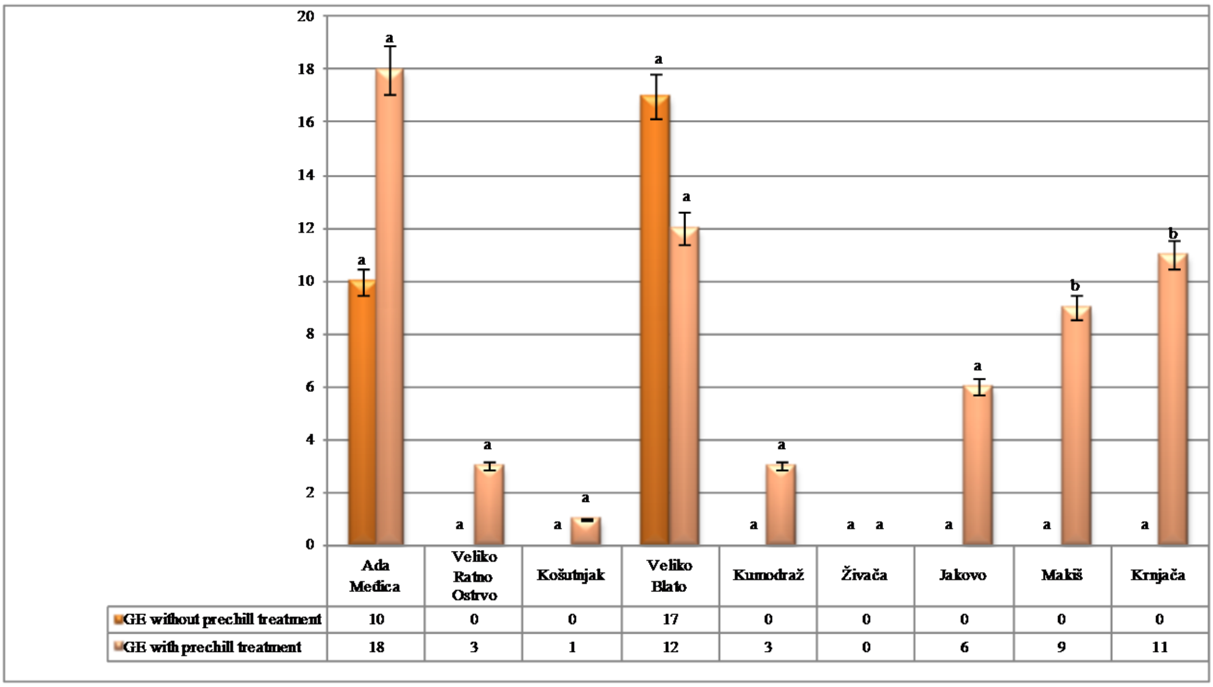
For a successful invasive process, number of seeds produced by the plant is important factor, because the greater number of seeds leads to a greater chance of successful establishment and spread into new areas (Leishman and Harris, 2010). *A. lanceolatus* have relatively high seed set amounting to 70% or more of the potential number of achenes in a head (Jones, 1978). Jedlička and Prach (2006) calculated expected output of 200 000 seeds per one highly branched plant. Therefore, plants from genus *Aster* has the highest seed production among invasive plant in Europe (Jedlička and Prach, 2006). Due to achenes with pappus and small seed mass, *A. lanceolatus* is well adapted to long distance dispersal. These adaptations are advantageous in open vegetation communities (Lake and Leishman, 2004).

Some species from genus *Aster* retained seed viability for at least 4 seasons at room temperature (Jones, 1978). Conversely, McDonald (2005) reported that storage life of seeds for genus *Aster* is less than one year. Baskin and Baskin (2005) found out that plants from Asteraceae family have non-deep dormancy which is break with low temperature. Germination rate of *A. lanceolatus* without stratification is between 60 and 80%, and after refrigeration for 2 months that rate is higher (Jones, 1978). Schmid and Bazzaz (1990) identified 39.5 and 43.7 germination rate in *A. lanceolatus*. Jedlička and Prach (2006) reported germination rate from 18.7 to 89.4 and from 42.6 to 83.8 in 1998 and 1999, respectively.



	Ada Međica	Veliko Ratno Ostrvo	Košutnjak	Veliko Blato	Kumodraž	Živača	Jakovo	Makiš	Krnjača
GC without prechill treatment	13	3	3	20	3	3	7	0	7
GC with prechill treatment	18	6	1	12	6	0	7	9	11

Figures 1: *Mean values of germinative capacity (GC) and differences between treatment*



	Ada Međica	Veliko Ratno Ostrvo	Košutnjak	Veliko Blato	Kumodraž	Živača	Jakovo	Makiš	Krnjača
GE without prechill treatment	10	0	0	17	0	0	0	0	0
GE with prechill treatment	18	3	1	12	3	0	6	9	11

Figures 2: *Mean values of germinative energy (GE) and differences between treatment*

Figure 1 shows that in this study, germinative capacity (GC) ranged from 0 to 18% in samples with prechill treatment and from 0 to 20% in samples without prechill treatment. GC showed significant differences between treatments on 3 locations. Germinative energy (GE) (Figure 2) ranged from 0 to 18% in samples with prechill treatment and from 0 to 17% in samples without prechill treatment. GE showed significant differences between treatments on Makiš and Krnjača. Results showed small differences between treatments. Dormancy was not confirmed in all samples. This could be due to genotype of parent plant or due to method of sampling since seeds from disc florets in Asteraceae family are less dormant than those from ray florets (Fenner and Thompson, 2005).

The reason for the low germination rate could be due to seeds storage. It is possible that room temperature was detrimental to seed viability. However, the findings of the current study were similar to previous one (Obratov-Petković *et al*., unpublished) which showed similar germination rate of *A.* lanceolatus seeds, tested immediately after collecting. Low germination rate could be due to hybridizations or genetic constructions of *A. lanceolatus* clones.

Vegatative reproduction

Clonal growth allows plants to quickly colonize available space and thus influence its success in vegetation succession (Prach and Pyšek, 1994). Species *A. lanceolatus* forms extensive stands with long and tangled horizontal rhizomes (Jones, 1978). *A. lanceolatus* have spreading genet architecture (Schmid and Bazzaz, 1987). Different genets form uniform stands of high shoot density between genet and low shoot density within genet (Schmid and Bazzaz, 1987).

Table 1. *Mean values of analyzed parameters*

Species	Number of shoots	Total leaf number per plant	Number of primary roots	Length of primary roots (cm)
Aster lanceolatus	1.88	8.37	4.58	32.05

In this study, percentage of rooted rhizomes was 100%. Number of shoots was 1.88, number of leafs per plant was 8.37, number of primary roots was 4.58 and length of primary roots was 32.05 cm (Table 1). Analyzed parameters suggest that *A. lanceolatus* has high ability to reproduce via rhizome segments and have great invasiveness potential.

Picture 1: *Cuttings of Aster lanceolatus Willd. after 3 weeks*

Picture 2: *Cutting with downward-oriented bud*

Some rhizome cuttings of *A. lanceolatus* were accidentally placed with downward-oriented buds (Picture 2). However, this had no effect on rooting of cuttings, which indicates that *A. lanceolatus* could have high ability to survive in disturbed ecosystems. In favor of the previously mentioned ability goes the observation that vegetative buds on the rhizomes have survived in a small soil sample exposed to the winter temperatures, for more than one year and succeeded to produce shoots with leaves.

This paper has investigated reproductive traits of invasive species *A. lanceolatus* and attempted to predict how climate change could reflect on reproductive potential of these invasive plants. Community ecology theory suggests that invasive species may be so successful because they have different phenologies than native species does or are able to adjust their phenologies to a new community or climate (Wolkovich and Cleland, 2010). Transcontinental distribution in native ranges (Chmielewski and Semple, 2001) gives *A. lanceolatus* predisposition to more easily adapt to changing climatic conditions. Shifts toward longer growing season could extend flowering period and benefit achenes maturation. Results of germinative capacity differ from some published studies. More research is needed to better understand reasons for low germination rate which may be due to several reasons, such as different genotypes of studied plants or the way seeds were sampled. According to Jones (1978), Delisle (1954) suggested that more fertile achenes were produced by ray florets than by disk florets. However, Jones (1978) observations do not support this. Future research should therefore concentrate on testing seeds taken from different parts of the inflorescence and different part of flower head, with diverse time of storage and treatments.

Studies of secondary succession include *A. lanceolatus* as significant contributor (Chmielewski and Semple, 2001). Plants which are producing vegetative offspring at a distance of 0.5 m or more during one year of growth are more successful in later succession than species with phalanx growth form (Prach and Pyšek, 1994). Competitive performance of *A. lanceolatus* may be enhanced by long rhizomes with large capacity for vegetative reproduction. By vegetative reproduction, *A. lanceolatus* is capable to migrate from less favorable places for development, such as the shadow places, to more suitable ones.

Taken together, these findings showed that potential for generative reproduction of *A. lanceolatus* is limited. However, great ability of vegetative propagation could be the cause of its spread. With a more pronounced climate change, it is reasonable to expect further expansion of population *A. lanceolatus.* Future research is needed to provide more definitive evidence.

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THE OCCURRENCE AND DEVELOPMENT OF FUNGI ON TREES WITH MECHANICAL INJURIES UNDER THE INFLUENCE OF THE ANTHROPOGENIC FACTOR AND CLIMATIC CHANGES

Miroslava MARKOVIC[1], Snezana RAJKOVIC[2], Vlado COKESA[3]

Abstract: *The climatic changes have brought about numerous injuries on trees, which along with damages caused by the anthropogenic factor, leads to occurrence of numerous wood-decay fungi in the stands. For the purposes of protection and preservation of beech in Serbia, this paper researched the occurrence of pathogenic microorganisms on beech trees relative to the presence of injuries on trees. The testing was conducted in the Forest Holding Kucevo, in a hillside beech forest Fagetum moesiacae submontanum of generative origin. The research was carried out on 23 testing plots with a total of 324 trees. It was found that the appearance of fungi primarily depends on the presence of mechanical damage on trees (as much as 73.46%), while the presence of abiotic damage has almost no bearing (only 3.21%), which indicates that the health condition of high beech stands is heavily dependent on careful and proper manipulation during harvesting. Each injury inflicted on a beech live tree during logging opens the door to infection with pathogenic microorganisms.*

Key words: Climatic changes, damage, forest, fungi

1. INTRODUCTION

Serbia's forest area relative to the global aspect is close to the world's level of 30%, but significantly below the European average of 46%. Out of the total 29.1% of forest area in Serbia, 7.1% is in Vojvodina whereas 37.6% of forests are located in Central Serbia [1]. Compared to the reference year of 1979, the area under forests has increased by 5.2%, which contributed to the positive effect on the overall state and quality of the living environment. The national inventory of Serbia's forests in the total volume and bulk growth is dominated by beech, whose presence amounts to 42.4%, or 32.3% [2].

The strategy of preserving the biodiversity and genetic resources of economically most valuable species of tress dictates that Serbia's forestry should primarily be concerned with preservation of the abundance of natural forests as a national wealth [3]. According to the internationally adopted definition, sustainable forest management means "*the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil relevant ecological, economic and social functions, and that does not cause damage to other ecosystems"* (MCPFE, Helsinki, 1993, as cited in Medarević *et al* [4]).

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Due to their presence in the forest reserves of Serbia, beech forests undoubtedly have the greatest significance. We can therefore conclude, quite justifiably, that management of beech forests is a much more complex and difficult task compared to management of any other tree species. In addition, available references most frequently speak of the quality of tall beech forests in descriptive and general terms – that it is unsatisfactory and in need of improvement [5, 6].

Owing to its bio-ecological properties and conditions of its living environment, as well as the stewardship methods applied to date, beech has preserved its natural structure, the areal of its natural spread and possibility to be regenerated naturally. Given the fact that natural rejuvenation is the only regeneration method for beech, Serbia has no artificially established beech forests or forest cultures. All of this makes up the foundation of their biological diversity, stability and sustainability. The biological properties, ecological demands, natural distribution, stewardship values and generally beneficial functions of beech forests, along with their structure, make beech the basic tree species for Serbian forestry [8], although the use of beech lumber on a wider scale is limited by its short lifespan.

Beech wood is vulnerable and represents an excellent base for development of numerous parasitic and saprophytic organisms, among which primarily parasitic fungi and harmful insects. In beech coppice forests in Serbia, the total of 147 species of fungi were found on beech trees, out of which 33 species occur on crowns, fruits and young crop, 56 species occur on leaves and bark of the branches and the trunk, whereas 58 species of fungi cause rot and coloration of wood [8].

The cause of beech forests dieback is a consequence of simultaneous negative impact of climatic (climate changes), management and biotic factors. Among these a special place belongs to man, whose irrational exploitation of beech forests resulted in Serbia's area under forest being cut almost in half. Deforestations of beech woodland that occurred in the past (in particular immediately after World War II) were not at all conducted as regeneration harvests, but almost exclusively for exploitation purposes. As a consequence of such management practices, forests have become extremely sensitive to harmful effects of numerous abiotic and biotic factors, notably parasitic fungi and harmful insects among the latter. The problem of protection of beech forests is further complicated by the occurrence of dangerous diseases and a large number of wood destructors that start their development as parasites on living trees and continue as saprophytes on timber [9, 10, 11].

This paper researched one aspect of occurrence of pathogenic microorganisms on beech trees, with the aim to contribute to the most rational approach to use of beech timber while preserving the beech stands in Serbia to the maximum extent.

2. MATERIAL AND METHODS

The sites selected for research were the ones on which the observation method revealed a large number of injuries on trees. The paper provides an analysis of the impact of tree injuries on occurrence of pathogenic and epixylic fungi on live trees in beech woodlands.

The research was carried out in the forest holding "Severni Kucaj" in Kucevo, forest administration Kucevo, Eastern Serbia, in a hillside forest of *Fagetum moesiacae submontanum* beech of generative origin. Tested site was located in the administration unit Majdan Kucajna, division 33.

The 500-m2 trial experimental plots were circular, placed in the stands at 100 x 100 m distances (according to the method described by Koprivica [12]). Each experimental plot included between 4 and 24 trees. Injuries noted on each tree were classified as mechanic (injuries from felling and hauling during harvest) and abiotic (injuries from wind, snow, ice, frost and excessive insulation that caused bark inflammation). The methods used were those described by

Koprivica *et al* and Markovic *et al* [13, 14]. In addition, any presence of pathogenic and epyxilic fungi on trees was also noted. On the basis of the received data, statistical analysis was conducted in order to determine the correlation link.

3. RESULTS AND DISCUSSION

Table 1 presents an overview of the fungi identified on Administration unit Majdan Kucajna, division 33 according to their frequency of occurrence. It is evident from the table that the first 4 fungi are present in all experimental plots (noted on 12.6% to 29% of all trees), whereas the presence of the latter 8 fungi was noted, on t he average, in only 4 plots and no more than 0.3% to 0.9% of trees. The fungi with ordinal numbers 5 through 9 are present on over 50% of experimental plots (or 6.5% to 11.1% of trees), while the fungi with ordinal numbers 8 through 13 were identified on less than 50% of the plots and spread on 1% to 20% of the tested trees.

Table 1: *Fungi identified on site I – Administration unit Majdan Kucajna, division 33*

Ordinal number of fungus	Type of fungus	Significance of fungus	% plots on which the fungus is present	% trees on which the fungus is present
1	***Apiognomonia errabunda***	***	100.0	29.0
2	***Coriolus versicolor***	**	100.0	24.6
3	***Hypoxylon* sp.**	**	100.0	8.9
4	***Stereum* spp.**	**	100.0	12.6
5	***Diatrype stigma***	*	65.2	11.1
6	***Fomes fomentarius***	***	57.0	6.5
7	***Trametes* spp.**	**	52.2	8.6
8	***Diatrype disciformis***	**	47.8	20.9
9	***Nectria galligena***	***	30.4	4.0
10	***Armillaria mellea***	***	26.0	1.2
11	***Lenzites trabaea***	**	17.4	1.8
12	***Nectria coccinea***	***	8.7	1.2
13	***Fomes igniarius***	**	8.7	1.5
14	***Pleurotus ostreatus***	***	4.3	0.6
15	***Poria obliqua***	***	4.3	0.3
16	***Dedalea quercina***	**	4.3	0.9
17	***Exidia recisa***	*	4.3	0.3
18	***Hydnum* sp.**	*	4.3	0.3
19	***Auricullaria auricila judae***	-	4.3	0.3
20	***Auricullaria mesenterica***	-	4.3	0.3
21	***Bulgaria polymorpha***	-	4.3	0.6

Table 1 presents fungi classified according to their significance, where those with 3 stars represent dangerous fungi with high significance, the fungi with 2 stars have medium significance, the fungi with one star have low significance, and those without stars have no significance. Under the classification proposed by Karadzic [15], the present fungi were classified as follows:

******* fungi with high significance (the highest significance is given to fungi that act that both as parasites and saprophytes, i.e. whose activity starts on standing, live trees and then persists on dead trees, following the harvest). These species of epyxilic fungi demonstrate a very high level of destruction and degrade primarily lignin, as well as cellulose and hemicelluloses, but to a lesser degree. Among the identified fungi, this group comprises Armillaria mellea, Fomes fomentarius, Pleurotus ostreatus and Poria obliqua. Besides the above-named wood-decay fungi, this group also includes the following pathogenic fungi: *Apiognomonia errabunda, Nectria coccinea* and *Nectria galligena*).

** fungi with medium significance (this group comprises the fungi that cause a somewhat lower degree of destruction, but appear on both injured, weakened trees and the freshly harvested ones). This group is represented by *Coriolus versicolor*, *Dedalea quercina*, *Diatrype disciformis, Hypoxylon* sp., *Stereum* spp. and *Trametes* spp.

* fungi with low significance (this group comprises the fungi that appear on rotting trees, frequently causing their complete degradation). Among the identified fungi, this group includes *Exidia recisa*, *Hydnum* spp. and *Diatrype stigma*.

- fungi with no significance (representatives of this group identified include *Auricullaria auricula judae, Auricullaria mesenterica* and *Bulgaria polymorpha*).

Table 2 presents the testing results for the total number of the present fungi and the total number of mechanical and abiotic damage.

One of the most significant fungi identified on the tested sites is *Nectria coccinea* (Pers. Ex Fr.) Fries., which together with the insect *Cryptococcus fagisuga* Lind. causes the so-called "beech bark disease". This fungus was found on 1.2% of trees or on 3 experimental plots (1,3 and 9). This disease is lately being regarded as a major factor compromising normal development of beech trees, which merits special attention given the fact that it is spreading over ever-larger areas. Measures undertaken against this fungus are classified into several categories:

- biological preventive measures, including use of predators and super-parasites against insects (prior to infection with fungus),
- bio-control of the fungus by means of antagonists (once the infection occurs),
- silvicultural measures – removal of diseased trees (in advanced stages of the infection),
- chemical measures, which are non-economical for forests and thus applied only to parks and alleys of trees.

It is important to note that following the infection of beech trees with this fungus, the necrotic bark sections very quickly get infested by wood-decaying fungi and wood-destroying insects, which also play a role in rapid tree decay and extinction of beech trees [15, 16].

Table 2: *Overview of attack by fungi and injuries on beech trees on Administration unit Majdan Kucajna, division 33*

Ordinal no. of plot	(x') No. of trees on the plot	Number of fungi found			(x_1) Number of mechanical injuries (damage from hauling and felling during harvest)	(x_2) Number of abiotic injuries (damage from wind, snow, ice, frost and excessive insulation – bark inflammation)	(x_3) Total number of mechanical and abiotic injuries	Index (x_3/ x')
		(y_1) No. of dangerous fungi	(y_2) No. of other fungi	(y_3) Total number of fungi				
1	12	1	3	4	2	3	5	0.42
2	24	1	4	5	3	4	7	0.29
3	9	1	3	4	2	3	5	0.56
4	11	1	3	4	1	3	4	0.36
5	16	1	5	6	8	1	9	0.56
6	9	1	4	5	6	2	8	0.89
7	16	4	6	10	15	6	21	0.06
8	12	4	6	10	20	9	29	2.42
9	23	6	9	15	27	4	31	1.35
10	15	1	6	7	3	1	4	0.27
11	21	2	6	8	17	9	26	1.24
12	18	3	6	9	21	3	24	1.33
13	8	1	5	6	14	2	16	2.00
14	11	2	6	8	15	3	18	1.64
15	19	2	6	8	11	10	21	1.11
16	4	1	5	6	4	1	5	1.25
17	15	3	5	8	16	42	20	1.33
18	9	1	4	5	9	6	11	1.22
19	23	4	8	12	19	7	25	1.09

Ordinal no. of plot	(x') No. of trees on the plot	Number of fungi found			(x_1) Number of mechanical injuries (damage from hauling and felling during harvest)	(x_2) Number of abiotic injuries (damage from wind, snow, ice, frost and excessive insulation – bark inflammation)	(x_3) Total number of mechanical and abiotic injuries	Index (x_3/ x')
		(y_1) No. of dangerous fungi	(y_2) No. of other fungi	(y_3) Total number of fungi				
20	8	2	4	6	7	3	14	1.75
21	8	1	5	6	14	3	17	2.12
22	17	4	6	10	12	8	20	1.18
23	16	3	7	10	23	4	27	1.69

The data presented in Table 2 served as basis for performance of a statistical analysis – simple and multiple linear regression between all pairs in the presented columns, and correlation matrixes made between columns x', y_1, y_2 and y_3, as well as columns x_1, x_2, x_3 and x_3/ x'. The correlation analysis clearly demonstrates that in all cases there is a link between the number of trees (x') and other columns. Next, there is a correlation link between the number of dangerous fungi (y_1) and other columns, with the exception of abiotic injuries (x_2) and index representing a quotient between the total number of injuries and the number of trees (x_3/x'). The same applies to columns y_2 (other fungi), y_3 (total number of fungi) and x_1 (mechanical injuries). Column x_2 has no correlation links with any other column, whereas x_3 (the total number of mechanical and abiotic injuries) has links to all columns except abiotic injuries (x_2). Column x_3/x' (index) is not linked to other columns, except to columns x_1 and x_3 (mechanical injuries and total number of injuries).

This practically means that, the occurrence of fungi (both dangerous and other) – column y_3 is primarily contingent upon the presence of mechanical injuries - x_1 (as much as 73.46%), while the remaining 26.54% depends on other factors – tree condition (susceptibility to disease), position inside the stand (open trees or within a dense canopy, land elevation, geological base, etc.), climatic conditions during the year that may or may not favour the development of fungi, etc. On the other hand, statistical analysis of the data received shows that the occurrence of fungi is not linked to damage caused by activity of abiotic factors (the correlation link is very low at 3.21%).

Therefore, careful and proper handling of trees during felling is critical for the health condition of tall beech stands. Every injury sustained by live beech trees during felling opens the door to infection by pathogenic microorganisms.

It is a well-known fact that health status of the stands is contingent upon a large number of factors, among which year-round climatic conditions must be considered as one of the most critical. Rainy, humid and relatively warm weather favours the activity of the fungi and increases the yield, and thus enables not only faster colonization by the fungi but also more precise identification of the existing microflora. It should also be noted that diagnosis of the disease is greatly impeded by long incubation of the fungi colonizing vital trees, while primary symptoms appear on the surface only after several years of attack (reproductive organs – visible carpophores may not appear at all or their appearance might be extended over a number of years). In addition to an accurate diagnosis, it is essential to make a precise prognosis of the dynamics of development of pathological processes in the plant. However, this prognosis cannot be determined with any reliable level of accuracy for the upcoming calendar years, as climatic conditions are a determining factor for the development of the infection. It is thus possible to make only a rough prognosis, based on mapping the parts of the forest under attack according to the destructor species and attack intensity, and use it as basis for planning the sanitary and silvicultural activities.

Sanitation felling and other phytosanitary measures, which may or may not be carried out in forests, certainly have a great impact on general health condition of the stands. Proper stewardship can minimize the existing infections and thus eliminate or greatly mitigate any new infection, which significantly contributes to having the health status of the stands restored and maintained on a satisfactory level.

4. CONCLUSIONS

On the first tested site, the occurrence of fungi primarily depended on the presence of mechanical damage, where this link was quite strong with as much as 73.46%, while the remaining 26.54% were contingent upon other factors. On the other hand, statistical analysis of the data received showed that the occurrence of fungi had almost no connection to the presence of abiotic damage (the correlation link was only 3.21%).

The number of injuries may be identified as the determining factor linking the occurrence of fungi and the damage on trees. On sites with fewer injuries the correlation links between the occurrence of fungi and the injuries are less strong, and vice versa.

Careful and proper handling of trees during felling is critical for the health condition of tall beech stands. Every injury sustained by live beech trees during felling opens the door to infection by pathogenic microorganisms. Proper stewardship may minimize the existing infections and thus eliminate or greatly mitigate any new infection, which significantly contributes to having the health status of the stands restored and maintained on a satisfactory level.

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BIOENGINEERING METHODS FOR ERODED REGIONS WITH APPLICATION OF SOME USEFUL PLANT SPECIES

Vjačeslava MATIĆ[1*], Nevena TATOVIĆ[2]

Abstract: *Paper is considering possibilities of application of some useful plant species as innovative approach in bioengineering protection of soil and groundwater. The analysis included melliferous, aromatic and medicinal plants that provide effective erosion control and high level crops in agricultural production, i.e. beekeeping. This kind of slope stabilization also bears importance for landscape planning providing new image of degraded areas, revitalization of degraded and eroded mountain areas and revival of their local communities and traditions. Since inappropriate harvest of these plants and intensive farming are endangering land conservation, paper examines new possibilities for embankments and slope designs and conservation and protection of existing natural areas. Species most suitable for application were reviewed on their biological and aesthetic characteristics such as depth and root development, growth rate, sprouting capacity, canopy width and power of water retention, visual characteristics of plants, color and appearance of leaves, flowers and fruits and average yields in production of honey.*

Key words: bioengineering, erosion control, land conservation, useful plant species

INTRODUCTION

Bioengineering measures for erosion control include various methods for slope stabilization using different forms of vegetation, taking into account both the cost-effectiveness and visual appearance. Selection of species is based on their biological and aesthetic features such as root depth and development, growth rate, sprouting capacity, crown width, power of water retention, and the plant visual characteristics, leaf, flower and fruit colour and shape. The most suitable species are fast-growing plants with strong roots spreading over large areas. Grass species are very tolerant to habitat conditions providing low-cost solutions, as dense grass cover develops in a very short time period (Matić, 1994). Their disadvantage is shallow roots and regular maintenance requirements. Herbaceous plants, especially the legumes valuable for nitrification, with deeper rooting and ornamental value, are expensive and their success is not always guaranteed. On the other hand, shrubs present a very powerful and relatively inexpensive ground cover with low maintenance requirements. *Spartium junceum* L. (Spanish broom) colonizes even the peaks and cliffs, stabilizing the area up to 45^0 in the soil layer thickness of 0,6

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meters (Tosi, 2007). In addition, many of them are propagated by seed, and evergreen species provide effective protection throughout the year. However, the disadvantage of this method is the fact that shrub establishment often requires substantial financial resources. Tree planting provides the most effective protection as trees have the deepest root system, and once established tree plantations rarely require further investments. Thanks to their excellent power of vegetative propagation, willows and poplars are most widely used in bioengineering. Their plantations are established in a short time period, using one of many methods of propagation by cuttings. At higher altitudes, willows (*Salix amygdalina* L., *Salix purpurea* L., *Salix alba* L., *Salix caprea* L.) are used for wattles - a bioengineering technique usually applied in autumn or spring (Matić, 1994).

One of the new bioengineering methods for erosion control is the use of aromatic and medicinal plant species with strong roots. Since ancient times, aromatic and medicinal plants have had wide applications in medicine and pharmacy, but beekeepers during spring also use these plants for honey (with different aromas and tastes), pollen and bee-glue (Weiss, 1997). A great production of aromatic and medicinal plants comes from wild plants, while more marketable species (mint, lemon balm, lavender, chamomile, etc.) are cultivated with conventional or ecological production systems (Rodríguez, 2006). Their application in terrain stabilization is important both from erosion control aspects and in terms of landscape planning, as they improve the visual appearance of the degraded areas and the landscape in general. For example, flower hedges spreading throughout England are mostly constructed as low earth embankments with trees and shrubs growing on their peaks (Gray, 1996). Ornamental species of aromatic and medicinal plants characterised by rapid expansion, by their various textures, shapes and colours of leaves, flowers and fruits, play a significant role in landscape planning. Urban landscape, as well as rural countryside, can be created with the purpose of production, growth and introduction of endemic and endangered species of aromatic and medicinal plants (Arslan, 2010).

In addition to these beneficial effects of bioengineering, equally important is the cost-effective use of aromatic and medicinal melliferous erosion-control plants in terms of revitalization of degraded and devastated mountain areas through organic farming. The downside of their implementation is, however, the delayed plantation establishment due to slower growth and financial requirements much higher than for grassing (Coppin, 1994). The study in the south-eastern Spain during 2006 monitored the run-off and the soil erosion by using various aromatic plant covers with the aim to determine the changes in the degree of runoff and soil erosion according to the plant cover used (Rodríguez, 2006). The final results showed that the lowest-growing plant covers (*Thymus serpylloides* and *Salvia lavandulifolia* Vahl.) discouraged the soil erosion and runoff more effectively than did the taller and open medium-sized shrubs (*Santolina rosmarinifolia* L., *Genista umbellate* Poiret , *Thymus baeticus* Boiss and *Lavandula stoechas* L.). This review paper gives brief summary on some of the most important melliferous types of aromatic and medicinal plants with an enviable potential in agriculture and land conservation – black locust (*Robinia pseudoacacia* L.), lavender (*Lavandula angustifolia* L.), sage (*Salvia officinalis* L.), creeping thyme (*Thymus serpyllum* L.) and summer savoury (*Satureja subspicata* L.). Data known from literature and empirical observations are reviewed comparatively in tabular form.

SPECIES TO CONSIDER FOR APPLICATION: MAIN CHARACTERISTICS

Due to various negative influences and impacts of living in modern society, there is an increasing trend of using the substances and products of natural origin, particularly in nutrition and medicine. Hilly and mountain areas in Serbia mainly occupy excellent sites beyond the reach of any pollution sources, distant from densely populated zones and characterized by extensive agricultural production. Bearing in mind these conditions, erosion control with aromatic and medicinal, melliferous plants may represent a valuable opportunity for development of small family farms and thus the revival and preservation of local communities and traditions. The two species important to consider for erosion control regarding soil binding and honey production are *Robinia pseudoacacia* L. and *Lavandula angustifolia* L.

Robinia pseudoacacia L. has been used against erosion, for afforestation of sandy terrains, bare areas and for slope stabilization from the early 17th century, when the species was introduced to Europe. It grows as a deciduous tree with airy crown, intensely scented white flowers, and the root reaching the depth of 20 meters in the soil (Jovanović, 2007).

Black locust is widely used in many varieties with different forms of habitus and has great power of vegetative reproduction. As it is tolerant to various environmental conditions, it grows on various soil types with modest maintenance requirements. Flowering lasts from May until the end of June, although the beginning of blooming season may be significantly conditioned by the altitude and insolation conditions. As a result, bees can have up to three pastures per season, which contributes to the quantity of honey. Interestingly, solitary trees and older trees show a much higher productivity than younger trees, or those growing in the forest (Umeljić, 2002). Also, productivity decreases with the altitude, but average yield is still very high and many beekeepers classify black-locust honey among the best of honeys.

Lavandula angustifolia L. is a perennial plant shrub growing wild in the arid conditions of the Mediterranean region. Plants develop a strong root system with numerous roots, reaching the depth of seven meters in the ground (Table 1). Lavender plants will tolerate many growing conditions, they are resistant both to low temperatures and drought which allows successful implementation in soil protection. Lavenders flourish best in full sun, in dry soils, they cannot grow only in waterlogged and acid soils. The highest quality lavender grows in France at the altitude of about 1600 meters, and although some growers believe that the optimum altitude is 700 - 1200 meters, the species is successfully cultivated at the elevation of 150 - 300 meters with satisfactory production results (Stepanović, 2011). Lavender has a long tradition in pharmaceutical industry and traditional medicine, but it is also highly valued as melliferous plant providing high-quality honey with annual average yield reaching 500 kg P ha^{-1}.

Salvia officinalis L. is a Mediterranean perennial species distributed in coastal karst areas and in the continental limestone areas. Plants grow successfully even on bare rocks and thus are invaluable in the combat against karst erosion - in such areas they dominate the landscape with the scent and hue of dark silvery leaves and bluish flowers. In Serbia, sage is the most widespread in the area of the gorges Sićevačka and Niševačka, though it should be noted that plants growing around the city of Niš have very similar composition of essential oils as plants growing within the species natural range in the Mediterranean (Jančić, 1995). Whole plants have pleasant scent reminiscent of balm, they bloom gradually from lower to higher altitudes during May and June. Sage flowers are a rich source of nectar and the average daily yield ranges up to 70 kg of honey per hive, or annually up to 600 kg P ha^{-1}. Sage is one of the most important medicinal plants - Romans called it "the holly plant’’. However, it is the importance and popularity as a medicinal plant that threatens the beekeeping today. Therefore, its collection and harvesting has to be limited to the areas that are not used as bee pastures. This request could easily be satisfied with the sage application in bioengineering, especially as the species is characterized by generative reproduction with good seed germination.

Thymus serpyllum L. is a perennial subshrub species growing in the spontaneous flora of Spain, Portugal, Greece and France. It is one of the best known medicinal plants dating back to ancient Egyptian times. It is an ornamental plant of white to pink flowers, characterized by a strong branched root system with several roots that, penetrating the soil up to 0.5 meters in depth, use the maximum of available water and nutrients. Thanks to this feature, creeping thyme grows in poor soils, on the sunny side of mountain meadows, up to 1700 meters. In Serbia, creeping thyme is widespread in the sandy areas of northern Serbia, especially in the mountain region Fruška Gora (Jančić, 1995). It tolerates drought and provides abundant amounts of nectar even in the hottest days when other vegetation is scorched. It blooms from May to September and produces one of the best types of honey, providing up to 180 kg P ha^{-1} annually.

Satureja subspicata L. is a perennial subshrub with long roots and white flowers. It grows only on rocky terrains, at the altitudes to 1200 meters above sea level, and as an authentic Mediterranean species it inhabits the crevices of bare rocks, without any soil. In Serbia, the only known site where summer savoury grows naturally is the valley of the river Beli Rzav (Jančić, 1995). It provides a high quality honey and blooms from August to October with the bee pasture lasting for only 30 days. Although the average honey yield is significantly decided by weather conditions, particularly rainfall, the secretion of nectar is best recorded between 12 and 16 h, i.e., in the afternoon under optimal conditions (Umeljić, 2002.). *Satureja montana* L. has red to pink flowers and grows at somewhat lower altitudes, up to 400 m, but is equally effective both in binding soil and in honey production.

Brief summary of the previous review points out that black locust, which is highly productive in beekeeping, is recommended for wattling at the sites where no other kind of vegetation can be used. Lavender, which is reproduced mostly by cuttings, should be successfully applied with gabions to protect the roads from landslides and at other sunny locations vulnerable to erosion. Creeping thyme is reproduced by seeds and rooted cuttings and therefore it is recommended for grassing the earth embankments and endangered slopes. Sage and summer savoury may be applied in several forms, though sage particularly in karts erosion control.

CONCLUSIONS

Regardless of the application method, this review is indicating that positive effects of these species implementation in bioengineering are multiple. An understanding of the effectiveness of vegetation in protecting the soil surface against erosion is not only scientific and environmental interest, but can be of great practical value in land management and agriculture in semi-arid environments (Rodríguez, 2006). They are primarily valuable to the threatened bee population since a trend of bee extinction has been noticed worldwide over the last decade. The scientists are worried because bees have an important role in the production of about one third of the total food man uses daily. It is reported that, over the last four years, bees have been inexplicably leaving the hives and mysteriously dying due to several causes, i.e. a combination of causes such as parasites, viruses, poor nutrition, and especially pesticides. The results were particularly negative during the cold long winter 2009/2010 in the United States, when the studies showed that the hives contained also a high percentage of pesticides. There are no conclusive studies to indicate the specific chemicals, and a special committee formed within the EU has not yet reported its findings. However, it is considered that strong pesticide actions infringed the bee immune system and consequently increased their high vulnerability to viruses.

From the aesthetic aspect, the use of aromatic and medicinal plants for honey production and bioengineering will contribute to a significantly different image of once degraded areas, which would indirectly contribute to a new perception of the landscape. In economic terms, this would make possible the production of low-cost and good quality raw materials for pharmaceutical, cosmetic and food industries. The inappropriate harvest of aromatic plants and the intensity farming systems of mountain areas endanger land conservation, and there is an urgent need to implement appropriate land management which has a large-scale perspective but acts at the local level (Durán Zuazo, 2008). Eventually, the afforestation of streams, abandoned and degraded sites and steep slopes, will ensure indirectly the protection of endangered medicinal and aromatic plant species in nature. Their use in erosion control and land stabilisation is a potential for rural area development in terms of organic farming, beekeeping, and particularly large-scale production of aromatic and medicinal plants since lavender, creeping thyme and sage are considered as the most important medicinal plants widely used in traditional medicine. This would in turn lead to the revival and development of small family farms and abandoned properties, thus contributing to the sustainable use of natural resources.

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http://www.spos.info/main.php

Table. *Bio-ecological and aesthetic characteristics with yields in beekeeping*

Species	Height (m)	Crown width (m)	Root depth (m)	Flower colour	Blooming period (months)	Average annual yield of honey (kg P ha^{-1})
Robinia pseudoacacia L.	35	5-7	~20	white	V - VI	~1000
Lavandula angustifolia L.	0.7	0.7	~3	blue	VII - VIII	~500
Salvia officinalis L.	0.8	0.7	~0.8	blue	V – VII	~600
Thymus serpyllum L.	0.5	0.5	~0.5	white/pink	V – IX	~180
Satureja subspicata L.	0.4	0.5	~0.5	white	VIII - X	~100

THE RESPONSE OF NORWAY SPRUCE, EUROPEAN BEECH AND SILVER FIR ON CLIMATE VARIATION IN WEST CARPATHIANS

Rudolf PETRÁŠ[1], Michal BOŠEĽA[2], Julian MECKO[3], Vladimír ŠEBEŇ[4]

Abstract: *We present up-to-now knowledge about the response of radial growth of spruce, beech and fir trees in homogeneous and species-mixed forests on climate variation in West Carpathians, of which the majority part is within the Slovakia territory. We use the results from different studies that had been conducted recently as well as first results of ongoing project focused especially on mixed forest stands created by species of so called "Carpathian mixture". The first material come from the central part of Slovakia and was acquisited in 2004-2006. The material consists of 455 dominant and co-dominant trees of spruce and beech from 18 homogeneous and even-aged forest stands. Second material has being conducted during the ongoing project. Here, the main attention is paid to the mixed, uneven-aged stands constituted by spruce, fir and beech trees. The inter- and intra-species variation in the response of radial growth on climatic variation is analyzed. The use of standard dendrochronological methods for study of the response of the species on climate variation is analyzed here, and several suggestions are presented.*

Keywords: climate change, dendrochronology, spruce, fir, beech

1. INTRODUCTION

In Slovakia, dendrochronological and dendroecological methods have been used since 80th and 90th years of 20th century, when air pollution and its influence on tree growth and decline had been arising (Priesol 1989, Scheer 1990, Petráš at al. 1993, Ďurský 1994, Ďurský and Šmelko 1994, Ďurský 1995). The 1970s and 1980s in Slovakia were associated with high sulphur emissions. Heavy metals emissions (lead, cadmium) increased in some regions. Average concentrations of tropospheric ozone grew. Acidification and atmospheric pollution caused various environmental problems. The Forest Research Institute in Zvolen initiated a wider program which was aimed at the research on changes in production of tree species damaged by air pollution. The program was started in 1989. The results showed the significant effect of defoliation on tree growth causing loss in all the increments. In a quantitative explanation it means, that the defoliation of 20% caused 16% loss in volume increment, while the defoliation of 80% led to volume increment loss by 95% (Petráš et al. 1993). Dendrochronological research in Slovakia had been followed by studies focused on diameter and height increment of pine trees (Pinus sylvestris) damaged by defoliation (Petráš et al. 2000) and influence of climatic factors on radial increment of spruce trees and stands (Petráš et al. 2007) and influence of climate change

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on Norway spruce growth in Slovak mountain forests (Ďurský et al. 2006). Most recent study using dendrochronological methods was focused on the effect of climatic factors on the dynamics of radial increment of Norway spruce, European beech and sessile oak (Petráš and Mecko, 2011).

2. NOWADAYS DENDROCHRONOLOGICAL RESEARCH IN SLOVAKIA

In 2011, we started the project entitled "The research of the growth and production pattern of mixed spruce-fir-beech forest stands in the West Carpathians" granted by Slovak Research and Development Agency. The aim of the project is to acquire the original knowledge about the whole-life dynamics of the growth of stands consisting of trees in mixed forest of Western Carpathians. The aim will be fulfilled through the partial aims such as the investigation of the influence of growth factors on radial increment of mentioned species in mixed forest, and the investigation of the influence of main growth factors (site, growth space, tree species composition, clime) on dynamics of growth and production of forest stands. The first aim is to obtain experimental material and quantify the influence of environmental factors on radial increment of trees in mixed forest stands. Experimental material will be collected on long-term permanent research plots. Core samples were taken from the all trees inside (except for thinnest) the plot and the position of the trees was fixed as well. Employing up-to-date dendrochronological methods the influence of site, climatic, tree, stand and space parameters on whole-life dynamics of growth of the trees and forest stands will be discovered. The most important factors will be selected and models of diameter growth and increment of trees in mixed forest stands will be derived. The second aim is to repeatedly measure approximately 30 research plots located in mixed forest stands consisting of spruce, fir and beech. The investigation will focus on the influence of site and climatic factors on the dynamics of growth and production of species-mixed forest stands. Finally, the models and causalities of long-time development of growth and production for mixed stands will be derived. Comparison of the results of the project to up-to-know knowledge about growth and production of unmixed forest stands will be performed. The aims are of unique in the investigation of joint and long-term affect of site, climatic and management factors to the radial increment, growth and production of trees in species-mixed stands.

2.1. Experimental Material

Seven permanent research plots with different composition of spruce, fir and beech in different growth regions of Slovakia were selected for the project (Figure 1). The research plots were established in the years 1966-1969 and since then they have been repeatedly measured a few times for the development of the yield tables for main tree species (Halaj et al. 1987, Halaj, Petráš 1998). Particularly, the growth region belonging to the west rim of Slovenske Rudohorie Mountain (adjacent to Poľana mountain massif) and Spiš region located in eastern part of Slovakia were selected. Plots established in Poľana mountain massif are placed on mesotrophic sites (*Abieto-Fagetum inf.*). Bedrock consists of gneiss, granite, granodiorite. Altitude ranges from 750 to 900 meters above sea level. Second group of plots belonging to Spiš region is located in eastern part of Slovenské rudohorie with altitude range of 700 – 925 meters above sea level. Sites are of mesotrophic character (*Abieto-Fagetum inf.*) and bedrock is created of fylits. All of trees growing on the plots were permanently marked and repeatedly measured in the interval of 5-10 years. The stand age at the establishment of the plots ranged from 69 up to 159 years and from 110 to 202 at the last measurement. Site index of silver fir is from 28 to 36 meters, European beech has site index from 20 to 34 meters, and spruce from 26 up to 40 meters. In each plot almost every tree, except for thinnest ones, were bored with Pressler's increment borer from the up-slope side (in 45° angle to up-slope line). In Total, 64 core samples of silver fir, 18 of beech, 94 of spruce, 22 of mountain ash, and 1 of maple were taken and measured for tree-ring-width in our laboratory.

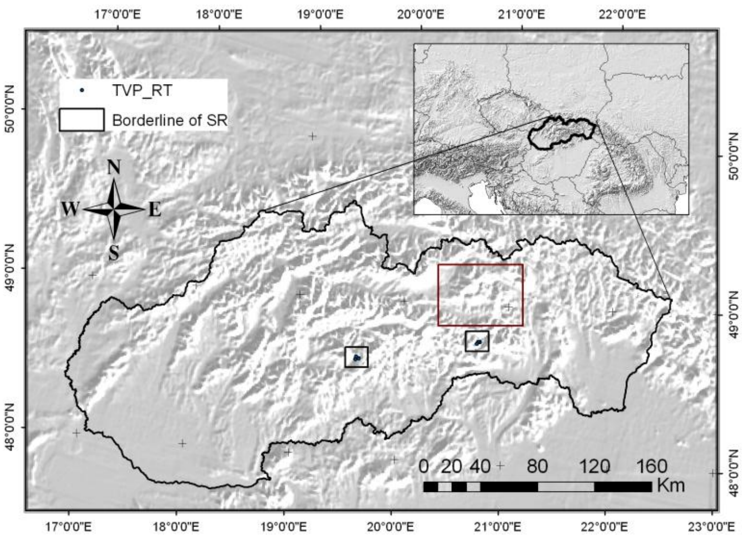

Figure 1. *Location of permanent research plots used for dendrochronological study*

2.2. Cross-dating and detrending of the tree-ring-widths

The core samples were dried and placed into the wooden slats and sounded by vibration sander. The ring widths were measured in the laboratory using the digital positiometer at the precision of 0.01 mm. Next steps were performed in the R environment (R Development Core Team 2011). First of all core samples were cross-dated using the R package called "dplR" (Bunn 2008, 2010). Employing the function "ccf.series.rwl" we can have a look at the correlation between individual tree-ring-widths and master chronology according to the user-defined segments (Figure 2 on the left).

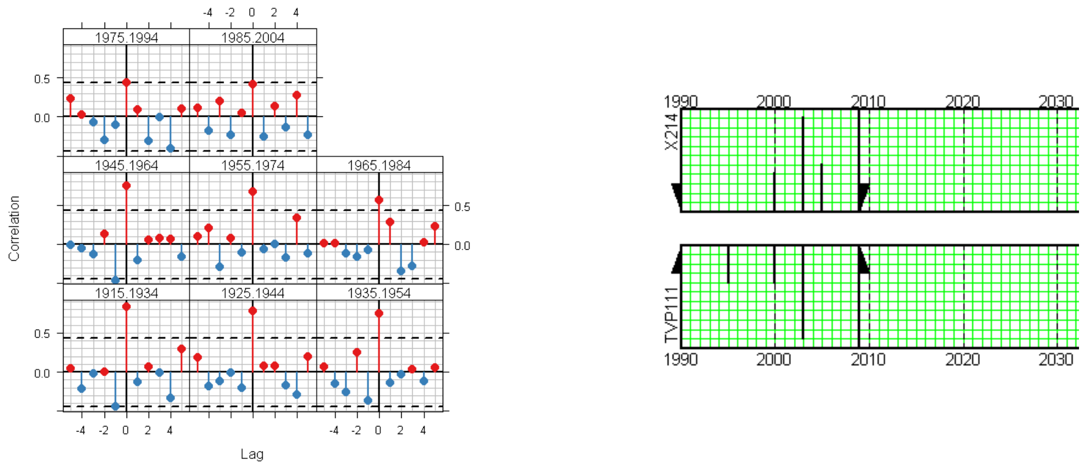

Figure 2. *Left - Plot of correlation between individual RWI and master chronology in user-defined segments; Right - Skeleton plot for comparison pointer years between individual tree-ring-width index and master chronology*

Using the function "skel.plot", it was possible to create a skeleton plot by calculating departures from high frequency growth for each year by comparing that year to the surrounding three years (Figure 2 on the right). These departures are assigned a relative scale of 1-10. A

Hanning filter is used to remove low-frequency variation. For studying the impact of various factors on tree-ring-width the ring-width indices are usually used in dendrochronological research. However, it is somewhat difficult and a kind of iterative work to obtain relevant indices for different aims and studies. Thus, one need to try several functions from the kind of both empirical and stochastic nature. In this sense one can use for instance exponential-based growth functions (e.g. Huggershoff, Negative exponential, etc.), spline (e.g. Cubic spline), or ARMA (autoregressive moving average – mathematical model of the persistence or autocorrelation in a time series). We started by the cubic spline using different setting regarding the number of knots (number of segments, or length of segments for fitting the polynomial function) and smoothing parameter to define a degree of smoothness (Figure 3).

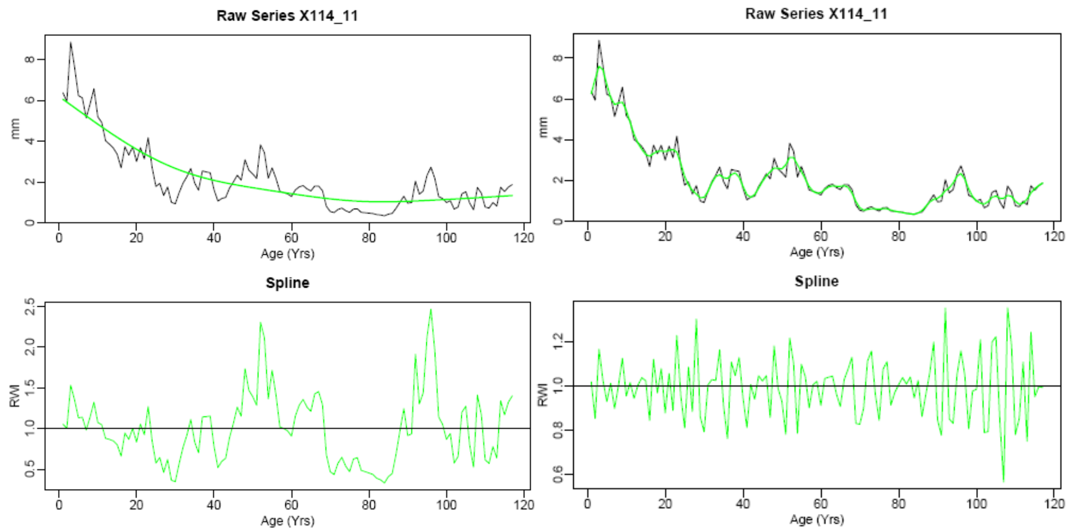

Figure 3. *Cubic spline with different setting: left (segment length = 80 yrs, smoothing parameter = 0.4); right (segment length = 10 yrs, smoothing parameter = 0.9)*

2.3. First results

First analysis of climatic data

First analysis was oriented on climate dynamics over the last few decades. We used climate stations which are closest to the research plots. For precipitation analysis we selected three nearest stations to calculate an average precipitation characteristics, while for temperature only the nearest station located at the very similar altitude was considered, since the temperature highly correlates with the altitude. In the following text we present only the results of temperature analysis for April, since this month is considered as the beginning of the growing season. Time series of temperature were split into segments taking into account the reference climate reported to be up to 1980 (Hlásny 2007). We fitted the linear regression to the segments analyze the increase or decrease in temperature in the localities. One can see (Figure 4 and 5) a significant increase in the average temperature in both localities since 1980, while the minimum temperature increases only slightly without significance (except for June minimum temperature since 1980).

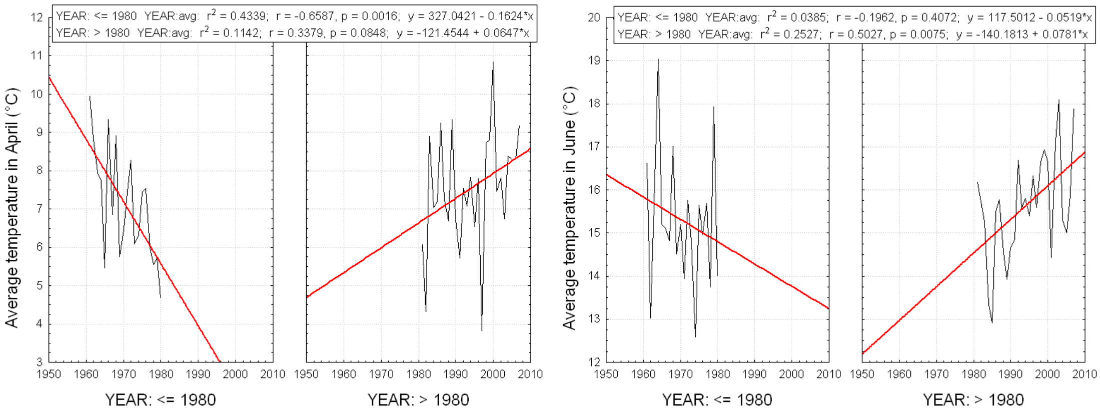

Figure 4. *Average temperature in the locality of Spiš since 1960*

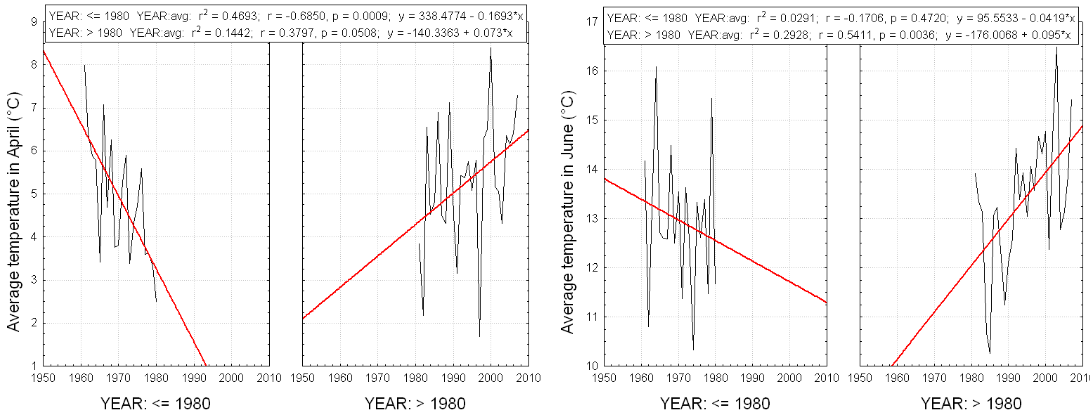

Figure 5. *Average temperature in the locality of Poľana since 1960*

There are many methodological possibilities how to deal with tree-ring-width data in connection to climate dynamic. One can perform analysis at tree, stand, or site level. At tree level each tree is analyzed separately. The tree level seems to be relevant in the case the trees were selected from fully covered forest stand, where other factors might have significant impact on the increment such as competition. At stand or site level, a master chronology is built and then regressed over the climate or other factors. However, in this method, it is very important to build a reliable master chronology using appropriate methods. In our case, we first started with a site level and built a master chronology for silver fir separately for two localities (sites) (Figure 6).

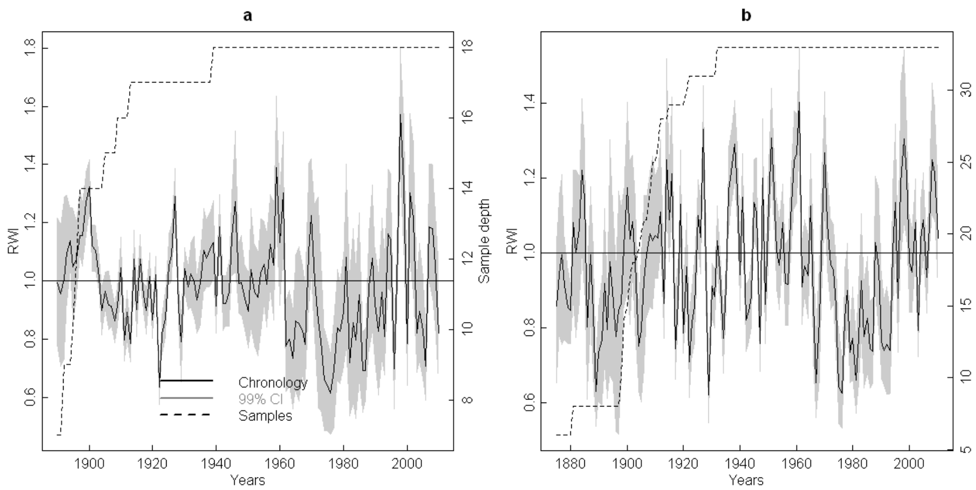

Figure 6. *Mean chronology of silver fir ring-width indices in locality of a) Poľana and b) Spiš*

Next, we used the master chronologies to be regressed over the particular climate variables using the stepwise regression analysis (both directions). As seen from the preliminary results (table 1), the most important months or periods within a year in the locality of Poľana was average temperature in January, February, July as well as the temperature in June and October of previous year. Moreover, the sum of temperature from April to September for previous year was shown to have an impact. In the Spiš locality, the climatic variables with highest impact were little bit similar to the Poľana, but with some differences (the precipitation and temperature of previous year is more frequented).

Table 1. *Result of the multiple stepwise regression, where the dependent variable was mean chronology of silver fir from locality of Poľana*

Effect	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-0.11882	0.411134	-0.289	0.77411
T_jan	0.016623	0.010027	1.658	0.10536
P_jul	0.001027	0.00044	2.334	0.02486
P_jun	0.001468	0.000624	2.354	0.02368
T_feb	0.022106	0.009721	2.274	0.02855
T_jul	0.048066	0.017277	2.782	0.00828
P_dec_prev	-0.0018	0.000636	-2.837	0.00719
T_jun_prev	0.067627	0.021286	3.177	0.00291
T_sumAPR_SEP_prev	-0.0133	0.005516	-2.411	0.0207
T_okt_prev	0.034177	0.015966	2.141	0.03862

Residual standard error: 0.1507 on 39 degrees of freedom
Multiple R-squared: 0.573, Adjusted R-squared: 0.4745
F-statistic: 5.815 on 9 and 39 DF, p-value: 4.14e-05

Note: T – temperatute; P – precipitation; P_dec_prev – precipitation sum during december of last year

Table 2 *Result of the multiple stepwise regression, where the dependent variable was mean chronology of silver fir from locality of Spiš*

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-0.41869	0.285848	-1.465	0.151443
P_jul	0.001016	0.000396	2.565	0.014524
T_mar_prev	-0.01837	0.008607	-2.134	0.039509
P_jul_prev	0.000565	0.000417	1.354	0.183941
T_jan	0.025804	0.007111	3.629	0.000855
P_okt_prev	-0.00089	0.000315	-2.838	0.007318
P_jun	0.000787	0.000433	1.82	0.076933
T_dec_prev	-0.02247	0.009595	-2.341	0.024713
T_apr	0.026299	0.012743	2.064	0.046101
T_jun_prev	0.040647	0.01335	3.045	0.004275
P_aug	0.00082	0.000441	1.86	0.070833
T_jul	0.020347	0.012464	1.632	0.111066

Residual standard error: 0.1078 on 37 degrees of freedom
Multiple R-squared: 0.7158, Adjusted R-squared: 0.6313
F-statistic: 8.471 on 11 and 37 DF, p-value: 3.395e-07

Note: the same as in the table 1

These results are only preliminary ones and we intend to analyze it deeper with inclusion of competition as one of the explaining factors. Since all the plots have been repeatedly measured since 1950s and 1960s, it would be possible to use some more time series analysis employing competition indices as well. We expect to build a growth model that would reflect the majority of growth-influencing factors. We also intend to answer the question on what is impact of climate change on tree or stand growth of silver fir, Norway spruce, and European beech in different mixtures.

3. CONCLUSION

Species-mixed uneven-aged forest stands have been increasing during the last decades due to the policy that have governed the management in the forests leading to its sustainability. In the West Carpathians, such forest stands will probably dominate in the near future, thus forcing the forest management to improve its knowledge by broadening to mentioned forest stands. Within this project we expect to bring novel information on how trees in mixed forests response to major environmental factors.

Acknowledgements

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EFFECTS OF CLIMATE CHANGE ON THE TURKISH FORESTS

Ahmet Alper BABALIK[1]*, Oguzhan SARIKAYA[2]

Abstract: *Climate chancing by this way risk of drought and desertification danger is the most global problem in present. Also, Turkey is situated in the most risky countries related to this problem with its geographical location, climate, topography and soil characteristics. Approximately, 51 million hectares areas have (65 % of total area in Turkey) arid and semi arid features. 54 % of forest stands, 59 % of agricultural areas and 64 % of pastures are exposed medium strong and strong erosion problem. A total of 21.189.000 million hectares are forests and this come across 27,7 % of total terrestrial area of country. A half of these grounds are unproductive. It is expected that negative effects of climate changing will increase on forests and forest products in the big part of earth. Reflects of forests ecosystems against to this changing are differed between systems. Managing forests like plantation forests are face to face with human activities as breeding, thinning and other applications. This kind of managing activities can reduce the effects of changing on climate.*

Flora composition varies belonging to altitude differences, existing of different climate types. Approximately 12000 plant taxa are growing up in Europe and 9000 of them are present in Turkey. Also, 3000 taxa are endemic plant. These endemic species can be damaged by exposing to negative effects of climate changing. Also, biological diversity, fresh water resources and wild life habitats will be affected by this problem. In addition to this, by global warming, damages of pest insects and other forest pests will be increased and unexpected problems can be occurred in controlling of them. Mediterranean Basin of Turkey is under risk for forest fires. Also, increasing of burned areas by forest fires will be inevitable by global climate chancing. Approximately 7,5 million forest villagers who live in rural areas will be directly effected by changing in forest ecosystems of Turkey.

The most significant way of preventing or delaying to global warming is increasing to amount of absorbed CO_2 from atmosphere. Forests are considered as the most effective tool owing to consume much more CO_2 than other ecosystems and keep attributed carbon very long period.

Key words: Global warming, Climate change, forest ecosystems, the Turkish forests

INTRODUCTION

Climate is the overall average values of atmospheric event occurring over a long period in a particular geographic region. However, climate consist not only conditions close to average, but also extreme values and statistical variations. In general approach, climate change is defined as changes in climatic conditions has that large scale and important local effects and are long term and slow growing changes (Turkes, 2002).

Global climate change is defined as all the changes in climate by human activities that effect nature structure of atmosphere during comparable time period (Anonymous, 2010). Greenhouse gases cumulate and effect chemical properties of atmosphere as results of fossil fuel burning, changes in land use, forest damages since 1850's when industrialization started. This also causes climate change in global scale owing to greenhouse effect in long time period. CO_2

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exhausting is the most important subject about damages of human activities on climate. Greenhouse gases which cause global warming are arising from use of fossil fuels, industry, transportation, changes in land use, waste management and agricultural activities (Turkes, 2003). These also cause increasing greenhouse gases in atmosphere and by this rapid increase changes occur in surface temperature and precipitation.

Forests provide livable environment for more than half of species that live on continents. Therefore, forests stock great amount of carbon in vegetation and soil. By this way, carbon balance is regulated and global warming reduces. Forests supply water for agricultural and industrial production by local and regional precipitation. Therefore, forests are vital resources for billions of human for food, medicine, and fresh water, recreational and aesthetic benefits.

Carbon storage has a global importance. Plants and soil in forests keep CO_2 by photosynthesis and release by respiratory. By this way, they can manage and arrange global carbon balance (Anonymous, 2012a). Three sides of Turkey are surrounded by sea also it has rough topography and orographic characteristics. Therefore, different regions would be effected different way and scale.

In this study, global warming and climate change are emphasized. Also, situation of forests in Turkey and World will be referred and effects of climate change on forests and importance of forests for control of climate change.

GLOBAL WARMING AND CLIMATE CHANGE

Global warming expresses, increase of global average surface temperature depending on greenhouse gas emission increase. Greenhouse gases which cause global warming are basically arising from fossil fuel usage, industry, transportation, land use changes, waste management and agricultural activities.

The most important reason of global warming is rapidly increasing of gases like CO_2, CH_4 and NO_2 that cause greenhouse effect. According to global calculations, global carbon balance cannot be provided because of exhausting of greenhouse gases. In addition to carbon cycle, 1.6 MMt (million meter ton) by deforestation and 6.3 MMt fossil fuel usage totally 7.9 MMt carbon (C) is exhausted to atmosphere (IPCC, 2007).

Two main components of global carbon cycle continental ecosystems and oceans keep 4.6 MMtC of total carbon. It can be seen easily that 3.3 MMtC is exist in atmosphere by human activities. The focal point of preventing to global changing is removing remain 3.3 MMtC (Anonymous, 2005).

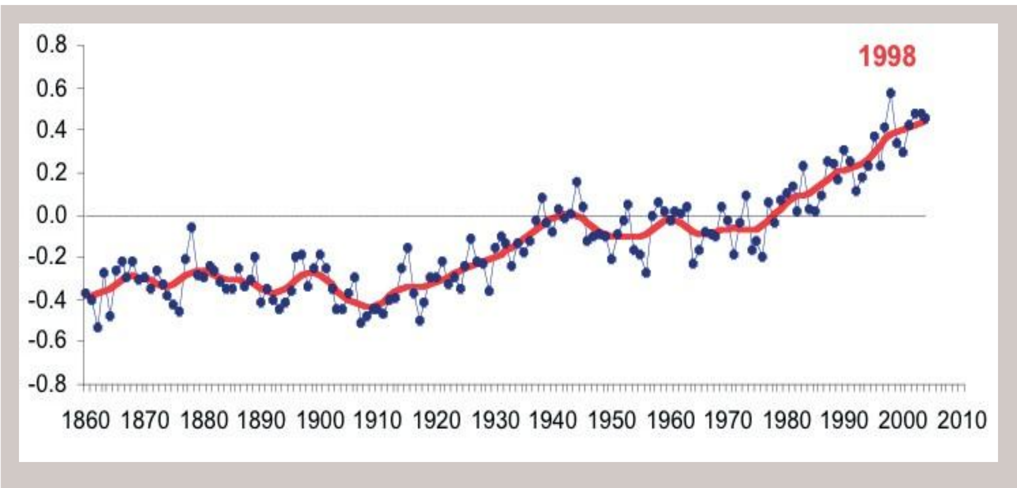

Figure 1. *Variations of anomalies on global annual average surface temperature in 1860-2004 periods (Baycelebi, 2011)*

Belonging to increasing in global temperatures; drought, desertification, melting of continent and sea glaciers can cause serious changes which can affect social-economical sectors, ecological systems and human life like changing of climate belts, epidemic diseases and pest outbreaks.

According to IPCC (International Climate Changing Panel) 2007 Report, global warming is exactly real and the most reason of this is human. Earth weather warmed 0.74 ^{o}C in recent 100 year, also it is expected that it will increase 0.2 ^{o}C in next decade. The average of global temperature rise of 3 ^{o}C in this century. According to IPCC report, the Mediterranean Basin will be in among the most effected regions.

As a Mediterranean country, Turkey will be under impacts of global warming like weakening of the water resources, forest fires, erosion, and changes in agricultural productivity, drought and ecological damages, deaths belonging heat wave. Therefore, Turkey is among the risky countries in point of potential impacts of global warming (Baycelebi, 2011).

GENERAL EFFECTS OF CLIMATE CHANGE

Temperature increases may cause a global scale effects on ecosystems and human life. Ecosystems have big importance for sustainability of human life and continuity of natural life cycle. The relationship between economic processes of natural ecosystems like agriculture, forestry and fishery are vital for human.

Minimal increases in global average temperature can cause climate changing in regional climate. This changes effect capacities of plant breeding and self-renewal. There are a lot of numbers about global warming increasing. In different references, 3-5 ^{o}C increases is expected. Slipping will occur by 1-3.5 ^{o}C increasing in global average temperatures. Warming on mountainous areas effect ecosystems in these areas also changing conditions in precipitation will effect hydrological cycle.

Likewise, ice melting, changes in snow border and on semi-frozen soils can effect hydrological process, other ecosystems and human systems. Also, plant life which is directly belonging with water will be affected. It is expected increases in natural disaster such as flood. Sea level will get higher belonging to global warming and ice melting cause losses in coastal areas which are used as agriculture and tourism today.

Physical and biological changes such as increase in salinity in estuaries, changes in tidal regularity, delta formation process will inevitable. These structural changes will cause degradation changes in coastal ecosystems where are under threaten high population and environmental pollution.

Climate changes will affect human healthy belonging to damages on natural ecosystem and human systems. These effects can cause negative impacts like death and also increases in epidemic diseases can be occur. Besides these impacts, physiological trauma can occur by natural disasters like tropical tornados, floods.

As a subtropical country Turkey will be affected much more. These negative effects can be observed as storms, floods, heat and cold weather waves and extreme weather conditions. Effects of climate changes belonging to global warming will be observed in regional scale. Regional conditions are very important. Especially, geographical factors like altitude; aspect etc. will determine intensity and spreads.

Accordingly, as a result of climate changes, effects and densities of natural disasters will increase belonging to tropical cyclones and bad weather conditions in some part of World in coming years while in other regions there may be an effective long-term droughts and desertification process.

Turkey is also affected by the alteration due to the general atmospheric circulation, as well as ecologically sensitive, such as Mediterranean climate with a character in the process of climate change under the influence of climatic conditions, is expected to be affected negatively.

The results of precipitation and temperature trend show that rainfall decrease in Aegean and Mediterranean costs of Turkey, contrary to expectations any changes have not observed in Central Anatolia. This result arises from instability of annual total precipitation and false land and water usage. It is observed that temperatures are increasing in winter in Eastern Anatolia and in summer in western regions. Among effects which are caused by global warming, drought risks, degradation ecosystem changes and problems in human activities will take effect to most of parts in Turkey.

Effects on ecosystems also are estimated on sectorial scale. Tourism and agriculture are most risky sectors. Besides these, a lot of business sectors like industry and transport will be affected. The effects of climate changes concerning Turkey, can change human life and economic structure. Environment problems should be controlled and approaches about adaptation to future climate process should put forwarded (TURCEK, 2012).

EFFECTS OF CLIMATE CHANGE ON FORESTS

The negative impacts of climate change on forests in many parts of the earth are expected to increase even more. Paleoclimate and paleobotany studies cited that forests adapted to temperature increasing in 2-3°C level.

The most important potential climate change impacts on forests and forestry sector can be summarized as follows:

1. It is expected that tree species will move to the North and mountainous areas as response to temperature increasing.
2. Higher temperatures will lead to more frequent and severe forest fires
3. Forest productivity will change.
4. According to several scientific studies estimated that CO_2 fertilization can forced forest growing. By this way, forest areas range and productivity can be rise. If this fertilization doesn't occur, forest growing will be weakened (Anonymous, 2007).

It is estimated that world forests storage 289 gigaton (Gt) in own biomass. Forest management, plantation and improvement keep and rise carbon storage. Whereas deforestation, damages in forests and inadequate forest management reduce carbon storage. Carbon storage in forest biomass all around the world reduced as 0.5 Gt between 2005-2010 periods (Anonymous, 2012c).

The effects of climate change on forests are classified in different references. Steven et al. (2001), cited these effects in four main title; forest production, biodiversity change, damages such as fire, insects and social-economical changes.

Mediterranean ecosystems are among the ecosystems which are expected to negative affected from global climate change (Sala et. al, 2000). The main changes are increasing in deforestation (Talkkari and Hypen, 1996; Iverson et al.., 1999; Iverson and Prasad, 2002). Important social-economical changes are expected relating to deforestation and the other effects of climate changes.

The effects of climate changes are summarized as in following;

- Flora composition varies belonging to altitude differences, existing of different climate types. Approximately 12000 plant taxa are growing up in Europe and 9000 of them are present in Turkey. Also, 3000 taxa are endemic plant. These endemic species can be damaged by exposing to negative effects of climate changing. Also, biological diversity, fresh water resources and wild life habitats will be affected by this problem.

- Turkey is face to face with desertification risk by relating climate, topography, geology, hydrology, vegetation, rangelands and forest stand characters. Moderate, severe and very severe erosion are seen in approximately 80 % of land in Turkey. Climate change will cause changes on ecosystem structure and function of evaluation reports provided by the IPCC. Turkey, both linked to the Mediterranean climate zone climate characteristics, but also because of the high and rugged landforms, is very sensitive to deforestation.
- The effects of insects and other pests will increase and some problems will exist about controlling of these pests. Besides that, forest stands become weaken by abiotic effects like storm, snow, avalanche etc. these negative factors can effect biological diversity, gen reserves and carbon keep capacities.
- 12 million hectares forest areas which consist 60% of total forest stands are exist in the Mediterranean basin where forests are very sensitive for forest fires. Densities, period and range of forest fires can expand belonging to length of warm and drought period. Therefore, management of forest fires will become more important in the Mediterranean and Aegean regions of Turkey.
- Turkish forests are affected by social-economical pressures because of approximately 7.5 million forest villagers. Forest villagers, who gain their livelihood from forestry activities, are thrilled negatively and this situation increase social pressure (Baycelebi, 2011).

THE IMPORTANCE OF FORESTS ON CLIMATE CHANGE

The world's total forest area is approximately 4 billion ha, and 31% of the total land area is covered by forests. Mean of 0.6 ha per hectares forest area are in the World. The richest five countries (Russia, Brazil, Canada, USA and China) for forests have half the total forest area. 10 countries on the World have not any forest area and in addition to this, forest areas of 54 countries are less than 10% of total areas.

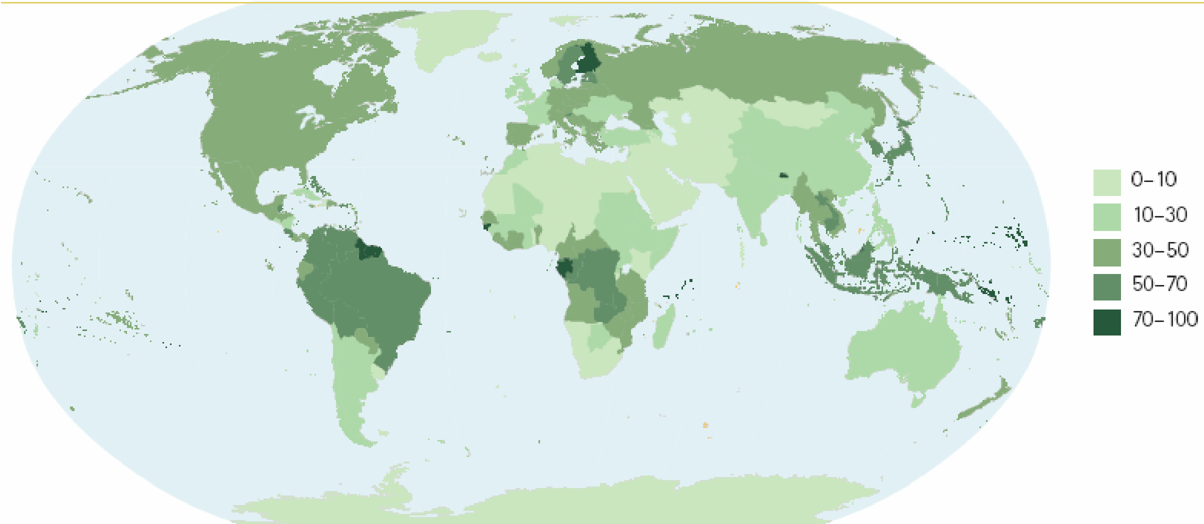

Figure 2. *Rates of forest areas in total areas of countries (Baycelebi, 2011)*

Each year, approximately 13 million hectares of forest land is being damaged. According to FRA 2010 Report, first five country which showed a decrease in forest areas are Brazil, Australia, Indonesia, Republic of Democratic Congo and Bolivia between 2005 and 2010 (Baycelebi, 2011).

Forests play key role owing to remove CO_2 from atmosphere and storing carbon to stems, leaves, shoots, roots of plant. Except of sedimentary rocks, 67 % of carbon is storing in forest ecosystems. 75 % of carbon keep by vegetation are storage in forests (Anonymous, 2012b).

Emissions which occur by damages approximately 13 million hectares forest stands constitute of 17% total emissions by human sources. In this case, controlling of climate change is impossible, in this case forests are protected well and rehabilitated.

The first inventory results related forest resources in Turkey obtained in 1972. Second is could renewed in 2004. According to inventory results of 1972, 21.188.746 hectares (ha) areas were forests. It was determined as 21.188.746 ha in 2004. Latest results which obtained in 2009 showed that totally 21.5 million ha areas are forests and this value constitute 27.6 % of total areas in Turkey (Baycelebi, 2011).

Forest ecosystem keeps carbon by increasing of living biomass and participation of fallen leaves to soil carbon reservoir. Large portion of carbon goes to developing biomass when trees are planted. By this way, during the first 30–40 years of development of the tree are large amounts of carbon. The vast majority of carbon sequestration takes place within the first 60-100 years

A well developed, 100-year-old beech tree can absorb 40 million m^3 airs and also it can bind 6 tones carbon from 1200 m^3 carbon dioxide.

In addition to being a collection tress, forest is an environmental system and unity of life by soil, millions of plants, animal and microorganisms and their relationships together. The duty of people in the world to protect the vegetation on the forest, plant trees, reduce to human pressure on forests and reform to damaged stands (Anonymous, 2012b).

CONCLUSION

Forests play key role on reducing and controlling effects of climate changes. They are very important resources which keep carbon on earth and greenhouse gases in atmosphere (Magnani et al., 2007).

Forest ecosystems bind about three billion tons of carbon which emitted as a result anthropogenic effects every year. This also constitutes 30% of CO_2 from fossil fuels (Canadel et al., 2007; Canadel and Raupach, 2008).

The world forests, covering four billion hectares, tie up carbon to biomass twice as much carbon as in atmosphere (Sabine et al., 2004; FAO, 2006).

In order to reduce carbon emissions through forestry activities, it is possible to bring the four main proposals.

1. Afforestation works for the expansion of forest areas
2. Increase the amount of carbon binding of forests in forest and landscape scale
3. Preventing CO_2 emitting arising from destroying and damaging forests
4. Expanding and promoting the scope of use of forest products for preventing CO_2 emitting arising from fossil fuel usage (Canadell and Rapuach, 2008).

Forests play an important role in regulating the climate in the world. But, forests are not strong enough to absorb CO_2 owing to changes in gas concentration in atmosphere and climatic deterioration. Therefore, the protection of forests in combating climate change and the establishment of new forests, as well as adaptation measures need to be improved in many other subjects.

As a result, the most significant way to preventing or at least delaying of global warming, is increasing the amount of CO_2 absorbed from the atmosphere. Forests are considered as the most effective tool owing to consume much more CO_2 than other ecosystems and keep attributed carbon very long period.

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SECTION IV

FOREST GENETICS, NURSERY PRODUCTION AND PLANT BREEDING

CHAIRMEN – MODERATORS:

Roman Longauer

Vera Lavadinović

International Scientific Conference
FORESTS IN THE FUTURE – SUSTAINABLE USE, RISKS AND CHALLENGES
4-5 October 2012, Institute of Forestry, Belgrade, Republic of Serbia

USE OF INNOVATIVE PRACTICES AND NEW TECHNOLOGY IN THE PRODUCTION OF WIDE VARIETY AND HIGH QUALITY FORESTRY SEEDLINGS IN ORDER TO ENHANCE REGENERATION SUCCESS AND INCREASE BIODIVERSITY

K. RADOGLOU[1,2]

Abstract: *A high priority for Greek Forest nurseries is cost-effective regeneration efforts in order to enhance forest biodiversity and sustainability. Nonetheless, overcoming transplanting stress in Mediterranean forest ecosystems is a great challenge. Adverse growth conditions in semi-arid environments, such as intense droughts, substantially decrease regeneration success. Nurseries aim to produce the best seedlings that have the potential to overcome transplanting stress and successfully grow on a site. The main aim of this project is the introduction of new technology based on pre-cultivation protocols in mini-plugs in order to serve large-scale production of forest regeneration material for a wide range of species. Specifically, 26 species will be studied and initially their germination and growth protocols will be determined. This will help understand the physiology of each species, and consequently increase seedling quality and quantity through the integration of this new technology. Both morphological (e.g. seedlings height) and physiological (e.g. root to shoot ratio) variables will help determine the best growth conditions (e.g.. use of a specific soil substrate) for each species in order to achieve the best seedling quality. This combined with the increased seeding production that mini-plus can achieve should help maximize both the quantity and the quality of the seedlings. Furthermore, these seedlings will be studied under field conditions at three highly disturbed sites that had been burned in the past. The use of this new technology will allow a large scale production of seedlings that until now was unreachable through the use of the conventional techniques. The new technology, in conjunction with increased number of different forestry species will result to increased biodiversity levels that lead to more sustainable ecosystems.*

Keywords: Ecosystem sustainability, regeneration, forest nurseries, containerized seedling, mini plugs

STRUCTURE OF THE "VERENIKE" PROJECT

"Verenike" is a "LIFE" project financially supported by the European Communion (EC). The total budget reaches the 1.324.725 €, with eligible project budget of 1.306.725 E, out of which the EC financial contribution is 653.362 € (50% of total eligible budget). The duration of project is 40 months; it started in September 2010 and will end in December 2013. The policy area of the project is "LIFE+ Biodiversity" that is "Demonstration and/or innovative project contribution to the objective of the Commission Communication COM (2006) 216 final: "*Halting the loss of Biodiversity by 2010-and beyond*".

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The beneficiaries that are associated with the project as well as the involved personnel have been very carefully selected in order to be able to fulfil the objectives of the project and successfully complete the related actions. Specifically, the coordinating beneficiary is the Greek organization of the "Hellenic Agricultural Organization DEMETER/Forest Research Institute (DEMETER/FRI)", with coordinator Prof. K. Radoglou and with main involved researchers Mr. George Chalivopoulos, Dr. Gavril Spyroglou and Dr. Valasia Iakovoglou. In addition, the other two Greek beneficiaries are the "Decentralized Administration of Macedonia & Trace-Directorate for Reforestation in Central Macedonia (DAMT-DRCM), and the "Decentralized Administration of Macedonia & Trace-Directorate for Coordination and Supervision of Forests (DAMT-DCSFA) with main involved personnel Mrs Georgia Viglaki, Mr Fotis Kiourtsis, Mrs Olga Maslarinou and Mr Stavros Karaisaridis. The Italian beneficiary is represented by the private Italian nursery of Vivai Torsanlorenzo (VT) and the involved personnel are Mrs Elisabetta Margheriti and Mrs Silvia Giannissi

SCOPE AND OBJECTIVES

A high priority of the Greek Forest nurseries is a cost-effective regeneration effort in order to enhance regeneration success, forest biodiversity and sustainability. Nonetheless, overcoming transplanting stress in Mediterranean forest ecosystems is a great challenge (Fancher et al., 1989; Mendoza et al., 2009). Adverse growth conditions in semi-arid environments, such as intense drought conditions, substantially decrease regeneration success. Nurseries aim to produce the best seedlings that have the potential to overcome transplanting stress and successfully grow at a site.

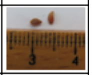
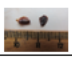
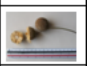
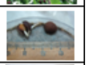
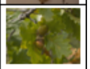
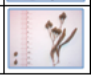
The project entitled "Use of innovative practices and new technology in the production of wide variety and high quality forestry seedlings in order to enhance regeneration success and increase biodiversity" addresses those problems and is aiming in fining possible solutions. Further, the main objective is the enhancement the biodiversity through the introduction of "new technology". This new technology is initially aiming in the creation of a "prototype" unit that would serve for the easy and fast production of vast amounts of regenerating material (Photo 1).

Specifically, this prototype has automated controlled photoperiods, temperatures and watering system that can be altered as needed by the user. In addition, it has sixteen rows for the placement of containers, with each row retaining seven "mini-plug" type of containers (Photo 1). Further, the use of mini-plugs enables the large-scale production of high quality and quantity seedlings under the most cost-efficient way for a wide range of species (Photo 1). The use of the prototype in conjunction with the high number of cells within each mini-plug allows the production of tremendous number of seedlings (Landis, 2007). That, along with the ability to grow seedlings during winter time and the low shipping cost, makes it one of the most promising ways in the production of seedling for a wide number of species. Further, the biodiversity level is enhanced by the "Verenike" project by having to examine and regenerate "fire-disturbed areas" with 26 highly valuable species that occur at the northern parts of Greece. Detailed eco-physiological information for each studied species is provided by Table 1.

Photo 1. *The prototype unit, the three mini-plug sizes (3-, 9-, and 18 cm^3) and the two soil substrates (enriched peat and stabilized medium).*

Nonetheless, additional objectives were also aimed by this project. Specifically, seed germination protocols are also aimed to be developed for all 26 species. This type of information should provide a higher percent of germinated seeds despite the fact that some of the studied species might experience intense seed dormancy levels. In addition, when regenerating seed-derived seedlings the genetic superiority of the regenerated material is sufficiently greater to others (such as cuttings). That, along with the increased number of regenerated species, sufficiently favours the sustainability of the ecosystems. So far, some of the results of the "Verenike" project have been presented at International conferences (Iakovoglou and Radoglou, 2012a; Iakovoglou and Radoglou, 2012b; Radoglou and Iakovoglou, 2012) and reported by the project's reports.

Table 1. *Eco-physiological information for each of the 26 studied forest species.*

N	Scientific name	Common English name	Family	*(E) or (D)	*(T) or (S)	*(De) or (Me)	Type of flower	Flowering	Hardy Zone	Pollinated by	Seed collection	Photo
1	***Acer pseudoplatanus* L.**	Sycamore	Aceraceae	D	T	Me	Male or Female	April to June	5	Bees	September to October	
2	***Arbutus andrachne* L.**	Grecian Strawberry Tree	Ericaceae	E	T	Me	Hermaphrodite	March to April	8	Bees, self-fertile	September to October	
3	***Arbutus unedo* L.**	Strawberry Tree	Ericaceae	E	T	Me	Hermaphrodite	October to December	7	Bees, self-fertile	October to December	
4	***Buxus sempervirens* L.**	Box	Buxaceae	E	S	Me	Male or Female	April to May	5	Bees, flies	September	
5	***Celtis australis* L.**	Nettle Tree	Ulmaceae	D	T	Me	Hermaphrodite	April	6	Bees	October to November	
6	***Cercis siliquastrum* L.**	Judas Tree	Leguminosae	D	T	Me	Hermaphrodite	May	6	Bees	September to October	
7	***Cornus mas* L.**	Cornelian Cherry	Cornaceae	D	S	Me	Hermaphrodite	February to March	5	Bees	September to October	
8	***Cornus sanguinea* L.**	Dogwood	Cornaceae	D	S	Me	Hermaphrodite	June to July	5	Insects	June to July	
9	***Cupressus sempervirens***	Italian Cypress	Cupressaceae	E	T	Me	Male or Female	January to February	7	Wind	Early spring	
10	***Erica arborea* L.**	Tree heath	Ericaceae	E	S	Me	Hermaphrodite	May		Insects, self-fertile	Middle May	
11	***Fraxinus ornus* L.**	Manna Ash	Oleaceae	D	T	De	Male or female	May	6	Wind	September to October	
12	***Myrtus communis* L.**	Myrtle	Myrtaceae	E	S	Me	Hermaphrodite	July to August	8	Bees, self-fertile.	October	
13	***Phillyrea latifolia* L.**	Phillyrea	Oleaceae	E	T	Me	Hermaphrodite	April to May	7		September to October	
14	***Pinus brutia* Ten.**	Calabrian pine	Pinaceae	E	T	Me	Monoecious	April to May			April to May	
15	***Pinus halepensis* Mill.**	Aleppo Pine	Pinaceae	E	T	Me	Monoecious	April to May	8	Wind. Not self-fertile.	April to September	
16	***Pinus nigra* J.F.Arnold.**	Austrian Pine	Pinaceae	E	T	Me	Monoecious	May to June	6	Wind. Not self-fertile.	3d year in April of	
17	***Pinus pinea* L.**	Italian Stone Pine	Pinaceae	E	T	Me	Monoecious	May to June	8	Wind. Not self-fertile.	Novembe r to February	
18	***Platanus orientalis* L.**	Oriental Plane	Platanaceae	D	T	Me	Monoecious	May	7		October to February	
19	***Prunus avium* L.**	Wild Cherry	Rosaceae	D	T	Me	Hermaphrodite	Apr to May	3	Bees. Not self-fertile.	July to August	
20	***Prunus spinosa* L.**	Sloe	Rosaceae	D	S	Me	Hermaphrodite	Mar to April	4	Insects	October	
21	***Pyrus pyraster* Burgsd.**	Pear	Rosaceae	D	T	Me	Hermaphrodite		6	Insects	September	
22	***Quercus frainetto* Ten.**	Hungarian Oak	Fagaceae	D	T	Me	Monoecious	May	6	Wind	Fall	
23	***Quercus ilex* L.**	Holly Oak	Fagaceae	E	T	Me	Monoecious	May to June	7	Wind	September to October	
24	***Quercus pubescens* Willd**	Downy Oak	Fagaceae	D	T	Me	Monoecious	May	5	Wind	Fall	
25	***Rosa canina* L.**	Dog Rose	Rosaceae	D	S	Me	Hermaphrodite	June to July	3	Insects. Self-fertile.	October to December	
26	***Tilia tomentosa* Moench.**	Silver Lime	Tiliaceae	D	T	Me	Hermaphrodite	July to August	6	Insects	Fall	

* Evergreen (E)/Decidious(D), Tree (T)/ Shrub (S), Diecious (De)/Monecious (Me)

Depending on the species different methods have been used. More specifically, some of the species required only a few months of cold stratification (e.g. *Arbutus unedo* L.), others indicated positive impact of alternating stratification of warm and cold temperatures (e.g. *Prunus avium* L.), while others required combination of chemical treatments as well as altering stratification (e.g. *Rosa canina* L.).

Another objective is the development of cultivation protocols of those species in association with the innovative technology use of both the prototype and the mini-plugs. The evaluation of seeding quality, based on the soil substrate as well as the size of the mini-plugs that reflects the volumetric availability for root growth, could benefit the production of high quality seedlings. Researchers have indicated that those factors could substantially affect the characteristics of the produced seedlings that would help the regeneration success (Pinto et al., 2011; Radoglou et al., 2009). They have also suggested that seedlings with more vigorous root systems were able to overcome transplanting stress at regenerated sites (Crossnickle, 2005; Villar-Salvador et al., 2008). So far, those effects have also been shown for a number of species by the "Verenike" project (Iakovoglou et al., 2011; Iakovoglou and Radoglou, 2012c). The studied variables that were both morphological (e.g. seedlings height) and physiological (e.g. root to shoot ratio), should help determine the best growth conditions (e.g. use of a specific soil substrate) for each species in order to achieve the best seedling quality. So far, the main conclusion is that both soil substrate and mini-plug size should be studied for each species if the best desired characteristics are aimed based on the main objective of the producer.

An additional objective also includes the evaluation of the seedling quality after being regenerated on the sites. Past research has indicated for *Robinia pseudoacacia* L. that mini-plugs with soil substrate of stabilize medium had greater survival when compared to standard containers that the Greek nurseries use (Dini-Papanastasi et al., 2012). So, the evaluation of seeding quality based on the soil substrate as well as the size of the mini-plugs, could benefit the production towards better quality seedlings with specific desired characteristics (e.g. greater roots).

Another objective is the introduction of this production system to the public Greek forest nurseries. The Greek nurseries will be frontiers (pioneers) at the seedling production through the use of those new innovative technologies by the combined use of the "prototype" and "mini-plugs". Consequently, this knowledge will be transferred initially to the staff of the Greek nurseries that until now was unreachable through the use of the conventional techniques. In addition it will increase the amount of the produced seedling, even under the "no-production" periods, like winter time. That will allow early-spring seedling transplant and further seedling growth that will allow immediate regeneration efforts right after sever disturbance events such as fires.

THE REGENERATED SITES

Fires events are very common in Greece (Lloret et al., 2002; Thanos, 2000). So, all three regenerated sites have been highly disturbed in the past by sever fire events. They are all located at the northern part of Greece, with each reaching five hectares. The first area is a recreational forest in close proximity to the city of Thessaloniki. The other two areas are both forests located at the Assiros and Kassandra areas (Figure 1). For those sites when regenerating, it is aimed not to interfere at areas where natural regeneration has occurred.

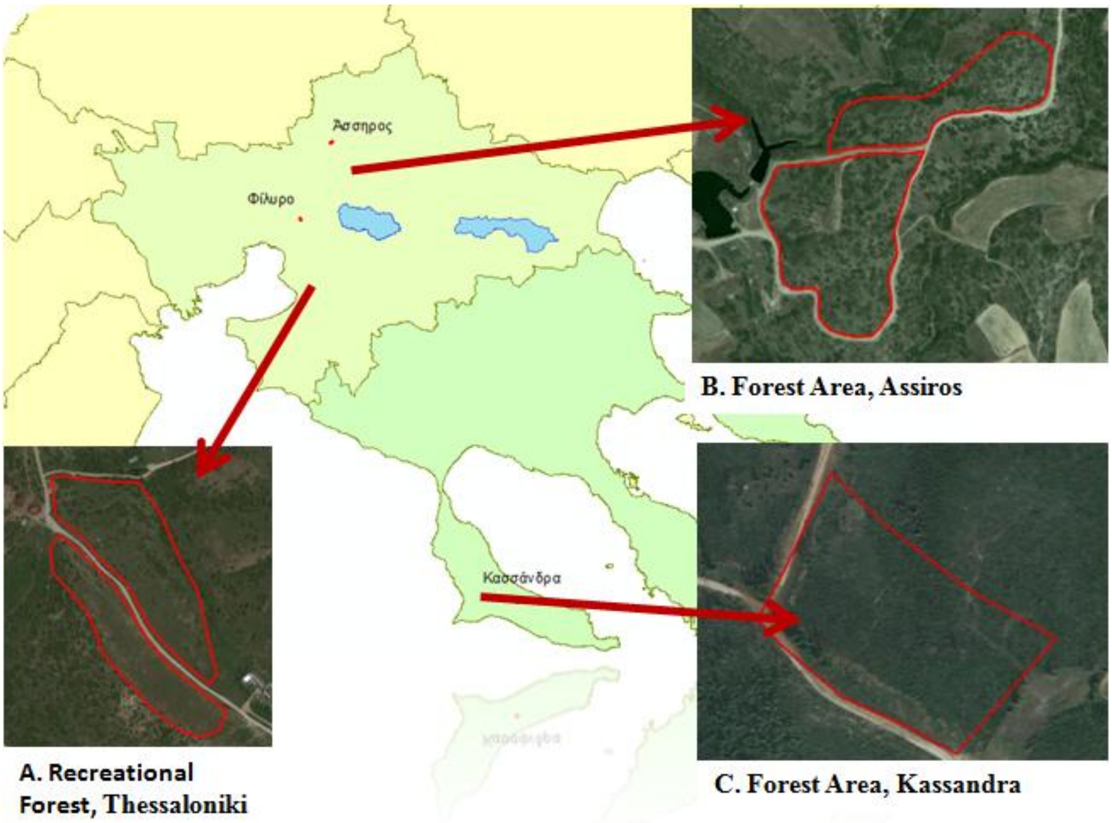


Figure 1. *The regenerated study areas of the "Verenike" project; A) Recreational forest of Thessaloniki (A), forested area of Assiros (B) and Kassandra (C).*

CONCLUSIONS

The project aims to increase biodiversity of burned forest areas and of reforested areas in general by increasing the number of planting species. Furthermore, it aims to develop germination and cultivation protocols for valuable forest species and introduce a new technology for the production of forest regeneration material. The introduction of a new seedling production technology and the establishment of the prototype unit produced in the facilities of the associated beneficiary of forest service nursery will be one of the major steps for the large-scale production. Hopefully this technology will produce wide range of species in order to facilitate restoration of forest ecosystems and increase biodiversity levels. Further, the additional knowledge that will be gained by the breakage of seed dormancy should help to increase seedling production, while the proper use of mini-plugs combined with the proper soil substrate should provide the best seedlings. These actions should help increase the biodiversity levels at those sites, while enhancing ecosystem sustainability at those sites.

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SIBERIAN AND SWISS STONE PINE OF CLONES IN KRASNOYARSK FOREST STEPPE

G.V.KUZNETSOVA[1]

Abstract: *A large collection of Siberian and Swiss stone pine of clones established in 1963- 1965 in Krasnoyarsk forest steppe enabled to study the character of individual and geographical variability of growth, biology of anthesis and seed producing of grafted Siberian pine trees. The most economically valuable clones have been selected: fast growing, vital and high productive. The plantation of the half- sibling posterity of studied Siberian and Swiss stone pine of clones has been established. Observing the growth and state of graftings of Siberian pine trees, also studying the radial growth in components of heteroplastic grafts enabled to ascertain reasons of anatomical- morphological incompatibility and death of mature grafts*

Key words: Siberian pine, cembra pine, grafting plantation, provenance, growth, incopatibility

INTRODUCTION

In the last 50 years the grafting of conifer species obtained a wide recognition in forestry as one of selection methods.

Siberian pine grafting to Scots pine takes a special place among activities in establishing seed grafting plantations. Some work was realized to improve grafting methods, to reveal the best rootstocks, to study grafted tree growth and their seed producing (Severova, 1957; Grabovskaya 1966; Khirov, 1980; Kamaltinov, 1982 etc.) also to introduce Siberian pine in regions where it does not naturally grows (Ryabchinskaya, 1961; Rubanik, Zheronkina, 1963; Kirgizov, 1986; Drozdov, 1989 etc.). Besides, the recommendations in Siberian pine reproduction by grafting for obtaining seeds and establishing seed plantations have been elaborated (Dokuchaeva, 1967; Khramova, 1969; Veresin, Ulyukina, 1970; Reshetnikov, Khirov, 1987; Titov, 1995 etc.).

Results of studying the grafting methods are successfully applied in industry (Cherepovskiy, 1999; Goroshkevich, 2001 etc.). According to foreign classification the foundation of collection- maternal graft plantations is considered as a formation of the bank of genes. The valuable rare forms of trees as well as vegetative posterity of plus trees can be kept safe in these plantations.

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STUDY OBJECTS

Siberian pine grafting plantation was founded by the laboratory of forest genetics and selection of the Institute of Forest SB RAS (supervised by A.I.Iroshnikov) in 1963- 1965. Development of methods for establishing geographical forest seed and grafting Siberian pine plantation under Siberian conditions was the main task.

This plantation was laid in the area of experimental base of the Institute of Forest SB RAS named as "Pogorelskiy Bor". This area is located in central regions of Krasnoyarsk krai. The climate is here sharply continental with large temperature variations in years. Average annual air temperature is – 1,3º C, the temperature sum above 5º C makes 1968, annual precipitation is 410 mm, average vegetation period duration equals to 149 days.

When establishing the seed and grafting Siberian pine plantation the grafting was realized by cuttings taken from different provenance trials, forest sites and from types of natural growing. Cuttings of Siberian pine (*Pinus sibirica* Du Tour) trees were taken from more than 40 sites of their natural growing, including Tyumen', Sverdlovsk, Kemerovo, Irkutsk, Tomsk, Novosibirsk oblasts; Krasnoyarsk krai; Kazakhstan, Sakha (Yakutia) Republic, Tyva, Buryatia, Khakassia, Mountain Altai Republic.

The Swiss stone pine (*Pinus cembra* L.) cuttings were obtained also from Karpathian forest station, Ukraine (Ivanovo- Frankovsk, Ust- Chernyanskiy leskhoz). Every site was presented by 3- 6 clones and every clone – by 5- 20 cuttings. The natural 7- 10 aged Scots pine (*Pinus sylvestris* L.) regeneration was used as a stock at the felled area (Fig.1).

A

B

Fig.1 *Clonal plantation of Siberian pine of different populations (A) and plantation of Swiss stone pine in the Krasnoyarsk forest steppe.*

RESULTS AND DISCUSSION

Growth. Long- term observations of different clones presented at the Siberian pine grafting plantation enabled to reveal their growth peculiarities in Krasnoyarsk forest steppe depending on their provenance site (Kolegova, 1977; Kuznetsova, 2001).

In Krasnoyarsk forest steppe the growth of grafts from different provenance sites increases, as a rule, with air temperature raise. This relation is obviously seen usually in the second and third 10-day periods of June, i.e. in the period of intensive growth of grafts and air temperature raise. Growth energy of Siberian pine grafts is also determined by geographical and forest site growing conditions of mother trees from which cuttings were taken.

Duration of phenological phases within one species of different climatypes we may consider approximately equal in the observing period. Only some shifts of phases in time was observed: phenological phases of southern provenances finish in the third 10-day period of June, whereas that one of other provenances finish in the middle of the second 10-day period of June. Maximum air temperature for provenances which start to grow first is 10- 23ºC and that one of provenances which growth starts later makes 23- 25ºC. Further the growth character of grafts from different provenances remains identical. The phase of bud breaking and the phase of needle unrolling start as the first the northern Siberian pine provenances, the southern Siberian pine and Swiss stone pine provenances start these phases the last. In Krasnoyarsk forest steppe these phases proceeded at the average maximum air temperature 24-28ºC and at relative air humidity 75- 87%. Shoot growth of Siberian pine grafts stops in the same succession: Siberian pine climatypes from northern and mountain regions finish their growth as the first and *Pinus cembra* from the Karpathians stops it as the last. Variability of clone ramets (ramets are trees grown from cuttings which are taken from one tree) in vegetation start and seasonal increment is absent or is very low.

Duration of growth period of shoots depends directly on heat supply of Siberian pine provenance site and decreases beginning from the flat, low- and middle mountain regions where the sum of positive average daily temperatures makes 1600- 1800ºC for the period with the temperature above 10ºC to the northern and mountain regions where the sum of temperatures is less than 1400ºC. So, the average time of seasonal growth of climatypes in flat regions (Tyumen, Sverdlovsk, Tomsk, Novosibirsk oblasts, Krasnoyarsk krai, Republic of Buryatia) makes 51- 62 days but that one in mountainous regions (East Kazakhstan, Krasnoyarsk krai, Ermakovskoye – 1500 m a.s.l) and that one also in northern regions (Krasnoyarsk krai: Yeniseisk and Baikit) makes only 38- 48 days. Studying the growth rhythm of Siberian pine grafts from different provenances has shown the geographical variability in the start of phenological phases both in one vegetation period and in different years. The whole growth rhythm and vegetation period time of climatypes has an inherited character and the more the difference between temperature regime in the provenance site of cuttings is the more the inherited character differs.

Most promising clones prominent in height as well as in diameter of stem and crown were selected at the grafting plantation. Such clones were found in flat and taiga populations of Siberian pine from Krasnoyarsk krai (Kozulskiy, Maganskiy, Yeniseiskiy leskhozes), also from Tyumen' oblast (Surgutskiy, Vagaiskiy leskhozes), and Novosibirsk oblast (Kyshtovskiy leskhoz) having 8-10 m height and 14-18 cm diameter as well as in low mountainous provenances from Krasnoyarsk krai (Ermakovskiy leskhoz), Irkutsk oblast (Cheremkhovskiy leskhoz) having 8 m height and 18 cm diameter. The southern mountainous population of Khakasia (Kop'evskiy leskhoz) has a good growth of grafts – 9 m height and 22 cm diameter. High indices of variability coefficient in diameter are observed on the plantation both within clones and between provenances (from 44 to 64%) what is connected with peculiarities of genotypes of distinct trees in these populations (Kuznetsova, 2001).

Crown diameter of all the above mentioned Siberian pine provenances differs from that one of other climatypes and is 1-1,5 meters. Nut harvest of Siberian pine, and particularly of grafts, depends, first of all, on crown structure and development. The annual shoot is the bearer of productive organs, therefore the number of buds on geographic grafts being developed on an axial shoot has a great importance for crown formation of trees. The most number of branches (9- 12) in a whorl is found on Siberian pine grafts from the Sayan population, from Buryatia population (Zakamenskiy) and from middle mountain belt of the Altai (East- Kazakhstanskiy, Verkhne-Katunskiy). Due to lateral shoots these grafts have the more spreading crown which is typical of mother trees of these provenances.

Inherited peculiarities of Siberian pine of different provenances influence on their response to weather regime in the form of modification variability of needle length and needle coverage of shoots. The performed studies have also shown that the needle growth of Siberian pine grafts depends on weather, and mainly, on hydrothermic conditions of the period of temperature accumulation of the current year. Studies have shown the needle of Siberian pine grafts appears in late of May or in early of June. A sharp increase of needle length takes place approximately up to mid-July. Further needle growth becomes slower and stops practically by end of July. Needle increment greatly varies during the period of growth and it is more closely connected with varying weather factors than the increment of axial shoot. The late spring frosts negatively influence on needle growth in this region. In result of these frosts the needle length diminishes in some years but in favorable years the needle length is longer. Especially sensitive to late spring frosts the needle of grafts from middle mountainous growing sites which start their vegetation later (Mountain Altai, Sverdlovsk oblast, Republic of Buryatia and Khakasia).

The many year studies at the Siberian pine grafting station from different provenances have shown the most needle length (on the average 13,3 cm) of grafts which cuttings were brought from regions of optimal growing the Siberian pine trees: populations from low mountain and flat sites of Krasnoyarsk krai (Ermakovskiy leskhoz) and Tomsk oblast (Timiryazevskiy leskhoz). The needle of grafts from Khakasia, Buryatia Republic and mountain regions of Altai and Sayan is shorter – 9,5-9,9 cm.

Yellowing and falling of needle on grafted Siberian pine trees are observed in the three year of age. These indices vary in connection with geographic origin of grafts as well. So, the least percent of needle fall in the third and fourth growth year is found in Siberian pine grafts of northern provenances (Baikit and Yeniseisk climatypes) and in grafts of local origin, and also in grafts from mountainous regions of the Altai (Todygemskiy climatype). Life length of needle of Siberian pine grafts in Krasnoyarsk forest steppe makes 3- 6 years, but life length of cembra pine is 5 years.

Inherited peculiarities of Swiss stone pine clones and of different ecotypes of Siberian pine show themselves in their response to weather conditions by variability of needle length and needle coverage of shoots. Studies performed earlier at the Siberian pine clone plantation have shown that needle growth of clones depends on hydrothermic regime of the period of the current year temperature accumulation (Kuznetsova, 2001). Species regularities were revealed in seasonal growth in Siberian pine clones growing in Krasnoyarsk forest steppe. Vegetation start, needle growth of Siberian pine occurs 10 days earlier that that one of Swiss stone pine and in some years the difference in dates of vegetation start and needle growth of both species varies from 8 to 20 days.

Studies of variability of needle growth and needle coverage of shoots in the contrast clones of Siberian and Swiss pines were carried out in 2006 to compare these both species (Table 1). Analysis of statistical data in comparing the needle length of clones of these both species has shown the certain population- specific distinctions. The Swiss stone pine has the least needle length (9,5 cm). The Surgut clone with cuttings from trees growing on flat country has the most (13,3 cm) needle length among studied Siberian pine from flat populations. The northern (Baikitskiy) and mountainous (Leninogorskiy) clones have a much lesser needle length. Such a distinction in needle length between these clones is also remained in the over- year cycle differentiating needle growth in years (Kuznetsova, 1999). Siberian pine grafts of various provenances have a light differentiation in needle length what is connected with homogeneous growing of Siberian pine forests on the large part of its areal. Difference in needle length we can observe in clones of the Siberian pine contrast climatypes (Table 1).

Table 1. *Variability of needle length and needle coverage of Siberian pine clones in Krasnoyarsk forest steppe*

Provenances, clones	Needle length, cm			Needle coverage (needles/cm)		
	X±m	σ	V,%	X±m	σ	V,%
Siberian pine						
Evenkia, Baikitskiy	10,3±0,1	1,1	11	3,9±0,4	0,8	20
Tyumen oblast, Surgutskiy	13,3±0,1	1,3	9	2,9±0,5	0,6	18
Kazakhstan, Leninogorskiy	11,0±0,1	1,0	9	4,9±0,9	2,0	41
Swiss stone pine, Carpatskiy	9,5±0,1	1,2	13	7,0±0,5	2,4	34

The variability level of needle length of Siberian pine clones is remained low (from 9 to 11%) and average (13%) what is characteristic of all coniferous species (Mamaev, 1972). This indicator is genetically and is less impacted by external factors, mainly, the needle length varies in years. Needle coverage of shoots is impacted more by different environmental factors (climatic, edaphic, biotic) (Table 1). The most number (7 needles) of needles per one shoot is met in the Swiss stone pine clone at the high (34%) variability level. The most number of needles (4,9 needles) among Siberian pine clones is found in mountainous Leninogorskiy population.

The Student's criterion (t) was computed in order to compare these indices of the studied Siberian pine climatypes. Statistical indices of varying needle length and needle coverage of Siberian and Swiss stone pine clones being compared have shown great distinctions in needle coverage and needle length (Table 2).

Table 2. *Reliability of distinctions between Siberian pine provenances being compared*

Clones being compared	Needle length		Needle coverage	
	$t_{факт}$	$t_{табл.}$	$t_{факт}$	$t_{табл.}$
Baikitskiy(*Pinus sibirica*) – Karpatskiy (*Pinus cembra*)	5,3	1,96	6,8	2,0
Surgutskiy (*Pinus sibirica*) – Karpatskiy (*Pinus cembra*)	27,1	1,96	5,8	2,0
Leninogorskiy (*Pinus sibirica*) – Karpatskiy (*Pinus cembra*)	10,7	1,96	4,0	2,0

The results of studying the needle length and needle coverage of shoots of different Siberian and Swiss pine clones in Krasnoyarsk forest steppe conditions have revealed great distinctions in these indicators of the above tree species. Needle length of cembra pine clones is much less than of that one of Siberian pine but the number of needles per unit of shoot area of Swiss stone pine is much more at the high variability level.

The revealed regularities confirm the distinctions between Siberian and cembra pine trees. Needle length and needle coverage of studied Siberian pine clones is defined by some genetic and climatic factors determined by adaptation of mother trees to their previous natural-climatic site conditions. The shown specific peculiarities of Siberian pine indicators being studied on the clone plantation in Krasnoyarsk forest steppe demonstrate possible establishing the clone collections under different conditions.

Incompatibility. At characterizing the growth of Siberian pine grafts we should note that the concretion degree of grafted components which depends on the mother tree age, size of cuttings and other factors together with genetic peculiarities of trees impacts on growth of grafts. Using the over- year observing growth and state of Siberian pine grafts of different provenances in Krasnoyarsk forest steppe we have determined that on the average 50% of total provenances are anatomically and morphologically incompatible with Scots pine stocks. The number of grafts with such an incompatibility varies from 11 to 90% in different provenances. At different stages of graft growth the overgrowing intensity of a graft or a stock is expressed differently. During our work on the grafting plantation we have revealed that Siberian pine cuttings grafted on Scots pine trees are short- lived and die off with time. Safe keeping of grafts in the 35-year age made 18- 95%. In other regions of our country this safe keeping of 32- aged Siberian pine grafts in the Urals, the Pre-Urals, central regions of European part of Russia does not exceed 25- 80% (Alimbek, 1972; Petrov, 1981; Bryntsev, Drozdov, 1988; Drozdov, 1992, et al.). By T.F.Kovaleva, T.K.Plishkina data (1984) safe keeping of Korean pine grafted to Scots pine (Khekhtsirskiy leskhoz, Khabarovsk krai) made 40% in the age of 18 years.

The experiment during many years has shown that heteroplastic grafts result in physiological- biochemical incompatibility, i.e. the part of grafts dries up immediately or later in the elder age (Iroshnikov, 1985; Kuznetsova, 2003). On this plantation the Siberian pine grafts start already to dry up in the age of 25 years. Needle yellowing on the whole tree is the first sign of a graft drying up, later the fracture of young stem appears in the contact zone of grafted components, the break of conductive systems of xylem and phloem in the connection zone of grafting components and trees die off. Some authors (Kosichenko, Efimov, 1980; Copes Donald, 1980, 1999; Kosichenko et al., 1982; Efimov, 1984; Kovaleva, Plishkina, 1989; Drozdov, 1989; Titov, 1985; Evdokimov, Izotova, 2000 and others) indicate that the reason of incompatibility of a graft and a stock is the different diameter increment intensity of grafting components.

It is characteristic that at grafting Swiss stone pine to Scots pine (as distinct from Siberian pine) the anatomical incompatibility between a graft and a stock started to show itself only after 40 years of growth. A sharp overgrowing of a stock by a graft, and vice versa, is not observed, a cleft appears in the contact zone of grafted components, later needle yellowing takes place and a tree starts to dry up.

Studies of radial growth (increment) of a graft (Siberian pine and a stock (Scots pine) have been carried out together with laboratory of dendroecology at the V.N.Sukachev Institute of Forest SB RAS. The year- to- year variability of the tree ring width was found (Savva et al., 2004). Analysis of age changes has shown an increase of radial growth of a stock before grafting procedure (the year 1965), then a sharp growth (increment) depression during five years and later a gradual recovery during the following ten years.

A graft growth depression is observed during five years, then the recovery follows during 10 years, and further the growth results in the general age curve typical of Scots and Siberian pine trees. The comparative analysis of the year- to- year variability of radial growth in grafting components has shown that in the period when the age has a minimum impact on a tree ring width (it takes place approximately in 25 years after grafting) the radial growth of grafting components can equalize. Average values of the tree ring width in grafting components are equal and such a graft does not die, so the even re- distribution of nutrients between the grafting components proceeds. In another case, when a graft overgrows a stock then the surplus of nutrients in a graft determines, mainly, its growth but the stock feels its deficit. Being accumulated with the age this deficit of nutrients results in growth slowing down and stock weakening which by this time has lost its own assimilating branches. To the contrary, organic matter (synthesized in a graft) is accumulated in it in excess and provides its progressing growth. In result of different growth rate of conducting tissues in graft components as well as owing to discrepancy of tree ring width in a stock and graft the tree dies (Kuznetsova, Savva, 2004).

Since the accretion character of the Siberian pine graft to Scots pine is determined genotypically (every graft component keeps its rhythm of growth and development), then the selecting the graft components with similar growth rhythm and simultaneous vegetation phases is possible when performing heteroplastic grafting.

Based on results stated above the analysis of anatomical peculiarities of the tree ring structure in graft components of different Siberian pine climatypes, formed in the years when the tree ring of the stock and graft differed greatly, was realized. Differences in anatomical structure of xylem tree rings of a stock concrescent with the grafts from different provenances were noted. Conservatism of genetic system was shown as not absolute but adaptive one, therewith different graft climatypes influence differently on differentiation of a stock xylem. No doubt, such unique objects as Siberian pine grafting to Scots pine can bring much new to understanding of coordination of growth processes between single organs and tissues of perennial plants. And just on these experiment objects the further studies are perspective using not only anatomical but also genetic methods.

The experiment in establishing the Siberian pine collection in Krasnoyarsk forest steppe enabled to assess and select the best tolerant clones in their growth and reproductive capacity in 30- year age. The plantation of half- sibling Siberian pine seed posterity of different provenances was established in the year 1987. Seeds were collected from 13 best clones. Seed material from cembra pine clones which has been grown in the tree seed orchard is supposed to be replanted as well. Presently the new collection grafting plantation of the more perspective Siberian and Swiss stone pine clones is being established the stock of which Siberian pine trees are.

CONCLUSION

Studying the growth and reproduction of 20- 30- aged Siberian and Swiss stone pine grafts in Krasnoyarsk forest steppe, cuttings for which were taken in natural populations of their areal, has confirmed that the established clone collection gives a comprehensive information on mother trees which is needed for their assessment. A great differentiation in growth, also in formation of macro- and microstrobile of Siberian pine clones has been shown. Distinctions in Siberian and Swiss stone pine species in phenology, needle length and needle coverage of shoots, also incompatibility of grafted components has been stated.

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THE QUALITY OF SEEDS OF MACEDONIAN PINE *Pinus peuce* Grisebach IN MACEDONIA

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Abstract: *Were studied in seed quality of four natural populations of Pinus peuce Griss Pelister National Park in Macedonia. Seeds of studied populations are of high quality seed: viability from 70 to 83.6%, share of filled seeds from 82 to 96%, a well-developed embryo. Weight of 1000 seed pieces is more than 50g.*

Key words: Pinus peuce, populations, seed, quality, viability

INTRODUCTION

The Makedonian pine Pinus peuce Griss refers to the endemic and relict pines of the Tertiary period. It is widespread in the Balkan Peninsula: in Macedonia, Serbia, Albania, Montenegro, Bulgaria and Greece. This is a fast growing, stable, beautiful pine tree, it can be found in many gardens and parks.

The seeds used in the restoration and cultivation of forests should be of high sowing qualities (germination, vigor, purity) and varietal qualities, which are determined by hereditary valuable properties. The study of quality seeds Pinus peuce in natural populations will assess the seed production of trees, select the best population and recommend them for breeding work.

The task of the research was to study the quality of seeds Pinus peuce in National Park Pelister, where this species is more widespread. It is the first National Park in Macedonia and ex Yugoslavia founded 1948. The mean reason for establish of National Park the Macedonian pine Pinus peuce. Following Pinus peuce Grisebach, 1843 he discovered the following taxa for which Pelister is the "locus classics". Here these pines make a most compacted wood than anywhere in the world. This pine is also distributed and in the other two Nationals Park Galicica and Mavrovo but in most rate unique tree. Behind the pine in the National Park there are some endemic plants which are locus classics such as Dianthus myrtinervius and others. The stone rivers morenes are also characteristic of this NP (Hristovski, 2007).

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MATERIAL AND METHODS

To study the quality of seed samples were collected seeds of four populations from mountain ridges in National Park Pelister. All seeds were collected from trees Pinus peuce in natural stands.

The first population of Pinus peuce is near the village of Dihovo Nizhopole. This young natural stands in the common birch and spruce, the high "male" fern. Altitude 900 m. Seeds from Nizhopole (Fig. 1)

The second population of Pinus peuce located above the village Rotino. It is also natural in the young plantations meets Evla, "male" fern. Altitude 1050 m. Seeds from Rotino (Fig. 2).

A third population of Pinus peuce located above the village Magarevo. Young natural stands in the common wild plum, "the male fern." Altitude 1100 m. Seeds from Magarevo (Fig. 3).

The fourth population of Pinus peuce is near the village of Capari. . Natural plantings in the common juniper, wild plum, and "male fern". Altitude 1010 m. Seeds from Capari (Fig. 4).

Figure 1. *Population of Pinus peuce from Nizhopole.*

Figure 2. *Population of Pinus peuce from Rotino.*

Figure 3. *Population of Pinus peuce from Magarevo.*

Figure 4. *Population of Pinus peuce from Capari*

The existing methods for determining the viability and the degree of development of seeds (dissection, staining, sprouting) is very time consuming. The process of seed development and status of the embryo during germination reflected in the rough. To determine the viability of the seeds in our study used industry-standard X-ray diffraction method, designed specifically for Siberian pines Laboratory of Forest Genetics and Plant Breeding Institute of Forest SB RAS, Krasnoyarsk.

The viability of seeds was determined by X-ray analysis on the basis of the internal structure of classes and seed development without compromising their integrity and viability. Determination of viability of seeds was carried out on three or four samples of 100 seeds each. X-ray analysis was based on visible differences in the development of the embryo and endosperm. By radiographs seeds were divided into five classes depending on the degree of development of the embryo and endosperm, the size and shape. Seed germination was calculated as the arithmetic mean of the results of decoding of samples and expressed as a percentage.

Determination of viability. N-total number of seeds in the sample.

$$F = ((0.93\ (R1 + R2 + R3)) / N) \times 100\%\ Kn\ classes.$$

RESULTS

The results of studies appear in Table 1. As shown in table 1 shows, all four populations of Pinus peuce have a good seed from 70% to 83.6%. The highest viability of the seeds of individuals in a population of Capari. The viability of the seeds depends mainly on the interest of empty seeds. Populations of different Magarevo large number of empty seeds (17.9%) and, accordingly, in this population seed viability – 70%.

Tab. 1. *Characteristics of seeds Pinus peuce*

Population	Full seed ratio among all seeds (%)	Empty seed ratio among all seeds (%)	With polyembryony, %	Viability, %	Mass 1000 pieces seeds, g
Nizhopole	90.5	9.5	1.6	80.5	56
Rotino	96.1	3.9	7	82.6	52
Magarevo	82.1	17..9	2.7	70.0	53
Capari	92.1	7.9	2.0	83.6	54

The percentage of empty seeds, most likely related to the absence of fertilization or in violation of the embryo during development (Kuznetsova, 1987; Romanovsky, 1989). There is a view that a high percentage of empty seeds are associated with self-pollination (Sarvas, 1962; Hagman, Mikkola, 1963; Zemlyanoy, 1981). Studies Ishikure Shinsuke Bull (1982) showed that 40% of empty seeds from the germination of cross-pollination in seed orchards were obtained by self-pollination. Also, Hadders Custaf (1983) in experiments on artificial pollination of larch, spruce and pine pollen own empty seeds were obtained. Research (Forschell, 1974; Lindgren, Vazdani, 1988) of seeds after self-pollination and cross pollination of Scots pine and arborvitae have folded (Owens, Colangeli, et al., 1990) showed that after cross-pollination formed well-developed seeds viable embryos and seeds after self-pollination were characterized by gradual loss of germ and endosperm. Some researchers believe that the appearance of empty and immature seeds - a kind of release agent populations of woody plants on the genetic load (Koski, 1973; Svintsova, 1984; Abaturova, 1987), as well as the effect of adverse climatic factors (Nekrasova, 1983, Tretyakova, 1990; Shigapov, 1997, etc.). For all populations have a high percentage of full seeds (Table 1). Specific differences in of full seeds depending on the geographic area in climatypes not revealed. It is known that a strong decrease of this index is usually in years of poor harvests.

Mass of 1000 seed pieces depends on the number of full seeds per cone. According H.Mattes (1999), the mass of 1000 pc. seeds in Pinus peuce average amount '49 g. In our studies in four populations of Pinus peuce from Park Pelister weight of 1000 pieces of seeds than in '50 g (Table 1). In years when weather promotes the successful development of the embryo and the accumulation of reserve substances in the endosperm, seed mass may be higher. It is believed that the endosperm is required for the formation of a warm, moderately humid weather in summer. Drought, like a cold with an excess of moisture, prevents the normal development of seeds, the endosperm is more frail, among a lot of empty seeds, and the absolute weight of a normal versus reduced by 20-35% (Nekrasova, 1972). However, this feature remains relatively stable and less dependent on weather conditions. Along with taking into account the data size of cones and seed quality, it can serve as a basis for selection of the most productive tree with good quality seeds.

In all populations studied a slight from 1 to 4% of the phenomenon of seeds with polyembryony (Table 1). The appearance of the emergence of seed with polyembryony can affect both genetic and environmental factors. The reasons identified in plants of seed with polyembryony are not enough. In years with unfavorable weather conditions of full seeds dramatically increases the proportion of seeds with polyembryony, which significantly reduces the germination and germination energy (Shimak, 1973). There is also a view (Berlin, 1962) that species with large seeds polyembryony is stronger than the species with small seeds.T.P. Nekrasova (1972) notes that polyembryony - one of the hallmarks of ancient species.

Seeds with polyembryony have a lower quality for forest practices than the normal full monoembryonaly seeds. It is desirable in the selection of breeding material for seed orchards, except for the growth, yield trees (the number of cones), with forestry value, taking into account their reproductive adaptation to climate and quality characteristics of seed (embryo and endosperm). The degree of maturity and suitability of seed for sowing is also determined by the level of development of embryos of seeds (Table 2).

Table 2. *Performance length of the seeds of different populations of Pinus peuce*

Population	The distribution along the length of the embryo on the length of the embryonic canal (% of seeds)			
	embryo 0,8-1,0	embryo 0,5-0,9	embryo 0,3-0,7	embryo 0,1-0,2
Nizhopole	14.6	38.4	33.8	13.7
Rotino	31.9	31.3	25.0	3.9
Magarevo	29.6	29.1	16.7	6.7
Capari	26.8	37.4	25.7	2.1

As shown in Table 2. seeds of the studied populations of Pinus peuce generally have well-developed embryo especially in seed populations Magarevo and Of Capari. The embryo is more than 0.5 length embryonic canal in the seeds of Pinus peuce.

CONCLUSION

Our studies shown that the seeds of the three populations: Nizhopole, Rotino, Capari have a high seed viability to 83.6%. Less than 70% viability of seeds Pinus peuce population from Magarevo. In seeds of this population was higher number of empty seeds having no embryo (17.9%). The degree of maturity and suitability of seed for sowing is determined by the level of development of embryos. For all the studied populations characterized by the presence of seeds with a polymorphism of 1.6 to 4%. As shown by our study of 4 populations Pinus peuce were of higher quality seed population of Capari.

The studied population of Pinus peuce from Park Pelister not significantly differs in altitude and latitude, so the large differences in seed quality between populations weren't found.

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THE PROVENANCE OF FOREST REPRODUCTIVE MATERIAL MATTERS: EXAMPLES WITH NORWAY SPRUCE, SILVER FIR, COMMON BEECH AND SESSILE OAK IN THE WESTERN CARPATHIANS

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Abstract: *Common garden experiments proved significant differences among provenances of local Norway spruce, common beech, silver fir and sessile oak provenances even within the geographically limited area of Western Carpathians. At the age of 45 years, mean stem volume differed by 21-44 % and growing stock 39-96 % among the provenances of Norway spruce. Comparative tests with silver fir and sessile oak revealed the difference of 64-88 % in the mean stem volumes, and even more than 100 % in their growing stock.*

In order to analyze adaptability of forest tree species, effects of ecological distances between source populations and provenance plots (planting sites) on the growth and survival of provenances were assessed.

Eleven autochthonous provenances of Norway spruce were studied at the series of 5 parallel provenance plots situated along an altitudinal gradient from 480 to 1,310 m. Changed altitude, temperatures, precipitation and vegetation period influenced their growth and survival significantly. Our findings indicate adaptation of Norway spruce to a common optimum located in a somewhat lower altitude than the origin of tested provenances. Altitudinal shift, mean temperature of July and number of days warmer than 10°C proved to be the most important underlying variables.

Effects of changed site conditions on the growth and survival of beech, silver fir and sessile oak were tested in single-plot provenance trials. Despite of a simple experimental design, ecological distances between source populations and planting sites were significant for all species. From among the underlying variables, altitudinal shift had the strongest effect on the growth and survival of silver fir and sessile oak. Provenances of silver fir performed better when they were planted in a lower altitude while oak provenances in a higher altitude from their source populations.

Key words: forest reproductive material, provenances, ecological distances, adaptability

INTRODUCTION

In Slovakia, alike much of Central-Europe, artificial forest regeneration prevails over the natural one for many decades. Despite of more recent efforts to increase the share of natural regeneration of forest stands, planting and seeding of forest trees will be important also in the future (Moravčík et al. 2010). The reasons include high felling of losses due to windstorms, outbreaks of forest pests, fungal infections, increasing incidence of extreme weather including droughts, heavy snow and rime. Reconstruction of secondary coniferous stands towards more stable mixed forests relies on planting and seeding to a large extent too, however.

From the point of view of adaptation of forests to climate change, competent decisions in forest reconstruction require reliable information about future climates and site conditions, but

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also about ecological plasticity and adaptability of forest tree species. The quality of basic materials and its provenance (origin) predetermine largely the ecological stability (vitality, health) and production of artificially established forest stands throughout their life cycles. It is due to the genetic background of many ecologically and economically important properties of forest tree species:

1) Their differential response to changed sites conditions which differ from conditions prevailing at the place of their origin (e.g. Hannerz, Westin, 2005, Mátyás and Yeatman 1992, Krutzsch 1968).
2) High heritability of important traits such as the growth rate, crown shape, stem shape, forking, branch thickness, susceptibility to diseases (e.g. Cornelius 1994, Geburek 2005).

Production and marketing of forest reproductive material is, among few forestry subjects, regulated at the EU level. A global standard in this area is provided by the OECD Scheme for certification of forest reproductive material moving in international trade. The purpose of the both is to guarantee the identity of each lot of a forest reproductive material, quality of its basic material, and information about the region of provenance.

The assessment of adaptability of forest tree species relies largely on provenance (common garden) experiments. It is done by means of comparative testing of provenances representing different source populations. First provenance experiments were planted more than 200 years ago for practical reasons: in order to identify well growing, sufficiently adapted populations of forest tree species, which were suitable as sources of seeds for artificial forest regeneration (König 2005). The term "provenance" is used to describe the location of the source population from which a seed, progeny plants or parts of plants for vegetative propagation were collected. The most frequently studied characteristics of provenances include growth, survival, health condition and phenology of tested provenances. For many reasons, geneticists still consider provenance experiments a methodologically unique and reliable source of comprehensive information about the site adaptability of forest tree species (see, e.g., Jensen and Deans 2004, Giertych and Mátyás 1992, Vančura 1993, Krutzsch 1968).

The purpose of our study is to assess the role of source populations and genetic component of adaptability of forest tree species under different site conditions. Building on the obtained results, recommendations will be drawn regarding the choice of appropriate provenances and regarding the quality of basic materials of a forest reproductive material used for artificial forest regeneration.

MATERIAL AND METHODS

Our analysis of the adaptability of Norway spruce, common beech, silver fir and sessile oak was based on the evaluation of provenance trials. They are field trials comprising progenies of different source populations (provenances). Ecological characteristics of a planting (trial) site are usually different there in comparison with source populations of individual provenances.

The effect of changed site conditions on the growth and survival was studied in autochthonous provenances representing natural ranges of individual species in the Western Carpathians. The provenances and provenance trials included:

Spruce: 12 autochthonous provenances measured at the age 40 years on a series of 5 provenance plots in Central and Northern Slovakia in altitudes ranging from 480 to 1,270 m.

European silver fir: 30 autochthonous provenances measured at the age 33 years in a single plot experiment Dubová, Slovak Ore Mts., Central Slovakia, altitude 600 m.

Sessile and pedunculate oak: 35 autochthonous provenances measured at the age 33 years in a single plot experiment on Tríbeč Mt., Central Slovakia, altitude 550 m.

Common beech: 19 provenances measured at the age of 30 years in a single plot Bieň in the Kremnician Mts., Central Slovakia, altitude 500 m.

The study included 3 consecutive steps:

1) Field measurement and evaluation of the growth (height, diameter at the breast height DBH, mean stem volume) and survival in the provenance trials.
2) Assessment of ecological distances („ecodistances“) between source populations and provenance trials in the following environmental variables:
   a) Differences in altitude, latitude and longitude.
   b) Climatic characteristics derived from the climatic model of Slovakia (Hlásny 2007) providing rather accurate estimate of real climatic conditions for source populations and provenance trials in the period 1960-2000:
      - mean air temperature of July, April-September (vegetation) and of the whole year,
      - mean precipitation totals of July, April-September and of the whole year,
      - mean annual number of days with mean air temperature over 0°C, 5°C a 10°C.
3) Analysis of site adaptability of individual species based on the regression (correlation) analysis of the influence of ecological distances between the planting site and source population (predictors) on the growth and survival of provenances (response variables).

Table 1: *Basic characteristics of the series of provenance plots with Norway spruce 1964/1968 (seed sown 1964, outplanted 1968)*

	Veľký Lom, Lešť	Bujakovo, Beňuš	Zelenô, Beňuš	Luxová, Biely Váh	Mútne, Zakamenné
Altitude and slope aspect	480 m, flat	610 m, E	760 m, NW	1,020 m, SW	1,310 m, SE
No. of provenances	49	51	12	12	49
Design	4 repeats × 25 individuals per provenance				
Forest vegetation belt	2-*Fageto Quercetum*	5-*Fageto abietum*	5-*Fageto abietum*	6-*Fageto aceretum*	6 *Fageto abietum* / 7 *Sorbeto picetum*
Mean annual temperature	7.7 ^{o}C	6.2 ^{o}C	5.5 ^{o}C	4.3 ^{o}C	1.7 ^{o}C
Annual precipitation	726 mm	800 mm	917 mm	889 mm	1,386 mm
Trial area	3.37 ha	3.37 ha	0.94 ha	0.94 ha	3.37 ha

Table 2: *Basic information about provenance trials of sessile and pedunculate oak 1974, common beech 1969 and silver fir 1964*

Name and locality:	Jelenec, Tríbeč Mt.	Bieň, Kremnician Mts.	Dubová, Slovak Ore Mts.
Altitude and aspect	550 m, SE	500 m, E	600 m, flat
No. of provenances	35	19	30
Design	3 repeats × 49 individuals per provenance	3 repeats × 25 individuals per provenance	3 repeats × 36 individuals per provenance
Forest vegetation belt	2 - *Fageto-Quercetum*	4 - *Fagetum typicum*	4 – *Abieto fagetum nst*
Mean annual teperature	8.2 ^{o}C	7.1 ^{o}C	7.5 ^{o}C
Mean annual precipitation	730 mm	880 mm	816 mm
Trial area	2.55 ha	0.95 ha	1.55 ha

While all provenances included in the experiments were autochthonous, their reaction to changed site conditions can be attributed to adaptation to ecological conditions in which their source populations have evolved. Survival of individual populations was evaluable also thanks to the fact that all experiments were left without silvicultural intervention until the age at which the age of evaluation presented in this study.

RESULTS

Effect of provenance on the growth and survival of forest tree species

For this purpose, the mean height, mean stem volume and growing stock of provenances were compared. As expected, comparisons revealed significant differences between provenances even in a scale of a geographically small region of Western Carpathians (Table 3 and 4).

While the mean height differed by less than 25 % among the studied provenances, the mean stem volume, which incorporates both height and diameter of trees, differed by 24-88 %. The biggest difference - more than 100 % - was revealed in the growing stock per provenance. It means that the wood production of stands established using a reproductive material derived from appropriate and inappropriate basic material can differ more than twice as early as in a pole stage of a stand at the age of 30-40 years. The provenances of oak and silver fir differed in the growing stock and mean stem volume more than those of Norway spruce.

Table 3: *Role of provenance in the growth. survival and wood production of 11 autochthonous provenances of Norway spruce from Western Carpathians at a series of 3 provenance plots, age 45*

Differences between well and poorly performing provenances:	Altitude of field trials		
	480 m	760 m	1 310 m
- mean heigth in meters and %	20.8 - 22.3 7 %	24.3 - 25.8 6 %	15.8 - 19.0 20 %
- mean stem volume m^3 and %	0.41 - 0.50 24 %	0.55 - 0.67 21 %	0.32 - 0.45 **44 %**
- survival rate (%)	53 - 75 %	35 - 46 %	30 - 51 %
- growing stock per provenance in m^3	25 – 35 **39 %**	14 – 28 **96 %**	12 - 21 **73 %**

Table 4: *Role of provenance in the growth. survival and wood production of beech, sessile oak and silver fir at the age of 30-33 years.*

Differences between well and poorly performing provenances:	Common beech, altitude 500 m	Sessile oak, altitude 550 m	Silver fir, altitude 600 m
- Mean heigth in meters and %	10.2 - 12.3 20 %	9.7 - 11.5 18 %	10.9 - 13.5 24 %
- Mean stem volume m^3 and %	-	0.05 - 0.8 **64 %**	0.09 - 0.17 **88 %**
- Survival rate (%)	60 - 87 %	25 - 67 %	44 - 74 %
- Growing stock per provenance in m^3	-	1.5 - 4.5 **196 %**	4 - 11.5 **181 %**

Presented comparison includes only local provenances. In the experiments of Norway spruce and European silver fir, also provenances from other Southeast and Western Europe are present. If those were included in our comparisons, differences among provenances were considerable bigger.

Site adaptability of Norway spruce

Survival rate correlated positively (r = 0.55 – 0.77, P > 99%) with the difference in the altitude, temperature and precipitation between source populations and planting sites. Survival rates of provenances increased thus towards planting sites in lower altitudes with higher temperature and longer vegetation period, despite of lower precipitation there.

Growth: Strong non-linear correlations were found between the growth and altitudinal and latitudinal distance from source populations to the planting sites (R^2 = 0.632 and 0.574, respectively, P > 99%). Regression function for height growth reached its maximum when the planting site was 120 m down and 0.32 latitudinal degree South from source population.

In all temperature-related characteristics, ecological distances between source populations and planting sites revealed strong positive non-linear correlations (R^2 = 0.570–0.695, P > 99%). Maximum growth was found when the difference between source population and planting site was higher by

- 1.4 °C in the mean air temperature of July, i.e. the warmest month of a year,
- 1.25 °C in the mean air temperature from April to September, corresponding with vegetation period,
- 1.27 °C in mean annual air temperature,

At the optimum, the annual number of days warmer than 0 °C was higher by 20, warmer than 5 °C higher by 12 and number of those warmer than 10 °C was higher by 10.

Precipitation and growth were correlated too. Correlations were less close (R^2 = 0.425 – 0.452) yet still highly significant (P > 99%). Regression function for the height growth reached its maximum for a planting site where mean precipitation of July was lower by 24 mm, mean precipitation of April to September by 127.3 mm and mean annual precipitation by 106 mm in comparison with source populations. This paradox can be explained by a stronger positive effect of higher temperature, longer vegetation and better soils in lower altitudes.

From among all of the predictor variables tested, the altitudinal shift, change of the mean temperature of July and number of days warmer than 10 °C, i.e. the vegetation period, revealed closest correlations with ecological distances

Site adaptability of common beech, silver fir and sessile oak

Common beech

The only older beech provenance experiment available includes 19 Slovak provenances. Regarding their adaptability, significant (P > 95%) relationship was revealed only between the survival and longitudinal position of the source populations at the age of 30 years (Figure 1). In local situation, the climate tends to be more continental in West-East direction. Positive correlation indicates a better survival of beech from more oceanic Western Slovakia in comparison with provenances from more continental areas.

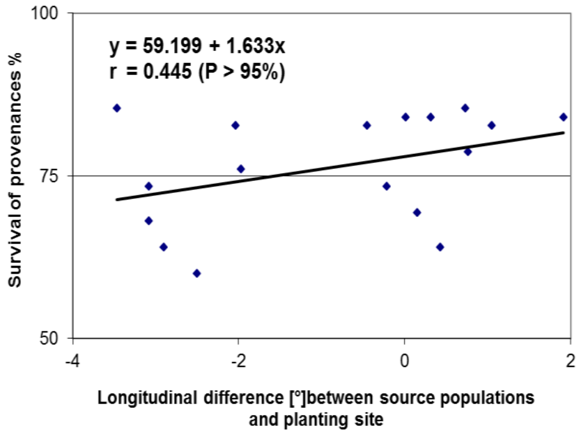

Figure 1: *Effect of latitudinal transfer of forest reproductive material on the survival (%) of common beech at the age of 30 years (Bieň, Central Slovakia, alt. 550 m)*

European silver fir

Our provenance experiments suggest that the growth and survival of forest reproductive material is influenced by altitudinal rather than horizontal transfer (Figure 2). The size of Slovakia should be taken into the account in this respect, however. If foreign provenances were included, the provenance effects would be much bigger.

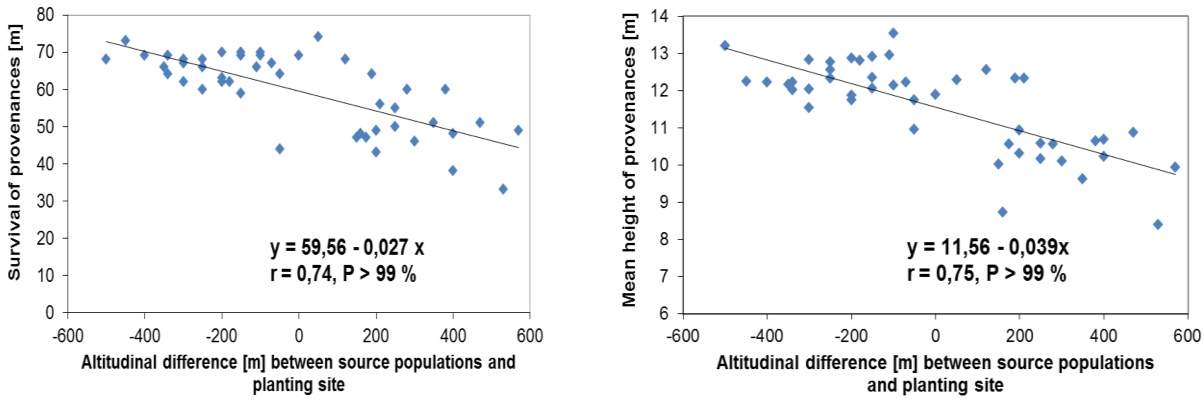

Figure 2: *Effect of altitudinal transfer of forest reproductive material on the survival (%) and height growth of silver fir at the age of 33 years (Dubová, Central Slovakia, altitude 600 m)*

In international provenance experiments, provenances Carpathians and Southeast European provenances of silver fir perform better than local provenances in Germany, Austria, Switzerland and Czech Republic. Western Carpathian provenances therefore became officially recommended for the use in Bavaria Southern provenances prove to be highly adaptable in spite of the transfer to different site conditions even beyond the northern limit of the species natural range, however (Larsen 1986).

Better adaptability of silver fir from southern and southeastern Europe correlates well with the levels of their genetic variability as revealed by means of genetic markers. On the contrary, the lowest genetic variation was found in northern populations, where the dieback of silver fir is present for a long time. The mean observed heterozygosity of silver fir haunted by the dieback in the Czech Republic is twice lower than in Macedonia and Southern Italy free of the dieback symptoms (Longauer 2003).

Sessile and pedunculate oak

The trial with Slovak provenances of sessile and pedunculate oak at the age of 30 years (Central Slovakia, altitude 550 m) revealed better growth of provenances moved from lower elevations upwards (Figure 3). Besides it, alike to the Austrian-Hungarian oak provenance experiment established in 1903 and measured at the age of 100 years (Geburek 2005), there are significant differences in the stem shape and quality of provenances. The phenotypic quality of source populations proves thus to be extremely important for the both oak species.

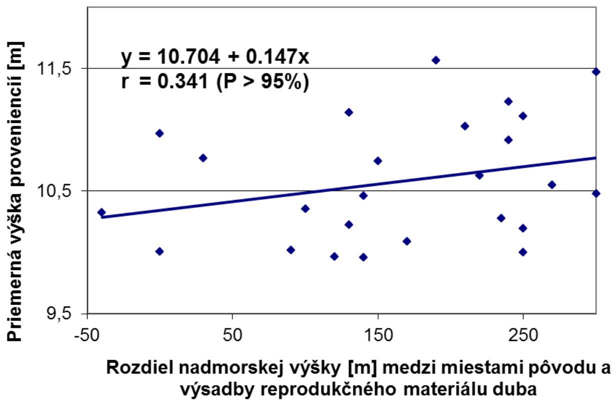

Figure 3: *Effect of altitudinal transfer of forest reproductive material on the height growth of 25 provenances of oak at the age of 33 (Jelenec, Central Slovakia, altitude 550 m).*

Regarding the adaptation to climate change, our result suggests the possibility of transferring their reproductive material from lower altitudes upwards. Although only limited conclusions can be drawn on a basis of a single provenance plot, a transfer 100–250 meters upwards appears to be allowable. It is important to consider, however, somewhat different climatic envelopes and sites preferred by sessile and pedunculate oak. The latter species tolerates more continental climate and occurs also in inner mountain basins of Western Carpathians. There are also many approved seed stands which are mixed or where the species identity of oaks needs to be checked. Their reliable discrimination is still difficult even by means of genetic markers. Sessile, pedunculate and pubescent oak share major part of their genomes and only few alleles can be used for their discrimination (Gömöry & Schmidtova 2007).

The Western Carpathian populations of sessile and pedunculate oak are genetically similar to populations present in the Eastern Alpine, Apennine and Dinaric area (Petit et al. 2004). It would suggest a possibility a transfer of their southern provenances northwards under progressing climate change.

DISCUSSION AND CONCLUSIONS

Results of our provenance studies confirm importance of the geographic origin of a forest reproductive material in regard to the growth and survival of forest stands, and thus also production and ecological stability and thus also ecological stability of established of forest stands. Due to the high heritability of economically and ecologically important phenotypic characters, the quality of parent stands of forest reproductive material is equally important.

In Table 5, we summarize heritabilities of relevant phenotypic characteristics of forest tree species obtained from Paule (1992) Geburek (2005), Cornelius (1996), Doede, Adams (1997), Kanowski et al. (1990), Savill et al. (1999), Kanowski et al. (1990), Kumm et al. (2000), Teissier Du Cros et al. (1980, 1983) and many others (see also references). Most references are for the species native or cultivated in Europe: Norway spruce, Scots pine, common beech, sessile and pedunculate oak, common ash, alder and Douglas fir. Some information was added about species from other geographic regions, such as *Abies procera* and *Platanus occidentalis*.

Our survey indicates that phenotypic quality of parent trees pays a significant role due to the heritability of qualitative traits of forest tree species: spiral grain, forking, stem bow, frost cracks. In practical terms, the heritability values indicate that „systemic“ forking or spiral appears in about 50% of an offspring of parents which carry these characteristics. In addition, undesirable characteristics may accumulate in the progenies of phenotypically poor stands. Such progenies, if marketed as a forest reproductive material, deteriorate considerably production, economic value and frequently also ecological stability of future stands as early as in the moment of their establishment. And all it is done for reduction of cost of planting stock which value represents a negligible fraction of the expected value of a forest stand in its rotation age, cost of silvicultural operations and protection of forest stands.

Table 5: *Heritability of economically and ecologically important traits in forest tree species.*

Heritability %	Height growth	Diameter growth	Stem bending (bow)	Spiral grain	Forking
Conifers	10 - 85	17 – 40	14 - 33	**55 - 70**	10 - 45
Broadleaves	25 - 95	8 – 26	**26 - 60**		**50 - 60**

	Branching angle	Branch diameter /knots	Wood density	Stem cracks	Vegetative phenology
Conifers	8 - 40	13 - 64	**41 – 90**	**30 - 90**	**80-100**
Broadleaves	16 - 62				

High heritability of forking and spiral grain of broadleaved tree species implies that more than a half of progenies inherit these traits from parents which are their carriers. While forking reduces the value of produced wood, it also impairs static stability of beech stands in the mountains with high winter precipitation including snow and rime. Our results concerning the growth and survival of different provenances, along with high heritabilities of undesirable growth traits indicate clearly that the use of forest reproductive material derived from inferior basic materials results in economic losses and ecological problems. Negative effects of inappropriate basic material are quite comparable or even bigger than genetic gains from selection and forest tree breeding. For instance, a gain which materializes in a better phenotypic quality and growth of a reproductive material of category selected originating in approved seed stands ranges from 3-5%. Following Lindgren (2008), Paule (1992) and Ramskogler (2012), genetic gains vary from 6-10% in untested orchards to 17-23% in tested seed orchards after genetic thinning. Higher gains are possible only in a case of hybridization (controlled crosses) of tested parents of families are combined with vegetative propagation of their progenies (Table 6).

Table 6: *Genetic gains for different types of basic materials of a forest reproductive material arising from forest tree selection and breeding. Based on the data available from Lindgren (2008), Paule (1992) and Ramskogler (2012)*

Realized genetic gain ΔG:	Approved seed stands	Seed orchards	Seed orchards with tested clones	Vegetatively propagated tested clones
	3 - 5 %	6 - 10 %	17 - 23 %	25 %

Results of field experiments combined with information about heritability of important phenotypic traits and genetic gains from forest tree breeding suggest strongly that the quality system for forest reproductive material generates considerable added value. Vice versa, ignoring the quality of basic materials and recommended region of provenance contributes to significant losses and problems: Consequences of the use of inappropriate forest reproductive material can be seen throughout rotation cycles of artificially regenerated forests. They are manifested in a poorer phenotypic quality, occurrence of repeated snowbreaks due to unsuitable tree form and branching patterns, higher susceptibility to diseases and parasites due to insufficient adaptation. From the ecological point of view, they contribute to ecological instability and shorten life expectations of forest stands. In financial terms, they cause production losses and increase costs of forest protection and reconstruction. Saving small money on a planting stock of obscure identity is thus totally unacceptable with regard to future complications its use may cause to a forest owner.

Acknowledgement

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EFFECTS OF GIBBERELLIC ACID, KINETIN AND COLD STRATIFICATION ON SEED GERMINATION OF *Pyrus pyraster* Burgsd. AND *Malus dasyphylla* Borkh. SPECIES

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Abstract: *Germination tests were carried out to determine the best treatment to be used in order to overcome dormancy and maximize the germination of P. pyraster and M. dasyphylla seeds. In both species, the effects of gibberellic acid (GA_3), kinetin (6-Furfurylaminopurine), cold stratification, a combination of GA_3 with cold stratification and a combination of kinetin with cold stratification on seeds germination were investigated. Seeds of both species were treated with solutions of GA_3 or kinetin for 30 hours and were, subsequently, cold stratified at 3 - 5ºC for 0, 1, 2 and 3 months. The concentrations of GA_3 and kinetin solutions were 500, 1000 and 2000ppm. In addition, seeds from each species, which were not treated with GA_3 or kinetin (control), were subjected only to cold stratification for 0, 1, 2 and 3 months. Non-stratified P. pyraster seeds, despite having been treated with GA_3 or kinetin solutions, exhibited very low germination percentages. In P. pyraster, germination percentages of control seeds subjected to cold stratification for 2 and 3 months were higher ($p<0.05$) than those of control seeds subjected to cold stratification only for 1 month. In each period of cold stratification, there were no significant differences ($p>0.05$) in germination percentages between control seeds and seeds treated with GA_3 and kinetin solutions. In M. dasyphylla, GA_3 or kinetin application did not improve the germination of non-stratified or one-month stratified seeds. In control seeds and seeds treated with GA_3 or kinetin, an increase in the period of cold stratification, increased germination percentages significantly ($p<0.05$). In each period of cold stratification, there were no significant differences ($p>0.05$) in germination percentages between control seeds and seeds treated with GA_3 and kinetin solutions except for one case. After 2 months of cold stratification, the germination percentage of control seeds was higher ($p<0.05$) than the germination percentages of the seeds which had been treated with 500 and 2000ppm kinetin. In both species, low values of mean germination time were observed. The results demonstrated that the optimum germination percentages of P. pyraster and M. dasyphylla seeds (control) were obtained after a 2- or 3-month and a 3-month cold stratification period, respectively. In both species, the application of GA_3 or kinetin did not replace or shorten the required cold stratification period.*

Key words: cold stratification, dormancy, gibberellic acid, kinetin, *Malus dasyphylla*, *Pyrus pyraster*.

INTRODUCTION

The species *Pyrus pyraster* Burgsd. and *Malus dasyphylla* Borkh. belong to Rosaceae family. Both are fruit-bearing trees indigenous to Europe. In Greece, the species at issue are found in the continental part of the country, mostly in sub-mountainous and mountainous regions

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(Boratynski *et al.*, 1992; Arabatzis, 1998). Frequently, they grow individually or in small groups in broadleaved or conifer forests. In a forest ecosystem, the ecological significance of the above species is great due to forage (fruits) which they offer to many wildlife species. As a result, the specific species have to be propagated in nurseries and, subsequently, introduced in reforestation programmes.

P. pyraster and *M. dasyphylla*, similar to a number of other woody plants, can be propagated with seeds. Although this method is considered cost-effective (Macdonald, 2006), it is rather difficult to apply due to seed dormancy. According to Nikolaeva (1977), dormancy is determined by both the morphological and physiological properties of seeds; based on the specific properties, dormancy is distinguished in exogenous, endogenous and combined dormancy. The first type of dormancy (exogenous dormancy) involves characteristics of structures (fruit walls, seed coat, endosperm) covering the embryo which prevent germination, whereas endogenous dormancy includes characteristics, such as underdeveloped embryo (morphological dormancy), physiological inhibiting mechanism of the embryo (physiological dormancy) and a combination of underdeveloped embryo with physiological inhibiting mechanism (morphophysiological dormancy) which prevent germination. Combined dormancy comprises cases of combining exogenous with endogenous dormancy. Depending on the specific type, various methods are used to overcome dormancy so that the highest percentage of viable seeds would be brought to the point of germination.

Seeds of both *Pyrus* and *Malus* genus have dormant embryos which require cold stratification (Hummer and Postman, 2008; Anderson and Crossley, 2008). The length of cold stratification period required for dormancy removal varies among the species of each genus. According to Hummer and Postman (2008), seeds of *Pyrus* species should be stratified for 60 to 100 days at about 4ºC. I.S.T.A. (1999) recommends 3 – 4 months of CS (3 - 5ºC) for breaking dormancy in seeds of *Pyrus* species. In contrast, Piotto *et al.* (2003) recommend 2 – 4 weeks of warm stratification followed by 12 – 16 weeks of cold stratification as an effective treatment in breaking dormancy in seeds of *Pyrus* genus. For seeds of *Malus* species, a stratification period of 30 to 120 days at 2 - 5ºC is required to remove embryo dormancy (Anderson and Crossley, 2008).

Various chemical solutions are used to stimulate seed germination (Macdonald, 2006). In addition, growth regulators, such as gibberellic acid and kinetin, are used to partially or fully replace the necessary period of cold moist stratification in a number of plant species (Baskin and Baskin, 1998).

In the published literature, there is no description concerning the combined effect of cold stratification with gibberellic acid or kinetin treatments on germination of *P. pyraster* and *M. dasyphylla* seeds.

The objectives of the present study are to i) examine the effectiveness of gibberellic acid, kinetin and cold stratification on germination, ii) describe the effects of gibberellic acid and cold stratification treatment combinations on germination, iii) describe the effects of kinetin and cold stratification treatment combinations on germination and iv) propose effective treatments to maximize germination of *P. pyraster* and *M. dasyphylla* seeds.

MATERIALS AND METHODS

Mature fruits of *P. pyraster* and of *M. dasyphylla* were collected from a number of trees growing in their natural habitat (40º22΄13΄΄N, 22º03΄31΄΄E, 860 m elevation and 39º58΄36΄΄N, 21º11΄06΄΄E, 990 m elevation respectively) in northern Greece. Fruits of *P. pyraster* were collected on 18 August 2008, and of *M. dasyphylla* on 6 October 2008. After collection, the fruits of both species were pulped and the separation of seeds and pulp was achieved using sieves and running water. In addition, floated seeds were removed during cleaning, and subsequently, the clean seeds of both species were spread out on filter papers in laboratory conditions and left to dry. After drying, the seeds were stored in glass containers in the refrigerator (3 - 5ºC) until they were used in the experiments.

Seed treatment

Germination experiments were carried out in the following winter in the laboratory of Silviculture, Faculty of Forestry and Natural Environment, Aristotle University of Thessaloniki. For each species, an experiment was carried out to determine the effects of gibberellic acid (GA_3), kinetin (6-Furfurylaminopurine), cold stratification (CS) and combination of GA_3 with CS, as well as combination of kinetin with CS on seed germination. Seeds of each species were soaked in solutions of GA_3 and kinetin for 30 hours. The concentrations of GA_3 and kinetin solutions were 500, 1000 and 2000ppm. Subsequently, the treated seeds were placed in plastic containers with moist sterilized river sand and given CS at 3 - 5ºC for 0, 1, 2, and 3 months. For each species, there were six plastic containers which corresponded to the two growth regulators with the three concentrations. For each species, 24 treatments (combinations of GA_3 solutions with CS periods and combinations between kinetin solutions with CS periods) were applied. In addition, seeds (control) from each species were soaked in distilled water for 30 hours and then were subjected to CS for 0, 1, 2, or 3 months. For each species there was a plastic container. During stratification, sand moisture was checked periodically and water was added, when necessary, to keep it moist.

Germination test

For each species, at the end of each CS period, a random sample of 120 seeds was taken out from each plastic container and randomly placed in 4 plastic Petri dishes (30 seeds per Petri dish). For each treatment, there were 4 replications of 30 seeds. Seeds were placed on sterilized river sand moistened with distilled water in 9-cm plastic Petri dishes. Prior to the arrangement of seeds in Petri dishes, the seeds were dusted with fungicide (Captan) to avoid fungi development. The Petri dishes were randomly arranged on the shelves of the growth chamber and were watered with distilled water, as necessary. The temperature in the growth chamber was set at 20ºC for a 16-hour dark period and 25ºC for an 8-hour light period. Germinated seeds were counted once a week for a period of 6 weeks. A seed with at least 2 mm long radicle was considered to be germinated (I.S.T.A., 1999). Finally, for each treatment of each species, the germination percentage (GP) and the mean germination time (MGT) were calculated as the average of the 4 replications. The MGT was calculated for each replication per treatment according to the following equation:

$$MGT = \Sigma(Dn)/\Sigma n$$

where n is the number of seeds which germinate on day D, and D is the number of days counted from the beginning of the test (Ellis and Roberts, 1981).

Statistical analysis

For each species, a completely randomised experimental design was used. In *M. dasyphylla*, treatments, in which none of the seeds germinated, were not included in the statistical analysis. The germination percentage data were arc-sine square root transformed before analysis (Snedecor and Cochran, 1980). The transformed data were checked for normality and homogeneity of variances and then analysed by one-way ANOVA. Comparisons of the means were made using the Duncan test (Klockars and Sax, 1986). All statistical analyses were carried out using SPSS 12.0 (SPSS, Inc., USA).

RESULTS

Pyrus pyraster

There were significant differences in GPs (α=0.05) among the treatments applied in *P. pyraster* seeds ($F_{27,84}$ = 134.47, *P* = 0.00). Seeds, which were not stratified, regardless of GA_3 or kinetin treatment, exhibited very low GPs (0.8 to 1.7%). In control seeds, an increase in the CS (up to 2 months) demonstrated a significant increase ($p<0.05$) in germinated seeds. Seeds, which were only stratified for 2 or 3 months (control seeds), exhibited GPs with no significant difference ($p>0.05$). In each CS period, there were no statistically significant differences ($p>0.05$) in GPs between control seeds and seeds treated with GA_3 or kinetin. In each treatment with GA_3 solution (500, 1000 and 2000ppm), there were no significant differences ($p>0.05$) in GPs between CS periods (1, 2 and 3 months), whereas in each treatment with kinetin solution (500, 1000 and 2000ppm), significant differences ($p<0.05$) in GPs were observed between CS periods. In addition, in each CS period, seeds, which had been treated with the same concentration of GA_3 and kinetin solution, did not exhibit significant differences ($p>0.05$) in GPs, except for one case. After 3 months of CS, the GP of seeds treated with 500ppm of kinetin was higher ($p<0.05$) than that of seeds treated with 500ppm of GA_3.

The MGT of control seeds, GA_3-treated and kinetin-treated seeds, which were all subjected to CS (from 1 to 3 months), ranged from 7.06 to 7.98 days. In control seeds and seeds treated with GA_3 and kinetin, the increase of CS period led to a slight decrease of MGT.

Table 1. *Effects of CS, GA_3 combined with CS, and kinetin combined with CS on GP and MGT of P. pyraster seeds.*

GA_3 (ppm) Kinetin (ppm)	CS (months)	GP (%, ± S.D.)	MGT (days, ± S.D.)
Control	0	0.8 h ± 1.67	*
	1	76. 7 fg ± 5.44	7.81 ± 0.46
	2	87.5 abcde ± 5.00	7.54 ± 0.21
	3	89.2 abcd ± 5.00	7.27 ± 0.22
500[1]	0	1.7 h ± 1.92	*
	1	83.3 cdefg ± 6.09	7.62 ± 0.31
	2	86.7 abcdef ± 5.44	7.47 ± 0.41
	3	84.2 bcdefg ± 5.00	7.28 ± 0.24
1000[1]	0	0.8 h ± 1.67	*
	1	78.3 efg ± 4.30	7.30 ± 0.26
	2	85.8 abcdefg ± 5.69	7.27 ± 0.23
	3	85.8 abcdefg ± 5.69	7.06 ± 0.13
2000[1]	0	1.7 h ± 1.92	*
	1	78.3 efg ± 6.38	7.37 ± 0.13
	2	83.3 cdefg ± 5.69	7.36 ± 0.27
	3	85.8 abcdefg ± 3.19	7.14 ± 0.16
500[2]	0	0.8 h ± 1.67	*
	1	78.8 efg ± 4.30	7.98 ± 0.32
	2	91.7 ab ± 4.30	7.25 ± 0.20
	3	92.5 a ± 5.69	7.19 ± 0.23
1000[2]	0	0.8 h ± 1.67	*
	1	75.8 g ± 3.19	7.85 ± 0.31
	2	87.5 abcde ± 5.69	7.20 ± 0.13
	3	88.3 abcde ± 4.30	7.07 ± 0.13
2000[2]	0	1.7 h ± 1.92	*
	1	80.0 defg ± 5.45	7.30 ± 0.26
	2	90.8 abc ± 5.69	7.25 ± 0.20
	3	87.5 abcde ± 3.19	7.13 ± 0.15

Means are statistically different at $p<0.05$, when they share no common letter. The comparisons were made using the Duncan test.
[1] Concentrations of GA_3 solutions.
[2] Concentrations of Kinetin solutions.
* MGT was not calculated because in one of the four replications, no seed germinated.

Malus dasyphylla

There were significant differences in GPs (α=0.05) among the treatments applied in *M. dasyphylla* seeds ($F_{20,63} = 125.45$, $P = 0.00$).

No un-stratified seeds of *M. dasyphylla* germinated. After 1 month of CS, control seeds and seeds treated with GA_3 or kinetin exhibited very low GPs (2.5 to 5%). In control seeds and seeds treated with GA_3 or kinetin, an increase in the CS period (from 1 to 2 or 3 months), demonstrated a significant increase ($p<0.05$) in GP. In each CS period (1, 2 and 3 months), there were no significant differences ($p>0.05$) in GPs between control seeds and seeds treated with GA_3 solutions (500, 1000 and 2000ppm). In relation to treatments with kinetin solutions, after 2 months of CS, the percentages of the germinated control seeds were higher ($p<0.05$) than those of the seeds treated with 500 and 2000ppm of kinetin. In the other two periods of CS (1 and 3 months) no significant differences ($p>0.05$) in GPs between control seeds and seeds treated with kinetin solutions were observed. In each CS period, seeds, which had been treated with the same concentration of GA_3 and kinetin solution, demonstrated no significant differences ($p>0.05$) in GPs except for two cases. After 2 months of CS, seeds which had been treated with 500 and 2000ppm of $GA_{3,}$ exhibited higher ($p<0.05$) germination than seeds treated with respective concentrations of kinetin.

The MGT of control seeds, GA_3-treated and kinetin-treated seeds, which were all subjected to 2- and 3-month period of CS, ranged from 7.42 to 8.80 days. In control seeds and seeds treated with GA_3 and kinetin, the increase of CS period led to a slight decrease of MGT.

Table 2. *Effects of CS, GA_3 combined with CS, and kinetin combined with CS on GP and MGT of M. dasyphylla seeds.*

GA_3 (ppm) Kinetin (ppm)	CS (months)	GP (%, ± S.D.)	MGT (days, ± S.D.)
Control	0	0,0	
	1	2.5 f ± 1.67	*
	2	46.7 bc ± 4.71	8.14 ± 0.51
	3	65.8 a ± 5.69	7.80 ± 0.18
500[1]	0	0,0	
	1	5.0 f ± 3.34	*
	2	48.3 b ± 4.30	7.95 ± 0.32
	3	70.8 a ± 4.19	7.83 ± 0.44
1000[1]	0	0,0	
	1	4.17 f ± 1.67	*
	2	43.3 bcd ± 4.71	8.45 ± 1.02
	3	66.7 a ± 6.09	7.62 ± 0.2
2000[1]	0	0,0	
	1	5.0 f ± 1.93	*
	2	49.2 b ± 5.00	8.37 ± 0.84
	3	67.5 a ± 5.69	7.42 ± 0.32
500[2]	0	0,0	
	1	3.3 f ± 2.72	*
	2	35.8 de ± 4.19	8.80 ± 0.61
	3	63.3 a ± 2.72	7.56 ± 0.48
1000[2]	0	0,0	
	1	5.0 f ± 3.34	*
	2	38.3 cde ± 4.30	8.10 ± 0.38
	3	67.5 a ± 5.69	7.52 ± 0.19
2000[2]	0	0,0	
	1	4.2 f ± 1.67	*
	2	34.2 e ± 4.19	7.84 ± 0.61
	3	64.2 a ± 5.69	7.46 ± 0.19

Means are statistically different at $p<0.05$, when they share no common letter. The comparisons were made using the Duncan test.
[1] Concentrations of GA_3 solutions.
[2] Concentrations of Kinetin solutions.
* MGT was not calculated because in one of the four replications, no seed germinated.

DISCUSSION

Non-stratified seeds of *P. pyraster* and *M. dasyphylla*, regardless of GA_3 or kinetin treatment, exhibited very low germination or failed to germinate, which confirms that seeds of both species are dormant. As noted in the introduction, seeds of both *Pyrus* and *Malus* genus display dormancy and require a period of cold moist stratification to germinate (Hummer and Postman, 2008; Anderson and Crossley, 2008). This is in agreement with the results of Bao and Zhang (2011a), who state that non-stratified seeds of *P. betulaefolia* and *P. calleryana* failed to germinate. In addition, Lin *et al.* (1994) demonstrate that non-stratified seeds of *P. serotina* did not germinate at 25ºC within a 21-day germination period, whereas, according to Al-Bukhari *et al.* (2002) and Yildiz *et al.* (2008), non-stratified seeds of *P. syriaca* and *P. communis* exhibited very low GPs (13% and about 5%, respectively).

In the present study, *M. dasyphylla* seeds, receiving a one-month CS period (control seeds and seeds treated with GA_3 and kinetin) exhibited low GPs (2.5 – 5%), which demonstrates that a one-month period of CS was insufficient to release dormancy of *M. dasyphylla* seeds. Yilmaz (2008) states that after a 4-week CS period the GPs of *M. trilobata* seeds of three provenances ranged from 6.5 to 14.5%. An increase of the CS period from 1 to 2 months induced a significant increase ($p<0.05$) in the GPs of control seeds and seeds which had been treated with growth regulators. However, a 2-month period of CS was insufficient for complete release from physiological dormancy of *M. dasyphylla* seeds. After 3 months of CS, the GPs of *M. dasyphylla* seeds (control seeds and seeds treated with GA_3 and kinetin) reached their highest points. Similarly, Yilmaz (2008) reported that an 8-week CS period was not enough to break dormancy of *M. trilobata* seeds, whereas a 12-week CS period was sufficient to break seed dormancy completely; additionally, after a 12-week CS period, germination at 18ºC of *M. trilobata* seeds from three provenances range from 87% to 99%. It was also demonstrated by the same author that, after studying the effect of temperature on germination of *M. trilobata* seeds, the optimum temperature was 18ºC, and an increase of temperature from 18ºC to 21ºC, and 24ºC induced a significant decrease in GP. Similarly, Ozga and Dennis (1989) observed a reduction in GP of *M. domestica* seeds with an increase in temperature from 20º to 30ºC. Secondary dormancy can also be induced in seeds of *Malus* spp. by high temperatures (Harrington and Hite (1923) in Baskin and Baskin (1998)). In the present study, if lower than 20º - 25ºC germination temperatures were used, the GP of *M. dasyphylla* seeds may be better.

On the other hand, a one-month CS period of *P. pyraster* seeds (control seeds and seeds treated with GA_3 and kinetin) significantly improved germination. In control seeds, longer CS period (2 or 3 months) significantly enhanced ($p<0.05$) germination. Al-Bukhari *et al.* (2002) report that the GPs of *P. syriaca* seeds subjected to 30 and 60 days of CS were equal to 81 and 98%, respectively. The germination of *P. serotina* seeds, receiving a 21-day period of CS, reached 63%, and the extension of the CS period up to 28 days did not enhance germination (Lin *et al*., 1994). *P. betulaefolia* and *P. calleryana* seeds, subjected to 40 and 50 days of CS, gave GPs equal to 81.8 and 82.8%, respectively. Thus, the present study demonstrates that a 2-month period of CS was sufficient to break physiological dormancy in *P. pyraster* seeds completely.

In both species a slight reduction of MGT with an increase in the CS period was observed. In a number of species, a reduction of MGT of seeds with an increase in the CS period was observed (Yilmaz, 2008; Pipinis *et al*., 2009; Pipinis *et al*., 2012a; Pipinis *et al*., 2012b).

According to Baskin and Baskin (1998), physiological dormancy is the most important type of seed dormancy in species of the temperate zone, and seeds require a 1 to 4-month period of CS (depending on species) to come out of dormancy. Plant hormones are involved in seeds with physiological dormancy. A number of studies have shown that abscisic acid (hormone that is responsible for maintenance of dormancy) levels in seed decrease during the CS (Balboa-Zavala and Dennis, 1977; Pinfield *et al.*, 1987; Chen *et al*., 2007; Bao and Zhang, 2011b), and gibberellin (hormones that promote seed germination) levels in seed increase during cold stratification (Powel, 1987; Chen *et al*., 2007; Bao and Zhang, 2011b).

The results of the present study demonstrate that neither GA_3 nor kinetin treatment improved seed germination of the two species. In both species, it is obvious (Tables 1 and 2) that, after each period of CS, there were no significant differences ($p>0.05$) in GPs between control seeds and GA_3-treated seeds. As far as kinetin treatments are concerned, only in *M. dasyphylla* seeds subjected to a 2-month period of CS (Table 2), GPs of seeds treated with 500 and 2000ppm were lower ($p<0.05$) than the GP of control seeds. In contrast, exogenous GA_3 application has been reported to be effective in breaking dormancy and substituting for the CS requirement in seeds of many species (Karam and Al-Salem, 2001; Smiris *et al*., 2006; Pipinis *et al*., 2011; Pipinis *et al*., 2012a; Pipinis *et al*., 2012b). Al-Bukhari *et al*. (2002) report that GA_3 application did not improve germination of *P. syriaca* stratified seeds. In addition, according to Bao and Zhang (2010), the treatment with chemicals and hormones (H_2O_2, H_3BO_3, KNO_3, PEG-6000, GA_3, 6-BA and 3-IAA) increased GPs of *P. betulaefolia* and *P. calleryana* non-stratified seeds without seed coat significantly, whereas non-stratified seeds with seed coat exhibited low GPs. The positive effect of GA_3, cytokinin and ethephon on germination of non-stratified embryos of *M. domestica* was reported by Sinska (1989), and Zhang and Lespinasse (1991). It is likely that embryo covers (endosperm, seed coat) of *P. pyraster* and *M. dasyphylla* seeds are either impermeable to GA_3 and kinetin or mechanically restrict embryo growth. The inhibitory effect of embryo covers on seed germination may be declined by CS.

In conclusion, the results of the present study demonstrate that CS is essential for breaking dormancy in *P. pyraster* and *M. dasyphylla* seeds. It is also worth emphasizing that the application of GA_3 or kinetin in seeds of both species does not replace or shorten the required CS period.

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AN IMPACT OF SUGAR TYPE AND CONCENTRATION ON INDUCTION OF EMBRYOGENESIS IN ANTHER CULTURE OF *Aesculus carnea* Hayne

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Abstract: *Haploid plant production increases variability of the germplasm, allows fixation of recessive traits, and accelerates plant breeding through double haploid production. This is especially important for the breeding of woody plants, as they have a long reproductive cycle with several years of juvenile phase. With the aim of increasing the efficiency of androgenesis in red horse chestnut, an impact of sugar type and concentration on embryo production in anther culture was tested. Anthers of red horse chestnut were isolated from surface sterilised flower buds (5 mm), cultured on solid MS medium supplemented with 5 μM 2,4-dichlorophenoxyacetic acid (2,4-D) + 5 μM 6-furfurylaminopurine (kinetin, Kin) and either sucrose or maltose at 2%, 5%, 10% and 15%, and kept in darkness for 8 weeks. Thereafter, the anthers were transferred to MS medium with 0.05 μM 2,4-D, 5 μM Kin and 2% sucrose and exposed to 16h light photoperiod. The highest embryogenic response was attained in anthers cultured on media supplemented with 10% and 15% maltose during the induction phase. Androgenic embryos were capable of high frequency secondary somatic embryo formation on medium with 0.05 μM 2,4-D + 5 μM Kin + 2% sucrose. Secondary somatic embryos (SSE) at cotyledonary stage of development germinated readily on the same medium, and developed radicle at high frequency (82.16 ± 1.31%), while 11.59 ± 1.62% of SSEs developed epicotyl, and only 5.13 ± 0.92% of SSEs developed both radicle and epicotyl. Further research is needed to increase the conversion rate from embryos to plantlets.*

Key words: anther culture, embryo germination, red horse chestnut

INTRODUCTION

Plant cell, tissue and organ culture is a powerful tool for mass and rapid plant propagation. Beside fundamental significance, it could be exploited for a large-scale vegetative propagation. This includes micropropagation and somatic embryogenesis for clonal propagation of plants. However, another approach, androgenesis, also offers great possibilities. Haploid plant production allows for increased germplasm variability and fixation of recessive traits, and accelerates plant breeding through double haploid production. This is especially important for the breeding of woody plants, as they have a long reproductive cycle with several years of juvenile phase. Androgenic and somatic embryos have the same course of differentiation, resembling that of zygotic embryos, despite their different origin and ploidy levels. In addition, secondary somatic embryogenesis is an efficient mean for androgenic embryos multiplication. To take advantage of these processes, protocols for embryogenesis ought to be refined, including optimisation of sugar type and its concentration.

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Sugars have very complex and multiple roles during somatic embryogenesis, serving as sources of carbon and energy, osmotica, stress protectants, and signal molecules (reviewed in Lipavská & Konrádová 2004). A variety of saccharides were used in tissue culture of different plant species, including sucrose, glucose, fructose, maltose, lactose, cellobiose, mannitol, sorbitol, myo-inositol etc., but sucrose is a far more used carbon source than any other sugar.

Cultured tissues excrete enzymes that breakdown discaccharides present in culture medium. It was shown that hydrolysis of sucrose into glucose and fructose is relatively rapid (Tremblay & Tremblay 1995), but despite the fact that sucrose rapidly vanishes from the culture medium, it was clear that it still has certain stimulatory effects on somatic embryogenesis, that could not be assigned to its breakdown products (Iraqi & Tremblay 2001a,b). Iraqi & Tremblay (2001a, b) suggested a regulatory role of exogenous sucrose during spruce somatic embryo development via the regulation of the carbohydrate metabolism, essentially through the activation of invertases. Changes in the activity of invertases influenced sucrose: hexose ratio, and that might be a signal for the synthesis of starch and storage proteins, resulting in improved quality and germinability of spruce somatic embryos.

In some cases maltose proved to be a better carbon source than sucrose for the induction and development of androgenic and somatic embryos (Lentini et al. 1995; Daigny et al. 1996; Blanc et al. 1999, 2002; Gutièrrez Pesce & Rugini 2004; Redha & Talaat 2008). In *Havea brasiliensis*, glucose, fructose and sucrose stimulated callus growth, while maltose was not beneficial for callus growth. Instead, it induced somatic embryogenesis much more rapidly and in a higher extent than sucrose (Blanck et al. 2002). Maltose hydrolyses slowly to glucose, so it was hypothesized that the effect of maltose may be through keeping endogenous hexose contents at a low level (Scott et al. 1995). A drop in carbohydrate availability in the plant cell might create a signal that changes development programmes (Koch 1996), which eventually triggers somatic embryogenesis. This is so-called "carbohydrate deficit" hypothesis. In light of this, Blanc et al. (2002) suggested that a limited hexose supply, due to slow maltose hydrolysis, might reorientate the plant cell metabolism towards somatic embryogenesis through starch catabolism.

Literature data suggest that the preference to sugar type is specific for every single plant species, cultivar or even cell line (Tremblay & Tremblay 1991; Lipavská & Konrádová 2004), and it has to be optimised empirically. In addition, plant tissues may not have only different requirements in sugar type and concentration for induction of androgenesis or somatic embryogenesis, but these preferences might be changed during the course of embryo development (Blanc et al. 1999).

The aim of the present study was to optimise sugar type and concentration for the highest embryo regeneration from anther culture of red horse chestnut.

MATERIAL AND METHODS

Plant material

The inflorescences of *Aesculus carnea* were collected from the tree growing in Dr. Zoran Đinđić Boulevard, Belgrade, Serbia. Flower buds (5 mm) (Fig. 1a) were washed with running water and a few drops of detergent (Fairy, Procter & Gamble), and then surface sterilised in 95% ethanol for 5 min, followed by 70% ethanol for 5 min, rinsed three times with sterile distilled water and blotted dry on a piece of sterile filter-paper. Anthers (Fig. 1b, c) were isolated (without filaments) and placed on media for the induction of embryogenesis.

Basal medium

The basal medium contained Murashige & Skoog (MS) mineral solution (Murashige & Skoog 1962), variable type and concentration of sugar, 100 mg/l myo-inositol, 200 mg/l casein hydrolysate, 2 mg/l thiamine, 2 mg/l adenine, 5 mg/l nicotinic acid, 10 mg/l panthotenic acid, all purchased from Sigma-Aldrich (St. Louis, MO, USA). The media were gelled with 0.7% (w/v) agar (Torlak, Belgrade, Serbia). pH of the media was adjusted to 5.6 using a pH-meter and the media were sterilized by autoclaving at 114°C for 25 min.

Induction of regeneration

Isolated anthers were placed in Petri-dishes, on solid MS medium supplemented with either sucrose or maltose (Torlak, Belgrade, Serbia) at 2%, 5%, 10% or 15% and 5 μM 2,4-dichlorophenoxyacetic acid (2,4-D) + 5 μM 6-furfurylaminopurine (Kinetin, Kin) (induction medium). The Petri dishes were sealed with Parafilm®M (Pechiney Plastic Packing, Chicago, IL, USA) and incubated in darkness without subculturing for 8 weeks. Thereafter, the anthers were transferred to solid MS with 0.05 μM 2,4-D + 5 μM Kin + 2% sucrose (maintenance medium). Androgenic embryos were maintained on the same medium. Embryogenic lines, originating from one regeneration event, were maintained as separated cultures.

Culture conditions

All cultures were maintained under cool white fluorescent light with a photosynthetic photon flux density of approximately 50 μmol m^{-2} s^{-1} (as measured by an LI-1400 DataLogger equipped with an LI-190SA Quantum sensor, LI-COR Biosciences) for 16 h per day at 25 ± 2 ºC.

Recordings and statistical analysis

A completely randomised design was used for culture placement. Five samples (Petri-dishes), each with 30 subsamples (anthers), were used per treatment (n=150) for androgenic embryo induction. Regeneration in anther culture was recorded with the aid of a stereomicroscope at 4-week intervals over a period of 8 weeks. Embryo germination was analysed in 5 embryogenic lines. Two replicates, each with five samples (Petri-dishes) with 10 subsamples (embryos) (n=100) were used per embryo line. Formation of radicle and epicotyl was recorded after 4 weeks in culture.

Percentage data were subjected to angular transformation and androgenic embryo (AE) number data to square root transformation before analysis and inversely transformed for presentation. The data were subjected to standard analysis of variance (ANOVA) and the means were separated using Duncan's *post-hoc* test for $P \leq 0.05$. For embryo induction, the results were expressed as the frequency of embryogenic anthers and the mean number of AE per regenerating anther during 8-week period. To take into consideration both values simultaneously, we used an index of embryo-forming capacity (EFC), calculated as follows: EFC = (mean AE number per regenerating anther) x (% of regenerating anthers) / 100. For embryo germination, the results were expressed as the frequencies of radicle and epicotyl formation.

RESULTS

Anthers cultivated on media with different sugar content were different in appearance. Those cultivated on medium supplemented with 2% sucrose or maltose formed voluminous showish calli (Fig. 1d). Callus formation decreased with the increase of sugar concentration (Fig. 1 e, f). In all cases callus was formed from the anther wall and connective tissue. No regeneration was observed on induction media. Regeneration commenced 2 weeks following the transfer to medium with 0.05 μM 2,4-D + 5 μM Kin + 2% sucrose. Androgenic embryos arose directly from the anther sacs (Fig. 1g). First embryos appeared from anthers which were cultivated on maltose-containing media, while regeneration in anthers cultivated on sucrose-containing media was delayed for 2 weeks.

ANOVA indicated significant effect of sugar type and concentration on both the frequency of embryogenesis and the mean embryo number (not shown). The highest response was observed in anthers cultivated on 10% and 15% maltose (Tab. 1).

Androgenic embryos developed rapidly, and within a week most of them reached the cotyledonary stage of development (Fig. 1h). Embryogenic lines, originating from one regeneration event, were maintained as separated cultures. They were multiply and maintained through the process of secondary (also called recurrent or cyclic) somatic embryogenesis (Fig. 1i).

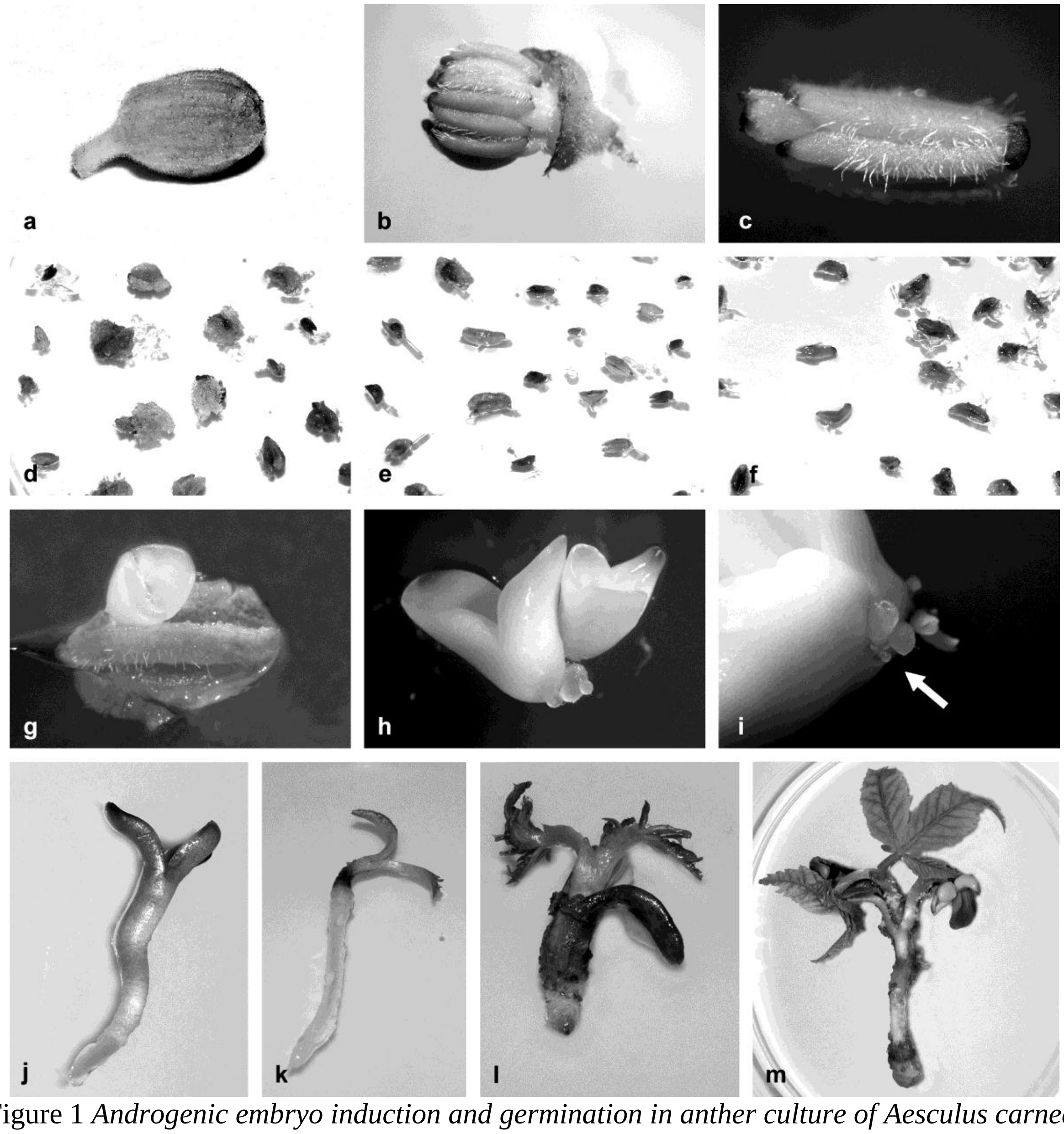

Figure 1 *Androgenic embryo induction and germination in anther culture of Aesculus carnea. a) Flower buds (5 mm) which were used for isolation of anthers. b) The same flower bud after removal of the perianth. c) Red horse chestnut anther. d) Anthers cultured on induction medium with 2% sucrose for 8 weeks. e) Anthers cultured on induction medium with 5% sucrose for 8 weeks. f) Anthers cultured on induction medium with 10% sucrose for 8 weeks. g) Androgenic embryo emerging from an anther. h) Androgenic embryos at the cotyledonary stage of development. i) Secondary somatic embryos formation at radicle pole of an androgenic embryo. j, k) Germinating embryos. i) An embryo with developing epicotyl. m) A plantlet of red horse chestnut.*

The majority of embryogenic lines was able to germinate on maintenance medium with 0.05 μM 2,4-D + 5 μM Kin + 2% sucrose. They developed radicle at high rate (62.5-100 %), although the epicotyls were developed in fewer number of embryos (Tab. 2). However, the radicle and epicotyls quite rarely developed on the same embryo (5-20%), and in two embryogenic lines no conversion of embryos to plants was observed.

Table 1. *Embryo regeneration in anther cultures of red horse chestnut. Anthers were cultivated on MS medium supplemented with 5 μM 2,4-D + 5 μM Kin and variable concentration of sucrose or maltose for 8 weeks and then subcultivated on MS medium with 0.05 μM 2,4-D + 5 μM Kin + 2% sucrose for an additional 8 weeks.*

Sugar (%)	**Embryogenic anthers (%)**	**Mean embryo number**	**EFC**
2% Sucrose	1.37 ± 0.37 d	7.42 ± 0.07 c	0.15 ± 0.06 d
5% Sucrose	1.98 ± 0.53 cd	11.85 ± 1.64 bc	0.21 ± 0.01 d
10% Sucrose	5.33 ± 0.38 bc	12.13 ± 0.47 bc	0.71 ± 0.01 c
15% Sucrose	6.0 ± 0.91 bc	17.28 ± 2,16 b	1.14 ± 0.10 c
2 % Maltose	2.67 ± 0.04 cd	8.23 ± 0.59 c	0.29 ± 0.04 d
5% Maltose	4.01 ± 0.18 c	13.92 ± 0.33 bc	0.58 ± 0.01 cd
10 % Maltose	14.67 ± 0.11 a	32.58 ± 1.44 a	4.91 ± 0.11a
15% Maltose	8.55 ± 1.17 b	28.15 ± 1.26a	2.21 ± 0.09 b

Data represent mean values. Five samples (Petri-dishes) each with 30 subsamples (anthers) (n=150) were used per treatment. Data in a column denoted by the same letter were not significantly different ($P \leq 0.05$) according to Duncan's test. EFC is an index of embryo-forming capacity, calculated as follows: EFC = (mean AE number per regenerating anther) x (% of regenerating anthers) / 100.

Table 2. *Red horse chestnut somatic embryo germination. Embryos of five lines were cultivated on solid MS medium with 0.05 μM 2,4-D + 5 μM Kin + 2% sucrose for 4 weeks.*

Embryo line number	**Embryos forming radicle (%)**	**Embryos forming epicotyl (%)**	**Embryos forming both radicle and epicotyl (%)**
13	62.5 ± 2.03	12.5 ± 0.04	12.5 ± 0.32
15	100	50.32 ± 0.96	20.12 ± 0.12
20	75.61 ± 1.38	12.19 ± 0.28	9.76 ± 0.96
21	81.82 ± 0.95	0	0
27	71.43 ± 4.01	5.36 ± 0.13	0
Mean	82.16 ± 1.31	11.59 ± 1.62	5.13 ± 0.92

Data represent mean values. Two replicates, each with five samples (Petri-dishes) with 10 subsamples (embryos) (n=100) were used per embryo line.

DISCUSSION

We reported here on beneficial effect of maltose on induction of regeneration in anther culture of red horse chestnut, but the frequencies of regeneration obtained in the present study are quite modest. By contrast, Radojević et al. (1989) achieved higher frequencies of regeneration (up to 38%) in red horse chestnut using 2% sucrose as a carbon source. This discrepancy may be explained by different genetic background of donor plants, as the material was collected from different red horse chestnut individuals. This is in accordance with results obtained by Ćalić-Dragosavac et al. (2010), who demonstrated a significant effect of both genotype and the environment on embryogenic capacity of horse chestnut (*A. hipocastanum*) anthers.

Maltose has been reported to be beneficial for somatic embryo production in cherry rootstock "Colt" (Gutièrrez Pesce & Rugini 2004), apple cultivar "Gloster 69" (Daigny et al. 1996), and anther culture of highly recalcitrant rice genotypes (Lentini et al. 1995). It was also useful in regeneration of green plants in anther culture of wheat (Redha & Talaat 2008). By contrast, maltose was inefficient in induction of somatic embryogenesis from floral organs of cocoa (Traore & Guiltinan 2006) and immature pearl millet embryos (Oldach et al. 2001). Sucrose was superior to maltose in somatic embryo production from floral organs of cocoa (Traore & Guiltinan 2006), root explants of *Prunus incisa* (Cheong & Pooler 2004), and anthers of niger (Hema & Murthy 2007) and cucumber (Ashok Kumar & Murthy 2004).

As was previously mentioned, different plant species display different requirements for sugars at different stage of development. Blanc et al. (1999) demonstrated that most of the cells of *H. brasiliensis* calli acquired embryonic characteristics after two weeks of cultivation on a maltose treatment, but afterwards they had to be transferred to a new medium; otherwise the cells in globular proembryos degenerate. This might be in accord with a finding of Troch et al. (2009), who found different sugar preferences in later stages of horse chestnut somatic embryos. In their study sucrose proved to be superior over other sugars (glucose, fructose and maltose) for somatic embryo maturation and their conversion into plantlets.

Somatic embryos obtained in the present study were efficiently multiplied by secondary somatic embryogenesis, as was demonstrated in our previous report (Zdravković-Korać et al. 2008), as well as in horse chestnut (Kiss et al. 1992; Ćalić et al. 2005). However, conversation rates obtained in the present study were embryogenic-line-dependent with only up to 20%. Troch et al. (2009) achieved conversion rates of up to 88.9% in *A. hippocastanum*, but the overall quality of the plantlets, as was judged by the subsequent plantlets' growth, was rather poor.

To conclude, in this paper we reported on beneficial effect of maltose on red horse chestnut androgenic embryo regeneration and subsequent embryo multiplication by secondary somatic embryogenesis. However, achieved conversion rates were unsatisfactory and this process is to be optimised in the future.

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SOMATIC EMBRYOS REGENERATION FROM FILAMENTS OF *Aesculus flava* Sol.

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Abstract: *Somatic embryogenesis is a powerful technique widely used for propagation of elite genotypes, especially mature, difficult-to-propagate woody species, like ornamental species of the genus Aesculus. For the purpose of clonal propagation of A. flava, callus was induced from the stamen filaments cultured in darkness on MS medium with variable levels of 2,4-dichlorophenoxyacetic acid (2,4-D) and 6-furfurylaminopurine (kinetin). Among the 2,4-D/Kin combinations tested, 5 μM 2,4-D + 5 μM Kin was optimal combination for the highest callus growth. Some of the friable filament-derived calli were dispersed in liquid MS medium supplemented with 5 μM 2,4-D + 5 μM Kin to induce cell suspensions. After 8 weeks of culture, the callusing filaments were transferred to solid plant growth regulator (PGR) - free medium, while microcalli in suspensions were spun down, resuspended in semisolid PGR-free medium and dispensed in Petri-dishes. Both types of cultures were exposed to 16h light photoperiod. Somatic embryogenesis was achieved by the two techniques after approximately 4 weeks, but cell suspension was a more efficient method. Both 2,4-D and Kin were indispensable for the induction of callus competent for somatic embryogenesis. Primary somatic embryos obtained by the two methods exhibited a great potential of secondary somatic embryogenesis, yielding numerous secondary somatic embryos. Cyclic somatic embryogenesis allowed the establishment of permanent embryogenic cultures.*

Key words: filaments, cell suspension, somatic embryogenesis, tissue culture, yellow buckeye

INTRODUCTION

Species of the genus *Aesculus* are used predominantly in the landscape as they are among the most attractive ornamental specimens (Chanon 2005). For clonal propagation of *A. flava,* propagation by stem cuttings, grafting and budding techniques have been used. However, the propagation of *Aesculus* by stem cuttings has limited success, as the rooting of stem cuttings varies from specimen to specimen, and commercially acceptable levels of rooting were rarely achieved (Chanon 2005). An alternative approach for clonal propagation might be *in vitro* propagation by the means of plant cell, tissue and organ culture. Micropropagation and somatic embryogenesis are widely recognised methods for propagation of "difficult-to-propagate" plant species (Von Aderkas & Bonga 2000, Bonga *et al*. 2010). However, these methods also have serious limitations, including lesser success with adult than with young trees. Fortunately, this problem could be overcome by using tissues that are in a more juvenile state than most other tissues of the tree (Von Aderkas & Bonga 2000). One possibility is the use of sporophytic stamen tissues, as was done in horse chestnut (Jörgensen 1989, Kiss *et al*. 1992, Capuana &

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Debergh 1997, Troch *et al*. 2009), cocoa (Alemanno *et al*. 1996), grape (Nakajima & Matsuta 2003, Dhekney et al. 2009) and feijoa (Stefanello *et al*. 2005).

In *Vitis* species and varieties, stamens exhibited high embryogenic response, so that highly reliable protocols were obtained for 29 *Vitis* species, varieties and hybrids (Dhekney *et al*. 2009). Plant recovery from germinated somatic embryos (SE), although was variety-dependent, in some varieties gave excellent result of 87%, and the plantlets were successfully established in a greenhouse after acclimatization. Nakajima & Matsuta (2003) were able to regenerate certain *Vitis* genotypes recalcitrant to regeneration by other methods using filament culture.

Alemanno *et al*. (1996) has demonstrated high embryogenic potential of cocoa stamen-filament-derived calli. The response of filaments to *in vitro* regeneration was genotype-dependent, not only in cocoa, but also in grape (Nakajima & Matsuta 2003, Dhekney *et al*. 2009) and feijoa (Stefanello *et al*. 2005).

In *A. hippocastanum*, stamen filaments were successfully used as an explant for the induction of somatic embryogenesis (Jörgensen 1989, Kiss *et al*. 1992, Capuana & Debergh 1997, Troch *et al*. 2009). However, this is not the case for *A. flava*, and, as well as we know, this is the first report on SE regeneration from stamen filaments of *A. flava*. The aim of the present study was to determine optimal 2,4-D/Kin balance for acquiring a competence for somatic embryogenesis in filament-derived callus cells of *A. flava*.

MATERIALS AND METHODS

Plant material

Plant material was collected from a tree growing in Botanical garden "Jevremovac", Belgrade, Serbia. Flower buds (5 mm) of *Aesculus flava* (Fig. 1a) were washed with plenty of running water and a few drops of detergent (Fairy, Procter & Gamble), and then surface sterilised in 95% ethanol for 5 min, followed by 70% ethanol for 5 min, rinsed three times with sterile distilled water and blotted dry on a piece of sterile filter-paper. The perianth was removed (Fig. 1b) and stamen filaments dissected out with the aid of a stereomicroscope (Fig. 1c).

Basal medium

The basal medium contained Murashige & Skoog (MS) mineral solution (Murashige & Skoog 1962), 2% sucrose, 100 mg/l myo-inositol, 200 mg/l casein hydrolysate, 2 mg/l thiamine, 2 mg/l adenine, 5 mg/l nicotinic acid, 10 mg/l panthotenic acid, all purchased from Sigma-Aldrich (St. Louis, MO, USA). The media were gelled with 0.7% (w/v) agar (Torlak, Belgrade, Serbia). pH of the media was adjusted to 5.6 using a pH-meter and the media were sterilized by autoclaving at 114°C for 25 min.

Induction of somatic embryogenesis in filament culture

Isolated filaments were placed in 90-mm Petri-dishes containing MS medium with 5 or 10 μM 2,4-dichlorophenoxyacetic acid (2,4-D) combined with 0 or 5 μM 6-furfurylaminopurine (Kinetin, Kin). The Petri-dishes were wrapped in Al-foil and incubated without subculturing for 8 weeks. Following 8 weeks of culture, equal number of callusing filaments was transferred to either solid plant growth regulator (PGR) - free medium or medium with 5 μM Kin. Both media were supplemented with 400 mg/l of filter-sterilised glutamine. The cultures were maintained in 16 h photoperiod with a photosynthetic photon flux density (PPFD) of approximately 35 $\mu mol\ m^{-2}\ s^{-1}$.

Suspension preparation

Some of the friable filament-derived calli, induced from filaments that were cultivated on solid medium with 5 μM 2,4-D + 5 μM Kin for 8 weeks, were dispersed in liquid MS medium

(50 calli/50 ml) supplemented with 5 μM 2,4-D + 5 μM Kin, as to prepare cell suspensions. Fine suspensions were prepared by sieving crude suspensions through a 200μm mesh. Suspensions were refreshed weekly by mixing equal volumes of suspension and fresh liquid medium of the same composition. Suspensions were maintained in darkness on a platform shaker at 85 rpm. These suspensions were used for experiments.

Induction of somatic embryogenesis in suspensions

For induction of somatic embryogenesis, microcalli (Fig. 2a) were washed with PGR-free liquid medium, somatic embryos removed with the aid of a stereomicroscope, and 200 mg of microcalli were inoculated in 50 ml of liquid medium with 1, 5 or 10 μM 2,4-D in combination with 0, 1, 5 or 10 μM Kin. Suspensions were shaken on a platform shaker at 85 rpm and maintained in 16h light photoperiod with a PPFD of approximately 20 μmol m^{-2} s^{-1}. Following 4 weeks, microcalli were spun down by quick spin, liquid medium carefully removed and discarded. Microcallus was resuspended in 30 ml of liquid PGR-free medium. The resulting suspension was mixed with 30 ml of solid PGR-free medium with 1.2% agar cooled to 38ºC, mixed well and dispensed in 3 Petri-dishes. The cultures were maintained at PPFD of 35 μmol m^{-2} s^{-1} for 16 h per day.

Culture conditions

All cultures were maintained under cool white fluorescent light with variable photosynthetic photon flux densities (specified in the text), as measured by an LI-1400 DataLogger equipped with an LI-190SA Quantum sensor, LI-COR Biosciences, for 16 h per day at 25 ± 2 ºC.

Recordings and statistical analysis

A completely randomised design was used for culture placement. For filament culture, six samples (Petri-dishes), each with 20 subsamples (filaments), were used per treatment (n=120). For induction of somatic embryogenesis in suspensions, six suspensions were prepared for each treatment. Regeneration in filament culture was recorded at 4-week intervals over a period of 12 weeks. The number of somatic embryos (SE) in suspensions was recorded 4 weeks following suspension inoculation (immediately after they were dispensed in Petri-dishes). Bipolar somatic embryos were counted with the aid of a stereomicroscope. SE classes of 1-2 mm (I class), 3-5 mm (II class) and > 5 mm (III class) were recorded.

Statistical differences among treatments were tested using standard analysis of variance (ANOVA). The means were separated using Duncan's *post-hoc* test for $P \leq 0.05$. SE number data were subjected to square root transformation prior to analysis, followed by inverse transformation for presentation. Results were expressed as the mean SEs number per suspension and an index of SE classes ratio, calculated as follows: I/(II + III).

RESULTS

Callus formation from filaments

Filaments enlarged and callus started to form from the basal part of filaments following a week of culture. ANOVA showed significant differences among the treatments, with Kin being a key factor affecting callus growth (not shown). In the absence of Kin only small solid calli formed (Fig. 1 d), regardless of 2,4-D concentration used (Tab. 1). The addition of Kin in culture medium significantly improved callus yield (Tab. 1). Voluminous, nodular, soft, yellowish-ocher callus, with no solid zones, was formed from filaments cultured on 5 or 10 μM 2,4-D in combination with 5 μM Kin (Fig. 1e).

Table 1. *Callus formation from filaments cultivated on solid MS medium with 5 or 10 μM 2,4-D in combination with 0 or 5 μM Kin for 8 weeks.*

2,4-D μM	**Kin μM**	**Callus weight mg**
5	0	18.05 ± 0.81 b
	5	72.77 ± 2.91 a
10	0	16.18 ± 1.34 b
	5	75.48 ± 2.86 a

Data represent mean values. Six samples (Petri-dishes) each with 20 subsamples (filaments) (n=120), were used per treatment. Treatments denoted by the same letter were not significantly different ($P \leq 0.05$) according to Duncan's test.

Induction of somatic embryogenesis in the filament culture

First somatic embryos were observed in the filament culture 4 weeks following the transfer to PGR-free or Kin-supplemented medium (Fig. 1f, g). There was no statistical difference between these treatments and in both of them, the frequency of embryogenic filaments was 5%. Only calli induced on medium with 5 μM 2,4-D + 5 μM Kin were embryogenic. Calli derived from other treatments have been kept for 12 weeks with no regeneration and then they were discarded.

SE obtained from filament culture multiplied by secondary somatic embryogenesis giving thousands of secondary SEs (Fig. 1h). These SEs germinated readily on 1 μM Kin or BA at very high frequency (Fig. 1i), although they rarely converted to complete plantlets.

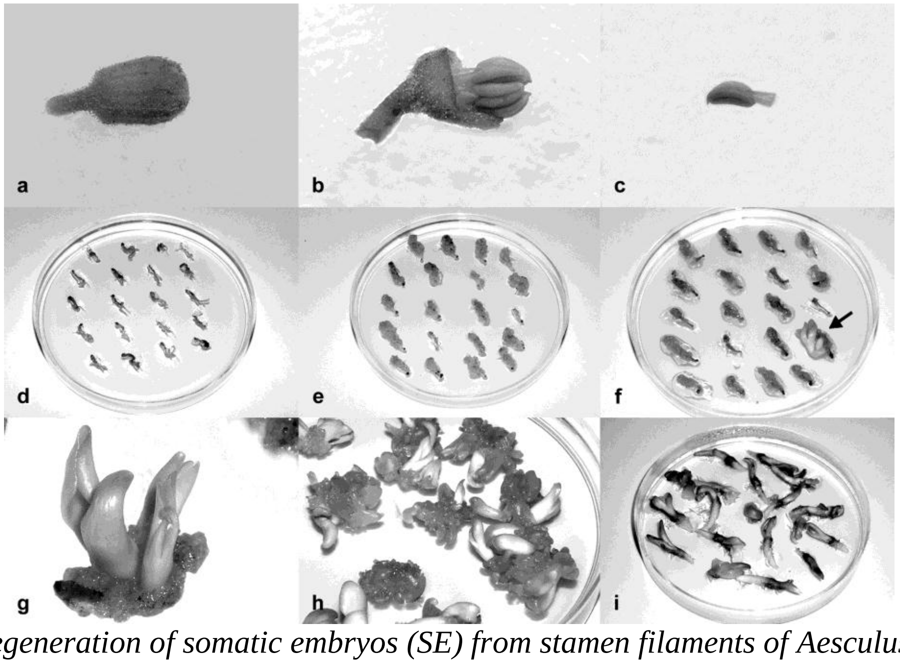

Figure 1. *Regeneration of somatic embryos (SE) from stamen filaments of Aesculus flava. a) A surface sterilised 5-mm-long flower bud. b) The perianth was removed. c) The stamens were dissected out and filaments isolated. d) Filaments (without anthers) cultured on solid MS medium with 10 μM 2,4-D, without Kin for 8 weeks. e) Filaments (without anthers) cultured on MS medium with 5 μM 2,4-D + 5 μM Kin for 8 weeks. f) SEs (arrow) regenerated 4 weeks following the transfer from 5 μM 2,4-D + 5 μM Kin to PGR-free medium. g) SEs emerging from filament-derived callus. h) Secondary SEs regenerated from primary SEs. i) Germinating SEs cultivated on MS medium with 1 μM Kin for 4 weeks.*

Induction of somatic embryogenesis in suspensions

Microcalli, which were used for inoculation of new suspensions, had very fine granulation, with particles of up to 1-2 mm (Fig. 2a). Bigger conglomerates fell apart as they were touched with forceps. The quality of callus was the same following experiment with different 2,4-D/Kin balance (Fig. 2b, d). Following the plating of suspensions, numerous SEs (Fig. 2b, c) emerging from microcalli (Fig. 2e, f) were observed.

ANOVA indicated significant effect of both 2,4-D and Kin, and their interaction as well, on SE regeneration (not shown). The highest SE mean number per suspension (2001.91 ± 2.38) was achieved in liquid medium containing 1 μM 2,4-D without Kin (Fig. 3). The number of SEs decreased with increased concentration of 2,4-D (5 and 10 μM 2,4-D). The inclusion of Kin in the liquid media, generally inhibited somatic embryogenesis, although 2,4-D/Kin balance appeared very important. SE mean number at 1/10 ratio (2,4-D/Kin) was significantly higher than at 1/1 or 1/5. This trend remained in the case of 5/10 and 10/10 ratio, indicating the positive influence of higher Kin levels on somatic embryo induction.

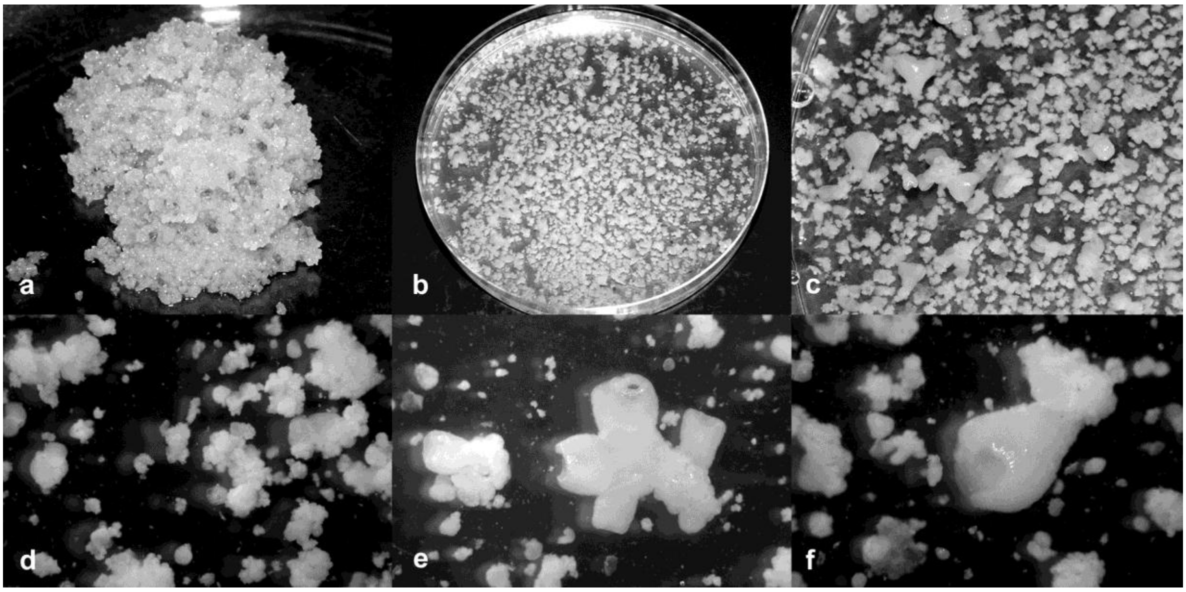

Figure 2. *Regeneration of somatic embryos (SE) from suspensions. a) Filament-derived embryogenic callus induced on MS medium with 5 μM 2,4-D + 5 μM Kin for 8 weeks and then maintained in liquid medium of the same composition. b) A suspension dispensed in a Petri-dish. c) Microcalli cultivated in liquid MS medium with 1 μM 2,4-D for 4 weeks and then dispensed in a Petri-dish. Numerous SEs could be seen. d) Microcalli. e-f) SEs emerging from microcalli.*

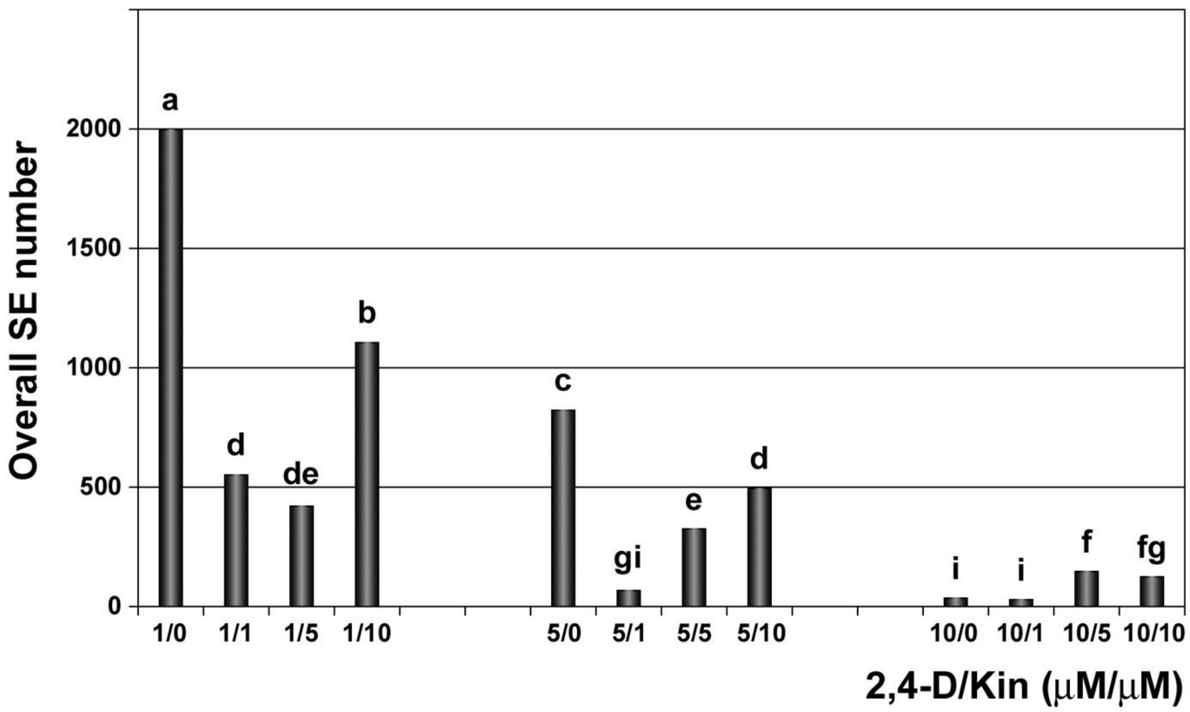

Figure 3. *The mean SE number regenerated from suspensions with 1, 5 or 10 µM 2,4-D in combination with 0, 1, 5 or 10 µM Kin. SE number was counted following 4 weeks of culture. Data represent mean values of six samples (suspensions). Treatments denoted by the same letter were not significantly different ($P \leq 0.05$) according to Duncan's test.*

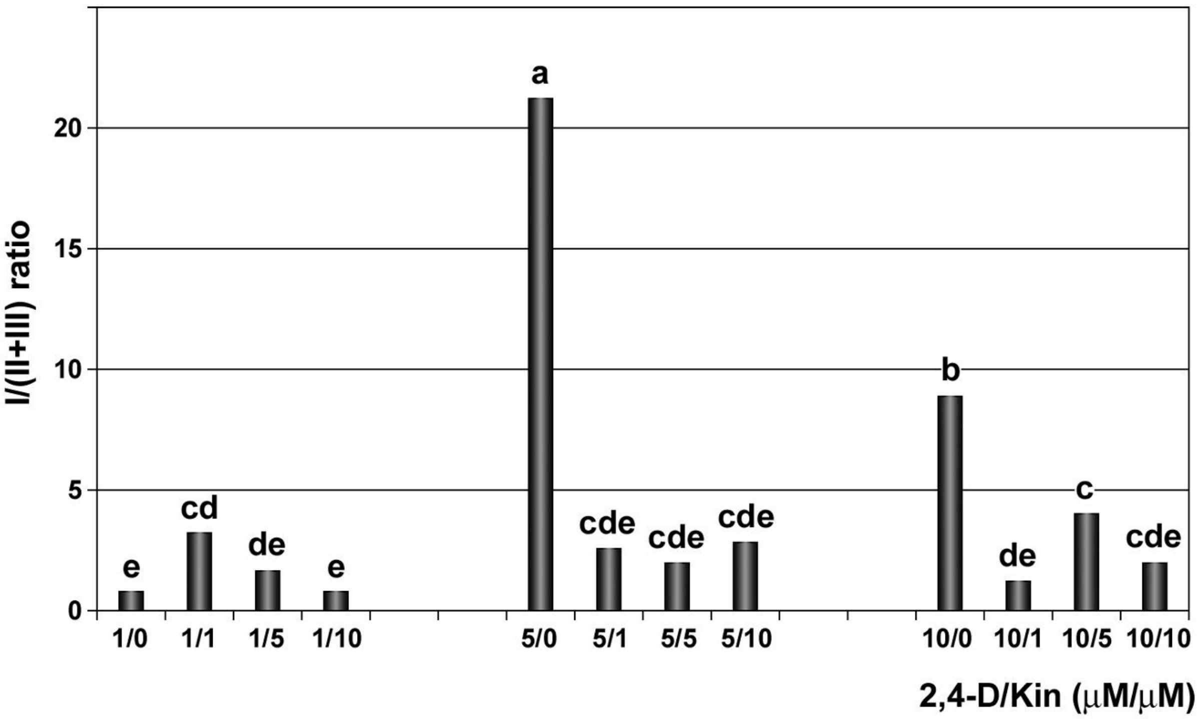

Figure 4. *SE classes ratio, calculated as I/(II+III), where I class SEs represent SEs of 1-2 mm, II class SEs of 3-5 mm and III class SEs > 5 mm. Data represent mean values of six samples (suspensions). Treatments denoted by the same letter were not significantly different ($P \leq 0.05$) according to Duncan's test.*

The level of 2,4-D affected not only the overall SE number, but also SE growth and development. ANOVA showed strong effect of 2,4-D, Kin and their interaction on index I/(II+III). 2,4-D at 1 μM allowed further SE growth, as bigger SEs (II+III class) dominated over small SEs (I class) (1175 vs. 811). The ratio I/(II+III) was 0.73 for this treatment (Fig. 4). This ratio was also achieved with 1/10 combination (0.76). In all other 2,4-D/Kin combinations the ratio ranged from 2 to 21. This indicates that 2,4-D at higher levels (5 or 10 μM) favoured the induction of SEs, whereas 1 μM 2,4-D and 2,4-D in combination with Kin favoured further SE development, rather than induction of new SEs.

DISCUSSION

We reported here on SE regeneration from filament-derived calli of *A. flava*. The process of regeneration in filament culture was rather inefficient (5%), but it is in accord with results obtained in many other plant species, including *A. hippocastanum* (Kiss *et al*. 1992, Capuana & Debergh 1997, Troch *et al*. 2009), *Vitis vinifera* L., *Vitis labruscana* (Nakajima & Matsuta 2003) and *Feijoa sellowiana* (Stefanello *et al*. 2005). In the present study, SE differentiated through an intermediary callus phase, like in *A. hippocastanum* (Kiss *et al*. 1992, Capuana & Debergh 1997, Troch *et al*. 2009), though Kiss *et al*. (1992) were able to obtain both direct and indirect SE regeneration from stamen filaments of horse chestnut.

Out of four 2,4D/Kin treatments used for callus induction in the present study, only those with 5/5 and 10/5 balance gave satisfactory callus yield, and SEs regenerated only from calli induced on 5/5 2,4-D/Kin ratio supplemented medium. This aspect is in contrast with the results of Capuana & Debergh (1997) and Troch *et al*. (2009) in *A. hippocastanum*, who found 10 μM 2,4-D to be the sole PGR suitable for embryogenic callus induction. In addition, the quantity and quality of callus obtained by Capuana & Debergh (1997) and Troch *et al*. (2009) differed from those obtained in the present study. Capuana & Debergh (1997) and Troch *et al*. (2009) obtained two types of calli: compact, yellowish embryogenic callus and less dense, whitish nonembryogenic callus. However, we obtained only nodular, soft, yellowish-ocher callus, with no solid zones. In accord with this, Alemanno *et al*. (1996) found morphological differences among calli from embryogenic and non-embryogenic genotypes of cocoa. Highly responsive genotypes produced yellowish nodular calli, while nonresponsive genotypes produced a white, compact callus. Nodules of cocoa embryogenic callus contained meristematic cells at the periphery, which divided quickly upon the transfer from callus induction medium to PGR-free medium, giving a rise to well developed meristematic masses and eventually SEs.

The problem with quite low frequencies of regeneration in filament cultures could be bypassed in two ways: by the process of secondary somatic embryogenesis and by combining liquid and solid media. Secondary somatic embryogenesis is a common method used for multiplication of SEs (Kiss *et al*. 1992, Capuana & Debergh 1997, Ćalić *et al*. 2005a, Zdravković-Korać *et al*. 2008, Troch *et al*. 2009). As it proceeds in a repetitive manner, the process of secondary somatic embryogenesis is widely used for the establishment and maintenance of permanent SE cultures (von Arnold *et al*. 2002). Suspensions of filament-derived microcalli yielded higher number of SEs than filament culture in the present study (not compared statistically). We were able to obtain as much as 2000 SEs from 200 mg of starting embryogenic callus for a 4-week period, while only a few hundreds of SEs could be obtained from filament cultures during the same time. It might be explained by the better supply of nutrients and PGRs in a liquid culture than in a solid culture. Better results with suspension culture than with filament culture were also reported for feijoa (Stefanello *et al*. 2005), horse chestnut (Kiss *et al*. 1992) and grape (Nakajima & Matsuta 2003).

Results obtained in this study clearly show that the development of SE could be controlled and manipulated by PGR balance. In the forthcoming experiments this thesis will be further elaborated, as to optimise a protocol for quick and efficient SE induction and development in the same culture by simple exchange of liquid medium.

SEs obtained in this study germinated readily, although development of the shoot apex was not so efficient. By contrast, SEs germination in *A. carnea* was difficult to achieve (Zdravković-Korać *et al*. 2008). Actually, further development of SEs in *Aesculus* species, including the germination and conversion into plantlets, was generally poor in all protocols, causing a bottleneck in clonal propagation of these species. These phases are affected by disturbed maturation, which is a key phase preceding embryo germination. These phenomena are usually associated with aberrant embryogenesis and shoot meristem formation. However, Troch *et al*. (2009) showed this was not true for horse chestnut somatic embryos derived from stamen filaments. They found that the vascular system and shoot and root apices were well established under histological examination. Therefore, they concluded that other factors, rather than improper shoot meristem organisation, were responsible for poor germination and conversion. Capuana and Debergh (1997) found an improvement in the maturation and post-maturation phases and increased somatic embryo germination and conversion when treating horse chestnut embryogenic calli with polyethylene glycol (PEG). Cold treatment (6°C) for four to six months, significantly improved both germination and conversion rates in horse chestnut androgenic embryos (Ćalić *et al*. 2005b). Optimisation of germination and conversion of *A. flava* SEs to healthy plantlets is underway in our laboratory.

To conclude, we described here a very efficient protocol for the induction of somatic embryos from stamen filaments of *A. flava*, which is suitable for clonal propagation of an elite mature specimens.

Acknowledgement

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ROOTING AND PREVENTING SHOOT-TIP NECROSIS OF *IN VITRO* CULTURED HORSE CHESTNUT SHOOTS

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Abstract: *Efficient bud regeneration was achieved from germinating horse chestnut (Aesculus hippocastanum L.) somatic embryos cultivated on 1-10 μM benzyladenine (BA). Adventitious buds were detached from the mother tissue and used to establish permanent shoot cultures on 0-20 μM BA. Secondary buds were regenerated from the shoot base of the explants. Bud multiplication was very poor (1.9) and shoot-tip necrosis was very high (100%) on plant growth regulator (PGR)-free medium. The highest multiplication was achieved on 5 and 10 μM BA (16.8 and 18.7, respectively), with no shoot-tip necrosis, while hyperhydration was rather frequent on shoots cultivated on BA above 5 μM. Individual shoots were elongated on medium with 1 μM BA and 500 mg/l polyvinylpyrrolidone (PVP MW 40 000) for 4 weeks. However, it was necessary to reduce BA level below 1 μM for shoot rooting and that caused mass shoot-tip necrosis. As classical rooting methods failed, the basal part of each elongated shoot was first wounded by cutting with a sterile blade and then dipped into a 0, 5 or 10 mM indole-3-butyric acid solution for 1 min and cultivated on solid half-strength MS PGR-free medium with 0.02% activated charcoal for 2-3 weeks. To prevent shoot tip necrosis during this phase, a BA solution was applied directly on apical meristem. Shoot-tip necrosis was completely eliminated by weekly application of 10 μl of 1 μM BA. As soon as the root initials were observed, the shoots were transferred to MS medium supplemented with 500 mg/l PVP and 5 μM BA. The frequency of rooting was 23%, and further optimisation of root-inducing phase is needed.*

Key words: *Aesculus hippocastanum*, rooting, shoots-tip necrosis

INTRODUCTION

Horse chestnut is one of the most popular ornamental trees, widely distributed throughout the temperate parts of the northern hemisphere, especially in the urban areas, as it withstands high pollution. However, conventional propagation of horse chestnut through cuttings and seedlings is rather inefficient (Radojević 1991). As the use of adult specimens for clonal propagation of woody plants is preferable to juvenile individuals because of its known genetic development potential (Bonga *et al*. 2010), seedlings are not suitable, since they represent genotypes of unknown performance. In line with this, cloning by the means of tissue culture is widely recognised technique for vegetative propagation of woody plants.

Modern biotechnological techniques are increasingly employed in the propagation of woody plants, with shoot culture being a convenient method for mass clonal propagation of elite specimens. However, despite its great potential, the application of *in vitro* propagation is often limited in some plant species due to the presence of physiological disorders, like shoot-tip

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necrosis (reviewed in Bairu *et al*. 2009a). This is especially the case in woody plant species, including *Castanea sativa* (Piagnani *et al*. 1996, Vieitez *et al*. 1989), *C. dentata* (Xing *et al*. 1997), *Quercus rubber* (Vieitez *et al*. 1989), and fruit trees like pear (Grigoriadou *et al*. 2000), apple (Kataeva *et al*. 1991), apricot (Perez-Tornero & Burgos 2000), grape (Thomas 2000) and banana (Martin *et al*. 2007).

Shoot-tip necrosis (browning of the apical shoot) could be caused by a variety of factors, including plant growth regulators (PGR), calcium and boron content, and culture environment (Bairu *et al*. 2009a). In fact, this is a rather complex phenomenon, which is the most probably caused by a synergistic action of multiple factors.

One of possible causes of shoot-tip necrosis is suboptimal level of cytokinins in the shoot apex due to decreased availability of cytokinins. This is because the level of endogenous cytokinins is low due to the absence of roots (the main site of their synthesis) and exogenously supplied cytokinins are generally excluded or kept at low level during root-inducing phase. Optimisation of cytokinin type and concentration in growth medium was essential for the control of shoot-tip necrosis in *Q. rubber* (Grigoriadou *et al*. 2000) and *Harpagophytum procumbens* (Bairu *et al*. 2009b, 2011), and the application of cytokinins directly to the shoot apex was helpful in preventing shoot-tip necrosis in some species, like apricot (Perez- Tornero & Burgos 2000) and *C. sativa* (Piagnani *et al*. 1996).

Bairu *et al*. (2011) demonstrated that changes in cytokinins availability, rather than their absence, may be related to shoot-tip necrosis in *H. procumbens*. They found higher levels of total cytokinins in all parts of the necrotic shoots comparing to normal shoots, and in both necrotic and normal shoots the level of cytokinins decreased acropetally. Further structural analysis of cytokinin compounds showed accumulation of inactive and toxic cytokinin-9-glucosides and lower levels of storage cytokinin-O-glucosides in necrotic shoots than in normal shoots (Bairu *et al*. 2011). The authors assumed that shoot-tip necrosis might be a consequence of the conversion of active cytokinin forms to inactive and toxic 9-glucosides.

Calcium and boron deficiencies may also cause shoot-tip necrosis. Calcium strongly affects plant growth and development participating in a number of physiological functions, including modulation of cytokinin activity (Hepler 2005, Hirschi 2004). Higher Ca^{2+} concentration in culture medium, its better uptake and efficient translocation decreased shoot-tip necrosis syndrome in certain plant species (Piagnani *et al*. 1996; Bairu *et al*. 2009b), although there are opposite reports (Grigoriadou *et al*. 2000). Boron deficiency also inhibits growth of shoot and root meristems (Hu & Brown 1994), and affects levels of auxins and cytokinins (Wang *et al*. 2006).

This study attempted to evaluate the capacity of horse chestnut shoots for *in vitro* multiplication and to find factors that can help to control necrosis of the shoot apex.

MATERIAL AND METHODS

Basal medium

The basal medium contained Murashige & Skoog (MS) mineral solution (Murashige & Skoog 1962), 2% sucrose, 0.7% agar, 100 mg/l myo-inositol, 200 mg/l casein hydrolysate, 2 mg/l thiamine, 2 mg/l adenine, 5 mg/l nicotinic acid, 10 mg/l panthotenic acid. pH of the media was adjusted to 5.6 using a pH-meter and the media were sterilized by autoclaving at 114°C for 25 min.

Bud induction and multiplication

Shoot buds were induced from germinating horse chestnut (*Aesculus hippocastanum* L.) somatic embryos (3 cm) cultivated on solid MS medium supplemented with 1-10 μM benzyladenine (BA) (Zdravković-Korać *et al*. 2008). Bunches of adventitious buds were detached from the mother tissue and subcultivated on solid MS medium with 5 μM BA until they were 1 cm high. These shoots (hereinafter referred to as the primary shoots) were split and the solitary shoots were cultivated on solid MS medium with 0-20 μM BA during four weeks, for secondary shoot induction.

Shoot elongation, rooting and preventing shoot-tip necrosis

For elongation and rooting of shoots, we used a procedure developed by Xing *et al*. (1997) for *C. dentata*. Briefly, individual shoots were elongated on solid MS medium with 1 μM BA and 500 mg/l polyvinylpyrrolidone (PVP, MW 40 000) for 4 weeks, and then the basal part of elongated shoots was wounded by cutting with a sterile blade, dipped into an indole-3-butyric acid (IBA) solution at 0, 5 or 10 mM for 1 min, and placed on half-strength MS PGR-free solid medium supplemented with 0.02% activated charcoal for 2-3 weeks. To prevent shoot tip necrosis during this phase, in another experiment, 10 μl of 0, 1, 5 or 10 μM BA solution was applied directly on apical meristem of 10 mM IBA-treated shoots by using a pipetman. As soon as the root initials were observed, the shoots were transferred to MS medium supplemented with 500 mg/l PVP and 5 μM BA.

Culture conditions

All cultures were maintained under cool white fluorescent light with a photosynthetic photon flux density of approximately 50 μmol m^{-2} s^{-1} (as measured by an LI-1400 DataLogger equipped with an LI-190SA Quantum sensor, LI-COR Biosciences) for 16 h per day at 25 ± 2 ºC.

Recordings and statistical analysis

A completely randomised design was used for culture placement in all experiments. Experiments were performed in two replicates, each with three samples (Erlenmeyer flasks) and five subsamples (shoot buds) for each treatment (n=30).

The number of shoot buds per somatic embryo and the number of secondary buds per primary shoot were counted with the aid of a stereomicroscope after 4 weeks of culture. The number of roots was recorded 4 weeks following the root-inducing treatment, and the presence of shoot-tip necrosis was evaluated at the end of bud multiplication experiment and 4 weeks following root-inducing treatment.

Statistical differences among treatments were tested using standard analysis of variance (ANOVA). The means were separated using Duncan's *post-hoc* test for $P \leq 0.05$. Percentage data were subjected to angular transformation and bud number data were subjected to square root transformation prior to analysis, followed by inverse transformation for presentation. For bud induction, results were expressed as the frequency of regenerating somatic embryos, the mean number of buds per somatic embryo, and an index of bud-forming capacity (BFC), which was used to evaluate the cumulative effect of the two aforementioned variables, calculated as follows: BFC = (mean bud number per explant) × (% of regenerating explants)/100. Bud multiplication was evaluated through the mean number of secondary buds per primary shoot and the fidelity of explants was evaluated by the frequency of shoot-tip necrosis. Finally, rooting was evaluated by the frequency of rooting.

RESULTS

Bud induction and multiplication

Shoots buds were induced from hypocotyls, cotyledons, apices and roots of germinating horse chestnut somatic embryos cultivated on media with BA (Fig. 1a). ANOVA indicated significant effect of BA concentration on both the frequency of bud regeneration, the mean number of shoot buds per somatic embryo and BFC (not shown).

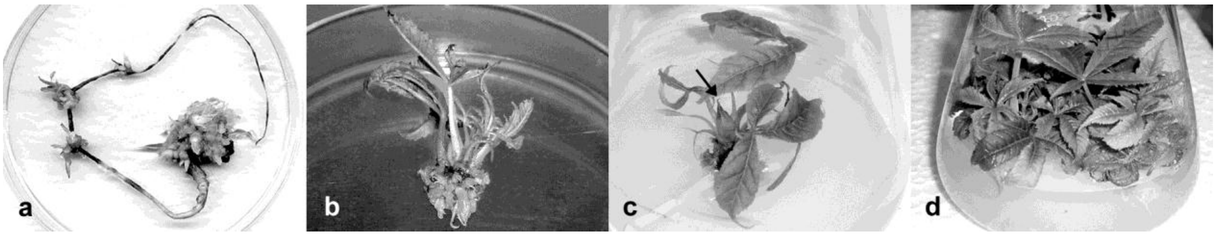

Figure 1. *Horse chestnut adventive bud regeneration and multiplication. a) Bud induction from somatic embryo cultivated on MS medium with 5 μM BA. b) Secondary bud regeneration from the primary shoot base cultivated on MS medium with 5 μM BA for four weeks. c) Shoot apex necrosis (arrow) of the shoot cultivated on MS medium with 1 μM BA. d) Shoot culture on MS medium with 5 μM BA.*

The highest values for all the three variables tested were achieved with 10 μM BA, although the frequency of regeneration and BFC index was not significantly different comparing to 5 μM BA (Tab. 1). As hyperhydration was frequently observed in shoot buds induced on 10 μM BA, 5 μM BA was the most appropriate treatment for bud induction.

Table 1. *Bud induction from germinated horse chestnut somatic embryos (3 cm) cultivated on solid MS medium with 0, 1, 5 or 10 μM BA for 4 weeks.*

BA concentration μM	**Frequency of regeneration**	**Bud mean number**	**Bud forming capacity**
0	3.55 ± 0.46 c	0.35 ± 0.03 d	0.42 ± 0.17 b
1	74.33 ± 1.25 b	2.49 ± 0.05 c	3.45 ± 0.96 b
5	94.82 ± 2.08 ab	12.33 ± 0.18 b	15.67 ± 4.84 a
10	100 a	20.27 ± 0.14 a	23.27 ± 3.59 a

Data represent mean values. Two replicates, each with three samples and five subsamples (n=30), were used per treatment. Treatments denoted by the same letter in a column were not significantly different ($P \leq 0.05$) according to Duncan's test.

Secondary buds were regenerated from the base of the primary shoots (Fig. 1b). ANOVA showed that BA concentration significantly affected both secondary bud number and the frequency of shoot-tip necrosis (not shown). Although they formed spontaneously (1.9 ± 0.3 on average), the addition of BA in culture medium significantly increased the number of secondary buds (Fig.2). The highest shoot number was achieved with 10 μM BA, although it was not significantly different from 5 μM BA. Necrosis of the shoot apices (Fig. 1c) occurred very frequently (76-100%) with BA levels up to 2.5 μM, while it was not observed with BA at 5 μM or higher (Fig. 2). However, hyperhydration was rather frequent in shoots cultivated on BA above 5 μM. Therefore, BA at 5 μM was the most appropriate for development of healthy secondary buds. The shoots formed rosette-like habitus (Fig. 1d), therefore they had to be subjected to a shoot elongation treatment.

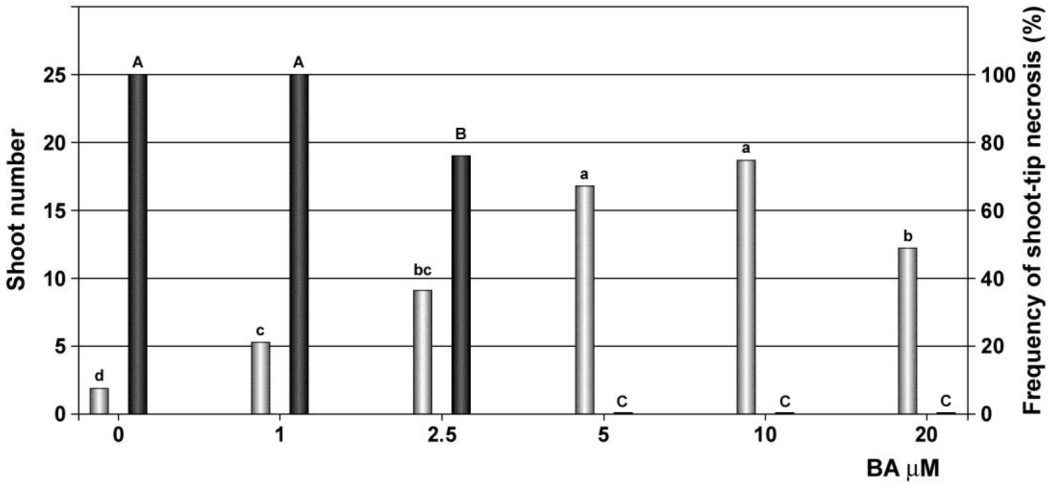

Figure 2. *Secondary bud formation from germinated horse chestnut somatic embryos cultivated on solid MS medium with 0-20 μM BA (white bars) and the frequency of shoot-tip necrosis (black bars). Data represent mean values. Two replicates, each with three samples and five subsamples (n=30), were used per treatment. Treatments denoted by the same letter were not significantly different (P ≤ 0.05) according to Duncan's test.*

Shoot elongation, rooting and preventing shoot-tip necrosis

Individual shoots elongated (Fig. 3a) at relatively high frequency (63%), and those treated with IBA developed root initials within 2-3 weeks (Fig. 3b). According to ANOVA, IBA significantly affected the frequency of root induction. Spontaneous rooting (in shoots dipped in dH_2O) was not observed, and the highest rooting rate was observed in shoots treated with 10 mM IBA (23%), whereas it was 8.3% with 5 mM IBA. Shoots developed a very good root system, with main root of 10-12 cm and many laterals within 4 weeks following the root inducing treatment (Fig. 3c). Despite well developed root system, the majority of these explants suffered from shoot-tip necrosis, and this problem was overcome by the application of BA directly to the shoot apex. Shoot-tip necrosis was completely cured by the application of 1μM BA (Fig. 3d). Higher levels of BA or shorter intervals of BA application caused hypertrophy of the shoot tip, which was even 7 mm in diameter in some shoots treated with 10 μM BA (not shown). Therefore, the weekly application of 1μM BA was optimal treatment.

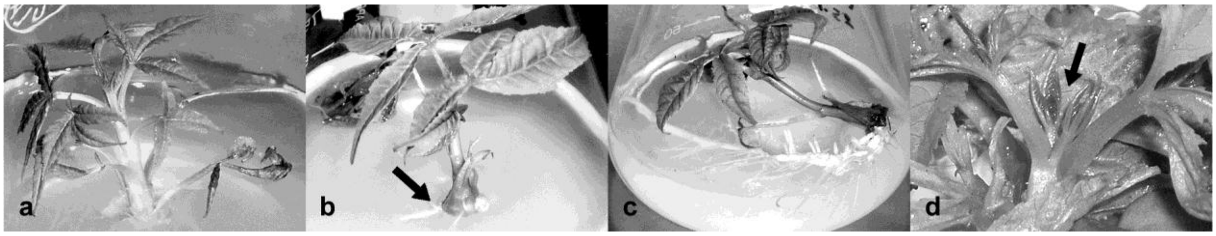

Figure 3. *Shoot elongation and rooting. a) Elongated shoot following 4 weeks on solid MS medium with 1 μM BA and 500 mg/l PVP. b) A root initial emergence (arrow) following the treatment with 10 mM IBA for 1 min and 2 weeks on half-strength MS PGR-free medium. c) The same plantlet after an additional 2 weeks. d) Healthy shoot apex (arrow) treated by weekly application of 10 μl of 1 μM BA.*

DISCUSSION

We reported here on efficient bud induction from all organs of germinated somatic embryos of horse chestnut. For this purpose, we used 3 cm long somatic embryos, as it was shown in a previous study that red horse chestnut somatic embryos of this size predominantly regenerate shoot buds (Zdravković-Korać *et al*. 2008), in contrast to smaller somatic embryos (≤ 1 cm) of horse chestnut (Kiss *et al*. 1992) and red horse chestnut (Zdravković-Korać *et al*. 2008), which almost exclusively regenerate secondary somatic embryos.

Somatic embryogenesis, an alternative method for *in vitro* clonal propagation, was previously achieved in horse chestnut (Dameri *et al*. 1986, Radojević 1988, Jörgensen 1989, Profumo *et al*. 1991, Gastaldo *et al*. 1994, 1996). Although it could be additionally amplified through highly efficient secondary somatic embryogenesis (Ćalić *et al*. 2005), a serious obstacle of this approach is the absence of an efficient protocol for conversion of somatic embryos to healthy plantlets and their successful acclimatization (Capuana & Debergh 1997, Troch *et al*. 2009). For this reason, we tried to develop an alternative protocol for mass *in vitro* vegetative propagation of this species. A protocol for *in vitro* propagation by meristem culture derived from shoot apex of both androgenic and somatic embryos, and dormant buds of horse chestnut is available (Radojević *et al*. 1987). However, with that protocol shoot multiplication occurred predominantly through less efficient axillary branching and adventitious buds were only seldom observed.

Efficient secondary regeneration from the shoot base enabled further multiplication of shoots in the present study and led to the establishment of a permanent shoot culture. We found 5 μM BA being an optimal for both healthy bud induction and multiplication, since higher BA levels provoked hyperhydricity. Increased hyperhydricity with higher cytokinin concentration is a common phenomenon (Ivanova *et al*. 2006).

It is well known that cytokinins inhibit root initiation, so it was necessary to reduce BA level for shoot elongation and rooting and that caused mass shoot-tip necrosis. These two phenomena, rooting and shoot-tip necrosis, have opposite requirements for growth regulators. Cytokinins are needed for the maintenance of the shoot apex and in the same time they inhibit rooting. This problem could be overcome by local BA application directly to the shoot-tip, as was described in *C. sativa* (Vieitez *et al*. 1989; Piagnani *et al*. 1996). In the present study, shoot-tip necrosis was completely eliminated by weekly application of 10 μl of 1 μM BA during root-inducing phase. Actually, it is important to maintain shoot-tip vigour only until root system develops. In this study week intervals for BA application was an optimal period. Initiation of roots, which are the main site of cytokinin synthesis, restores the development of shoot apex, as was seen in *C. sativa*, *Q. rubber* (Vieitez *et al*. 1989) and *H. procumbens* (Bairu *et al*. 2009b). Alternatively, development of axillary shoots, which is delayed comparing to apical shoot, may circumvent the time of root initiation (Thomas 2000).

Cytokinin application following the emergence of root initials was beneficial in decreasing shoot-tip necrosis in *C. dentata* (Xing *et al*. 1997). Despite cytokinins inhibit root initiation, they do not interfere with root growth if they are applied following root initiation. According to this, in the present study shoots were transferred to medium supplemented with 5 μM BA as soon as the root initials were observed.

A classical rooting method proposed by Radojević *et al*. (1987), which included a 10-day-dark treatment and rooting on solid medium with 2 mg/l IBA for a few weeks, failed in the present study, so we adopted a method of Xing *et al*. (1997). This method includes quick-deep of shoot base in a high-concentration-IBA solution, following a few weeks on a half-strength PGR-free medium and then subcultivation on cytokinin-containing medium. Although the method is rather laborious, it was very efficient in *C. dentata*, allowing rooting of 14-77% of shoots with 25-67% shoot-tip necrosis. Without the postrooting BA treatment, these authors found shoot-tip necrosis in 86% of shoots. Similarly, 77% shoots of *C. sativa* explants exhibited shoot-tip necrosis without postrooting treatment (Piagnani & Eccher 1988).

The frequency of rooting obtained in this study is better than by classical rooting (23% vs. 0%), but it is still unsatisfactory. In a previous study, we were able to increase the rooting rate of horse chestnut plantlets transformed with *Agrobacterium rhizogenes* strain A4GUS using the same rooting procedure (Zdravković-Korać *et al*. 2004). However, these plants have changed habitus due to the expression of the *rol* genes and could be used only for specific horticultural purposes. Generally, rooting of woody plants is rather inefficient, and poor results were obtained in many studies. Using a quick-deep rooting method, rooting was achieved only in approximately 20% of *C. sativa* explants (Piagnani & Eccher 1988), while Radojević *et al*. (1987) achieved rooting rate of 7-24% in horse chestnut shoots using 2 mg/l IBA.

In the present study, 10 mM IBA was the best rooting treatment. By contrast, Xing *et al*. (1997) found 5 mM IBA to be better than 10 mM IBA, in terms of both higher rooting rate and less shoot-tip necrosis. The authors concluded that IBA level should be adjusted for each genotype, and that is in accordance with Radojević et al. (1987), who found a rather high variability in rooting rates (7-24%) among different clones.

In conclusion, we described here a very efficient protocol for bud induction from somatic tissue of an elite horse chestnut specimen. In addition to an efficient shoot multiplication, this protocol made a significant contribution to mass vegetative propagation of this species. However, the inefficiency of rooting and necrosis of the shoot apex has limited our success. Although some solutions that may help to overcome these problems are proposed in the present study, further optimisation is needed and these experiments are underway in our laboratory.

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SEED DORMANCY NATURE OF *Poncirus trifoliata* (L.) Raf. AND OTHER CHARACTERISTICS IMPORTANT FOR POSSIBLE INVASIVENESS

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Abstract: *The three-leaf lemon (Poncirus trifoliata (L.) Raf.) is a high shrub from central China and Korea which is used in landscape horticulture and pomology (as rootstock for agrume grafting). The fruit, like all at Citrus genus, is hisperidium (kind of berry) which belongs to nonclimacteric fruits. It was interesting to investigate the influence of succulent pericarp on germination. A very frequent polyembryony is characteristic of this species. It was identified that apomictic embryos which origin from nucellus are larger and those that developed from zygote are smaller and during germination are suppressed by nucellar embryos. This can be significant for intraspecies taxa propagation.*

The inhibitor properties of succulent pericarp (pulp) were investigated on the lettuce seed. It was identified that the solution of the pulp sap influences germination retarding more or less, regarding to the concentration, and also influences seedling morphology. Explanted embryos shows a light physiological dormancy, because the samples treated with KNO_3 has a faster germination compared with nontreated. These and other features explored, suggest the properties of non-invasive species and the possibility of its use as a non-invasive neophyte in environmental alteration caused by climate change.

Key words: seed dormancy, three-leaf lemon, non-invasive species, presowing treatments

INTRODUCTION

Simultaneously with the creation of the list of invasive plants for an area usually have to propose alternative species that, unlike invasive species, express lack of enormous spread potential and threat to biodiversity. The simplest approach would be exclusion of alien species from planting program regardless the category of green space a priori. As for some categories it is required the presence of exotic species, and at the same time the danger to expand neophyte also not the same and depends on many factors (both biological and environmental), it should be proposed a list of non-invasive allochthonous species.

This approach requires a thorough knowledge of the general characteristics of alternative species, but also its behavior in concrete conditions for area for which it is recommended to be used. For taxa that have already been introduced it is important to study their behavior in the longer period of time in as many different environments and simultaneously examine all mechanisms related to neophytes reproduction, as generative and vegetative. In particular, it is necessary to pay attention to the behavior of the taxa under changed climate conditions that can, even in a relatively short period of time, significantly change the potential invasiveness, and on the other hand to limit the use of the recommended taxa, or change to such an extent that it becomes invasive.

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There are a number of examples of this. Only fifty years ago the North American creeper ***Campsis radicans*** (L.) Seem. ex Bureau in the city of Belgrade conditions was rarely survived, but now as undisturbed, reaches substantial age and also spreads from root shoots very intense. It is similar with ***Albizia julibrissin*** Durazz. species from tropical and temperate regions of Asia which until twenty years ago, was found in the Mediterranean region only.

In the green areas of Belgrade from year to year, there is an increasing number of exotic species that different firms, garden centers mainly, imported without any restrictions. Such are for example: ***Viburnum tinus*** L., ***Leycesteria formosa*** Wall., ***Photinia* × *fraseri*** Dress, and ***Xanthoceras sorbifolium*** Bunge recorded in the private gardens of Belgrade.

Through the Arboretum of the University of Belgrade, Faculty of Forestry also been introduced and successfully acclimatized more species that are flowering and fruiting and formed viable seeds. Among them are ***Flueggea suffruticosa*** (Pall.) Baill., ***Baccharis halimifolia*** L., ***Lagerstroemia indica*** (L.) Pers., ***Sarcococca hookeriana*** Baill., ***Zanthoxylum armatum*** DC., ***Eleutherococcus senticosus*** (Rupr. & Maxim.) Maxim ... All of these taxa were removed in 2003-05 through the reconstruction of the Arboretum. Poncirus was one of those species, which in the Arboretum reached 3m in height, and regularly fruited.

Trifoliate orange, Chinese bitter orange, hardy orange, bitter orange (***Poncirus trifoliata*** (L.) *Raf.*, basionym ***Citrus trifoliata*** L.) belongs to the monotypic genus that is related to genus Citrus. It originates from central China and Korea, while in Japan has been cultivated for centuries.

Poncirus trifoliata is a deciduous shrub or small tree, reaching a height of 3 to 6 m. The species is slow-growing, densely interwoven with green branches and lineal, solid, 3-5 cm long, green thorns, so that the plant stays green when the leaves drop. The leaves are alternate, with three leaflets. Leaflets are oval or elliptical, leathery, yellow or orange in the fall. Middle leaflet 3-5 cm long and lateral 2-3 cm. Blooms in spring, before leafout. The flowers are white with pink stamens, fragrant. The scent is less intensive than that of citrus. Flower ranging from 3-5 cm, depends on the varieties. The fruit is special kind of berry - hesperidium segmented berry with a leathery rind. The exocarp (peel) contains volatile oil glands (essential oils) in pits. The fleshy interior (endocarp) is composed of separate sections (carpels) filled with fluid-filled sacs (vesicles) that are actually specialized hair cells. This type of fruit is characteristic of subtribus Citrinae of Rutaceae family. The fruit is globular, yellow with gray velvety hairs 5 cm in diameter, with 6-8 carpels, and 1-6 seeds per carpel; seeds occupies much of the fruit. Seeds are white with parchment texture testa (*Grbic et al*, 2007).

For good development trifoliate orange requires a sheltered position, slightly acid, well-drained soil and bright and sunny to partly shaded sites. It is very resistant to low temperatures and survive up to -25°C.

Due to the low temperature resistance and good compatibility is used as a rootstock for citrus grafting. Poncirus provides resistance to ***Citrus tristeza virus*** (CTV) and the formation of higher quality fruit. However, there are some disadvantage of poncirus as rootstock, such as susceptibility to ***Exocortis Citrus Virus*** (CEV), and intolerance to alkaline soil and incompatibility to some species.

There are several ornamental cultivars of Poncirus such as ***'Frost'***, ***'Kryder'***, ***'Rich'***, ***'Large English'***, and the most common - ***'Rubidoux'***. The criterion for the selection of varieties is usually flower size. In addition to these, there is a dwarf form with twisted branches and thorns reason by which it was named ***'Flying Dragon'***. This variety grows to a height of 2.5 m and can be grown as bonsai. ***Poncirus trifoliata 'Flying Dragon'*** is most resistant cultivar to low temperatures.

Fruit are very bitter, not edible fresh, but can be made into marmalade, good jam, and when dried and powdered, they can be used as a condiment.

The aim of our investigation was to determine the caracteristics of seed significant to invasion, such as the fruit abundance, germination obstacles, seed dispersal, and longevity of seed, as well as some ecological characteristics based on experience with the species in Belgrade conditions. In other words, the ability to admit poncirus to the list of alternative non-invasive neophytes.

MATERIAL AND METHODS

The parent tree is located in the Botanická záhrada University Koménskeho, Bratislava. The fruits were collected on September 22nd, 2006 from the tree. Seeds were extracted immediately and stored wet in a plastic bag in refrigerator, until the germination test.

Germination was carried out by conventional procedure (4x100 grains per treatment) and by excised embryo test in growth chamber Type 1291 /TPC-1/ LP-113, on filter paper (3x25 embryos per treatment) at 20°C (± 2). Photoperiod was 16 / 8 (light - dark). Testing for grain lasted 57 days while period of testing for embryos was 21 days; germinative energy (EC) calculated based on the 7th day.

The first trial was a conventional germination test immediately after seed collection and extraction in order to determine the role of seed coat in germination process regarding its permeability for water and gases. The experiment was conducted with 4x100 grain.

The second trial, which was supposed to determine the intensity of internal dormancy, had two variants: (1) 3x25 explanted embryos treated with an aqueous solution of KNO_3 (0.2%), (2) 3x25 embryos are moistened by distilled water as the control.

The aim of the third trial was to investigate the presence of inhibitory substances in the pericarp (possible external chemical dormancy). Lactuca test was used in which the seeds of lettuce treated by pulp dissolved in water in a mass ratio of 1:10, 1:8, 1:6, 1:4, and 1:3. The test was performed with seeds ***Lactuca sativa 'Anushka'*** (89% germination). Testing lasted 7 days, and germinative energy (EC) was calculated based on the 4th day (in accordance with International Rules for Seed Testing, **ISTA**, 2003). In the same day morphometric analysis of lettuce seedlings by measuring the radical length was performed.

The result was presented by means of nine indicators of germination. Some of them reflect only the quantitative value of germination (germinative capacity (GC), real germination (RG), and germinative energy (GE)), others only the dynamics (mean germination period (MGP), germination intensity (GI), the coefficient of the rate of germination (CRG), and the coefficient of uniformity of germination (CUG), and still others refer to both groups (germination value by Czabator (GV (Cz)) and germination value by Djavanshir and Pourbeik (GV (Dj)). The parameters are common for this type of research and their definitions can be found widely in the literature: *Schopmeyer*, 1974; *Sarnavka*, 1954; *Czabator*, 1962; *Bewley et al*., 1994, *Djavanshir & Pourbeik*, 1976; *Grbic*, 1997. The abbreviations used in the text and tables are given within the brackets.

Obtained results were analyzed by “STATGRAPHICS Plus” (ANOVA) using the LSD as option of multiple range test with confidence level of 95% ($p < 0.05$).

Phenology of species monitored at the mother plant growing in the Arboretum of the University of Belgrade, Faculty of Forestry by scanning flowers, fruits and seeds in different stages of growth during the growing season and designing modified flower and fruit growth curves (*Kramer & Kozlowski*, 1979).

RESULTS AND DISCUSSION

Experiment with seeds pointed to a lower permeability of parchment seed coats due to the first seeds germinated 27 days after beginning of the test. Germination is extended for 30 days, and then ended in 57th day. During this period, 97% grains were germinated, while 3% were empty. Just two months after collection and extraction seed kept at room temperature in a dry condition, did not germinat at all. This fact shows recalcitrant and microbiotic character of seeds.

Explanted embryos also indicate the decelerate role of seed coats in germination. During the trial (21 days) 64% embryo germinated which speaks of internal obstacle i.e. embryo dormancy. According *Nikolaeva* (1977) internal dormancy may be morphological or physiological. Whereas trifoliate orange has exalbuminous type of seed, morphological dormancy is not possible. The results of treating embryos by solution of potassium nitrate simultaneously with the water moistened embryos are shown in figure 1 and table 1.

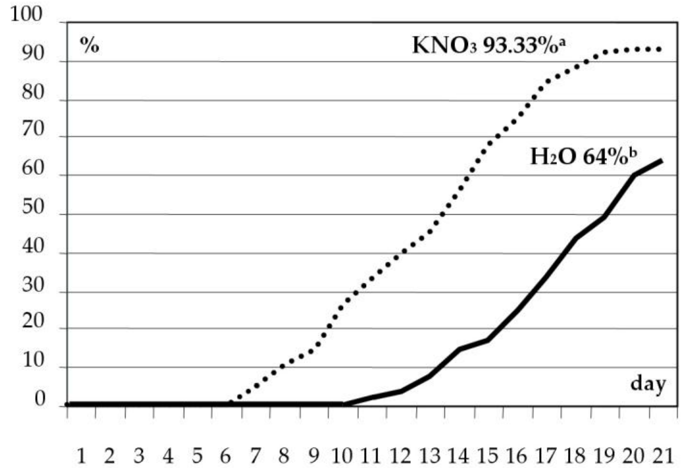

Figure 1. *Germinative capacity of excised embryos treated with solution of potassium nitrate and water.*

Table 1. *Germinative parameters of excised embryos treated with solution of potassium nitrate and water*

(Different letters indicate significant difference between means at confidence level of 95%).

	GC	RG	GE	MGP	GI	CRG	CUG	GV(Cz)	GV(Dj)
control	64[b]	64[b]	0[b]	4.17[b]	64.67[b]	5.96	0.15	2.46	2.83
KNO_3	93.33[a]	93.33[a]	5.33[a]	7.92[a]	183[a]	7.71	0.10	5.73	8.24

Mean values of the parameters germinative capacity and real germination in the control treatment were significantly lower than the value for the treatment of potassium nitrate solution. Other germination parameters indicate that the germination was faster and quantity parameters were better aided with solution of KNO_3 than in controls. Although clearly belonging to separate groups of multiple range test, untreated embryos germinate in a relatively high percentage which points to a light form of physiological dormancy. Sinusoidal curve of control which is translationally shifted 4 to 6 days, the unchanged embryos at the end of the test, and a positive reaction to potassium nitrate confirm light (shallow) dormancy. Dormancy broken by chemicals-potassium nitrate, thiourea, kinetin, ethylene, gibberellins considered as nondeep physiological dormancy (*Ellis et al*, 1985) (table 1).

Table 2. *Germinative parameters of Lactuca sativa 'Anushka' seeds in Lactuca test*

(Different letters indicate significant difference between means at confidence level of 95%).

	GC	RG	GE	MGP	GI	CRG	CUG	GV(Cz)	GV(Dj)
control	95[a]	95[a]	95[a]	5,85[a]	139.00[a]	87.82[ab]	11.54[a]	284.85[a]	79.38[a]
1 : 10	89[a]	89[a]	89[ab]	5.88[a]	131.00[a]	89.85[a]	4.84[b]	267.85[a]	71.27[a]
1 : 8	95[a]	95[a]	95[a]	5.61[a]	133.50[a]	74.30[c]	2.67[b]	249.71[a]	74.25[a]
1 : 6	93[a]	93[a]	92[a]	5.64[a]	131.00[a]	74.78[bc]	2.28[b]	258.85[a]	72.43[a]
1 : 4	89[a]	89[a]	84[b]	4.87[b]	108.50[b]	48.14[d]	0.80[b]	109.42[b]	49.53[b]
1 : 3	77[b]	77[b]	75[b]	4.13[c]	79.75[c]	35.06[d]	1.33[b]	57.12[c]	27.20[c]

Lactuca test showed the presence of inhibitory substances that are in the strongest concentration (1:3) significantly reduced the number of lettuce seed germination through germinative capacity and real germination (after 7 days). Germinative energy values are distributed in more homogeneous groups fairly regularly, so that the concentration decreases with increasing the percentage of germinated seeds to day 4. Mean germination period (MGP) also distinguishes two strongest concentrations in separated homogeneous groups, which clearly indicates the different dynamics of germination of control and lower concentrations of the pulp, on the one hand and the two strongest concentrations, on the other. The same or similar trends were recorded for the other indicators, it can be claimed that the pulp inhibits germination of lettuce, species with nondormant seed which germinate very quickly in optimal conditions (table 2).

Radicle length, at the end of the test period, also clearly indicates the growth retardation of lettuce seedlings, i.e. probable exogenous (chemical) dormancy of poncirus seed. Radicle from seed moistened with water is five times longer than radicle moistened with seed pulp solution in ratio 1:3 (pulp:water). The differences between the concentrations of certain pulp and water are distributed in five significantly different groups, with less overlap, which also supports assumption of retardants existence in the pulp (figure 2).

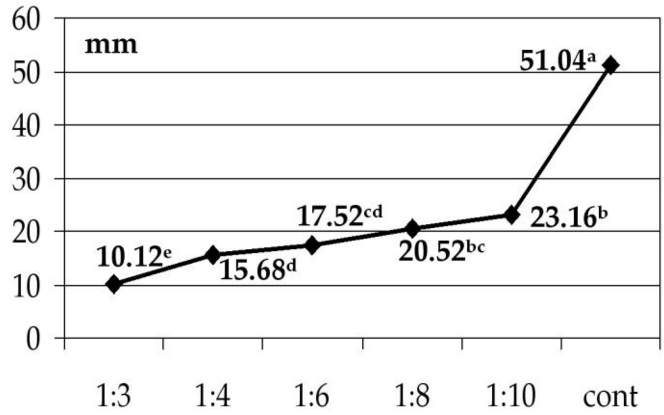

Figure 2. *Radicle length of seedlings of Lactuca sativa 'Anushka' treated with different pulp concentration and water.*

The phenological observations of the bush which was growing in Belgrade ecological conditions (Arboretum of the University of Belgrade, Faculty of Forestry) indicate abundant flowering and fruiting, and morphological properties of fruits and seeds (table 3), as well as the growth curves (figure 3) show the usual characters of the species. From one bush can be collected about 10 kg of fruit, with 20% seed yield per 100% of fruit approximately, is obtained 2 kg of seeds by extraction, i.e. about 10,000 seeds. This amount of seed is not considered sufficient potential to species become invasive, if it is known that some species may have abundance, which is more than 10,000 times larger. Thus, for example, an individual eastern cottonwood tree (***Populus deltoides*** W.Bartram ex Humphry Marshall), measured to be 12.3 m in height with a stem diameter of 60 cm and a crown spread of 13.8 m, bore about 32,400 catkins. These produced about 27 capsules per catkin and about 32 seeds per capsule. On this basis, it was estimated that this tree produced nearly 28 million seeds (*Bonner & Karrlfalt*, 2008).

Table 3. *Morphological indicators of bitter orange fruit and seed, and seed yield data.*

	min	average	max
fruit diameter (mm)	33.10	39.29	44.85
fresh mass of fruit (g)	19.30	32.35	47.33
seed number in fruit	12	23.30	39
seed yield per 100% of fruit	11.56		29.73
absolute mass of seed (g)	180	204	212

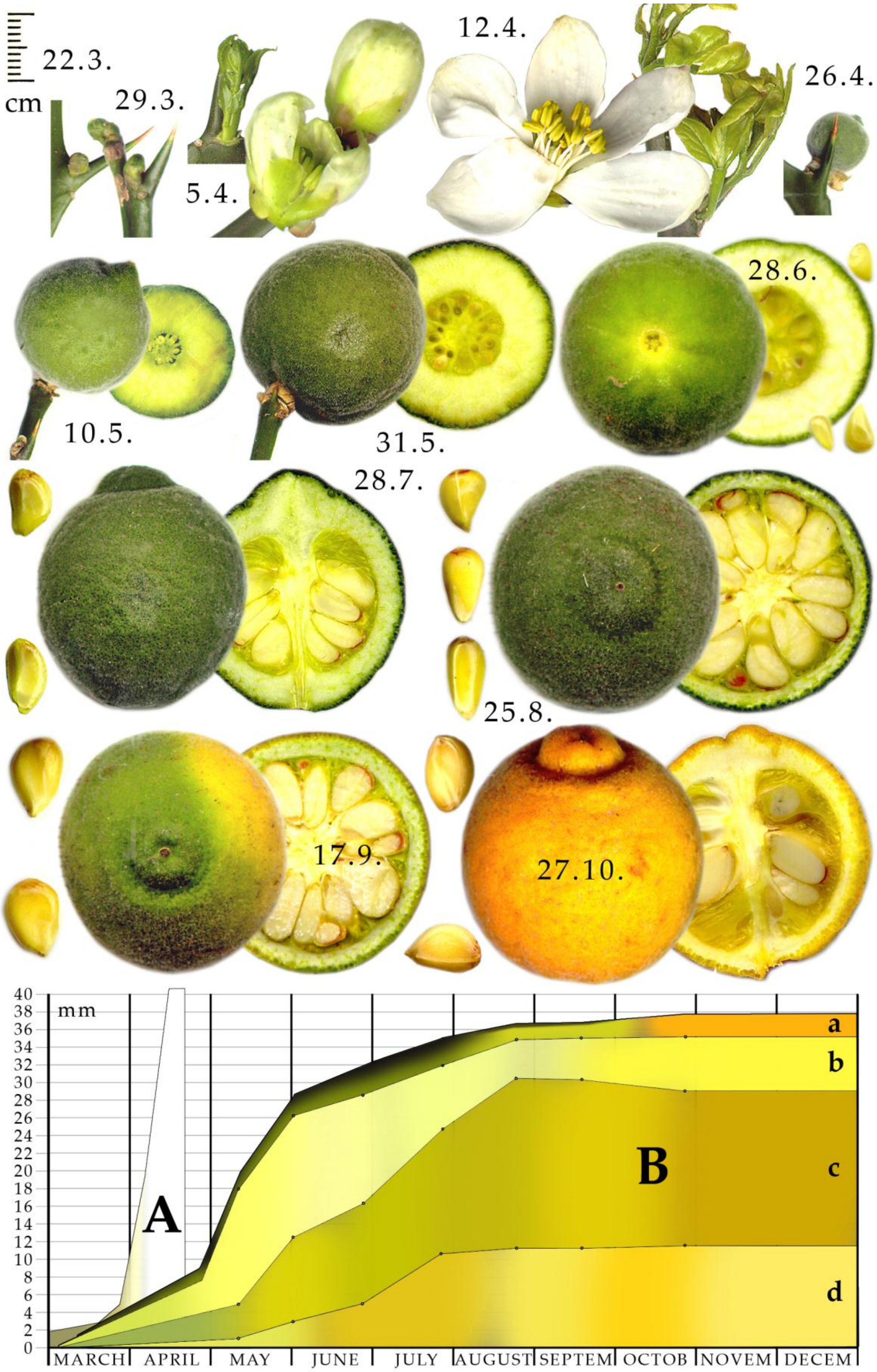

Figure 3. *Phenology of flowering and fruiting and growth curves of poncirus flower (A) and fruit (B): a- exocarp (flavedo), b- mesocarp (albedo), c- endocarp, and d- seed.*

Polyembryony in bitter orange seed is very common. Polyembryony is the occurrence of more than one embryo per seed. It is unusual in angiosperms (*Sedgley & Griffin*, 1989), but more common in gymnosperms with multiple archegonia, where pollination and fertilization produce multiple embryos, all differing in genetic composition. This type of polyembryony was found in araucaria, cypress, and all Pinaceae (*Chowdhury,* 1962; *Haines & Prakash*, 1980; *Konar & Banerjee*, 1963). Another type of polyembryony can be produced through cleavage or division of a developing embryo. It has been noted in many coniferous genera of the northern temperate zone (*Sedgley & Griffin*, 1989). In the case of bitter orange polyembryony belongs to the first type. Specialized nucellus or (sometimes) integuments cells have embryogenetic potential and undergo embryogenesis, creating nucellar or adventive embryos with the same genetic structure as the parent plant (*Hartmann et al*, 1990). About 60% of the investigated seed contains nucellar embryos in addition to zygotic one. During germination, usually nucellar embryos are superior, and embryos derived from zygotes are smaller. This provides an opportunity for cloning individuals with desirable feature.

Other biological traits that are associated with invasiveness such as dichogamy (protandry or protogyny) did not observed. On the other hand, species is self fertile and, in the case of isolation, gives viable seed, which is confirmed by these trials. The species begins flowering and fruiting at the age 4 to 5, and produce seedcrops regularly, but trifoliate orange is short-lived species, living up to 25 years (*Milev et al*, 2004).

Vegetative propagation outside the nursery did not observed. Poncirus forms root shoots from the root collar, but not from the roots so they do not pose a danger to spread this way.

CONCLUSIONS

Investigated biological properties of ***Poncirus trifoliata*** related to flowering, fruiting, seed dispersal, and longevity of seed, as well as recalcitrant character of seeds, decelerate role of seed coats in germination, shallow physiological dormancy, pulp which inhibits germination and cause growth retardation, nor seed abundance is not considered sufficient potential to species become invasive. Polyembryony, although represented with 60%, not a threat because usually only one embryo germinate and it is nucellar one which increases homozygosity of population which in many cases leads to reduced fertility.

Early detection of new invaders provides best chance of eliminating them from natural area where invaders may have the potential to do great damage, especially to biodiversity and to autochthonous plant species. Plant changes can alter the habitat of wildlife, and make it hard on animals such as birds that may depend on particular plants for food. Study of behavior of introduced species, potential invaders or non-invaders in given conditions, and collection of data from the literature about the species invasiveness are of great importance.

Trifoliate orange is declared as moderately invasive species for tropics. Which mean: species is spreading but still occur at low densities and is not considered an immediate problem (*Binggeli et al*, 1998). Based on state level agency and organization lists of invasive plants from Weed US database, trifoliate orange is on the list of invasive alien species in some south states, namely Texas, Louisiana, Mississippi, Florida, Georgia, South Carolina and West Virginia (mainly hardiness zones 10, 9, and 8). In those vastnesses trifoliate orange invades woodlands, forest edges, fence rows, and urban green spaces. Further north, there is little risk of it becoming invasive. On the contrary, the species is on the list of non-invasive species, and is recommended for use even in the natural areas such as Sligo Creek Park in Montgomery County, Maryland by the list of Alien Non-Invasive Plants of Sligo Creek, proposed by RIP, the Removing Invasive Plants Project (http://www.fosc.org/AlienPlantList.htm). Another example is from “Plant Selection Committee for Alternatives to Invasive Plants” of Long Island Horticultural Research & Extension Service. They suggest the hardy trifoliate orange, ***Poncirus trifoliate*** for thorny barrier hedge without any restrictions (http://www.dig-itmag.com/ features/ grounds _story/422_0_4_0_M/).

DAISIE project (Delivering Alien Invasive Species In Europe) funded by the sixth framework programme of the European Commission (Contract Number: SSPI-CT-2003-511202), which provides information on biological invasions in Europe, delivered via an international team of leading experts in the field of biological invasions, no mention trifoliate orange as an invasive species in any area of Europe (*DAISIE*, 2009).

All segments of the investigations make it possible to conclude that the trifoliate orange is non-invasive species for Serbian conditions, but that should be used with certain dose of caution due to global climate changes and temperature increase.

Acknowledgment

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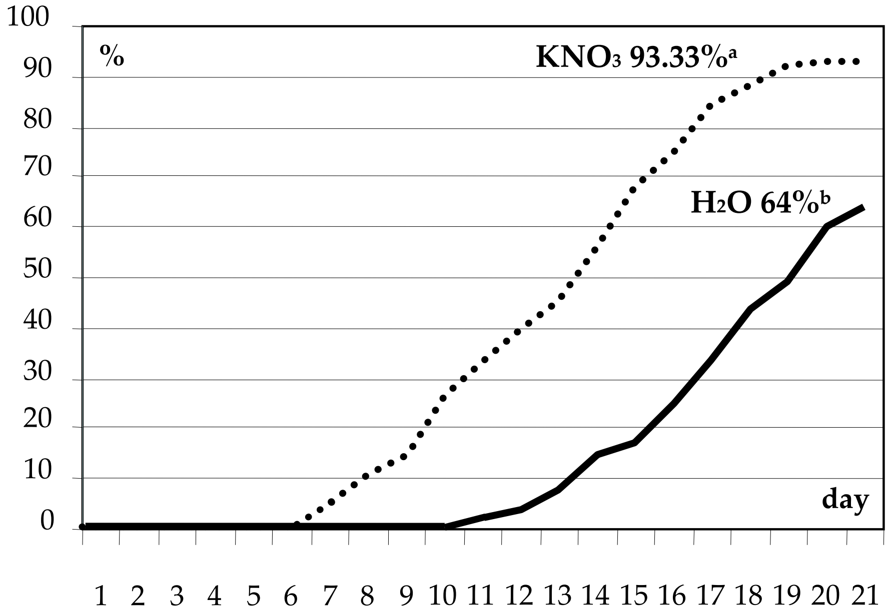

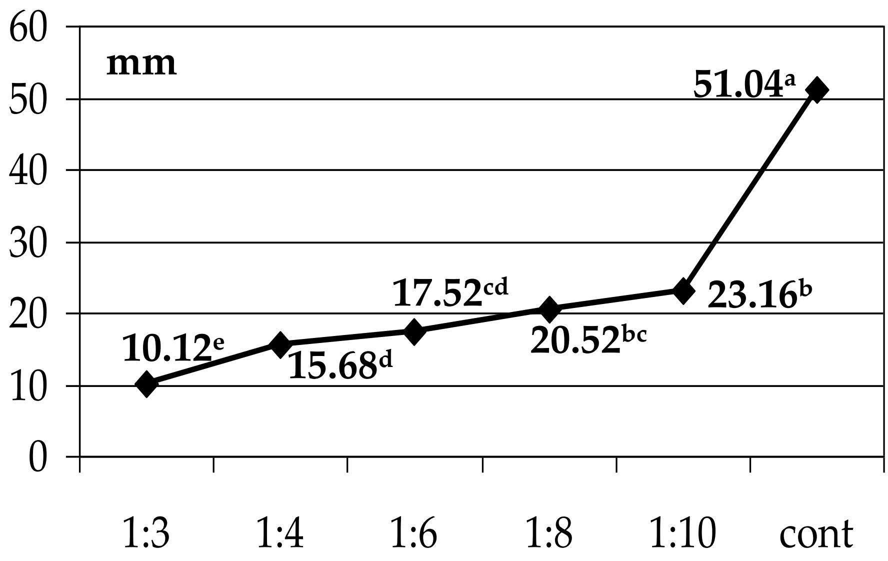

VARIABILITY IN CALCIUM CONTENTS IN THE NEEDLES OF DOUGLAS-FIR PROVENANCES ORIGINATING FROM CANADA

Vera LAVADINOVIĆ[1], Zoran MILETIĆ[1], Vasilije ISAJEV[2],
Vladan POPOVIĆ[1], Aleksandar LUČIĆ[1]

Abstract: *Urban development means increased using of quality and fast-growing trees. Douglas-fir is a species that is tolerant to a wide range of natural environmental conditions. As a result, many plantations are established in Europe and it is one of the most promising introduced species in Serbia.*

To satisfy the needs of timber industries, as well as landscape management and urban areas, the aim of the study was to identify and evaluate all the features and elements of the introduced fast growing species.

The dominant conifer species in the forests of North America and Canada is the Douglas-fir (Pseudotsuga mensiesii Mirb / Franco). Biological characteristics and also wood properties of Douglas-fir are the most interesting type of marketing for sawmill not only in America, but in Europe and New Zealand, too.

The intensity and dynamics of physiological processes of mineral nutrition of Douglas-fir is one of the important indicators of its successful adaptation and introduction to non-indigenous Douglas-fir habitats.

The experimental Douglas-fir habitat was established under the same stand conditions, and the calcium content in the needles was investigated. The established quantities of calcium in the needles are indicative of different capabilities of certain Douglas-fir provenances to adopt this nutritive element from the soil, under the same stand conditions in Serbia.

Keywords: Douglas-fir, provenances, calcium, nutrition elements, Serbia

INTRODUCTION

British Columbia's spectacular landscape has been sculpted over the last two million years by repeated glaciations, the most recent of which occurred between about 30 000 and 10 000 years ago. The South Coast was one of the first areas to be deglaciated, and by studying accumulations of plant pollen in lake bottoms, scientists have established that forests were growing here more than 12 000 years ago. A typical Douglas-fir can live more than 750 years in the absence of high-intensity fires or storms (Samantha Flynn et al., 1999).

While Douglas-fir trees are tolerant to a wide range of environmental conditions and grow in many parts of the province, many of the other plant species of the coastal Douglas-fir ecosystems are more specifically adapted to the summer droughts and winter rains that characterize this climate (Samantha Flynn et al., 1999).

Commercially**,** the tree is one of the world's most important and valuable timber trees and historically it was used by Westerners for telephone poles and railway ties among many other uses. Today Douglas-fir is also grown for Christmas trees (M. Kat Anderson, 2003). Douglas-fir

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is primarily used for building and construction purposes due to its strength advantages and availability of large dimensions from old-growth trees. It is one of the finest timbers for heavy structural purposes, including laminated arches and roof trusses. Structurally, it is used in the form of lumber, timbers, pilings and plywood.

Douglas-fir nutrition has been intensively studied for over three decades in the Pacific Northwest. Good summaries can be found in Oliver et al., (1986), the contribution on nutrition by Radwan and Brix being particularly useful.

Biogeochemical couplings between nitrogen (N), and calcium (Ca) are an important suite of interactions that impact the long-term health and stability of forest ecosystems (Steven S. Perakis et al., 2006)

The diagnosis of nutrient deficiency may be done by visual inspection, soil analysis, soil bioassay, fertilization trials and foliar analysis. The interpretation of foliar analysis by "vector analysis" has proved to be a useful method for conifers with determinate needle growth, such as Douglas-fir (Weeteman et al. 1989).

MATERIALS AND METHODS

This research was conducted in young Douglas-fir experimental plot in Serbia with seeds introduced from Canada (Table 1). Provenance No. 3 originates from the northernmost site of Mann Creek, (51°35' North latitude), and the most endangered one is No. 11 from the locality Sheep Creek (49°10' North latitude). Provenance No. 3 originates from the westernmost site Mann Creek (120°10' West longitude), and provenance No. 1 is from the easternmost Cranbrook 115°20' West longitude).

As for the altitudinal distribution of natural sites of the tested Douglas-fir provenances, it ranges between 488 m (Mara Lk 30460) and 1070 m (Gavia Lake 05227).

The experimental plots are established at two locations. The experiment includes fourteen Douglas-fir provenances from the natural habitats of the species in Canada.

The soil at one locality of the established provenance test is brown forest soil (eutric cambisol), and it is smonitza (vertisol) at the other locality. The tree groups of different Douglas-fir provenances are cultivated under identical site and stand conditions, and the ages of all analysed plants is 12 years. Both localities of the established experiments are flat areas, without any notable aspect, and the altitudes are approximately the same.

The content of calcium was researched in the needles. The determination of calcium content in the needles of different Douglas-fir provenances at both localities was performed on the samples of the needles from the upper third of tree crowns. Calcium content was determined by ash analysis after dry after dry incineration at the temperature of 550ºC and the conversion of nutritive elements into chlorides. The determination was performed by the complexometric method.

Table 1: *The geographical characteristics of the tested provenances from Canada*

Provenance		**Seed zone**	**Location**	**Geographical (°)**		**Altitude**
No	**Code**			**Latitude**	**Longitude**	**(m)**
1.	03333	East Kootenay	Cranbrook	49°25'	115°20'	1050
2.	00848	West Kootenay	Inonoaklin	49°50'	118°10'	671
3.	30667	Shuswap Adams	Mann Creek	51°35'	120°10'	600
4.	05227	East Kootenay	Gavia Lake	50°56'	116°35'	1070
5.	05226	East Kootenay	Nine Bay	50°58'	115°32'	975
6.	03356	Thompson Okanagan Arid	Trout Cr	49°40'	119°52'	884
7.	03360	Thompson Okanagan Arid	Michell Cr	49°54'	119°37'	1035
8.	01198	West Kootenay	Salmo	49°15'	117°30'	793

Provenance		Seed zone	Location	Geographical (°)		Altitude
No	Code			Latitude	Longitude	(m)
9.	30460	Shuswap Adams	Mara Lk	50°48'	119°00'	488
10.	00278	Thompson Okanagan Arid	Monte Crk	50°37'	119°52'	701
11.	03383	West Wootenay	Sheep Creek	49°10'	117°15'	1000
12.	30461	Shuswap Adams	Cooke Creek	50°38'	118°49'	900
13.	03389	West Kootenay	Benton Creek	49°12'	117°25'	933
14.	05092	East Kootenay	Sun Creek	50°08'	115°52'	1000

RESULTS

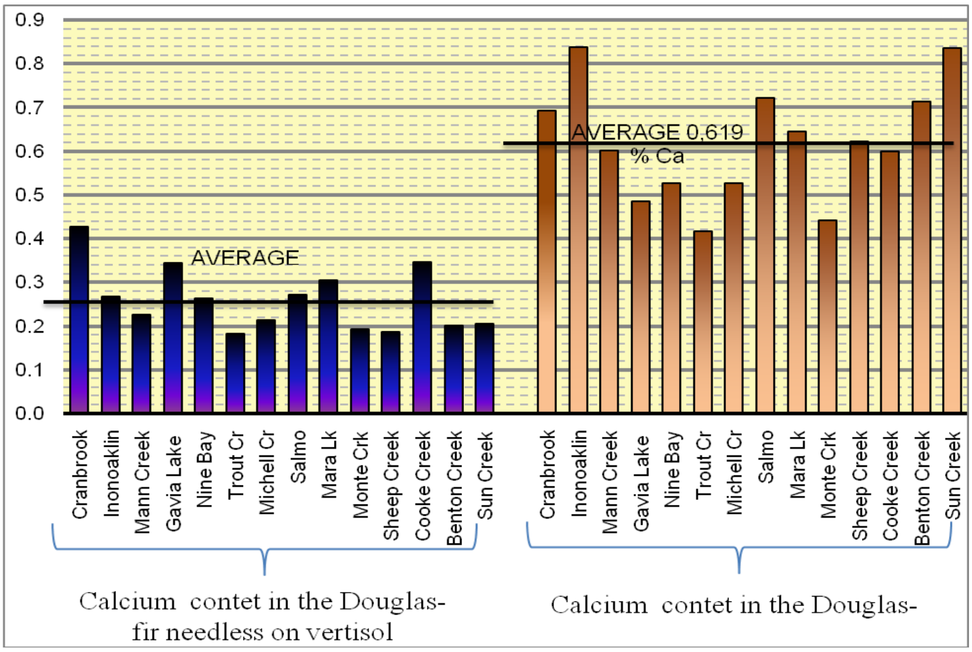
All 14 Douglas-fir provenances grown on brown forest soil (eutric cambisol) attained higher calcium contents in the needles than the same provenances grown on smonitza (vertisol) (Table 2, Graph 1). The difference in calcium nutrition on brown forest soil and smonitza is statistically significant and has a significance level of 1%.

Table 2. *The content of calcium in the needles of different Douglas-fir provenances*

No	Code	Locality	Sremčica - Vertisol		Belgrade - Eutric cambisol	
			Ca %	Z	Ca %	Z
1	03333	Cranbrook	0.427	2.27642	0.692	0.54929
2	00848	Inonoaklin	0.268	0.12195	0.838	1.64786
3	30667	Mann Creek	0.225	-0.4607	0.602	-0.1279
4	05227	Gavia Lake	0.345	1.16531	0.484	-1.0158
5	05226	Nine Bay	0.264	0.06775	0.526	-0.6998
6	03356	Trout Cr	0.182	-1.0434	0.417	-1.5199
7	03360	Michell Cr	0.213	-0.6233	0.526	-0.6998
8	01198	Salmo	0.272	0.17615	0.721	0.76749
9	30460	Mara Lk	0.304	0.60976	0.645	0.19564
10	00278	Monte Crk	0.191	-0.9214	0.44	-1.3469
11	03383	Sheep Creek	0.186	-0.9892	0.623	0.0301
12	30461	Cooke Creek	0.345	1.16531	0.599	-0.1505
13	03389	Benton Creek	0.201	-0.7859	0.714	0.71482
14	05092	Sun Creek	0.205	-0.7317	0.836	1.63281
		Average	0.259		0.619	
		S	0.0738		0.1329	
		min	0.182		0.417	
		max	0.427		0,838	

In the provenances grown on brown forest soil, the mean value of calcium content in the needles accounted for 0.619 %. The maximal quantity of calcium in the needles, 0.838 %, was determined in the provenance 14 from the site Sun Creek (provenance code 05092), and the minimal 0.417 %, in the provenance 6 from the site Trout Cr. (provenance code 03356).

In the provenances grown on smonitza, the average calcium content in the needles accounted for 0.259 %. The maximal quantity of calcium (0.427) was adopted by the provenance 1 from the natural site Cranbrook (provenance code 03333). The maximal quantity of calcium determined in the needles of the provenances cultivated on smonitza was almost equal to the minimal quantity of calcium in the Douglas-fir needles grown on brown forest soil. The minimal quantity of calcium on smonitza was adopted by the provenance 6 from the locality Trout Cr. This provenance adopted the minimal quantity of calcium also on brown forest soil. Considerably higher calcium content in the needles of all Douglas-fir provenances grown on eutric cambisol compared to calcium content in the Douglas-fir needles cultivated on vertisol is phenotypically conditioned, i.e. conditioned by different soil characteristics, and not by genetic ability of the provenances to adopt calcium from the soil.



Graph 1. *The variability of calcium content in the Douglas-fir needles on vertisol and on eutric cambisol*

Although all trees at both localities were cultivated under identical site and stand conditions, on the same type of soil and under identical climate conditions, there was a high inter provenance variability in calcium content in the needles, both in the provenances grown on eutric cambisol, and in the provenances cultivated on vertisol.

In both experimental plots, all conditions affecting the development of physiological processes in plants, and thus also the adoption of nutritive substances from the soil were identical for all provenances. Consequently, the variability in calcium contents in the needles of different provenances is the result of genetically inherited capacities of different provenances to utilise the soil potential and to realise the calcium nutrition.

The provenances Cranbrook Inonoaklin Salmo and Mara Lk, at both localities, attained better calcium contents than the average of all provenances. The provenances: Gavia Lake, Nine Bay and Cooke Creek on vertisol attained better calcium contents than the average of all provenances, and poorer calcium contents on eutric cambisol. The provenances: Benton Creek, Sheep Creek and Sun Creek grown on eutric cambisol attained higher calcium concentrations in the needles compared to the average at this site, whereas the same provenances grown on vertisol attained lower calcium concentrations than the average.

The provenances Mann Creek, Trout Cr, Michell Cr and Monte Crk reached lower calcium concentrations than the average of all provenances, both those grown on eutric cambisol, and those grown on vertisol.

CONCLUSIONS

Based on the results of the study analyses of calcium nutrition status of 14 Douglas-fir provenances originating from Canada, it can be concluded that eutric cambisol provides far more favourable conditions for plant nutrition with this element, compared to vertisol. All provenances adopted higher concentrations of the soil calcium from eutric cambisol than from vertisol.

Taking into account the uniform conditions of nutrient adoption from the soil at both localities where the provenance tests were established, it can be concluded that there are genetic specificities in calcium adoption. The inter-provenance variability in calcium contents in the Douglas-fir needles is the indicator of gene pool specificity of different provenances to calcium nutrition.

Acknowledgement

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MAIN CHARACERISTICS OF BALD CYPRESS SEED STAND (*Taxodium distichum* (L.) Rich.) NEAR BAČKA PALANKA

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Abstract: *Bald cypress as an allochthonous conifer species in Serbia can be considered as the species of rapid growth, one of the few conifer species that may be suitable for afforestation of lowland and especially floodplain habitats where it achieves high productivity.*

In Serbia is registered only one seed stand of Bald cypress located near Bačka Palanka, in the FMU "Palanačke Ade-Čipski poloj" section 11, department a, in area of 0.22 ha, with 111 trees. The plantation is about 70 years of age.

The goal of conducted researches is to introduce adaptive, productive and reproductive potential as a starting point for directed use of the available gene fund of this species. In October 2010 breast diameter and height of all trees were measured, yield was evaluated and seed was collected. The collected data were processed in the computer program "Statgraph 6.0".

Keywords: Bald cypress, adaptive, productive potential, diameter, height.

1. INTRODUCTION

Genus *Taxodium* Rich. in the past was widespread in Europe and North America. It consists of deciduous or evergreen, unicameral, tall trees growing on wet and flooded soil. Today it grows on saturated and periodically flooded soil in the southeastern and Gulf areas of the United States, from Louisiana to Florida. At the habitats within the range, according to their botanical and ecological characteristics, three types are distinguished: *Taxodium distichum* (L.) Rich., *Taxodium ascendens* Brongn. and *Taxodium mucronatum* Ten. (Vidaković, 1982).

In 1640, it is entered into Europe where it is grown mainly as a decorative plant in parks. Except for decorative purposes, it can be used for the establishment of forest plantations (Vidaković, 1982). Bald cypress can be planted on stands that are unproductive, which are free, wetland areas around unregulated watercourses, depressions, where failing softwood. Bald cypress tree is highly rated because of the durability in both dry and wet soil, it dries out hard, but it does not throw or bend. It has homogeneous structure, it is easy to process, it well receives color and it is easy to polish. Use value of Bald cypress is multiple: it is used for building docks, bridges, wooden roofs, floors, walls, doors, windows, in the art carpentry, in cooperage, etc. (Špiranec 1959).

In Serbia mainly grows *Taxodium distichum* (L.) Rich. although there is and *Taxodium ascendens* Brong. in park of Banja Koviljača (Ocokoljić, Tucović, 2005). The presence of

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wetland Bald cypess was recorded in the green spaces of major cities: Belgrade, Novi Sad, Vršac, Kraljevo and Vrnjačka Banja (Ninić-Todorović, Ocokoljić, 2001, 2002, Dražić, Batos, 2002, Ocokoljić, Tucović, 2005). Also, the groups of trees were recorded in the circle of the Institute "Vinča" as well as at Plavna in the courtyard of the hunting facility. The presence of Bald cypess was also recorded in the area of protected natural resource Veliko ratno ostrvo in Belgrade, in City Municipality of Zemun (Šijačić-Nikolić et al. 2011).

On the territory of the FE "Novi Sad" there is a registered seed stand of wetland Bald cypress located near Bačka Palanka (Petrović, 1951, Tucović, Stilinović, 1970). Within MU "Palanačke Ade-Čipski poloj", section 11, department a, in area of 0.22 ha there are 111 trees of wetland Bald cypress. The stand is about 70 years of age.

2. MATERIAL AND METHOD

MU "Palanačke Ade-Čipski poloj" has a plain character with an average elevation of the terrain about 80 m above sea level. Surface soil layers of this Management Unit are alluvial formations of the Danube River. Soil belongs to the group of alluvium with different mechanical properties. Bald cypress seed stand is located in section 11a and it has an area of 0.22 ha. It is not influenced by flood waters because it is separated from the Danube by embankment, but it is strongly influenced by groundwater which in the wetter period is rising to the surface.

In order to acquire knowledge about adaptive, productive and reproductive potential of Bald cypress in this seed stand, the field survey was conducted in September 2010 when were recorded 111 trees of Bald cypress. On that occasion the breast diameter of each tree was measured using a millimeter caliper with an accuracy of 1 mm. By the altimeter Vertex III with an accuracy of 0.1 mm was measured the height of all trees. Diameter and height structure was presented using the numerical parameters: the arithmetic mean (d_s, h_s), standard deviation (s_d, s_h), coefficient of variation (c_d, c_h), minimum (d_{min}, h_{min}) and maximum (d_{max}, h_{max}) diameter and height, variational width ($v_š$), the coefficient of skewness (α_3) and flattening coefficient (α_4) (Stamenković, Vučković, 1988). Assessment of yield was performed after Kaper (Isajev, Mančić, 2001), and cones were collected from those trees on which was determined a good yield. In the seed testing laboratory of the Institute of Forestry in Belgrade was conducted an analysis of full-seed by method of seed bisection. The collected data were processed in a computer program Statgraph 6.0.

3. RESULTS AND DISCUSSION

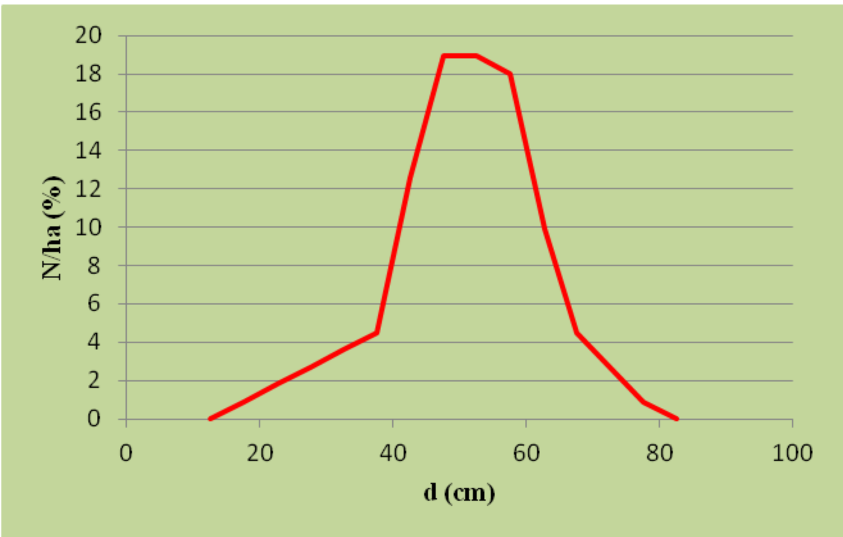
111 trees of wetland Bald cypress were recorded during the field survey. The stand is in the good condition, trees are physiologically strong with no signs of entomological and phytopathological damage. During the construction of canals, some trees were removed, but based on the current arrangement of trees can be reconstructed the rows where once seedlings were planted (Picture 1).

Picture 1. *Bald cypress seed stand*

In Table 1 are numerical indicators of Bald cypress diameter structure. The presented data show that in the stand are trees with the diameter of 20 up to 77 cm. Mean diameter of trees per basal area is 52.9 cm, and mean diameter per basal area of 20% of the thickest trees is 67.7 cm. Variational width of the diameter is 57 cm. Curve of distribution of number of trees by diameter degrees is approximately bell shaped with a maximum in diameter degree of 52.5 cm, a small right asymmetry (-0.259) which is characteristic for even-aged stands (Graph 1).

Table 1. *Numerical indicators of diameter structure*

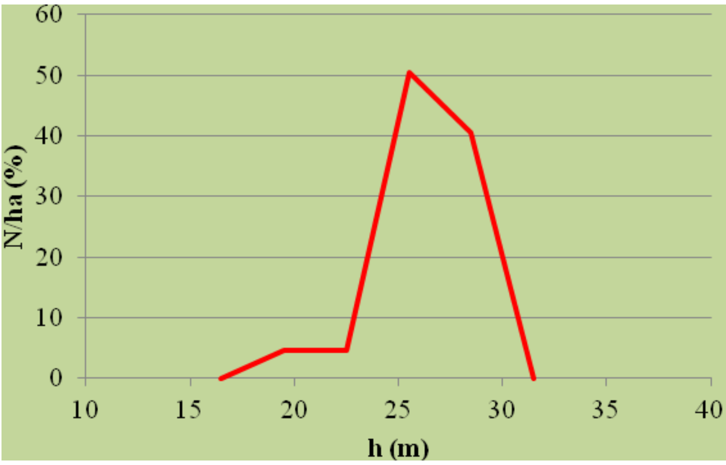
Diameter	
n	111
d_s (cm)	51,7
d_g (cm)	52,9
s_d (cm)	11,48
k_v (%)	22,2
d_{min} (cm)	20,0
d_{max} (cm)	77,0
$v_š$ (cm)	57,0
α_3	-0,259
α_4	3,109
$n_{20\%}$	22
$d_{g20\%}$(cm)	67,7



Graph 1. *Diameter structure*

Table 2. *Numerical indicators of height structure*

Height	
n	111
h_s (cm)	26,5
h_g (cm)	27,1
s_d (cm)	2,03
k_v (%)	7,6
h_{min} (cm)	18,3
h_{max} (cm)	29,5
$v_š$ (cm)	11,2
α_3	-2,046
α_4	7,616
$n_{20\%}$	22
$h_{g20\%}$(cm)	27,8



Graph 2. *Height structure*

In Table 2 are numerical indicators of Bald cypress height structure which show that in the stand are trees with the height of 18.3 up to 29.5 m, with variational width of the height of 11.2 m. Height of average tree per basal area is 27.1 m, and height of average tree per basal area of 20% of the thickest trees is 27.8 m. Curve of distribution of number of trees by height degrees is approximately bell shaped with a maximum in height degree of 25.5 m and right asymmetry (-2,046) which is characteristic for even-aged stands (Graph 2).

Based on values of mean and dominant breast diameters and heights of Bald cypress trees in 70 years of age it can be concluded that in the given site conditions the stand has a satisfactory growth. If these values compare with measurements that were performed at different locations and in different sites it can be concluded that Bald cypress adapted in the studied locality and achieved significant results. In 30 years of age in this stand were measured mean diameter of 31.9 cm and mean height of 19.5 m (Tucović, Stilinović, 1970). In Motovun forest in Istra in 35 years of age were measured mean diameter of 27.4 cm and mean height of 17.7 m (Špiranec, 1966). In North America, in the north of natural prevalence, in 50 years of age mean diameter was 28.1 cm, and mean height was 16.8 m (Petrović, according to Schenko, 1951).

Table 3. *Full-seed percentage*

Tree	Full-seed percentage
2	71
7	62
11	66
14	59
19	67

Yield of trees in the study year was assessed with mark 5 by Kaper. Cones were collected from five trees (trees labeled with 2, 7, 11, 14 and 19). Based on data from Table 3, it can be concluded that the full-seed in the study year is satisfactory and ranges from 59 to 71%. If these data are compared with data from the research of full-seed of Bald cypress trees which originates from Veliko ratno ostrvo (Šijačić-Nikolić et al. 2011), which ranges from 5 to 9%, it can be concluded that the quality of seeds in the studied seed stand is much better and it can be expected that seed from other trees has the approximate percentage of full-seed.

4. CONCLUSION

Written data and researches related to seed stand of Bald cypress near Bačka Palanka are very modest. According to origin trees from the stand can be defined as planted trees of unknown origin of seeds and nurseries where seedlings were produced. Conducted researches present a baseline for evaluating the condition of this seed stand through the introduction of adaptive, productive and reproductive potential.

In the studied site conditions Bald cypress gives satisfactory results of growth. Breast diameter of 52.9 cm of mean tree per basal area and breast diameter of 67.7 cm of mean tree per basal area of 20% of the thickest trees, as well as height of 27.1 m of mean tree per basal area and height of 27.8 m of mean tree per basal area from the category of 20% of thickest trees, show high productive potential of this seed stand. Health condition of the stand is good, with no signs of entomological and phytopathological damage and general appearance of the trees is satisfactory.

Seed yield in the study year was very good, and the percentage of full-seed in five studied genotypes ranges from 59 to 71%. Considering the characters of Bald cypress seed this result shows a good reproductive potential of seed stand.

The occurrence of yield at the stand should be regularly monitored and organized the seed collection from well-adapted genotypes that could be used as starting material for the production of seedlings.

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MINI-PLUGS: A REVIEW ON SIZE, SOIL SUBSTRATE AND SEED SOURCE

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Abstract: *Greek forest nurseries are urged to produce a substantial number of seedlings in order to respond to regeneration needs. Nonetheless, the transplanting success faces many obstacles, mainly due to the adverse environmental conditions that Mediterranean ecosystems pose. The ability to produce adequate number of seedlings, accompanied with the "best" quality is a great challenge. The use of mini-plugs enables to combine the ability to grow a great number of seedlings within a short period of time, while also altering the seedling's quality by using the proper mini-plug size. Further, the use of right size in conjunction with other parameters, such as soil substrate, could also improve the seedling's quality. This paper reviews research that has been conducted on the effect of mini-plugs that varied based on their size, soil substrate and seed source. Specifically, the citied forestry species were Arbutus andrachne L., Cupressus sempervirens L., Pinus nigra J.F.Arnold Pinus brutia Ten., Picea abies L. Karst., Robinia pseudoacacia L. The studied seedling characteristics were morphological (ex. shoot length) and physiological (ex. root growth potential). Based on the reported results, size substantially affected the growth of those seedlings that varied among the studied species, as well as among the studied variables of each species. Similarly, soil substrate as well as seed source also affected the seedling growth. Moreover, these effects have also been found to be carried over even under field conditions by substantially affecting survival success. Overall, specific desired seedling characteristics that favor regeneration success, such as greater roots, could be achieved by the use of the proper mini-plug size, soil substrate and seed source. Nonetheless, the results varied substantially among species, suggesting that species is a key factor that should always be taken into account in order to achieve the best seedling quality.*

Keywords: Mediterranean species, reforestation, restoration, seedling growth

IMPORTANCE IN SEEDING PRODUCTION

Regenerating sites is of high priority when promoting sustainable healthy ecosystems. High levels of disturbances, such as those after fire events, urge the nurseries to provide a substantial number of seedlings within short periods of time in order to serve regeneration purposes. However, forest nurseries in Greece usually work with a low number of different forestry species that mainly focus on the production of *Pinus* spp. that thrive at the Mediterranean ecosystems (Arianoutsou et al., 2002; Thanos and Doussi, 2000). Nonetheless, by promoting an increased number of various forestry species the biodiversity levels also increase that contributes to more sustainable ecosystems.

Seedling quality, in conjunction with seedling quantity, are substantial factors that affect seedling production practices at the nurseries. They are required to produce the best possible seedling quality that could promote regeneration success (Radoglou, 2001; Radoglou et al.,

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2009). For the Mediterranean semi-arid ecosystems, like those in Greece where drought events are more intense (Mendoza et al., 2009), it has been suggested that seedlings with more vigorous roots, help overcoming transplanting stress (Villar-Salvador et al., 2008).

MINI-PLUGS

The use of mini-plugs in the mass production of seedlings is a way to successfully produce high quantity and quality of seedlings. The high number of cells within each mini-plug tray enables the production of tremendous amount of seedlings for a variety of species by using the least amount of seeds or cuttings (Landis, 2007). Mini-plugs can also be machine transplanted to full size forest seedling containers or bare-root nurseries to complete seedling development prior to field planting (Sutton, 2002). Further, it enables seedling production during winter time that ensures planting stock early spring that is usually the regeneration time based on Greek nursery standards. They can also be shipped in large numbers under low cost. Based on current studies, when using the right mini-plug size and growth medium, the best seedlings could be produced in the most cost efficient way (Dini-Papanastasi et al., 2012; Kostopoulou et al., 2010a; Kostopoulou et al., 2010b; Radoglou et al., 2011). Factors like the size of the container, the soil substrate and the seed source can substantially affect the quality of the produced seedlings.

SIZE

Based on Iakovoglou and Radoglou (2012) it has been indicated for *Arbutus andrachne* seedlings a significant effect of the mini-plug size on the seedling height, the leaf area, the leaf- and the total seedling dry weight. The studied volume-wise mini-plug sizes were 3cm^3, 9cm^3 and 18cm^3. These effects where obvious from the first month of seedling growth and were more profound as the age of the seedlings reached the two months with greater mean values for the medium mini-plug size (9cm^3). For the species of *Cupressus sempervirens*, mini-plug size of 18 cm^3 indicated greater seedling height (sizes of 9 and 13 cm^3 also had similar effect), while Root Growth Potential (RGP) was greater for mini-plug sizes of 3cm^3 (Kostopoulou et al., 2010b). The positive effect of the 18 cm^3 was also reported for *Pinus nigra* species (Kostopoulou et al., 2010a). On contrary, there was not an apparent effect of mini-plug size on seedling performance when grown at mini-plug sizes of 3cm^3, 9cm^3, 13cm^3 and 18cm^3 for *Pinus brutia* Ten. (Radoglou et al., 2011). That suggests that the size of the mini-plug undoubtedly affects the performance of the seedlings, while its effect varies among species. Further, the impact of the mini-plug size should be taken into consideration and should be determined for each species for the best quality of the produced seedlings. Nonetheless, the size of the mini-plugs that reflect the volumetric soil availability for root growth as well as the density for seedling competition plays an important role even for one month old seedlings.

The volumetric effect has also been studied in terms of mini-plug depth for one month old seedlings of *Picea abies*, *Pinus brutia*, *Pinus nigra* and *Robinia pseudoacacia* (Kostopoulou et al., 2011). The studied depths were 37 and 60 mm, for seedlings that were grown under the same seedling densities. The results indicated a positive effect of the 60 mm for *Picea abies*, for the root length, the shoot length and the leaf area. For *Pinus brutia* and *Pinus nigra* the 60 mm also gave the best results for the shoot length and the root length, respectively. However, based on the RGP results, shallower mini-plugs worked better for *P. abies* based on root length and the root dry weights. The increased RGP for *P. abies* seedlings, when grown in shallow containers, could limit stressed growth conditions after transplanting, such as drought that is common in Mediterranean ecosystems (Plourde et al., 2009). Further, deeper mini-plugs resulted in improved shoot dry weights for both *P. brutia* and *P. nigra* and root dry weights for *P. nigra*.

On contrary, shallower mini-plugs provided seedlings with longer roots for *P. brutia*. *R. pseudoacacia* was the only species that based on the RGP measurements had greater shoot height for the deeper mini-plugs. That might suggest that when water availability is not an issue, under increased above ground competition, seedlings produced in deep mini-plug containers could be more suitable for competing with other species in terms of taller seedlings. On the other hand, seedlings that are produced in shallower containers, such as *P. brutia,* could be more suitable for transplanting to areas with dry soils, since a deep root system enables plants to access deeper soil water reserves. That is a substantial factor for plant survival during summer droughts in Mediterranean areas, especially during the first years after transplanting (Canadell and Zedler, 1995; Canadell et al., 1996; Costa et al., 2004). However, it needs to be mentioned that in this study the effect of container depth was absent or negligible on the photochemical efficiency or chlorophyll content of the seedling.

SOIL SUBSTRATE

Another factor that was very intensively studied was the effect of soil substrate on seedling performance. Based on Kostopoupou et al. (2010b) it has been indicated better seedlings in terms of above ground area (AGA), root and above ground dry weight and their ratio of one month old *Cupressus sempervirens* L. seedling that were grown in enriched peat (EP). On the other hand, the stabilize medium (SM), provided *Pinus brutia* seedlings with greater seedling height, RGP and better percent of survival under field conditions (Radoglou et al., 2011). In addition, greater root length and dry weight have been indicated for the EP, while taller seedlings were produced by the SM. Dini-Papanastasi et al. (2012) also indicated a significant effect of soil substrate on the broadleafed species of *Robinia pseudoacacia.* For this species it seems that the SM provided better results when compared to EP. Specifically, for one month old seedlings there was a positive effect on most of the studied variables; the seedling height, the root length, the leaf area, the root and the above ground seedling dry weight. Iakovoglou and Radoglou (2012) also indicated for *Arbutus andrachne* seedlings a positive effect of EP on the leaf area and the stem dry weight, while the leaf dry weights were greater for the SM soil substrate. From the above it is concluded that the effect of specific soil substrate that could be used to fill different sizes of mini-plugs should always be taken into account.

SEED SOURCE

To our knowledge, despite the fact that the effect of container size has been studied very intensively, the scientific input on the effect of seed source on seedling performance is very scarce and has been studied only for a few species in conjunction to the mini-plug effect (Dini-Papanastasi et al., 2012; Kostopoulou et al., 2010b). Dini-Papanastasi et al. (2012) indicated for *Robinia pseudoacacia* L. that seedlings that derived from Hungarian-origin seeds provided seedlings with better characteristics when compared to seedlings derived from Greek-origin seeds. They also indicated that the influences of the seed source on the seedling growth continued even after transplanting the seedlings into greater size containers, while the effect of mini-plug size did not. Kostopoulou et al. (2010b) also indicated an effect of seed source and mini-plug size on the performance of *Cupressus sempervirens* seedlings. The seeds derived from Cyprus had greater survival rates when compared to seeds that derived from Northern Greece. The seed source also affected seedling characteristics such as leaf area and root dry weight of the seedlings.

FIELD PERFORMANCE

Based on the so far cited literature, it has been indicated that it is possible to produce seedlings with characteristics that can better adapted to adverse environmental conditions and thus increase the transplanting success. Radoglou et al. (2011) has indicated that under field conditions, *Pinus brutia* that derived from a volumetric mini-plug sizes of 18 cm^3 and soil substrate of SM had higher percent survival when compared to other mini-plug sizes (3, 9 and 13cm^3). Dini-Papanastasi et al. (2012) also indicated a significant effect on *Robinia pseudoacacia* L. seedling survival and seedling performance after transplanting seedlings in the field from different mini-plug sizes and standard-nursery container sizes. Transplanted seedlings that were grown in SM indicated greater survival rates when compared to the other containers. Further, the SM indicated greater seedling height, leaf area and total seedling dry weight, while the LDW was better for the EP.

The above studies indicate that even at the early stage of growth, seedling characteristics are affected by the size of the container (volume- and depth- wise), the soil substrate and the seed source. Nonetheless, the results revealed that the outcome varied among species and that species is a factor that should always be taken into account when the best outcome, in terms of seedling quantity and quality, is aimed.

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ANALYSIS OF SURVIVAL AND VITALITY OF BEECH PLANTS GRAFTED BY METHOD OF SPLICE GRAFTING

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Abstract: *Besides the significance of beech as a forest species, the great importance of its numerous ornamental cultivars is often left out. The research object were genotypes of several ornamental cultivars of beech in Belgrade: Fagus sylvatica L. 'Purpurea', Fagus sylvatica L. 'Tricolor', Fagus sylvatica L. 'Purpurea Tricolor', and Moesian beech Fagus moesiaca (Domin, Maly) Czeczott, as well as the possibility of their heterovegetative reproduction. Ten parent trees were selected from four different locations – 7 trees from the site Beli Dvor and 3 trees from private gardens. Three hundred one-year rootstocks have been prepared for grafting. Grafting was done in the nursery of the Faculty of Forestry in Belgrade, in early spring 2011 year. A method of splice grafting was applied. The aim of this research was to analyze the percentage of survival and development of grafted beech trees, and to determine which parent trees are the most appropriate for reproduction. Analysis of the vitality included measuring of the* **root neck** *diameter and height of the grafted plants. The data were processed by the software package „Statistica". The percentage of surviving grafts was recorded four times during the growing season (June, August, September and October), to track changes and compare the values recorded at the beginning and the end of the growing season. While the first and second observations, grafted cultivars F. sylvatica L. 'Tricolor' and F. sylvatica L. 'Purpurea Tricolor' from different sites, showed the highest percentage of successfully grafting (80-87%), but also the biggest change in the third and fourth observations - the percentage of survival was lowest, only 17-27%. A possible cause is incompatibility of the rootstock and the scion. In 3 cultivars of F. sylvatica L. 'Purpurea' from sites Beli Dvor and Dedinje, was observed almost constant survival rates from 50-60%, in all four periods of observation.*

Key words: survival rates, grafting, beech, ornamental cultivars

INTRODUCTION

European beech (*Fagus sylvatica* L.) is one of the most important forest tree species with the largest distribution in Serbia. Nowadays, in addition to species formed by natural processes, there are cultivars with target characteristics obtained by tree breeding methods. Many significant ornamental cultivars of beech, with emphasized individual aesthetical features (e.g. leaf color and form), have been selected and described by selection and plant breeding. Along with significance as a forest species, European beech is renowned by numerous ornamental cultivars planted in green spaces worldwide, but they are very rare in Serbian green spaces.

The research object were test trees of several ornamental beech cultivars in Belgrade: *Fagus sylvatica* L. 'Purpurea', *Fagus sylvatica* L. 'Tricolor', *Fagus sylvatica* L. 'Purpurea Tricolor', and one Moesian beech - *Fagus moesiaca* (Domin, Maly) Czeczott, as well as the posibility of their heterovegetative reproduction. Ten test trees were selected from four different

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locations, as the sources of scion woods and three hundred one-year rootstocks have been prepared for grafting.

The aim of this research was to analyze the percentage of survival and development of grafted beech seedlings, and to determine which test trees are the most appropriate for reproduction.

It is supposed that production of certain beech cultivars in our conditions, may significantly contribute to the improvement of its use as an ornamental species.

MATERIALS AND METHODS

Ten test trees of ornamental beech cultivars – *Fagus sylvatica* L. 'Purpurea' (trees number 1, 5, 6, 7 and 8), *Fagus sylvatica* L. 'Tricolor' (trees number 2 and 3), *Fagus sylvatica* L. 'Purpurea Tricolor' (trees number 9 and 10) and one Moesian beech - *Fagus moesica* (Domin, Maly) Czeczott (tree number 4), were selected as the sources of scion woods for grafting. Trees were selected from 4 different locations in Belgrade: 7 trees at the site Beli Dvor and 3 trees were selected in private gardens on Dedinje, Banovo Brdo and Žarkovo.

A determination key for 76 ornamental cultivars of European beech (Puschner and Brus, 2008), as well as descriptions of 130 ornamental beech cultivars, written by Hatch (2007), were used for identification of test trees. Cultivar *Fagus sylvatica* 'Purpurea' is a beech whose leaves are bronze-green to very dark blackish-purple, and have a similar shape compared to the leaves of native species. During the summer, the leaves change color, becoming dark green (Hatch, 2007; Puschner and Bruce, 2008). *Fagus sylvatica* 'Tricolor' is a cultivar whose leaves are elliptical, asymmetrical, base color is green with pink margins becoming whiter, in summer (Hatch, 2007; Puschner and Bruce, 2008). *Fagus sylvatica* 'Purpurea Tricolor' is a cultivar whose leaves are dark red, purple, with pink margins, becoming margined pinkish-white (Hatch, 2007; Puschner and Bruce, 2008). *Fagus moesiaca* (Domin, Maly) Czeczott. – Moesian or Balcan beech whose leaves are green and egg-shaped (Ocokoljić ans Ninić-Todorović, 2003).

Collecting of scion woods was done before the begining of vegetation period. Collecting was done from test trees that has healthy, abundant buds on the branches in the dormant season. The cut ends of the scion woods were wraped in a moist paper towels and the entire cuttings were placed in a sealed plastic bags to prevent the woods from drying out. The scion woods were stored in the refrigerator to keep cold, untill grafting. Three hundred one-year rootstocks have been prepared for grafting. Rootstocks were seed propagated in one nursery in East Serbia (Boljevac). After one year (November 2010), the rootstocks have been planted in containers, in the nursery of Faculty of Forestry in Belgrade, where the grafting was done, in early spring 2011 year. A method of splice grafting was applied, because both the understock and scion were of the same diameter (Grbić, 2004, Isajev and Šijačić-Nikolić, 2011). Grafts were regularly watered, fed with liquid fertilizers applied to plant foliage (NPK – 20:20:20) and protected from pests and diseases.

The grafts survival percentage was recorded four times in first year, to track changes and compare the values recorded at the beginning of the first and second growing season. Analysis of the vitality included measuring of the height and root collar diameter of grafts in April 2011 (30 days after grafting) and April 2012 (before beginning of the second vegetation period).

The data were processed by the software package „Statistica". Following results were presented: descriptive statistics (min and max values, average value, standard deviation), LSD-test, analysis of variance and cluster analysis.

RESULTS AND DISCUSSION

In Serbia, no detailed research has been done so far on *Fagus sylvatica* 'Tricolor' and *Fagus sylvatica* 'Purpurea Tricolor' cultivars. Vilotić *et al.* (2006) analyzed the morpho-anatomical characteristics of leaves of cultivars *Fagus sylvatica* 'Luteofolia' and *Fagus sylvatica* 'Atropunicea', while Tošić (2005, 2006) has written about the yellow-leaf beech cultivar *Fagus sylvatica* L. 'Luteofolia'.

The results of the obtained research are relating to the survival percentage of grafted plants and analysis of their viability – 30 days after grafting (April 2011) and before begining of the second growing season (April 2012).

The grafts survival percentage was recorded four times during the growing season (June, August, September and October) in the first year (Табле 1). The degree of grafts survival was determined by counting the plants after leafing until the end of the vegetation period, and was compared.

Table 1: *Grafts survival percentage in the first year*

Grafts survival percentage in 2011 (%)				
Tree	Date of observation			
	13th June	10th August	15th September	20th October
1	30.0	56.6	36.7	30.0
2	63.3	76.7	36.7	36.7
3	80.0	86.7	26.7	26.7
4	63.3	80.0	43.3	43.3
5	70.0	73.3	36.7	33.3
6	56.7	56.7	50.0	50.0
7	70.0	76.7	53.3	53.3
8	46.6	66.7	56.7	60.0
9	83.3	86.7	20.0	16.6
10	63.3	53.3	26.7	20.0
Average	62.7	71.3	38.7	37.0

In the first and second observations, grafted cultivars *F. sylvatica* L. 'Tricolor' and *F. sylvatica* L. 'Purpurea Tricolor', whose scions were collected from the different sites (trees number 3 and 9), showed the highest percentage of successfully grafting (80.0-86.7%). On the other hand, these grafts showed the biggest changes in the third and fourth observations, when the survival percentage was lowest, only 16.6-26.7%. A possible cause is early incompatibility of the rootstocks and the scions (Tucović, 1989/1990). Graft incompatibility is a factor of the early death of some plants. Tucović (1989/1990) has written that the importance of the rootstocks in tree grafting is great and it is necessary to research relations between scions and rootstocks. Genetic similarity index could be useful to determine compatibility/incompatibility between scions and rootstocks. Grafts whose scions were collected from the test tree number 10 (*F. sylvatica* L. 'Purpurea Tricolor') also showed law survival percentage, only 20%.

However, in 3 *F. sylvatica* L. 'Purpurea' cultivars, from the site Beli Dvor and the private garden on Dedinje (trees number 6, 7 and 8), were observed almost constant survival rates from 50-60%, in all 4 periods of observation. Therefore, these test trees (trees number 6, 7 and 8) may be regarded as most suitable for collecting of scion woods, based on annual research. In fact, it can be concluded that cultivar *F. sylvatica* L. 'Purpurea' is suitable for grafting.

It is interesting that plants grafted by scions from the test tree number 8 (*F. sylvatica* L. 'Purpurea') showed lawer survival percentage at the beginning (first observation – 46.6%) than at the end (fourth observation – 60.0%) of growing season. A cause is probably use of scions with "sleeping (dormant) buds". These grafts (with dormant scions) started to leaf out later (in summer). On the other hand, plants grafted by scions collected from tree number 1 (*F. sylvatica* L. 'Purpurea'), showed the same percentage in first and last observations (30.0%).

The sum – average values of survival percentage for all grafted plants was the highest in the second observation period – 71.3%, and the lowest in the fourth period – 37.0%. It means that 1/3 of all grafts survived, in the first year.

The analysis of vitality included variability of morphometric characteristics of grafted plants (grafts height and root collar diameter) 30 days after grafting (April 2011) and before beginning of the second vegetation period (April 2012). Results of descriptive statistics for measured growth elements are shown in Table 2 and Table 3.

Table 2: *Results of descriptive statistics for height of beech grafts*

Tree	HEIGHT (*mm*)					
	X_{min} - X_{max}		$\overline{X}$		*Sd*	
	APRIL 2011	APRIL 2012	APRIL 2011	APRIL 2012	APRIL 2011	APRIL 2012
1	100-210	105-220	146.67	154.38	24.50	27.79
2	90-235	95-245	136.67	146.46	30.83	34.30
3	100-195	110-205	144.33	152.50	26.25	27.03
4	100-185	105-195	153.17	160.63	20.02	21.88
5	100-220	115-230	145.17	153.33	28.21	27.81
6	80-220	85-230	138.17	145.00	28.36	31.66
7	100-190	105-195	139.50	146.67	23.83	23.11
8	115-220	125-230	153.67	161.25	20.17	21.63
9	80-250	115-195	158.63	162.71	33.16	24.41
10	85-260	95-270	155.13	162.70	43.85	43.09

Legend: X_{min} - X_{max} - minimum and maximum values; $\overline{X}$ - average value; *Sd* - Standard deviation

Average values of grafts height in April 2011 (30 days after grafting) are significantly different in certain grafts. Values range from 136.67 *mm* to 158.63 *mm*, with the highest mean value observed in grafts whose scions were collected from the tree number 9 (*F. sylvatica* 'Purpurea Tricolor'), and the lowest from the tree number 2 (*F. sylvatica* 'Tricolor ').

In April 2012, the highest average value for the grafts height (162.71 *mm*), was again observed in grafts whose scions were collected from the tree number 9 (*F. sylvatica* 'Purpurea Tricolor'), and the lowest average value (145.00 *mm*) from the tree number 6 (*F. sylvatica* 'Purpurea'). Comparing the mean values of grafts height 30 days after grafting and before beginning of the second vegetation period, it may be noted that the grafts progressed during the first growing season.

The highest measured value for the grafts height in April 2011 was 260 *mm* (tree number 10 – *F. sylvatica* 'Purpurea Tricolor'), and the lowest was 80 *mm* (trees 9 and 6). The highest range of variation between the minimum and maximum values for the grafts height 30 days after grafting was recorded in grafted seedlings *F. sylvatica* 'Purpurea Tricolor' (trees 9 and 10). These values were ranged from 80-250 *mm* (tree 9) and 85-260 *mm* (tree 10). The lowest range of variation was recorded in the Moesian beech (tree 4), where the plants ranged from 100-185 *mm* in height.

The highest range of variation between the minimum and maximum values for the height in April 2012 was observed in grafts *F. sylvatica* 'Purpurea Tricolor' (tree 10) and *Fagus sylvatica* 'Tricolor' (tree 2). These values ranged from 95-270 *mm* (tree 10) and 95-245 *mm* (tree 2). The lowest range of variation was recorded in the cultivar *F. sylvatica* 'Purpurea Tricolor' (tree 9), where the plants ranged from 115-195 *mm* in height. The highest measured value for the height of seedlings in April 2012 was 270 *mm* (tree 10 – *F. sylvatica* 'Purpurea Tricolor'), and the lowest was 85 mm (tree 6 – *F. sylvatica* 'Purpurea').

Table 3 presents the results of descriptive statistics for the root collar diameter, measured in April 2011 and April 2012.

Table 3: *Results of descriptive statistics for root collar diameter of beech grafts*

Tree	**ROOT COLLAR DIAMETER (*mm*)**					
	X_{min} - X_{max}		$\overline{X}$		***Sd***	
	APRIL 2011	APRIL 2012	APRIL 2011	APRIL 2012	APRIL 2011	APRIL 2012
1	6.3-11.8	6.7-12.1	8.53	9.09	1.49	1.48
2	4.2-13.8	5.6-13.9	7.97	8.16	1.91	1.86
3	4.9-10.2	4.9-10.1	7.96	8.25	1.32	1.17
4	5.5-10.8	5.7-11.4	7.79	8.42	1.43	1.66
5	6.0-12.6	6.3-12.8	8.25	8.82	1.65	1.76
6	5.1-12.3	5.6-12.7	7.96	8.50	1.69	1.96
7	4.9-10.6	4.9-11.6	7.66	8.59	1.60	1.82
8	5.9-11.3	6.3-10.5	7.76	8.25	1.40	1.29
9	3.3-11.2	6.9-11.4	8.28	8.97	1.61	1.21
10	5.5-11.4	6.3-11.9	8.49	8.81	1.64	1.59

Legend: X_{min} - X_{max} - minimum and maximum values; $\overline{X}$- average value; ***Sd*** - Standard deviation

Average values of root collar diameter (Table 3) in April 2011 ranged from 7.66 *mm* to 8.53 *mm*, with the highest mean value observed in grafts whose scions were collected from the tree number 1 (*F. sylvatica* 'Purpurea'), and the lowest collected from the tree number 7 (*F. sylvatica* 'Purpurea'). In the first year the tree from which scions were collected should not have an impact on the root collar diameter, because it is, in fact, the diameter of the rootstock. In April 2012, these values are slightly higher and ranged from 8.16 *mm* (tree 2 – *F. sylvatica* 'Tricolor') to 9.09 *mm* (tree 1 – *F. sylvatica* 'Purpurea').

The highest measured value for the root collar diameter, in April 2011, was 13.8 *mm* (tree number 2 – *F. sylvatica* 'Tricolor'), and the lowest was 3.3 *mm* (tree number 9 - *F. sylvatica* 'Purpurea Tricolor'). It is interesting that grafts whose scions were collected from the tree number 9 showed the lowest value for the height, in the same year.

The highest range of variation between the minimum and maximum values in April 2011 was observed in grafts *F. sylvatica* 'Tricolor' (tree 2) where the minimum and maximum values differ by 9.6 *mm*. In April 2012 the highest range of variation was observed in grafts whose scions were collected from the same tree (number 2), but it was slightly smaller, about 8.3 *mm*. On the other hand, the lowest range of variation was recorded in Moesian beech (tree 4), where the difference between the minimum and maximum value was 5.3 *mm F. sylvatica* 'Purpurea Tricolor' (tree 9), where the plants ranged from 115-195 *mm* in height. In April 2012, the lowest range of variation between the minimum and maximum values was observed in tree number 8 (*F. sylvatica* 'Purpurea').

Table 4 presents the results of LSD test and Analysis of variance for the height of grafted plants in April 2011 and April 2012. The trees were grouped to identify similarities and differences between the average values. Average values of beech grafts height obtained in April 2011, showed that are significantly different. The first homogeneous group consists of grafts whose average values of height were less than 140 *mm* (trees 2, 6 and 7). The second group consists of grafts whose average value of height was between 140-150 *mm* (trees 3, 5 and 1), and in the third homogenous group are grafts whose average value of height exceed 150 *mm* (tree 4, 8, 10 and 9).

Comparing this results with the results of LSD test, for the same measured characteristic, but in April 2012 (Table 4), differences in average values of height of beech grafts, were not statistically significant. This result may indicate that, during the first growing season, different cultivars became similar in height. Results of Analysis of variance for the height of beech grafts, showed that the obtained differences between average values were statistically significant (P-value <0.05) in April 2011(P-value = 0.02), but were not in April 2012 (P-value = 0.19).

Table 4: *LSD-test and Analysis of variance for height of beech grafts*

HEIGHT (*mm*)					
LSD-test					
Date	April 2011		April 2012		
Tree	Average value	Homogenous groups	Tree	Average value	Homogenous groups
2	136.67	X	6	145.00	X
6	138.17	X	2	146.46	XX
7	139.50	XX	7	146.67	XX
3	144.33	XXX	3	152.50	XX
5	145.17	XXX	5	153.33	XX
1	146.67	XXX	1	154.37	XX
4	153.17	XX	4	160.65	XX
8	153.67	XX	8	161.25	XX
10	155.13	X	10	162.70	X
9	158.83	X	9	162.71	X
Analysis of variance					
Date	April 2011		April 2012		
Mean Square	F-Ratio	P-Value	Mean Square	F-Ratio	P-Value
1800.40	2.19	0.02	1171.86	1.40	0.19

Table 5 presents the results of LSD test for root collar diameter of beech grafts in April 2011 and April 2012, as well as Analysis of variance. Differences in average values root collar diameter, in April 2011 and 2012, were not statistically significant, which was confirmed by Analysis of variance. This result can be explained by the fact that the values of this characteristic in the first growing season were the values of root collar diameter from rootstocks. Since the rootstocks were of the same origin, same age, and grown under identical environmental conditions, thereby this result was expected.

Table 5: *LSD-test and Analysis of variance for root collar diameter of beech grafts*

ROOT COLLAR DIAMETER (*mm*)					
LSD-test					
Date	April 2011		April 2012		
Tree	Average value	Homogenous groups	Tree	Average value	Homogenous groups
7	7.66	X	2	8.15	X
8	7.76	XX	8	8.25	XX
4	7.80	XX	3	8.25	XX
3	7.96	XX	4	8.43	XX
6	7.96	XX	6	8.50	XX
2	7.97	XX	7	8.60	XX
5	8.25	XX	10	8.81	XX
9	8.28	XX	5	8.82	XX
10	8.49	X	9	8.97	X
1	8.53	X	1	9.09	X
Analysis of variance					
Date	April 2011		April 2012		
Mean Square	F-Ratio	P-Value	Mean Square	F-Ratio	P-Value
2.79	1.12	0.35	2.51	0.98	0.46

According to the diagram of Cluster analysis (Diagram 1), it can be concluded that the shortest linkage distance is recorded between trees 9 and 10 (*F. sylvatica* 'Purpurea Tricolor').

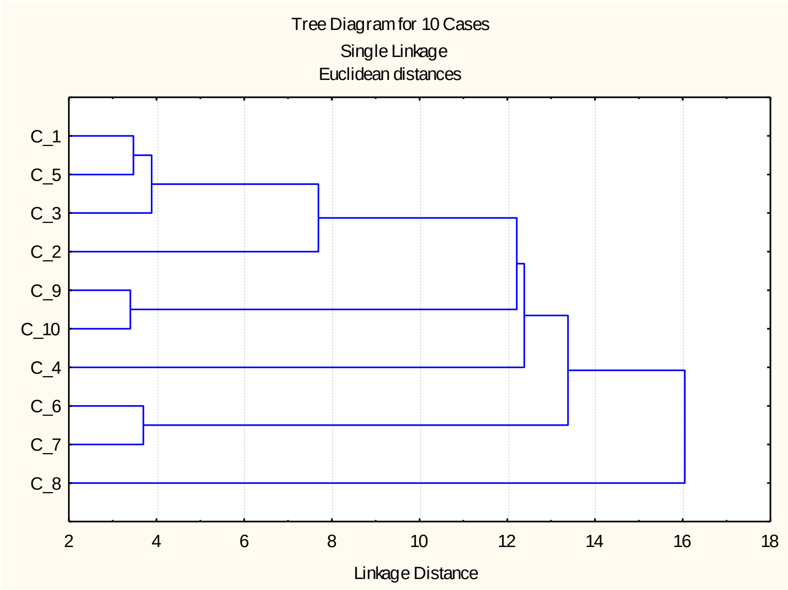

Diagram 1. *Cluster analysis diagram based on survival percentage and morphometric characteristics of beech grafts in April 2012*

Three homogeneous groups can be defined from all analyzed grafts: the first one is consisted of trees number 1, 5 (*F. sylvatica* 'Purpurea'), 3 and 2 (*F. sylvatica* 'Tricolor'), the second includes trees number 9, 10 (*F. sylvatica* 'Purpurea Tricolor') and 4 (*F. moesiaca*) and the last one includes trees number 6 and 7 (*F. sylvatica* 'Purpurea'). Tree number 8 (*F. sylvatica* 'Purpurea') are in a distance from all analyzed trees.

CONCLUSIONS

According to the results of conducted research it can be concluded that:

- differences between average values of height of beech grafts are statistically significant in April 2011, but not in April 2012;
- there is a differentiation between cultivars with red leaves and tricolor leaves in height and survival percentage;
- cultivars *Fagus sylvatica* 'Purpurea Tricolor' are characterized with higher values of grafts height than cultivars *Fagus sylvatica* 'Purpurea'.

Based on the foregoing, the examination of survival and variability of beech grafts in the first growing season showed that is important to analyze the same plants in second growing season, especially grafts whose scions were collected from trees number 9 and 10. These trees showed the highest average values for height and the highest survival percentage (number 9) in the first and second observation period. But, also the lowest survival percentage (< 20%), at the end of growing season. It is important to analyze compatibility between scions and rootstocks, because it can be reason for early death of some grafted plants. For this reason, it is necessary to continue with similar investigations on these and other cultivars of this significant forest species.

It can be concluded that, as for survival percentage and height of beech grafts, the grafts of the cultivar *Fagus sylvatica* 'Purpurea Tricolor' were different from the other cultivars. On the other hand, the grafts of the cultivar *Fagus sylvatica* 'Purpurea' showed almost constant survival rates (50-60%), in all 4 periods of observation. Therefore, trees of cultivar *Fagus sylvatica* L. 'Purpurea' may be regarded as most suitable for grafting, based on annual research.

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ROLE OF PERICARP IN TREE OF HEAVEN'S *(Ailanthus altissima* [Mill.] Swingle) SEED GERMINATION

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Abstract: *Tree-of-heaven (Ailanthus altissima [Mill.] Swingle) is an invasive tree species which has colonized numerous ecosystems and affected ecosystem processes worldwide. It is a common woody plant weed in the conditions of the urban environment, both in our and in other European countries. Tree-of-heaven fruits abundantly every year and successively suppresses indigenous shrubs and young native trees, preventing regeneration of the natural plant communities and habitats of other autochthonous species. It presents serious harmful factor to biodiversity and affects the unsecure survival or much more fully impossible growth of indigenous species offspring with source of sunlight blocking, or space and soil nutrition taking. The study of tree of heaven's biology has particular importance because of the fact that this species was not closely examined in the territory of Serbia. Existing data of tree of heaven's ecology are often related to populations from geographically distant areas of Europe. As a result, each closer study of tree of heaven is a contribution to better understanding of this introduced plant. One of the major shortcomings of previous studies was often neglecting the geographical, ecological differentiation and the divergence of local populations in their new settlements. Many questions related to ecology, genetics and taxonomy of this woody plant have not yet been determined. The aim of this study was to investigate the influence of pericarp on the germination of tree of heaven seeds, which would contribute to the better understanding the biology of invasive prediction of future course of its expansion and opportunities for its suppression. The study further refines the knowledge on the effects of similar and newly used treatments, improving the management techniques to reduce the presence and growth of this aggressive invasive tree.*

Key words: germination, *Ailanthus altissima*, pericarp, invasive tree species

INTRODUCTION

Tree-of-heaven (Simaroubaceae: Sapindales) is naturally distributed in China and Taiwan. It was the first introduced to Europe in the mid-18th century from China, and, subsequently, to America. The first plants were cultivated in botanical gardens, where they were planted as decorative trees on account of their beauty, particularly distinct in autumn, when characteristic fruits appear and leaves acquire red colour. This tree was first recorded in Serbia by Josif Pančić in 1871, who recommended it for afforestation of barren land jointly with black locust, after which it was spread throughout the entire country (Vukićević, 1996).

Some of the main characteristics of this tree are its not being demanding in terms of soil, rapid growth, formation of thicket and ability to survive in places where other species are cannot grow. Most commonly, this species appears in house and building cracks, abandon construction sites, rubble and disposal sites of other building material, along railways, even in gutters of city sewerage (Stilinović, 1985).

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With its root, the species may cause damage to carriage ways and building foundations. Locations in which tree of heaven is found indicate that it excellently bears air pollution and various other forms of pollution. One mature tree can produce 350,000 seeds per year, while its germination ability is exceptionally high (Stilinović, 1987). A seed may be transported by wind over long distances and cover large area. In addition to seed, this species may also propagate vegetatively by root sprouts, which makes its control exceedingly difficult (Rick *et al* 2006).
Tree-of-heaven represents one of the best-adapted broadleaved species to life in urban areas. It is very tolerant to extreme temperatures, drought and it best grows in sunny areas (Tucović *et al* 1996a). The major problem with respect to control of this invasive species is the fact that it has no natural enemies, which additionally facilitates its rapid spread and invasion of new areas (Google 1). It is very difficult to remove it, once it established a root system. It is very resistant, despite felling or use of herbicides (Tucović *et al* 1996b).

Considering generally all regions in which tree of heaven intensively occurs, the absence of other woody vegetation could be noted under its crowns, with development which is suppressed as a result of its influence (Dietz & Edwards, 2006).

A certain number of plant species exude chemical substances that can have an inhibitory or stimulating effect on other plants. It is very important to determine reactions and tolerance between certain plant species and establish existence of substance which, exuded from a certain part of plant, can have an allelopathic effect (Lawrence *et al* 1991; Prati & Bossdorf, 2004). Seed of some plants frequently contains substances that exert adverse impact on seed germination or growth of other plants (Gómez-Aparicio & Canham, 2008). During the period of maturing, fruits also exude ethylene in the surrounding atmosphere, which may have an inhibitory effect on other plants, (Đukić M, 2006).

MATERIAL AND METHODS

• *Material*

Tree-of-heaven seed was collected in June 2008, in the area of Belgrade racecourse, from the trees located in the immediate vicinity of the road, along which this species most commonly grows. Trees are of up to 10 m height and of good vitality.

The *Lactuca* sp. (lettuce) seed from commercial packaging was used.

• *Methods*

Following the seed collection, 300 seeds were selected, 150 out which had their pericarp removed and 150 did not. After that, seeds were separated into three groups of 50 seeds with no pericarp and three groups of 50 seeds with pericarp. Then, the seeds were placed for germination. An immediate (direct) method was used for investigation of germination (Inderjit & Callaway, 2003a). The substrate was a filter paper poured over by distilled water. During the period of 17 days (a recommended period of investigation, according to a literature source 'Seeds of Woody Plants the U.S.A, Forest service, Washington D.C., 1974.) the course of germination was monitored on daily basis.

When the germination of Tree-of-heaven seed was completed, the seed of species *Lactuca* sp. (lettuce) was placed onto the same substrates, 50 seeds in three repetitions. The seed germinated very rapidly, therefore the period of germination monitoring lasted seven days. The purpose of placing lettuce seeds was to establish the existence of inhibitory substance, exuded from the Tree- of-heaven fruit or seed that affects germination. The obtained results were processed by a programme Statgraphics ver. 2.1. A statistical test of variance analyses was used (Goffe *et al* 1994).

RESULTS AND DISCUSSION

The results of germination were presented by means of four germination indicators:

- Technical germination (TG)
- Germination energy (GE)
- Germination intensity (GI)
- Mean germination period (MGP)

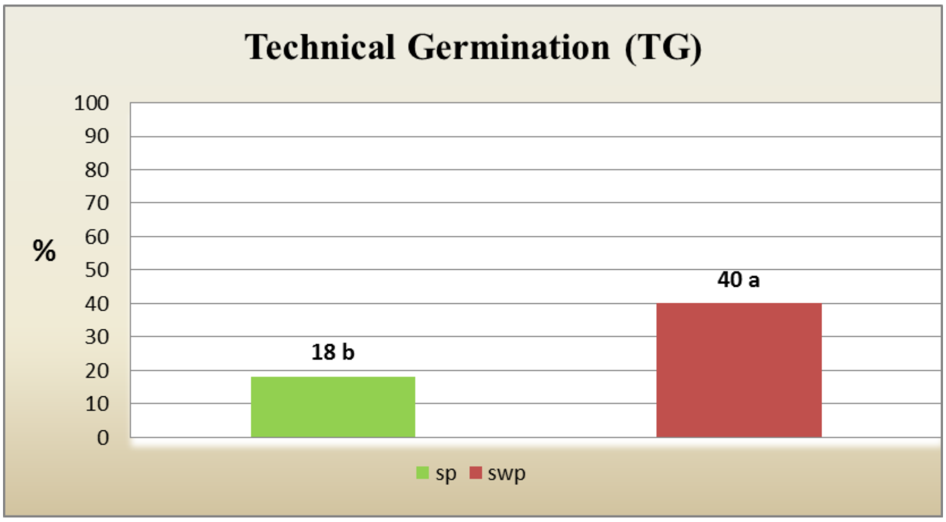
Other germination indicators – germination extent coefficient (GEC), germination association coefficient (GAC), germination evaluation according to *Djavanshir* (GE (Djav)) and germination evaluation according to *Czabator* (GE (Czab)) – are used for planning of nursery production, hence, they were not considered in this paper (Inderjit & Callaway, 2003b).

The results of analysis of multiple scopes of all seed with pericarp parameters and seed without pericarp parameters are presented in **Table 1**. Mean values of indicators TG, GE, GI, MGP and designations of homogenous groups are exhibited.

Table 1 *The layout of homogenous groups is denoted by letters a and b (SP – seed with pericarp and SWP – seed with no pericarp)*

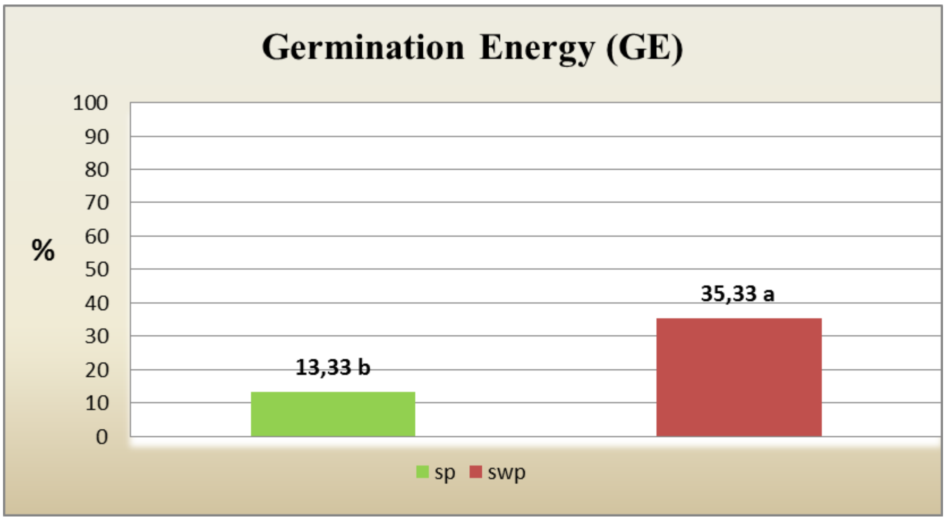
TREATMENT	Technical germination	Germination energy	Germination intensity	Mean germination period
SP	18^a	13.33^a	120.33^a	13.48^a
SWP	40^b	35.33^b	307.66^b	15.38^b

The results of variance analysis are presented in the text below:



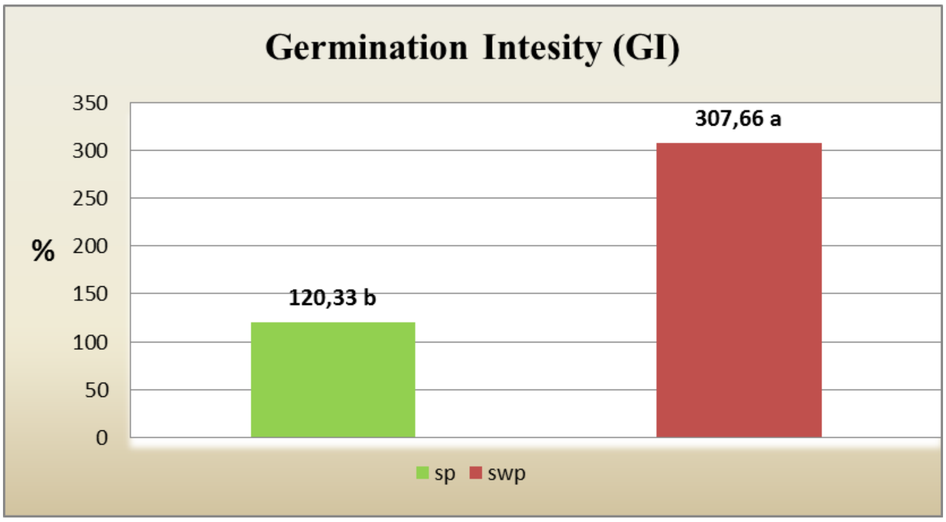
Graph 1 *Mean value of TG parameters, with designation of homogenous groups*
***Sp** – seed with pericarp and **swp** – seed with no pericarp*

The seed without pericarp (swp) had higher technical germination values (TG). Consequently, the analysis of technical germination mean values (TG) indicates that the seed with no pericarp (swp) produced better results in comparison to the seed with pericarp (sp). TG value is significantly lower in comparison to the seed with pericarp (sp).



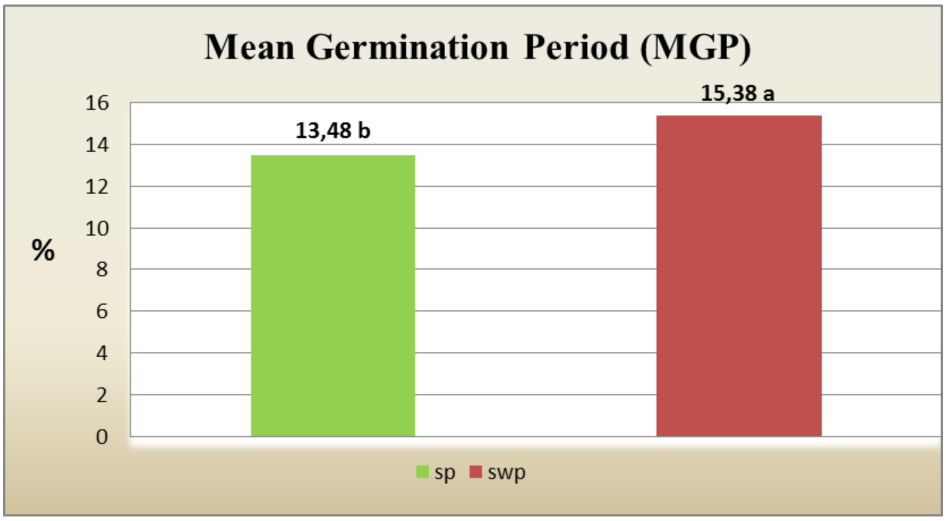
Graph 2 *Mean values of GE parameters, with designations of homogenous groups*
Sp *– seed with pericarp and* ***swp*** *– seed with no pericarp*

The (GE) parameter of seeds with no pericarp (swp) has a higher value than the parameter of seeds with pericarp (sp).



Graph 3 *Mean values of GI parameters, with designations of homogenous groups*
Sp *– seed with pericarp and* ***swp*** *– seed with no pericarp*

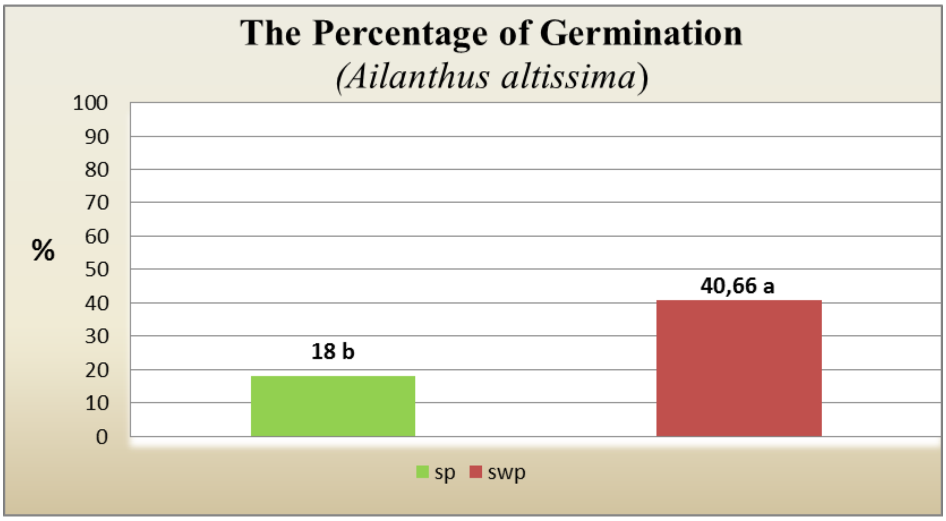
The seed without pericarp (swp) has higher germination intensity (GI) in comparison to the seed with pericarp (sp). The GI value is significantly lower in the seed with pericarp (sp).



Graph 4 *Mean values of MGP parameters, with designation of homogenous groups*
***Sp** – seed with pericarp and **swp** – seed with no pericarp*

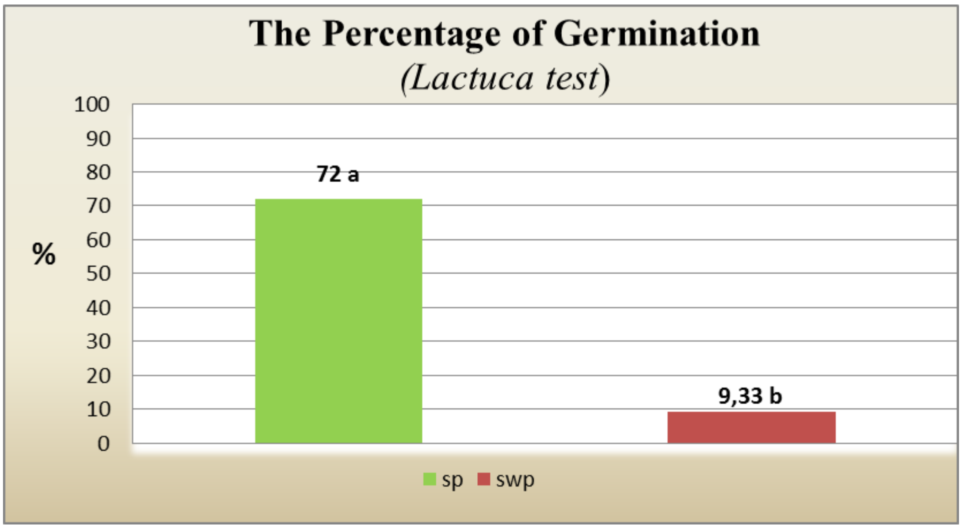
Germination period mean values (MGP) of seed with pericarp (sp) and seed with no pericarp (swp) do not display significant difference, which means that germination period is approximately the same for both types of seed.

Germination percentages, that is, their mean values, are presented in the following graphs.



Graph 5 *Mean values of A. altissima germination percentage*
***Sp** – seed with pericarp and **swp** – seed with no pericarp*

Pericarp probably physically protracts swelling; therefore germination without pericarp is more intensive, although it is possible that pericarp contains a certain inhibitory substance, which protracts Tree-of-heaven germination until the substance is washed away with rain, that is, until better germination conditions develop in nature. However, this substance, when present, does not inhibit lettuce seed germination.



Graph 6 *Mean values of lettuce germination percentage*
***Sp** – solution in which Tree of heaven seed with pericarp previously germinated*
***Swp** - solution in which Tree of heaven seed with no pericarp previously germinated*

Germination of lettuce seed in a solution in which Tree-of-heavens seed with no pericarp previously germinated is probably inhibited by substances exuded from a seed membrane, or it is inhibited by the secondary metabolites of endosperm, degraded in the course of germination process, and a developing germ, since bio-chemical processes are very intensive in that period, or by all these factors jointly. At any rate, it may be considered an allelopathic relation. It would be interesting to investigate the impact of these substances on seed of other plants, woody plants in particular.

CONCLUSIONS

This paper examines the germination indicators (technical germination (TG), germination energy (GE), germination intensity (GI), mean germination period (MGP)) of the seed with pericarp and the seed without pericarp of species Tree-of-heaven, where, following the seed germination on identical substrates (distilled water), *Lactuca sp.* (lettuce) seed was administered, with a view to establishing the existence of substances, occurring after the germination of Tree-of-heavens seed, which inhibit germination.

From the above mentioned findings it could be concluded as follows:

- In the investigated species, the seed with no pericarp exhibited far better germination ability (40.66%) in comparison to the seed with pericarp (18%)
- In contrast, the results obtained in lettuce proved that its seed germinated better on a substrate contained the Tree-of-heavens seed with pericarp – 72%, whereas the results obtained on the seed sample with no pericarp accounted for 9.33%
- Based on the obtained results, it can be assumed that a discharge of inhibitory substances from Tree-of-heavens seed occurs during the germination course.

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forests. Studies and observation were carried out in Serbia continuing, with the National Focal Centre at the Institute of Forestry since 2003. The underlying idea of this project is to monitor harmful factors (biotic, abiotic and anthropogenic) on the status and development of forest ecosystem with special attention to the evident harmful impact of introduced plants.

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VARIABILITY OF FLOWERING AND SEED CROP IN A CLONAL SEED ORCHARD OF SCOTS PINE (*Pinus sylvestris L.)*

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Abstract: *The analysis of quantitative and qualitative characteristics of flowering and cones crop abundance was carried out in clone seed orchard of the Scots pine (Pinus sylvestris L.) at the location Stanovi near Doboj on 37 year-old trees. Phenological observations were carried out on on 214 ramets in 20 clones in the springs of years 2005 and 2006. The obtained results indicate the presence of the notable variability of regularity and the abundance in creation of micro- and macrostrobiles of Scots pine in the seed orchard, where all the flowering abundance grades ranged from "+" to "5". The conducted analysis of crop abundance showed a high percentage of ramets without crops (70% - 79%). The results indicated that the function of the orchard is not compatible with its purpose, and that there are possible genetic and ecological factors that cause the absence of seed crops. The results of two-year-old analyses are important for future activities related to establishing new seed orchards.*

Key words: Scots pine, clone seed orchard, flowering, crop.

INTRODUCTION

Establishing seed orchards is one of the most important ways of breeding trees. Phenotype selection and vegetative propagation of selected trees, as well as the establishment of clonal seed orchards was initiated with the aim to realize more regular periodicity of crops and obtain genetically good quality forest seeds. Funds invested in founding and organizing seed orchards can't be fully justified if the seed crops are low, as it is the case with many seed orchards raised up to date. Studying the functionality of seed orchards was performed in the clonal seed orchard ofScotspine in Stanovi on 20 clones and 214 ramets during 2005 and 2006. In our research, we studied the following characteristics: flowering abundance of male and female flowers, flowering ratio, sexual characteristics of a clone seed orchard, flowering intensity, and the abundance of cones crop. The results of the study are important for further work on establishing new seed orchards, as well as improving the crops in the existing ones.

OBJECT OF RESEARCH

The Scots pine plantation is located near Doboj, in the nursery Stanovi. It was established in autumn 1968 in Ozimice, but in spring 1972 the nursery was transplanted in Stanovi. The plantation containing 20 clones was established on a 1 ha plot, at an altitude of 155m. The

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distance between the ramets of each clone was about 5m, and the distance between the rows was 4.5 m. By applying the method of individual selection in the area of Knežinski Palež on mountain Romanija, about 20 "plus" trees, ie. 20 best tree phenotypes were selected. In establishing the seed orchard, each orteta was represented through 20 copies-ramets, which makes a total of 400 ramets. Due to the war in Bosnia there was a reduction of the number of ramets compared to the plot size and the number of ramets in the plantations establishment. Since establishing the seed orchard in 1968 up to date out of 400 built-in ramets in twenty clones 46.5% or 186 ramets failed. The total number of ramets today is 214, and the clones are represented as follows: clones 3, 7, 12 and 17 account for 40%, clone 10 for 45%, clones 15 and 19 for 50%, clones 1, 2, 6, 11 and 13 for 55 %, clones 4 and 5 for 60%, 18 and 16 for 65% while clones 9 and 14 are most common, accounting for 70% (Table 1). The plantation is located on the primary pseudogley with Aoh-A/Ig-IIg-C profile type, and the climate in the area where the plantation is is moderately humid, D a n i č i ć V., 2008.

Table 1. *Number of repetitions of 20 clones on a plantation*

Clone	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Number of ramets	11	11	8	12	12	11	8	12	14	9
Clone	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Number of ramets	11	8	11	14	10	13	8	13	10	8

METHOD

Rating the abundance of microstrobilae and makrostrobilae

Monitoring the abundance of male and female strobilae was carried out on all 214 ramets. These analyses were conducted during 2005 and 2006. Estimating the abundance of forming male strobilae was carried out after the prior counting of all the strobilae on a selected branch in the middle of the crown and the approximate value was determined for the entire crown of the tree. The abundance of female strobilae was determined by directly counting makrostrobilae by using binoculars. The rating was based on quantitative criteria shown in Table 2. Based on the obtained nominal values related to the abundance of both sexes strobilae in all 214 ramets, the extent of variation was determined in the number of male, the number of female flowers, flowering ratio, the intensity of flowering and sexual characteristics of a clone seed orchard ,table 2 .

Table 2. *Criteria for assessing the abundance of formed strobilae (by Tosic, M. 1991).*

Number of strobilae		**Rating**
Male	Female	
Up to 150	Up to 50	+
151 – 300	51 – 80	1
301– 500	81 – 130	2
501 – 800	131 – 180	3
801– 1200	181 – 230	4
over 1200	over 230	5

Rating crops abundance

Crop yield abundance of cones in a *Scots pine* seed orchard was performed by estimating the number of cones on each ramet of an individual clone during the period from 2004 to 2006, whereas in 2004 the estimates were based on the presence of three-year old cones. The assessment was performed by quantitative criteria presented in Table 3.

Table 3. *Number of cones on a tree corresponding to the given scale (by Tosic, M. 1991)*

Number of cones	Rating
do 50	0
51-80	1
81-130	2
131-180	3
181-230	4
preko 230	5

RESEARCH RESULTS

Variability of the number of micro-and and macro-strobilae

The data related to the regularity and the estimates of the number of formed microstrobilae and macrostrobilae according to the criteria given in Table 2 and the flowering year are presented in Table 4. The obtained results related to the flowering abundance of micro- and macrostrobilae in both years showed the presence of marked variability among and within clones. On all ramets in all 20 clones in both years, the formation of both male and female flowers was recorded. In the second year of the research, all analyzed ramets had lower grade of flowering abundance of micro- and and macrostrobilae.

Table 4. *Evaluation of the number of micro-and macrostrobilae per clone in percentages*

Rating	CLONE																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
MICROSTROBILAE-2005																				
+	18,18	0	0	16,67	0	9,09	12,50	0	7,14	11,11	0	0	9,09	7,14	10	15,38	12,50	7,69	10	0
1	9,09	0	25	0	8,33	0	0	0	14,29	11,11	0	12,50	18,18	7,14	0	15,38	0	0	10	0
2	27,27	45,45	0	16,67	33,33	27,27	12,50	33,33	14,29	0	27,27	25,00	0	7,14	30	15,38	25	15,38	20	37,50
3	9,09	9,09	12,50	16,67	33,33	18,18	37,50	8,33	7,14	22,22	18,18	0	27,27	14,29	10	0	25	15,38	10	12,50
4	9,09	18,18	37,50	33,33	8,33	18,18	0	33,33	35,71	22,22	18,18	37,50	9,09	42,86	30	30,77	0	38,46	30	12,50
5	27,27	27,27	25,00	16,67	16,67	27,27	37,50	25	21,43	33,33	36,36	25,00	36,36	21,43	20	23,08	37,50	23,08	20	37,50
MICROSTROBILAE-2006																				
+	27,27	9,09	12,50	25	8,33	27,27	12,50	0	28,57	33,33	9,09	12,50	18,18	14,29	10	38,46	12,50	15,38	20	12,50
1	36,36	27,27	25	0	25	9,09	25	25	21,43	11,11	27,27	12,50	27,27	7,14	10	0	12,50	7,69	40	25
2	0	9,09	25	16,67	16,67	18,18	12,50	25	7,14	0	27,27	0	9,09	35,71	30	0	25	15,38	0	37,50
3	0	27,27	0	25	16,67	18,18	12,50	8,33	7,14	11,11	27,27	50	27,27	21,43	20	23,08	25	38,46	10	0
4	9,09	9,09	12,50	8,33	16,67	18,18	0	25	28,57	33,33	9,09	25	0	14,29	20	23,08	12,50	23,08	30	12,50
5	27,27	18,18	25	25	16,67	9,09	37,50	16,67	7,14	11,11	0	0	18,18	7,14	10	15,38	12,50	0,00	0	12,50
MACROSTROBILAE-2005																				
+	18,18	27,27	12,50	16,67	16,67	9,09	25	0	21,43	22,22	9,09	12,50	18,18	21,43	10	23,08	12,50	0	10	0
1	36,36	0	25	25	25	27,27	37,50	33,33	14,29	0	27,27	12,50	18,18	28,57	50	23,08	25	23,08	40	37,50
2	18,18	27,27	25	25	33,33	27,27	12,50	25	28,57	11,11	18,18	37,50	18,18	7,14	10	23,08	12,50	30,77	10	25
3	18,18	9,09	12,50	8,33	8,33	9,09	12,50	16,67	14,29	33,33	27,27	37,50	27,27	7,14	10	0	12,50	23,08	30	12,50
4	0	0	12,50	8,33	8,33	9,09	12,50	8,33	14,29	11,11	9,09	0	9,09	7,14	10	15,38	0	15,38	10	12,50
5	9,09	36,36	12,50	16,67	8,33	18,18	0	16,67	7,14	22,22	9,09	0	9,09	28,57	10	15,38	37,50	7,69	0	12,50
MACROSTROBILAE-2006																				
+	36,36	27,27	25	33,33	16,67	18,18	37,50	8,33	28,57	22,22	27,27	25	18,18	28,57	10	23,08	12,50	7,69	10	12,50
1	36,36	27,27	25	25	50	54,55	25	41,67	35,71	11,11	27,27	50	27,27	35,71	60	15,38	37,50	46,15	70	37,50
2	18,18	9,09	25	8,33	8,33	0	25,	25	7,14	33,33	18,18	0	36,36	14,29	10	30,77	25	15,38	10	50
3	0	0	12,50	8,33	8,33	18,18	0	16,67	21,43	11,11	18,18	25	0	7,14	20	15,38	12,50	23,08	10	0
4	9,09	36,36	12,50	25,00	16,67	9,09	12,50	8,33	7,14	22,22	9,09	0	18,18	14,29	0	15,38	12,50	7,69	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

In 2005 out of the analyzed 214 ramets, 26% were graded "5" for forming ramets microstrobilae, which also show the highest presence, and in the second year it was 13% (Figure 1). In the first year 24% of ramets got grade "4", while in the second year, the proportion was smaller, reaching 17%. A total of 43% of ramets got grades "3", "2" and "1", while 7% of ramets got grade "+". In 2006 52% in total got grades "3", "2" and "1", while 18% of ramets had ramets compliance "+".

In 2005 the results of the analysis related to the number of macrostrobila showed that female flowering of ramets was variable and grade "1" was the most common. In 25% of ramets between 51 and 80 strobilae were recorded. In 14% of ramets the number of macrostrobila was graded "+" and "5", and grade "4" was given to only 9% of ramets. A total of 37% of ramets got grades "2" and "3".

The results of the analysis of the number of formed macrostrobila in 2006 show that the most common grade is "1", as in the first year, but with a slightly higher percentage, ie. 37%. Out of the total number of ramets, 21% or 50 had flowers and their number was rated with "+", while 12 % of ramets got grade "3" and "4", and 18% got grade "2". Grade "5" was not recorded in this year of flowering in a seed orchard.

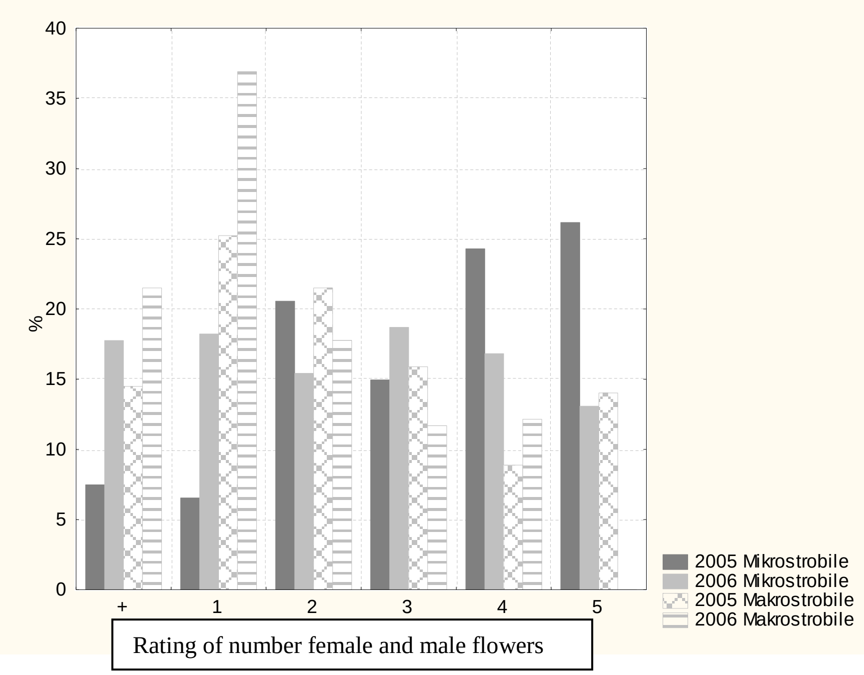

Figure 1. *Abundance of formed strobilae ratings by years*

Abundance assessment of micro- and macro-strobilae

Obtained results indicate the presence of marked variability of regularity and the abundance of flowering of Scottish pine micro- and macro-strobilae in a seed orchard, where the presence of all the ratings of the bloom abundance from "+" to "5" can’t confirm the variability in the number of formed micro- and macro- strobilae.

Productivity of clones in flowering

The ratio between male and female inflorescences is the feature of sexual characteristics of clones. Clones that produce a very small number of female flowers compared to male flowers can functionally be considered male, and clones that produce a very small number of male flowers compared to female flowers can_functionally be considered female. Female clones are very important for producing seed orchard crops. Clones that do not produce or produce very small number of male and female flowers are sterile and they are of no significance for the planned functioning of seed orchards (Tucovic, A., et al. 1982).

Counting flowers on 38-year-oldScotspine ramets in the seed orchard during the period of two years (2005 and 2006) showed that there is a difference between clones in their productivity capacity (Table 5). The average number of female flowers per ramets of clones ranged from 84.8 to 129.3, and male from 578 to 927 flowers. Flowering ratio in a seed orchard of 20 clones, which was calculated from the total production of flowers during 2 years is 7:1 in favor of male flowers. This ratio represents the average plantation sexual characteristic. The flowering ratio for individual clones varies slightly, and that is from 5.7:1 to 10.3:1, representing the sexual characteristics of clones. Three most productive clones in the production of female flowers per clone ramets were clone 2, clone 10 and clone 18, represented with 15.4% share of ramets, and 17.4% of the total production of female flowers where only clone 18 has a lower ratio of flowering (5.7:1) than the average value for_the plantation, which shows the tendency towards femininity. Two of these three clones (clone 2 and clone 10) are the best in the production of male flowers per ramets in two years, as well as clone 7, which represented 13.1% of ramets, and its participation in the production of male inflorescences is 17.8%. Clone 7 has an inflorescence ratio a little higher than average value for the plantation (10.3:1), showing a tendency towards male features. This clone produced a very small number of female flowers compared to male flowers and its role in the production of pollen is to fertilize the seed orchard cones, but the yield has little practical value. For the purpose of getting more information about the nature of the observed phenomenon it would be necessary to conduct several-year observations on host trees from which scions originate. Out of the 20 clones not a single clone has an extremely high or low ratio of flowering, neither male nor female.

The particular ratios of blooms in some years are 6.8:1 and 7.2:1 (Table 6) and shows regularity, indicating that the intensity of flowering does not lead to significant changes compared to the blooming of the whole orchard.

For 2005 we can say that for the formation of male inflorescence the average grade for all clones is "4", and for female flowers it is "3", while in 2006 the grade for male inflorescence is "3", and female "2".

Table 5. *Number of male, number of female flowers, and the average value per ramet and the flowering ratio in 20 clones of Scots pine trees during the two-year observation period*

Clone mark	Total # of blooms 2005-2006		Total # of ramets	The average number of flowers per Ramet		Blossom ratio 2005-2006		
	♂	♀	2005-06	♂	♀	♂		♀
1	15610	1865	22	709.5	84.8	8.4	:	1
2	20395	2845	22	927.0	129.3	7.2	:	1
3	13390	1780	16	836.9	111.3	7.5	:	1
4	19530	2655	24	813.8	110.6	7.4	:	1
5	20445	2540	24	851.9	105.8	8.0	:	1
6	14705	2445	22	668.4	111.1	6.0	:	1
7	14430	1405	16	901.9	87.8	10.3	:	1
8	20555	2665	24	856.5	111.0	7.7	:	1
9	19345	2940	28	690.9	105.0	6.6	:	1
10	16260	2315	18	903.3	128.6	7.0	:	1
11	15700	2415	22	713.6	109.8	6.5	:	1
12	11855	1615	16	740.9	100.9	7.3	:	1
13	18465	2550	22	839.3	115.9	7.2	:	1
14	19050	3095	28	680.4	110.5	6.2	:	1
15	13390	1950	20	669.5	97.5	6.9	:	1
16	21100	2935	26	811.5	112.9	7.2	:	1
17	12255	1855	16	765.9	115.9	6.6	:	1
18	17530	3050	26	674.2	117.3	5.7	:	1
19	11560	1880	20	578.0	94.0	6.1	:	1
20	10810	1585	16	675.6	99.1	6.8	:	1
Grand total	326380	46385	428					
Average				765.5	108	7	:	1

Table 6. *Total production of male and female bloom flowers and the ratio to 20 clones of Scots pine during the two-year observation period*

year	Number of ramets	Total # of blooms		Total #of blooms	The average number of flowers per ramet		Blossom ratio		
		♂	♀	♂ + ♀	♂	♀	♂		♀
2005	214	202590	28090	230680	946.7	131.3	7.2	:	1
2006	214	123790	18295	142085	578.5	85.5	6.8	:	1
Average					762.6	108.4	7		1

Variability of cones yield

According to the three-year analysis of the quantity of grain it was noted that the crop is weak and that there is a pronounced inter-and intra-clone variability. Table 7 shows the three-year results of the participation percentage of ramets per clone for a specific grade related to crop abundance. The evaluation was performed in 2004 and the abundance of three-year old cones shows that the predominant abundance rating for all 20 built-in clones is "0". It was also found that not a single ramet of 20 clones got grades "3", "4" and "5" for crop abundance assessment. Clones 5, 6, 7, 12, 15, 16 stand out as extreme clones, where no ramets had crops. Similar results were obtained when two-year old cones were assessed. Grade "0" for the abundance of crops in all 20 clones also dominated in this year, with the exception that the crops abundance for clone 1 was rated with "3". In this clone, on one ramet out of 11 ramets of this clone, yield abundance was evaluated with "3". In 2005 was recorded crops abundance the same as in the previous year, i.e. cone crop abundance for all embedded clones was evaluated with "0" and no ramets got grades "3", "4" or "5". In 2006 harvest abundance was little higher, although for the majority of clones crops abundance was assessed with "0". However, on clones 3, 4, 8, 13 and 18 on one ramet yield was recorded, and its abundance was rated "3". The same abundance was found in three ramets of clone 1. One clone of ramet 17 had grade "4", out of 8 ramets of this clone.

Table 7. *Cone crop abundance per clone in percentages*

Rating	CLONE																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
2004-three years old cones																				
0	63,64	72,73	87,5	75	100	100	100	75	70,59	88,89	81,82	100	81,82	78,57	100	100	87,5	76,92	90	87,5
1	27,27	18,18	12,5	16,67	0	0	0	16,67	0,00	11,11	9,09	0	18,18	21,43	0	0	0	23,08	0	12,5
2	9,09	9,09	0	8,33	0	0	0	8,33	14,29	0	9,09	0	0	0	0	0	12,5	0	10	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004-two years old cones																				
0	63,64	63,64	50	58,33	75	54,55	50	91,67	64,71	66,67	81,82	75	72,73	50	80	69,23	87,5	61,54	90	75
1	27,27	36,36	37,5	25	25	45,45	37,5	0	14,29	33,33	18,18	25	18,18	42,86	20	30,77	0	38,46	10	25
2	0	0	12,5	16,67	0	0	12,5	8,33	7,14	0	0	0	9,09	7,14	0	0	12,5	0	0	0
3	9,09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005- two years old cones																				
0	72,73	81,82	62,5	75	66,67	90,91	87,5	66,67	76,47	88,89	72,73	62,5	72,73	85,71	70	100	75	76,92	70	87,5
1	9,09	18,18	37,5	25	8,33	9,09	12,5	33,33	7,14	11,11	27,27	37,5	27,27	14,29	30	0	12,5	23,08	30	12,5
2	18,18	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	12,5	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006- two years old cones																				
0	45,45	63,64	62,5	66,67	66,67	72,73	87,5	50	70,59	77,78	70,59	62,5	63,64	57,14	70	84,62	75	69,23	80	87,5
1	27,27	0	12,5	16,67	33,33	18,18	12,5	33,33	22,22	18,18	14,29	25	27,27	21,43	20	15,38	12,5	0	10	12,5
2	0	36,36	12,5	8,33	0	9,09	0	8,33	0	9,09	0	12,5	9,09	14,29	10	0	0	23,08	10	0
3	27,7	0	12,5	8,33	0	0	0	8,33	0	0	0	0	0	7,14	0	0	0	7,69	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,5	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The results of the crop analysis for three-year old cones in 2004 showed that in 86% of the total number of the analyzed ramets there was no crop, i.e. in 184 ramets out of 214 ramets in the plantation, while 21 ramets were rated "1" (10%), and 9 ramets got grade "2", i.e. 4% of the analyzed ramets.

In 2004 the results of the analysis of two-year old cones showed that a total of 149 ramets i.e. 70% of the analyzed ramets produced no crop. Crop abundance rated "1" was found in 55 ramets or 26%, 9 ramets (3.5%) got grade "2", and one ramet or 0.5% of the analyzed ramets got grade "3"

Crop abundance in 2005 was slightly lower than in the previous two years because there were 168 ramets without any crop (79% of the total number of ramets in the orchard), while 21% of ramets got grades "1" and "2".

In 2006 a large percentage of ramets without crop (70%) or 149 ramets were also recorded, 56 ramets produced a crop evaluated with grade"2", in 18 ramets the crop was rated "3" and only one ramet was rated "4". No ramets out of 20 clones planted in the Scots pine plantation had crop abundance assessment rated "5" (Figure 2).

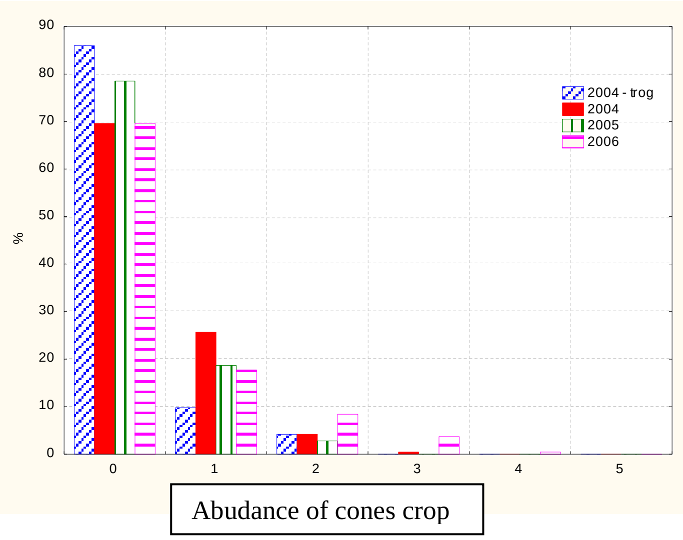

Figure 2. *Presence of crop abundance assessment by years*

The results of the analyses of cone crops abundance of clones in three consecutive years indicate that there are inter-clone and intra-clone variations (Table 7). Based on the obtained results it can be concluded that the cone crops were negligible and that none of the 20 built-in clones stand out, indicating that the clones in the plantation have low productivity. When cleaning the undergrowth in the plantation, the presence of spontaneous regeneration was not observed, which can also be an indicator of poor seed production of built-in clones, as well as the unsuitability of habitat for Scots pine seed orchard.

Given the poor cone production seed analyses were not performed during years 2004 and 2005. Pilot seed tests were carried out in 2004 and 2005. 10 closed cones from the middle part of the crown were collected from the random sample of 5 ramets differently positioned in the plantation – from edge trees and from the central part. In 2004, 39 cones out of 50 cone crops opened at room temperature and 302 seeds were collected, while in 2005 37 cones opened, and 299 seeds were collected. The assessment of the utility value of the seed was made, by using the method of cutting the grain sample 3x100. The results showed that there is a high percentage of poor seed (47%). According to the data related to the quality of grain in 1980 and 1981, obtained from the analyses conducted at the Faculty of Forestry in Sarajevo, the percentage of poor seed was 47.5% (in 1980) and 52.5% (in 1981). These results and the data obtained in the study in 2004 and 2005 can be considered reliable indicators of poor clones yield.

CONCLUSION

The results of the analyses indicated that the plantation is not functioning in accordance with its purpose and they also point to the possible genetic and environmental factors which cause the absence of crops.

Adverse environmental factors for Scots pine (primarily climatic and soil) in the location "Stanovi", as an integral factor, probably hinder its functionality. The analysis of algal and yield abundance justifies establishing seed orchards outside the natural distribution range of species, but in the habitats where the influence of extreme adverse factors on the reproductive cycle of trees is eliminated.

The crops in the analyzed Scots pine seed orchard in the nursery "Stanovi" in Doboj are not the same as expected. The main cause of this phenomenon is that many built-in clones bloom poorly, or do not form a sufficient number of male and female strobilae. The actual seed yield is reduced to a small number of individuals, which affects the functionality of the planned seed orchards. Even in years when a sufficient number of flowers is formed, a large number of them fall off**,** and when the cones ripen the ratio between filled and empty seeds, as a rule, is extremely unfavorable. Since the primary functional objectives of plantations are the production of maximum yield and maximum seed quality, it means that it is necessary to make the corrections and changes in the selection methods for producing surface orteta and Scots pine**.**

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SECTION V

AFFORESTATION, SILVICULTURE AND FOREST ECOLOGY

CHAIRMEN – MODERATORS

Hristo Tsakov

Ljubinko Rakonjac

International Scientific Conference
FORESTS IN THE FUTURE – SUSTAINABLE USE, RISKS AND CHALLENGES
4-5 October 2012, Institute of Forestry, Belgrade, Republic of Serbia

ADAPTATION PROCESS AND HEALTH CONDITION OF JUVENILE STAGES OF SPRUCE ON CALAMITY AREA AFTER DESTRUKTION IN THE SPRUCE MONOCULTURES

Anna TUČEKOVÁ[1], Valéria LONGAUEROVÁ[1]

Abstract: *Spruce stands in Kysuce region (north-western part of Slovakia) are heavily damaged due to infection by bark beetles (Ips typographus a Pityogenes chalcographus) and fungal diseases (Armillaria spp.) what results in a dieback of high number of adult spruce trees and trees in juvenile stage as well. In the paper we deal with screening of the most significant parasitic wood destroying fungi that attack spruce trees in Kysuce region. Wood destroying honey fungus Armillaria spp. prevails on the roots of the youngest spruce trees, on the trees from natural regeneration or artificial regeneration. We verified that a frequent reason of the infection of spruce in juvenile stage by parasitic wood destroying fungi is a tree physiological weakening caused the most frequently by insufficient water and lowering of the pH value as a consequence long term influence of pollutants in the spruce monocultures. Fine rootlets of young plants may be mechanically damaged also during their lifting and transplanting. Thus disturbed root system is more susceptible to infection by honey fungus and other parasitic fungi as well. Honey fungi attack all age classes of spruce – plants, plantations; adult stands as well as adult trees of different age from natural regeneration.*

Key words: spruce, artificial and natural regeneration, Armillaria spp.

1. INTRODUCTION

Unfavourable effects of a complex of injurious agents, especially emissions and air pollutants, have led in last decades to significant disturbance of ecological stability, damaging of forest stands and even decline of forest stands in Central Europe. In last decades also the forests in Slovakia have been subjected to long-term impact of the complex of injurious anthropogenic agents, air pollutants as well as many biotic and abiotic agents (like wind, drought and others). Regarding the mentioned above regions Kysuce and Orava are of four the most endangered regions in Slovakia. Spruce is a dominant tree species accounting for a half of the forest coverage in these regions. In last years the spruce stands in Kysuce regions have been seriously damaged due to attack of bark beetles (*Ips typographus and Pityogenes chalcographus*) and fungal diseases (*Armillaria* spp.), which cause dieback of many trees, great losses in wood production and deterioration of the environment. Most of forests infested by bark beetles and the fungus *Armillaria* are spruce monocultures or mixed stands with the proportion of spruce more than 75 %.

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2. PROBLEMS

Problems of honey fungi – *Armillaria* spp. As of primary parasites causing white rot of wood is common for all continents. These fungi are a natural part of ecosystem. Their main source of nutrients decayed wood. As a parasite honey fungus causes slowing down the growth of infested treed, decay of wood and subsequent dieback of trees. Honey fungi infest and cause dieback of trees that are weakened by the competition of other individuals, by the negative effect of other pests and climatic factors. Honey fungi attack sound trees and they cause directly their dieback or create preconditions for infesting the trees by other fungi or insects (Williams et al., 1986).

Infection of forest tree species by honey fungus occurs usually on trees roots in the soil, less frequently on root buttresses and stem base close to litter in the place of tree injury (Černý 1976). Infection by *Armillaria ostoyae* prevails on coniferous trees whereas these are infested less frequently by *Armillaria gallica, Armillaria cepistipes* or *Armillaria borealis*.

The fact spruce trees are growing in monoculture or in mixed stands may influence development of wood destroying fungi in stands as well. Weakened tree species are directly predetermined to infection by honey fungus (or by *Heterobasidion sp.).* Bark beetles attack weakened trees, infest them and use for own reproduction. Due to that destabilization or even fast disintegration of infested stand may follow (Jančařík, Jankovský 1999). Such destabilization and disintegration of spruce monocultures (frequently non-autochthonous) as well as a spruce tree being in juvenile stage has been going on in a large extent also in Kysuce region (Tučeková et al. 2007, 2008).

The aim of our research was to evaluate growth parameters, health condition of spruce plantations by fungi *Armillaria* during juvenile stage of the adaptation process of plantations of spruce. At the same time a screening of *Armillaria* was performed in natural regeneration of spruce with visual symptoms of changes of assimilatory organs.

3. MATERIALS AND METHODS

Model territory was chosen in interest region Kysuce at the affiliated forest enterprise Čadca, working-plan area Čadca, named after local municipality "Oščadnica", which is situated in forest region 33B. We performed screening of the occurrence of species *Armillaria* in natural regeneration of spruce in the localities Oščadnica –Tichá and Čadca.

Stands in the locality Oščadnica belong the category of commercial forests. Our research was concentrated in JPRL (unit of spatial arrangement of forest) 5206, 5226 and 5227, at the altitude 890-950 m. Prevailing part of the research plot in located in fir-beech altitudinal vegetation zone. Slopes are slightly steep up to steep (12° – 27°), aspect is mostly western, from northern to southwestern, soil type 4409421.

Regarding climatic conditions the locality Oščadnica is characteristic for long-term temperature average of 4.7° C and average precipitation total of about 1,196 mm (1951-1980).

We established semi-operation research plots (RP) by artificial spruce regeneration (2+1) on the model territory on large-scale calamity clearing after the disintegration of spruce monocultures. We used traditional hole planting and non-containerised planting stock, which was planted out in space 1.2 x 1.2 m. After finding shortcomings and imbalance of nutrients (processed laboratory soil analyses) we applied into the holes organic-mineral fertilizer Rokosan (20 g/ 1 hole) and soil conditioner BactoFil® B (10 granules/ 1 hole) in combination with hydro-gels of the order Stockosorb and Aquaholder as well as mycorrhizal preparation Vambac to the root system of plants.

The soils in the locality were characteristic for considerable acidity and imbalance of nutrient conditions. Contents of available forms of main nutrients (P, K, Ca and Mg) were low, while supplies of calcium, magnesium and phosphorus were very low and therefore it was necessary to carry out a modification of soil nutrient environment. During vegetation period we evaluated survival (losses) of plants, we analysed shock after spruce planting, its health conditions, damaging and whole adaptation process as well.

At the end of vegetation period we carried out measurements of planting stock that was planted out and treated. We measured growth parameters of aboveground parts, including detailed assessment of the architecture of the root system. At the end of each vegetation period we sampled by random sampling 10 plants of spruce in all variants of treatment on the plots with control spruce plantations. From all samples there were taken parts of roots, root collar for the cultivation in wort agar.

We performed in two localities (replication) the evaluation of the presence and occurrence frequency of fungi species *Armillaria* in juvenile spruce stands – in the monoculture and naturally regenerated spruce stand in surrounding advance growths and spruce plantations. The localities were namely Čadca (2 plots) and Oščadnica (1 plot).

We have chosen in each locality at least 50 pairs of closely neighbouring individuals with contrast vitality. During visual choosing of these individuals a discolouration and reduction of height and lateral increments were indicators of different vitality.

Samples for laboratory detection of the presence and concrete species of fungi of the genus *Armillaria* were taken after careful uplifting of plants. We sampled on plants rhizomorphs or sporocarps, soil from root collar where syrocium is concentrated. We conducted determination of respective species of the samples by the method PCR – RFLP.

4. RESULTS AND DISCUSSION

4.1. Adaptation process of spruce plantations, their health condition in the first two years after application of various reclamation preparations

Continual assessment of the effect of preparation on artificial plantations of spruce tested statistically after the 1st and 2nd vegetation period are given in table 1. Beginning effect of preparations on growth parameters of aboveground part spruce tree can be recorded already in the 1st year. It is confirmed also by statistically significant differences. In the 2nd year statistically significant differences between individual variants have been lasting. The effect of treatment is evident not only on growth parameters (height and height increment) but mainly in the health condition of treated and fertilized plantations. Treated plantations have evidently better – healthier assimilatory apparatus, undamaged terminal and more favourable content of nutrients in comparison with control.

Table 1. *Survival and biometric evaluation of spruce plantations with the application of preparations on research plot Oščadnica after one year and two years*

Research plot	Tree Variant	Applied preparation	Height spring	Height after 1 year	Height after 2 years	Diameter spring	Diameter after 1 year	Diameter after 2 years	Survival rate in the 1st year
			cm			mm			%
Oščadnica	Spruce 1st replication	Vambac	33.9 ^{a}	38.7 ^{ab}	48.1 ^{a}	5.3 ^{a}	7.0 ^{a}	10.3 ^{a}	72
		Rokosan	35.3 ^{a}	45.0 ^{a}	47.2 ^{a}	4.8 ^{a}	5.7 ^{b}	10.1 ^{a}	68
		BactoFil B	36.7 ^{a}	45.5 ^{a}	47.5 ^{a}	5.2 ^{a}	5.9 ^{b}	8.9 ^{b}	56
		Control	35.3 ^{a}	37.2 ^{b}	44.8 ^{b}	4.7 ^{a}	5.6 ^{b}	9.9 ^{ab}	72
	Spruce 2 nd replication	Vambac	37.5 ^{a}	45.0 ^{a}	43.3 ^{ab}	4.7 ^{a}	5.2 ^{a}	8.6 ^{b}	88
		Rokosan	37.1 ^{a}	38.5 ^{a}	46.2 ^{a}	5.4 ^{a}	6.3 ^{a}	9.2 ^{b}	96
		BactoFil B	32.7 ^{a}	37.1 ^{a}	47.3 ^{a}	4.5 ^{a}	6.6 ^{a}	10.3 ^{a}	96
		Control	33.9 ^{a}	34.9 ^{b}	43.5 ^{b}	4.6 ^{a}	5.8 ^{a}	9.8 ^{ab}	96

Different letters indicate statistically significant differences of $p<0.05$, (n=50)

After the analysis of the root system of individual treated variants of spruce we may state that the effect of several applied preparations on the development of fine root hair is "approximately the same" (after application of Vambac, Rokosan and BactoFil). Control variants show weaker skeletal roots but mainly weaker root hair in the whole root area. Fine roots and their hair are physiologically the most active part of root systems. They secure uptake of water and nutrients for organism of tree species. At the same time they are also a sensitive indicator of the health condition of tree species and of their growth conditions.

In all uplifted and assessed samples we observed visually before planting out mycorrhizal root tips that were transported on planting stock already from nursery. Plants that have before transplanting symbiotic mycorrhizal fungi on own roots should demonstrate positive effect on the shock due to transplanting, total survival and growing of plantations. Percent of losses in some variants of spruce, closing 25% - 30% has not confirmed that.

Rhizosphere bacteria (soil bacteria of the order Azotobacter) had also positive effect on the growth of plants, especially the development of fine roots of the root system. This fact was repeatedly confirmed after adding soil bacteria to the soils in the region Kysuce and Orava (Tučeková 2006, Tučeková et al. 2008).

In the 1st year we have not recorded more marked effect of the applied preparations on growth parameters of aboveground part. The shock after transplanting is important. It is frequently caused by low quality planting stock and low quality works during transplanting as well as unfavourable climatic conditions (mainly imbalance and lack of water).

What is striking that a high percent of new spruce plantations are already after the 1st year infested by black rhizomorphs of honey fungus, that grown on surrounding stumps and under the bark of spruce trees. Sporocarps of honey fungus are in high percent in close surrounding of new plantations as well as in new plantations (figure 1-3). We may observe the most frequently attacking deformed root system (deformations caused by non-observance of technological discipline during transplanting) of newly planted spruce.

Figure. 1-3 *Sporocarp of Armillaria spp. at a more outplantings too fot the remainder stumps folloving a minning on research plot Oščadnica (©Tučeková)*

4.2. Screening of honey fungus (Armillaria **spp.***) occurrence on the root systems in new plantations on research plot Oščadnica after using various preparations*

Occurrence of bacteria was recorded in laboratory analyses of sample trees after the 1st and 2nd year of treatment from new plantations with application of BactoFil, which are not present in other variants. We found for 1/10 of control samples of all tree species the presence of honey fungus rhizomorphs on the roots already after the 1st vegetation period. The rhizomorphs are of permanent mycelium type that reminds morphologically roots of plants. They are formed from coherent tissues of mycelium with black bark on the surface. With help of them honey fungus is able to spread under litter to the soil and attack the roots of a host. In the 2nd year the attack increased to 40%. Higher percentage was recorded for tree species whose root system was of low quality, it means deformed either in cultivation in nursery or in transplanting.

Table 2. *Results of cultivation of live organisms occurring on the root collar and the root of planted sample spruce trees after the 1st and 2nd year following the application of various preparations*

Locality	**Tree species**	**Variant of application**	**Result of cultivation after the 1st year**	**Result of cultivation after the 2nd year**
Oščadnica	Spruce - planting	BactoFil B	Bacteria, *Fusarium*	Bacteria, *Fusarium, Trichoderma*
		Rokosan	*Verticilium*	*Trichoderma, rhizomorphs of Armillaria*
		Vambac	*Fusarium, Verticillium*	*Fusarium, Verticillium, rhizomorphs of Armillaria*
		Control	*Verticilium, Trichoderma rhizomorphs of Armillaria*	*Trichoderma, rhizomorphs of Armillaria*

We have found that the deformation of the root system after transplanting is very unfavourable phenomenon being caused by inconsistent observance of technological discipline during planting of any tree species, either non-containerised or containerised plants, and any planting method (hole planting, slit planting) (Tučeková, Longauerová 2008, tučeková 2011).

Several authors presented similar results. The authors Mauer, Palátová, Rychnovská (2004), found very significant facts as for example for spruce trees with great deformations of the root systems almost 100% infestation by honey fungus, whereas the development of the root systems of damaged trees delayed in comparison with the development of aboveground part, biomass was reduced significantly as well as lifetime of fine roots. Kriegel (1998) found deterioration of the health condition of pine plantations (mainly damaging by honey fungus) in case of using such technologies of planting stock cultivation and transplanting this planting stock, where the root systems are deformed. In the cultivation on wort agar there was found, in addition to honey fungus, also the occurrence of fungi *Trichoderma* spp.., *Fusarium* spp., *Verticillium* spp.., which commonly occur in the soil as saprophytes being able to turn to parasitism. *Fusarium* is a pathogen causing tracheomycoses of tree species. It attacks internal tissues and causes tracheomycotic diseases of seedlings and of older plants as well.

We confirmed that a main reason of spruce infection by primary parasitic wood destroying fungi is most frequently disturbing of roots functions due to lack of moisture (spell of drought). Fine roots and tips of roots of plants are frequently damaged mechanically during handling – uplifting and subsequent transplanting. Damaged root system susceptible to infection by honey fungus as well as other parasitic and facultative parasitic fungi results from that. Arising root rots cause even higher water deficit of host tree species. Transplanted spruce individuals with markedly damaged root systems start to wilt, loose fresh green colouration of needles, their height increment reduces and they start to desiccate as well. Honey fungi attack all age classes of tree species – plants, plantations as well as mature stands. We confirmed that there are not existing any direct ways of protection against honey fungus (*Armillaria* spp.), only indirect ones (as finding vitality of tree), using high quality of planting stock, applying hole planting, to put plants deeper to the soil and to add to roots organic matter as it is presented also by Mauer, Palátová, Pop (2008).

Regarding continuing occurrence of parasitic wood destroying fungi on the plots where they had occurred also earlier it is important that in remnants of infested roots and stumps vital mycelium inoculum is present for a long time and thus it represents a potential source of infection for next plantation either from natural regeneration or artificial regeneration by plants cultivated in nurseries. Honey fungi (and other wood destroying fungi as well, e.g. *Heterobasidion* spp.) are also capable of forming spores in sporocarps repeatedly for a long time, which every year in autumn start to grow on the remnants of decaying stumps and roots (Černý 1989).

Regarding this fact we propose choosing of larger spacing in plantation and planting out the planting stock in relative safe distance from infested stumps of the same host tree species (1 – 2 m).

4.3. Assessment of the presence and frequency of species of the genus Armillaria in juvenile stages of spruce

The influence of *Armillaria* spp. infection on the vitality of juvenile spruce was analysed at thre sites in the Kysuce area. (Zákopčie 1, Zákopčie 2, Oščadnica). The presence of fungi was assessed at 50 couples of vital (A) and declining trees.(B) Pair wise sampling of neighbouring trees with contrasting vitality was done in order to minimize the effect of heterogeneous site conditions. The numbers of individuals infected by *Armillaria* spp. between the subsets of vital and declining trees differed significantly (Figs. 4,). This indicates that infection by *Armillaria* spp. is an important predisposing as well as contributing factor for spruce decline. In view of the presence and frequency of several *Armillaria* species, it is worthy of note that subsets of declining spruces were frequently attacked also by the presumably less-aggressive species *A. cepistipes* and *A. gallica*.

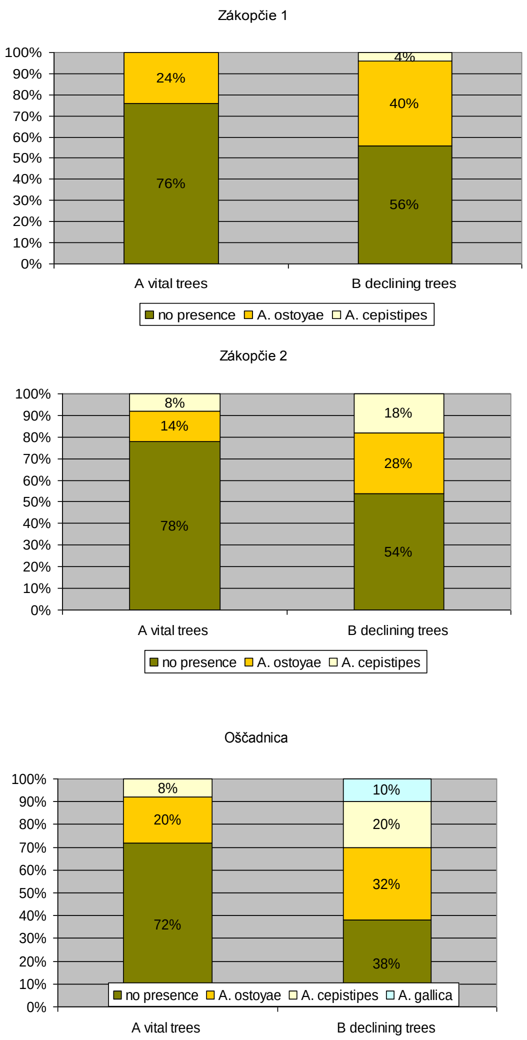

Figure 4: *Proportions of individual Armillaria species on vital and declining juvenile spruce trees (Zákopčie 1, Zákopčie 2, Oščadnica site)*

5. CONCLUSION

Observations and partial results from applying some given preparations on the soils with acidic reaction, where considerably less bacteria and fungi are present, show that soil conditioner (BactoFil) supports soil bacteria activity. By adding microorganisms in new artificial plantations bacteria of the order Azotobacter start to activate (through decay of plants remnants binding aerial and soil nitrogen) and thus they start to support adaptation and growth process of newly established plantations. In combination with hydrogels the effects of microorganisms increase, as they affect positively survival, adaptation process and several of the studied growth parameters (especially root development) already in the 1^{st} year. Favourable health condition of plantations appears also after application of organic-mineral fertilizer Rokosan and mycorrhizal preparation Vambac. Presence of honey fungi rhizomorphs had negative effect after the 1^{st} year in 1/10 of control samples of all trees in artificial stands on the roots and root collars.

In the 2^{nd} year this attack by rhizomorphs of honey fungus on spruce plantations grows even to 40%. From the viewpoint of continuing occurrence of parasitic wood destroying fungi on the plots where they had occurred also earlier, it is important that in the remnants of infested roots and stumps vital mycelium inoculum is present for a long time and thus it represents a potential source of infection for next plantation either from natural regeneration or artificial regeneration by plants cultivated in nurseries.

With regard to increased occurrence of rot decays caused by species of the genus *Armillaria* the intensity of tending treatments in the stands should be reduced in establishing new stands (infections through lesions and cutting areas on fresh cut stumps). It is necessary to apply larger spacing in the plantation, to plant out the plants in relatively safe distance, minimally 2 – 5 m from infested stumps of the same host tree species. We recommend also to shorten rotation of heavily infested stands, to consider phytological aspects in choosing tree species composition, prefer tree species less susceptible to attack and infection than spruce (like larch, fir, ash, maple) and to observe consistently the high quality of planting stock and of reforestation works, minimise damage, deformations of root system and thus the risk of subsequent infection.

We found that facultative parasites, such as *A. cepistipes* and *A. gallica* can qualify themselves get into the category of primary pathogens on sites where its hosts are under the combined stress evolved by climate extremes and air pollutions.

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EFFECTS OF BIOFERTILIZATION ON SPRUCE (*Picea abies* L. Karst) AND PINE SEEDLINGS (*Pinus sylvestris* L.) GROWTH IN DEPOSOL

Vera GUJANICIC[1], Vesna GOLUBOVIC-CURGUZ[2], Vera RAICEVIC[3], Blazo LALEVIC [3], Ivana SPASOJEVIC[3], Dragan KIKOVIC[4]

Abstract: *Biofertilizers are substances that contain living microorganisms which promote plant growth by numerous direct and indirect mechanisms that make nutrients more available or increase plants access to nutrients. Bearing in mind the importance of PGPR in sustainable agricultural production, the goal of this paperwork was to test the possibility of using biofertilizers in forestry with the aim to improve plant growth on anthropogenic, degraded soils.*

The effect of biofertilization on growth of Norway spruce (Picea abies L. Karst) and Scots pine (Pinus sylvestris L.) seedlings, grown in deposol of Kolubara basin (Serbia) were examined. Bacterial consortium was consisted of: Azotobacter chroococcum, Bacillus megaterium, B. circulans, B. licheniformis, B. pumilus, B. amyloliquefaciens. The effects were recorded by growth parameters (shoot and root length, fresh and dry shoot and root biomass, collar diameter, number of branches).

Biofertilization affected all observed growth parameters. Increase in root length and weight of Norway spruce and Scots pine were noticed. At Norway spruce seedlings, the increase of root length was 63% comparing to the control, and weight was increased 30% comparing to the control. Root length was increased by 23% compared to the control, and weight was increased by 21% compared to the control, at Scots pine seedlings.

These results indicate the validity of using biofertilization for forest species grown in deposol.

Key words: deposol, spruce, pine, biofertilization, PGPR

INTRODUCTION

Biofertilizers are substances that contain living microorganisms which completely or partly supplant mineral fertilizers and promote plant growth through a variety of mechanisms (*Whipps 2001; Compant et al. 2005; Berg 2009*). These substances, when applied to seed, plant surfaces, or soil, colonize the rhizosphere, rhizoplant or the interior of the plant and promote growth, usually, by increasing the supply or availability of nutrients to the plant (*Vessey 2003*).

Biofertilizer is live formulation of beneficial microorganisms which are capable to develop the soil micro- and macroflora, improve the soil health and biological balance (*Berc et al. 2004; Christry et al. 2005*), increase soil fertility, alleviate contamination of soil and water, and promote antagonism and biological control of phytopathogenic organisms (*Tilak et al. 2005; Chirinos et al. 2006*).

All these benefits are achieved through diverse mechanisms that are involved in plant–microbe interactions (*Whipps 2001; Compant et al. 2005*) and, in many cases; the comunication

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on plant-microbe relation includes several mechanisms (*Berg et al. 2009; Haas and Défago 2005; Müller et al. 2009*). These beneficial microorganisms are usually called plant growth promoting rhizorbacteria, PGPR (*Niranjan et al. 2005*). Lately, a strong growing market for microbial inoculants has been observed. This interest is linked to environmental concerns and struggles to reduce the use of chemicals in agriculture (*Tilak et al. 2005*). Conventional agriculture demands the use of chemical pesticides and fertilizers, and theirs inadequate use provokes severe environmental and health problems (*Gunnell et al. 2007; Leach and Mumford 2008*). In the other hand, the plant–microbe interactions proffer environmentally benign strategies for conventional agriculture (*Berg 2009*).

Organic farming excludes the use of any chemical substances, so the use of biofertilizer is recommended for improving the soil fertility in such practice (*Sharama et al. 2009*).

Research on the use of PGPR in forestry is much less widespread than for agricultural applications. Inoculation of tree seedlings with growth promoting rhizobacteria before re-transplantation is a low cost, environmentally safe and simple to apply nursery activity (*Chanway 1997*). With this research, we were aiming to improve one specific aspect of tree growth by inoculation – biomass, aspect that is considered as the most important in forestry.

Results with various tree species showed that seedling characteristics can be significantly improved and productivity per area increased with a help of bacterial inoculation of root systems (*Charvajal-Munoz et al. 2012*).

The main aim of this work was to examine if mixed population of several plant growth promoting bacteria facilitated the growth of Norway spruce and Scots pine seedlings cultivated in deposol originated from coal-field Kolubara.

MATERIALS AND METHODS

Microbiological properties of deposol: The abundance of microorganisms was determined on different nutrient mediums by the dilution method. Total microflora was determined on 0.1xTSA, and total number of fungi on Potato dextrose agar. *Actinomycetes* were counted on starch-ammonia agar and *Azotobacter sp.* on Fyodorov's solid agar by drop method. All experiments were performed in triplicate. Moisture of samples was determined after drying on 105ºC for 2 h. The number of microorganisms was calculated on 1g of air-dried substrate and expressed as CFU g^{-1}deposol.

Microorganism Materials: Microorganisms used for the experiment were obtained from collection of Microbiological laboratory, Department for Soil Microbiology, Faculty of Agriculture, University of Belgrade. Bacterial consortium was consisted of *Azotobacter chroococcum, Bacillus megaterium, B. circulans, B. licheniformis, B. pumilus, B. amyloliquefaciens*.

Plant Materials: Plant seedlings were Norway spruce (*Picea abies L. Karst*) and Scots pine (*Pinus sylvestris L.).* Seedlings of Norway spruce (3+0) and Scots pine (2+0) were obtained from nursery Rasina, Krusevac.

Experiment was conducted in field conditions. The study of the effect of bacterial strains on seedling growth was carried out in pot experiment with deposol from coal-field Kolubara (Serbia). Six weeks after plating, one half of seedlings were inoculated with 100ml/plant of suspension (10^8 CFU/ml). During the vegetation period, bacterial suspension was added three times, in the span of one month. The other half of seedlings was used as a control.
Statistical analyses were performed in Excel 07 by using Independent Two Sample t-Test.

RESULTS AND DISCUSION

At the end of growing season the growth parameters such as, shoot and root length, fresh and dry biomass, collar diameter, number of branches were recorded. Table 1 and 2 show the results obtained.

Table 1. *Growth parameters of Pinus sylvestris L.*

	Shoot			Root			Total length	Collar diameter	Number of branches
	Length [cm]	Fresh biomass [g]	Dry biomass [g]	Length [cm]	Fresh biomass [g]	Dry biomass [g]			
Control	23.4	6.41	1.97	28.6	3.05	1.04	52.00	3.24	1.8
Treatment	24.1	6.64	2.15	35.3	3.69	1.39	59.40^{ns}	3.58	1.4

ns- No significant, using Independent Two Sample t-Test

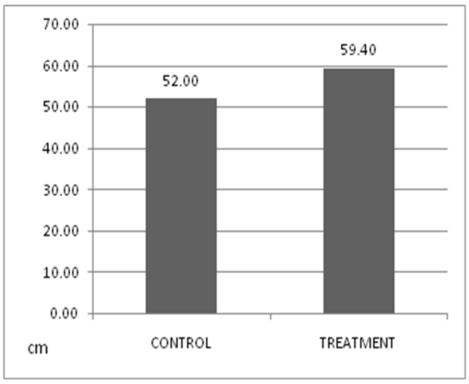
Table 2. *Growth parameters of Picea abies L. Karst*

	Shoot			Root			Total length	Collar diameter	Number of branches
	Length [cm]	Fresh biomass [g]	Dry biomass [g]	Length [cm]	Fresh biomass [g]	Dry biomass [g]			
Control	27.6	8.65	3.64	19.8	6.51	3.24	47.4	4.26	15.2
Treatment	30.5	10.26	4.04	32.3	8.46	3.98	62.8^{*}	4.48	18.6

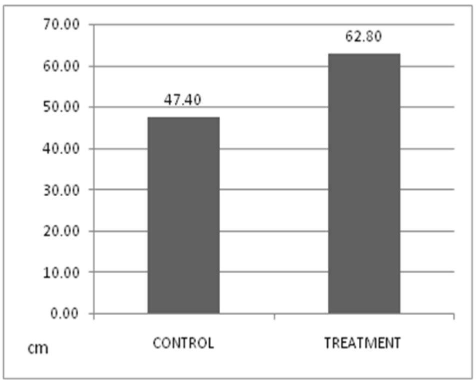
*Significantly different from the control (P<0.05), using Independent Two Sample t-Test

Comparing the results of control and treatment in both plant species, positive effect of inoculation, in terms of all observed growth parameters, was noticed. Increase in root length and weight of Norway spruce and Scots pine was noticed. At Norway spruce seedlings, the increase of root length was 63% comparing compared to the control, and weight was increased by 30% comparing to the control. At Scots pine seedlings, root length was increased 23% compared to control, and weight was increased by 21% comparing to the control. Total fresh biomass of Norway spruce seedlings was increased by 23% and of Scots pine by 9%. Earlier researches have proven the increase of pine and spruce biomass by 32%-49% one year after inoculation and outplanting at a reforestation site (*Chanway 1997*). Same author empasized that inoculation with certain strains of root colonizing bacteria can enhance infection by desired species of ectomycorhizal fungi. In both plant species, larger collar diameter is gained in treated seedlings. The only growth parameter that showed higher results in control was number of branches in case of Scots pine. On the other hand, treated Norway spruce seedlings showed better branching characteristics.

Graph 1. *Total length of Pinus sylvestris L. at the end of the experiment*



Graph 2. *Total length of Picea abies L.Karst. at the end of the experiment*



Graph 1 shows comparison of total length of Scots pine's treated and non-treated seedlings. Even though, the graph shows pretty obviously that treated seedlings are higher; statistical analysis didn't characterize this difference as significant. In 2002 Probanza reported that bacterial strains of *Bacillus licheniformis* CECT 5106 and *Bacillus pumilus* CECT 5105 promote the growth of *Pinus pinea* seedlings, most likely by gibberellins production. But he, also, reported that this effect was not found while combining both strains, which perhaps implies a competition effect (*Probanza et al. 2002*).

Graph 2 shows comparison of total length of Norway spruce treated and non-treated seedlings. Statistical analysis confirmed that this difference is significant with 95% confidence. Examined microbiological characteristics of deposol from coal-field Kolubara showed satisfying presence of *Actinomycetes* and *Azotobacter* species (Table 3).

Table 3. *Microbiological properties of deposol*

MICROORGANISMS	CFU x 10^4 g^{-1}
Azotobacter sp.	0.24
Bacteria	400
Fungi	1.2
Actinomycetes	34

After the removal of cultivated seedlings, microbiological analyses of deposol were not conducted. But, from the other experiences (*Badaluccoond and Kuikman 2001*) we can assume that growing plants in this substrate had positive effect on microbial communities. In comparison to the bulk soil, the number of microorganisms in the rhizosphere is always high er, because of the plants and the influence of their exudates. Root exudates are believed to have a major influence on the diversity of microorganisms within the rhizosphere (*Brimecombe et al. 2007*). Increase of microorganisms in the soil will exhibit positive effects on organic matter content and structure properties of deposol. Plant-associated bacteria, with all their positive mechanisms, can be of great value in enabling plants to establish or to grow better on marginal land or on disturbed soils of the post mining landscape (*Hoflich et al. 2001*). According to this, the application of combined microbial groups can be used for the biological reactivation of devastated soils.

Soil microorganisms are integral components of forest ecosystems, and many of them have the potential to influence plant growth positively. Inoculation of tree seedlings with bacteria with this potential can facilitate plant growth, plant nutrition, root growth pattern, and responses to external stress factors (*Chanway 1997*). A large number of researches, carried out on different tree species, showed that seedling characteristics can be significantly improved and productivity per area increased by bacterial inoculation of root systems (*Charvajal-Munoz et al. 2012*).

The inoculums we used were consisted of well known growth promoting bacteria. Those bacteria use different mechanisms, and sometimes, a few of them, in communication with plant.

Azotobacter sp. is one of the growth promoting bacteria that bases its positive effect on plant growth on its ability to fix N_2 (*Vessey 2003*). Silicate bacteria are generally placed in the species *Bacillus circulans* and are widely used in biological fertilizers (*Lian et al. 2001*). Also, *Bacillus circulans* is well known as potassium solubilizing bacteria (*Hassan 2010*). *Bacillus megaterium* is best known as one of the phosphate solubilizing bacteria (*Antoun et al. 2005*) that has the ability to solubilize rock phosphate and increase its availability to plants (*Goenadi et al. 2000; Lal et al. 2002*). On the other hand, Ponmurugan (2006) noticed that phosphobacteria improve plant growth through biosynthesis of plant growth substances rather than releasing available phosphorus. *Bacillus pumilus* and *Bacillus licheniformis* species produce phytohormone, gibberellins, and promote plant growth and yield increase through this action (*Gutierrez-Manero et al. 2001*).

There are a lot of authors who reported that *Bacillus* species are able to promote the growth of a wide range of plants (*De Freitas et al. 1997; Kokalis-Burelle et al. 2002*), and also are very effective as biocontrol agents. Jetiyanon *et al*. in 2003 observed that mixture consisted of *Bacillus amyloliquefaciens* strain IN937 and *Bacillus pumilus* strain IN937b, induced systematic resistance of tomato to disease caused by *Sclerotium rolfsii,* resistance of long cayenne pepper to *Colletotrichum gloeosporioide* pathogenic influence, and, also, resistance of cucumber on viral mosaic disease. *Bacillus pumilus* SE34 showed a rapid colonization of all tissues in tomato and reduced disease (*Yan et al. 2002*). Inoculation of tobacco plants with *Bacillus amyloliquefaciens* EXTN-1 caused rapid transcript accumulation of defense related genes (*Ahn et al. 2002*). *Bacillus megaterium* is recorded as a species with biocontroling effects on a broad range of plant pathogenic fungi (*Jung and Kim 2003*). Antifungal influence was also reported in a case of *Bacillus licheniformis (Sadfi et al. 2001*). Beside these antifungal effects, the PGPR versus nematodes interactions have been extensively studied with the aim to cope with plant-parasitic nematodes (*Antoun et al. 2005*). These studies involve the selection of bacteria that can be used as biocontroling agents against nematodes and *Bacillus* was one of the genera included (*Siddiqui and Mahmood 1999*).

Numerous studies show positive effects of bacterial species, used for inoculums preparation in this experiment, on various plant species' growth. Results of Ramos *et al.* from 2002 showed that *Bacillus licheniformis*, improved European alder growth. Egamberdiyeva and Haahtela (2004) reported that inoculation with bacterial strains *Bacillus megaterium* KMNL1A and *B. longisporus* KNOL6 increased the shoot growth of pine and birch up to 64% compared to a control. Inoculation with *Azotobacter chroococcum* resulted with biomass increase of 13 to 26% in case of oak and ash, and 38% in case of quercus (*Pandey et al. 1986*). Results on wheat and sunflower inoculated with *Azotobacter chroococcum* Ps1, Z-1, S-07, S-13, *Bacillus megaterium* R-1, S-19 and *Bacillus circulans* V2, O-21 showed 10% enhancement of the sunflower yield and 29-32% of wheat yield compared to non inoculated sample (*Raicevic et al. 2006*). Statistically significant increase in growth of silver spruce, supported by separated *Bacillus licheniformis* CECT and *B. pumilis* CECT 5106 strains was recorded by Probanza (2002).

CONCLUSION

As we already emphasized, the object of this experiment was to found out if bacterial inoculums consisted of *Azotobacter chroococcum, Bacillus megaterium, B. circulans, B. licheniformis, B. pumilus, B. amyloliquefaciens* have improving effects on growing parameters of chosen plant species, cultivated in substrate that is not very favorable for plants. It was proved that used bacterial species improve ability of seedlings to accommodate to new soil conditions. According to the results, applied microorganisms mixture had positive effects on all growing parameters that were followed.

Compared to Scots pine, Norway spruce seedlings gave better results in terms of shoots and root length and biomass production. But, the most important information is that the seedlings of both plant species showed good response on applied inoculum in terms of biomass production, which is the most desired effect in forestry. This is especially important when the seedlings are planed to be planted on poor or devastated soils.

The validity of biofertilization usage for forest species growing in deposol is confirmed.

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EFFECT OF VARIABILITY OF ALLUVIAL SOIL PROPERTIES ON GROWTH OF WHITE POPLARS *Populus alba* L. cl. L-12

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Abstract: *White poplar (Populus albae L) is naturally found in phytocenosis of Populetum nigro-albae Slavn.1952, Populetum albae Knopp, Jov.1965, and Populeto albae- Quercetum roboris Jov. et Tom. 1979. In additon to natural communities, the artificial stands of white poplar and its clones are also being established on alluvial soils with pronounced sand content.*

The influence of micro-relief and changes in the composition of the soil fractions over small areas on the white poplar growth (Populus alba L. cl. L-12) was studied at the Trail field of the Institute of lowland forestry and environment in the vicinity of Novi Sad (N: $45^0 17' 23''$,E: $19^0 53' 43''$) on fluvisol sandy soil.

The trial was established in 1991 with planting material type 1/1, and at planting distance of 3 × 2,5 m (1333 trees ha^{-1}) using rectangular survey system. Ten years after trial stand development the selective thinning was conveyed, and density was reduced to some 650 to 700 trees ha^{-1}.

The area of the trial stand was divided into two micro relief forms. Diameters and heights of all trees were measured aimed at determining the elements of growth influenced by micro relief forms and variability of soil over small areas (cca 40m). In each of the relief form separated in this way, three medium trees were felled and analyzed by method of section aimed at determining elements of growth and yield. Twenty years after white poplar stands development significant differences between tree dimensions and other growth parameters depending on the changes in soil compositions over small areas were determined. The obtained results revealed significant differences regarding all elements of growth influenced by changes occurring in micro relief and soil composition.

Key words: Leuce poplars, clonal selection, soil variability

1. INTRODUCTION

Poplar selection in Leuce section (white and gray poplars and aspen) has lower requirements in regard to habitat conditions than the most forest tree species, and can be grown in habitats less favorable for other forest tree species. Euroasian aspen (*Populus tremula* L), white poplar (*Populus alba* L.), and hybrid species the gray poplar (*Populus × canescens* Ait. Smith) are indigenous species to this region (O r l o v i ć, et al. 2003).

Our domestic poplars from this section occur in small or large groups in very vast area of altitudinal distribution, and can be seen in the areas ranging from river banks to the hilly and mountain regions, and some of their forms can be found close to forest vegetation. This indicates the possibility of their use in various forms of forest cultivation (introduction into forest gaps and forest clearings, use as previous crops, etc.) and for establishment of the intense stands of selected clones and hybrid families (G u z i n a and B o ž i č, 1984). In the forest management

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little attention was paid to these species, and the yields were most often given under ‘’other species’’. However, it was estimated that these species can have very significant role in terms of ecology, due to their higher adaptability in relation to most other species. They can thrive even on marginal soils, and thus are used for establishment of stands outside the forests, and various forms of greening in urban and rural areas. Due to very frequent hybridization of various forms within the species, as well as frequent interspecific hybridization, many various forms, among which are genotypes characterized by abundant growth, and beautiful, and often very attractive phenotypes exist in this section. However, often due to inter and intraspecific hybridization, generative progenies (plants obtained from seed) even from the most beautiful trees have very heterogeneous properties, so a reliable homogenous planting material of desirable phenotype cannot be obtained in this way. For growing in urban area, the fact that it is impossible to make distinction between male and female genotypes among planting material obtained from seed has special significance. It should be noted that adult trees of this tree species are very prolific, and that their seeds ripen gradually over prolonged periods, and thus have negative influence on the environment over the same periods.

Bearing this in mind, the planting material representing clone progenies of chosen decorative genotypes of adult trees should be used for growing in urban areas. Under modern conditions a significant amount of planting materail can be obtained by micropropagation, which will be multiplied by conventional method in the future.

White poplars and their clones very often inhabit various areas (in terms of texture) of the alluvial plains.

The fluvial process changing over time and space is the most significant for the formation and development of alluvial (fluvisol) soils. So, the flood flows are responsible for erosion, and sedimentation of coarse and fine material. The consequence of that is a distinct layered cross-section profile. This characteristic is the cause of great variability of the fluvisol properties over short distances, and thus two profiles of the same physical-chemical and ecological characteristics cannot be found Ž i v a n o v, 1977,

Previous studies on the soils in innundations of rivers pointed out to the fact that for poplar growing the most important thing is to pay special attention to mechanical composition of individual horizons and layers, and in particular the order and thickness of horizons of the soil profile Ž i v a n o v, 1977. Given the very pronounced spatial variability of alluvial soils over very small areas, it is very significant for the producer of poplar trees to become familiar with this variability, and based on that knowledge to adapt variability. i.e. poplar clone and technology of development.

It is of great importance for poplar growing on alluvial soils to know the micro relief. The consequence of the rapid movement of flood waters in the coastal zone where large sediments are deposited is formation of the specific micro relief in the form of beams and depressions. This feature of alluvial soils determines various soil moisturizing, i.e different topographic-hydrological position. This means that in satisfying the requirements of the micro relief special attention has to be paid to poplar clone (variety) selection and planting technology. Until the construction of the embankment in 1928, moisturizing of the tested soil was in direct connection with the water level in the river bed. Ground waters withdraw rapidly, due to well drained fluvisol soils. Thus in this soils no reduction processes, except depression and beams were pronounced, hence G_{so} horizon appeared in deeper layers, which was soon replaced by bluish gley.

The aim of this investigation was to determine pedological characteristics of two micro localities, spatially very close, as well as the elements of white poplar tree growth of the genotype *P. alba* L. cl. L-12, which is still in experimental stage.

2. OBJECT OF INVESTIGATION AND WORKING METHOD

Studies were carried out at the Field trial of the Institute of lawland forestry and environment in close vicinity of Novi Sad (N: $45^0 17^{'} 23^{''}$, E:$19^0 53^{'} 43^{''}$). Areas on which the studies were conducted were flooded at higher water levels of the Danube river until the construction of the embankment in 1928.

Prevailing climate of the tested region was moderate continental, with some specificities. The coldest month was January with mean air temperature of – $1,1^0$C, and the hottest was July with $20,3^0$C, and the mean annual air temperature $10,9^0$C.

Mean precipitation for the mentioned region was 592 mm. From the annual average precipitation some 333 mm or 56% occurred during vegetation period (K a t i ć 1979).

Under such ecological conditions the soil coverage was formed on alluvial sediments of pronounced variable textural composition, with rapid changes in micro relief over small areas (R o n č e v i ć and I v a n i š e v i ć, 1982; Ž i v a n o v and I v a n i š e v i ć, 1985). Field trial stand was established in spring of 1991 with three replications using clone *Populus alba* cl. L-12.

Planting was done in holes 0,80 m deep with a planting distance of 3,0 × 2,5 m using one year old planting material type 1/1 by applying so-called ‘’normal planting’’. After first year of trial stand development the planting material, which failed to develop, or was damaged by wildlife attack was replaced. One sanitary and one correctional thinning were done in the stand so it developed at density of approx. 700 plants ha^{-1} in the previous period. In the trial stand over the area of 0,94 ha two exemplary areas representing two distinctly different micro relief shaped terrains were separated.

On each of the isolated areas, which were separated by some 40 m from each other, the soil was probed. This time, the care was taken to cover the distinct micro relief forms (dents and protuberances) by the probe. Each probe was described and a sample of disturbed soil was taken from each horizon layer in which granulometric composition, pH value, $CaCO_3$ and humus contents were determined. Based on the results of total measurements of the trial stand after 22 years of development, two areas representing two distinct micro relief forms were isolated for determination of the medium stand trees.

Determined medium stand trees were felled and their heights were measured using the measuring tape. From the felled medium trees the cross section of the stem were viewed at the height of 1,3 m, used to determine the growth of breast height diameters. Aimed at obtaining an objective comparison between the elements of medium tree growth, the testing was done by t-test with software package STATISTICA 10 (StartSoft, Inc, (2011).

3. RESULTS OF INVESTIGATION AND DISCUSSION

3.1. Soil characteristics

Relief of the studied object is formed as the consequence of previous flooding of these terrains and represents a significant factor of spatial variability of alluvial soils. For the assesment of soils characteristics, due to fairly uniform morphological appearance of the vertical cross section of the pedological profile (stratigraphic structure) the analysis of traits and analytical indicators was performed on two probes representing two different micro relief forms over small area. Analytical data on studied probe are given in Table 1.

The current knowledge clearly indicates that alluvial soils in the Danube basin have very heterogeneous mechanical composition, with various textural classes presented ranging from sand to clay (Ž i v a n o v, 1977). It has also been known that textural classes are being replaced with various combinations, both with profile depth, and in space.

It was observed that great participation of sand and the power of layers caused disruption of capillary rise of water in the driest part of vegetation period, which greatly influenced the poplar stand development. Granulometric composition according to previous investigations was the most important analytical indicator of yield on which all parameters off potential fluvisol soil fertility used for black poplar growing were functionally dependent (Ž i v a n o v, 1977).

It can be seen from Table 1 that the fraction of tiny sand ranging from 47,82 to 95,40% was the most common in analyzed fluvisol soil. It can be observed that participation of this fraction increased significantly just below the humus horizon, and it generally increased with depth. Participation of silt fraction was higher in the upper part of the profile, which together with tiny sand fraction made this soil compact.

Clay and silt fractions in the upper part of the profile form loamy to sandy loam textural class, i.e. optimal textural class for poplar development (Ž i v a n o v, 1978).

Table 1 – *Analytical data on soil fertility according to micro relief forms.*

Depth	$CaCO_3$	Humus	pH	Granulometric composition %				Total		Textural class
[cm]	[%]	[%]	H_2O	>02	0,2 – 0,02	0,02– 0,002	>0,002	sand	clay	
Probe 1 (OPP1)										
0-30	14,36	2,13	8,16	0,50	47,82	31,36	20,32	48,32	51,68	Loam
30-60	13,54	0,67	8,35	0,98	80,30	12,80	5,92	81,28	18,72	Loamy sand
60-120	12,31	0,44	8,42	0,82	87,10	8,60	3,48	87,92	12,08	Sand
120-150	10,67	0,27	8,56	1,58	93,18	2,28	2,96	94,76	5,24	Sand
150-180	11,49	1,22	8,26	0,83	66,09	2,20	11,08	66,92	33,08	Sandy loam
Probe 2 (OPP2)										
0-25	9,44	1,82	8,11	0,90	79,50	12,40	7,20	80,40	19,60	Loamy sand
25-140	15,10	1,21	8,21	3,00	95,40	-	1,60	98,40	1,60	Sand
140-170	14,80	1,10	8,32	0,50	92,70	4,40	2,40	93,20	6,80	Sand
170-315	15,00	0,21	8,42	2,90	93,10	2,00	2,00	96,00	4,00	Sand

Under the same conditions other than when it comes to growing poplars, the productive capacity tipically increases from sandy to loamy soils, and vice versa on the cross section profile (Živanov, 1977.)

It can be seen from Table 1 that the $CaCO_3$ content in probe No. 1 ranged from 14,36 to 11,49%, i.e. from 9,44 to 15,10% in probe No.2.

Another significant chemical characteristic was the active acidity which in studied samples was uniform for both probes and ranged from 8,11 to 8,56 pH values.

As well as could be expected, since the protected part of innundation was in question, the greatest amount of humus was found in the surface horizon. Humus content per depth generally decreased. Based on the obtained analytical data on the studied soils in terms of soil classification (Š k o r i ć et al. 1985), they belong to the following forms: sandy (probe 2) and sandy loam (probe 1). These two forms differed significantly in terms of potential fertility, for they had significantly different content of silt+clay, humus, accessible water, i.e. different physiological active profile depth. Given the differences between the above mentioned fertility parameters, the soil represented by probe 1 had significantly higher fertility potential for white poplar growing.

3.2. Elemens of tree growth

In the stand established in TF-1 (trial field 1), the mean breast height diameter of 35,4 cm was significantly higher than the mean diameter measured in TF-2, where it was only 55% of the diameter measured in TF-1. Similarly, the mean height of 33,6 m measured in TF-1 was significantly higher than the height meausred in TF-2 where it was 66% of the height measured in TF-1 (Table 2).

Medium trees in the studied trial fields had uniform breast height diameters only in the first two years of development. In the following period the mean breast diameter measured in TF-1 was significantly higher with tendency to increase till the end of investigation (Graph 1, Table 3).

Table 2. *Mean quadratic diameters and mean heights on two plots and results of t-test.*

	TF-1	TF-2	t-value	p-value
d_g [cm]	35,4	19,4	24,449	1,66076E-05
h_g [m]	33,67	22,10	19,16	4,37255E-05

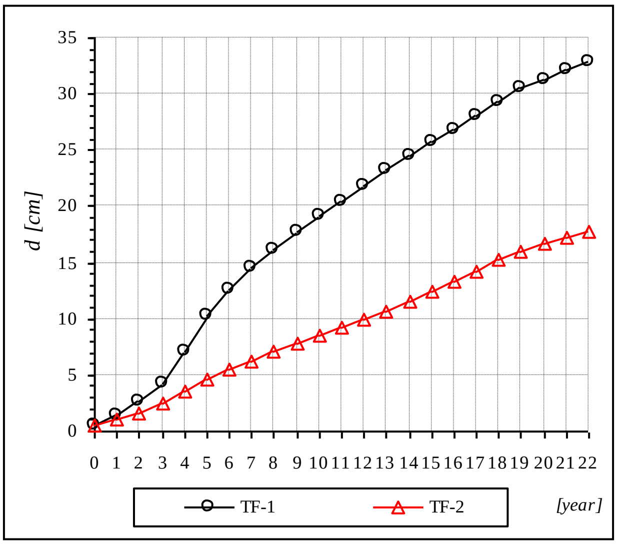
Table 3. *Mean value of diameters and current diameter increments during development of two experimental field and results of t-test.*

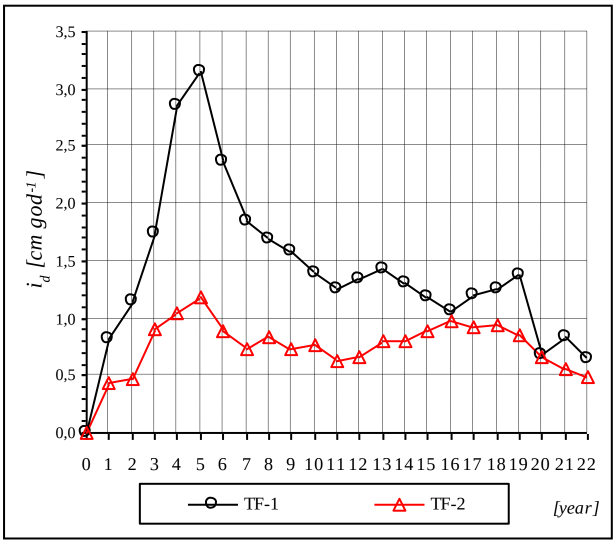
Age	Diameter				Current diameter increment			
	d [cm]		Statistical test		i_d [cm·yr^{-1}]		Statistical test	
year	TF-1	TF-2	t-value	p-value	TF-1	TF-2	t-value	p-value
0	0,617	0,617	0	1	0	0	-	-
1	1,433	1,05	2,065	0,10778	0,817	0,433	2,438	0,07136
2	2,583	1,517	2,454	0,07012	1,15	0,467	1,788	0,14835
3	4,333	2,417	3,363	0,02821	1,75	0,9	3,9	0,01754
4	7,183	3,467	5,966	0,00396	2,85	1,05	6,056	0,00375
5	10,33	4,65	9,591	0,00066	3,15	1,183	6,607	0,00272
6	12,7	5,533	10,86	0,00041	2,367	0,883	6,543	0,00282
7	14,55	6,267	11,11	0,00037	1,85	0,733	5,876	0,00419
8	16,23	7,1	11,46	0,00033	1,683	0,833	2,547	0,06352
9	17,82	7,833	12,43	0,00024	1,583	0,733	2,28	0,08471
10	19,22	8,6	9,846	0,0006	1,4	0,767	2,235	0,08909
11	20,47	9,233	9,642	0,00065	1,25	0,633	3,544	0,02393
12	21,8	9,9	10,63	0,00044	1,333	0,667	3,763	0,01973
13	23,23	10,7	11,03	0,00038	1,433	0,8	3,372	0,02799
14	24,53	11,5	11,94	0,00028	1,3	0,8	3,78	0,01944
15	25,72	12,38	12,67	0,00022	1,183	0,883	4,81	0,00858
16	26,78	13,35	13,64	0,00017	1,067	0,967	0,606	0,57717
17	27,98	14,27	14,14	0,00014	1,2	0,917	2,507	0,0663
18	29,23	15,2	15,01	0,00012	1,25	0,933	1,648	0,1748
19	30,62	16,05	15,77	0,00009	1,383	0,85	5,48	0,00537
20	31,3	16,72	14,2	0,00014	0,683	0,667	0,095	0,92863
21	32,13	17,27	15,72	0,0001	0,833	0,55	1,606	0,18347
22	32,78	17,75	18	0,00006	0,65	0,483	0,783	0,47725

Current increment of the medium tree breast height diameter in TF-1 was higher throughout the studied period in relation to the current increment of diameter of the medium tree in TF-2. Significant differences between the current increments of the medium tree diameter in the studied fields were determined in the period from 3 to 7 years of trial stand development (Table 3). The highest difference was determined in the culmination period reached in the 5th year in both trial fields. After the culmination, the current diameter increment rapidly declined in

TF1, unlike that in TF2, where decline was less pronounced (Graph 2). Decline in the current diameter increment after 19th year in TF-1 could be correlated with stand density and need for thinning. Culmination of the current diameter increment in the white poplar stands largely coincided with the culmination of the current diameter increment in the black poplar stands (M a r k o v i ć, 1980; R o n č e v i ć, 1984; A n d r a š e v 2008).

Figure 1. *Growth of diameters (left) and current diameter increment (right) of mean trees on experimental fields.*





4. CONCLUSIONS

Poplars in the Leuce section (white and gray poplars, and aspens) were less demanding in terms of habitat conditions than the most forest trees, thus they could be grown on habitats less suitable for growing of other forest trees.

Based on the obtained analytical data the studied soils belonged to the following soil forms: sandy (Probe 2), sandy loam (Probe 1).

These two forms differed significantly in terms of potential fertility for they had significantly different contents of silt+clay, humus, accessible water, i.e. different physiologically active profile depth. Given the content of the above mentioned fertility parameters, the soil represented by probe 1 had significantly higher fertility potential for poplar growing.

Significant differences in heights and diameters of medium trees were determined at the end of the 22nd year of stand development depending on micro relief form. Diameter growth was uniform in the first two years, and significant differences in current increments among studied micro relief forms were determined in the period ranging from 3 to 7 years. Current diameter increment of medium trees culminated in the 5th year in both studied micro relief forms which coincided with the culmination of the current increment in black poplar stands.

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CHANGES OF LAND USE IN THE REGION OF VRANJSKA VALLEY IN THE PERIOD 1963-2010

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Abstract: *A land use is the sole erosion factor that can be controlled and governed by man. Since an inadequate land use can cause intensification of erosive processes, it is possible to reduce their intensity by its change.*

The paper presents the changes of land use in the region of Vranjska Valley in the period between 1963 and 2010 and the impact of the changes on the intensity of erosive processes. The identification of wooded land, arable land, meadows, pastures, orchards, vineyards and infertile land performed in 2010 was based on field works and the analysis of high resolution satellite images. The comparison of the obtained results with the data for 1963 proved that the categories of barren land, forest, meadow and pasture underwent most intensive changes. The above-mentioned changes, along with derived erosion control works, resulted in a reduction of intensity of erosive processes in the observed period. The mean erosion coefficient for the region of Vranjska Valley in 1963 amounted to Zsr = 0,67 (medium intensity erosive processes), while in 2010 Zsr = 0,34 (low intensity erosive processes).

Key terms: land use, erosive processes, erosion coefficient (Z)

1. INTRODUCTION

The region of Vranjska Valley, along with Grdelica Gorge, represented the focus of development for the highest intensity erosion processes taking place during the 1950s. Destructive torrential streams endangered human lives, as well as the motorway and the railway Belgrade-Skopje-Thessaloniki, ploughed land, etc. By studying the change of intensity of erosion processes, the causes of their reduction were determined in the period of 1963-2010.

A land use, in addition to analysis of meteorological and climatological conditions, relief and distribution of the observed erosion processes, represents one of the key factors in erosion process identification and mapping. By using land and other natural resources for the purpose of social and economic development, the man, by his activities, may disturb and endanger naturally established balance, or preserve and improve it. For that reason, the land use as a significant anthropogenic erosion factor, represents the main interest of the study. The paper presents the study of change of land use in the region of Vranjska Valley in the period 1963-2010.

2. WORK METHOD

Based on the available topographic maps, field mapping and use of satellite images of the study area, a 2010 land use has been processed and defined. The structure of the areas has been

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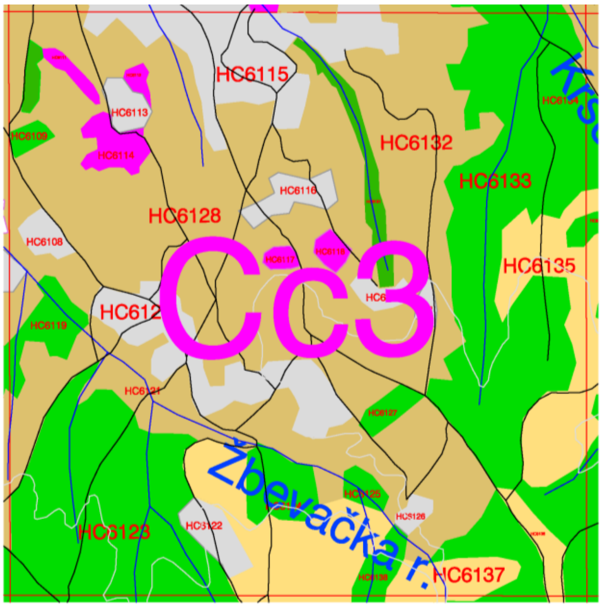
defined by application of homogenous plots. Primarily, productive and non-productive areas have been identified within the homogenous units. Productive areas comprise forests, degraded forests, meadows and pastures, degraded meadows and pastures, high-mountain meadows and pastures, ploughed land, vineyards, orchards, house-adjacent plots and gardens. Non-productive areas consist of gullies, stone fields, gravel, road network, streams and building land. In accordance with the above-mentioned categories, 4100 homogenous plots have been identified within the study area. Based on the above-mentioned systematisation, a digital map of land use has been drawn up.



Picture 1. *Map detail of land use 2010 (Vranjska Valley)*

3. STUDY AREA

Vranjska Valley is situated in the south-east part of Serbia. It stretches from Vladičin Han to Bujanovac in the length of 45 km, in the NE-SW direction. It is of indefinable geometrical form, of a 5km average width. In the north part, it reaches its maximum width in the area between Vladičin Han and Surdulica (15 km), whereas in the south part the maximum width is between Gornji Vrtogoš and the village of Klenike (20 km). The brim consists of older rocks, and the bottom is covered by Neogene sediments (1).

The area is 1302,16 km^2. Of these, the torrential catchments 1240,45 km^2 (95%), while outside the catchment 61,71 km^2 (narrow construction area of Surdulica, Vranje and Bujanovac, road networks and watercourses). In administrative terms, the Vranjska Valley region belongs to municipalities Vladičin Han, Surdulica, Vranje and Bujanovac. The length of the Južna Morava's main stream in the section Vladičin Han–Bujanovac is 47 km (Table 1).

The hydrographic network is well-developed. The main stream has 73 tributaries (rivers, streams and gullies), 36 on the left and 37 on the right side. The largest tributary of Južna Morava in this area is the river Vrla, of a 217,6 km^2 watershed area. The next largest watershed tributary is the Vranjsko Banjska river. In the class of tributaries of a surface area over 100 km^2, are the Kozarska and Trnovačka river. Tributaries of a 50-100 km^2 watershed area are the Džepska, Jelašnička, Korbevačka, Tibuška, Trnovačka, Krševička and Ravnorečka river. There are 15 tributaries of a 20-50 km^2 watershed area, the largest among those are Preobraženska, Trebešinska and Jovačka river.

Table 1. *Hydrographic and topographic characteristics of the Vranjska Valley*

Parameter	Symbol	Vranjska valley
Drainage basin area	F (km^2)	1302,16
Drainage basin lenght	L (km)	47,00
Drainage basin perimeter	O (km)	189,96
Elevation of the source	K_{izv}	394,5
Elevation of the mouth	K_u	324,0
Coefficient of the watercourse meandering	K_k	0,80
Number of stream tributaries		73
The average slope in the section	I_p (%)	0,15
Mean area width	$S_š$ (km)	27,76
Total length of hydrographic network	ΣL (km)	572,50
Density of the hydrographic network	G ($km \cdot km^{-2}$)	0,47
Coefficient of the drainage basin asymmetry	a	0,64
Coefficient of the drainage basin shape	A	0,83
Highest point in the drainage basin	(K_v)	1923,00
Mean elevation of the drainage basin	N_{mean}	804,30
Mean elevation difference	D (m)	480,30

Mean slope of the torrent tributaries are significantly higher and range from 3 – 20 %. All tributaries in the watershed area have typical torrent characteristics.

Picture 2. *Study area*

4. RESEARCH RESULTS

The data on land use in 1963 were calculated based on the available data from 'the inventory of torrents of the Južna Morava river's right and left tributaries in the section Vladičin Han-Bujanovac, the Register of torrent watersheds and descents' prepared by the Regional section for protection of soil against erosion and torrent regulation Vladičin Han in 1964. By means of synthesis of the above-mentioned data, it has been established that forests accounted for 33,19%, ploughed land for 32,80%, meadows and pastures for 7,39%, orchards for 1,46%, house adjacent plots and gardens for 0,43 % of the total watershed surface area, that is, productive areas constituted 75,27% of the study area's surface area. In 1963, barren land accounted for 22,38% of the watershed, that is, over 1/5 of the study area (2). When the representation of areas denoted by the term 'the out of watershed areas' (built up areas, asphalted roads and watersheds) is added to a barren land share in the total surface area, it may be concluded that non-productive areas occupied 24,73%, or one quarter of the Vranjska Valley surface area (Table 2).

Table 2. *Land use in Vranjska Valley (1963)*

	VRANJSKA VALLEY	
	Area (km^2)	%
Forests	432,25	33,19
Meadow and pastures	96,23	7,39
Ploughed land	427,15	32,80
Orchards	18,96	1,46
House adjacent plots and gardens	5,60	0,43
Total productive areas	980,19	75,27
Barren land	291,38	22,38
Outside the watersheds[1]	30,59	2,35
Total non-productive areas	321,97	24,73
Total	1302,16	100,00

In 2010, productive areas in the region of Vranjska Valley occupied 96% area. Forests covered 47% of the area, whereas degraded forests, located in the proximity of settlements, accounted for 3,6% (oak stands). Forest pruning for leaf fodder still takes place, but in small areas. Meadows and pastures covered 21% of the area, out of which 5% accounted for degraded pastures, while high mountain meadows and pastures constituted 9%. Ploughed land covered 21% of the area, and it stretched along the valley of Južna Morava river and lower streams of its larger tributaries. Very small areas of ploughed land were situated on higher altitudes and high inclination slopes. Non-productive areas accounted for 3,8% of the total surface area. Barren land was recorded on 307 ha, out of which gullies covered 53 ha (Žuta voda, the Trnovačka river basin, the Muhovska river, the surroundings of Veliki Trnovac).

The representation of ploughed land in the study area decreased in the period 1953-2011. In comparison to 1953, a 13.4% increase of forest area was recorded, resulting in the present forestation level of 46%. In comparison to 1963, non-productive areas were decreased by nearly 21%. The representation of ploughed land in the total surface area was reduced, that is, ploughed land had been abandon and naturally ’transferred’ to the category of meadows and pastures, the representation of which was increased by 14%.

Table 3. *Land use in Vranjska Valley (2010)*

	VRANJSKA VALLEY	
	Area (km^2)	%
Forests	584,57	44,89
Degraded forests	21,78	1,67
Meadow and pastures	238,29	18,30
Degraded pastures	13,58	1,04
High mountain meadows and pastures	26,02	2,00
Ploughed land	280,69	21,56
Vineyards	11,22	0,86
Orchards	20,01	1,54
House adjacent plots and gardens	56,70	4,35
Total productive areas	1252,84	96,21
Settlements (building land)	30,53	2,34
Gullies	0,53	0,04
Stone field	2,08	0,16
Gravel	0,46	0,04
Road network and watercourses	15,72	1,21
Total non-productive areas	49,32	3,79
Total	1302,16	100,00

[1] Built up areas, asphalted roads, watercourses

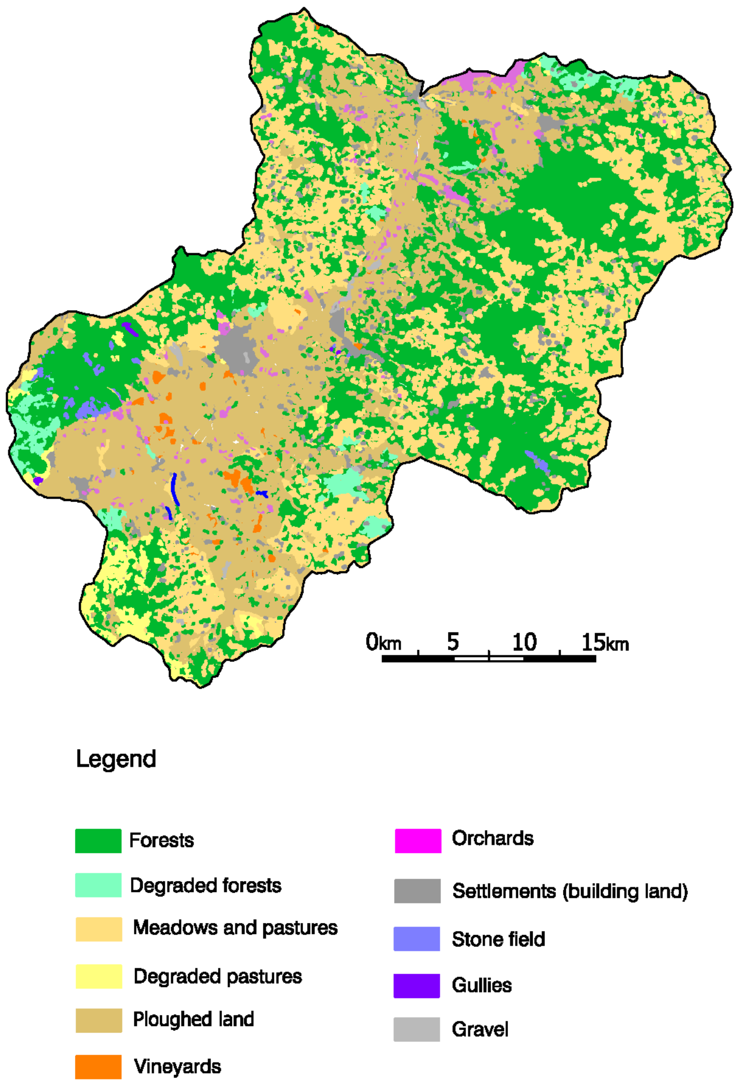
Based on a land use map, drawn up in 2010, it has been established that the productive area constitutes 96,2%, whereas the non-productive area accounts for 3,8% of the Vranjska Valley region. The created land use map, in addition to its primary purpose, was used as the basis for drawing up of an erosion map (3).

The value of the Vranjska Valley region mean erosion coefficient, calculated based on the Prof Gavrilović's methodology (4), in 1963 amounted to Zsr = 0,67 (medium erosion processes), whereas in 2010 it was reduced to Zsr = 0,24 (weak erosion processes).

Table 4. *Erosion process intensity in the Vranjska valley (in 1963 and 2010)*

Category	Zsr	Area (ha)	%	Zsr	Area (ha)	%
	1963			2010		
Excessive	1,25	235,33	18,07	1,25	1,84	0,14
Strong	0,85	477,35	36,66	0,85	10,35	0,79
Medium	0,55	176,40	13,55	0,55	115,3	8,85
Weak	0,30	178,20	13,68	0,30	573,5	44,04
Very weak	0,10	234,88	18,04	0,10	601,17	46,17
Total	Z_{sr} = 0,67	1302,16	100,00	Z_{sr} = 0,24	1302,16	100,00

Reduction of intensity of erosion processes (Table 4) is the effect of the change of land use in the study area.



Picture 3. *Land use map – Vranjska Valley 2010*

5. CONCLUSION

The comparison of the obtained results with the data in 1963 indicated that the most significant changes of land use took place within the categories of barren land, forests, meadows and pastures. A decrease of barren land, ploughed land, meadows and pasture areas occurred because the erosion control works were performed. Another reason for the changes is the migration from high-hilly areas towards urban centres, resulting in abandonment of agricultural areas, which were spontaneously covered by vegetation with the time. The changes of land use in the observed period, in addition to other factors, had an impact on reduction of the erosion process intensity. The mean erosion coefficient in the region of Vranjska Valley in 1963 amounted to Zsr = 0,67 (medium erosion processes, whereas in 2010 it amounted to Zsr = 0,34 (low erosion processes).

Acknowledgement
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INVESTIGATION OF THE PESTER PLATEAU SITE CHARACTERISTICS AS A BASIS FOR THE SELECTION OF POTENTIAL VEGETATION

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Abstract: *This paper presents the results of investigating site characteristics in the Pester plateau region. The purpose of this investigation was to determine the potential vegetation of the region. Parent rock, climate characteristics and soil characteristics were studied. The paper includes a short outline of orographic and hydrological characteristics of the investigated area.*

The whole plateau is a depression with its own characteristic local cold highland climate. Regarding its parent rock, the Pester plateau can be divided into several areas. The soil is highly diverse: from undeveloped, humus – accumulative, and cambic to eluvial-alluvial, etc. The results are here presented in an abridged form because a detailed summary of the results will be given in a separate monograph.

Key words: Pester, site characteristics, climate, soil, potential vegetation

1. INTRODUCTION

The object of investigation are forest sites on the Pester-Sjenica plateau, which are located in the border zone between the Dinaric and Rodop mountains, on the territory of Stari vlah in southwestern Serbia. The geographical coordinates of the Pester plateau together with Sjenica valley are 43°16.5' N and 20° E. This area is in the center of Stari vlah and it is surrounded by high mountains. Its central part consists of Sjenica Valley and Pester field and the surrounding mountains are: Golija (1833 m) and Radocelo (1634 m) to the north-east, Javor and Mucanj (1534 m) to the north, Zlatar (1627 m) to the northwest, Jadovnik (1734 m) and Ozren (1652 m) to the west, Mokra Planina and Mokra Gora on the border with Metohija. The total area of the plateau is 1058.6 km^2.

In the past, it used to be a very important trading place on the old caravan road from Dubrovnik to Constantinople (Istanbul). Sjenica, as the main and central part of this region was mentioned for the first time in 1253 as a place where many merchants rested and paid taxes while going from Dubrovnik to Constantinople. Its name means the `country of hay` in the old Slavonic language. This fact shows that even then the forests were greatly destroyed and there was a disharmony between forests and meadows.

With regard to its forest economic conditions and the existence of forests in the past, we can say that the forests of this once highly forested region were gradually destroyed through several epochs: pre-pastoral, pastoral, pastoral-farming and modern. The present state of the forests can be described as unsatisfactory. According to the forest registry data, the last

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reforestation actions were carried out before 1985. Since then, there have been no large-scale reforestation activities and now forests and forest plantations cover 28.365 ha, 19.390 of which are state-owned, and 8.975 are in private ownership. Since privately-owned forests are not managed, there are no data about their structure and quality. Therefore, these forests cannot be a subject of our study. The largest part of state forests is managed and there are data available on them. With regard to silvicultural structure of these forests, there is a very low percentage of natural high forests, and a very high percentage of forests of poor quality and low productivity in the form of coppice, scrub and shrub forests which was caused by various human factors in the past.

2. WORKING METHOD

The account of climate characteristics is based on the data provided by the weather station in Sjenica and Republic Hydrometeorological Service of Serbia. This standard analysis of the following climate parameters: general climate characteristics, air temperatures, relative humidity, cloudiness, sunlight duration, wind, precipitation and hydric balance, is based on the average values recorded in a period of several decades (1958-1996).

In order to determine **soil characteristics**, a required number of pedological profiles were taken in the studied forest communities. Soil types were determined according to the soil classification (Skoric, Filipovski, Ćiric, 1985).

The following laboratory methods were used for the purposes of determining properties of the soil samples:

- Soil texture was determined by International pipette B method with the soil textural triangle after Ferre being used for fine-textured soil classes;
- The amount of absorbed alkaline cations and hydrolytic acidity values were determined according to Kapenn and the acidity of the soil dissolved in water and KCl by applying the electrometric method;
- The amount of the total humus was determined by the method of Tjurin;
- The content of the total nitrogen was determined by Macro-Kjeldahl method;
- Easily accessible forms of phosphorus and potassium were determined by Al-method

Potential natural forest vegetation was determined with respect to all individual site characteristics and distinguishing features. Potential natural forest communities of certain sites on the Pester plateau were determined on the basis of recent vegetation characteristics, distribution of plant communities, their sites, possible succession and line of development.

Potential vegetation was determined for separate geographical and ecological-site complexes. The outline of its regressive succession was provided for all climatogenic, climate-regional, azonal and intrazonal forest communities in these complexes through all vegetation stages up to pasture and meadow communities. The principle of similarity between current forest areas and deforested terrains or between different deforested areas in their edaphic, orographic and microclimatic conditions was respected in the determination of potential natural vegetation.

3. RESULTS

3.1. Orography, hydrology, forest management characteristics

The relief of the Pester plateau is undulating and it is composed mostly of limestone. It belongs to the high regions of the Dinaric Karst. There are several small mountains on the Pester plateau itself, the highest of which is Giljeva (1617 m), which separates the plateau of Pester from Sjenica Valley. There are also several small calcareous mountains in the direction of

Golija, the most significant being Pometenik and Ninaja, as well as between Sjenica valley and Zlatar.(Cvijić,1924). These small mountains, which are mostly of limestone origin, are now deforested and subject to soil erosion. The relief is karstified and it is composed of mountain ridges, rocky hilltops, plateaus, long and wide valleys, funnel-shaped holes and abysses. Only the part towards Montenegro, which covers the south and west facing slopes of Ozren and Bare, has more forests and it is less subject to erosion. The southern slopes of Golija, which face the Pester plateau, have gentler forms of relief (Zeremski, 1959).

The Pester plateau has a wide range of distinctive hydrological elements. These are springs, rivers, underground rivers, ponds, swamps and lakes. The springs of this region include Sjenicko, Sarsko, Stupsko and the springs of the rivers Vapa, Kamesnica and Skudla. The best-known thermal springs are Banja and Banjica. Although a substantial part of the Pester plateau is composed of water porous limestone, there is a great number of surface streams on the water impermeable and partially limestone terrains. The most important rivers are the river Uvac (119 km), a right tributary of the river Lim, and the Vapa. The Uvac is the longest and the Vapa the largest river. Besides them, the following tributaries of the river Uvac are also very important: Jablanica (25 km), Grabovica (15 km), Kladnica, Studenicka reka, Radevska reka, Veljusnica, Goracanska reka. The following tributaries of the river Uvac are also important because they make the river Vapa: Tuzinjska and Jelova, Rasanska, Zitnicka, Kamesnicka, Dragojlovica, and Brnjicka rivers. Kneznica, Bacevska and Kanjevska rivers are right and Jablanica is a left tributary. The most important underground rivers are Borostica, which is in its upper flow known as Djerekarska river, then Visnjevska, Zaljevska, Dragojlovica, Skudla, and Trijebinska rivers. Once large swamps – Stavljanska and Pesterska swamps – lost their importance after partial amelioration had been carried out (KRSTIĆ,1966).

Out of the total area of high forests, 54% is degraded, while coppice forests have 38% of its area degraded. However, if we know that coppice forests cannot ensure production of high quality wood assortments, it is clear that this silvicultural form is less preferred and that these so-called preserved coppice forests should be converted into a high silvicultural form. The scrub forests do not produce usable timber at all and they are mostly composed of hazel, with occasional aspen and birch on degraded sites of former high forests (KRSTIĆ,1956).

3.2. Climate characteristics

The above stated climate characteristics and the values of climate factors can be summarized in the following way:

Since it is surrounded by high mountains, this plateau together with Sjenicka Valley is isolated both from the sea and from nearby valleys. The whole plateau has characteristics of a depression, with no influences of other climates but with its own local cold highland climate. In winter, cold air masses sink to the bottom of the valley, making so-called lakes of cold air and decreasing the air temperature to –38°C. Winter is about five months long. It is harsh with a lot of snow and cold winds. Springs are short because the snow cover stays long and there is no vegetation until the beginning of May. Summers are cool with warm days and cold nights. Autumn is usually only two months long because November has more characteristics of a winter month.

The Pester plateau is a region with a very distinctive relief which creates a very complex climate system. Basically, temperate continental climate dominates the lower and mountainous climate the higher parts of the region. Summers are cooler and shorter and winters longer and colder than in the valleys of Raska and Ibar.

The mean air temperature ranges from 16.0°C in the lower to 12.5°C in the higher regions in the hottest month (July) and from -2.4°C to -4.1.°C in the coldest month (January).

The annual mean temperature is from 7.7°C in the lower areas and 6.2°C on the Pester plateau itself to 4.5°C in the high mountain areas.

The minimal temperature can drop as low as −38.0°C in higher mountain areas, and −28.0°C in lower areas. The maximal temperatures reach 38.0°C in Raska Valley, but they do not exceed 33°C on the Pester plateau. Thus, the annual amplitude can reach very high values, sometimes even 71°C.

The relative humidity doesn’t fluctuate much during the year. The highest relative humidity on the Pester plateau is in December (85%), and the lowest in April (72%). Thus, the difference between the month with the lowest and the month with the highest relative humidity is 13%.

There is a considerable cloudiness throughout the whole year. Approximately six tenths of the sky is overcast per year. Cloudiness is the highest in January (7.3), and the lowest in August (4.6).

The duration of sunlight is not long, approximately 1393 hours per year, or 43% of the possible annual duration. It is the longest in July and August, when there are few clouds and the days are long. It is the shortest in December and January when the cloudiness is the highest and the days are short.

The average annual precipitation ranges from 668.6 mm at 1000 m.a.s.l. to 1176 mm at 1600 m.a.s.l. Rainfall is fairly evenly distributed per months. The wettest month gets double the amount of rainfall than the driest month.

The area receives the maximal rainfall in May and the minimal in February. According to this feature, the Pester plateau belongs to the continental pluviometric regime. However, it is under a significant influence of the maritime climate, which is reflected in the high secondary maximum in November.

The highest number of rainy days (15) is in May and the lowest in September (7) and August (10).

Therefore, May is the month with the greatest possibility and frequency of rainfall, and September with the smallest. It rains every other day in May and in September only two in ten days are rainy.

In winter, snow cover may stay 60-70 days on average. However, during extremely snowy winters, this period may last up to 100 days.

The meso-climate of the Pester plateau may be classified as a distinct type of boreal forest climate (according to Köppen) or as continental climate of the temperate belt (according to Alisov`s genetic classification).

3.3. Parent rock characteristics

Regarding the distribution of parent rock, the Pester plateau can be divided into several areas. The central or the lowest part of the region, which includes Sjenica with its surroundings, is composed of clay and sand, occasionally gravel. This is particularly evident on the elevated areas around valley rivers, such as the rivers Vapa, Jablanica and Grabovica. However, there is mostly alluvium around the rivers themselves, to the nearest elevations. The part of the plateau towards Montenegro is characterized by the presence of the ultramafic complex, particularly on Ozren and Revusa and in the valley of the river Dubocica with its tributaries. There is a large limestone complex, which starts on the western part of Giljeva, stretches across Duga Poljana and the slopes of the mountain Golija and ends at the foot of the mountain Zlatar. The complex of sandstone, claystone, marlstone and chert starts from the area west to Zlatar, stretches towards Sjenica and then one part branches off between Budjevo and Rasno and the other widens from Trijebine and covers the area of Bare and Visnjevo (Parent rock map of Yugoslavia 1: 100000 , sheets Sjenica, Bijelo Polje, Prijepolje, Ivanjica).

3.4. Soil characteristics

The following summary of the soil characteristics of the investigated area is based on the data obtained from field investigations and on the results of laboratory analyses.

THE SOILS OF (A)-C PROFILE (UNDEVELOPED)

Lithosol (skeletal soils). – Lithosols may be found in the valley of the rivers Uvac, Velika Ninaja and Fijuljka, over limestone.

Regosol. - Regosol is registered only in the community of Scots pine and white-bark pine on serpentinized harzburgite. It is a poorly developed soil (up to 5 cm), characterized by light texture and an alkaline reaction. In comparison to other analyzed profiles, this type of regosol recorded the highest value of active acidity (7.8).

Colluvium. – These soils are 80 cm deep. They are characterized by light texture, sandy loam to loam. Here, they occur over serpentinite, limestone and acid silicate rocks. The reaction of these soils over serpentinite and limestone ranges from moderately acidic to moderately alkaline. The adsorptive complex has a high total adsorption capacity which is due to a high content of humus and organic matter. The degree of saturation of basic cations is also high.

THE SOILS OF A-C PROFILE (HUMUS-ACUMMULATIVE)

In this class of soils, calcareous chernozems and eutric rankers were registered and investigated.

Calcareous chernozems (calcomelanoso)l. – There are organogenic, organomineral, colluvial and brownized types of chernozem in the forest communities of the Pester plateau. Organogenic calcareous chernozems occur in the majority of soil profiles. They occur on ridges, steep slopes and at higher altitudes. Brownized chernozems occur on gentler mountain slopes, in depressions and terraces. They attain considerable depth for this type of soil and in the forest communities these soils can be about 50 cm deep. They are very skeletal and with regard to their texture, the analyzed profiles can be classified as sandy loam to clay loam. They have a neutral, to a moderately acidic and a moderately alkaline reaction.

Humus-silicate soil (ranker). – Humus-silicate soil (ranker) occurs in the forest communities in the form of its subtype - eutric humus-silicate soil (ranker).

Eutric ranker. – Eutric rankers occur in the forest communities on Ozren, and Revusa and in Dubocica. They are distributed on steeper slopes with all aspects in the combination with brown soils over serpentinite, gabroamphibolites and other parent rocks. They occur in the varieties of brownized and colluvial eutric rankers. Colluvial rankers in the forest communities of the Pester plateau can be found at considerable depths, even as deep as 100 cm. They have light texture, ranging from sandy loam to loam. They are porous, loose and permeable. They have a moderately acidic to a neutral reaction.

THE SOILS OF A-(B)-C PROFILE (CAMBIC)

This soil class is in the forest communities represented by the following soil types: brown calcareous soil (calcocambisol), brown soil over ultramafic rocks and other alkaline substrates (eutric cambisol) and acid brown soil (dystric cambisol).

Eutric brown soils (eutric cambisol). – They occur in the forest communities over ultramafic rocks of Ozren, Revusa and Dubocica on neutral and alkaline sediments, serpentinite, gabroamphibolite, spilite and diabase rocks on the lower parts of the ororelief. They can reach the depth of 100 cm, but they are mostly 70 cm deep. With regard to its texture, they can be classified as sandy loam to loam. They are light, water permeable and loose, but with a high proportion of skeletal materials. They have an acidic to neutral reaction. Their acidity reduces with the depth which is due to the stronger influence of the parent rock on the characteristics of the solum.

Acid brown soils (dystric cambisols). – These soils occur on the localities towards the river Uvac and the village of Aljinovici, on the higher positions of the mountain Revusa, in Bare and towards the village of Kladnica. They can be found in different forest communities –from the relict communities of sessile oak and hornbeam to the birch or beech communities. They are up to 75 cm deep, light and with regard to its texture, they can be classified as sandy loam to clay loam. They are highly skeletal, particularly in cambic horizons. They have an extremely acidic to moderately acidic reaction. The degree of saturation of basic cations is low. In a few cases it reaches the value of 50%, which is the upper limit between dystric and eutric soils.

Brown calcareous soil (calcocambisol). – Brown calcareous soils are registered in beech communities at different altitudes as well as in spruce communities. In beech communities, they are often slightly shallower and highly skeletal. Brown calcareous soils are 90 cm deep and with regard to their texture, they belong to sandy loam to clay. They have moderately acidic to moderately alkaline reactions. The profiles with alkaline characteristics have free carbonates present.

THE SOILS OF A-E-B-C PROFILE (ELUVIAL-ILLUVIAL)

Luvisols are the only soil type of A-E-B-C profiles found in the forest communities, and only on small areas.

Illumerized or loessivized soil (luvisol).- Luvisols can be found on small areas of the Pester plateau, mostly on terraced terrains and at the foot of the mountains. The soils are up to 72 cm deep with almost no skeletal material in the profile. On the plateaus, luvisols occur in the form of pseudogley. The surface soil layers are light textured and well-structured. According to their texture, they can be classified as sandy loam, clay loam to clay. The soils have a highly acid to acid reaction, from 3.8 pH to 5.2 pH.

PSEUDOGLEY SOILS OF A-E/G-BG-C PROFILE

Pseudogley.-Pseudogleys occur on Dubinje, on the elevated terrains of the river Vapa valley, in Stavljanske breze in the community of grey and common alder (400 ha), on the slopes of Ozren in the community of beech and fir, around the river Uvac and the village Lopiza, towards Caricina and in the relict communities of sessile oak and Turkey oak on Babinjaca. These soils are very deep in this area, exceeding the depth of 70 cm in all analyzed profiles. They are classified as sandy loam to clay. The top soil layers are light-textured and the amount of clay significantly increases with the depth.

SOILS OF (A)-G OR (A)-C PROFILE (UNDEVELOPED SOIL) -FLUVISOLS

Fluvisols.- Fluvisols are in the Pester plateau common in the valleys of high mountain brooks and streams in the community of grey alder *Alnetum incana*, for instance in the valley of the river Dubocica and its tributaries or in the valley of the brooks near the village of Kladnica. They mostly occur on alkaline bedrocks and serpentinite, but they can be also formed over acidic schistose sandstone. They are generally up to 70 cm deep, but the depth of their solum is often unlimited because the bedrock is made of alluvial deposits. There is a soil horizon formed on the surface with a layer of gravel and earth beneath it. These soils are light-textured and they range from sandy loam to loamy sand. Their reaction is moderately acidic to neutral.

SOILS OF A-G PROFILE (GLEY SOILS)

Gley soil is common in common alder communities in Stavljanske Breze and partly in grey alder communities in the valleys of the tributaries of the rivers Vapa, Trijebinska reka and Uvac. According to its textural features, this soil is classified as heavy clay which means that it has low water and air permeability. Humus-accumulative horizon is composed of loam while the lower profile layers are made of clay. The profiles differ in depth ranging from 30 to 110 cm. These soils have an extremely acidic to moderately acidic reaction (pH from 4.1 to 6.5).

4. POTENTIAL VEGETATION

Reconstruction and presentation of potential vegetation poses a great number of dilemmas, which are reflected in various approaches and methods of solving this problem, regardless of whether the vegetation is preserved or not (TOMIĆ, 1992). An additional problem that occurred in defining the natural potential forest vegetation in the Pester plateau was the poor state of the natural recent forest vegetation. Our own investigations of recent forest vegetation, grass vegetation on clearings, pastures and meadows were used in determining syntaxa on each particular area of potential forest vegetation. The paper presents permanent stages of zonal and azonal vegetation succession, or climazonal forests and permanent stages.

For the purposes of investigating potential vegetation, the investigated area was divided into several geographical, ecological and microclimatic parts.

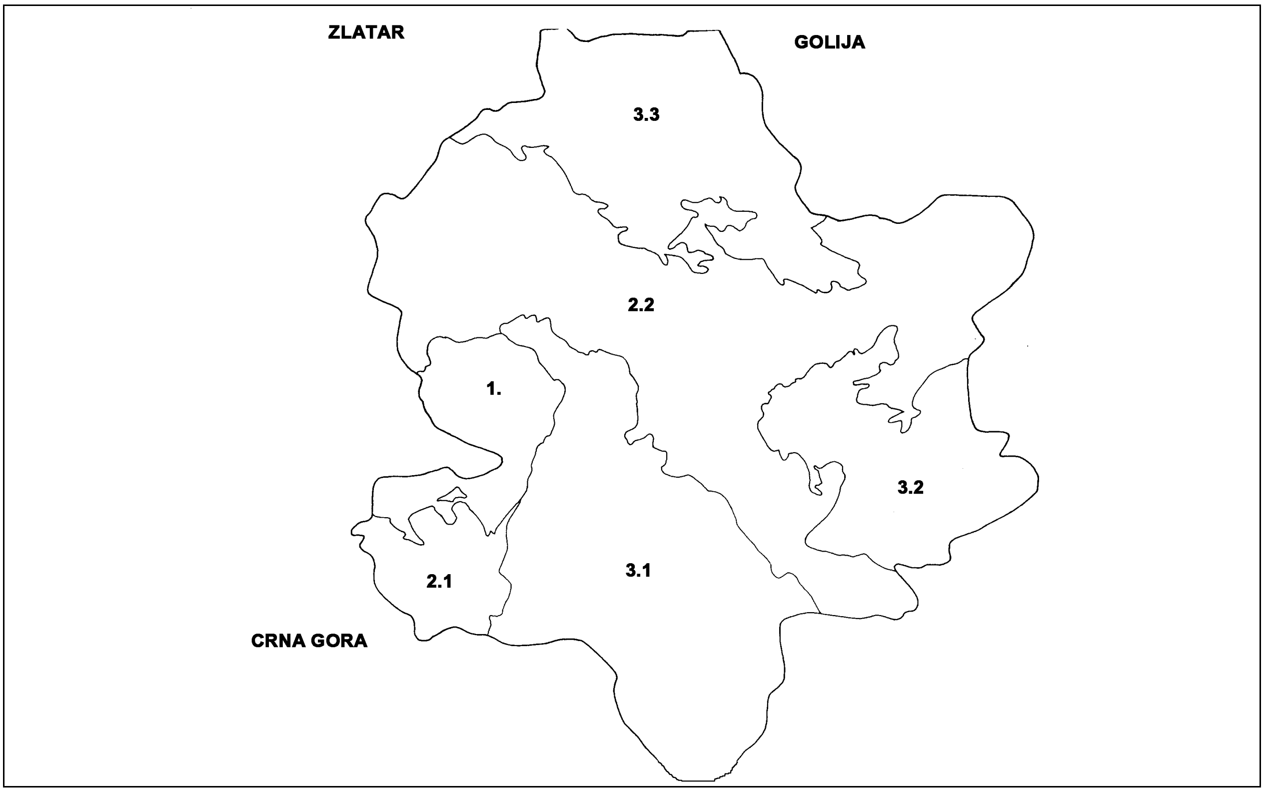

Figure 1. *Spatial distribution of geographical-ecological complexes*
1. The ultramafic complex towards Montenegro; 2.1. The complex of acid silicate rocks towards Montenegro; 2.2. The central complex of acid silicate rocks; The limestone complex - 3.1Giljeve; 3.2. Suhara and Homara; 3.3 Lise, Borovca and Kladnice

The following text is a review of potential vegetation made on the basis of site characteristics, forest vegetation and its succession (Rakonjac, 2002).

ULTRAMAFIC COMPLEX TOWARDS MONTENEGRO

- Balkan sessile oak forests (*Quercetum dalechampii serpentinicum* Vuk. 64., Cvj. 1999) on a series of (ranker-eutric brown) soils over serpentinite present potential forest vegetation in the zone from 900 m.a.s.l. in the valley of Krainovica river to 1150 m.a.s.l. on Travnik, on very steep and warm south-facing slopes.
- Goc Austrian pine forests (*Potentillo-Pinetum nigrae gocensis* Jov. 1959) on a series of (ranker-eutric brown) soils over serpentinite make potential forest vegetation of the river Dubocica cliff, at 800 to 1200 m.a.s.l., on very shallow eutric rankers and steep slopes. In the middle and lower watercourse of the river Dubocica, the community of Goc Austrian pine is the permanent stage of succession.
- Beech and fir forests (*Abieti-Fagetum moesiacae* Jov. 1953) on eutric and dystric brown soils are potential vegetation of higher altitudes, above the zone of Balkan sessile oak and Goc Austrian pine forests. They occur on the serpentinite prevailing part of the complex above 1150 m.a.s.l., in the sheltered zone towards the valley of the river Lim which is on eutric cambisols and has a mild climate.
- Spruce, fir and beech forests (*Piceo-Fago-Abietetum* Col. 1965) on a series of (ranker-eutric) soils on ultramafic rocks are potential vegetation at the altitudes between 1300 and 1500 m. Regarding the type of soil, this is a community on eutric cambisols and brownized eutric rankers. The terrains have different aspects and the slope ranges from 20° to 30°. The belt of the potential beech-fir-spruce community on the eastern and northeastern slopes of the mountain Revusa, where there are now remnants of the old beech-fir-spruce forests, reaches an altitude of 1550 m.
- Whitebark pine forests (*Pinetum heldreichii continentalae*. Blec. et Lks. 1969) on a series of (ranker-eutric brown) soils over serpentinite and serpentinized harzburgite cover the areas above the belt of *Piceo-Fago-Abietetum*, from 1550 m.a.s.l. to the tops of the mountains of Ozren and Revusa (1692).
- Grey alder (*Alnetum incanae* s.l.) and grey willow (*Salicetum incanae*) forests occur as azonal vegetation on recent gravel-sandy alluvial deposits in the lower part of the serpentinite complex, in the middle course of the river Dubocica.

THE COMPLEX OF ACID SILICATE ROCKS TOWARDS MONTENEGRO

- Sessile oak and Turkey oak forests (*Quercetum-petreaeae-cerris* Jov. 79 s.l) on a series of (dystric-cambisol-loessivized) soils over silicate rocks. - In the part of the complex towards the valley of the river Lim, dominated by sandstone, limestone, chert and marlstone, below 1200 m.a.s.l., potential vegetation is composed of *Quercetum petraeae-cerris* on warm aspects and in alternation with beech forests (Fagetum moesiacae montanum silicicolum) on colder aspects.
- Montane beech forests (*Fagetum moesiacae montanum* Jov. 76) on dystric cambisols. – This complex of beech forests descend as low as 700 m.a.s.l., around the villages of Konatar, Plana, Pusina to Tutice on the north, encompassing the part of the Dubocica river cliff beyond the serpentinite complex, on steep slopes. The belt of beech forests stretches below 1200 m.a.s.l.
- Spruce-fir-beech forests (*Piceo-Fago-Abietetum* Col. 1965) on a series of (ranker-dystric cambisol) soils over acid silicate rocks. – Above 1200 m, with the increase of altitude, the sites of beech forests are replaced with the sites of potential beech-fir-spruce community. This type of zoning of natural potential vegetation on acid silicate rocks also occurs on the slopes of Golija, towards Bele vode in the valley of the river Ljutska reka.

THE COMPLEX OF ACID SILICATE ROCKS OF THE CENTRAL PART OF THE PESTER PLATEAU

- Purple osier forests (*Salicetum purpureae* Zel. 52) on coarse gravel-sandy alluvial deposits on fluvisol and gley – is pioneer azonal vegetation of this part of the plateau, in the middle and upper course of the rivers Vapa and Jablanica, at the altitudes around 1000 m. The community of purple osier also develops on the localities occupied by the community of *Carycetum vulpinae-riparae* and the communities of *Cynodontetum* type.
- The forests of grey alder with common alder (*Alnetum incanae-glutinosae* Br.-Bl. 1915) on pseudogley can be found in the region of Stavljanske breze, above the terraces of the river Vapa valley, at the altitudes between 1020 and 1148 m on neogenic sediments (gravel, sand and clay).
- Sessile oak and Turkey oak forests (*Quercetum petraeae-cerris* Jov. 1960) on a series of (ranker-dystric) soils on neogenic sediments stretch over silicate terrains on both sides of the route between Sjenicka kotlina and Zlatar, at the altitudes from 900 to 1250 m.
- Montane beech forests (*Fagetum moesiacae montanum silicicolum*) on dystric cambisols. – Beech communities on acid silicate rocks (*Fagetum moesiacae montanum silicicolum)* are potential vegetation at the altitudes from 1050 to 1200 m. They occur on deep soils, mostly pseudogleys, luvisols, dystric cambisols to slightly eutric and less exposed to sun. They alternate with *Quercetum petraeae-cerris* communities, occupying colder aspects.
- Spruce-fir-beech forests (*Piceo-Fago-Abietetum* Col. 1965) on a series of (ranker-loessivized) soils over acid silicate rocks. – These forests make the belt at the altitudes from 1250 to1500 m, on sandstone, claystone, chert and marlstone on different aspects and on dystric cambisols.

LIMESTONE COMPLEX OF GILJEVA, HOMAR, SUHAR, LISA, VELIKI BOROVAC WITH THE SURROUNDINGS

- Sessile oak and hornbeam forests (*Querco-Carinetum moesiacum* Rud. 45 s.l.) on brown soils. – *Querco-Carpinetum* is the potential vegetation in the lowest part of the calcareous mountains in the western area of the plateau in the sheltered, moist, once frosty valleys of the rivers Uvac, Kladnicka and Radevska reka and their tributaries, from 900 to 1110 m.a.s.l. There are remnants of the community of sessile oak and hornbeam with Oriental hornbeam, somewhere with hop-hornbeam. With regard to the ecological conditions, it occurs here in a mosaic of limestone and diabase chert and the bedrocks are often mixed.
- Hop-hornbeam and Austrian pine forests (*Ostryo-Pinetum nigrae calcicolum* Col. 65) on initial soils over limestone. – There are rocky grounds in the calcareous canyons of the rivers Uvac, Vapa, Radevska reka and Kladnica where a mosaic of soils occurs between large skeletal aggregates. This community is the permanent stage of azonal vegetation on shallow calcareous soils.
- Montane beech forests (*Fagetum moesiacae montanum calcicolum)* on a series of (shallow and skeletal to deep and very deep) soils over limestone are potential vegetation (beyond rocky gorges, valleys and depressions) of the lower belt of this part of the plateau, from 1050 to 1200 m.a.s.l., on slopes up to 40°.
- There are no traces of beech-fir forests on barren limestone massifs. There are only traces of beech coppice forests at certain altitudes, which imply the former existence of beech-fir forests.
- Spruce-fir-beech forests (*Piceo-Fago-Abietetum* Col. 1965) on a series of (chernozem-brown-illimerized) soils over limestone. – This vast area, which is mostly composed of limestone, at the altitudes between 1200 and 1500 m belongs to the zonal vegetation of the

beech-fir-spruce community *Piceo-Fago-Abietetum calcicolum* in the border zone towards Montenegro and Bosnia, on Zlatar, the Pester plateau and Jadovnik.

- Spruce forests (*Piceetum excelsae serbicum* Greb. 50).- On the territory of the Pester plateau, pure spruce forests as potential communities occur in inversion, by the rivers and in cold, deep valleys, such as the valley of the Radevska river, on bunk, marly or layered limestone and on the slopes of the mountain Zlatar.
- Grey alder forests (*Alnetum incanae* s.l.) on recent gravel-sandy alluvial deposits. – The azonal vegetation of grey alder (*Alnetum incanae* s.l.) occurs in strips on the whole territory of the Pester plateau as a pioneer shrub vegetation along brooks and creeks at the altitudes around 1000 m. It occurs on gentler slopes, on various bedrocks from colluvium and fluvisol to gley.

5. CONCLUSIONS

1. The Pester plateau is a region with a very distinctive relief which creates a very complex climate system. Basically, temperate continental climate dominates the lower and mountainous climate the higher parts of the region. Summers are cooler and shorter and winters longer and colder than in the valleys of Raska and Ibar.
2. The parent rock of the investigated area can be divided into several complexes: 1.) the complex of clay and sand with gravel, 2.) ultramafic complex, 3.) the complex of limestone and 4.) the complex of sandstone, claystone, marlstone and chert.
3. The following soil types are present: lithosol, regosol, colluvium, calcomelanosol, dystric ranker, eutric ranker, calcocambisol, eutric cambisol, dystric cambisol, luvisol, pseudogley, fluvisol, gley.
4. The potential vegetation communities are as follows:

   – Balkan sessile oak forests (*Quercetum dalechampii serpentinicum* Vuk. 64., Cvj. 1999
   – Goc Austrian pine forests (*Potentillo-Pinetum nigrae gocensis* Jov. 1959)
   – Beech and fir forests (*Abieti-Fagetum moesiacae* Jov. 1953)
   – Spruce, fir and beech forests (*Piceo-Fago-Abietetum* Col. 1965)
   – Whitebark pine forests (*Pinetum heldreichii continentalae*. Blec. et Lks. 1969)
   – Grey alder forests (*Alnetum incanae* s.l.) i sive vrbe (*Salicetum incanae*)
   – Sessile oak and Turkey oak forests (*Quercetum-petreaeae-cerris* Jov. 79 s.l
   – Montane beech forests (*Fagetum moesiacae montanum* Jov. 76)
   – Purple osier forests (*Salicetum purpureae* Zel. 52)
   – The forests of grey alder with common alder (*Alnetum incanae-glutinosae* Br.-Bl. 1915)
   – Sessile oak and Turkey oak forests (*Quercetum petraeae-cerris* Jov. 1960)
   – Montane beech forests (*Fagetum moesiacae montanum silicicolum*).
   – Sessile oak and hornbeam forests (*Querco-Carinetum moesiacum* Rud. 45 s.l.)
   – Hop-hornbeam and Austrian pine forests (*Ostryo-Pinetum nigrae calcicolum* Col. 65).
   – Montane beech forests (*Fagetum moesiacae montanum calcicolum*)
   – Spruce forests (*Piceetum excelsae serbicum* Greb. 50).
   – Grey alder forests (*Alnetum incanae* s.l.)

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DYNAMICS AND PROPERTIES OF GROUNDWATER IN HUMOFLUVISOL SOIL IN A PROTECTED PART OF THE ALLUVIAL PLAIN

Saša PEKEČ, Saša ORLOVIĆ, Petar IVANIŠEVIĆ, Marina KATANIĆ, Vladislava GALOVIĆ, Marko KEBERT[1]

Abstract: *This paper presents the dynamics of groundwater, soil moisture and quality of groundwater during two years. During 2006 the highest relative level of groundwater was 147 cm from the soil surface, the middle level 234 cm, while the lowest level reached 285 cm. The amplitude of the groundwater variation was 138 cm. In 2007, the highest relative level of groundwater was 120 cm, the middle level of 260 cm, while the lowest was 385 cm. The amplitude of variation for this year was 265 cm. The correlation between the Danube water level and groundwater level was high during first study year and higher water levels (r = 0.96), while during the second year water level was lower and the correlation was low (r = 0.21). Soil moisture during the test period was accessible to plants, and was increased with depth of soil profile. Based on the groundwater analysis, assessment of water quality was made according to U.S. Salinity Laboratory classification and the FAO classification and quality classes of the groundwater of humofluvisol soil are presented.*

Key words: ground water level, humofluvisol, class of water quality

INTRODUCTION

In the distribution area of the alluvial plain, the largest impact on soil water regimes have water levels of rivers. In part that is situated behind the embankment govern completely different wetting conditions, which have an impact on soil properties. The construction of embankment eliminated the flooding, so wetting in this part of the soil depends on the groundwater regime which is still under some influence of river water levels. In a secured area of the alluvial plain of the Middle Danube Basin hydrological conditions have been changed significantly and creation of soil is no longer subjected to fluvial sedimentation. After 30 years of the last century when the embankment was built along the Danube, the soil is exposed to wetting only through the groundwater. It is believed that the Danube has an impact on ground water up to 2 km from the river bed in sandy soils, with the largest impact at 500 meters from the bed. On heavy texture soils as Stojšić (1968) stated the impact of the Danube in the coastal zone is at a distance of 1 km. According to Pavićević (1973), there are three particularly important sources of influence on the level and fluctuation of groundwater during the year. The first source consists of permanent waters in Quaternary deposits of gravel and sand. Second source is derived from the water of the Danube and its tributaries in the lower flow which constantly communicate with the groundwater of wetland through the sand beneath the embankments and third sourse is precipitation water.

Vasileva (1978) designated areas that show the intensity of interaction between Danube water and water of phreatic aquifers which are: direct impact zone of the Danube to the level of

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phreatic aquifer (width 700-800 m), transition zone (1500 m wide) and zone of negligible impact of water on the changes of the phreatic aquifers level (up to 2200 m far from the river.) Savić, et al. (2004) studied Koviljski rit and its alluvial plain and observed that for the period from 1991 to 2000 depth of the groundwater ranged from 1,6 to 2,8 m, while on the terrace it was significantly deeper and was 6,4 m. They also noted the relation between groundwater and the water level of the Danube, i.e. groundwater level declines nearer to the alluvial terrace. In humofluvisol soils, located in the central part of the alluvial plain, groundwater level was on average about 2 meters deep. For a more extensive study of hydropedological properties in the area of the Middle Danube Basin, is important to determine groundwater quality. In addition to positive or negative affection to the existing vegetation with their oscillation, groundwaters with their chemical composition significantly affect vegetation on certain areas. If the quality of water is unfavourable, it leads to deterioration of soil quality.

Given the specificity of the protected part of the alluvial plain, this paper aims to show oscilations of groundwater levels during the growing season, moisture content in soil and groundwater quality of humofluvisol in the Middle Danube Basin.

OBJECT AND METHOD

The study was conducted in the central part of the alluvial plain of the Middle Danube Basin, between Novi Sad and Koviljski rit, where soil type is humofluvisol. In vegetation periods during 2006 and 2007, measurement of underground water level was carried out twice a month using installed piezometers. With the same dynamics, in the vicinity of each piezometers were taken soil samples with pedological corer in order to determinate immediate soil moisture. Content of immediate soil moisture was determined by gravimetric method. Samples of groundwater taken tree times during the years 2006 and 2007 were analyzed and evaluation of their quality was made according to classifications: U.S. Salinity Lab. (1956) and FAO classification (Ayers and Westcot, 1985).

RESULTS AND DISCUSSION

Analysing groundwater level can be noticed different dynamics during the study years (Figure 1). Highest relative level of groundwater in the year 2006 was 147 cm, intermediate level 234 cm, while lowest level reached 285 cm. The amplitude of oscillation was 138 cm.

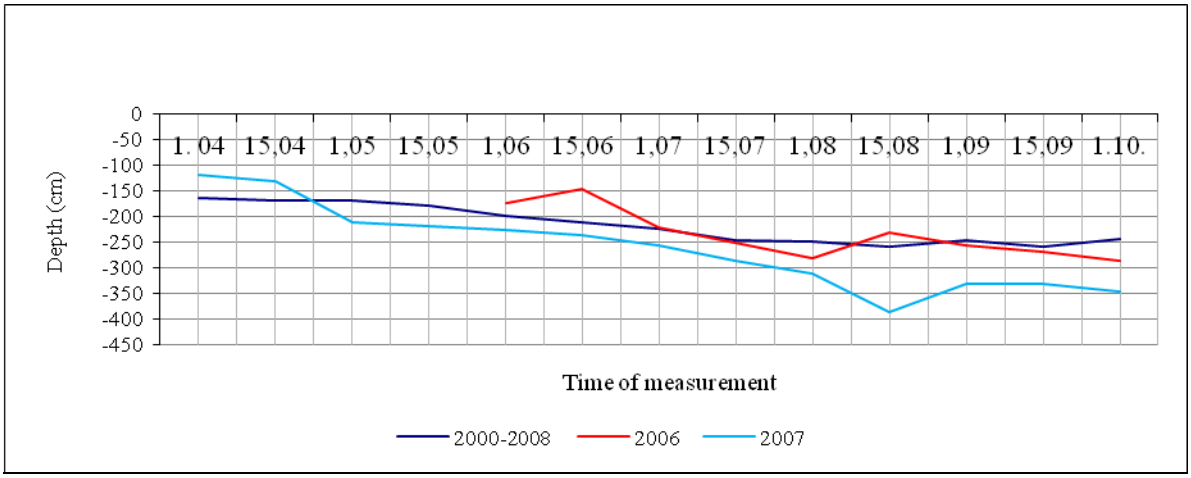

Figure 1. *The dynamics of groundwater*

In the year 2007 highest relative level of groundwater was 120 cm deep, intermediate level 260 cm and lowest level was 385 cm. The amplitude of oscillation for this year was 265 cm. Data from the official piezometers are in range of the annual average of the groundwater dynamics for the period 2000-2008 at the investigated site. It can be concluded that the groundwater level during the first year of the study was above the average for investigated period, while in the second year was below that average.

Content of immediate soil moisture (Figure 2.3 and 4) during the study also varied with study years and with the depth of horizons of investigated humofluvisol soil, which is in the close relation with the variation of groundwater. In the surface horizon 40 cm deep (Figure 2), immediate moisture was in the year 2006 mainly inaccessible to plants, while in 2007 it was accessible, except in certain period in August.

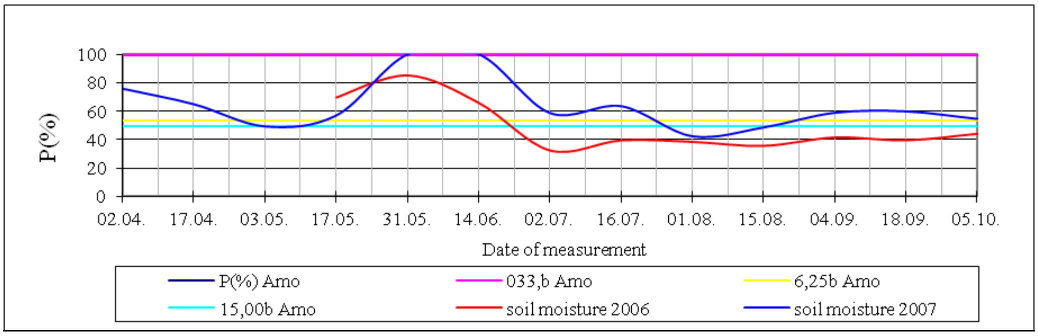

Figure 2. *The dynamics of soil moisture in the horizon Amo (0-40 cm)*

In the C horizon within depth from 40 to100 cm (Figure 3) the immediate moisture in both years was accessible to plants, except in July and August 2006.

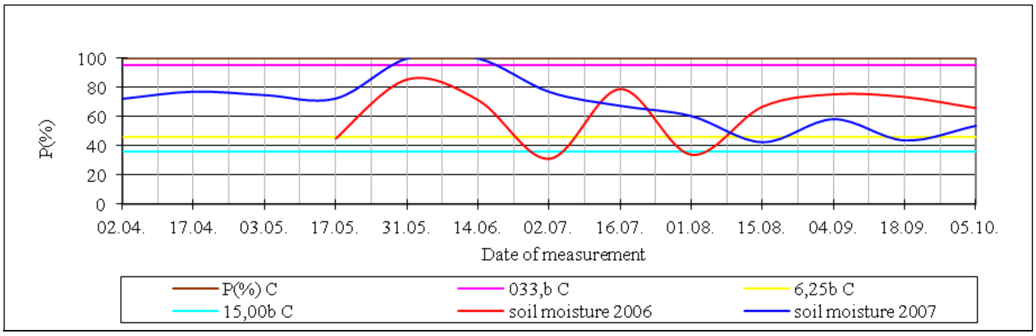

Figure 3. *The dynamics of soil moisture in the horizon C (40-100 cm)*

In subhorizon gley - Gso, within a depth 100 - 200 cm, immediate moisture was accessible to plants in both years.

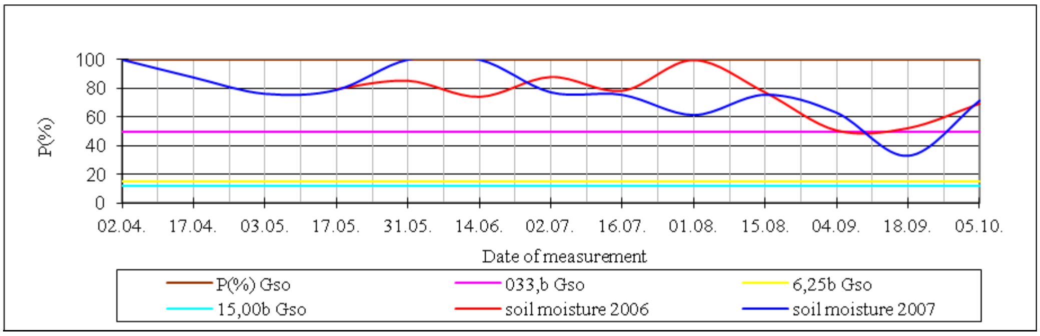

Figure 4. *The dynamics of soil moisture in the horizon Gso (100-200cm)*

Analyzing the immediate soil moisture can be concluded that its content increases with depth of humofluvisol soil, which is under the influence of groundwater level and the groundwater capillary climbing. Mayer (1996) during the study of groundwater and surface water made hydropedological classification of the soils according to the curves of underground and surface water duration. The author stated that the wet phase of the soil occurs when all pores are filled with water and are often located above piezometric level due to the rise in clay soil, moist phase occurs after gravitational water ran off and plants can use water that stayed (field water capacity), to lower accessible limits of moisture, or point of fading.

Under the influence of the Danube water level on the groundwater level in the investigated soil (Table 1) can be concluded that the correlation in 2006 was high (r = 0.96), while in the year 2007 was much lower (r = 0.21).

Table 1. *Correlation of the Danube water level and level of underground water*

Type of soil	The correlation coefficient in the year 2006	The correlation coefficient in the year 2007
humofluvisol	0.96	0.21

Analyzing classes of water shown in Table 2. can be concluded that according to the U.S. Salinity Laboratory classification quality of water is very poor i.e. this is very salty water (C4) and only in 2007 it was in the class of salty waters (C3). According to the degree of alkalization was found that investigated water belonged to the next classes: medium to high sodium content (S2-S3) in 2006, while in the year 2007 degree of alkalization decreased for one class and the values of sodium content were in range from small to medium (S1-S2). Studying groundwater quality of Bačka and Banat, Škoric (1994) also found poor quality of groundwater.

Table 2. *Qualitative classes of ground water*

Period of sampling	I/06	II/06	III/06	I/07	II/07	III/07
Classes of water[a]	C4S2	C4S3	C4S2	C3S1	C4S2	C4S1
Classes of water – need for restriction[b]	possible	possible	moderate	moderate	possible	moderate

[a]Classes water acording U.S. Salinity lab. (1956)
[b]Classes water acording modified FAO classification (Ayers & Westcot, 1985)

According to FAO classification, quality of this water is also very poor, and acorrding to necessarity of water restrictions for irrigation, studied water is in classes: possible to moderate restriction of water.

CONCLUSIONS

Based on the results of this work following conclusions can be made:

- Research in the year 2006 shows that the mean groundwater level at humofluvisol soil was 234 cm, with an amplitude of variation of 138 cm. In 2007 the average groundwater level was lower, i.e. 260 cm, and the amplitude of variation for this year was higher and amounted 265 cm.

- Content of immediate soil moisture during the research varied depending on the year of investigation and depth of studied humofluvisol soil horizons. With depth of the excavated soil, increased available water content which was under the influence of the level of groundwater and the capillary water climbing.
- The Danube water level had a significant impact on the groundwater level in the first study year (r = 0.96), while in the second year the impact of water levels was weaker (r = 0.21).
- The quality of the studied groundwater samples was poor and the U.S. Salinity Laboratory classified it in salty water to a very salty water with medium to high sodium content. According to FAO classification of water quality these waters are classified in class: possible to moderate restriction of the water for irrigation.

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THE MOST COMMON INSECTS AND DISEASES OF OAK SEEDS IN CENTRAL PART OF SERBIA

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Abstract: *On account of intensification of the process of oak forest dieback on the one hand, and the aim to increase the afforestation level in Serbia on the other hand, it is necessary to increase the production of quality acorn in order to provide sufficient quantities of quality seedlings for fulfilment of the above-mentioned aim. The causes for poor germination and failures in production of seedling material are most frequently the result of a presence of pathogenic fungi and harmful insects. The paper specifies the most common fungi and harmful insects in oak seed, observed in the course of a six-year long investigation. The isolated fungi can cause mummification (Stromatinia pseudotuberosa), as well as decay and anthracnose of acorn (Cytospora intermedia, Gloeosporium quercinum, Pestalotia glandicicola and Phomopsis quercella). In addition to the above-mentioned species, the presence of fungi that continue their development after harvest, reducing a seed germination and leading to wilting of seedlings and decay of roots (Fusarium, Pythium, Botrytis i Alternaria), was also identified. Furthermore, a presence of saprophyte species from genera Penicillium, Mucor, Aspergillus i Trichotecium was also established. The most frequently recorded insects affecting acorn belong to genera Curculio and Cydia.*

Key words: oak, seed, harmful insects, pathogenic fungi

INTRODUCTION

The afforestation level of the central part of Serbia accounts for 37.6% of its territory (Banković at al., 2009). Serbia is a country of a medium level afforestation, similar to the world level, which accounts for 30%, but considerably lower than the European afforestation level which reaches 46%. The Republic of Serbia Spatial Plan envisages the increase of afforestation level to 41% by 2050.

Serbian forests are dominated by broadleaved species. After beech forests, oak forests are most highly represented and most important Serbian forests. Ten deciduous oak species are represented in Serbia (*Quercus robur* L., *Q. policarpa* Schur., *Q. petraea* (Matt.) Liebl., *Q. dalechampii* Ten., *Q. farnetto* Ten., *Q. cerris* L., *Q. trojana* Webb., Q. *virgiliana* Ten., *Q. pubescens* Willd., *Q. pedunculiflora* K. Koch.), accounting for 25% of the total Serbian forest fund. Oaks account for 24.5% of the total wood volume, whereas in terms of annual increment they constitute 27.5% (Stojanović, 2007).

Sessile oak accounts for 5.9% of the total volume of Serbian forests and 6.1% of the annual increment; pedunculate oak accounts for 2.5% of the total volume and 1.7% of the annual increment (Banković at al., 2009).

Sessile oak represents one of the most important tree species in the Serbian forest fund, covering the surface area of 173,200ha. However, its technical value is limited, due to a

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dominant coppice origin. Pedunculate oak forests represent one of the most valuable forests, owing to their high technical and economic value, but, in spite of that, their considerable disadvantage is a relatively low areal representation.

The condition of the above-mentioned forest complexes in Serbia is not satisfactory. In addition to a low representation of pedunculate oak in Serbian forests, and a largely coppice origin of sessile oak forests, one of the most serious problems affecting oak forests is a dieback, which began in Europe already in late 19th century. The dieback, of a lower or higher intensity, has been recorded in all European countries. The last wave of oak forest dieback, which began in the 80s of the last century, is still present and displays tendency for further spreading (Marinković and Panić, 1987; Marinković at al.,1990; Karadžić and Marković, 1996; Milin at al., 1998; Oszako, 2000). Among oaks represented in Serbia, the dieback and deterioration process is most clearly marked in sessile oak, followed by pedunculate oak. The process of oak forest dieback is affected by several biotic and abiotic factors, among which climatic changes are of highest importance (global warming, severe and cold winters and dry summers), along with parasitic fungi and harmful insects.

It is essential to preserve and extend oak forest areas, in which mainly autochthonous vegetation will be preserved.

On account of the above-mentioned, for a successful establishment of artificial oak stands it is necessary to provide a healthy source material, by harvesting or introduction of seedlings.

A large number of insects feed on oak seed (Schwenke, 1974; Zemkova, 1980; Maksimović, 1983; Mikloš, 1991; Hrašovec, 1993; Glavendekić at al, 2004; Mihajlović, 2008). The most important identified insects affecting acorn belong to genera *Curculio* and *Cydia*. According to Drekić (2006), a presence of five species of harmful insects was identified in pedunculate oak seed - *Curculio glandium* Marsh., *C. elephas* Gyll., *Cydia splendana* Hb., *C.amplana* Hb. and *Andricus quercuscalicis* Burgsd.

This paper is focused solely on insects that are trophically related to seed. In the examined samples, a presence of representatives of genera *Curculio* and *Cydia* was established.

According to Lazarev and assoc. (2005), oak acorn diseases in seed stands are caused by the following species: *Stromatinia pseudotuberosa Rehm., Gloeosporium quercinum* West., *Gnomonia quercina* Kreb., *Pestalotia glandicicola (Cast.) Guba., Phomopsis quercella (Sacc.) Died.* and *Cytospora intermedia* Sacc. During storage, parasitic fungi of genera *Alternaria, Botrytis, Fusarium, Pythium,* along with saprophytic fungi of genera *Aspergillus, Penicillium, Trichothecium* and *Mucor,* most frequently occur. These fungi are frequently present on a seed surface, and, under certain conditions, can penetrate not only as far as to seed cotyledon and endosperm, but to its embrio. In that manner, a disease can break out in a seed germination phase, and lead to wilting.

In their studies, Karadžić et al. (2007), observed 18 species of fungi in sessile oak (fruits and cupule) and roots of plants aged up to one year. *Fusarium* species *Botrytis cinerea, Diaporthe eres, Gloeosporium quercinum, Glomerella cingulata, Phomopsis glandicola, Phomopsis quercella* and *Stromatinia pseudotuberosa* are of major importance.

MATERIAL AND METHOD

The analysis of data on seed health condition in three oak species, two autochthonous (*Quercus petraea, Q. robur*) and one allochthonous (*Q. borealis*), was presented in the paper, encompassing the period 2006-2011. A presence of insects was established by ocular examination, which was followed by a dissection of 50 randomly selected seeds. The identification of harm inflictors was performed based on a larva appearance and harm symptoms. Following the examination, a percentage of acorn harmed by a presence of larvae *Cydia sp*. and *Curculio sp* was determined.

A presence of disease was established by ocular examination of oak seed samples, followed by a surface examination by magnifying glass, and then an examination of a longitudinal section. After that, the seed, on which presence of mycelia, spore-carrier bodies and other disease symptoms was established, was isolated and samples were taken for microscopic analysis. The seed was surface sterilised and put into Petri dishes on an artificial nutrient substrate, consisting of PDA and MA. After the obtainment of pure cultures and their analysis (morphological appearance, sporulation ability), a determination of microorganisms inhabiting the seed samples was conducted. The keys of B.C. Sutton (The Coelomycetes, 1980), J.V. Carmichael and assoc. (Genera of Hyphomycetes, 1980), J.A. Arx (Genera of Fungi Sporulating in Pure Culture, 1974) i R.W.G. Dennis (British Ascomycetes, 1978) were used for identification of fungi.

A statistical processing of data involved two-factorial analysis of variance, with a yield year and oak type as factors and pest and pathogen groups as variables. Testing of differences between mean values was conducted by means of the Dunkan test (α=0,05). On account of high variance of source data, the variance analysis and testing of mean values were preceded by a normalisation, performed by means of a square root of x+1 transformation, where x represents a variable.

RESULTS

A percentage representation of the most important groups of oak seed pests and pathogens according to a yield year and oak types was presented in the Table no 1.

During 2006, 2007 and 2008, a presence of *Cydia* species in the seed of analysed oak species was not established. A slightly increased number of pests from this group was registered in 2009, in red oak and sessile oak seed. A significantly increased numbers were observed in pedunculate oak seed in 2010. Unlike *Cydia* species, a group of pests of genus *Curculio* was most numerous in 2010 in pedunculate oak seed. A slightly increased number of oak seed pests from this group (over 10%) was recorded in 2009 in sessile oak and in 2011 in pedunculate oak. *Stromatinia pseudotuberosa* (cause of mummification in oak acorn) was observed in one sessile oak sample, as well as in pedunculate oak in 2010 and 2011. A presence of fungi of genus *Penicillium* was recorded in sessile oak seed in 2009 and in pedunculate oak seed in 2010 and 2011.

Tab. 1. *A percentage representation of the most important pest and pathogen groups in oak seed: presentation according to years and analysed oak species*

Year	Oak species	*Cydia* sp.	*Curculio* sp.	*Penicilium* spp.	*S. pseudotuberosa*
		Mean	Mean.	Mean.	Mean.
2006	*Q. borealis*	0,0**a**	0,0**a**	0,0**a**	0,0**a**
2006	*Q. petraea*	0,0**a**	85,0**b**	0,0**a**	0,0**a**
2006	*Q. robur*	0,0**a**	0,0**a**	0,0**a**	0,0**a**
2007	*Q. borealis*	0,0**a**	0,0**a**	0,0**a**	0,0**a**
2007	*Q. petraea*	0,0**a**	5,0**a**	0,0**a**	0,0**a**
2007	*Q. robur*	0,0**a**	0,0**a**	0,0**a**	0,0**a**
2008	*Q. borealis*	0,0**a**	0,0**a**	0,0**a**	0,0**a**
2008	*Q. petraea*	No data	No data	No data	No data
2008	*Q. robur*	0,0**a**	0,0**a**	0,0**a**	0,0**a**
2009	*Q. borealis*	5,5**ab**	5,5**a**	0,0**a**	0,0**a**
2009	*Q. petraea*	13,3**ab**	13,3**ab**	3,8**a**	2,5**a**
2009	*Q. robur*	0,0**a**	0,0**a**	0,0**a**	0,0**a**

2010	*Q. borealis*	1,3**a**	0,0**a**	0,0**a**	0,0**a**
2010	*Q. petraea*	0,0**a**	2,0**a**	0,0**a**	4,5**a**
2010	*Q. robur*	34,9**b**	10,0**ab**	9,0**b**	0,0**a**
2011	*Q. borealis*	0,0**a**	0,0**a**	0,0**a**	0,0**a**
2011	*Q. petraea*	0,5**a**	2,3**a**	0,0**a**	0,0**a**
2011	*Q. robur*	1,0**a**	2,3**a**	4,3**a**	7,1**a**

Means followed by the same letter not significantly different at the 0.05 level using Duncan test

The data on percentage representation of the most important pest and pathogen groups in oak seed according to oak species, regardless of a yield year, were presented in the Table no. 2.

A pest group of genus *Cydia* largely prefers pedunculate oak seed, an autochthonous oak species, whereas a pest group of genus *Curculio* mainly prefers sessile oak, also an autochthonous oak species. A presence of fungi *Stromatinia pseudotuberosa* and *Penicillium* spp. was most frequently identified in pedunculate oak seed and, on one occasion, in sessile oak seed.

Tab. 2. *A percentage representation of the most important pest and pathogen groups in oak seed: presentation according to species for the observed period 2006-2011*

Oak species	*Cydia* sp.	*Curculio* sp.	*Penicilium* spp.	*S. pseudotuberosa*
	Mean	Mean	Mean	Mean
Q. borealis	1,1**a**	0,9**a**	0,0**a**	0,0**a**
Q. petraea	2,8**a**	21,5**a**	0,8**a**	0,5**a**
Q. robur	6,0**b**	2,1**ab**	5,2**b**	4,1**b**

Means followed by the same letter not significantly different at the 0.05 level using Duncan test

The data on percentage representation of the most important pest and pathogen groups in oak seed according to a yield year, regardless of oak species, were presented in the Table no.3

A presence of *Cydia* species in the analysed samples of various oak types was not recorded in the period 2006-2008, whereas a significantly increased value (over 10%) was observed in 2010. A significantly increased value of a pest group of genus *Curculio* was recorded in 2006, nearly in 30% of the examined seed, whereas in 2009, this value was slightly over 6%. In the remaining part of the year, a percentage representation of seed with a recorded presence of species of this genus was insignificant, or not recorded at all, as it was the case in 2008. A presence of fungi *Stromatinia pseudotuberosa* was recorded in last three years of the study (period 2009-2011). The lowest percentage of infested seed (5%) was recorded in 2009, whereas the highest (20%) was observed in pendunculate oak in 2011. A presence of fungi of genus *Penicillium* ranged from 15% in 2009 and 2011 and 20% in 2010.

Tab. 3. *A percentage representation of the most important pest and pathogen groups in oak seeds: presentation according to years for all three analysed oak species*

Year	*Cydia* sp.	*Curculio* sp.	*Penicilium* spp.	*S. pseudotuberosa*
	Mean	Mean.	Mean	Mean
2006	0,00**a**	28,33**c**	0,0**a**	0,0**a**
2007	0,00**a**	1,67**a**	0,0**a**	0,0**a**
2008	0,00**a**	0,00**a**	0,0**a**	0,0**a**
2009	6,28**ab**	6,28**b**	1,7**a**	1,1**a**
2010	12,06**b**	4,00**a**	6,4**b**	3,2**a**
2011	0,50**a**	1,53**a**	1,8**ab**	2,9**a**

Means followed by the same letter not significantly different at the 0.05 level using Duncan test

DISCUSSION

Seed and fruit of forest trees can be contaminated by viruses, bacteria, fungi and harmed as a result of feeding of insects. However, unlike the harm caused by insects and mycoses, the harm caused by viroses and bacterioses has no economic significance.

Larvae of economically important insects bite out a seed content and, by doing that, prevent germination of acorn. Fungi inhabit seed and fruit, both on trees and later, during the course of their processing and storage. Outbreak and spread of disease and pests in forest seed primarily depend on external factors, place and method of collection, quality, processing method and storage method and conditions. A seed is easily infested if its seed vessel is damaged. In our study of investigated oak seed, mycoses caused by species *Stromatinia pseudotuberosa Rehm.* and species of genus *Penicillium,* as well as the harm inflicted by insects of genera *Cydia* and *Curculi,* were most frequently recorded.

Species of genera *Curculio* and *Cydia* represent the most important harm causing insects, larvae of which, by their nutrition, completely or partially, damage a seed internal content and prevent its germination.

Cydia splendana Hb. and *C.amplana* Hb., species of an identical life cycle, often occur jointly, inflicting a substantial harm. *C.amplana* is more rarely present and hence the harm it causes is less severe. Butterflies swarm in June and July. Caterpillars penetrate into a seed, by biting out its content. Inside the seed they leave large portions of excrement connected by cobweb-like filaments. They complete their development in October, inside the seed or in the soil surface layer, making a cocoon and transforming into a pupa which hibernates during winter (Grbić, 1999; Mihajlović, 1992; Maksimović at at., 1982).

Curculio glandium Marsh. and *C. elephas* Gyll., oak and chestnut weevil, are species of similar bionomy. Imagos swarm from the beginning of May to the end of July. A female lays eggs in fruit that is still green. Larvae develop in fruit, leaving a red-brown excrement. In addition to acorn, these two species also harm sweet chestnut and common hazel fruits (Schwenke, 1974). The inflicted fruit falls off prematurely. A fully mature larva bites out exit opening and moves to the soil, where it spends winter. In spring it transforms into a pupa. An exit opening in acorn made by weevil is circular, whereas moths bite out an ellipsoid opening. Sexually immature oak weevil imagos have a period of supplemental nutrition, on which occasion they harm leaves and young fruits. Chestnut weevil imagos, according to studies by Drekić and assoc. (2011) do not have a period of supplemental nutrition, but immediately after eclosion begin laying of eggs.

Species of genera *Curculio* and *Cydia* have, most often, one generation per year, however, a part of population may remain in diapauses for one or several years. For the above-mentioned acorn pests, the critical number has not been established (Karadžić et al, 2011).

S. pseudotuberosa causes mummification of oak acorn. Three phases in disease development can be distinguished. Firstly, small orange spots are formed, which turn into brown in phase two, while small mycelium is formed under a vessel. In the final phase, mummification of juicy part of fruit occurs and vessel is transformed into a porous substance, clearly separated from a thick layer of mycelia. The disease breaks out after a fall off of fruits, while a source of disease is contaminated fruits, fell off in a previous year. The disease spreads during a period of fruit storage, when mycelia spread by contact with healthy fruits. This species forms, on a 3-30mm long leg, apothecia of 2-7mm diameter. Asci are of size 120-150 x 6-9 μm, whereas ascospores are 8-10 x 5-6 μm (Žuralev i sar. 1974).

Species of genus *Penicillium* most commonly develop as saprophytes on soil and plant food. Their mass development represents a result of inappropriate collection and transport of seeds or an inadequate storage. The most sensitive are large seeds with a high content of water and nutrient matter (acorn, chestnut, walnut, forest fruit). Sexual stadia of some representatives of this genus were also described (*Penicilliopsis*, *Talaromyces*, *Hemigera*).

In addition to the above-mentioned, the following species were also identified in the seed of investigated species: *Cytospora intermedia*, *Gloeosporium quercinum*, *Pestalotia glandicicola*, *Phomopsis quercella*, *Mucor mucedo, Trichotecium roseum, Botrytis cinerea, Alternaria alternata*, along with species of genera *Fusarium, Pythium* and *Aspergillus*.

CONCLUSIONS

In our studies of oak seed, a presence of insects of genera *Curculio* and *Cydia* was established. A presence of the following species of fungi was also identified: *Stromatinia pseudotuberosa*, *Cytospora intermedia*, *Gloeosporium quercinum*, *Pestalotia glandicicola*, *Phomopsis quercella*, *Mucor mucedo, Trichotecium roseum, Botrytis cinerea, Alternaria alternate*, along with the species of genera *Penicillium, Fusarium, Pythium* and *Aspergillus*.

Based on the obtained results, it may be concluded that a species *Q. borealis* is slightly more resistant to pests of genera *Curculio* and *Cydia*, in comparison to species *Q. petraea* and *Q. robur*.

The lowest number of fungi was recorded in the seed of species *Q. borealis*, whereas the highest number was identified in the seed of species *Q. robur*.

During the course of the study, an increased number of pests from genera *Cydia* and *Curculio* was recorded in 2009, while the highest number of pests of genus *Curculio* was identified in 2006, when as much as 85% of oak seed was affected.

Among the investigated oak species, the species *Stromatinia pseudotuberosa* and the species of genus *Penicillium* were most frequently observed. A presence of fungi *S. pseudotuberosa* was recorded in last three years of the investigation (period 2009-2011). The lowest percentage of infested acorn in sessile oak (5%) was recorded in 2009, whereas the highest percentage in penduculate oak (20%) was identified in 2011.

A presence of fungi of genus *Penicillium* ranged between 15% in 2009 and 2011, to 20% in 2010.

A presence of fungi *Stromatinia pseudotuberosa* and *Penicillium* spp. was most frequently recorded in pedunculate oak seed and, on one occasion, in sessile oak seed.

Among the isolated species of fungi, the most severe damage in seed production facilities is caused by *Stromatinia pseudotuberosa*, *Cytospora intermedia*, *Gloeosporium quercinum*, *Pestalotia glandicicola* and *Phomopsis quercella*.

Harmful insects of genus *Cydia* inflict harm predominantly to pedunculate oak seed, whereas pests of genus *Curculio* primarily cause harm to sessile oak, both being autochthonous oak species, and, at the same time, also more susceptible to attacks of pathogenic fungi. A harm inflicted by the above-mentioned pests to an allochthonous species, red oak, is less severe, that is, entirely absent in the event of an attack by phytopathogenic fungi.

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PHYSICAL CHARACTERISTICS AND POTENTIAL USE OF HUMOFLUVISOL IN THE PROTECTED AREA OF ALLUVIAL PLAIN

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Abstract: *Humofluvisol soils spread out in the central part of the alluvial plain, and have a distinctive morphological structure. In studied soil ratio of the total sand and total clay was 61.64% and 38.36% respectively. Textural class of this soil was clay in surface horizons and sandy loam to sand in deeper horizons. Total porosity of investigated humofluvisol was on average 52.21%, while the value of the water accessible to plants was from 9.05 to 31.11 vol.%. The vertical permeability had different values with the depth of the soil profile and ranged from $1.3x10^{-3}$ to $8.9x10^{-5}$ cm/sec. Capillary rise, tested under laboratory conditions related to different horizons, had values from 12.7 to 24.9 cm. Based on the content of pores studied soil had the largest share of medium pores represented with 19.25 vol.%, while the coarse and fine pores were presented with 16.25 vol.% and 16.72 vol.%. Good supply of groundwater, soil moisture and favorable water-air condition point out that this soil has high potential for growing of soft broadleaves, primarily poplar cultivars.*

Keywords: humofluvisol, particle size composition, water-air conditions, poplar cultivars

INTRODUCTION

Soils situated in the alluvial plain have a different distribution with respect to the influence of fluvial sedimentation. Humofluvisol belongs to the semigley soil class and hydromorphic order according to soil classification Škorić et al. (1985) and it was formed in the central part of the alluvial plain (Šumakov 1959). Through the power of flood waters whose strength decreases with distance from the bed, the finer particles of soil were deposited in the central part of the alluvial plain what is the basis for favorable physical properties of this soil (Pekeč, et al. 2009). The morphological structure of this soil is A-C-G, and it has developed surface humus loam horizon, while the middle horizon is loam to loamy sand, in the lowest part there is the sand gley horizon with sub horizon oxidation (Gso) and reduction (Gr). Given that the studied soil is now situated in the area protected with embankment, it is no longer exposed to flood waters, but is more or less under the influence of groundwater (Pekeč, et al. 2010). Physical properties of the studied soil, the ground water fluctuations, which depends on the nearest water course determine the purpose of this soil. Since this soil has a good water-air properties and it is sufficiently supplied with groundwater, it is most favorable compared to other hydromorphic soils for the cultivation of clonal poplars which on this soil show their full genetic potential and achieve a maximum volume per hectare.

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OBJECT AND METHOD OF STUDY

The study was conducted on the humofluvisol soil in a protected part of the alluvial plain of the Danube River. The coordinates of the studied soil profile were: $45^0$16'1.2" and $19^0$55'23", with altitude of 74.20 ma.s.l. and site is 2026.00 m far away from the river Danube. The collected soil samples in disturbed and natural state were analyzed in the laboratory of the Institute of Lowland Forestry and Environment. The following analyzes were performed:

- Determination of particle size distribution according to the international B-pipette method of preparation in sodium-pyrophosphate, and soil textural klass using triangle
- Determination of particle density of soil (g/cm^3) by the method of Albert-Bogs with use of xylol as inert liquid, Bošnjak et al. (1997),
- Determination of bulk density (g/cm^3) in the Kopecky cylinders of 100 cm^3 volume, Bošnjak et al. (1997),
- The total porosity (%), calculated from the particle density and bulk density values by Bošnjak et al. (1997),
- The useful water capacity (water accessible to plants), calculated from the difference between retained water at a pressure of 0.33 bar and 15.0 bar.,
- Category of pores was determined from the difference between total porosity and moisture retention under different pressures,
- Water permeability of soil, according to Bošnjak et al. (1997).

RESULTS AND DISCUSSION

According to the granulometric composition of humofluvisol soil (shown in the Table 1) it can be concluded that this soil has the least proportion of coarse sand fractions, only 1.66%, proportions of clay and dust were 11.11% and 27.25% respectively, while the highest proportion has fine sand fraction 59.98%.

Table 1. *Aggregate size composition*

Horizon	Depth (cm)	Coarse sand (%)	Fine sand (%)	Dust (%)	Clay (%)	Total sand (%)	Total Clay (%)	Texture class
Amo	0-40	2.53	37.55	47.2	12.72	40.08	59.92	Loam
C	40-100	0.21	31.75	46.72	21.32	31.96	68.04	Loam
Gso	100-200	0.88	77.68	14.32	7.12	78.56	21.44	Loamy sand
Gr	> 200	3.01	92.95	0.76	3.28	95.96	4.04	Sand
Average		1.66	59.98	27.25	11.11	61.64	38.36	

The average value of the total sand and total clay ratio is 61.64%: 38.36% for the entire profile depth, while for the physiologically active part of the profile (up to 200cm) this ratio is 50.20% : 49.80%. Total sand content increases, while total content of clay decreases with depth, which can be seen also according to the disposition of textural classes where loam texture class is up to 100 cm, and below are loamy sand and sand.

Picture 1. *The internal morphology A-C-Gso-Gr*

Picture 2. *The external morphology Populus x euramericana cl. „I-214"*

Water-air properties of this soil are presented in the Table 2. Analyzing the specific and volume mass of the soil can be stated a little variation of their values in the studied horizons, which influenced low variation of total porosity per depth of the studied soil. Moisture retention values varied depending on the textural structure and thus obtained values of water accessible to plants were lowest in the lowest part of the profile (Gr subhorizon) where occurred texture class sand. The vertical water permeability also depended on the textural class, and it was the lowest in the surface layer (clay), slightly higher in the Gso subhorizon (loamy sand), and highest in Gr subhorizon (sand). According to the differential porosity can be concluded that in the surface horizons (A and C), where is texture class clay, dominated fine and medium pores. In the Gso subhorizon with texture class loamy sand dominated course and medium pores, while in the deepest part of the profile, in Gr subhorizon, are the most common coarse pores due the highest content of total sand.

Table 2. *Water-air properties of soil*

Horizon	Depth (cm)	Particle density (g/cm^3)	Bulk density (g/cm^3)	Total porosity (%)	Water accessible to plants (vol%)	Darcy's coeff. cm/sec	Soil pores (% vol.)		
							Coarse (>10 µm)	Medium (10-0.2 µm)	Fine (<0.2 µm)
Amo	0-40	2.83	1.33	53.00	26.27	$8.9*10^{-5}$	0.48	24.07	28.45
C	40-100	2.82	1.32	53.19	31.11	$1.3*10^{-3}$	2.76	26.00	24.43
Gso	100-200	2.82	1.32	53.19	20.21	$2.1*10^{-4}$	26.63	18.40	8.16
Gr	> 200	2.81	1.42	49.46	9.05	$1.9*10^{-3}$	35.13	8.51	5.82

Analyzing participation of dust + clay in the studied soil, it can be concluded that the proportion of these fractions in the physiologically active part of the profile is on average 49.8%. The total porosity of the soil is satisfactory according to the classification of Kačinski (1965) according to Dugalić and Gajić (2005), in the physiologically active part of the profile that is up to 200 cm. Plant affordable water in this part of the profile has also satisfactory values of 20.21 vol.% of Gso subhorizon to 31.11 vol.% in C horizon. The analyzed soil has a medium speed of water conductance according to the classification of Kutilek accordind to Vučić (1987). The content of micropores compared to macropores in the rhizosphere is extremely increased to a depth of 100 cm, indicating the storage possibility of required quantity of water. In soil depth of 100 to 200 cm, the ratio of macro-and micropores is 50-50%, which is considered as the most favorable ratio (Antić et al., 1982; Bošnjak et al., 1997), and in this part is balanced the water-air regime. Bearing in mind that this soil is located in a secured area of alluvial plain, its supply with water is affected by precipitation and mostly wetting directly from groundwater and the capillary groundwater in higher layers. Ground water in this soil is generally at a depth of 2 meters and its depth varies because of changes in water level of the Danube and the terrain microrelief.

As Živanov and Ivanišević (1986) stated potential productivity of humofluvisol is very high and depends on the amount of humus, mechanical composition and allocation of the underground water and that is why these soils are considered very suitable for poplars cultivation. In addition, same authors presented data that average growth of American black poplar had achieved volume of 28 m^3 in 10^{th} year at the area of middle Danube. Orlović et al., (2006) investigated 7 black poplar (*Populus deltoides* and *Populus x euramericana*) clones on humofluvisol, as the optimal soil for poplar breeding, and found that investigated clones showed significant genetic potential. Andrašev et al., (2010) stated that volume values of clone I-214 (*Populus x euramericana*) on humofluvisol of Sava alluvium after 31 years were in range from 464.12 to 582.65 m^3/ha. Also, the current findings show that the most important property of the soil for the cultivation of poplars is the content of the dust + clay in the physiologically active part of the profile, and the best yields are achieved with the ratio of the fraction of 30-50% (Živanov, 1977), also all indicators of soil fertility depend on the participation of these factions.

Given the characteristics of the studied soil: affordable water for plants and air regime, the possibility of water storage in surface horizons, wetting with groundwater, the ratio of the macro and micro pores and the average content of the dust + clay in the physiologically active part of the profile, the purpose of this land would be extremely beneficial for poplar clones cultivation.

CONCLUSION

The analyzed samples in physiologically active part of soil profile had a favorable ratio of total sand and total clay. These properties are responsive for satisfactory total porosity and affordable water of this soil, and also medium speed of water conductance. The content of micropores in relation to macropores in surface area of the rhizosphere was increased up to 100 cm depth, indicating the possibility for deposition of required quantity of water. Also, in the deeper part of the rhizosphere up to 200 cm, ratio of macro and micropores was ideal. This soil is supplied with water from rainfall and also depends largely from wetting with groundwater. The purpose of investigated soil is determined with physical properties and the impact of groundwater. Since this is a hydromorphic soil with favorable water-air properties, it is recommended for the cultivation of varietal black poplars where their genetic potential comes to the full expression.

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PHYTOCENOLOGICAL CHARACTERISTICS AND DIVERSITY OF GROUND FLORA IN ARTIFICIALLY ESTABLISHED STANDS OF WEYMOUTH PINE, DOUGLAS-FIR AND LARCH IN THE AREA OF BOGOVAĐA

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Abstract: *The paper presents the results of phytocoenological research and diversity of ground flora in artificially established stands of Weymouth pine, Douglas-fir and larch in the area of Bogovađa, on the site of Hungarian Oak and Turkey Oak with hornbeam (Carpino betuli-Quercetum farnetto-cerris (Rud.1949) Jov.1979). In forest cultures, richness and heterogeneity of ground flora becomes lower. The reduction of floristic composition diversity is to some extent the result of morphological properties of introduced coniferous species, and partly it is due to the different response to site conditions, which is largely reflected in their floristic composition. Also, the late thinning in the artificially established stands conditioned the presence of a large number of trees with reduced crowns and a high slimness coefficient, which led to a snowbreak, causing a severe damage. That was most evident in the artificially established larch stand, where a sudden opening of the canopy occurred, conditioning the presence of a large number of species in the shrub storey, which stopped developing ground flora.*

Key words: Artificially established stands, conifers, ground flora, diversity.

1. INTRODUCTION

According to van Oijen et al. (2005) the impact of trees on soil and vegetation are manifold. Stem flow and throughfall of nutrients affect nutrient availability (Norden, U., 1994), large litter quantities and large leaf surface area inhibit sprouting of certain species (Sydes, C., Grime, J.P., 1981; den Ouden, J., Vogels, D., 1997) and the depth or density of tree roots affect below-ground competition for water and nutrients (Falifiski, J.B., Falifiska, K., 1986). Tree species differ in their phenology, and the quantity and quality of penetrating light depends on crown structure, leaf position and texture (Rackham, O., 1980), wich also influences the development of different species of ground flora. Tree species composition is a key driver of forest biodiversity, influencing structural components of the environment from soil and litter to vegetation layers and the canopy, and ecosystem processes, such as nutrient cycling (Oxbrough, A. et al., 2012).

According to Vojniković et al. (2005), a relatively small number of researchers dealt with the study of flora and vegetation characteristics of ground diversity in forest cultures. The purpose of the present study was to provide a focus on the species diversity of the herbaceous layer of artificially established stands of Wemouth pine, Douglas-fir and larch.

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2. STUDY AREA AND METHOD

The forest complex 'Bogovađa' is located in the upper upstream part of the Colubara basin, at an approximately 4 km straight line distance from the confluence of the river Ljig into the river Kolubara, in the south direction. This forest complex range at the altitudes from 130 m to 235 m and, in geographical sense, from 20°11′to 20°24′10″ East longitude and from 44°19′ North latitude.

The forests of Bogovađa were owned by the Monastery Bogovađa till 1945, and therefore they are relatively well conserved. The highest percentage of coppice forests in this complex was created during the First World War and their age is about 90-100 years. The terrains of Bogovađa forests are situated in the area of a climatologically conditioned Hungarian oak and Turkey oak forest, which is the most represented phytocenosis in this forest complex. The previous works in this complex consisted of the substitution with Weymouth pine (*Pinus strobus* L.), Douglas-fir (*Pseudotsuga menziesii*), larch (*Larix decidua* Mill.), Scots pine (*Pinus silvestris* L.), Austrian pine (*Pinus nigra* Arn.), fir (*Abies alba* Mill.), Atlas cedar (*Cedrus atlantica* Man.) and Chamaecyparis (*Chamaecyparis* Spach.).

The research of site conditions and the state of the stand was performed by means of series of trials, conducted in artificially established stands of Weymouth pine (*Pinus strobus* L.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and larch (*Larix decidua* Mill.).

The plant species composition on the sample areas was characterized by classical phytosociological plots according to Braun-Blanquet cover-abundance values, which means that total coverage for each species (vertical projection onto the ground) was estimated visually and recorded within seven cover classes: r: 1 or 5 individuals; +: few individuals (< 20) with cover < 5 %; 1: many individuals (20–100) with cover < 5 %; 2: 5 % –25 % cover; 3: 25 %–50 % cover; 4: 50 %–75 % cover; 5: 75 %–100 % cover.

To quantify the relationship between species diversity (plant diversity) on all research plots, based on phytosociological releves of the understorey vegetation, the following parameters were calculated: Shannon diversity index, Simpson's index of diversity and Simpson's reciprocal index were selected to characterize diversity indices of plant compositions and evenness.

Prior to analysis by Shannon and Simpson index, Braun–Blanquet scores were transformed to relative cover (r: 0.01; + : 0.02; 1: 0.04; 2: 0.15; 3: 0.375; 4: 0.625; 5: 0.875) (Fontaine, M. et al. 2007).

a) Shannon diversity index [H' = - Σ (pi log (pi))],
b) Simpson diversity index [D= 1 - Σ pi2],
c) Simpson's index of diversity [1-D]
d) Simpson's reciprocal index [1/D]
d) Evenness [E = H'/ln (S)];

pi – share of plant species of total;
S – species number.

3. RESEARCH RESULTS AND DISCUSSION

The parent substrate of the Bogovađa complex soil is composed of marl and claystone (bedded and laminated), conglomerates and sandstones (bedded and thick-bedded) and reef limestone, a complex of lake sediments of Older Neogene and Oligocene, contorted and strongly cracked (Antić, M., Marković, D., 1971). Based on detailed studies, it has been established that the soil in all investigated stands is pseudogleyed luvisol (loess soil with elements of pseudogley).

Bogovađa belongs to the zone of the moderate continental climate, with somewhat more humid climate from Posavina and West part of Serbia. By Lang's bioclimate classification this area belongs to the humid climate in which weak forests develop, and by Thorntweite climate classification, the observed area is characterised by the humid mean climate.

The investigated stands are located at the altitude of 207-212 m, at different slope expositions and mild elevations of 3-8°. The canopy ranges in the interval from 0.7 to 0.9. The basic data on the investigated stands are presented in table 1 (Stajić, S., Rakonjac, Lj., 2006).

Table 1. *Main characteristics of the three study stands*

Tree species	Altitude	Exposition	Slope	Number of trees per ha	Growing stock (m^3/ha)
Pinus strobus	211	N	3	775	354,42
Pseudotsuga menziesii	207-211	N-NE	3	656	282,75
Larix decidua	210	N-NW	8	625	271,61

3.1. Phytocenological characteristics and diversity of ground flora

According to the studies conducted by Glišić, M. (1968), the climatologically conditioned Hungarian oak and Turkey oak forest *(Quercetum farnetto-cerris* Rudski) is represented in two variants on the terrains of the Bogovađa forest complex: a Hungarian Oak and Turkey Oak with butcher's broom forest (*Rusco-Quercetum farnetto-cerris* Jov.1951.) and a Hungarian Oak and Turkey Oak with hornbeam forest *Carpino betuli-Quercetum farnetto-cerris* (Rud.1949) Jov.1979.

Based on their floristic composition (Stajić et al., 2008; 2011), it is concluded that the investigated artificially established stands were established at the site of Hungarian Oak and Turkey Oak with hornbeam forest *(Carpino betuli-Quercetum farnetto-cerris*)

In the course of their development, the above-mentioned species were exposed to various anthropogenic impact, and responded differently to microhabitat conditions, which was largely reflected in their floristic composition. As a result of the late thinning, trees with a high slimness coefficient were formed in all coniferous stands, which contributed to infliction of severe damage caused by snow and wind, to which those species are particularly sensitive. As a consequence, an increased diversity of ground species was created, whereas in the larch stand, on the account of larch being a species with a thin crown, it resulted in an increased number of accessory species in the shrub storey.

A submontane beech forest *Fagetum submontanum* Jov., which occurs at the immediate vicinity of the investigated stands, is orographically conditioned in this area and it appears in shaded and humid stands, where it remains as a permanent stadium. That is the reason for the appearance of certain species of ground flora, typical of beech forests, in the phytocoenological records.

In the tree storey of the artificially established Wemouth pine stand, in addition to the above-mentioned species, the presence of large-leaved linden and silver linden was observed. The shrub storey is poorly developed, and along with silver linden (*Tilia argentea*), flowering ash (*Fraxinus ornus*) occurs individually. In the areas in which the stand is interrupted due to snowbreak and windbreak, the ground layer is abundant, as a result of an increased light inflow. The following species are observed in those areas: *Glechoma hirsuta*, *Carpinus betulus*, *Hedera helix*, *Ruscus aculeatus*, *Helleborus odorus*, *Mycelis muralis*, *Euphorbia amygdaloides*, *Polygonatum multiflorum*, *Viola silvestris*, *Cardamine bulbifera*, *Galium cruciata*, *Ruscus hypoglossum*, *Veronica chamaedrys*, *Galium aparine*, *Sorbus torminalis*, *Clematis vitalba*, *Asarum europeum*, *Asperula odorata*.

In the tree storey of the artificially established Douglas-fir stand, in addition to Douglas-fir, hornbeam (*Carpinus betulus*), silver linden (*Tilia argentea*) and large-leaved linden (*Tilia grandifolia*) occur individually. The shrub storey is poorly developed and, as in the case of eastern white pine, *Tilia argentea* and *Pyrus pyraster* are individually present. Among present species in ground flora, *Glechoma hirsuta* is slightly more represented, whereas other species constitute 5-10%. The species observed in this layer are the following: *Carpinus betulus*, *Rubus hirtus*, *Hedera helix*, *Ruscus aculeatus*, *Helleborus odorus*, *Euphorbia amygdaloides*, *Viola silvestris*, *Cardamine bulbifera*, *Fraxinus ornus*, *Galium cruciata*, *Asarum europeum*, *Asperula odorata*, *Polygonatum odoratum*, *Galium aparine*.

In the tree layer of the artificially established larch stand (*Larix decidua* Mill.), naturally mixed linden (*Tilia argentea i Tilia grandifolia*) and hornbeam (*Carpinus betulus*) are also present, in addition to larch. The shrub layer is far more represented in comparison to previous two stands, and it is composed of hornbeam, linden, common hawthorn and flowering ash. The ground story consists of *Carpinus betulus*, *Rubus hirtus*, *Glechoma hirsuta Hedera helix*, *Ruscus aculeatus*, *Helleborus odorus*, *Galium silvaticum*, *Euphorbia amygdaloides*, *Acer tataricum*, *Cardamine bulbifera*, *Tamus communis*, *Fraxinus ornus*, *Ruscus hypoglossum*, *Asarum europeum*, *Asperula odorata*.

Although having been much criticized, diversity indices are still widely used in plant ecology to evaluate, survey, and conserve ecosystems. Species diversity is one of the most important indices used for evaluating the sustainability of forest communities. To quantify the diversity of the plant species, the Shannon index (H) as a measure of species abundance and richness is applied. This index which takes both species abundance and species richness into account, is the most commonly used index (Kent, M., Coker, P., 1992). In addition, the Simpson index (1-*D*) and the evenness index (*E=Evenness*) are considered as a measure species dominances and a measure for evenness of spread respectively (Magurran, A.E., 1988).

Table 2. *Diversity indices in artificially established stands of Weymouth pine, Douglas-fir and larch*

	Douglas-fir		Weymouth pine		Larch	
	Cover (%)					
Tree layer	85		85		75	
Shrub layer	20		10		60	
Herb layer	50		50		30	
	Four most abundant species					
	Cardamine bulbifera	3.1	*Glechoma hirsuta*	2.3	*Rubus hirtus*	1.2
	Ruscus aculeatus	1.3	*Helleborus odorus*	1.1	*Hedera helix*	1.1
	Glechoma hirsuta	1.2	*Rubus hirtus*	1.1.	*Galium silvaticum*	1.1
	Asarum europaeum	1.2	*Helleborus odorus*	1.1	*Glechoma hirsuta*	1.2
	Measures of species diversity					
Simpson 1-D	0.771		0.896		0.936	
Simpson recip. 1/D	4.363		9,618		15.536	
Shannon	2.223		2.625		2.78	
Evenness index	0.75		0.91		0.98	

The results indicated that the lowest diversity index for the ground flora was observed in Weymouth pine stand (Table 2). Although this stand had greatest number of ground flora, given that all other species are present with a maximum of 10%, a reduction in diversity was affected by the increased presence of species *Cardamine bulbifera* of nearly 40%.

Simpson index was similar for each of the two remaining artificially established stands of Douglas-fir and larch, since they have almost the same number of species in the ground flora. In Douglas-fir stand only species *Glechoma hirsuta* is represented with 15%. The highest value of Shannon diversity index was calculated in larch stand, while this index was lowest for the Weymouth pine stand.

It is known that, if the species are evenly distributed then the H (Shannon diversity index) value would be high. So the H value allows us to know not only the number of species but how the abundance of the species is distributed among all the species in the communitie.

Species evenness varied between a minimum of 0.75 in artificially established stands of Weymouth pine, to a maximum of 0.98 in artificially established stands of Douglas-fir. Maximum evenness values are represented by uniformly distributed, homogeneous communities having similar species distribution (Fossa, A.M., 2004). Low evenness values of forest communities can possibly be due to suppression and out-shading of associated species by the dominate conifers getting maximum of lightand water (Murcia, C., 1995).

4. CONCLUSION

The depletion of floristic composition that occurred in artificially established coniferous stands, is evident when compared to natural stands. The decrease of floristic composition diversity is, to some extent the result of morphological properties of introduced coniferous species. In the course of their development, the above-stated cultures were exposed to various anthropogenic impact and responded differently to microhabitat conditions, which was largely reflected in their floristic composition.

Thinning was not performed in due time in the artificially established stands, whereas the late thinning was not of adequate intensity, which resulted in presence of a large number of larch trees with reduced crowns and a high slimness coefficient. Such state of the investigated stands led to the occurrence of snowbreak, which caused severe damage. That was most evident in the artificially established larch stand in which, as a result of snowbreak, a sudden opening of canopy occurred and conditioned the presence of a large number of accessory species in the shrub storey.

The lowest diversity index for the ground flora was observed in Weymouth pine stand. Although this stand had greatest number of ground flora, given that all other species are present with a maximum of 10%, a reduction in diversity was affected by the increased presence of species *Cardamine bulbifera* of nearly 40%. Shannon diversity index was highest in stand of larch, while the minimum value of this diversity index was noted in the artificially established stand of Weymouth pine.

Species evenness varied between a minimum of 0.75 in artificially established stands of Weymouth pine, to a maximum of 0.98 in artificially established stands of Douglas-fir.

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THE EFFECT OF THE PERFORMED BIOLOGICAL WORKS ON THE INTENSITY OF EROSION IN THE CATCHMENT OF THE RIVER GABROVNIČKA REKA

Svetlana BILIBAJKIĆ[1], Tomislav STEFANOVIĆ[1], Radovan NEVENIĆ[1]

Abstract: *The subject of the investigation presented in this paper is the effect of the performed biological and biotechnical works and changes in land use on the intensity of erosion and sediment yield in the catchment of the river Gabrovnička reka.*

Biological works carried out in the catchment of the river Gabrovnička reka as well as changes in land use due to population migration in the period from 1955. to 2009. had a significant impact on mitigating erosion processes.

The results of conducted investigations show that in 2009 the intensity of erosion processes on the investigated area was reduced in comparison to the period before the erosion control works were performed.

This reduction is manifested in the assessed state of the erosion processes (mean erosion coefficient) and in the calculated sediment yield and transport, which are caused by erosion processes.

Apart from the erosion control works performed in the catchment Gabrovnička reka, a change in the catchment demography also significantly contributed to the mitigation of the erosion processes. In the period from 1955 to 2009, there was a constant decrease in the population number in the catchment area and deterioration of its age structure. Due to the effects of depopulation and population ″ageing″, a great deal of arable land, which was left uncultivated, was in time covered with forests and grass, which also had beneficial effects on the reduction of erosion processes.

Key words: biological works, erosion processes, erosion coefficient, sediment transport.

INTRODUCTION

The main goal of this study was to determine the effects of performed erosion control works and demographic changes in the intensity of erosion and sediment production in the Gabrovnička river catchment area.

Raising forest plantations, development of indigenous vegetation and changes in land use due to the migration of people from areas of the basin have resulted in positive changes in the intensity of erosion processes and sediment yield and discharge.

The paper describes intensity change of erosion and sediment production and discharge in this period, for the study area, measured on the basis of the technical documentation consulted before control works and field explorations in 2008 and 2009.

MATERIALS AND METHODS

This study object is the catchment area of the Gabrovnička River as right tributary of Trgoviški Timok River. This river basin is located on the territory of the villages Gabrovnica,

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Tatrašnica and Aldina reka. The basin is very elongated and located at highland region, with surface of 32.88 km2. The overall length of Gabrovnička River is 12.5 km. Its springs at elevation of 1240.0 m. at locality called Jovanove livade, above the village Tatrašnica, and its embouchure is at elevation of 328.0 m. which is three kilometers downstream of Kalma. The average decline of flow is 7. 3%, while the averages slope angle of the basin is 30%. The flow direction is the north-east / southwest. With left tributary Mala reka as the major one, there are 15 smaller tributaries which flow into it.

The research methodology included:

- Collecting data on natural conditions in the basin before control works from the existing technical documentation and cartographic material.
- For the determination of climatic characteristics, the data of Meteorological Service of Serbia were used.
- Digitized topographic, geologic and soil map scale 1:50000 were used to process parameters of geomorphological, geological, soil and terrain characteristics.
- Processing of socio-demographic characteristics of the area was made on the basis of the collected statistical data of the Statistical Office for the period 1948 to 2002.
- Collecting data on current land use and erosion intensity was performed by direct excavations, separating areas with different land use patterns and erosion processes of different intensity on topographic maps of scale R =1:50000.
- Based on digitized topographic maps in scale 1:50000, satellite images and field survey was conducted, digitalization of Gabrovnička river basin erosion map were done in 2009. Erosion map was prepared by the methodology developed by the Gavrilovic, S., (1970, 1972). Coefficient of erosion for the studied basin was defined on the basis of the map.
- The total amount of sediment that is produced in the basin, in both time periods, was calculated by the method of potential erosion according to Professor Gavrilovic, S., enabling a comparative analysis of the production and sediment transport in the first period (1955) to state in 2009.

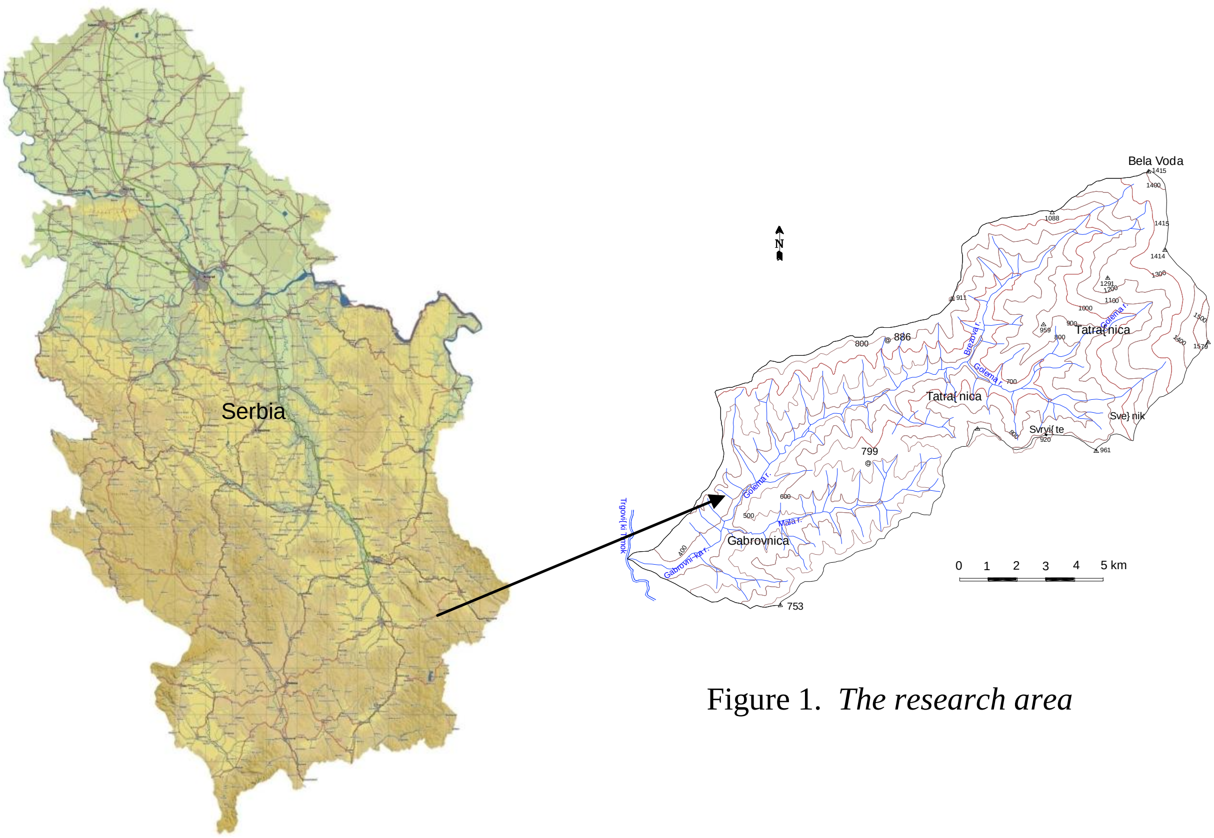

Figure 1. *The research area*

Assessments of the effects of erosion control works were shown according the state and the calculated erosion processes and sediment production.

RESULTS AND DISCUSSION

The shape and size of the catchment area are the parameters that indicate the potential for rapid and simultaneous concentration of flood water from the catchment area.

The main parameters affecting the basin genesis of erosion and sediment transport processes are given in Table 1.

Table 1 *Natural characteristics of the Gabrovnička river basin*

Parameter	Code	Gabrovnička river
Catchment surface area	F (km^2)	32,88
The extent of the basin	O (km)	30,09
The length	L (km)	12,5
The coefficient for the basin shape acc. Gavriloviću	A	0,178
Module development basin watersheds	E	1,469
Morphological coefficient	n	0,036
Mean basin elevation	N^{mean}(m)	792,00

Based on the value of the coefficients (A, E, n) could be concluded that inspected basins physical and geographical conditions are unfavorable for simultaneous floodwater fluctuations regimes.

Data provided by the Hydro meteorological Service of Serbia, with climatological stations and precipitation stations located in Knjaževac, Papratina and Kalna, have been used for determination of climatic characteristics of the Gabrovnička river basin.

Table 2 *Mean monthly and annual mean temperature and amplitude of air (°C)*

Climate station	Climate station altitude	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual	Amplitude
Knjaževac	280	-1,2	1,0	5,0	10,8	15,8	19,0	20,5	19,8	15,7	10,2	5,1	0,7	10,2	21,7

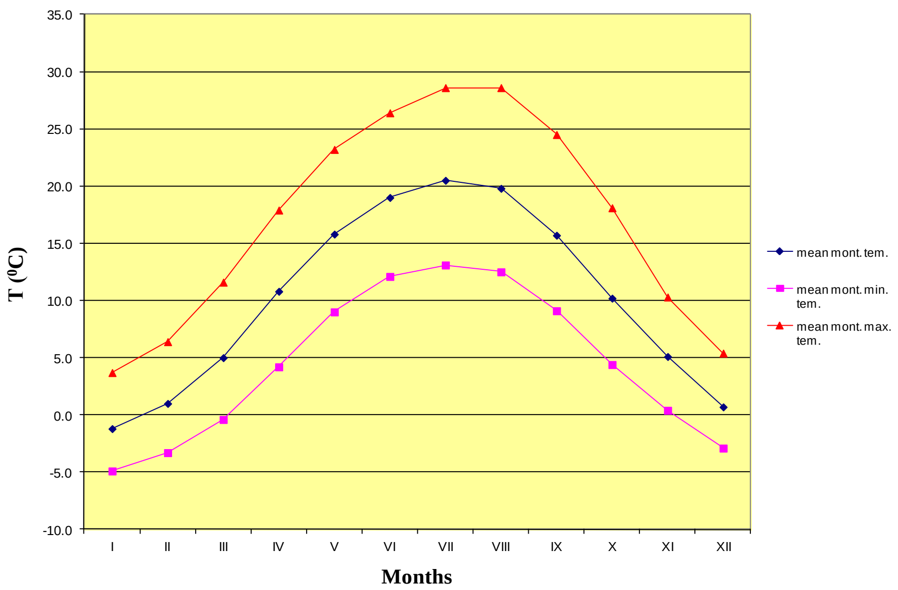

Diagram 1. *The annual flow of air temperature measured by C.S. Knjaževac*

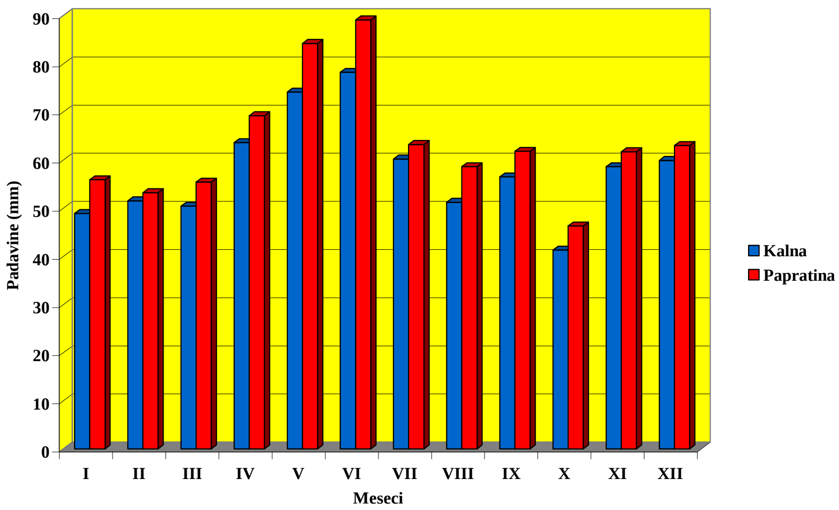

Diagram 2. *Mean monthly precipitations measured by C.S. Kalna and Papratina*

Mean annual total precipitation at Kalna station for the analyzed period was 694.4 mm, and Papratina station it was 761.5 mm. Month with the lowest average monthly amount of precipitation at both stations is October, and the highest average monthly amount of precipitation is in June.

Basin surface in geological way is consists of granite, gneiss, green and green shale rocks and gabbro. The most common type of soil is distric cambisole.

In the basin dominate forests of oak and beech, and as also common tree species there are hornbeam, ash, hazel and black locust and pine cultures.

In terms of administrative territorial affiliation the Gabrovnička river catchment area includes cadastral units Gabrovnica, Tatrašnica and Aldina reka, where Gabrovnica has a share of 34.18% in the area, 55.08% for Tatrašnica and rest 10.74% belongs to Aldina reka in whole basin area.

Demographic analysis of the area was made on the basis of statistical data since 1948, when was performed the first post-war population census, up to data from census in 2002. (Source -Republic Statistical Office of Republic of Serbia).

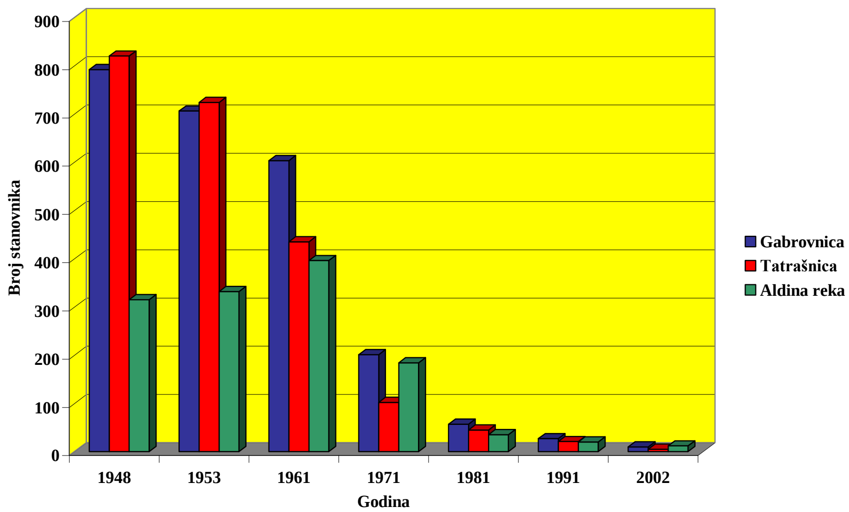

Chart 3. *Change of population in Gabrovnička river catchment area*

Given view of the population census in Gabrovnička river catchment area, in period 1948 to 2002, shows that the population is declining. At this period the number of population in the Gabrovnica decreased from 792 to 10, in Tatrašnica with 820 to 5, and in Aldina reka from 315 to 12 people. The population in Gabrovnička river catchment area was older than 50 years, with age structure of the population over 70 years dominating with 56% of the total population. The causes of migration in the basin depend on the historical and economic factors. Characteristics of this migration are that an old people remain holding farming, while young people are leaving to cities to provide their existence in the industry and other economic activities. So eventually empty villages being left without residents or with a very small population, age structured generally over 70 years.

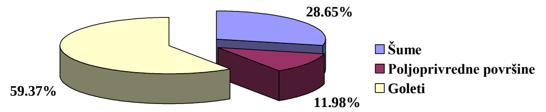

Diagram 4. *Land use in Gabrovnička river catchment area - 1955*

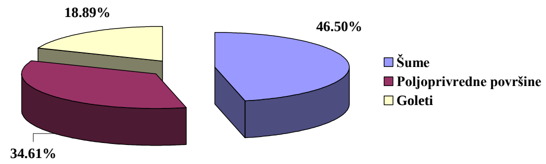

Diagram 5. *The Land use in Gabrovnička river catchment area - 2009*

In order to understand the changes in land use over time survey provides an overview of the structure of land use in the basin for the period before control works (1955) and the state of land use in 2009.As a result of improper land use in the first period (1955), 59.37% of the catchment area was under barren lands.

Structure changes of land use in 2009 were evident. Most of the catchment area was covered mostly by natural vegetation, with artificially restored forest (46.50%) and meadows (31 787%). The barren land surface was reduced to 18.89%.

Gabrovnička river basin area in the period before 195 was subjected to accelerated erosion processes (Table 4). Coefficient of erosion in 1955 amounted 1.19, which means that excessive erosion processes had been ruled in the basin, within Category I of destructiveness.

Table 4. *Conditions and sediment production in Gabrovnička river basin in 1955 and in 2009*

Year	Category of erosion					Total	Z_{mean}	$W_{per\ year}$	$G_{per\ year}$
	Excessive	Strong	Medium	Low	Very low				
	%	%	%	%	%	%		$m^3_{per\ year}$	$m^3_{per\ year}$
1957	88,50	8,06	3,44	0,00	0,00	100,00	1,19	106. 457,00	70.262,00
2009	17,34	17,64	63,90	1,12	0,00	100,00	0,71	49.062,00	32.380,00

To mitigate the erosion processes in the Gabrovničke river basin was planned performing erosion control works including afforestation of 949.0 hectares on surface area, controlling the length of riverbeds with the construction of 7 transversal structures in length of 100.0 m.

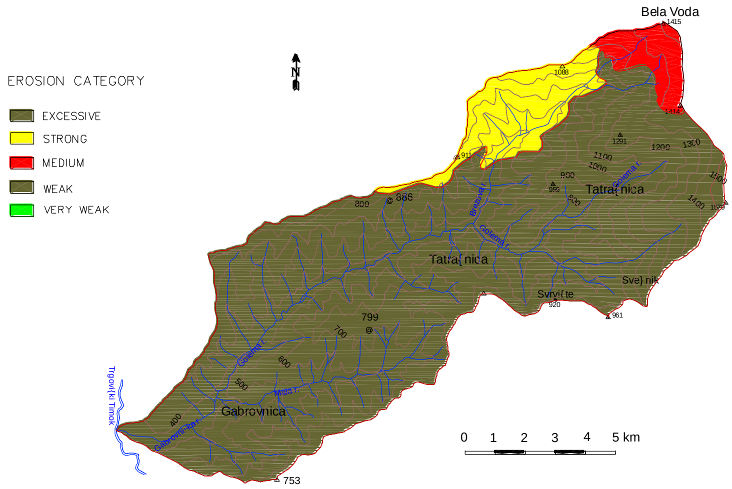

Figure 2. *Erosion map for 1955*

Against erosion of the anticipated Gabrovnička river basin renovation works were carried out on catchment area territory and in riverbed. Considering biological measures in the basin afforestation was carried on 268.0 hectares. Forested areas are smaller on the right bank in the upper reaches of the Golema River near Čovekova glava mountain top with black pine seedlings-planting pits method and on the right bank of the Mala River with black locust and black pines.

Technical works was carried out in riverbed in length of 100.0 m with no regulation covering.

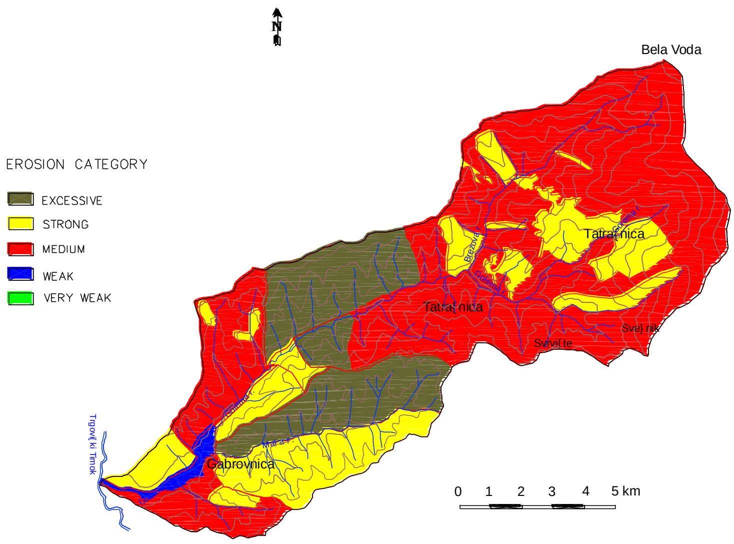

Figure 3. *Erosion map for 2009*

Conditions of erosion processes in the observed river catchment in 2009, shows that the surface area under excessive erosion are reduced. Mean coefficient of erosion was 0.71 and it shows that, in 2009, the state of erosion was between medium and high erosion, in contrast to the previous period when excessive erosion ruled.

Sediment production calculations within the pre-control works in the Gabrovnička River basin for 2009 show that the total sediment production in this period decreased to about 46% of the previous value.

In addition to erosion control works in the Gabrovnička River basin, mitigation of erosion processes have had significant impact on demographic changes. In this period (1955-2009.) observing settlement changes on territory of basin show that there had happened evident decline in population age structure and deterioration. Due to the depopulation of rural areas and migration from the countryside to the cities many of arable land remain uncultivated. On the abandoned surfaces spontaneous forest vegetation develops and grass cover that has a positive effect on erosion processes mitigating. Also, these demographic changes lead to a reduction in the number of cattle which significantly affects the reduction of pasture and pruning the trees which also limits the erosion process. All this has led to changes in land use in favor of increasing forest and agricultural area primarily grassy area under meadows.

The resulting changes in the structure of land use as a result of erosion control works and demographic changes in the basin have contributed to a significant reduction in the intensity of erosion, a significant reduction in production and sediment transport regime and improving of water quality of Trgoviški Timok River, due to reduction of sediment that Gabrovnička river had been ingested in.

CONCLUSIONS

The results showed that the performed erosion control works with major demographic changes in the basin contributed to a significant reduction in the erosion intensity and sediment production quantity in the Gabrovnička river catchment area.

In the prior period before studies started and performing of anti-erosion works process the 88.50% of whole basin area was affected by excessive erosion, erosion coefficient and catchment was Z_{SR} = 1.19, while the value of production of sediment was W_{year} = 106,457.00 m3year^{-1}

Studies have shown that the state of erosion processes in the second reporting period (2009) in the basin differs significantly from the previous and that in 2009 values for indicators of erosion intensity had been reduced. Middle coefficient of erosion for the whole basin is now Z_{SR} = 0.71, which means that the processes prevailing in the basin are between medium and severe erosion, and that the annual sediment production decreased to W_{year} = 49062.00 m3year^{-1}.

Land use has proved to be a major modifier of erosion processes intensity. Changes in land use caused by erosion control works and demographic changes have also resulted in changes in the intensity of presented erosion parameters.

Erosion and flooding flows in the Gabrovnička river basin remain as a problem; such damages demand needs of continued work on controlling erosion and torrential processes. The aim of this works should be completing system of erosion control which was started in the previous.

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VEGETATION-CLIMATE CHARACTERISTICS OF GOČ MOUNTAIN IN SERBIA

Rade CVJETIĆANIN, Milun KRSTIĆ, Milorad JANIĆ, Zoran NIKIĆ, Marko PEROVIĆ[1]

Abstract: *Occurrence and survival of the vegetation in a certain area, as well as zoning, in addition to the other ecological conditions, mainly depends on the climate characteristics of the area and their change due to the altitude. This paper presents the climate-vegetation (bio-climate) characteristics of the mountain massif Goč, in central Serbia, based on the climate date obtained by the multi-annual measuring (from 1961 to 2005), at the selected meteorological stations. The method of the altitudinal gradients of the climate elements was applied. The values of the gradients were obtained by the use of the data of the lowland meteorological stations (Kraljevo), as well as the data collected by one mountain meteorological station (Kopaonik) in the investigated area. By the application of the calculated linear gradients, the values of the climate elements for the defined altitude (from 750 to 1543 m), characterized by the altitudinal distribution of the certain forest zones in Goč, were obtained. Both annual values and values in the vegetation period of the major climate elements are presented: temperature conditions and precipitation regime, as well as climate-geographic characteristics - Lang's Rain Factor, as a basis for the climate-vegetation classification of the climate. The climate type by using the method by Thorntwhite and Lang was also determined. Spatial distribution of forest communities and climatic characteristics is shown on thematic maps using GIS technology. The interdependence of the occurrence and survival of the forest vegetation in this area, its distribution and altitudinal differentiation, and the climate characteristics, is proved in this reseach as well. Each altitudinal forest zone are characterized by the specific microclimate conditions.*

Key words: Goč, climate conditions, vegetation characteristics

1. INTRODUCTION

The territory of Serbia is floristically one of the most complex areas of southeastern Europe, because of its geographical position, climatic, geological-pedological and orographic diversity, as well as the fact that it represents significant refugium of terciary flora. The area of Goč mountain, according to the floristic division of Serbia, belongs to the region of central Serbia, together with Rasina, Jastrebac, Toplica, western part of Jablanica, western Pomoravlje, Stolovi, Željin, Kopaonik and Ibar valley (Stevanović 1992). Goč mountain is located between mountains Stolovi and Željin, between upper sream of Ibar river and western Morava river. The highest summit is Crni vrh, located at 1543 m above the sea level.

According to Rakićević (1980), there are three climatic areas in Serbia: continental, temperate-continental and modified mediterranean. The area of temperate continental climate comprises the biggest part of Serbia proper, bigger part of Kosovo and Metohia and Srem areas, in which "islands" of real alpine climate on high mountains and "oasis" of milder modified temperate continental climate are located. The area of modified mediterranean climate is represented in a part of Kosovo and Metohia, i.e. on the territory closest to the Adriatic sea.

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According to Rakićević (1980) Goč belongs to temperate-continentaln area, and according to climate classification of Kolić (1988) it belongs to Kopaonik-Toplica region.

Morphologically, Goč belongs to the category of medium and high mountains. The occurrence of the steep or gently inclined slopes, saddles, deep and steep brooks, as well as gorges, reflects the well-expressed relief characteristics. The highest mountain ridges are located on southern side, with the altitude from 980 (peak Visoka) to 1543 m.a.s.l. (Crni vrh). Goč area is rich in water, especially eastern part located on parent material composed of granodiorite and phyllite. There are a lot of streams, the biggest is Gvozdačka reka. Western part of the area, located on sepentine parent material also contains a lot of streams, but they get dry in the sumertime. Geologic bedrock is diverse and contains the following parent materials: granodiorite, phyllite, quartzite, cornite, marble, serpentin, dacite and gneiss (Gajić 1984; Urošević et al, 1973). Scientific-study object of Forestry faculty in Goč is divided in two management units, „A“ and „B“. Management unit „A“ is located in eastern part and is dominated by acid siliciferous rocks, while management unit „B“ is located on western part, with serpentine as a predominant rock (Tomić, Jović 2000). Research was done in management unit „A“ which coordinates are from $43^o31'$ to $43\,^o34'$ of the north latitude, and from $20^o39'$ to $20^o47'$ of east longitude.

Flora and vegetation of Goč was studied by: Jovanović (1957,1959), Jovanović and Vukićević (1980), Vukićević (1964, 1968, 1991), Gajić (1984), Tomić and Jović (1985, 2000), Jović et al. (1997), Tomić and Cvjetićanin (1991), Cvjetićanin (1988, 1999), Perović (2007) etc. The most detailed description of forests in Goč was presented by Tomić and Jović (2000), who separated 36 ecological units there. In this paper, the characteristics of most widespread forest plant communities in Goč are presented, i.e. those which reflect climatic characteristics of the area.

Investigated plant communities in this paper are: Balkan sessile oak forest (*Quercetum dalechampii serpentinicum* Cvj. 1999), beech-fir forest (*Abieti-Fagetum moesiacae* Jov. 1953), subalpine beech forest (*Fagetum subalpinum* Greb. 1950) and beech-greek maple forest (*Aceri heldreichii-Fagetum* B. Jov. 1957).

The aim of this work was to establish the existence of correlation between forest vegetation and climatic belts in Goč and its intensity, as a tool for the monitoring of the future vegetation belt modifications as a consequence of climate changes.

2. MATERIAL AND METHODS

On the basis of the prior research on vegetation and climate in Goč, the correlation between forest vegetation and climate belts is provided in this paper. The area of research is limited to the domain of scientific-study object of Forestry Faculty of Belgrade in Goč. The forest vegetation data are mostly processed according to Typological classification of forest ecosystems in scientific-study object in Goč (Jović et al. 1997; Tomić and Jović 2000).

Climate data were obtained by the multi-annual measuring (from 1961 to 2005), at the selected meteorological stations, typical for this area. The method of the altitudinal gradients of the climate elements was applied. The values of the gradients were obtained by the use of the data of the lowland meteorological stations (Kraljevo – located at 215 m a.s.l.), as well as the data collected by one mountain meteorological station (Kopaonik – located at 1,710 m a.s.l.) in the investigated area. By the application of the calculated linear gradients, the values of the climate elements were obtained for the defined altitude (from 750 to 1550 m), characterized by the altitudinal distribution of the certain forest zones in Goč. Both annual values and values in the vegetation period of the major climate elements, important for the development of the vegetation are presented: temperature conditions and precipitation regime, as well as climate-geographic characteristics - Lang's Rain Factor, as a base for the climate-vegetation classification of the climate. The climate type was determined by using of the Thornthwaite and Lang methods.

Digital map of Management unit „A“ was produced on the basis of cadastre plans scales 1:25000 and 1:50000 provided by Republic Geodesy Office, as well as on the basis of basic forestry map in analog form, produced by Faculty of Forestry, Belgrade. All maps are scanned, callibrated, georeferenciated, connected in continual area and than vectorized (Janić i Grujović 1999). Digital area model was produced by oleat digitalization with altitudinal performance of topographical map scale 1:25000 produced by Institute for Military Geography. GIS analyzes were done in AutoCAD Map 3D program surrounding and additionally developed applications of program system Survey (Janić 2012).

3. RESULTS

Climate characteristics of Goč for defined altitudinal belts and forest vegetation according to these belts in Management unit „A“ of scientific-study object of the Faculty of Forestry, Belgrade, are presented in this chapter (Fig 1).

3.1. Climate characteristics of Goč

The main characteristics of the temperature regime for the mentioned altitudes in the analyzed altitudinal zone are the following (Table 1): at the lower limit of the zone (located at 750 m a.s.l. at the north side of Goč) the average annual temperature is 8.5^{o}C, and at the upper limit (located at 1.550 m a.s.l.) it is 4.0^{o}.

The average annual quantity of precipitation (P) at the lower limit of the analyzed forest zone is 827 mm, whereas at the upper limit it is 935 mm. During the growing season from 59% to 60% of the annual quantity of the water sediment is distributed. Due to the increase of the altitude by 100 m, the annual quantity of precipitation increases by about 14 mm.

Table 1. *The change of the average air temperature and precipitation with altitude in Goč*

Altitude (m)	**Air temperature (^{o}C)**			**Precipitation (P mm)**		
	An	**GS**	**A**	**An**	**GS**	**%**
750	8.5	14.6	19.9	827	489	59.1
800	8.2	14.3	19.7	833	493	59.2
900	7.7	13.6	19.4	847	502	59.3
1000	7.1	13.0	19.1	861	511	59.4
1100	6.6	12.3	18.8	874	520	59.5
1200	6.6	11.7	18.4	888	529	59.6
1300	5.4	11.0	18.1	901	538	59.7
1550	4.0	9.4	17.4	935	560	59.9

Legend:
An – average annual value
GS – value during growing season
A – temperature amplitude
% – amount of precipitation during growing season

The calculated elements of the hydric balance (the ratio of deficit to surplus of water in the soil), by the use of Thornthwaite's method, for the analyzed altitudes show the following (Table 2):

Table 2. *The changes of the annual values of the elements of the hydric balance calculated by the use of Thornthwaite's method due to the increase of the altitude (Al) in the period from 1961 to 2005 in Goč.*

Al.(m)	PE m	AE mm	WS m	WS/P %
750	614	614	213	25.8
800	606	606	228	27.4
900	588	588	259	30.1
1000	571	571	290	33.7
1100	553	553	321	36.7
1200	536	536	352	39.6
1300	516	516	385	42.7
1550	478	478	457	48.9

Legend:
Al - altitude
PE – potential evapotranspiration
AE – actual evapotranspiration
WS – surplus of water in soil

- the potential evapotranspiration (PE) decreases by the increase of the altitude - at the lower limit of the analyzed zone it is 614 mm, which accounts for about 74% of the annual quantity of precipitation, whereas at the upper limit it is 478 mm, i.e. only about 51% annual quantity of precipitation;
- actual evapotranspiration (AE) at all altitudes is equal to potential evapotranspiration;
- there is no deficit, i.e. lack of water in the soil;
- the surplus of water in the soil (WS) occurs in the colder part of the year and accounts for 26% of the annual quantity of precipitation at the lower limit of the analyzed zone (WS/P), whereas it is 49% at the upper limit.

The climate classification using the method of Thornthwaite was conducted based on the values of the calculated hydric balance. In the analyzed altitudinal forest zone, based on the climate index of Thornthwaite (Im), the climate ranges from mildly to extremely humid (B_1-B_4) (Table 3).

Based on the climate classification using Lang's method, which is defined based on the rain factor (RF), it can be observed that in the forest zone of Goč, up to 800 m a.s.l. the forests do not reach their climate-physiological-biological optimal level, in contrast to the greater altitudes. The perhumid climate occurs at the altitudes above 1.500 m a.s.l.

Table 3. *The change of the climate characteristics and climate classification using Lang's and Thornthwaite's methods due to the increase of the altitude (Al) in the period from 1961 to 2005.*

Al (m)	Lang's method		Thornthwaite's method		
	RF	Climate type	Im	Climate type	
750	97	Climate of the weak forests – did not in the optimal level	34.5	B_1	Mildly humid
800	101	Climate of the high forests – reached the optimum level	37.6	B_1	Mildly humid
900	109	Climate of the high forests – reached the optimum level	44.0	B_2	Moderately humid
1000	118	Climate of the high forests – reached the optimum level	50.8	B_2	Moderately humid
1100	128	Climate of the high forests – reached the optimum level	58.0	B_2	Moderately humid
1200	140	Climate of the high forests – reached the optimum level	65.8	B_3	Intensely humid
1300	153	Climate of the high forests – reached the optimum level	74.6	B_3	Intensely humid
1550	200	Perhumid	95.6	B_4	Extremely humid

Legend:Al – altitude
RF – climate index by Lang's method (Kolić, 1988)
Im – climate index; A, B_1-B_4 – the symbol of the climate type by using the Thornthwaite's method

3.2. Climate-vegetation characteristics of the area

Management unit „A“ is located in eastern part, mostly on siliciferous rocks, and management unit „B“ in western part, mostly on serpentine (Tomić, Jović 2000). In management unit „B“, as a consequence of serpentine mother rock, altitudinal belts of forest vegetation are shifted upwards, and the map of this management unit was presented by Vukićević (1991).

This paper delas with the most important forest vegetation in management unit „A“ which formed under the influence of macroclimate. Here, on altitudes below 800 m Balkan sessile oak forests are formed (*Quercetum montanum* Čer. et. Jov. 1953), from 800 to 1300 m a.s.l. climaregional beech-fir forests are most widespread (*Abieti-Fagetum moesiacae* Jov. 1953), and on higher areas occur subalpine beech forests (*Fagetum subalpinum* Greb. 1950) and beech-greek maple forests (*Aceri heldreichii-Fagetum* Jov. 1957).

Balkan sessile oak forest (*Quercetum montanum* Čer. et. Jov. 1953) represents oroclimatogenic vegetation belt, and Krstić et. al. (2001) produced data about distribution of these forests in Serbia and their connection to climate belts. Balkan sessile oak forests in „A“ management unit produces vegetational belt up to altitude of 800 m, and above this altitude (up to 1050 m a.s.l.) it could be found in fragments, mostly on steep slopes and ridges. These forests are sindinamically conected with black pine forests (*Potentillo-Pinetum nigrae gočensis* Jov. 1959), on one hand, and climaregional beech-fir forests (*Abieti-Fagetum moesiacum* jov. 1953) on other hand. Climate characteristics are the following: the average annual air temperature ranged above 8.5 ^{o}C (in the growing season it is above 14.3^{o}C); the annual quantity of the precipitation is lower than 833 mm (Fig 1). According to Lang's bioclimatic classification the forests in the lower part of the zone have not reached the optimal climate-physiological value, whereas they reached it in the upper part of the zone. The limit is located at about 800 m a.s.l. By Thorwthite's climate classification, the climate is mildly humid.

Bech-fir forest (*Abieti-Fagetum moesiacae* Jov. 1953) is climaregional community, developed on altitudes 800-1300 m a.s.l, occupying the biggest part of management unit „A“ (Fig 1). Climate is characterized by the average annual temperature from 5.4 to 8.2^{o}C (in the growing season it ranges from 11.0 to 14.3^{o}C), and the annual quantity of precipitation ranges from 833 to 901 mm. The surplus of water in the soil is not registered only during summertime. In this altitudinal zone, according to Lang's bioclimatic classification, the climate is humid, and the forests have reached their biological optimal level. According to Thornthwaite's classification the climate ranges from mildly humid to intensely humid.

Subalpine belt of forest vegetation, above 1300 m a.s.l, contains two plant communities: subalpine beech forest (*Fagetum subalpinum* Greb. 1950) and beech-greek maple forest (*Aceri heldreichii-Fagetum* Jov. 1957). Climate characteristics are the following: average annual air temperature is below 5.4^{o}C, annual quantity of the precipitation is above 901mm (Fig 1). According to Lang's bioclimatic classification the forests reached the optimal climate-physiological value. By Thorntwaite's climate classification, the climate ranges from intensely to extremely humid.

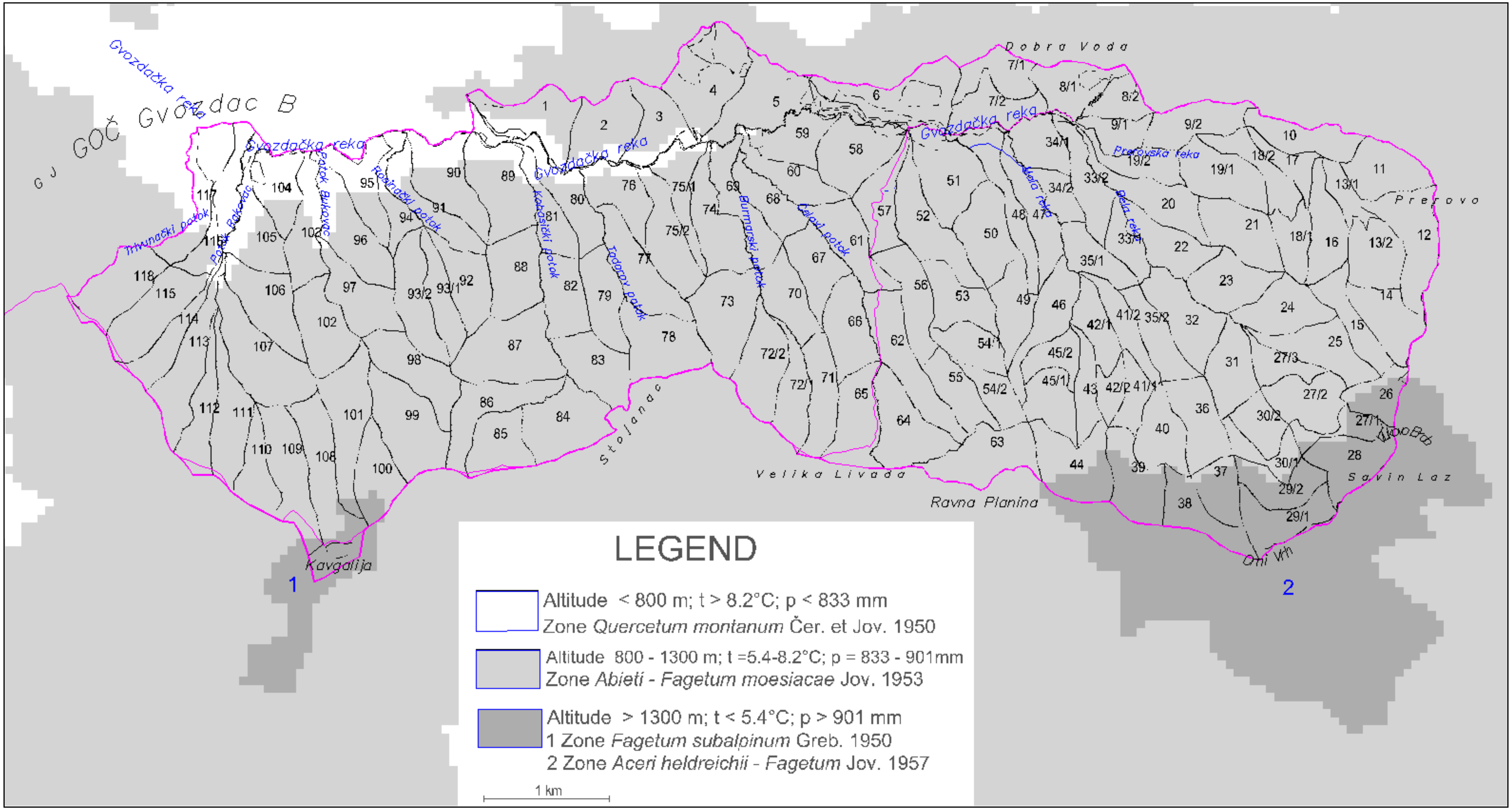

Fig. 1 *Map of climate-vegetation zones of management unit A" on scientific-study object of the Faculty of Forestry, Belgrade on Goč*

4. CONCLUSIONS

The existence and intensity level of correlation between forest vegetation to climate belts in Goč mountain is investigted in this paper, as a tool for monitoring of vegetation changes as a consequence of climate changes.

On Goč, according to Lang's climate classification, mildly humid climate of low forests is represented on altitues below 800 m a.s.l, which is not optimal for the development of forest vegetation. Above 800 m a.s.l. the climate is humid and represents optimal conditions for the development of forest vegetation, and on altitudes above 1300 m a.s.l. the climate is perhumid.

Vertical distribution of forests in management unit „A“ of scientific-study object of Faculty of Forestry, Belgrade, fits in this climate division, developed on siliciferous rocks, where forests of Balkan sessile oak (*Quercetum montanum* Čer. et. Jov. 1953) dominate on altitudes below 800 m a.s.l. and they represent oroclimatic belt of forest vegetation. Climate characteristics are the following: the average annual air temperature ranged above 8.5^{o}C (in the growing season it is above 14.3^{o}C); the annual quantity of the precipitation is below 833 mm. According to Thornthwaite’s climate classification, the climate is mildly humid.

From 800 to 1300 m a.s.l, the beech-fir forest (*Abieti-Fagetum moesiacae* Jov. 1953) is well developed, and it represents climaregional forest plant community. Climate is characterized by the average annual temperature from 5.4 to 8.2^{o}C (in the growing season it ranges from 11.0 to 14.3^{o}C), and the annual quantity of precipitation ranges from 833 to 901 mm. According to Thornthwaite’s classification the climate ranges from mildly humid to intensely humid.

Above the beech-fir belt, on elevations from 1300 to 1543 m a.s.l. fir is missing and two communities occur: subalpine beech forest (*Fagetum subalpinum* Greb. 1950) and beech-greek maple forest (*Aceri heldreichii-Fagetum* Jov. 1957). Climate characteristics are the following: average annual air temperature is below 5.4^{o}C (in the growing season it is below 11.0 ^{o}C), annual quantity of the precipitation is above 901 mm. By Thornthwaite’s climate classification, the climate ranges from intensely to extremely humid.

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ANALYSIS OF *Fagus sylvatica* L. S.L. REGENERATION FORMATIONS UNDER OPEN CANOPIES IN THE CENTRAL RHODOPE MOUNTAINS OF NORTH-EASTERN GREECE, A PRELIMINARY STUDY

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Melina GOTSI, Vasilis KETIPIS, Kostas VRIZAS[1]

Abstract: *The present study was conducted in the central Rhodope mountains of north-eastern Greece. In order to analyze the Fagus sylvatica regeneration formations under open canopies, 20 plots of 2 m x 2 m were established. The plots were established, in F. sylvatica stands that were under a regeneration process using the shelterwood method, but the completion of the process has been significantly delayed. The establishment of plots was made using the simple random sampling method. In each plot, for all the F. sylvatica plants the height and diameter at the ground level (stem base) were recorded. Moreover all the F. sylvatica plants were cut and a cross section was taken from each plant, at the stem base. The number of annual growth rings (tree age) was counted in each cross section using a stereoscope. The age difference of regeneration plants inside a plot ranged from 11 to 37 years, while the height difference ranged from to 1.1 to 5.65 m. Moreover the highest mean annual height increment of all plants that were cut (and measured) was 0.31 m and the lowest was 0.035 m. The relationships of height (h) and age (t) and height and base diameter (d) of plants that were cut were found been better expressed with the equations: $h= 0.105t+0.001t^2$ and $h=0.794d-1.655/(d+1)+1.3$, correspondingly. The better knowledge of growth characteristics, as well as other ecological features of F. sylvatica regeneration plants established under open canopies, will contribute to having improved silvicultural systems regarding the species as well as to more efficient silvicultural treatment of F. sylvatica regeneration formations.*

Key words: *Fagus sylvatica* L. s.l., regeneration plants, growth, shelterwood, south Europe.

INTRODUCTION

Fagus sylvatica L. is a shade tolerant plastic species (Assmann 1970, Athanasiadis 1986) that has the ability to exhibit high growth rates in favorable growth conditions as well as to show very low growth rhythms for many decades enduring heavy shade and suppression (Milios 2000a, Milios and Akritidou 2002). Usually, the regeneration procedure of *F. sylvatica* takes place under the overhead shelter (see Matthews 1991, Dafis 1992). The better knowledge of growth characteristics, as well as other ecological features of *F. sylvatica* regeneration plants established under open canopies, will contribute to have improved silvicultural systems regarding the species as well as to more efficient silvicultural treatment of *F. sylvatica* regeneration formations.

In the present study, the main objectives were: a) to analyze *F. sylvatica* L. s.l. regeneration formations under open canopies in the central Rhodope mountains of north-eastern

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Greece and b) to analyze the growth of *F. sylvatica* saplings growing under these open canopies and to develop allometric equations regarding their characteristics.

MATERIALS AND METHODS

Site characteristics

The study was conducted in the central part of the Rhodope Mountains, in north-eastern Greece, close to the Bulgarian border. The area is under the management of the forest service of Xanthi. The elevation ranges from 1200 to 1600 approximately.

The study area is covered by pure *F. sylvatica* stands, *Pinus sylvestris - F. sylvatica*, *P. sylvestris - F. sylvatica - Abies xborisii-regis* and *F. sylvatica - A. xborisii-regis* stands (Milios 2000a, 2000b; Tsiripidis 2001; Tsiripidis et al. 2005).

The mean annual air temperature is 8.0°C and the annual precipitation averages 980 mm. Geologically, the study area belongs to the Rhodope Massif, and the parent rocks are gneiss, granodiorite, rhyolite and granite. The forest soils are acid brown forest soils (Dystric Cambisoils) (Milios 2000a).

The regeneration of beech in the area in many cases is established in gaps created by the removal of one or two trees with large dimensions. Later, the gaps were enlarged through cutting of adjacent trees or by a progressive overstorey removal in areas surrounding the gaps. Also, in many cases the regeneration plants are established under the overhead shelter of an open mother stand canopy in the frame of a silvicutural system that resembles the shelterwood uniform system (see Matthews 1991). In the study area, there are many scattered areas (total area over 100 ha), where the progressive removal of the overstorey has not proceeded (has been significantly delayed). As a result, regeneration formations under open canopies are created.

During the 1960s the first cuttings took place by the Forest Service. Previously, only people from the nearby villages and shepherds had (illegally) cut trees in the area.

METHODS

During the summer of 2009, 20 plots of 2 m x 2 m were established in regeneration formations under open canopies of mother stands. The plots were established in open canopy stands where, in the frame of regeneration cuttings, the progressive removal of the overstorey has not proceeded. The age of the mother stand trees in the main canopy are over 150 years old and the density of trees having a breast height diameter (bhd) of over 30 cm approximately, ranges from 50 to 500 trees/ha. The densities of 400 and (mainly) of 500 trees/ha, are found in small areas. Even though the main shelter is imposed by the larger trees, the density of trees having a bhd diameter of over 20 cm approximately, ranges from 100 to 600 trees/ha (the density of 600 trees/ha, is found in very small areas).

The site productivity in these stands is medium (unpublished data, see Milios 2000a). The establishment of plots was made using the simple random sampling method. In each plot, for all the *F. sylvatica* plants, the height and diameter at the ground level (stem base) were recorded. Moreover, in each plot, all the *F. sylvatica* plants (saplings) were cut and a cross section was taken from each plant, at the stem base. In total 411 saplings were cut. The number of annual growth rings (tree age) was counted in each cross section using a stereoscope. Nine cross sections (from nine saplings) that were cut from four plots were destroyed and the number of annual growth rings (tree age) was not counted in them. In total 402 cross sections were measured. For each sapling that was cut (and measured) the ratio MAHI (Mean Annual Height Increment: height, divided by the total age) (Husch et al. 1982) was calculated. It is considered that the inability to measure the age of nine regeneration plants does not substantially influence the results of this study.

Statistical analyses

Forty-two height-age (*h*-*t*) and twenty-eight height-diameter (*h*-*d*) models were tested (Kitikidou 2008) and those who were best fitted to our data were selected. Statistical analyses were performed using SPSS v.19 (IBM 2010).

RESULTS

The mean density of regeneration plants in the plots is 20.55 saplings/plot (51,375 saplings/ha). The highest maximum sapling age that was found in a plot was 44 years and the lowest maximum sapling age was 21 years. On the other hand, the highest minimum sapling age that was found in the plots was 15 years, while the lowest minimum sapling age was 5 years. The age difference of saplings in the plots ranged from 11 (highest age: 21 years – lowest age: 10) to 37 years (highest age: 44 years – lowest age: 7).

The highest height difference in the plots is 5.65 m (maximum height: 6 m in a sapling 31 years old – minimum height: 0.35 m in a sapling 7 years old) while the lowest height difference in the plots is 1.10 m (maximum height: 1.85 m in a sapling 19 years old – minimum height: 0.75 m in a sapling 10 years old). The highest MAHI that was observed in the saplings that were cut in the plots was 0.306 m and the lowest was 0.035 m.

In Figure 1, the greatest density of saplings in the 20 established plots is observed in the height class of 1.5 m and the lowest in the class of 6.5 m, while as far as the stem base diameter of regeneration plants is considered, the greatest density is observed in the diameter class of 1.5 m and the lowest in the class of 8.5 cm (Figure 2). In the diameter class of 7.5 m no plant was observed.

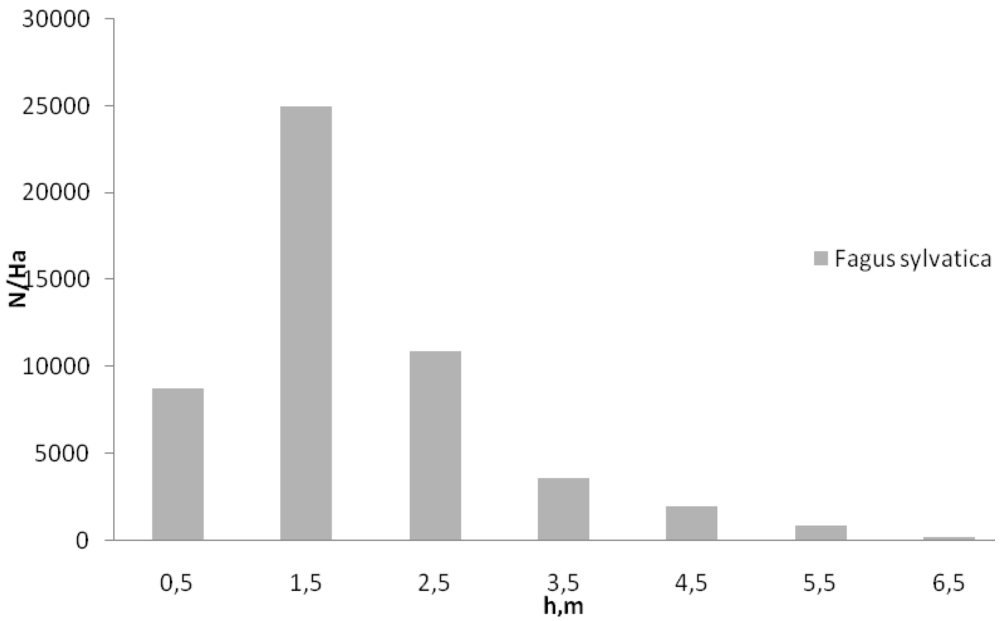

Figure 1. *Height frequency distribution of regeneration formations*

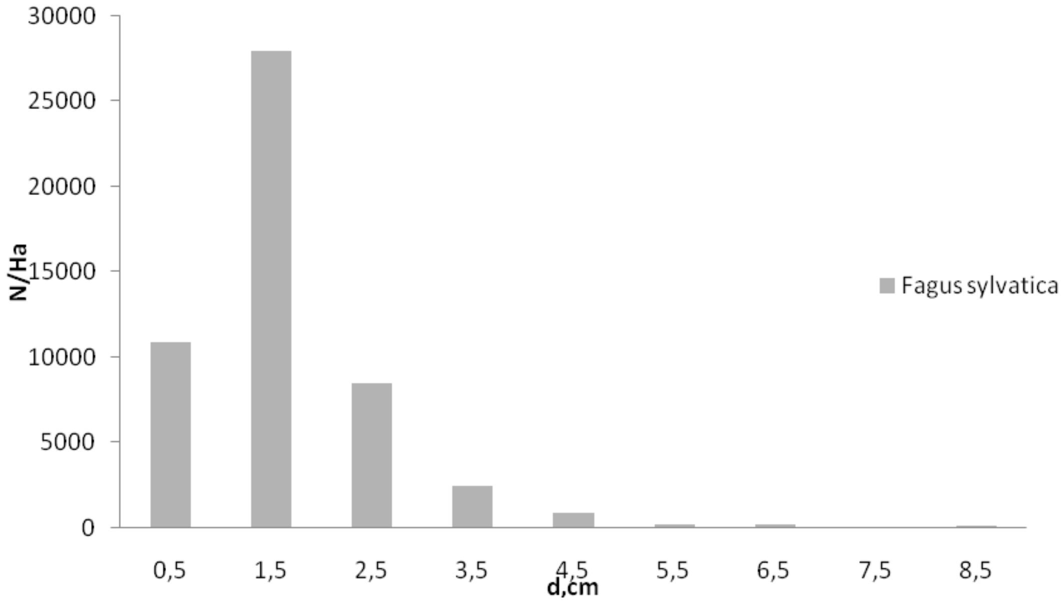

Figure 2. *Stem base diameter frequency distribution of regeneration formations*

The regression equations obtained for age-height and age-diameter relationships are shown in Figures 3 and 4, respectively. The equations that correspond to these lines are given in Table 1. The equations fitted to data were highly significant, with R^2 values greater than 0.80 (Table 1). Parameters of the models were all significant (p<0.05). Residuals had zero mean and were approximately normally distributed (age-height model's p=0.015) and normally distributed (age-diameter model's p=0.700).

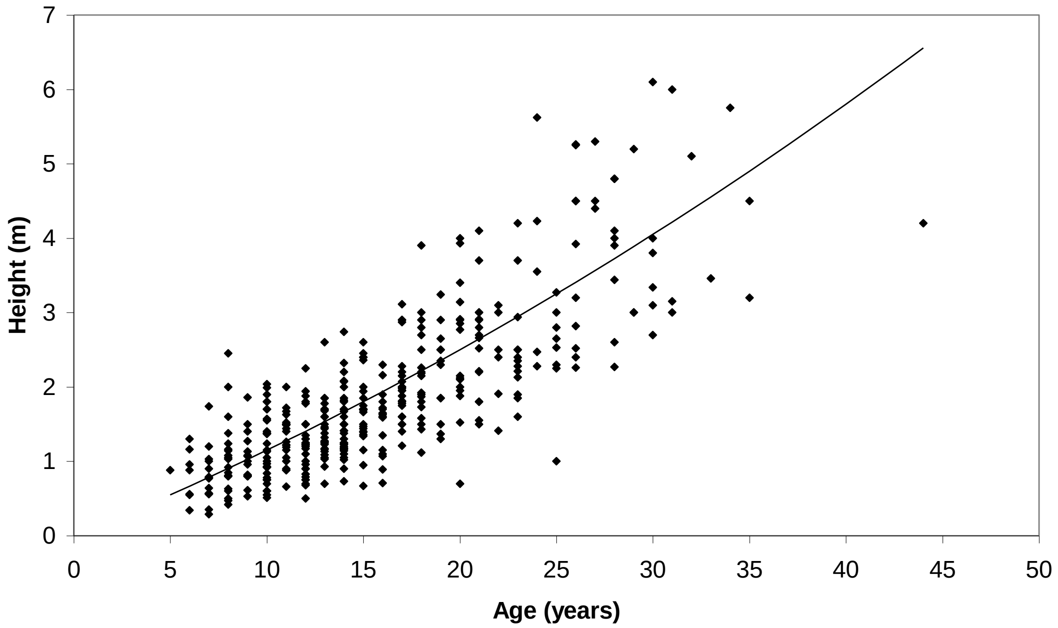

Figure 3. *Age-height scatter diagram of Fagus sylvatica, showing the fitted least-squares line*

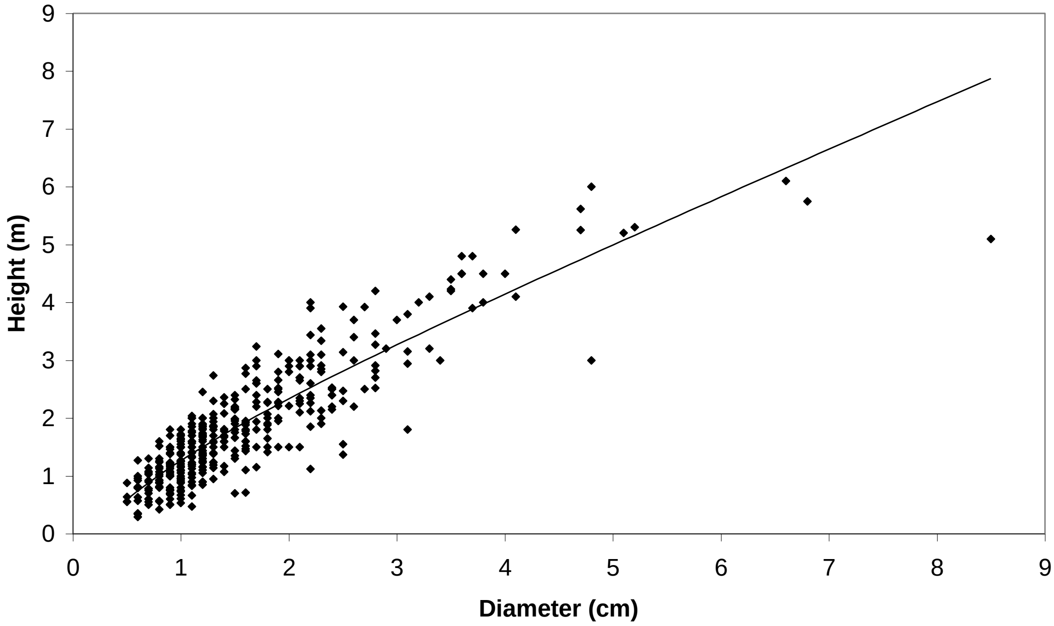

Figure 4. *Diameter-height scatter diagram of Fagus sylvatica, fitted the obtained least-squares line*

Table 1. *Regression equations for estimating sapling height h (m) from age t (years) and diameter d (cm) (n=402)*

Equation	Coefficient of determination (R^2)	Standard error of the estimate
$\hat{h} = 0.105t + 0.001t^2$	0.913	0.636
$\hat{h} = 0.794d - 1.655\frac{1}{d+1} + 1.3$	0.837	0.486

DISCUSSION

The regeneration formations under open canopies in the central Rhodope mountains exhibit adequate sapling density that is higher than the afforestation rate recommendations (10000/ha) (see Modry et al. 2004). Papalexandris and Milios (2010) found 6852 seed origin and 3519 sprout origin saplings (having height up to 3 m) per hectare in areas where regeneration fellings took place in low elevation beech stands located in northeastern Greece.

The high age difference of regeneration plants (up to 37 years) found inside plots is the result of beech seedling and sapling ecology. According to Collet et al (2001) the broad range that exists in natural beech regeneration is related to the ability of beech seedlings to survive under low light levels as well as to the low growth of beech regeneration plants under such unfavorable conditions. They mentioned in particular that young seedlings are established and grow since the old seedlings (having low growth rates) do not impose competition on them. In the present study more than 95% of the saplings that were cut have an MAHI lower than 0.2 m.

Beech regeneration can endure dense shade (Emborg 1998, Milios and Papalexandris 2008). Emborg (1998) reported that in Denmark, in a mixed deciduous forest where *F. sylvatica* dominates, in above 3%, relative light intensity regeneration of beech developed successfully. Milios and Papalexandris (2008) reported that in low elevation beech stands located of northeastern Greece regeneration plants can appear and grow in visible sky values of between 0.033 – 0.076. Visible sky is the proportion of the sky that is visible, regarding the whole hemisphere, when viewed from a point. The visible sky is related to the ability of the canopy to transmit incident light (Hale 2001).

The lowest MAHI (0.035 m) as well other low MAHI values are observed in saplings having low heights. These saplings grow under adverse shade environment, since they are under the shade of the open overstory as well as under the shade of other taller regeneration plants (see also Milios et al. 2008). Milios and Smiris (2001) reported that a co-dominant beech tree after the first 27 years of its life exhibited periodic annual height increment lower than 3 cm for a period of over 100 years. Stancioiu and O'Hara (2006) reported that growth efficiency of regeneration, in mixed multi-aged forests of the Carpathians in Romania, generally increased with light. Moreover, according to Modry et al. (2004), light climate significantly affects height and diameter of beech regeneration plants in a beech stand in Czech Republic. According to Milios (2004), in the central Rhodope mountains, in the medium productivity sites, the dominant trees, having a height that approaches the average height of the 100 highest trees per hectare, at the age of 20 years, had a height of 5.6 m. This means that they exhibited a MAHI of 0.28 m. This value is more or less the same with the highest MAHI values observed in the present study.

The obtained age-height relationship could correspond to the species' growth in low quality sites of Denmark (Nord-Larsen 2006). If we consider that in the case of Denmark the heights of the 100 thickest trees per hectare were used for the model construction, the growth of the regeneration plants in our study can be characterized as quite high.

More research is needed in the Rhodope mountains as well as in southern Europe, in order to determine the structure and growth characteristics of regeneration formations under open canopies.

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MONITORING OF SITE CONDITIONS IN THE *Quercetum frainetto-cerris* STANDS

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Abstract: *Monitoring of site conditions is an important issue of research in science today. In research a special importance belongs to the climate zones vegetation types. In Serbia climate zones vegetation types are represented by typical association of Quercetum frainetto-cerris. The paper will shown data of site conditions for this vegetation type in 2009, 2010 and 2011. year.*

The average monthly air temperature and relative air humidity are shown for July and August (the period in year with the most prominent extremes). Thus, the average monthly temperature in July was the lowest in 2010. year (21.2ºC), and the highest in 2009. year (22.2ºC). Compared to the average air temperature in July, in August, the highest average monthly air temperatures recorded in 2011. year (23.2ºC), and the lowest in 2010. year (21.2ºC).

In the period of research the greatest anomaly was recorded in September 2011. The average mean monthly air temperature was 20.9ºC. This temperature was in comparison to 2009. and 2010. higher by 2,1 and 4.9ºC respectivily.

The average relative humidity in this period was low in August 2011. (61%). In other months it was recorded moderate average relative humidity.

The lowest values of soil moisture were recorded following the month with the lowest average humidity.

Key words: *Quercus frainetto, Quercus cerris,* monitoring, site conditions

INTRODUCTION

Monitoring of site conditions is an important issue of research in science today. In research a special importance belongs to the climate zones vegetation types. In Serbia climate zones vegetation types are represented by typical association of *Quercetum frainetto-cerris* (Jović et. all 1991, Tomić 1992).

Available observational evidence indicate that global climate change as a result of natural forcing and human activity are consistent in direction and coherent across diverse localities and regions with the expected effects of regional changes in air temperature (IPCC, 2001).

The most severe drought in 2000 with extremely high air temperatures, and without snowcover during winter 2000/2001 were only some of the last in the series of climate extrems in the region of South Europe. Extreme climate events such as spring temperature fluctuations and summer drought will increase in frequency and duration. In combination with a raised mean temperature, climate extremes will negatively affect trees and increase their susceptibility to secondary damage through pests and pathogens. Extreme events are likely to have a profound affect on Europe's forests and natural resources, for example on boreal (Schlyter *et al.*, 2006), alpine (Fuhrer *et al.*, 2006) and lowland forests (Dorland *et al.*, 1999).

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The paper will shown data of site conditions for typical association of *Quercetum frainetto-cerris* in 2009, 2010 and 2011. year.

MATERIALS AND METHODS

Research was conducted in the associations *Quercetum frainetto-cerris* (locality: PE Srbijiasume, Kragujevac, Topola). Data on microclimate indicators were collected during a year 2009, 2010 and 2011 (temperature, relative humidity).

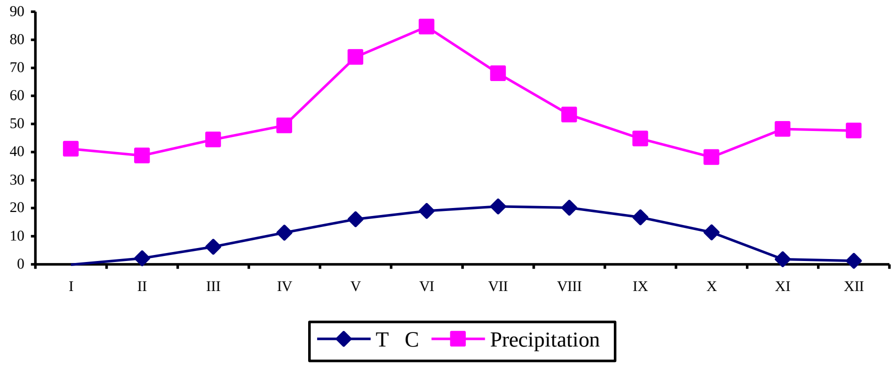
Climatological data are analyzed on the basis of annual report of Republic Hydrometeorological Service of Serbia (2009, 2010).

Soil moisture content (% mass) was determined on 10, 30 and 50 cm of soil depth. Soil volume was determined in Kopetcky cilindres.

RESULTS AND DISCUSSION

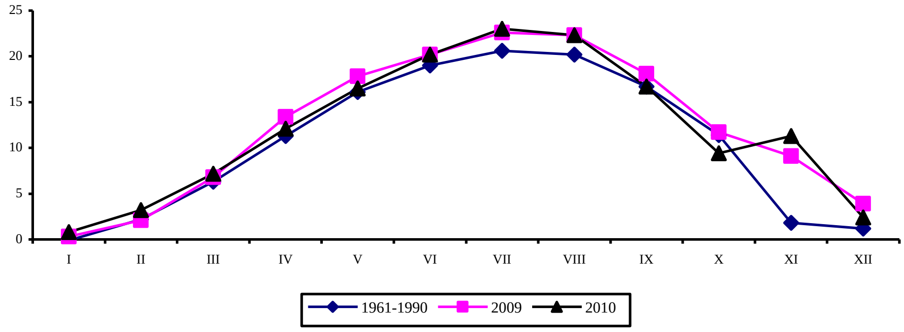
Increasing annual air temperature is registered throughout the entire territory of Serbia (Spasov *et al.* 2001). This climate observation proved the existence of warming trend and correlation that the 12 hottest years observed globally since 1880 all occurred between 1990 and 2005 (Lindner et al. 2010). The mean annual air tempereture and precipitation for Kragujevac for period 1960-91 are shown in graph. 1.

Graph 1. *Mean annual air temperature and precipitation for period 1961-1990*



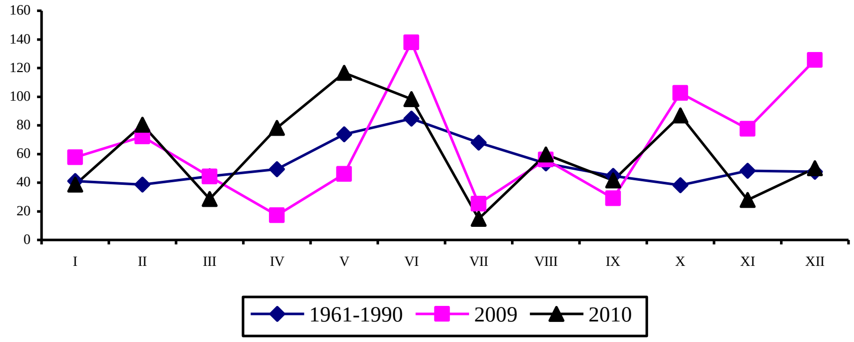
Mean annual air temperature for period 1961-1990 (graph 1.) in Kragujevac was in 2009 and 2010 higher in June (for more than 1°C), and in July and August (for more than 2°C) – graph 2.

Graph 2. *Mean annual air temperature for period 1961-1990, 2009 and 2010*



The largest decrease of precipitation (to the period 1960-91) was recorded in July (graph 3.).

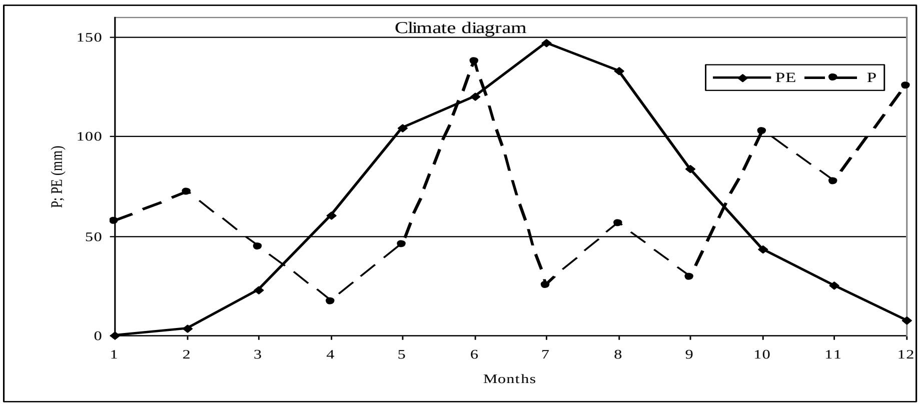
Graph 3. *Precipitation for period 1961-1990, 2009 and 2010*



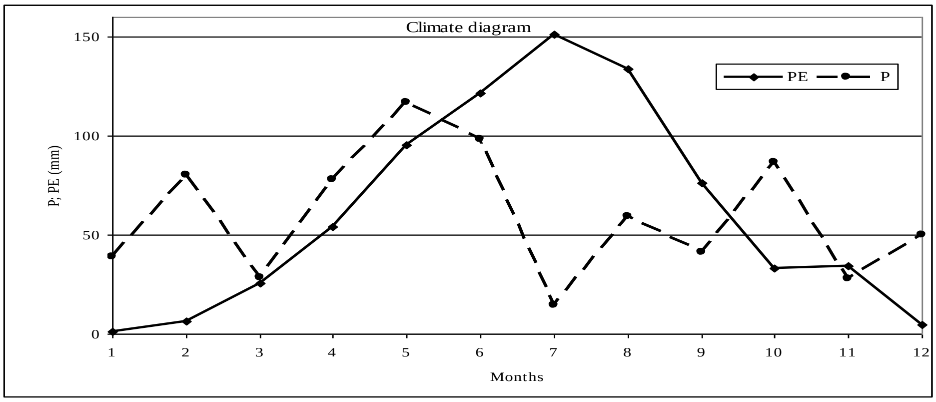
This data indicate unfavorable climatic conditions and also showed risks to drought. The previous research of climatic conditions in Serbia also showed severe drought (Bošnjak, 1997; Dragović,1997; Jovanović and Popović, 1997; Spasova *et al.*,1997; Spasova *et al.*, 1999; Spasov and Zelenhasić, 1990; Spasov, 1997; Spasov and Spasova; 2001; Stojšić and Škorić, 1997). Few aspects, very important for each drought analysis are: time period (duration of drought), possibility (expected frequency of drought phenomenon) and deficit of precipitations (drought intensity).

On the climate diagrame (graph 4. and graph 5.) are shown the water deficit in 2009 and 2010 was in July, August and September.

Graph 4. *Climate diagram for 2009*



Graph 5. *Climate diagram for 2010*



The average monthly air temperature in *Quercus frainetto-cerris* forests are shown in table 1.

Table 1. *Mean montly temperature in Quercus frainetto-cerris forests*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2009	0,5	2,3	7,1	13,6	17,2	20,4	22,2	22,3	18,8	12,2	9,6	3,3
2010	-0,2	3,1	7,6	12,4	15,8	19,0	21,2	21,7	16,0	12,3	8,8	0,5
2011	1,3	0,8	7,2	12,4	16,3	20,6	21,6	23,2	20,9	11,7	3,8	4,2
2012	0,7	-3,9	9,2	13,0	15,9	21,9						

The period in year with the most prominent extremes are July and August. Thus, the average monthly temperature in July was the lowest in 2010. year (21.2ºC), and the highest in 2009. year (22.2ºC). Compared to the average air temperature in July, in August, the highest average monthly air temperatures recorded in 2011. year (23.2ºC), and the lowest in 2010. year (21.2ºC).

In the period of research the greatest anomaly was recorded in September 2011. The average mean monthly air temperature was 20.9ºC. This temperature was in comparison to 2009. and 2010. higher by 2,1 and 4.9ºC respectivily.

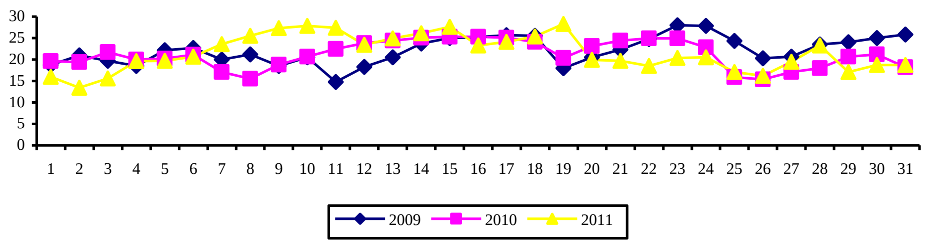
Mean montly realtive humidity was the lowest in August and September 2009 and 2011 (table 2).

Table 2. *Mean montly relative humidity in Quercus frainetto-cerris forests*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2009	90,2	85,2	70,0	72,5	79,5	80,1	70,4	69,5	68,8	83,6	81,1	93,1
2010	93,2	85,1	71,4	72,0	81,9	88,8	85,0	79,2	81,4	96,1	75,5	89,5
2011	89,9	88,0	87,0	83,6	71,5	75,7	73,0	63,3	66,8	85,1	88,0	88,8
2012	91,3	87,2	58,5	71,6	79,0	70,7						

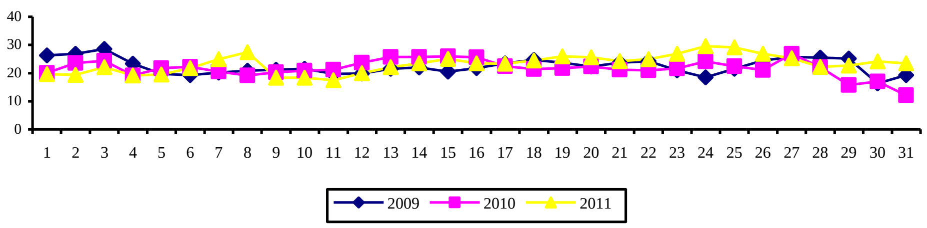
Mean daily air temperature in *Quercetum frainetto-cerris* forests in July and August are shown in graph 6 and graph 7.

Graph 6. *Mean daily air temperature (T°C) in Quercetum frainetto-cerris – July*



The highest recorded mean daily air temperature in July was 28,3°C (in 2011) and 28,0°C (in 2009). In 2010. the highest mean daily temperature was lower (25,3°C).

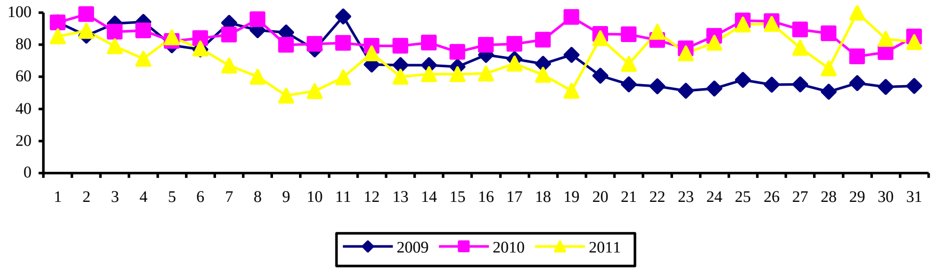
Graph 7. *Mean daily air temperature (T°C) in Quercetum frainetto-cerris – August*



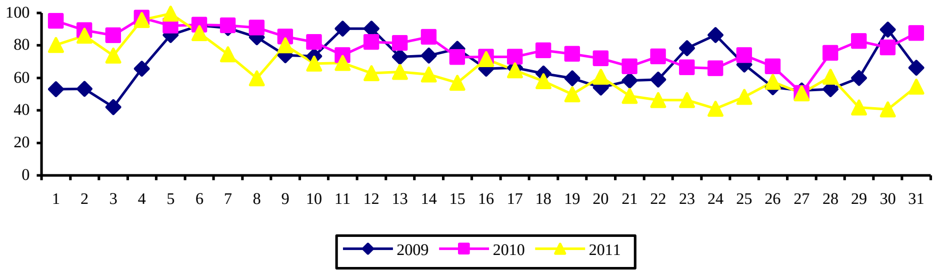
In August 2011 the highest mean daily temperature was 29,6°C, In this period the lowest mean daily air temperature was 28,5°C in 2009 and 26°C in 2010.

Mean daily relative humidity in July and August was mainly lowest in 2009 and 2011 (graph 8 and 9).

Graph 8. *Mean daily relative humidity (%) in Quercetum frainetto-cerris – July*

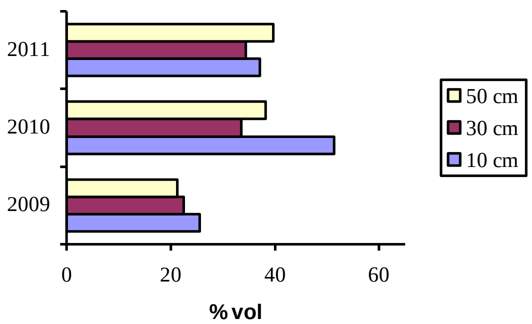


Graph 9. *Mean daily relative humidity (%) in Quercetum frainetto-cerris – August*

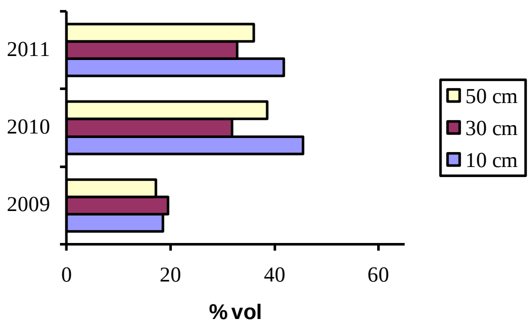


The simulation of the effects of possible factors on the development of investigated sites in altered climatic conditions can be derived based on research that was conducted during the years 2009, 2010 and 2011. The quantity of available water depended on hydrological conditions throughout the year (Graph. 10, 11, 12 and 13). If hydrological conditions were closer to normal, the water soil supply was higher (year 2010). Long periods of drought led to relatively uniform reductions in the quantities of available water in the soil, and thereby caused unfavorable conditions for plant growth.

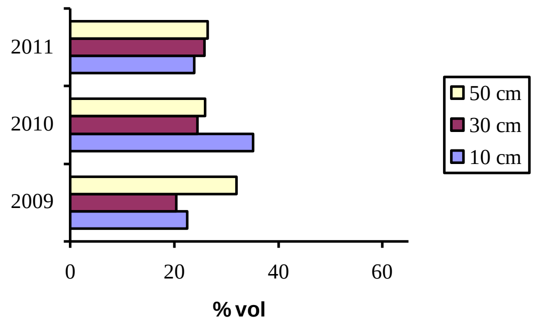
Graph 10. *Volumetric soil moisture content (%) – April*



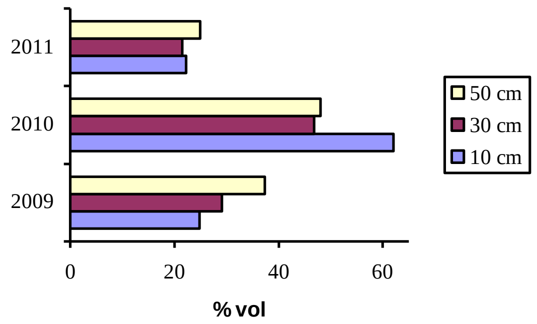
Graph 11. *Volumetric soil moisture content (%) – June*



Graph 12. *Volumetric soil moisture content (%) – August*



Graph 13. *Volumetric soil moisture content (%) – November*



There is no sufficient information available regarding the sensitivity of ecosystems to climate changes over the long-term, and thus it is necessary to conduct monitoring over longer periods.

CONCLUSION

Increasing annual air temperature is registered throughout the entire territory of Serbia.

Mean annual air temperature for period 1961-1990 in Kragujevac was in 2009 and 2010 higher in June (for more than 1°C), and in July and August (for more than 2°C) . The largest decrease of precipitation (to the period 1960-91) was recorded in July. The water deficit in 2009 and 2010 was in July, August and September.

The period in year with the most prominent extremes are July and August. In the period of research the greatest anomaly to perid 1961-1990 was recorded in September 2011. The highest recorded mean daily air temperature in July was 28,3°C (in 2011) and 28,0°C (in 2009).

Long periods of drought led to relatively uniform reductions in the quantities of available water in the soil, and thereby caused unfavorable conditions for plant growth.

There is no sufficient information available regarding the sensitivity of ecosystems to climate changes over the long-term, and thus it is necessary to conduct monitoring over longer periods.

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EFFECTS OF DIFFERENT REGENERATION METHODS ON YIELD OF BLACK LOCUST (*Robinia pseudoacacia* L.) STANDS: A CASE STUDY

Zsolt KESERŰ[1], Károly RÉDEI[1], Imre CSIHA[1], János GÁL[2]

Abstract: *Black locust (Robinia pseudoacacia L.) is one of the most important stand-forming tree species in Hungary, covering approximately 23% of the forested land and providing 25% of the annual timber output of the country. One-third of these black locust stands are high forest (seed origin) and the remainder are of coppice origin. In Hungary according to the forestry regulations black locust stands can be regenerated by root suckers and with seedlings. The paper investigates the influence of different regeneration methods on wood production, the quality of stems and the health of trees. According to the reckoned data the professional and careful regeneration from root suckers produced higher yield at final cutting age than the regeneration carried out with seedlings. There was no considerable difference between the average quality of stems and the health of trees in stands regenerated by root suckers and seedlings. On the basis of the results of investigations and considering the economic requirements, regeneration of black locust stands from root suckers may be recommended on sites of yield classes I-III (Rédei, Gál,* 1985*) on a larger scale.*

Keywords: *Robinia pseudoacacia* L.; regeneration methods; yield

INTRODUCTION

Robinia pseudoacacia was the first forest tree species to be imported from North America to Europe (to France) sometime after 1601. Its rapid spread all over the word may be attributed to its adaptability to a wide range of conditions, favourable breeding properties, frequent and abundant seed production, excellent coppicing, fast growing and high yield (Keresztesi,1988).

Black locust was introduced in Hungary between 1710 and 1720. The first large black locust forests were established at the beginning of the 19th century on the Great Hungarian Plain stabilizing the wind-blown sandy soil. In the country, black locust occupied 37.000 ha in 1885, 109.000 ha in 1911, 186.000 ha in 1938 and 420.000 ha in 2010. At present, it is the most widely planted species in Hungary, covering 23% of the country's total forest area. One-third of these stands are high forests and two-third of them are of coppice origin. In the 1960s, Hungary had more black locust forests than the rest of European countries together.

The mean wood volume ha^{-1} in all black locust forests is 125 m^3 ha^{-1}, with a mean volume of 190 m^3/ha at final cutting age (31 years on average). Black locust forests in Hungary have been established on good as well as medium and poor quality sites. Establishment of black locust stands, producing timber of good quality is possible only sites with adequate moisture and well aerated and loose structured soil, rich in nutrients and humus. Black locust forests on medium and poor site quality are utilized for the production of fuelwood, fodder, poles and

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props, as well as production of honey, soil protection and environmental improvement (Keresztesi, 1988, Rédei, 1996).

Black locust can be regenerated by root suckers (natural way) and with seedlings (artificial way). In Hungary one-third of black locust stands are seed origin and the remainder are of coppice origin. There are some favourable plant characteristics of black locust which make both regeneration methods possible: seeds produced in many environments, high seed production, long-lived seed, seeds germinate rapidly, on the other hand very plastic root system, vegetative growth from fragments and hard to uproot.

The most important black locust growing regions in Hungary are located in the south and southwest Transdanubia (hill-ridges of Vas-Zala county, hill-ridges Somogy county), the plain between the rivers Danube and Tisza (Central Hungary) and north-east Hungary (Nyírség region) (Figure 1).

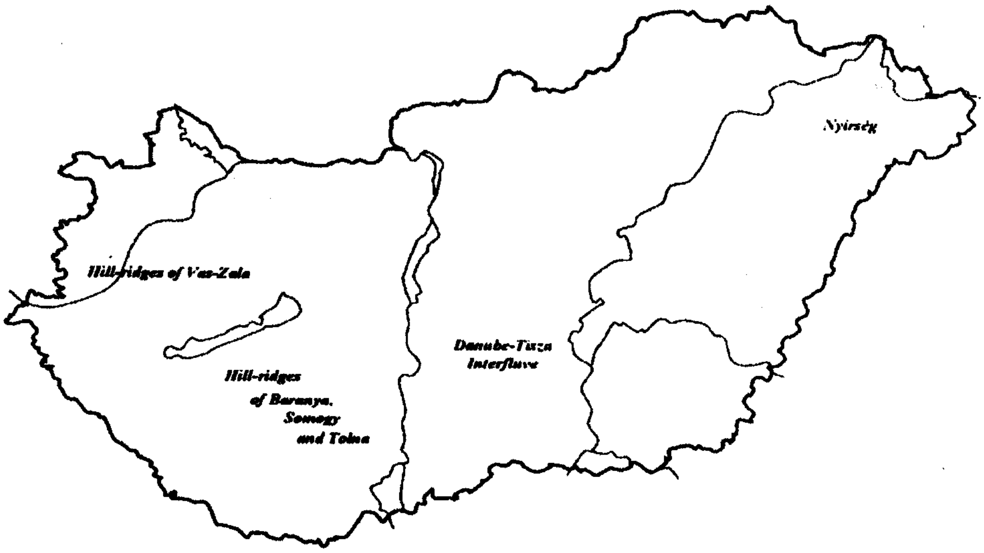

Figure 1. *The main growing regions of black locust (Robinia pseudoacacia L.) stands in Hungary.*

In the future there are two bigger regions where the fast spread of black locust can be expected. In Europe the Mediterranean countries (Italy, Greece and Turkey), while in Asia China and Korea may become the most prominent black locust growers.

Geographic distribution and variability as well as physiological attributes of black locust

Within the genus *Robinia* the species *R. pseudoacacia* L. black or common locust, and some of its varieties (shipmast locust - *var. pyramidalis),* and spineless locust are promised for forest tree breeding. Other varieties are rewarding with respect to breeding for honey prduction: early flowering *(var. praecox),* late flowering *(var. galiana)* and continuously flowering *(var. semperflorens Car.*), in addition two late flowering and abundantly nectarine species, *R luxurians* (rich locust) and *R viscosa* (sticky locust); and hybrids of the latter two species with black locust.

The species is indigenous to the eastern and central part of USA between latitudes 43° N and 35° N. In its natural range tree types of black locust are distinguished by shape:
Pinnata (feathered) type: the stem is straight. It occurs along the northern edge of the species' area at the elevation of about 800 m with *Picea rubra* and *Acer saccarinum.*

Palmata (palm-like) type: the main part of the stem is crooked and not clearly visible in the crown. Its natural area is in the medium elevations of the Appalachians.
Spreading type: it seems to be unsuitable for selection. It occurs at the low elevations of the Appalachians, and in the southern part of the natural area.

Physiological attributes of black locust are the followings (Hanover, 1992):

- rapid growth rate, out-competes weeds,
- indeterminate growth habit,
- nodulated roots, fixes atmospheric N_2
- high density wood,
- good pulping qualities,
- highly resistant to fungi, pests,
- tolerates low fertility sites,
- resistant to drought stress,
- resistant to air pollutants,
- resistant to low temperatures,
- resistant to high temperatures,
- very high net photosynthetic rates,
- high light demand,
- high leaf area accretion rate,
- high transpiration rate,
- rapid leaf position adjustment to changes in light intensity,
- small leaflets minimalize self-shading,
- vigorous sprouting of root cuttings,
- very plastic root system: strong tap and dense fibrous upper roots,
- flowers at early age,
- produces abundant seed crops,
- high seed viability and longevity,
- seeds easily cleaned, stored, sown,
- seeds germinate rapidly,
- easily micropropagated,
- high leaf protein,
- much genetic variation.

Stand establishment, forest tending and yield

Climate, hydrology and genetic soil types are the factors that determine the site type, and this in turn determines the choice of tree species. The water regime of the soil is also highly influenced by the texture of the soil, whether it is humus, coarse sand, loam or clay. Black locust - because of its high requirement for both water and aeration in the soil - cannot be grown even on any soil composed of humus, coarse sand or clay if the rooting depth is very shallow (Keresztesi, 1988).

Black locust requires well-drained soils with adequate moisture until the associated nitrogen-fixing *Rhizobium* bacteria are able to thrive. That is why soil preparation (total or partial) to improve aeration and the water regime of the soil and tilling of the inter-row space may become necessary. Black locust afforestation and artificial regeneration may utilise seedlings.

The most popular spacing for black locust in Hungary is 2.4 m by 0.7 to 1.0 m, requiring at least 4000 seedlings/ha. Black locust stands are often regenerated by coppice (from root suckers) as well. In young stands of coppice origin, a cleaning operation should be carried out to adjust spacing when the stands are 3-6 years old and should reduce stocking to less than 5000 stems/ha.

The black locust is a fast-growing tree species, which, up to the age of 10-15 years, is able to close canopy openings caused by tending operations quickly, but the closure is much slower in later years. Height growth peaks within the first five years, while diameter growth culminates in the first decade. The peak of current annual increment is at about the age of 20, whereas that of the mean annual increment is at about the age of 35- 37 years (Rédei, Gál, 1985).

To find the right cleaning and thinning intensity, the so-called growing space index is a good method. This index expresses the mean distance between trees (in a triangular pattern) as a percentage of mean height after cleaning and thinning. The mean value of the index for black locust stands should be 23-24 %. Pruning of crop trees should also be carried out. After finishing selective thinning, stems must be free of branches up to a height of 4-6 m.

The objective of tending is to produce a high proportion of good quality saw-logs from stands of yield class I and II; some saw-logs and a high proportion of poles and props from stands of yield class III and IV; and poles, props and other small-dimension industrial wood from other yield stands (Rédei, 1992).

In order to investigate the influence of different regeneration methods on wood production in black locust stands, several experimental trials were established in Hungary (Keresztesi, 1965, 1987, Rédei, 1997). In this paper a case study on this subject is presented.

MATERIAL AND METHODS

Description of the study area

In the 1950s and 1960s the Hungarian Forest Research Institute established several experimental plots in the various forest regions of the Great Hungarian Plain for investigating regeneration and tending of black locust forests.

In the Danube-Tisza Interfluve region, in the central part of the Hungary three comparative experimental parcels with size 0.24 ha were allocated in subcompartment Pusztavacs 224C in spring 1968. According to the Hungarian classification of site types, the main ecological characteristics of the study area are the followings:

- forest steppe climate zone: the humidity is less than 50% in July at 2 pm, the annual precipitation is less than 550 mm,
- hidrology: free draining,
- genetic soil type: humous sand and combinations.

The latitude and longitude coordinates of the experimental area are *N 47.11*, *E 19.30.*

Regeneration of the former black locust stand of coppice origin has been carried out in these parcels by the following methods: (Keresztesi, 1987)

- Regeneration from suckers developed *from large roots* (root Ø>3cm<6 cm) after felling trees with stump extraction (I).
- Regeneration from suckers developed *from small roots* (root Ø>1cm<3 cm) after felling with stump extraction and removal of large roots (II).
- Regeneration *with seedlings* planted into deep-ploughed soil, after trees with stump extraction (III).

Regeneration and tending cuttings have been carried out in conformity with the regulations on the intensive silviculture of that time. A cleaning was carried out at age of 5 and 10, a selective thinning at age of 15 and an increment thinning at age of 20. The investigated plots were harvested at age of 34 and regenerated with seedlings.

According to the yield table for black locust stands (Rédei, Gál, 1985) the yield class of the investigated stand is II.

Determination of stand parameter

The following parameters were measured and calculated at age of 6, 17, 24, 29 and 34 years: stem number, d.b.h., basal area, tree height, stem volume, stand volume and mean tree volume. The stem volume was calculated using the volume function based on the volume table for black locust (Sopp, 1974):

$$V=\frac{d^2 \cdot h^{po+1}}{(h-1{,}3)^{po} \cdot 10^8} \cdot \left(p_1 \cdot d \cdot h + p_2 \cdot d + p_3 \cdot h + p_4\right)$$

where d is d.b.h.(cm), h is tree height (m), p_o=4, p_l=-0.6326, p_2=20.23, p_3=0.00 and p_4=3034.

Tree quality classification

Tree classes used by us are as follows at the age of final harvesting (for calculating the stand-value index):

1) Trees providing high quality industrial wood. Straight, cylindrical, healthy stems, reaching to the top of the crown. Crooks are tolerated in one dimension only, not more than twice the stem diameter. The lower two-thirds of the tree must be suitable for industrial purposes and free of live branches.
2) Trees providing lower quality industrial wood. The stem is straight, forks are tolerated, but only if they are in the uppermost third of the tree. Crooks are tolerated in one dimension only, not more than four times the stem diameter.
3) Trees suitable for short logs of poor quality. The stem is crooked and leaning. Crooks may reach six times the stem diameter in one dimension and minor crookedness in a second dimension is tolerated. Only short logs of poor quality and firewood can be produced from these trees.
4) Trees suitable for firewood only. Very crooked in more than one dimension, low branching, forked trees with stem defects, broken crown or stem rot.

For investigating for butt rotting caused by fungus Fomes fraxineus, Cooke 30 sample trees were selected in each plot. Rot on cut surface and upwards in trunk were measured.

The stand-value index (SVI) was determined on base of the following formula:

$$\text{SVI} = \frac{x_1 n_1 + x_2 n_2 + x_3 n_3 + x_4 n_4}{n_1 + n_2 + n_3 + n_4}$$

where $x_1, x_2, x_3, x_4 =$ tree quality classes,

$n_1, n_2, n_3, n_4 =$ tree numbers belonging to the single tree quality classes

RESULTS

Table 1 includes the most important stand parameters of the plots. On the basis of it there is no considerable difference in stem number per ha between the plot I coppiced from suckers developed from large roots and the plot III regenerated with seedlings. In plot II regenerated from suckers sprouted from small roots a number of sprouts died, repair planting was not effected, the missing seedlings were replaced by sprouts again. It is to be noted that at the age of six the difference in stem number per ha was 1188 pieces between the plots regenerated from suckers sprouted from large and small roots.

Figure 2 gives the mean height values as a function of age of stand. It can be seen that the tendency of growth rates in height in black locust stands of seed and coppice origin are similar to each other. At the age of final cutting the mean height of crop regenerated from suckers (Plot I and II) developed from large roots is just as large as that of crop regenerated from suckers developed from small roots. The growth rate in height of crop regenerated with seedlings (Plot III) is somewhat lower than that of crops regenerated from suckers.

Table 1. *Stand structure and quality parameters of the experimental plots (Pusztavacs 224 C)*

Age Year	Stem number per ha	Mean height M	Mean DBH cm	Basal area m^2/ha	Volume m^3/ha	Mean tree volume dm^3	Stand-value index (SVI)
Regeneration from suckers developed from large roots (I)							
6	5060	6.2	4.2	7.1	35.2	7.0	-
17	1283	16.8	13.7	19.0	165.8	129.2	1.7
24	607	21.6	19.0	17.2	182.6	300.8	1.8
29	601	23.1	21.5	21.8	248.5	413.5	1.9
34	601	24.2	23.2	23.6	297.1	494.3	1.9
Regeneration from suckers developed from small roots (II)							
6	3872	6.6	4.9	7.2	37.2	9.6	-
17	896	17.4	15.4	16.7	153.3	171.1	1.6
24	395	22.6	19.8	12.1	135.7	343.5	1.7
29	395	23.3	22.4	15.6	178.0	450.6	1.8
34	395	23.9	23.8	15.7	200.0	506.3	1.8
Regeneration with seedlings (III)							
6	4004	6.2	4.2	5.5	27.6	6.9	-
17	1225	16.5	13.7	18.0	155.6	127.0	1.7
24	607	21.6	18.6	16.6	177.0	291.6	1.7
29	596	22.4	20.9	20.5	228.0	382.5	1.8
34	596	22.8	21.5	22.9	258.9	434.4	1.8

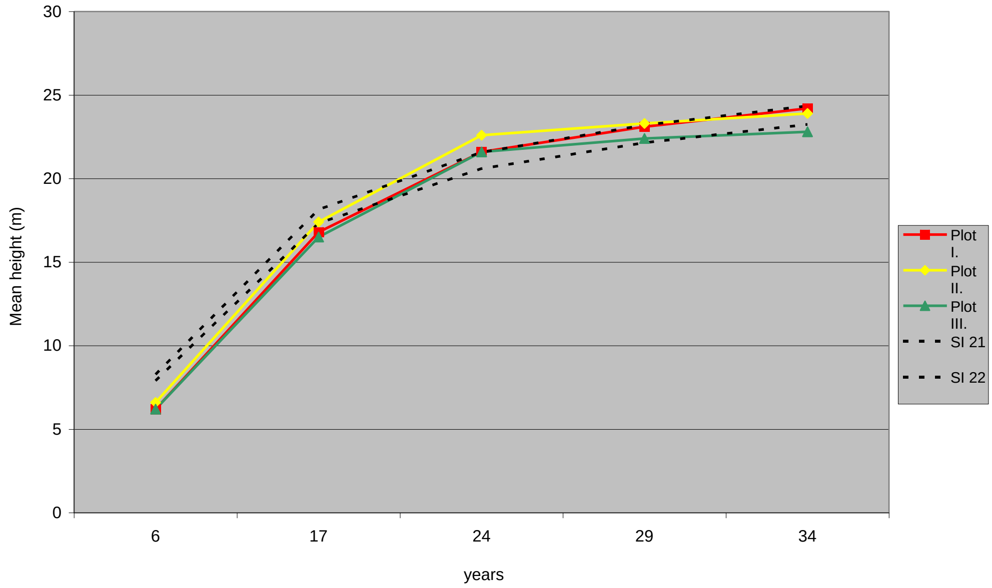

Figure 2. *Mean height values of the crops along with site index curves*

To investigate possible differences in curve shapes and asymptotic values of height growth a growth function, the modified Chapman-Richards function was fitted to the height over age data. The function has the following form:

$$h = p_1(1 - e^{p_2 t})^{p_3}$$

where h is the height
t is the age
p_1, p_2 and p_3 are the parameters

Parameter p_1 is the asymptotic (maximum) value of the height growth; parameters p_2 and p_3 are responsible for the shape of the curve.

Table 2. *Parameter estimates for the height growth curves of the three different plots using the modified Chapman-Richards function*

	Plot I	Plot II	Plot III
p_1	27,10	25,89	24,83
p_2	-0,07968	-0,09681	-0,09624
p_3	1,5384	1,6927	1,7136

It can be seen from the parameter estimates in Table 2 that the height growth of plot II and III are similar in shape (nearly identical $p2$ and $p3$ parameters) at a slightly different asymptotic level, and the curve of plot I is different both in terms of asymptotic value and curve shape.

To compare the height growth pattern of the experimental plots with that of the yield table for black locust constructed by Rédei-Gál (1985) the site index curves for the site indices 21 and 22 (height at the age 25) are shown in Figure 2 (dotted black lines). The growth pattern is very similar, so the site index curves of the yield table are supported by long term observations on actual plots.

Figure 3 gives the mean DBH values as a function of age of stand. In spite of difference in stem number per ha between the plots regenerated from suckers sprouted from large and small roots there is no considerable difference in DBH of their crops. The DBH values of crop regenerated with seedlings are somewhat lower than that of crops regenerated from suckers but the deviation is negligible from practical point of view.

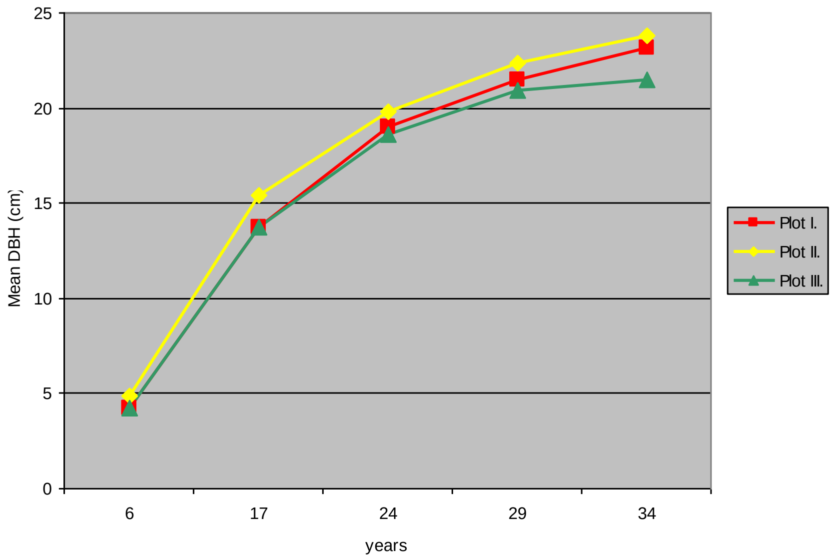

Figure 3. *DBH values of the crops*

The parameters of the Chapman-Richards function were also estimated for the DBH over age data. The parameters are in Table 3.

Table 3. *Parameter estimates for the DBH growth curves of the three different plots using the modified Chapman-Richards function*

	Plot I	Plot II	Plot III
p_1	29,75	28,28	25,21
p_2	-0,05827	-0,06772	-0,07659
p_3	1,6260	1,5995	1,8320

To compare the yield of crops regenerated by different methods at the age of final harvesting mean tree volume was used (Figure 4). Taking the arithmetic mean of the mentioned parameter as 100%, (478.3 dm^3) comparison of the influence of regeneration methods on change in yield becomes easier and more exact. According to the data, the result achieved in case of plot II, regenerated from suckers developed from small roots, was the highest (105.9%). It is followed by the crop regenerated from suckers sprouted from large roots (plot I, 103.3%) and finally the crop regenerated with seedlings (plot III, 90.8%). According to these data, the crops raised from suckers produced higher yield in both cases than the crop of seed origin.

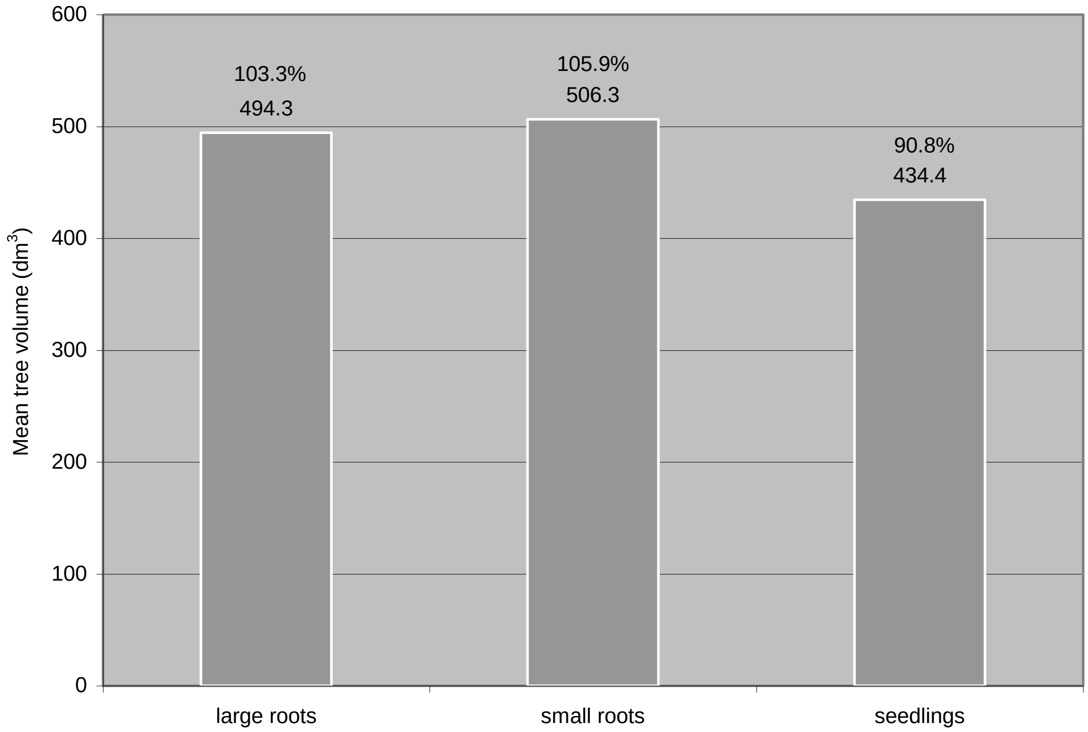

Figure 4. *Mean tree volume of the crops at age of 34 years*

According to the investigations on the stem quality of the experimental stands - which maturity at age 34 - the calculated stand-value index was in the plot I (large roots) 2.2, in the plot II (small roots) 2.0 and in the plot III (seedling) 2.1. The differences between the plots are not significant, in other words, stem quality does not depend essentially on the method of regeneration.

After harvesting the degree of butt rotting caused by Fomes fraxineus, Cooke was investigated on 30 trees in each parcel by measuring rot on cut surface and also upwards in trunk. This upward rotting ranged to 50 cm in 72% and from 50 to 100 cm in 28% of the investigated trees. But rot over 100 cm was not found in any tree. According to the investigations butt rotting degree was 46% in the plot I (large roots), 43% in the plot II (small roots) and 40% in the plot III (seedlings). From these data it is evident that the infection caused by the butt-rotting fungus does not depend essentially on the method of regeneration.

CONCLUSIONS

Investigation carried out at Pusztavacs (Central-Hungary) answered several important questions. By purposeful and systematic tending operations black locust stands of yield class II and III have been developed this area. Mean tree volume of the stands established by various coppicing methods and by planting seedlings did not differ from each other significantly at the age of final harvesting. The stand of seed origin did not produce better stem quality than stands of coppice origin. It can be said that the coppice stands - especially regenerated from large and small roots - did not produce less valuable assortments for industry than stands of seed origin.

Investigations carried out at Ófehértó (East-Hungary) answered several important questions. By purposeful and systematic tending operations black locust stands of yield class II and III have been developed in this area. Yield data of the stands established by various coppicing methods and by planting seedlings do not differ from each other significantly (Keresztesi, 1987).

In Hungary regeneration of black locust forests from suckers is allocated only in those areas where the stands of good or medium quality are of seed origin or first coppiced. Based on our trials, it is reasonable to ponder the regeneration of these stands from suckers more than once. The forest management plans do not include data on how many times the stand in question was coppiced. Therefore, the problem, whether the stand is to be regenerated by coppicing or not, should be decided on the basis of its growing stock and health. Black locust stands of good and medium quality (yield classes I, II and III) may be regenerated from suckers in general until their growing stock attains, or exceeds, the wood volume given in yield table for the yield class in question, and if their health is also adequate; not more than 50% of the stumps are butt rotted and rotting in trunks penetrates maximum up to 1 m.

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PROPOSAL FOR SILVICULTURAL TREATMENTS IN THE BEECH COPPICE STANDS IN MOUNTAIN KUKAVICA

Igor MILOSAVLJEVIĆ[1]

Abstract: *A large area under the beech coppice stands, aged about 70 years, in southern Serbia is a major technical challenge for their successful transformation into a high beech stands. The goal of management is more fully use the potential habitat and improve environmental conditions. This paper provides recommendations for carrying out silvicultural treatments in beech coppice stands in their interpretation of beech stands high in the mountains Kukavica, near Leskovac. In this area there is also explored in detail a sample surface, measuring 20 x 25 m. Tree taxation elements were measured for all trees and made dendrometric analysis of diameter and height of the thickest trees. Data were collected on the environmental conditions of habitat. Also, all the trees is biologically determined position, the quality of the crown, stem quality and health. Given the large number of trees per hectare, and the obtained results it was proposed high-performance selective thinning operations to the strength of 26.35% by volume.*

Keywords: beech coppice stands, ecological factors, silvicultural measures, conversion, thinning

INTRODUCTION

Large area under the beech coppices, aged 70 years, in south Serbia represents a major technical challenge for successful transformation into a high beech stands. The goal of management is the complete use of site potentials and improvement of environmental conditions. The importance of melioration of degraded forests and coppice forests arises from the large area occupied by these forests in Serbia. Melioration of these forests is often done without the established policy priorities and the use of clear scientific and professional positions. The main problem that arises is the selection of the optimal method of melioration, depending on the extent and type of forest degradation.

The total area of coppice beech forests in Serbia is 111.055 hectares, with a total volume of 16.262.368 m3 and the average volume of 146,43 m3/ha with an average volume increment of 3,90 m3/ha. The average amount of volume ranges from 87 to 233 m3/ha (304 m3 · ha-1), and the average increment ranges from 1.59 to 6.55 m3/ha. In relation to the high forests, production potential in coppice forests is used with 65% by volume and 85% by volume increment. In this state of coppice beech forests in Serbia, we can say that the average volume should be increased by 100 m3/ha-1, ie. the current lack of an area of 111.055 ha is 11.105.500 m3 (Medarević M. 2004).

A beech forests in the Jablanica forest area extends to 23.753 ha with a total volume of 5.236.473 m3, with 122.962 m3 volume increment per year, average volume of 220.45 m3/ha

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and an average volume increment of 5.18 m3/ha covering 6.5% of the total volume and area of beech in Serbia.

The goal of this paper is to study the stand condition of beech coppice origin in management unit “Kukavica I“ that would be based on the current situation. Here would be explaned the explained the proposed measures for their rehabilitation (conversion to high silvicultural form), that provide better insight into the state of coppice beech forests in the FMU " Kukavica I " from the theoretical, and the practical point of view, and to awaken interest in the prompt recovery of the present status.

STUDY AREA AND METHOD

The study area is a coppice stand of beech, situated in South Serbia (stand 101a, management unit “Kukavica I“). Stand area is 19.01 ha. Its altitude is 440 -670 m, while its slope is 300. The prevailing aspect is north-northwest. The parent rock consists of mica schists and the soil is Siliceous soil humus (Ranker), 15-30 cm deep. The stand is classified as a montane forest of beech (Fagetum moesiacae montanum B. Jov. 1976). By silvicultural and structural form, it belongs to a coppice even-aged preserved stand of beech, with coppice forest characteristics.

Single sample plot of 500 m2 was established in the area 20 x 25 m (Figure 1). The main criteria for establishing of this plot were previously acquainted environmental conditions and stand characteristics, so sample plot is representative of the average conditions in the MU "Kukavica I". Stand is described, sample plot is marked, all trees are marked and measured. The trees of the future were determined and marked. Also, trees for cutting are marked. Diameter and height of all the trees were measured in plot and the quality of tress was determined. Also, the lenght of the tranks without branches were mesured. Data were collected and processed in a way that is common when working on permanent sample plots. Volume and volume increment were determined using adequate regression equations (Koprivica-Matović 2005).

The collected data is accessed and processed in order to obtain the results of an experimental study. The data processing in this study was carried out in the usual way. After collection, data was processing and sorting. For sample plot data is adjusted and shown both tabelar and grafically with all the necessary information about the stand.

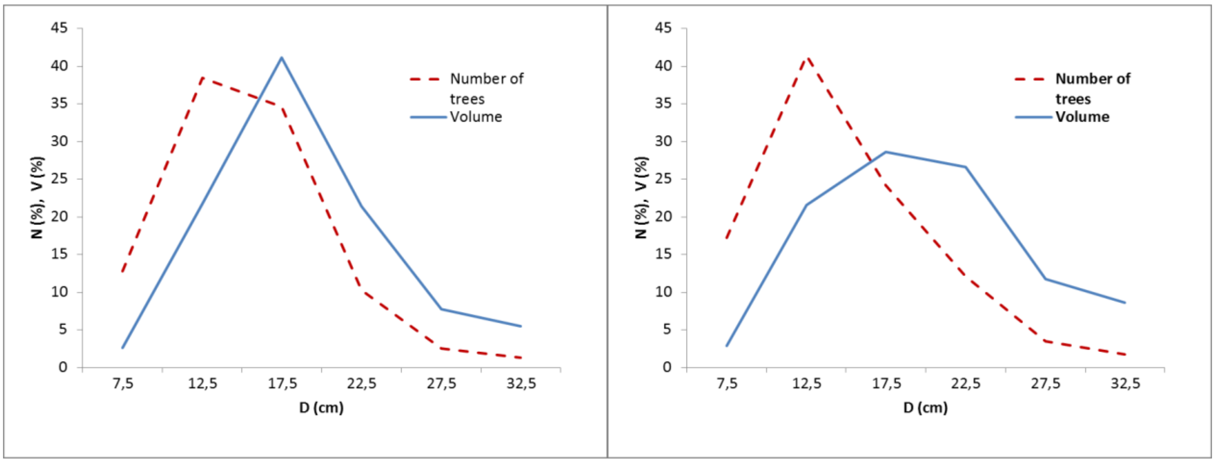
RESULTS AND DISCUSSION

Stand is described as coppice even-aged preserved stand of beech, canopy closure is dense (0.8-0.9). Beech trees are straight, clear from branches to two-thirds of the height and good health. Stand is medium cultivated (with the remaining felling volume), about 70 years old at the optimum stage for coppice forests. Health condition of the stand is good. The basic purpose is ground protection of the first degree. Data about number of trees, basal area and volume for state of forest before felling and after felling, marked trees and trees of future are shown in table 1.

Table 1. *State of stand before and after felling*

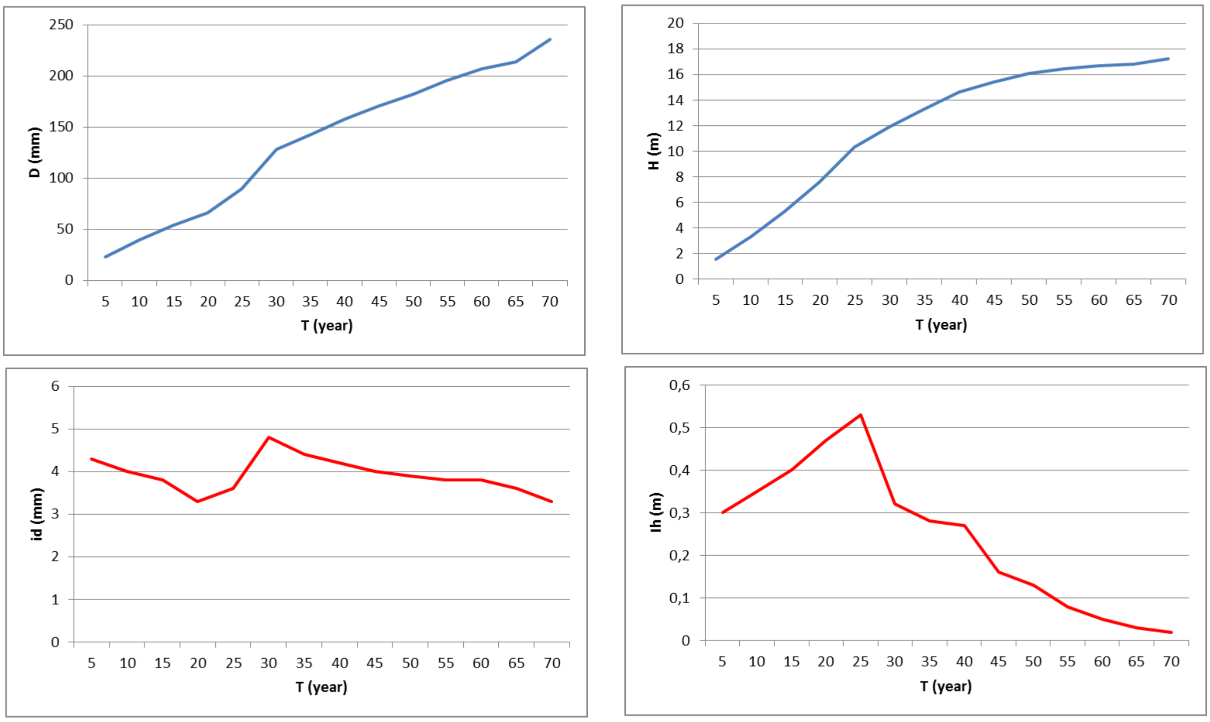
Diameter class	STATE BEFORE FELLING						TREES OF FUTURE					
	N		G		V		N		G		V	
	Pcs.	%	m²/ha	%	m³/ha	%	Pcs.	%	m³/ha	%	m³/ha	%
7,5	200	12,82	0,88	2,79	5,56	2,57						
12,5	600	38,47	7,36	23,27	52,87	21,7						
17,5	540	34,62	12,98	41,07	107,8	41,14	40	15,38	0,96	8,47	7,99	8,09
22,5	160	10,25	6,36	20,12	59,48	21,36	160	61,54	6,36	56,00	59,48	56,75
27,5	40	2,56	2,37	7,51	23,01	7,78	40	15,38	2,37	20,92	23,01	20,68
32,5	20	1,28	1,66	5,24	16,89	5,45	20	7,70	1,66	14,61	16,89	14,48
Σ	**1560**	**100**	**31,61**	**100**	**265,64**	**100**	**260**	**100**	**11,35**	**100**	**107,37**	**100**
	dg=16,07 cm			**hg=14,66 m**			**dg+=23,58 cm**			**hg+=16,89 m**		
Diameter class	MARKED TREES						STATE AFTER FELLING					
	N		G		V		N		G		V	
	Pcs.	%	m²/ha	%	m³/ha	%	Pcs.	%	m³/ha	%	m³/ha	%
7,5							200	17,24	0,88	3,82	5,56	2,84
12,5	120	30	1,47	17,28	11,41	16,18	480	41,38	5,89	25,49	42,30	21,61
17,5	260	65	6,25	73,38	52,10	73,87	280	24,14	6,73	29,14	55,91	28,57
22,5	20	5	0,79	9,34	7,02	9,95	140	12,07	5,56	24,09	52,04	26,59
27,5							40	3,45	2,37	10,28	23,01	11,76
32,5							20	1,72	1,66	7,18	16,89	8,63
Σ	**400**	**100**	**8.51**	**100**	**70,53**	**100**	**1160**	**100**	**23,09**	**100**	**195,71**	**100**
	dg-=16,46 cm			**hg-=14,28**			**dg=15,92 cm**			**hg=14,79 m**		

Table 1 shows that total number of trees is 1560/ha, all the trees are distributed in six degrees of diameter from 7.5 to 32.5 cm. The largest number of trees (600) is in degree of 12.5, which is 38.47% of the total number of trees, also a large number (540) of trees is in the degree of 17.5 which is 34.62% of the total number of trees. Mean stand diameter is 16.07cm, and mean stand height is 14.66m. Total basal area is 31.61m3/ ha, and the highest value of basal area is in the degree of 17.5 (41.07%, 12.98 m2/ha). The total volume of the stand is 265.64 m3/ha, maximum volume is in the degree of diameter 17.5 cm, is 107.83 m3/ha (41.14%). This volume is cauused by large number of trees (Pantić et al 2003).



Graph 1.*The distribution of trees per diameter degrees before and after felling*

The distribution of volume is normal with left asymmetry (Graph 1).



Graph 2. *Justified development diameters and height of trees of the future*

Graph 2 shows culmination of the current diameter increment occurs at the age of 30 years, and the culmination of the current height increment appearances earlier, at the age of about 25 years. Time of the culmination of the height increment is consistent with the results reported by Krstić et al (2005), conducted in a similar stand and site conditions in northeast Serbia. From these data it can be concluded that this state is a consequence of the lack of thinning in young years of this stand. We can expect a significant increase in current diameter increment of trees after the release of trees of future from competitors.

As part of the stand, which has 1560 trees per hectare, 260 trees were marked as future trees which is 16.6% of the total number of trees or 40.42% of the total volume in the stand. Mean diameter of the trees of the future is 23,8 cm and is 7.51 cm higher than the mean diameter of the stand. Based on visual assessment of the quality of trees, all trees in stand are clasified in three categories. The percentage distribution of trees is shown in Table 2.

Table 2: *Biological position, trunk quality and crown quality*

Quality evaluation	**Biological position (%)**	**Trunk quality (%)**	**Crown quality (%)**
1– good	43,59	44,87	39,74
2-moderate	25,64	30,77	23,08
3-poor	30,77	24,36	37,18

Table 2 shows that stem quality is very high, 44.87%, a large percentage of the trees is in the first biological position (43.59%), while the good crown quality has a 39.74% of trees in a stand. These data indicate that this is quality stand on the right habitat, and, therefore, long-term breeding goal will be a direct conversion of coppice to high forest, and as a short-term goal is tending (thinning) of the existing stand.Tree heights with the percentage of clear trunk are shown in Table 3.

Table 3: *Justified height of trees with percentage of clear trunk*

Diameter degree	7,5	12,5	17,5	22,5	27,5	32,5
Height of trees (m)	10,2	12,0	14,5	16,8	17,2	18,2
Length of the crown (m)	4,4	5,1	6,4	7,0	7,1	7,0
Length of clear trunk (m)	5,8	6,9	8,1	9,8	10,1	11,2
Clear trunk (%)	56,9	57,5	55,9	58,3	58,7	61,5

Table 3 shows that the lowest percentage of clear trunk (55.9%) is in the degree of 17.5, while the highest percentage of clear trunk (61.5%) is in the degree of 32.5. This is due to small amounts of light in the lower floor of the stand, and the lowest tree struggling for diffuse light and develop a longer crown, while trees from the upper floors are clear of the branches and have a smaller crowns because of the help from lower trees.

According to data, trees are marked for harvest, and 400 trees per hectar is marked which is 25.4% of all trees, and 26.35% of total stand volume. Mean diameter of marked trees is 16.46cm and it is for 0.39 cm higher than mean stand diameter, but for 7.22 cm lower than trees of future diameter. We can conclude that high selective thinning is conducted, and after 8-10 years, we need to re-enter in the stand with regeneration felling. This is next step in conversion of this stand in high forest.

CONCLUSION

- Based on analysis of the distribution of trees, basal area and volume per diameter degrees can be said that this is typical even-aged forest with normal distribution of trees;
- Based on the present state of this stand, it can be classified as good coppice on the right habitat;
- Due to the current state of the stand and the desired goal, as the best measure conversion from coppice to high beech forest is proposed, with goal of production of timber and fuelwood;
- We can achieve this by regeneration felling with intesity of 25 - 30%, with the focus on removal of major competitors for trees of future;
- Number of trees of future is 260 per hectare, and by proposed marking (26.35% by volume) 400 trees per hectare will be removed;
- Next thinning should be done for 8-10 years with the same intensity (from 25 to 30% by volume) when the trees bear abundantly with quality seeds, by regeneration felling to convert coppice into high forest.

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HYDROLOGICAL FUNCTION OF FOREST IN WATERSHED AREA OF PALJANSKA MILJACKA ON JAHORINA MOUNTAIN

Branka RAJIĆ-BIJELIĆ[1], Azra ČABARAVDIĆ[2]*, Izet ČENGIĆ[3]

Abstract: *The aim of this paper is to examine if hydrological function of forest is preserved in Paljanska Miljacka watershed area on Jahorina mountain in central Bosnia.*

Here is applied GIS modeling according to adapted Slovenian methodology (Ferreira et al. 2007). GIS modeling is based on intersection of internal (forest stand structure, canopy, management regime) and external (slope terrain, erodibility, porosity) factors resulting with maps of hydrological needs and forest capacity to maintain hydrological function. Joint map presents areas with different degrees of hydrological conditions. Resulting map for forested watershed area of Paljanska Miljacka showed large area with emphasized hydrological function while in neighborhood commercial forests several stands are assigned as areas of high risk in hydrological sense.

This research provides methodology adaptable for forest management plans which could strength environmental protection as integral part of sustainable forest management planning.

Key words: environmental protection, forest hydrology modelling

HIDROLOŠKA FUNKCIJA ŠUMA U VODOZAŠTITNOM PODRUČJU PALJANSKE MILJACKE NA JAHORINI

Abstract: *Cilj ovog rada je istražiti da li je hidrološka funkcija šuma očuvana u širem području izvorišta Paljanska Miljacka na planini Jahorini u centralnoj Bosni. Ovdje je primjenjeno GIS modeliranje prema prilagođenoj Slovenačkoj metodologiji (Ferira et al. 2007). GIS modeliranje je bazirano na intersekciji internih sastojinska struktura, sklop, sistem gazodvanja) i externih (nagib terena, erodibilnost, poroznost) faktora rezultirajući kartom hidroloških potreba i šumskih kapaciteta za održavanje hidrološke funkcije. Sintezna karta predstavlja područja sa različitim stepenom hidroloških uslova.*

Dobijena karta šumovitog područja izvorišta Palajnske Miljacke ukazuje na veću površinu sa naglašenom hidrološkom funkcijom dok je u susjednim produkcionim šumama više sastojina označeno kao područja viskokog hidrološkog rizika.

Ovo istraživanje predstavlja metodologiju koja je prilagođena za planiranje gazdovanja šumama sa jačanjem zaštite okoline kao integralnog dijela održivog gazdovanja šumama.

Ključne riječi: zaštita prirode, modeliranje hidrološke funkcije šuma

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1. INTRODUCTION

Sustainable forest management deals with overall forest functions (productive, protective, hydrological, social and others) depending of particular importance for area in consideration. Usably forest functions are in interactions and it is important to manage forest resources to harmonize and enhance all natural resources for human use. Considering climate changes and growing risks for fires, erosions, water deficient the protective forest function could be assigned as the most important. Recently particular attention has been paid on non-productive forest functions important for social development. Growing social demand for water pointed out importance of watershed management which is in interaction with forest management directly or indirectly.

Traditional forest management considers hydrological function of forest as erosion and water protective functions. Medarević (1991) emphasized that infiltration and stream flow in catchments are influenced by several factors: relief, micro-clime, watershed properties, geology, soil and vegetation cover type acting interactively.

In recent years, there have been several studies worldwide about complex relations between forests and watershed hydrological properties (Ivanović 1992, Shahwahid et al. 1997, Ollinger et al. 1998, Kershner et al. 2004, Rubinić et al. 2005, Vilhar et al. 2006, Ferreira et al 2007, Beckers et al. 2009, Kuglerová L. 2010, Nikić et al. 2010, Vilhar et al. 2010, Câmara et al 2011, Rajić-Bijelić 2011). Need for additional researches in interaction water-mountain areas in Bosnia and Herzegovina was quoted in year 2002 (Čengić et al. 2002).

The purpose of this research was to examine hydrological function of forest in study area using GIS modeling as additional tool for forest management decision. Particular attention is paid on comparison forest hydrological function in two separate areas: productive and protective forests in one forest management unit aiming to examine how forest management activities influence forest hydrological function.

2. MATERIAL AND METHODS

The study area for this research was the forested catchment's zone of Paljanska Miljacka watershed in the central Bosnia. The study area covered the Forest management unit "Jahorina" Pale containing state owned productive and protective forests on 6273,04 ha[1]. About 95% forests are native, multi-layers, multi-species assigned as selective forests. Other areas are artificial stands, coppice forests or non-forested land. Terrain is plan manly with several stands on slope positions. Present soil types according to national soil classification are calkocambisol (FAO: eutric lepotosols), calkomelanosol (FAO: lithic leptosols) and dystrict cambisol (FAO: humic cambisols) (Resulović et al. 2006).

Forest management unit contains complete catchment's area which is divided in three zones (the first zone - without forest management activities and the second and the third zones with regular management activities). Forest stands were delineated and digitized based on the map of basic forest management units while boundaries of catchment's zones was delineated and digitized according to the Elaborate for water source protection (Ćorović et al. 1987). Thematic map of soil types was used for categorization of erodibility and porosity.

Here is applied GIS modelling according to modified methodology published in Ferreira et al. 2007. Methodological modification is based on external and internal factors definitions. In this research those factors are defined according to site conditions, available data and information from regular Forest management plan (Table 1.). So GIS modelling is based on intersection of internal (forest stand structure, canopy, management regime) and external (terrain slope, erodibility,

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[1] JPŠ „Šume Republike Srpske", Istraživačko-razvojni i projektni centar, Banja Luka (2002): Šumsko-privredna osnova za Paljansko ŠPP.

porosity) factors resulting with maps of hydrological needs and forest capacity to maintain hydrological function. Joint map presents areas with different degrees of hydrological conditions. Detailed description is given in Rajić-Bijelić (2011). Here is used improved classification system for one of the internal factors – the canopy.

Table 1. *Specific defined factors influencing forest hydrologic function*

Value (rank)	External – ecological factors		Internal – stand factors		
	Terrain slope	Erodibility and ground porosity	Stand structure	Canopy	Management system
1. Good	<25%	Low erodibility, normal porosity	Beech>20% Fir >30%	80-100%	Sanitary cutting
2. Acceptable	25-50%	Medium erodibility, normal porosity	Fir >60%	60-80%	Regular cutting with limits
3. Bed	>50%	High erodibility, low porosity	Spruce and other	<60%	Regular cutting

GIS layers related to internal factors were created using data and information from Forest management plan[1]. GIS layers of external factors were based on digital elevation model and thematic soil map. After evaluating basic data layers the results were combined for further analysis. Using specific defined factors, three analytical steps as in original methodology (Fereira et al. 2007) were conducted. Firstly, ecological factors: terrain slope and soil properties were examined in cross-sectional analysis delivering the map used for determination of needs for forest hydrologic function. Then, forest stand factors: stand structure, canopy and management system were used in cross-sectional delivering the map of forest capacities to maintain hydrologic function. Finally, cross-sectional analysis of needs for forest hydrologic functions and forest capacities to maintain this function was performed delivering joint map.

GIS layers were overlaid and after each cross-section new values were determine using following matrix:

1.1.	1.2.	1.3.
2.1.	2.2.	2.3.
3.1.	3.2.	3.3.

Combinations 1.1, 1.2. i 2.1. were assigned as good (value 1), combinations 1.3, 2.2. i 3.1. were assigned as acceptable (value 2) and combinations 2.3, 3.2. i 3.3 were assigned as critical (value 3).

3. RESULTS

Compiling thematic maps of internal and external factors three type of maps were created: the map of hydrological needs, the map of hydrological potentials and the map of hydrological function on the study area.

The map of hydrological needs is based on external factors (terrain slope, erodibility, porosity) (Figure 1). The light grey areas are related to low hydrology needs (plain terrain, low erodibility and normal porosity), the medium grey are connected with acceptable and dark grey areas with high hydrological needs (steep terrain, high erodibility and low porosity).

It was found that about 95% of protective catchment’s area was situated on plain terrain with low erodibility and normal porosity while less then 1% of area has critical external factors influenced by steep terrain with high erodibility and low porosity.

[1] Ibid.

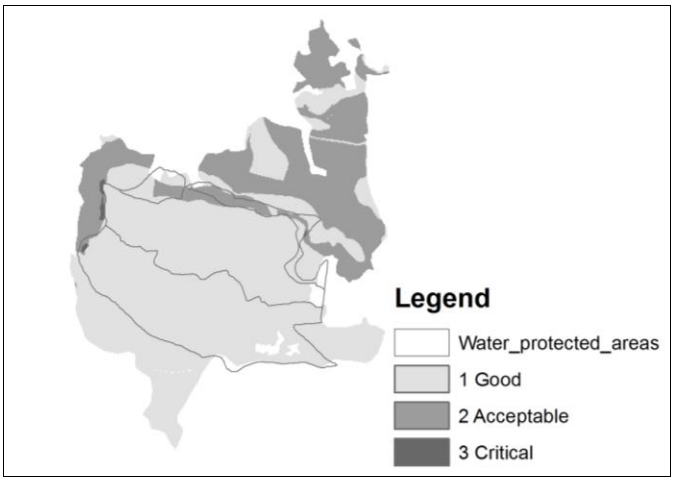


Figure 2. *The map of hydrologic needs*

In the surrounding area where the main forests role is productive external factors were good on about 49% area, acceptable on about 50% while on more then 1% area were present steep terrain with high erodibility and low porosity.

On this area forest vegetation should be treated by silvicultural measures (vegetation conversion, forest stands establishment or completing, mechanical measures for erosion prevention) in order to compensate and improve terrain and soil condition.

The map of forest capacity to maintain hydrological function was based on the internal factors (forest stand structure, canopy, management regime) (Figure 2). The light grey areas are related to high forest capacity (dominant beech-fir stands, closed canopy and sanitary cutting), the medium grey are connected with acceptable and dark grey areas with low forest capacity to maintain hydrological function (spruce or coppice stands, broken canopy and regular cutting). Here should be planed improved forest management activities in order to enhance forest protective function. Measures related to less intensive selective cutting, species conversion, plant completion or soil melioration could be used.

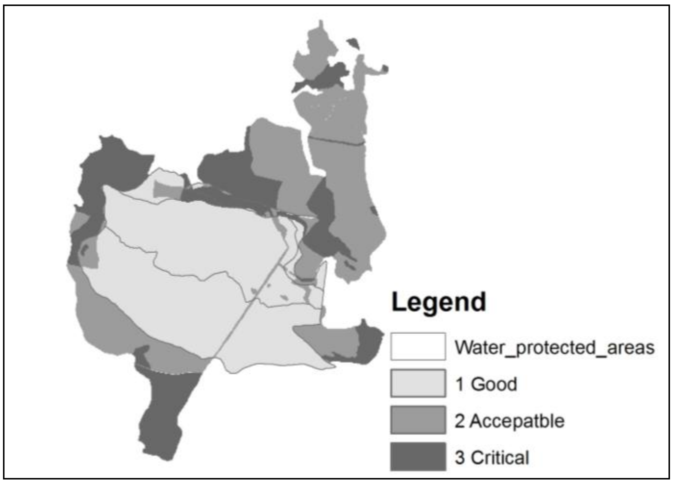


Figure 2. *The map of forest capacity*

It was found that on more then 90% of catchment's area forest stand condition were god while on about 4% of area the internal factors were critical. On surrounding area in productive forest about 3% of area had good external condition, about 58% acceptable condition while on about 39% of area corective measures should be conducted (to improve management system or silvicultural activities).

Compiling maps of resulting external and internal factors the final map of stand hydrological condition was derived (Figure 3).

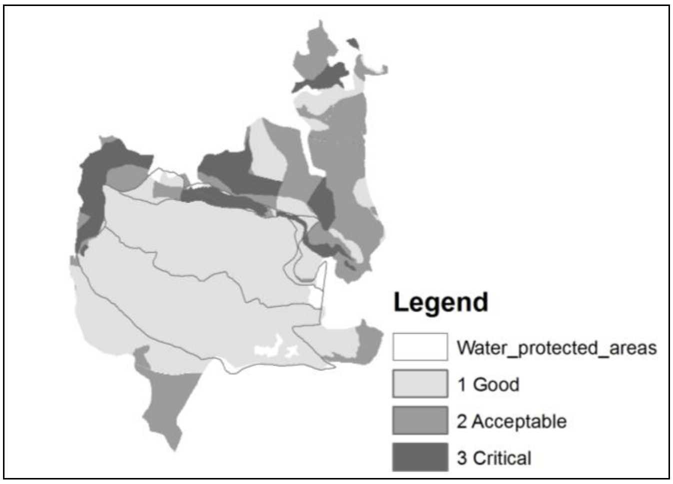
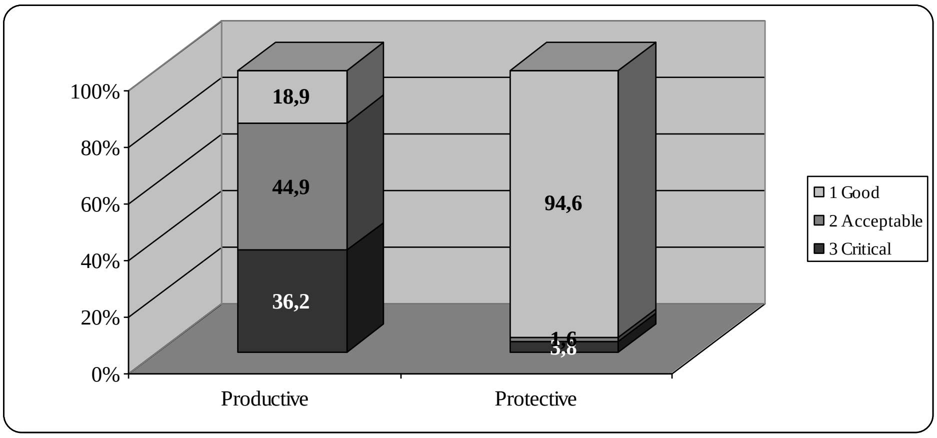


Figure 3. *The joint map of hydrologic condition*



Graph 1. *Percentage of area with different hydrological conditions*

Here were determined areas with good (light grey), acceptable (medium grey) and critical stand hydrological condition (dark grey). In protective catchment's area about 95% hydrological function based on external and internal factors was good (Graph 1). In surrounding forested area only about 19% area had good hydrological function. On about 45% of area the hydrological function was acceptable while on about 36% area conditions for maintaining hydrological function were critical. It is visible and logical that the worse conditions appeared on area overlaid by bad external and internal factors. Here are present spruce or coppice forests with broken canopy on steep erodable positions. Spruce has shallow root system with plenty of peripheral roots negative influencing erodibility and porosity. Also here are even-aged young stands with broken canopy with decreased potential to maintain hydrological function. On the final map are visible areas where compensative and corrective measures should be conducted.

4. DISCUSSION

Classical forest management prefers productive function of forests although recognize other forest functions too (protective, hydrological, social and others). Forest management plans consider hydrological function of forest and try to maintain water potentials on forested areas assuming complete environmental protection.

GIS modelling based on digitized forest stands and catchment's area zones compiling with thematic raster derived from official forest management plan and watershed management elaborate resulted with presented thematic maps. Critical areas are determined and visualized specifying inadequate terrain and forest stand conditions related to hydrologic function on study area. Resulting map for forested catchment's area of Paljanska Miljacka watershed showed large area with emphasized hydrological function while in neighbourhood commercial forests several stands are assigned as areas of high risk in hydrological sense.

It is visible that hydrologic function is preserved in catchment's area even regular cutting or cutting with limitations were performed on the dominant part of area. It points out that forest management activities are suitable and did not have negative influence on terrain and hydrological capacity. Also it is visible that GIS modelling confirmed emphasized hydrological potentials on area that were assigned as watershed protective.

Obtained results are consistent with findings in Rajić-Bijelić (2011). Noticed differences originate from different classification system of external and internal factors. Those factors could be extended and harmonized with other available information from regular forest taxation. It could contribute to develop the complex models in forest management planning process.

5. CONCLUSION

Classical sustainable forest management is based on productive forest function but support other forest functions (protective, hydrological, social and others) in a mutual interaction aiming to use, preserve and improve natural resources. Recent technological possibilities, especially GIS contribute in research of interaction of environmental and management factors in forest management planning.

Here is analyzed hydrological function of forest in one forest management unit containing catchment's area of Paljanska Miljacka watershed. Obtained results support the fact that regular forest management activities consider and maintain hydrological function as integral part sustainable forest management especially in catchment's area. Selective cutting with limitations in the second and third catchment's zones are suitable achieving planned economical issue but preserving high potential of forest to contribute in regular hydrology regime.

More emphasis should be paid on critical area in surrounding steep area with inadequate forest cover having in mind influence of potential erosion caused by extreme precipitation or snow melting. Critical areas could be assigned as priorities for silviculatural measures related to forest condition and soil properties improvement.

Applied methodology used available data and information from regular forest management and could be used as additional tool in regular forest management planning. This research provides methodology adaptable for forest management plans which could strength environmental protection as integral part of sustainable forest management planning.

Further research should clarify to how to integrate proposed approach in procedures used for creation of forest management plan for next management period.

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CURRENT STATE AND PROPOSAL OF RECLAMATION MEASURES IN THE COPPICE TURKEY OAK FORESTS IN THE TERRITORY OF LIPOVICA

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Abstract: *This paper studies the stand state in the coppice Turkey oak forest in a suburban zone of the city of Belgrade, in which Hungarian oak participates with less than 10%. The investigated stand is 65 to 70 years old and it is located in the FMU Lipovica, compartment 30. The number of trees is 495 trees per hectare. Turkey oak accounts for 460 trees per hectare or 92.9%, and Hungarian oak for 35 trees per hectare or 7.1%. Wood volume amounts to 326.1 m^3/ha, in which Turkey oak participates with more than 317.0 m^3/ha or 97%, and Hungarian oak with 9.1 m^3/ha or 3.0%. The study of current diameter and height increment of individual Turkey oak trees shows that the first culmination occurs around the age of 10 (from 5 – 15 years of age) and the second around the age of 35. (from the age of 30 to 40). All the above presented data indicate that the investigated stand is of coppice origin with irregular implementation of tending measures. Future silvicultural treatment should include implementation of reclamation operations with the aim of converting the stand into a high silvicultural form with a more favourable mixture and uneven-aged structure. The final goal is to provide conditions in which the special-purpose forests can fulfill their basic functions, with regard to the specific importance and position of the forest complex Lipovica.*

1. INTRODUCTION

According to data of NFI, (Banković, S. *et al*., 2009), the largest area of state owned forests in Serbia is covered with beech forests (37.3%). They are followed by Turkey oak forests which account for 9.7% of the total area of state-owned forests. However, if we take a look at **forests in private ownership**, we can notice a reverse order in the distribution of these forest complexes. They are dominated by Turkey oak forests that participate with 21.6% of the total area of forests in private ownership. Beech forests are in the second place with 20.4% and Hungarian oak forests in the third place with 11.1% of the total area of privately-owned forests in our country. The share of beech forests in the total wood volume of state-owned forests amounts to 40.1%, while Turkey oak forests, as second ranked, participate with 13%. The share of beech forests in the total wood volume of privately-owned forests is 29.2%, followed by Turkey oak forests which participate with 21.0% and Hungarian oak forests with 11.0%.

In the category of coppice forests, Turkey oak forests are the most frequent and account for 22.4% of the total area of these forests, followed by beech forests that participate with 21.3%. The total area of Turkey oak forests is 345 000 ha, 33.6% of which or 116 000 ha is in state and 66.4% or 229 200 in private ownership. High forests account for 19 600 ha or 5.7% of the total area of Turkey oak forests, while coppice forests cover 325 600 ha or 94.3%. All these data and figures lead us to the conclusion that Turkey oak forests make a significant part of Serbian growing stock. A very high percentage of coppice Turkey oak forests in the total growing stock

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is a result of negative effects of historical and anthropogenic factors. However, these forests have rarely been a subject of scientific investigations, primarily due to low value of their wood assortments or technical timber. Some important investigations have been carried out in mixed forests of Turkey oak and Hungarian oak (J o v a n o v i ć, B., 1954a; 1954b; 1970; 1974; 1986; J o v a n o v i ć, B., D u nj i ć, R., 1951; J o v a n o v i ć, B. *et al*., 1997; J a n k o v i ć, M., 1970; 1974; G a j i ć, M., 1955; 1959; 1980; 1986; G a j i ć, M., T e š i ć, Ž., 1992; S t o j a n o v i ć, Lj., 1987; S t o j a n o v i ć, Lj. *et al*., 2006a; 2006b; 2007; I s a j e v, V. *et al*., 2006; K a r a dž i ć, D., 2006; K r s t i ć, M., 2006; 2008; K r s t i ć, M. *et al*.,2006; 2010; S t a j i ć, S., R a k o nj a c, Lj., 2006; S t a j i ć, S., 2007; S t a j i ć, S. *et al*., 2008; V u k i n, M., Bjelanović, I., 2006, 2010; V u k i n, M., S t a v r e t o v i ć, N., 2007).

A considerable percentage of Turkey oak forests in the total growing stock of Serbia, as well as their high participation in the total wood volume, the importance of Turkey oak wood as an energy source and above all these, the importance the greatest part of the area under these forest complexes has as special purpose forests suggest the need to carry out a thorough scientific investigation of the state of Turkey oak forests and to put forward the proposals of silvicultural operations that have to be carried out. Considering the above mentioned the following research tasks ensued:

- to study the state of the investigated Turkey oak forests;
- to propose optimal reclamation measures with the aim of improving the present state of these forests.

2. MATERIAL AND METHOD

The field data collection was carried out in a coppice Turkey oak forest, in the FMU Lipovica, which is located in the suburban belt of the city of Belgrade. Four sample plots were singled out and the data were collected by applying the principle used on permanent sample plots. Average values for all four sample plots were used in calculations. All field research activities were carried out in the period from 2006 to 2009. The criteria for the selection of stands were affected by the uniformity of site and stand conditions within the selected sample plots. The study included ecological conditions, stand state, development and biological status of trees.

The study of climate, which was carried out within the study of ecological conditions, was based on the data provided by the Republic Hydro-meteorological Service of Serbia for the period between 1990 and 2009. By applying the *Thorntwaite* method, monthly and annual air temperature and precipitation values were used to assess soil moisture deficit and surplus, potential and real evapotranspiration, aridity index, humidity index and climate index. The climate index was further used to define the climate of the investigated area. For the purposes of soil study, the samples taken in the field were analyzed in the Pedological Laboratory of the Faculty of Forestry in Belgrade. Physical and chemical properties, structure, taxonomic classification and origin of the soil were determined. On the basis of phytocoenological recordings taken in the field, a phytocoenological table was made and the phytocoenological classification of the study stands determined. *Braun-Blanquet method* was applied for this purpose. By analyzing and synthesizing the results of pedological and phytocoenological investigations, the stands were typologically classified. Biometric analysis was carried out by using the standard methodology of The Faculty of Forestry in Belgrade. Sample plots were singled out, their stand estimation elements measured and the data collected and analyzed. Dendrometric study included diameter and height analysis as well as the analysis of current height and diameter increment. These measurements were carried out on three mean stand trees that were singled out from the 20% of the largest trees from the dominant part of the stand in each sample plot respectively. The trees were distributed in 5cm diameter degrees. Wood volume (wood mass) was calculated by using the tables after Trifunovic. Height curves and diameter increment lines were analytically fitted. Biological position of the trees was determined. Sample trees provided average data for the study stand, which were then statistically processed at the stand level. Computer software *Statgraph* and *Statistica 6* were used for the statistical data processing. The data are presented both in diagrams and in charts.

3. RESEARCH RESULTS AND DISCUSSION

3.1. Ecological conditions

Due to the format limit of this paper, we can present only the final results of studying the ecological conditions. The selected stand is located at the altitude of 205 m, west facing slope of 5%. It is a coppice stand of Turkey oak, 65-70 years old. Within the study of climatic factors, the following values of the hydric balance elements were obtained: aridity index (I_a) 19.54; humidity index (I_h), 13.37 and climate index (I_k) 2.64. These values indicate that the study area has **a moist subhumid climate of C_2 type.** There were certain variations in the type of climate in the study period, from arid type E (in 2000) to humid temperate type B_2 (in 1999). The soil is classified as lessive brown and phytocoenologically it is a **Turkey oak forest on a plateau (*Quercetum cerris typicum*).** The stand is typologically classified as **a Turkey oak forest on a plateau (***Quercetum cerris typicum***).) on lessive brown soil.**

3.2. Stand state

The basic data on the investigated stand are presented in *Tables 1 and 2*. The total number of trees ranges from 460 to 540 trees per hectare, or on average 495 trees per hectare. Turkey oak accounts for 460 trees per hectare or 92.9% and Hungarian oak for 35 trees per hectare or 7.1%. Mean stand diameter is 26.4 cm. Mean stand diameter of Turkey oak amounts to 26.9 cm, and 18.2 cm of Hungarian oak. All trees are distributed in diameter degrees of 15 to 35 cm, with the maximum abundance in 25 and 30 cm diameter degrees (34%). The line of tree distribution per diameter degrees is a bell-shaped curve which is typical of even-aged forests.

The total wood volume is 326.10 m^3/ha, and ranges from 321.10 m^3/ha to 330.24 m^3/ha. Turkey oak accounts for 316.99 m^3/ha or 97.2%, and Hungarian oak for 9.10 m^3/ha or 2.8%. All these figures indicate that the investigated stand is a pure Turkey oak stand, with an insignificant percentage of Hungarian oak trees. The presence of a small number of Hungarian oak trees in smaller diameter degrees clearly indicates that this species belongs to the lower storey in the vertical stand structure.

Table 1. *Basic data on the study stand*

SAMPLE PLOT	Turkey oak				Hungarian oak				total			
	N		V		N		V		N		V	
	per ha	%	m^3/ha	%	per ha	%	m^3/ha	%	per ha	%	m^3/ha	%
1	400	87.0	305.08	95.0	60	13.0	16.02	5.0	460	100	321.10	100
2	540	100	330.12	100	-	-	-	-	540	100	332.12	100
3	440	84.6	309.83	93.4	80	15.4	20.40	6.6	520	100	330.24	100
4	460	100	322.95	100	-	-	-	-	460	100	322.95	100
average values 1-4	460	92.9	316.99	97.2	35	7.1	9.10	2.8	495	100	326.10	0.4

Table 2. *Average data on the study stand*

FMU Lipovica							compartment 38							sample plot 1-4						
altitude: 205 m							slope: 5°							aspect: W						
TYPOLOGICAL CLASSIFICATION: **Turkey oak forest on a plateau** (*Quercetum cerris typicum*) **on lessive brown soil**																				
diameter degree (cm)	total						Turkey oak						Hungarian oak							
	N		G		V		N		G		V		N		G		V			
	per ha	%	m^2/ha	%	per ha	%	per ha	%	m^2/ha	%	m^3/ha	%	per ha	%	m^2/ha	%	m^3/ha	%		
10																				
15	30	6.1	0.53	2.0	4.70	1.4	10	2.2	0.18	0.7	1.62	0.5	20	57.1	0.35	38.7	3.08	33.8		
20	90	18.2	2.82	10.4	31.88	9.8	80	17.4	2.51	9.6	28.65	9.0	10	28.6	0.31	34.4	3.23	35.5		
25	170	34.3	8.35	30.8	102.86	31.5	165	35.9	8.10	30.9	100.07	31.6	5	14.3	0.25	26.9	2.79	30.7		
30	170	34.3	12.01	44.4	148.11	45.4	170	37.0	12.01	45.9	148.11	46.7								
35	35	7.1	3.36	12.4	38.54	11.8	35	7.6	3.37	12.9	38.54	12.2								
40																				
45																				
Σ	495	100	27.07	100	326.10	100	460	100	26.16	100	316.99	100	35	100	0.91	100	9.10	100		
	d_g = 26.4 cm						d_g = 26.9 cm						d_g = 18.2 cm							
	h_g = 25.3 m						h_g = 27.9 m						h_g = 18.3 m							
	I_v = m^3/ha						I_v = m^3/ha						I_v = m^3/ha							
	p_{iv} = %						p_{iv} = %						p_{iv} = %							
	stand age: 65-70 years.						participation of Turkey oak in the mixture						participation of Hungarian oak in the mixture							
							per N = 92.9%						per N = 7.1%							
							per G = 96.6%						per G = 3.4%							
							per V = 97.2%						per V = 2.8%							
							per I_v = %						per I_v = %							

The basic statistical data are presented in *Table 3*. Analysis of variance shows that the deviations in the total number of trees and in the number of Turkey oak and Hungarian oak trees separately are statistically random. However, there is a significant deviation in the wood volume of all tree species from the normal distribution with regard to skewness (standard kurtosis). Thus, there is a significant deviation of the Hungarian oak wood volume from the normal distribution with regard to skewness (standard kurtosis). Descriptive statistics provided results which indicate an insignificant participation of Hungarian oak in the study stand. Similar results of statistical analyses of the stand state in mixed forests of Hungarian and Turkey oak were obtained by C o j o a c a, F. D. 2010. and C o j o a c a, F. D. *et al.*, 2011.

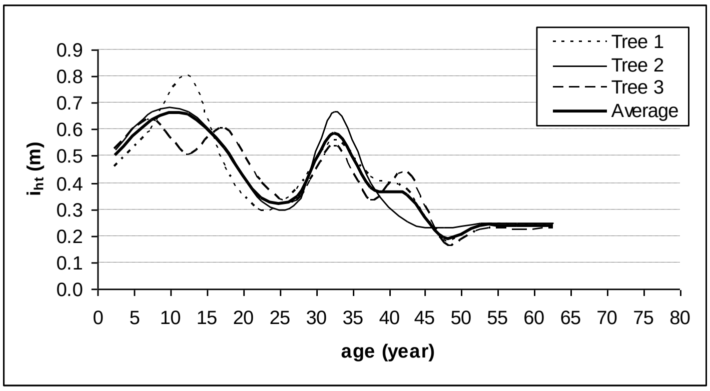
Table 3. *Statistical indicators of diameter and volume structure*

Element	Total		Turkey Oak		Hungarian Oak	
	N	V	N	V	N	V
Count	4	4	4	4	4	4
Average	495.0	326.1	460.0	316.99	35.0	9.10
Standard deviation	41.23	4.77	58.88	11.56	41.23	10.66
Coeff. of variation (%)	8.33	1.46	12.80	3.64	117.80	117.12
Minimum	460.0	321.1	400.0	305.08	0	0
Maximum	540.0	330.24	540.0	330.12	80.0	20.4
Range	80.0	9.14	140.0	25.04	80.0	20.4
Stnd. skewness	0.16	-0.10	0.77	0.145	0.163	0.1175
Stnd. kurtosis	-1.98	-2.15	0.61	-1.42	-1.98	-2.11

3.2.1 Analysis of individual tree development

D e v e l o p m e n t o f h e i g h t a n d c u r r e n t h e i g h t i n c r e m e n t

Development of height and current height increment of the analyzed Turkey oak trees is presented in *Graph 1*.

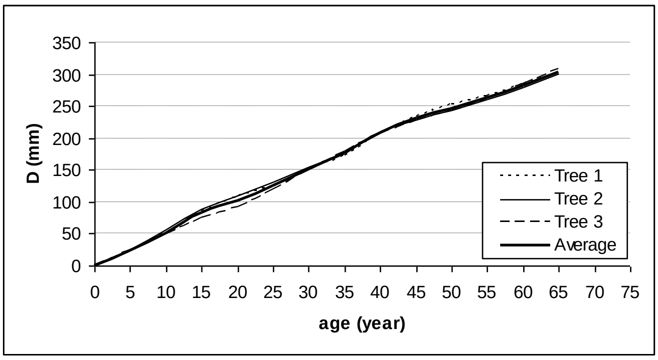


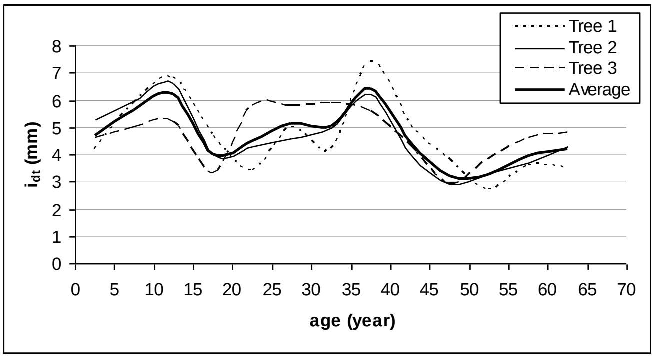
Graph 1. *Development of Turkey oak height and current height increment in the study stand*

The analysis of the current height increment shows that the first culmination occurs when the stand is approximately 10 years old (5-15 cm), which is followed by a sharp increment decline up to the age of 25 years. The second culmination occurs between the age of 30 and 35, followed by a decline until the age of 45 years. After this period, the increment values remain the same until the end of the analyzed age, i.e. 65 years of age. All three analyzed Turkey oak trees have identical flow of height development during the whole analyzed period.

Development of diameter and current diameter increment

Development of diameter and current diameter increment of the studied Turkey oak trees is presented in *Graph 2.* The line of development of current diameter increment clearly shows that the first culmination occurs between the age of 10 and 15, which coincides with the first culmination of current height increment. This is a common occurrence in coppice forests. The second culmination of current diameter increment occurs between the age of 35 and 40 years. Then the values of current diameter increment decline until the age of 50, when they start to increase again. This flow of current diameter increment is the result of the coppice origin of the trees and the absence of tending measures, i.e. thinning during the development of these stands.





Graph 2. *Development of diameter and current diameter increment of Turkey oak in the studied stand*

Proposal of reclamation measures

Based on the investigated ecological conditions, stand state and development of individual Turkey oak trees, we can propose appropriate reclamation measures which should be carried out with the aim of improving the state of the studied stand. The stand is characterized as a good (quality) stand on preserved soil. A set of 180 future trees was singled out. Their mean diameter amounts to 30.3 cm and it is larger than the mean stand diameter by 3.9 cm. All the selected trees are in the larger diameter degrees from 25 to 35 cm, which clearly shows that they were selected from the dominant part of the stand. Taking into consideration that the stands in the FMU Lipovica have been often thinned in the past several decades, weak selective thinning of 10% per tree number and per wood volume is proposed. Since the investigated stand is characterised as a pure Turkey oak coppice stand of even-aged structure and in the category of special purpose forests, the proposed reclamation operations will **combine three regeneration methods**, with the aim of converting the stand into a high silvicultural form, with a more favourable mixture of tree species, a higher percentage of Hungarian oak and other autochthonous valuable broadleaves and attainment of uneven-aged stand structure. The first regeneration method consists of enabling natural regeneration in the greatest part of the area. This type of regeneration should be accompanied with the *method of reserve trees*, as a specific part of reclamation operations. A certain number of vital and good-quality Turkey oak trees (50-60 trees per hectare) will be retained in the form of reserve trees for the duration of two rotation periods, while the rest of the stand regenerates naturally. At the same time, the stand should be artificially regenerated by sowing or planting (according to I s a j e v, V. *et al*., 2006a; 2006b) and by introducing individual trees or groups of different valuable broadleved species (Hungarian oak, ash, maple, red oak, fruit trees, etc) as well as some conifers (Atlas cedar). Since the study stand has a special importance in the system of suburban forests of the city of Belgrade, this operation should be carried out **gradually, over a longer period of time** in order not to endanger the safe running of the special purpose forests (K r s t i ć, M. 2008a; 2008b). This careful, specific and planned performance of reclamation operation is at the same time a **model solution** for improving the state of special purpose forests – special purpose forests of the oak belt in Serbia.

4. CONCLUSIONS

Based on the studied ecological conditions, stand state and development of individual trees in the pure Turkey oak stand in the territory of the forest complex Lipovica, the following conclusions can be made:

- the investigated Turkey oak stand is of coppice origin, about 70 years old, typologically defined as a **Turkey oak forest on a plateau** (*Quercetum cerris typicum)* **on lessive brown soil;**
- the total number of trees is, on average, 495 trees per hectare and the wood volume amounts to 326.10 m^3/ha;
- the first culmination of the current height and diameter increment is attained at almost the same time, around the age of 10 years, while the second culmination of the current height increment occurs between the age of 30 and 31, and the current diameter increment culminates for the second time between the age of 35 and 40;
- stand state, reduced tree crowns, development of height and diameter increment all indicate the absence of appropriate tending measures in the development of these forests;
- reclamation measures should be carried out by applying the method of reserve trees, which means that 50-60 Turkey oak trees will be retained, for the duration of two rotation periods, and a combination of natural and artificial regeneration will be applied on the whole area. At the same time, individual trees or groups of trees of other species, primarily of autochthonous valuable broadleaves should be introduced over a longer period of time;
- the proposed reclamation operations will enable the attainment of the desired silvicultural objective – a high, to some extent uneven-aged stand with a favorable mixture of different tree species, which can be managed on a significantly longer orientation rotation basis. The stand, regenerated and established in such a way will be able to enable smooth running of all functions of special purpose forests which are at the same time forests of special importance.

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SECTION VI

FOREST PROTECTION

CHAIRMEN – MODERATORS

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USE AND EFFICIENCY OF SOIL HERBICIDES IN CONTROLING COMMON RAGWEED (*Ambrosia artemisiifolia* L.) IN SPRUCE SEEDLINGS (*Picea abies* L. Karst) PRODUCTION

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Abstract: *Common Ragweed (Ambrosia artemisiifolia L.) is a weed very difficult to suppress due to its aggressiveness, strength and adaptability and in that respect it is one of the most dangerous weeds. The research was conducted during 2007 and 2008 on the sample plot set in a nursery (where two year- old spruce seedlings were transplanted) in the nursery "Stanovi" Doboj. The following herbicides were used: (1) Lasso-atrazine (a.s. alachlor+atrazine) with a dose of 3.5 +1.5 l/ha and concentration of 0.83% (2) Goal (a.s. Oxyfluorfen) with a dose of 3 l/ha and concentration of 0.5% and (3) Racer 25-EC (a.s. Flurohloridon) with a dose of 2.5 l/ha and concentration of 0.31%. The number of plants is determined by counting the total plants 75 days (in 2007) and 60 days (in 2008) after the completion of the treatment. Based on the obtained data, the efficiency coefficient (CE) was calculated for certain herbicides, which represents the relative ratio between the destroyed Ambrosia plants in relation to their number on the control plot.*

The number of Ambrosia plants on the control plots in the first and second year of production was 108, i.e. 72 per square meter. In experimental fields, where Lasso-atrazine treatment was performed, the efficiency ratio in the first year was 76%, while in the second year it was 86%. In the plots where Goal was applied, the efficiency ratio was 77%, while in the second year it was 89%. In the plots where Racer was applied, the efficiency coefficient was 94%, and in the second year it was 96%. According to the presented results we can conclude that the treatment against Ambrosia plants with Racer was the most efficient one, both in the first and in the second year of study in the nursery, while Lasso-atrazine treatment had the least effect in both years.

Keywords: herbicides, Ambrosia control, spruce seedlings

INTRODUCTION

Weed population and the problem of its prevention present a major limitation factor in the production of quality spruce seedlings. In this respect Common Ragweed (*Ambrosia artemisiifolia* L.) is one of the most dangerous weeds. Ambrosia is a plant that occurs in late spring, a one-year hardy herbaceous plant that only reproduces in a generative way, with the optimum temperature for germination of 20-22 °C. This weed-ruderal plant is characterized by aggressiveness, resilience and pronounced adaptability, which is very difficult to suppress. Aggressiveness and rapid expansion of this species is a result of biological and ecological

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characteristics (pronounced phenotypic plasticity, rapid growth and rapid reproduction, high dispersion potential, seeds longevity /up to 40 years/ in the soil) and global warming on our planet (Vrbničanin, S., Malidža, G. 2008). The same authors suggest, according to Weber and Gut's (2005), that there are only three weed species in Europe with a greater spread potential than Common Ragweed. This indicates that it is a highly invasive species which quickly occupies the most unstable ecosystems, from where it rapidly expands. It was brought to Europe (Germany) from North America in 1863. When it became a domestic plant, ragweed also spread to the territory of other countries such as Italy, Switzerland, France, Austria, Hungary, Slovakia, Poland, Slovenia, Croatia, Bosnia, Serbia, etc. In our region, ragweed occurs after the Second World War (Kojić, M. et al., 1996). The number of plants in some localities ranges from a few hundred to a few thousand plants per m². Vrbničanin, S., Malidža, G. (2008) state, according to Mataruga, D. (2006), that in Bosnia, in the region of Kozarska Dubica 4112 plants per m² were reported. It is a strong competitor, prone to hybridization, and it is characterized by high population variability (Vrbničanin, S. , Malidža, G. 2008). In addition, ragweed pollen causes severe allergic reactions, and besides being a major problem in plants production, this weed species is dangerous to human health. One gram of pollen contains approximately 30-35 million pollen grains, and a well-developed plant, depending on the habitat quality, can produce more than 45 grams of pollen per year (Fumanal et al., 2005). According to Vrbničanin, S. and Malidža, G. (2008), one Common Ragweed plant, in the stage of full flowering, emits up to 2.5 billion pollen grains during the day. Considering the fact that people who are sensitive to pollen respond to a concentration of 10-(15)-30 of pollen grains per 1 m³ of air, it is quite clear what problem ragweed pollen causes these people during August and September. According to Taramarcaz et al., (2005), about 10 grains of ragweed pollen in m³ of air cause allergic reactions in more sensitive people, which is five times smaller amount than the amount of grass pollen. All this supports the notion that the ragweed, considered from different aspects, is a highly harmful and dangerous weed, which therefore imposes the need for timely implementation of appropriate suppression measures.

Considering the fact that weed control in large forest nurseries is nowadays justifiably and most often based on the use of chemical substances for fighting against it (using herbicides), our goal was to investigate the efficiency and selectivity in the application of herbicides after transplantation and before the beginning of the seedlings primary growth on weed-free soil, with the aim to suppress ragweed in spruce transplant bed.

While in the field of agricultural production significant attention is paid to the issue of weed vegetation and its control by using herbicides, in forestry this problem is unfortunately given too little attention and only a small number of authors are engaged in research related to weed control in forest nurseries. Therefore, there is almost no literature data concerning the results of the application of herbicides in controlling weed populations, especially ragweed, in spruce seedlings production. According to Zekić, N. (1983), in preemergence phase the following herbicides are_acceptable for use in a spruce transplant bed: Radazin T-50, T-50, Atrazine and Atrapin 300 from the triazine group, then Caragard combi A-50, Caragard combi 500, combi Caragard A-5-G as combination of triazine, and terbutilazine which has a wider range of action, and Lasso, Alachlor and other herbicides based on active substance alachlor, and finally Simazin S-50, Radokor and Simapin 50. According to the results of a two- year study on the efficiency of flumioxazin, isoxaben, oxyfluorfen, simazine and sulfentrazone in the production of Christmas trees, Richardson, R., Zandstra, B. (2009), claim that in both years flumioxazin showed the greatest efficiency against Common Ragweed. Vasić V., Konstantinović B. (2008), based on a two-year research on the efficiency of herbicides (pendimethalin+prometryn, acetochlor+prometryn and acetochlor+metribuzin) in weed control in the production of poplar seedlings, indicate that in the research years a combination of acetochlor+prometryn showed the highest efficiency. Besides pendimethalin, Woeste et al. (2005) also tested the influence of azafenidine, simazine and sulfometurone on the development of oak, walnut, American ash, and other species during three years. Applied herbicides did not have a negative impact on the growth of seedlings and herbicide azafenidine showed the highest efficiency in weed control.

MATERIALS AND METHODS

A two-year research was conducted during 2007 and 2008 in the central nursery "Stanovi", which operates within the PFE "Forests of Republic of Srpska" a.d. Sokolac - "Centre for seed and nursery production" Doboj. After transplanting two-year old spruce seedlings (2+0), from the provenance "Han Pijesak", the most homogeneous lei was selected from the micro-orographic aspect and the trials were conducted on it. The choice of treatments types was carried out in a randomized block design with four replications (blocks) on the surface of 40 m². Each repetition was divided into three experimental and one control field, the size of 2.5 m², which means that the total number of sample plots is 16 (Photo 1.). In order to separate the treatments, buffer zones of the same size were set up between the sample plots. On the first three sample plots was studied the efficiency of herbicides which were applied after transplantation and before the beginning of the primary growth of spruce seedlings, weed-free soil (preemergence phase), and they included: (1) Lasso-Atrazine (a.s. Alachlor+Atrazine), (2) Goal (a.s. Oxyfluorfen) and (3) Racer 25-EC (a.s. Flurohloridon), while the fourth sample plot represented the control plot.

Photo 1. *Layout of the trial*

The treatments were carried in operational doses and concentrations which are used in the nursery "Stanovi" (Tables 1. and 2.). The characteristics of these herbicides are presented in numerous publications where they are described in detail (Janjić 1994, Janjić and Mitrić 2004; Kojić and Janjić 1994. etc.).

Table 1. *Treatments in the first year of trial*

R. br. Number	Naziv preparata Name of products	Aktivna materija Active substance	Doza (l/ha) Dose (l/ha)	Koncentracija (%) Concentration (%)	Dat. tretmana Date of treatment
1.	Lasso + Atrazine	*alachlor + atrazine*	5 (3.5+1.5)	0.83	05.04.2007.
2.	Goal	*oxyfluorfen*	3	0.5	05.04.2007.
3.	Racer 25-EC	*flurohloridon*	2.5	0.31	05.04.2007.

Table 2. *Treatments in the second year of trial*

R. br. Number	Naziv preparata Name of products	Aktivna materija Active substance	Doza (l/ha) Dose (l/ha)	Koncentracija (%) Concentration (%)	Dat. tretmana Date of treatment
1.	Lasso + Atrazine	*alachlor + atrazine*	5 (3.5+1.5)	0.83	09.04.2008.
2.	Goal	*oxyfluorfen*	3	0.5	09.04.2008.
3.	Racer 25-EC	*flurohloridon*	2.5	0.31	09.04.2008.

The total number of ragweed plants on the sample plots and control plots was determined by counting them, 75 days (2007) and 60 days (2008) after the completion of the treatment with herbicides. Based on the obtained data, the efficiency coefficient (CE) was calculated for certain herbicides, which represents the relative ratio between the destroyed ragweed plants compared to their number on the control plot.

Phyto-toxicity of the tested herbicides was determined by EWRC scale.

For simpler presentation of the research results, the treatments are coded as follows:

LA – Lasso-Atrazine treatment
G – Goal treatment
R – Racer 25-EC treatment
K – Control,
I, II, III, IV – Number of repetition

RESEARCH RESULTS AND DISCUSSION

According to the obtained results (figure 1.) it can be concluded that in the first year of trial the total number of ragweed plants on control plots was 1078 (107.8 per m^2), and in the second year of trial it was 724 (72.4 per m^2). On the sample plots where the treatment with Lasso-Atrazine was performed, the total number of ragweed plants in the first year of trial was 264 (26.4 per m^2) or 24% compared to the control plots, and in the second year it was 99 (9.9 per m^2) or 14%. In the experimental fields where Goal was applied, the total number of ragweed plants in the first year of trial was 250 (25 per m^2) or 23%, compared to their number in the control plot, while in the second it was 82 (8.2 per m^2) or 11% as compared to the control plot. On the sample fields where the treatment with Racer 25 EC was carried out, the total number of ragweed plants was the smallest and in the first year of trial it was 69 (6.9 per m^2) or 6% compared to the control plot, while in the second year it was 27 (2.7 per m^2) or 4% compared to the total number of ragweed plants in the control plot.

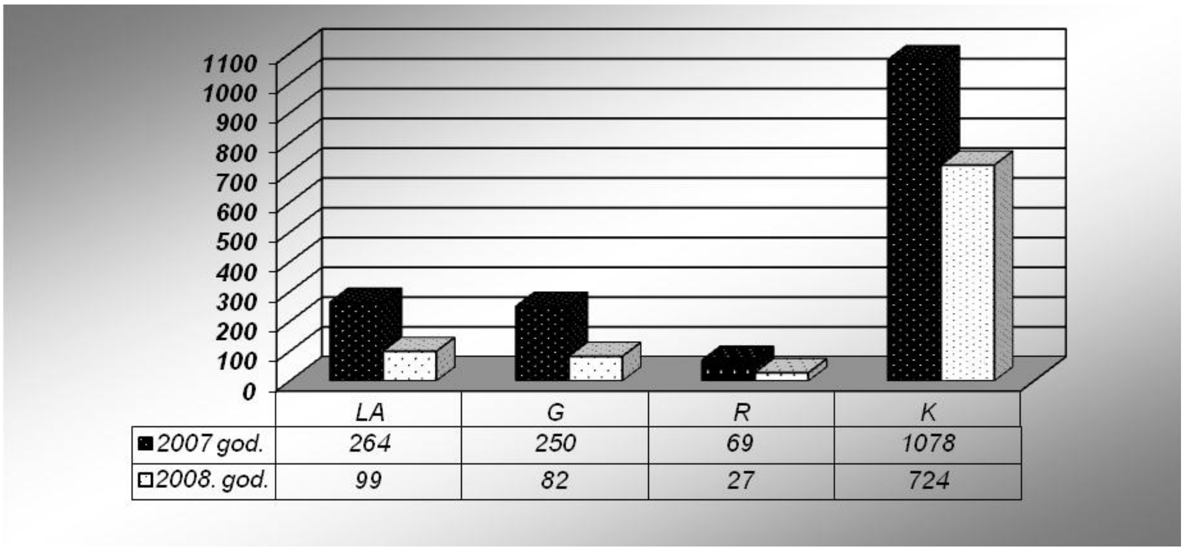

Figure 1. *Total number of Common Ragweed plants by treatments*

Based on the obtained data on the number of ragweed plants, the efficiency coefficient (CE) for the applied herbicides was calculated (table 3.).

Table 3. *Efficiency coefficient in (%) for the applied herbicides*

Year of research	***Efficiency coefficient in (%)***		
	alahlor + atrazine	*oxyfluorfen*	*flurohloridon*
2007	75.51	76.81	93.60
2008	86.33	88.67	96.27
Phyto-toxicity by EWRC scale (1–9)	1	1	1

In both years of research Racer 25-EC (*a.s. flurohloridon*) showed the greatest efficiency coefficient, whose value in the first year of trial was 93.60%, and in the second it was 96.27%. Lasso-Atrazine (*a.s. alachlor+atrazine*) in both years of trials showed the lowest efficiency, where the efficiency coefficient in the first year was 75.51%, while in the second year of research in spruce transplant bed it was 86.33%. According to the values of the efficiency coefficient (76.81% in the first year and 88.67% in the second year) Goal (*a.s. oxyfluorfen*) showed approximately the same level of efficiency as Lasso- Atrazine in both years. The tested herbicides did not have a phyto-toxic effect on spruce seedlings (table 3.).

Weediness measured 75 days after the treatment completion in the first year and after 70 days in the second year, is presented in photos 2-5 and 6-9.

Photo 2. *LA/II 17.06.2007.*

Photo 3. *G/II 17.06.2007.*

Photo 4. *R/II 17.06.2007.*

Photo 5. *K/II 17.06.2007.*

Photo 6. *LA/I 21.06.2008.*

Photo 7. *G/I 21.06.2008.*

Photo 8. *R/I 21.06.2008.*

Photo 9. *K/I 21.06.2008.*

During a two-year research Richardson, R., Zandstra, B. (2009) studied the efficiency of soil herbicides (flumioxazin, isoxaben, oxyfluorfen, simazine, sulfentrazone) in ambrosia suppression in the production of Christmas trees. Based on the obtained results, flumioxazin, which was applied in a dose of 0.43 kg/ha, showed the highest efficiency coefficient (80%), while sulfentrazone, which was applied in a dose of 0.56 kg/ha, showed the lowest level of efficiency (11%). Oxyfluorfen (Goal), which was applied in a dose of 1.12 kg/ha (much less compared to a dose of 3 l/ha which was applied during our research), showed the efficiency coefficient of 46%, which indicates that with small doses a significant degree of efficiency in ragweed control can't be achieved.

Mataruga, D., et al. (2004) studied the efficiency of Herbokor SL (*a.s. glyphosate 480 g/l*) in the control of ragweed. According to the obtained results, herbokor showed a high degree of efficiency and depending on the applied dose and the growth stage of ragweed, it ranges from 54.6% to 100%. The same authors suggest that high efficiency in suppressing ragweed can be achieved with a small amount of this herbicide, and if applied in a quantity of 2.5 l/ha at the time when the ragweed is up to 5 cm heigh, the efficiency ratio relative to the above-ground plant mass was 81.2%, while if implemented at the time of the formation of flowers the efficiency ratio was 98.8%. Considering the type of the action, the use of glyphosate is limited to a period of spruce seedlings dormancy, since at this stage it shows tolerance to this herbicide. This means that glyphosate treatment can be carried out only in early spring, before the opening of the buds and the beginning of the primary growth, when there is no ragweed plants occurrence, or in fall, after the formation of the buds and the plants stop growing, and when the ragweed plants have already reached seed formation phase and spread the seeds over an area. However, the fact that spruce seedlings enter a dormancy phase that lasts 7-10 days in one part of the growing season, usually late July or August (depending on the weather conditions), makes foliar application of glyphosate in this period possible. In addition, this herbicide can be applied during the growing season, but the treatment has to be carried out with shields and between rows of seedlings.

CONCLUSIONS

Common Ragweed (*Ambrosia artemisiifolia* L.) belongs to the category of the most dangerous weeds, both in terms of plant production, and also in terms of human health, which is a result of its biological and ecological characteristics. This requires timely application of appropriate control measures, systematically and at all levels.

The tested herbicides, which were applied in preemergence phase, showed high efficiency in suppressing ragweed, and the treatments led to a significant reduction in the number of plants in spruce seedlings transplant bed. Based on the results of a two-year research, Racer 25-EC (*a.s. flurohloridon)* showed the highest efficiency coefficient in both years, while Lasso-Atrazine (*a.s. alachlor+atrazine*) showed the lowest degree of efficiency in both years.

The tested herbicides, in applied doses, had no phyto-toxic effect on seedlings, and they can be freely used in the production of spruce seedlings after transplantation.

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FLIGHT ACTIVITY AND BIOLOGY OF *Ips sexdentatus* Boerner IN BLACK PINE (*Pinus nigra* Arnold) FORESTS OF ISPARTA, TURKEY

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Abstract: *Bark beetles cause serious losses by their damage in Black pine forest of Isparta region every year. Ips sexdentatus Boerner (Col.: Curculionidae: Scolytinae) is one of the important harmful bark beetle species in these stands. Ips sexdentatus adults are strong fliers capable of covering several kilometers for searching suitable host trees. In Isparta region, sometimes it has higher population and can make epidemic belonging to climatic conditions. By damage, it causes important economic losses in Anatolian black pine forests. This study was conducted to determine flight activity and biology of I. sexdentatus during 4 year between 2006 and 2010. For this aim, Black pine forest of Aksu province in Isparta was choose as research area and studies were conducted in two different stands of this area by using trap trees and pheromone traps. Funnel type pheromone traps and pheromone dispensers and also trap trees are used for catching adults and monitoring of flight activity. Traps were checked weekly periodically and adults' numbers were recorded. Also, biology of I. sexdentatus was monitored by trap tree observations. It was observed that active flight period started when the average temperature was over 10°C in regional conditions and I. sexdentatus (Borner) has three generation. According to adult counting results, maximum population level of I. sexdentatus was occurred in 2009 in Black pine forest of Isparta region in Turkey.*

Keywords: *Ips sexdentatus, Pinus nigra,* Turkey, flight activity, biology.

INTRODUCTION

Tree species in the forests of Turkey are natural species in their spreading area. Nevertheless, their health began to wane by irregular utilization for many years. Large areas that have extreme cultivation conditions are exist because of unplanned and excessive usage. For providing continuity of forest ecosystem and taking advantage of them for many years, forest areas should be protected and developed most effectively.

Forest insect pests are among the most important threats that endanger the continuity of Turkish forests. Damages on stand tress in forests and also storage wood in forest depots by insect pests, cause very important economic losses. In Turkish forests, as well as insects, fungi and other biotic factors also cause damage. Insect damage plays a much more important than other factors. Therefore, more studies focused on controlling of harmful insects.

Bark beetles constitute the most important group among insect pests which cause damage in the coniferous forests of Turkey. These species also may cause serious damage depending on abiotic and biotic factors in the forests Isparta region which is located in the south-western part of Turkey.

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Ips sexdentatus Boerner (Col.: Curculionidae: Scolytinae) is one the most important harmful species among bark beetle species which cause serious economic losses in the coniferous forests of Isparta region especially in Black pine stands of this region.

Ips sexdentatus adults are strong fliers capable of covering several kilometers for searching suitable host trees. In Isparta region, sometimes it has higher population and can make epidemic belonging to climatic conditions. By damage, it causes important economic losses in Anatolian black pine forests.

Determining to flight periods and biology of bark beetles and monitoring of their populations are very important for preventing forest stands against outbreaks. For this reason, monitoring to adult flight period of *Ips sexdentatus* which cause serious damage in Black pine forests, is very important. This also play key role for controlling of this bark beetle by using most effective method in most suitable period. For this aim, Black pine forest of Aksu province in Isparta was choose as research area and studies were conducted in two different stands.

MATERIAL AND METHODS

Field studies were conducted to determine flight activity and biology in Black pine forests of Isparta-Aksu province for years between 2006 and 2010. Funnel type pheromone traps and pheromone lures were used for catching adults and monitoring of flight activity. Also, trap trees were placed for observing to biology.

Studies were carried out in two plot stands; Pazarkoy and Akkaya experiment sites. Observations and field studies were conducted in Pazarkoy site in 2006 and 2007; and also in Akkaya stand 2009 and 2010. Locations and geographical positions of research areas were noted in Table 1.

Table 1. *Locations and geographical positions of experiment sites*

Location	Geographical position	Altitude (m)
Pazarkoy	37º 46′41" N 31º03'56" E	1325
Akkaya	37º 43′ 34″ N 31º 04′ 30″ E	1250

Pheromone traps were hanged in sites and checked weekly and adult numbers were counted and recorded. Pheromone lures including 75 mg Ipsenol were used in each trap. Insect samples which were collected from pheromone traps, brought to laboratory by 15x10 cm size plastic jars and counted. 1 gram weight insect samples were used as scaling criteria and sensitive scale was used for measurements.

Trap trees were used for observing of biology. Five trap trees were prepared for each experimental site and they consisted of 12-16 logs of 15-35 cm diameter and 1m length. These logs were checked weekly and for this aim using entrance holes and sawdust around the stems as a guide, main galleries were opened using knives and axes. Barks were removed carefully and bark samples with beetles were placed in locked bags for carrying to laboratory.

Location, geographical position and altitudes of research areas were determined by using GPS. Daily average moisture and average temperature data were obtained from Aksu Meteorology Station where the closest station to research areas for relating between climatic conditions and biology and population dynamic of *Ips sexdentatus*.

RESULTS

The studies which aimed to determine flight activity and biology of *Ips sexdentatus* in Black pine forests of Isparta-Aksu province were conducted in Pazarkoy and Akkaya experimental sites between 2006 and 2010. The results of observations about flight activity by pheromone traps and also biology by trap trees were given in below.

Pazarköy Experiment Site

The studies were conducted in Pazarkoy Experiment Site in 2006 and 2007. 5 trap trees were placed for each year and also total 36 pheromone traps in 2006 and 12 pheromone traps in 2007 were hanged in site. Trap trees and pheromone traps were checked weekly and observations were made for determining to flight activity and biology.

In 2006, trap trees were placed in 6 March and first adults were seen in 5 April under bark. Larvae were started to find in 3 May, pupae in 24 May and young adults in 7 June. These adults which belong to second generation started to lay eggs in 28 June. Larvae were hatched in 5 July and these larvae started to become to pupa in 19 July. Also, adults of third generation were observed in 1 August in trap trees (Table 2).

Table 2. *Biological observations on trap trees at Pazarkoy experimental site in 2006*

Date	Observations	Date	Observations	Date	Observations
06.03.2006	Trap trees were placed	17.05.2006	Mature larva	12.07.2006	Adult, larva
29.03.2006	No entrance	24.05.2006	Mature larva, pupa	19.07.2006	Adult larva, pupa
05.04.2006	Adults which are open nuptial chamber	31.05.2006	Pupa	26.07.2006	Adult larva, pupa
12.04.2006	Adult, egg	07.06.2006	Pupa, young adult	01.08.2006	Pupa, young adult
19.04.2006	Adult, egg	14.06.2006	Pupa, young adult	08.08.2006	Young adult
26.04.2006	Adult, egg	21.06.2006	Pupa, adult	15.08.2006	Adult
03.05.2006	Egg, young larva	28.06.2006	Adult, egg	22.08.2006	Adult
10.05.2006	Larva	05.07.2006	Adult, egg, young larva		

Pheromone traps were hanged at Pazarkoy Experiment site in 26 March during 2006 trials and first adults started to come traps till first check time in 12 April. In this term, 3780 adults were caught when the average temperature was calculated 12 ºC and average moisture as 61.2 %. Following days, adult number became less till 10 May when average temperature was occurred between 11.4 and 13.6 ºC. In three weeks period between 17 May and 7 June when average temperature varied between 14.4 and 20.6 ºC, adult number increased again. However, observations on trap trees showed that these adults were not belonging to new generation. They probably increased by augmentation of temperature. Second generation adults were caught in 28 June when the average temperature reached 23.9 ºC and also third generation adults in 25 July when the average temperature was 24.6 ºC in that term (Figure 1).

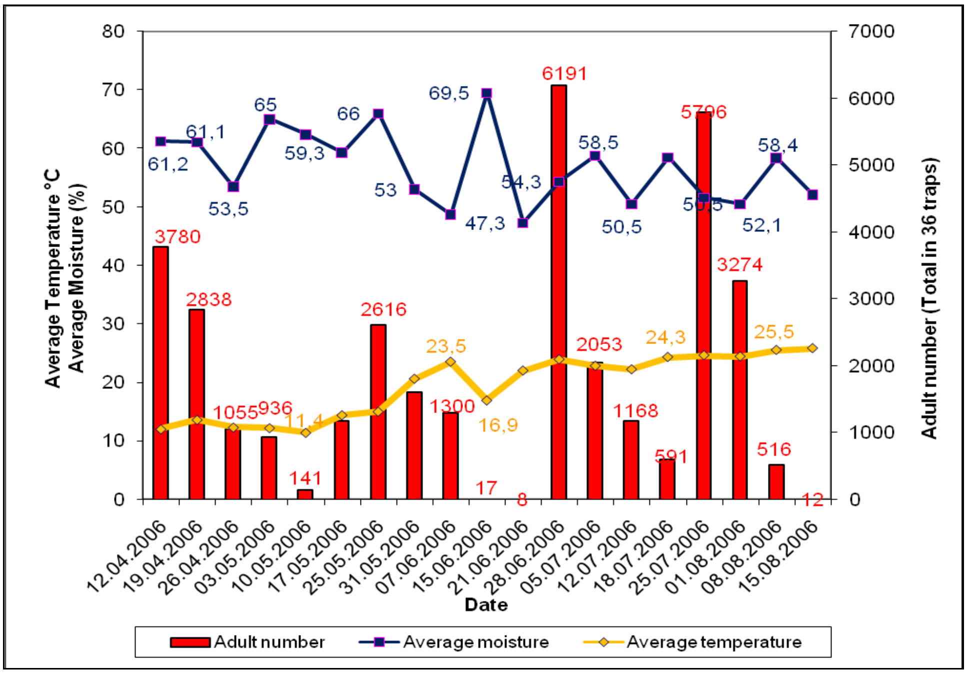

Figure 1. *Flight activity of Ips sexdentatus at Pazarkoy experiment site in 2006*

In 2007, trap trees were placed in 10 March and overwintering adults started to entry in trap trees in 24 April and first laid eggs were hatched in 15 May. Larvae were become to pupa in 29 May and these also started to pass adult period in 12 June. These adults which belong to second generation started to lay eggs in 22 June. Larvae were hatched in 3 July and these larvae started to become to pupa in 24 July. Also, adults of third generation were observed in 6 August in trap trees and young larvae were observed in 13 August. These larvae started to become pupa in 27 August and young adults were started to find in 5 September (Table 3).

Table 3. *Biological observations on trap trees at Pazarkoy experiment site in 2007*

Date	Observations	Date	Observations	Date	Observations
10.03.2007	Trap trees were placed	05.06.2007	Mature larva, pupa	31.07.2007	Pupa, young adult
17.04.2007	No entrance	12.06.2007	Pupa, young adult	06.08.2007	Adults which are open nuptial chamber
24.04.2007	Adults which are open nuptial chamber	19.06.2007	Young adult	13.08.2007	Adult, egg, young larva
01.05.2007	Adult, egg	22.06.2007	Adults which are open nuptial chamber	20.08.2007	Larva
08.05.2007	Adult, egg	03.07.2007	Adult, egg, young larva	27.08.2007	Mature larva, pupa
15.05.2007	Adult, egg, young larva	10.07.2007	Larva	05.09.2007	Pupa, young adult
22.05.2007	Adult, larva	14.07.2007	Mature larva	12.09.2007	Young adult
29.05.2007	Adult, mature larva, pupa	24.07.2007	Mature larva, pupa	19.09.2007	Adult

In 2007, pheromone traps were hanged at Pazarkoy site in 7 March. The adults of first generation were caught in 13 March. Population reached to peak in 1 May when the average (avr.) temperature occurred as 10.4 ºC and avr. moisture as 56.9 %. However, the temperature increased in following weeks, the adults number reduced. This number increased again in 12

June. In that period, avr. temperature was 15.3 ºC and avr. moisture was 69.5 %. There were two significant increasing about population in 24 July and 5 September. The avr. temperature measured as 23.7 ºC and also avr. moisture as 35.1 % in week which include 24 July. In the week of 5 September, the avr. temperature was calculated as 20.2 ºC and avr. moisture as 55.9 % (Figure 2).

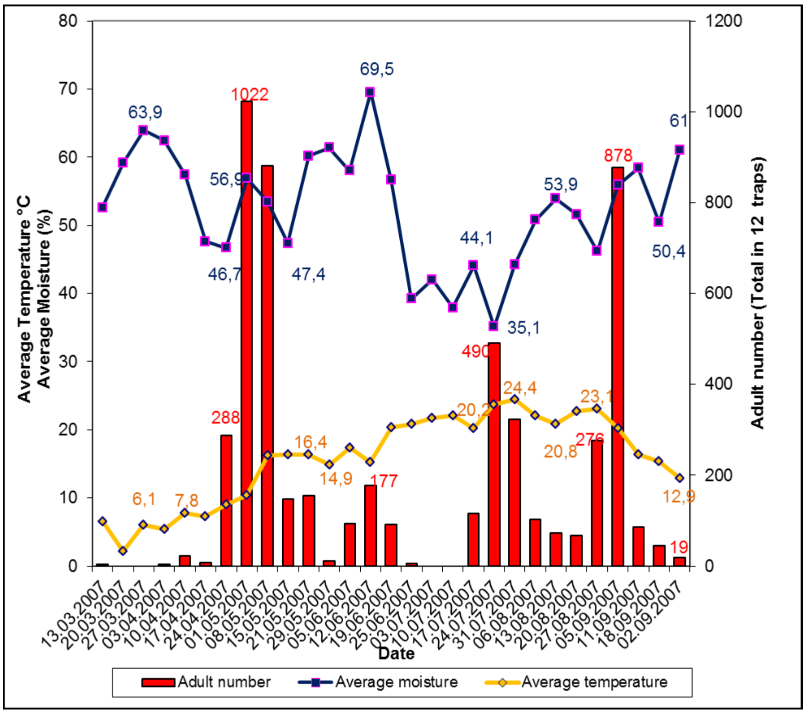

Figure 2. *Flight activity of Ips sexdentatus at Pazarkoy experiment site in 2007*

Akkaya Experiment Site

The studies were conducted in Akkaya Experiment Site in 2009 and 2010. 5 trap trees were placed in 2009 and also 20 pheromone traps were hanged to site for both of 2009 and 2010.

In 2009, trap trees were sited in 4 April. First adults were started to find from 25 April in trunks. First eggs were seen in 2 May and from these egg, larvae started to hatched in 15 May and they were become pupa in 30 May. Second generation adults started to lay their eggs in 3 June and they became pupa in 25 June. Third generation adults started to fly in 15 August (Table 4).

Table 4. Biological observations on trap trees at Akkaya experiment site in 2009

Date	Observations	Date	Observations	Date	Observations
04.04.2009	Trap trees were placed	06.06.2009	Mature larva, pupa	01.08.2009	Mature larva, pupa, young adult
11.04.2009	No entrance	13.06.2009	Pupa, young adult	09.08.2009	Pupa, young adult
25.04.2009	Adults which are open nuptial chamber	20.06.2009	Pupa, young adult	15.08.2009	Young adult, adult
02.05.2009	Adults laying egg	27.06.2009	Young adult, adult	22.08.2009	Adult
08.05.2009	Adult, egg	03.07.2009	Adult, egg	29.08.2009	Adult
30.05.2009	Mature larva, pupa	25.07.2009	Larva, mature larva, pupa		

Pheromone traps were hanged in Akkaya Experiment site in 1 April for 2009. The first adults were seen first in 18 April. Following days, population became higher till 25 April when the average temperature was 10.2 °C and average moisture was 60.5 %. After this day, adult number counted less. These number increased in 15 May and also in 3 July when avr. temperature occurred as 19.7 °C and avr. moisture as 56 % (Figure 3).

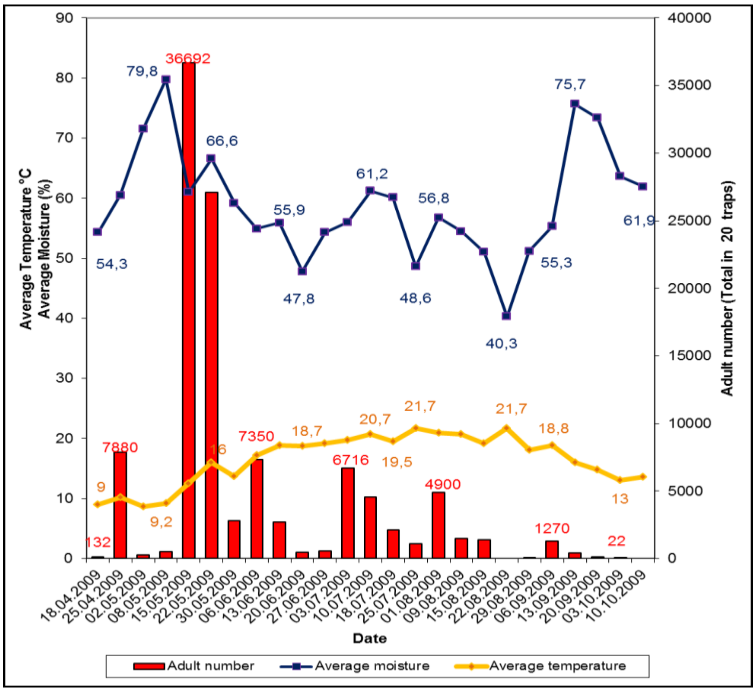

Figure 3. *Flight activity of Ips sexdentatus at Akkaya experiment site in 2009*

In 2010, adults started to come to traps in 30 April. Population reached peak in 14 May when average temperature was 15.6 °C and avr. moisture was 57.2 %. After this date, population decreased and it significantly rise again in 10 July when avr. Temperature occurred as 21.4 °C and avr. moisture as 65.3 %. Since that time, adult number reduced and it showed a little increasing in 4 September when avr. temperature was 19.1 °C and also avr. moisture was 61.4 % (Figure 4).

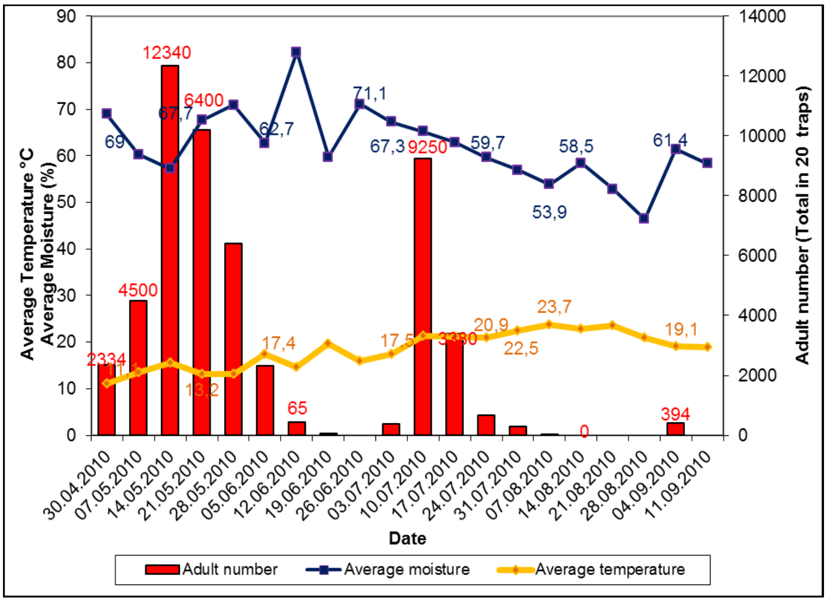

Figure 4. *Flight activity of Ips sexdentatus at Akkaya experiment site in 2010*

As result of studies which have been conducted by using trap trees and pheromone traps, it was determined that *Ips sexdentatus* (Borner) has three generation in Black pine forest of Isparta region. Little differences were shown between flight periods of each year belonging to climatic conditions. However, the first flight period occurred mostly in the end of April and in the first half of May. Second generation was observed in the end of June and in the first half of July and third generation was in the second half of August and in the beginning of September. It was observed that active flight period started when the average temperature was over 10°C in regional conditions.

According to adult counting results, totally 35078 adults were caught in 36 pheromone traps in 2006 and also 5383 adult came to 12 traps in 2007. In 2009, totally 110446 adults were counted in 20 pheromone traps and 52988 adults were caught in same number traps in 2010. Adults number for per trap were counted as 975 in 2006, 449 in 2007, 5522 in 2009 and 2649 in 2010 respectively. So, it is easily can be seen that maximum population level of *I. sexdentatus* was occurred in 2009 in Black pine forest of Isparta region in Turkey.

DISCUSSION

Ips sexdentatus (Boerner) is spreading in very large areas which include Europe, Caucasus, Asia minor, Siberia, Korea, Japan and North China. In these regions *Pinus sylvestris, P. nigra, P. leucodermis, P. sibirica, P. koraiensis* and *Picea orientalis* were reported as host trees (Pfeffer, 1995; Kolk and Starzyk, 1996; Faccoli, 2004; Gilbert et al., 2005).

In Turkish forests, It was reported that this pest is harmful on *Abies nordmanniana* subsp. *bornmülleriana, A. nordmanniana, Picea orientalis, Pinus brutia, P. nigra* and *P. sylvestris* trees in Black Sea, Middle Anatolia, Aegean, Mediterranean and Eastern Anatolia parts of Turkey (Defne, 1954; Chararas, 1966; Tosun, 1975; Serez, 1984; Yuksel, 1998; Sekendiz, 1991 and Yuksel et al., 2000).

The number of generations per year and the timing of the life cycle depend on climate. The species has only one annual generation north of the Arctic Circle, two generations in central areas of Eurasia and four to five generations in the Mediterranean area and in other areas with a long, warm summer season. The spring flight starts when the temperature exceeds about 20°C; in the north this is in May/June, in southern areas in March/April (Vité et al., 1974).

There were several studies about biology of *Ips sexdentatus* in Turkish forests. Chararas (1966) reported that generation number changed belonging to elevation in oriental spruce (*Picea orientalis*) forests in north-eastern of Turkey and it had two generation in 1000 meter elevation and one generation between 1400-1800 m. Also, Serez (1983) and Serez and Zumreoğlu (2001) determined as two generation in same forests. In addition to these, Yuksel (1998) studied in spruce forests and determined the generation number as mostly two and also three in lower elevations and appropriate weather conditions.

Selmi (1998) reported that *Ips sexdentatus* has usually two generation in Turkish forests and first flight period occurred in April-May and second was in June-July. He also noted that third generation might have started in favorable climatic conditions. Yuksel et al. (2000) determined the generation number as two in *Pinus sylvestris* forest of Sarikamis where is located in the eastern part of Turkey. Tosun (1975) stated that this species has two generation in coniferous forests of the Mediterranean part of Turkey where our experiment sites were situated. That study reported, first flight period was in May and second was in August.

In our study, it was determined that *Ips sexdentatus* (Borner) has three generation in Black pine forest of Isparta region and little differences between flight periods belonging to climatic conditions.

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OCCURENCE OF PATHOGENS FROM THE *Phytophthora* GENUS IN FLOODED FORESTS OF THE LOWER SREM

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Abstract: This paper presents the results of the investigation of occurrence of pathogens from the *Phytophthora genus* in higrophilic forests, *Fraxino angustifoliae - Quercetum roboris*, in the manage unit “Grabovacko - Vitojevacko ostrvo”. This area is under the impact of flooded water from Sava river, or under the impact of underground water in the no flooded period, and due to its habitat characteristics creates a favorable conditions for the development of pathogens from the *Phytophthora* genus.

The study has been performed during the growing season in the year 2011, at five locations in alluvium of Sava river. The observation of the fluctuations of groundwater levels is the ongoing project at the same localities.

Numerous *Phytophthora* species are related with hosts from *Quercus* and *Fraxinus* genus, and the aim of this study was to determine the presence of these pathogens, as well as to contribute to better understanding of the impact of flood and groundwater for the presence of *Phytophthora* species in this area.

Over 40 *Phytophthora* spp. isolates were obtained during this work, and after a detail morphological and molecular identification of obtained isolates, several different *Phytophthora* species have been confirmed. In addition, many *Pythium* spp. isolates were obtained.

Key words: *Phytophthora*, oak stands, higrophilic forests, water regime

1. INTRODUCTION

Phytophthora species are fungi like organisms within the kingdom *Chromista*, Straminipiles (Kirk et al. 2008). In their thick-walled and long resting structures (oospores and chlamydospores), they are able to survive unfavorable conditions, such as high or low temperatures and droughts, for a long period. Their multicyclic nature, persistance of resting spores and the high agressiveness makes *Phytophthora* species the most dangerous plant pathogen in general (Erwin and Ribeiro 1996). *Phytophthora* species can infect different plant tissues, such as fine roots, bark and cambium of woody roots and stems, shoots and leaves, of a very wide range of host species in parks, amenity plantings and forest ecosystems (Erwin and Ribeiro 1996; Jung et al. 1996, 1999, 2005; Jung & Burges 2009; Jung 2009). The main reason for their almost ubiquitous presence in the world natural and semi natural ecosystems is the growth of international trade of living plants (Brasier 2008), and the introduction of *Phytophthora* species with infected nursery stock into parks, forests and different natural ecosystems (Brasier & Jung 2006). Currently, about 150 species and informally designated taxa are known. Based on the exponential increasment of newly described *Phytophthora* species in the last 15 years (54 species up to 1996 (Erwin & Ribeiro 1996), 94 new species between 1997 and 2009), it is assumed that there might be a total of 500-600 species, or more (Brasier 2009).

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Different type of symptoms that could be indicative for *Phytophthora* infections were recorded in the lower Srem forests, such as wilting of leaves and twigs, dieback of shoots and branches, increased crown transparency, dieback, stem cankers and collar necrosis and deterioration and loss of fine and small roots. Taking into account a great threat posed by *Phytophthora* species to forestry and biodiversity in general (Orlikowski et al. 2011; Jung 2009, Jung et al. 1996, 1999, 2000, 2005; Balci and Halmschlager, 2003a, 2003b; Vettraino, et

al. 2002), a study was conducted during the growing season 2011 with aim to determine the presence and diversity of *Phytophthora* species in these forests.

Observation of fluctuations of underground water on piesometer stations (Fig. 2) is ongoing project in this area for the last 20 years. Localities for this study were chosen to be on these stations in order to check the presence of *Phytophthora* spp. on different depths through the soil profile. Five localities were chosen for these studies (Fig. 1). In total, over a 40 *Phytophthora* spp. isolates were obtained, and after the detailed morphological identification, several species were confirmed, including *P. cactorum* (Leb. & Cohn) Schröeter, *P. plurivora* Jung and Burgess, *P. quercina* Jung, *P. gonapodyides* (Petersen) Buisman and other unidentified species. Also, many *Pythium* spp. isolates were obtained. After isolation tests from samples of ground and flooded water, it was shown that underground water did not have some particular impact in occurrence and spreading of these pathogens, respectively.

2. MATERIALS AND METHODS

2.1. Studied localities

Study was performed in the lower Srem forest area, in the manage unit Grabovacko-Vitojevacko ostrvo – "GVO". Map of this manage unit, with marked localities is shown in Figure 1. For this study, five localities were chosen, and collecting of samples, as well as taking of ground water samples was repeated 3 times, during the April, May and June, in the 2011 growing season.

Locality No 1 belongs to the forest type *Fraxino – Quercetum roboris hygrophillum*, and it is situated in departement 24. Locality No 2 belongs to *Fraxino – Quercetum roboris subinundatum*, and it belongs to departement 26.

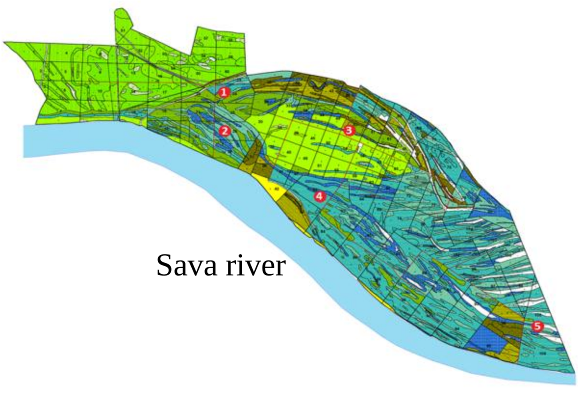

Figure 1. *Manage unit "GVO" with marked studied localities*

Third locality is poplar plantations, *Populus euramericana,* and it is in departement 53. Fourth locality is *Fraxino – Quercetum roboris subinundatum*, and it belongs to departement 81. And the last, fifth locality is *Carpino – Fraxino Quercetum roboris inundatum*, and it is in departement 105 (Figure 1).

Figure 2. *Piesometer station for water levels observation*

2.2. Sampling and isolation methods

Sampling and isolation methods were performed according to Jung, (1998, 2009) and Jung et al., (1996). Tissue samples were taken from necrotic parts, washed in distilled water and plated directly onto selective agar medium (V8-PARPNH). Soil, together with the root system was sampled in the form of soil monoliths measuring ~25x25x25cm, and isolation tests were performed using oak and beech leaves as baits for baiting methods (Jung et al. 1996, 2000; Jung 2009). Both, symptomatic and healthy trees were sampled. In addition, samples were also taken from different depths in the soil profile, using "Edelman (®)" auger hand probe (Fig. 3), with carful sterilization of these tools. Samples were taken from every half of meter going from the surface towards underground water levels. Also, samples of water from the surface logging were taken, as well as from the underground water at different reached levels.

Figure. 3. *Taking of samples with hand sonda. Srem, spring 2011.*

2.3. Identification of isolates

For morphological identification of isolates, non-sterile soil extract solution was prepared according to Erwin & Ribeiro (1996). Cultures were developed on clarified carrot juice agar, prepared with 100 ml/l of carrot juice (Biota®), 900 ml/l of distilled water, 16 g/l of agar-agar, and 3g/l of $CaCO_3$. After 3-4 days of growing, pieces approx. 1x1cm, were cut from the growing edges and flooded with non-sterile soil extract, and incubated at 20-22°C at daylight in the lab. After 6 h, soil extract was changed with distilled water. After additional 6 and 12 h, water was changed again. After 18-36 h, typical *Phytophthora* spp. structures were observed under the microscope at x400 magnification (Jung and Burgess 2009) (CETI®). For physiological analyses, 3 replicates per isolate were prepared on carrot agar media, and after initial incubation at 22-25 °C, they were set on 5, 10, 15, 20, 25, 30 and 35°C. In the next five days marking of edges were made with steel needle in for directions, and values were measured with precise ruler up to one decimal. Cardinal temperatures as well as growing rates were calculated. For colony morphology and growth patterns, all the representative isolates were sub-cultured on MEA, V8 and Carrot agar media. Colony morphology was described according to previously described patterns (Erwin & Ribeiro 1996, Brasier et al., 2003, Jung et al. 1999, 2002; Jung & Burges 2009).

3. RESULTS

3.1. Occurrence of Phytophthora species in different depths

Distribution of phytophthoras in different depths, according to localities and months is shown in tables 1, 2, 3 and 4.

Table 1. *Phytophthora presence through profile in April*

DEPTH ▼	PRESENCE OF *PHYTOPHTHORA* SPECIES - **April**				
	Loc. 1	Loc. 2	Loc. 3	Loc. 4	Loc. 5
Usual way	+	+	+	+	+
0,5	-	-	+	-	-
1,0	+	-	+	-	-
1,5	-	-	-	-	-
2,0	-	-	-	-	-

Table 2. Phytophthora presence through profile in May

DEPTH ▼	PRESENCE OF *PHYTOPHTHORA* SPECIES - **May**				
	Loc. 1	Loc. 2	Loc. 3	Loc. 4	Loc. 5
Usual way	+	+	+	+	+
0,5	+	+	+	-	-
1,0	-	-	-	+	-
1,5	-	-	+	-	+
2,0	-	-	-	-	-

Table 3. *Phytophthora presence through profile in June*

DEPTH ▼	PRESENCE OF *PHYTOPHTHORA* SPECIES - **Jun**				
	Loc. 1	Loc. 2	Loc. 3	Loc. 4	Loc. 5
Usual way	+	+	+	-	-
0,5	+	-	+	+	+
1,0	-	-	+	-	-
1,5	-	-	-	-	-
2,0	-	-	-	-	-

Table 4. *Total distribution of Phytophthora species within 3 months in different depths and localities*

DEPTH ▼	**PRESENCE OF *PHYTOPHTHORA* SPECIES**				
	Loc. 1	**Loc. 2**	**Loc. 3**	**Loc. 4**	**Loc. 5**
Usual way	+	+	+	+	+
0,5	+	+	+	+	+
1,0	+	-	+	+	+
1,5	-	-	+	-	+
2,0	-	-	-	-	-

The deepest level, in which *Phytophthora* spp. was found, was 1,5 m, in 2 out of 5 localities in May. In April and June, isolation of *Phytophthora* spp. was successful almost only from surface, with usual way of sampling (Jung et al. 1996, 2000; Jung 2009), except locality No 3 and 1 where *Phytophthora* spp. was found at 1m within these 2 months. Total distribution within these 3 months is shown in figure 4.

3.2. Identified Phytophthora species

In total, over 40 *Phytophthora* spp. isolates were obtained during these studies. The most common isolates were homothallic, semipapilate, different in sporangia shape, with optimum temperature for growith around 25 °C, which resembled on *P. citricola* Sawada. After comparing of patterns with data from the paper about re-evaluation of *P. citricola* complex of species from 2009 (Jung & Burgess 2009), these isolates were confirmed as *P. plurivora* Jung & Burgess (Tab. 5, Fig. 7). In addition, *P. quercina*, *P. cactorum*, and several isolates that resembled on *P. gonapodyides*, or other species from ITS clade 6 (Cooke et al. 2000), were also obtained (Tab. 5).

Table 5. *Identified Phytophthora species according to localities*

Phytophthora spp.	Locality No1			Locality No2			Locality No3			Locality No4			Locality No5		
	April	May	June	April	May	June	April	May	June	April	May	June	April	May	June
P. cactorum		x		x				x		x	x		x	x	
P. plurivora	x	x	x	x	x	x		x	x		x	x	x	x	x
P. quercina				x	x					x	x				
P. gonapodyides	x		x	x			x						x	x	x
P. spp.					x					x			x		

Also, many *Pythium* spp. isolates were obtained, and they were not particularly studied in these studies. Identification of isolates has been done based on morpho-physiological features, and DNA analyses with PCR amplifications and sequencing are ongoing up to date.

4. DISCUSION

Phytophthora species were obtained from all 5 localities, and four different *Phytophthora* spp. were obtained with another unidentified isolates which identification is ongoing (Tab. 5). The most widespread species was *P. plurivora* which was isolated in all 5 localities. Interestingly, this species was found in both localities at 1, 5 m depth, in locality No 3 alone, and in Locality No 5 together with *P. gonapodyides.* Ability of these pathogens to be present within the soil profile can be explained with favourable soil classes in these localities. Namely, according to Jung et al. (2000), clayey, loamy and sandy-loamy soil textures were favourable for *Phytophthora* development. Tentatively determined, clay and clayey textural classes seemed to be the most common in these localities.

In total, 6 different host species were tested during these studies, including *Q. robur* L., *Fraxinus angustifolia* Vahl., *Acer tataricum* L., *Malus sylvestris* (L.) Mill., *Carpinus betulus* L., and *Populus* spp. *Phytophthora* spp. were recovered under the 5 different hosts, and only samples taken under the *A. tataricum* were not positive on these pathogens. *Phytophthora* spp. under the poplar stands in Serbia were firstly recorded by Milenković and Keča in Kupinovo forest district (unpublished data), and found of *Phytophthora plurivora*, *P. cactorum* and *P. gonapodyides* under the poplar trees in these studies corespond to those data.

Phytophthora species were not recovered from water samples taken from underground watter levels with sonda, what suggested that these waters are not the source of *Phytophthora* surviving and resting structures (chlamydospores and oospores), as well as of sporangia and encysted sporangia as a source of inoculum.

This seems to be oposite to our hypothesist from the beginning of these studies that underground water could be the source of inoculum, due to the strong impact and hidraulic conection with Sava river stream (Fig. 1), and future studies should be performed in order to clarify this phenomenon.

Since this area is under the impact of flooded water in flooded period, this suggest us that the surface, flooded water is the source of *Phytophthora* inoculums, and probably of other organisms which were not tested in these studies. Several samples taken from water-logging (flooded water) in this area were positive in *Phytophthora* isolation tests, and from samples taken directly from Sava river near the locality No 2, *P. cactorum*, *Phytophthora* spp. and *Pythium* spp. were obtained. The role of water as a source of *Phytophthora* species is shown in previous studies (Orlikowski et al. 2007; Nechwatal and Mendgen, 2006).

Phytophthora quercina is a pathogen known as very agressive towards *Q robur*, and the role of this pathogen in European oak decline is shown in many studies (Jung et al. 1999; Balci and Halmschlager, 2003a,b; Johnoson et al. 2003) The role of *P. plurivora*, the most common species in these studies, under the previous name as *P. citricola* in decline of European oak stands was also shown in several studies (Jung et al. 1999, 2000; Hansen & Delatour 1999; Vettraino et al. 2002; Balci & Halmschlager 2003 a, b). Also, this pathogen was connected with decline of ash stands in Poland and Denmark (Orlikowski et al. 2011). Pathogenicity, soil infestation tests with several isolates and host species are ongoing and they will provide us clearer picture about the role of these pathogens in declining of different hosts in Serbia.

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DEGREE OF DEFOLIATION AND THICKNESS STRUCTURE OF TREE STANDS IN STARA PLANINA MT. (BALKAN RANGE), OBJECT OF LONG-TERM OBSERVATIONS

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Abstract: *The degree of defoliation of the crown of beech, oak and pine forests was investigated in the Fore-Balkan, Central and Eastern Balkan Range. Best growth in thickness (diameter) show trees from defoliation degree "0" (healthy). Oak forests are in worse health stands compared to beech ones and with higher degree of decreasing of their foliar mass. Pine plantations (not typical for the region) are in worsened condition. The intensity of defoliation is connected with decreasing of the size of needles and with forming of crowns with 1- and 2-year-old needles.*

Key words: defoliation degree, stands structure, crown, growth thickness, health status

INTRODUCTION

The seasonal dynamics of abundance of foliage is of significant importance for physiological processes, connected with growth and biological productivity of forest ecosystems.

Durable droughts in last years (especially from June to September), clearly expressed in the lower vegetation belt, are stress factor and prerequisite for decreasing of the vitality of trees in stands.

The index defoliation has big information value about health status of tree stands. This index is used to check the status of tree crown and degree of defoliation.

The partial defoliation brings to decreasing of biomass, reduction of assimilation activity and reflects on growth of the tree.

In the conditions of increased defoliation, considerable changes in the water regime characteristics, structural organization of cells, physical-and-chemical properties of protoplasm and entire metabolism occur and stem's cambium activity is depressed.

The hypothesis of the investigation is directed to determination of thickness structure of observed trees and defoliation degree of their crowns in e certain moment of growing season in 2011.

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MATERIAL AND METHODS

Object of investigation are natural stands and plantations growing in the hypsometric belt from 100 to 1000 m a.s.l. in the Fore-Balkan, Central and Eastern Stara planina Mt. (Balkan Range) at 50 to 150 years of age.

Soils are Cambisols (CMd), Luvisols (LVh) and Planosols (PLd), deep, fresh, providing relatively good conditions for growth and development of investigated 40 beech, oak and pine stands (Grozeva, 1997). The complicated orography of the terrain, fluctuations in temperature regime and atmospheric circulation in different parts of the mountain form precipitations values from 400-500 mm up to about 900-1000 mm (Pavlova, Rosnev, 2006).

In accordance with the requirements of the European monitoring programme (Forests), object of annual investigation are 40 trees grouped in four geographic sectors (N, E, W, S) of sample plots (SP), being at an equal distance from the centre. This relatively homogenous combination of close to each other specimen (with good habit and symmetrically shaped crowns, growing in the upper part of the canopy) forms elementary structural unit of the stand, which is the object of investigation.

The status of foliage was determined during biologically active period of growing season (middle of July 2011) at sustainable condition of temperature and precipitation parameters of the air. For the visual assessment of defoliation of observed tree species, 4-grades European scale was used (table 1).

Table 1. *Degrees of defoliation of tree crown (after ICP Forests)*

Degrees	**Defoliation in %**	**Status of crown**
0	0 – 10	unchanged (healthy)
1	11 – 25	slightly defoliated
2	26 – 59	medium defoliated
3	60 – 99	strongly defoliated
4	над 100	totally defoliated

After determination of grade assessment of crown status of observed trees, dendrometric measurements were carried out for determination of trees' thickness (diameters). On this base, the average circle area (G_{av}), average diameter for each grade and percentage of multitude (1-4) of defoliated trees were calculated.

RESULTS AND DISCUSSION

Table 2 shows data about thickness structure (calculated average diameter) of investigated stands in Stara planina Mt. according to degrees of defoliation and vitality status of unchanged (healthy) crowns and defoliated from 1 to 4 degree.

European beech (*Fagus sylvatica* L.) is main forest-forming species in Stara planina Mt. Defoliation percentage in beech stands is within the range from 5,0% (SP3) to 72,5 (SP8), and average diameters vary from 18,1 cm (SP3) to 47,6 cm (SP14). Healthy trees (without damages and defoliation) have percentage share from 27,5% (SP8) to 100% (SP13). In all investigated beech stands, trees not influenced by defoliation (grade „0") had average diameters with highest values (with the exception of SP1 and SP2). These two stands are the youngest with not yet finished differentiation of trees (SP2).

Average diameters of the healthy group – grade „0", change with increasing of the age from 25,1 cm (SP2) to 47,9 cm (SP12 – locality Bukaka). In each mature stand (about 120 years of age) there is one dieing tree (defoliation degree „4") as a result of stem breaking and disturbance of vital functions. Beech trees with defoliation degree of crowns „2" (from 26 to 59%) are relatively not much (SP4; SP7; SP8; SP9 and SP11).

In sample beech stands at the age of about 60, tree stands are with partial defoliation of crowns. The good status of foliage systems remains also in age limit of investigation (120-150 years). SP13 – Kotel is with 100% foliage of tree crowns and very well-formed stems and architecture of crowns.

Table 2. Thickness *structure (average diameters) according to defoliation degree of tree crowns in stands in Stara planina Mt.*

Sample plot (SP)	**Locality**	**Tree species**	A_{av}	**Defoliation degrees /d_{av}**							
				0	**1**	**2**	**3**	**4**	**1-4**	**0**	**%/cm**
Beech forests											
1	Churek	beech	54	47,5	45,0	7,5	-	-	52,5	47,5	%
			d_{av}	34,7	38,0	22,0	-	-	35,4	34,7	cm
2	Ribaritsa	beech	60	85,0	15,0	-	-	-	15,0	85,0	%
			d_{av}	25,1	27,3	-	-	-	27,3	25,1	cm
3	Plakovo	beech	62	95,0	5,0	-	-	-	5,0	95,0	%
			d_{av}	25,3	18,1	-	-	-	18,1	25,3	cm
4	Prolaz	beech	63	90,0	7,5	2,5	-	-	10,0	90,0	%
			d_{av}	26,2	21,5	22,0	-	-	21,6	26,2	cm
5	Partizani	beech	63	67,5	27,5	5,0	-	-	32,5	67,5	%
			d_{av}	24,0	24,0	24,0	-	-	24,0	24,0	cm
6	Vozheli	beech	64	65,0	35,0	-	-	-	35,0	65,0	%
			d_{av}	28,7	27,5	-	-	-	27,5	28,7	cm
7	Shipkovo	beech	74	40,0	55,0	5,0	-	-	60,0	40,0	%
			d_{av}	31,4	24,6	19,0	-	-	23,9	31,4	cm
8	Gorsko selo	beech	82	27,5	67,5	5,0	-	-	72,5	27,5	%
			d_{av}	29,8	27,9	26,1	-	-	27,7	29,8	cm
9	Kapincho	beech	94	32,5	65,0	2,5	-	-	67,5	32,5	%
			d_{av}	32,4	29,2	30,0	-	-	29,0	32,4	cm
10	Kotel Tsarevets	beech	103	85,0	15,0	-	-	-	15,0	85,0	%
			d_{av}	35,1	34,4	-	-	-	34,4	35,1	cm
11	Etropole	beech	111	45,0	42,5	12,5	-	-	55,0	45,0	%
			d_{av}	44,8	28,3	38,3	-	-	36,5	44,8	cm
12	Bukaka	beech	113	92,5	5,0	-	-	2,5	7,5	92,5	%
			d_{av}	47,9	38,0	-	-	38,0	38,0	47,9	cm
13	Kotel	beech	123	100,0	-	-	-	-	-	100,0	%
			d_{av}	47,6	-	-	-	-	-	47,6	cm
14	Karandila	beech	123	92,5	5,0	-	-	2,5	7,5	92,5	%
			d_{av}	40,1	40,4	-	-	60,0	47,6	40,1	cm
15	Topolitsa	beech	153	92,5	7,5	-	-	-	7,5	92,5	%
			d_{av}	41,9	34,1	-	-	-	34,1	41,9	cm
Oak forests											
16	Shamaka	1	54	2,5	87,5	10,0	-	-	97,5	2,5	%
			d_{av}	30,0	21,8	26,9	-	-	21,6	30,0	cm
17	Sarnevets	1	58	7,5	77,5	12,5	2,5	-	92,5	7,5	%
			d_{av}	21,3	20,9	18,4	14,0	-	18,4	21,3	cm
18	Shemshevo	1	58	-	80,0	20,0	-	-	100,0	-	%
			d_{av}	-	23,0	17,1	-	-	22,0	-	cm
19	Zelin	1	72	10,0	57,5	30,0	2,5	-	90,0	10,0	%
			d_{av}	28,7	32,5	26,9	22,0	-	30,0	28,7	cm
20	Gurkovo	1	75	7,5	82,5	10,0	-	-	92,5	7,5	%
			d_{av}	26,1	26,8	20,6	-	-	26,2	26,1	cm
21	Ralitsa	2	59	-	80,0	20,0	-	-	100,0	-	%
			d_{av}	-	17,3	16,6	-	-	17,1	-	cm
22	Grozdyovo	2	72	2,5	77,5	17,5	-	2,5	97,5	2,5	%
			d_{av}	28,0	24,7	23,2	-	24,0	24,5	28,0	cm
23	Sadovo	2	73	12,5	57,5	27,5	2,5	-	87,5	12,5	%

			d_{av}	31,9	25,1	22,0	18,0	-	24,0	31,9	cm
24	Staro Oryahovo	2	90	2,5	90,0	7,5	-	-	97,5	2,5	%
			d_{av}	30,0	45,8	39,4	-	-	45,3	30,0	cm
25	Podvis	3	50	92,5	7,5	-	-	-	7,5	92,5	%
			d_{av}	27,9	24,1	-	-	-	24,1	27,9	cm
26	Vishovgrad	3	58	17,4	73,9	8,7	-	-	82,6	17,4	%
			d_{av}	21,8	23,4	23,7	-	-	23,4	21,8	cm
27	Avren	3	61	7,5	87,5	5,0	-	-	92,7	7,5	%
			d_{av}	30,8	23,9	22,1	-	-	32,8	30,8	cm
28	Aytos	3	62	10,0	77,5	12,5	-	-	90,0	10,0	%
			d_{av}	22,4	21,9	19,5	-	-	21,3	22,4	cm
29	Isperih	3	65	-	67,5	-	12,5	20,0	100,0	-	%
			d_{av}	-	23,7	-	23,6	19,9	23,0	-	cm
30	Starozag. min. bani	3	65	22,5	77,5	-	-	-	77,5	22,5	%
			d_{av}	28,9	25,7	-	-	-	25,7	28,9	cm
31	Ravna gora	3	65	10,0	87,5	-	2,5	-	90,0	10,0	%
			d_{av}	25,0	23,9	-	22,0	-	23,8	25,0	cm
32	Devnya	3	67	7,5	70,0	10,0	5,0	7,5	92,5	7,5	%
			d_{av}	29,9	28,0	24,0	25,0	29,6	24,7	29,9	cm
33	Drentsi	4	47	55,0	42,5	2,5	-	-	45,0	55,0	%
			d_{av}	25,6	24,3	24,0	-	-	24,3	25,6	cm
34	Ostrovche	5	84	85,0	15,0	-	-	-	15,0	85,0	%
			d_{av}	34,4	30,8	-	-	-	30,8	34,4	cm
Coniferous plantations											
35	Vehtovo	6	47	-	47,5	52,5	-	-	100,0	-	%
			d_{av}	-	39,7	25,7	-	-	32,0	-	cm
36	Dzhanavara	6	52	-	20,0	70,0	10,0	-	100,0	-	%
			d_{av}	-	23,2	17,6	21,3	-	18,6	-	cm
37	Gostilitsa	6	60	-	30,0	70,0	-	-	100,0	-	%
			d_{av}	-	26,2	19,6	-	-	21,8	-	cm
38	Koprinka	7	57	-	55,0	45,0	-	-	100,0	-	%
			d_{av}	-	25,3	20,3	-	-	23,2	-	cm
39	Klisura	7	64	9,4	68,8	21,8	-	-	90,6	9,4	%
			d_{av}	28,9	27,4	26,4	-	-	27,2	28,9	cm
40	Boaza	7	64	-	22,5	62,5	15,0	-	100,0	-	%
			d_{av}	-	33,8	30,9	24,3	-	30,4	-	cm

1 = *Quercus petraea* Liebl.; 2 = *Q. frainetto* Ten.; 3 = *Q. cerris* L.; 4 = *Q. rubra* L.; 5 = *Tilia tomentosa* Moench.; 6 = *Pinus nigra* Arn.; 7 = *Pinus sylvestris* L.

During the growing season 2011, dendrometric and pathological investigations were carried out in oak forests of *Quercus petraea* Liebl., *Q. frainetto* Ten., *Q. cerris* L. and *Q. rubra* L. These forests are situated predominantly in the Fore-Balkan and lower vegetation belt of Stara planina Mt., growing under unfavourable soil-climatic conditions and often being under anthropogenic impact and non-regulated fellings, changing stands structure.

Durable droughts, damages by insect pests and fungal diseases are among the reasons for the small number of healthy trees from 0,0% (SP18, SP21, SP29) to 22,5% (SP30). Of course, there are few investigated stands with very good growth – d_{av}=27,9 cm, A_{av} – 50 and health status – group „0" - 92,5% (SP25). Also in oak forests tree stands from degree „0" are with biggest average diameters (about 30 cm) – SP16; SP23; SP27; SP32 and have a dominating role in the canopy.

In *Quercus petraea* Liebl. sample plots defoliation in degrees „1-4" reaches over 90% (SP16; SP17; SP19; SP18). Average diameters for defoliation degree „1" are from 3rd thickness group (over 20 cm) at average age up to 60.

In *Quercus frainetto* Ten. stands in grade „0" – participation of trees is also small – from 2,5 to 12,5%, average diameters are from 28,0 to 32,0 cm. In the oldest SP24 (A_{av} – 90 years) in degree „1” defoliation is up to 25%. Damaged trees are 90%, and average diameter – 45,8 cm. In SP21 defoliations are predominantly in group „1” – up to 25%, with 80% participation, and trees accumulate wood in second thickness group – up to 16-17 cm average diameter.

In Turkay oak forests pathological withering, which bring to large-scale defoliation during the last years, decreased (SP25 – A_{av} – 50). The number of vital (healthy) trees is very high – 92,5%, average diameter 27,9 cm. The Turkay oak stand in Isperih (SP29) is with sharply worsening health status. Defoliation is from 25 to 100%, average diameter 23 cm (A_{av} – 65). Determined silvicultural intervention is needed – carrying out of sanitation felling and control of dense grass sinusia, which prevents natural regeneration.

Intensive defoliations in investigated Turkay oak stands occur after quantitative maturity of stands. After 50 years of age there is decelerated growth, which is an indicator of decreasing of trees' vitality. Of course, site conditions, soil type, structure of stand and carried out rotations make some influence in this case.

The red oak, introduced in Shumen region (SP33) is in relatively good condition. Climatic anomalies brought to secondary growth, occurrence of epicormic shoots and smaller leaf blades. Healthy specimens from degree „0” are 55% (average diameter 25,6 cm at 47 years of age).

In the region of Razgrad heights, *Tilia tomentosa* Moench. stand was also observed – SP34, A_{av} – 84. The stand is in very good condition, habit of trees, symmetry of crowns and degree of defoliation only 15% in group „1”, average diameter 34,4 cm, forming large building timber.

Investigations on the health status of coniferous plantations (Scots pine – *Pinus sylvestris* L., Austrian black pine – *Pinus nigra* Arn.) and their defoliation were carried out in six permanent sample plots in lower and medium forest vegetation belts. Stands are with tracery crowns and with small, predominantly 1- and 2-year-old needles. In all sample plots there are no trees form zero degree of defoliation (exception: SP39 – participation 9,4%). In the summary group of defoliation of crowns („1-4”) average diameter in plantations at similar age (3rd age class – up to 60 years) changes from 18,6 cm (SP36 – stand quality IV) to 30-32 cm. In SP35 – d_{av} = 39,7 cm at A_{av} – 47) there is fast growth in thickness (diameter) thanks to the accumulated luminous increment, forming the edge of the forest.

SP37, A_{av} – 60 shows a trend to worsening of the health status of Austrian black pine trees, which is characterized by yellow needles and needle cast. The situation is similar in SP40, A_{av} – 64, locality Boaza. Scots pine complex shows diseases due to root fungus *Heterobasidion annosum* (Fr.) Bref., bringing to withering of certain trees. Foliar assessment of crowns shows gradual transition from lower to higher degrees of defoliation (from 15,0% to 62,5%) at average diameter about 24 cm.

Health status of Scots pine plantation (SP39, A_{av} – 66) is good, without considerable changes during the last years. Pathological influence is insignificant and is expressed through decreasing of the foliage volume.

CONCLUSION

As a result of the carried out investigation on crowns' defoliation and thickness structure of beech, oak and pine stands in Fore-Balkan, Central and Eastern Stara planina Mt. (Balkan Range) in July 2011, the following conclusions could be drawn:

- Investigated stands with best growth in thickness (diameter) and vitality are from zero (healthy) degree or defoliation degree „1”;
- Trees with degree „4” (died) in beech stands are few. Their defoliation (withering) is due to mechanic and pathogenic reasons;

- As a whole oak forests are with worse health status compared to beech ecosystems and with higher degree of defoliation;
- The condition of *Quercus petraea* Liebl. and *Quercus frainetto* Ten. stands is relatively satisfactory. Average values of defoliation are within the range 25-60%;
- In *Quercus petraea* Liebl. sample plots defoliation in degrees „1-4" reaches over 90%. Average diameters for defoliation degree „1" are from 3rd thickness group (over 20 cm) at average age up to 60.
- At Turkay oak stands the trend of worsening of health status is stopped. The share of withering and dead trees (defoliation degree „3" and „4") is insignificant;
- The number of vital (healthy) trees is very high – 92,5%, average diameter 27,4 cm.
- Pine plantations (not typical for the region) are in worsened condition. There are no trees with degree „0" (healthy). The intensity of defoliation is due to droughts in recent years, occurrence of top dry, smaller needles or presence of only 1- or 2-year-old needles.
- Foliar assessment of crowns shows gradual transition from lower to higher degrees of defoliation (from 62,5% to 15,0%) at average diameter about 24 cm.

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DISTRIBUTION OF *Entomophaga maimaiga* Humber, Shimazu and Soper (*Entomophthorales: Entomophthoraceae*) ON BALKAN PENINSULA

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Abstract: *Entomopathogenic fungus Entomophaga maimaiga Humber, Shimazu and Soper (Entomophtorales) (Entomophtoraceae) was introduced in three populations of gypsy moth (Lymantria dispar L., Lepidoptera: Erebidae) in Bulgaria in the end of 20th century. After the first strong epizootics in 2005 the species increased its distribution by a natural range extension. Nowadays it is widespread in nearly all regions of the country in which L. dispar occurs. In 2011 the fungus depressed gypsy moth outbreaks in oak forests of Central Serbia (Belgrade and Valjevo regions). In the same year E. maimaiga was found also in two localities of European part of Turkey (Strandzha Mountain). In 2012 mortality of gypsy moth larvae caused by the pathogen was observed in forests of Avala hill near Belgrade. In the same year E. maimaiga was established in Greece and F.Y.R Macedonia. It is very likely that the pathogen is distributed in other Balkan countries as well.*

Key words: *Entomophaga maimaiga*, distribution, *Lymantria dispar*, epizootics, Balkan Peninsula

The gypsy moth (*Lymantria dispar* L., Lepidoptera: Erebidae) is the most dangerous defoliating pest in deciduous forests of Europe, Asia and North Africa. The species has gradations and periodically (in 8-12 years) causes defoliations on large areas. Damages caused by the species it is the largest in Southeastern Europe, particularly the Balkans, where there are favorable conditions for its feeding and development.

In 1868, the gypsy moth was introduced to the Boston area in North America. Efforts to eradicate the population have been unsuccessful and the pest gradually spread in the northeastern regions of the U.S. and Canada. To limit the damages caused by the gypsy moth many programs for biological control through the introduction of parasitoids, predators and pathogens were developed in the U.S. Among them the most successful is the introduction of the entomopathogenic fungus *Entomophaga maimaiga* Humber, Shimazu and Soper (Entomophtorales) (Entomophtoraceae) from Japan in the late eighties of the last century. The species rapidly expands its range and is now distributed in 17 northeastern U.S. states (Smitley et al., 1995; Hajek et al., 2005) and one Canadian province (Ontario) (Howse, Scarr, 2002). It is host-specific, acts effectively at both high and low levels of population density of the host and contributes significantly to suppress the pest calamities (Hajek, 1999; Solter, Hajek, 2009).

Bulgaria is the first country in Europe where a successful introduction of *E. maimaiga* was conducted (Pilarska et al., 2000). During the period 1996-2001 the pathogen was imported from the U.S. in three gypsy moth populations – in the region of State Forestries (SF) Svoge,

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Karlovo and Asenovgrad (Table 1). In 2005, the first strong epizootics caused by *E. maimaiga* were recorded at 30-90 km from the place of introductions – Elovitsa vill. (SF Govezhda), Skravena vill. (SF Botevgrad), Spahievo vill. (SF Haskovo) and Kremen vill. (SF Kirkovo) (Pilarska et al., 2006).

Table 1. *Introductions of Entomophaga maimaiga in Bulgaria*

Year	State Forestry (State Hunting Enterprise)	Locality	Origin of biological material
1996, 2000	Svoge	Gabrovnitsa vill.	US
1999	Karlovo	Gorni Domlyan vill.	US
2001	Asenovgrad	Izbegli vill.	US
2005	Chekeritsa	Striama vill.	Bulgaria (Kremen vill.)
2008	Nova Zagora	Sadievo vill.	Bulgaria (Kremen vill.)
2009	Sofia	Sofia	Bulgaria (Kremen vill.)
2009	Gorna Oryahovitsa	Asenovo vill.	US
2009	Popovo	Slavyanovo vill.	US
2010	Sofia	Sofia	US
2010	Targovishte	Dalgach vill.	Bulgaria (Slavyanovo vill., Sofia)
2010	Targovishte	Ruets vill.	Bulgaria (Slavyanovo vill., Sofia)
2011	Staro Oryahovo	Solnik vill.	Bulgaria (Sofia)

During the period 2005-2011, 9 more introductions of *E. maimaiga* were carried out with inoculum of Bulgaria and the USA (Table 1). Through them any further infestations of the gypsy moth until 2011 were completely suppressed: in the region of SF Nova Zagora (village of Sadievo, 2008), Gorna Oryahovitsa (village of Asenovo, 2010, State Hunting Enterprise Popovo (village of Slavyanovo, 2010) and SF Targovishte (village of Ruets and village of Dalgach, 2011). The degree of pest infestation in some of the State Forestries reached up to 300 to 400 egg masses on 100 trees (3500-4000 egg masses/ha) – stock, which could cause several defoliations of the stands. Due to introductions of *E. maimaiga* in northeastern Bulgaria calamities in the region with the most oak forests and traditionally strongest pest attacks were stopped.

Observations on the prevalence of *E. maimaiga* in Bulgaria show that the species is found almost everywhere in the country. It is established in many locations on the territory of 20 State Forestries and Hunting Enterprises (Fig. 1).

Fig. 1. *Distribution of Entomophaga maimaiga in Bulgaria*

The pathogen occurs as an effective limiting factor of the pest in the country - after its introduction in 1999, the amount of the strong infestations of the last full gradation of *L. dispar* (2001-2009) was only about 5,000 ha, which accounted for only 0.5 to 1.0% of normal values of infestation in comparison with the infestations at previous gradations (492 to 1028 thousand ha) (Georgiev et al ., 2011).

In the new gradation of *L. dispar* after 2010 in Bulgaria severe pest attacks were recorded only in places where there was no rainfall in the spring and early summer – the Black Sea coast, Strandja and Eastern Rhodopes. It is well known that the limited impact of the pathogen is highly dependent on rainfall and air humidity during the larval development of the host. However, in some places of the Black Sea coast and the Eastern Rhodopes, where there were local precipitations in 2012 epizootics of *E. maimaiga* were established (unpublished).

In 2011, high mortality of *L. dispar*, caused by *E. maimaiga* in Serbia was registered in Bogovadja and Boracki Gaj in the regions of Belgrade and Valjevo (Tabaković-Tošić et al., 2012). Thanks to the fungus extremely strong calamities were suppressed and the number of the pest was reduced from 5000 and 3200 egg masses/ha to almost negligible levels, 15 and 0 in Boracki Gaj and Bogovadja, respectively. In 2012, a new epizootic caused by the pathogen was observed in the region of Avala hill near Belgrade and in some localities in Eastern Serbia (unpublished).

In 2011, *E. maimaiga* was found in two localities in the European part of Turkey – Vize and Yalikoy (Georgiev et al., 2012). It is not excluded that the pathogen can be found in the Asian part of Turkey, as in 2005 it was established in Georgia (Kereselidze et al., 2011).

Studies in 2012 showed that *E. maimaiga* was found in Greece and FYR Macedonia (unpublished). It is likely that the species has penetrated other countries of the Balkan Peninsula and Southeast Europe.

The results of research in Bulgaria and Serbia show that *E. maimaiga* emerged as a very promising biological agent, capable to cease gypsy moth calamities and maintain its population density at low level under favorable conditions. Regulating power of the pathogen characterizes it as a green alternative to the use of chemical and bacterial insecticides for pest control, thus contributing to biodiversity conservation in forest ecosystems and improving recreational qualities of the living environment. Spread of the pathogen in the Balkans requires monitoring to assess its impact on indigenous natural enemies of the gypsy moth and other insects in oak forests.

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PRESENT STATE OF BEECH BARK DISEASE IN SERBIA

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Abstract: *In the beech forests an specially great damage can be caused by the fungi causing bark necrosis and canker. „Beech bark disease" is currently regarded ae the most serious disease of beech. The cause is considered to be a combination of an insect known as the beech scale (Cryptococcus fagisuga Lind.) and a pathogenic fungus (Nectria coccinea /Pers.ex Fr./ Fries). „Beech bark disease" was first discovered in the beech forests of Serbia in 1983. Detailed surveys of the most beech stands in Serbia show that this disease is widely distributed. The disease occurs endemically and a greater damage was recorded on Majdanpečka domena, National park „Djerdap", National Park, „Fruška Gora", Mountain Goč, at several places in beech stands in the region Južni Kučaj. The paper presents the distribution of „Beech bark disease" in Serbia, as well as the description of the disease symptoms and development.*

Key words: Beech bark disease, distribution, Serbia

1. INTRODUCTION

Beech (*Fagus moesiaca* /Domin. Maly/ Czeczott) is the most widely distrubuted tree species in Serbia. Native to Europe, much cultivated throughout Europe for timber, ornament and shade. The edible nuts are a source of oil and may be made into a kind of margarine. Height to 45 m with a large thick trunk sometimes 2-2,5 across. Flowers open in May, numerous drooping clusters of males and one or two female clusters at the tip of the shoot. Fruit is ripe in September or October, releaising triangular nuts, about 1,5 cm long. Leaves have 5-12 (the most often 9) pairs of veins. Bark is smooth and grey. Beech grows in all our hilly and mountainous regions, and its stands are especially large in south-east and east Serbia. After Jovanović (1971), beech reaches the altitude of up to 2100 m at Prokletije, while its lower altitudinal level is even below 100 m (near Negotin). Thanks to its excellent technical properties, the significance of beech in Serbia's forest economy is great. Beech as a raw material is the base of a great part of wood industry and pulp and paper industry. An especially significant application of beech wood is in the production of sawn timber and railroad sleepers, furniture, plywood and veneer boards. However, wider use of beech wood is limited by its durability. Beech wood is non-resistant and an excellent medium for the development of many parasite and saprophyte organisms, primarily fungi. Also, wider use of beech wood (e.g. for railroad sleepers) is limited because of the occurrence of the so-called "false" or red heart. Immediately after felling, beech wood is colonised by wood rotting fungi. Thus according to Mocan and Hudson (cit. Lanier 1976) 77 species of wood rotting fungi are identified on beech trees, logs, thick branches, stumps, etc. Marinković and Šmit (1965), in their study of beech health condition, report 40 species of fungi

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typical destroyers of cell membrane of beech wood. Karadžić and Anđelić (2002) describe 57 species of beech wood rotting fungi. Karadžić et al. (2005) describe 147 fungi on beech. In the beech forests an specially great damage can be caused by the fungi causing bark necrosis and canker and among them *Nectria* species have a special place. „Beech bark disease" is currently regarded ae the most serious disease of beech. The cause is considered to be a combination of an insect known as the beech scale (*Cryptococcus fagisuga* Lind.) and a pathogenic fungus (*Nectria coccinea* /Pers.ex Fr./ Fries).

Based on our observation in the field, it sems that *Fagus moesiaca* is more resistant to beech bark disease than *Fagus sylvatica* L., and for this reason the damages in beech stands in Serbia are notably lower.

In cases of heavier infections silvicultural measure are recommended, consisting of felling and conversion of attacked trees especially at the beginning of the disease development.

The paper presents the distribution of „Beech bark disease" in Serbia, as well as the description of the disease symptoms and development.

2. MATERIAL AND METHODS

The material was collected on several locations from the beech forests. The fungi were identified after microscopic analyses, based on the appearance of the fruiting bodies (perithecia and sporodochia), spore bearing organs (asci and conidiophore), reproduction organs (ascospores and conidia) and the appearance of the fungus pure culture. The fungus were were isolated from the infected bark on the nutritive media [malt-extract agar (MEA) and potato-dextrose agar (PDA), Booth, 1971]. Fungus were isolated by using one of these two methods. In the first method, the parts from infected beech bark were immersed for one minute into 40% alcohol, and then for ten minutes into 0.15% solution of $HgCl_2$. After that the parts infected beech bark were washed twice in sterilized distilled water and cut to fragments of 2 – 5 mm, which were placed into media (malt extract agar, potato-dextrose agar). The second method was to sterilize the infected beech bark by immersion in a solution of sodium-hypochlorite with 1,5% active chlorine for 5 minute and then they were cut into fragments and placed on the nutritive media as above. Petri dishes with the media and host fragments were incubated at 15°C to obtain pure cultures. Usually after 4-5 days after the inoculation of the medium, colonies of fungi start to develop. After the appearance of the fungal colony on the media, the isolates were placed in thermostats and their growth was further monitored at the temperatures of 15 and 20ºC.

All the isolates from time to time they were examined and the rate of colony development was observed, as well as the fructifications in the culture, etc. Based on the sporulation in the culture, the appearance of hyphae, rate of growth, etc., the fungus was identified. For the identification was used keys of Booth, C. (1966), Breitenbach H, J., Kränzlin, F. (1986): Butin(1989), Dennis (1978), Ellis and Ellis (1985), Hanlin (1992, 1998), Kirk et al. (2008), Lanier et al. (1976 and 1978), Perrin, R. (1976) and Sutton (1980).

3. RESULTS

3.1. Present states distribution of "beech bark disease" in Serbia

Beech bark disease (i.e. *C. fagisuga* and *N. coccinea*) was first discovered from Serbia in 1983 in beech stands on Majdanpečka Domena (Marinković and Karadžić 1985). Detailed surveys of all beech stands in this region show that this phenomenon is widely distributed, but a great damage was not reported. The disease occurs endemically and a somewhat greater damage (occasional tree dying) was recorded only in the beech reserve near the spring Felješana. During investigations in 2011 and 2012.years the disease was discovered on many places. The fungus occurs endemically and a greater damage was recorded on Majdanpečka domena, National park „Djerdap”, National Park, „Fruška Gora”, Mountain Goč, at several places in beech stands in the region Južni Kučaj (the sites: Igrište-Tekuća bara; Kločanica, Kapatanske livade itc.). The most greates damages are observed in the beech stands of copice orgin on locality G.J. Igrište-Tekuća Bara (Š.U. Paraćin). Also, the latest surveys in the field indicate that the disease has the tendency of gradual spreading. The damage is greater in the beech stands of coppice origin.

3.2. Development of the disease and its symptoms

Beech bark disease is the result of the mutual attack of the insect *Cryptococcus fagisuga* Lind. (= *C. fagi* Baer) and the fungus *Nectria coccinea* (Pers.) Fr. *Cryptococcus fagisuga* is a scale insect which reproduces parthenogenetically, size 0.5-1 mm, adult insect is yellow and elliptic, and characterised by reddish-brown eyes, piercing (sucking) mouthpart 1.5-2 mm long, dwarfed antennae and legs and numerous small glands which excrete a white woolly material all over the body.

The first symptoms of infection are manifested by the appearance of the white wool. Isolated spots of white wool occur at the places with rough bark, below the lichens, below branches, at the level of the scars. In cases when the *C. fagisuga* population is growing, the whole bole can be covered with the white woolly excreta. In such cases, due to a great density of insects and intensive feeding, trees weaken physiologically. However, large-scale dying and bark disease occurs subsequently, after the *N. coccinea* infestation. The time needed for *N. coccinea* to colonise the bark tissue after the first insect attack has not been precisely determined, but it is thought that it is the period between 3 and 6 years.The ruptures on the bark, where the insect pierced by its sucking mouthpart, are entry points where *N. coccinea* hyphae penetrate and cause infection. Without the presence of these fine wounds in the bark, the fungus could not be able to penetrate and cause infection. Immediately after the penetration, the fungus causes bark necrosis and the necrotic zones exude a reddish-brown or black exudation. According to some authors, these dead stains on the bark are the first symptoms of infection and they are usually subsequently surrounded by perithecium stromata of the fungus *N. coccinea.*The mycelium of the fungus then disperses, attacks the cambium and the surface layer of softwood causing their death. In the zones of fungal activity, if the bark is removed, one can see clearly the orange coloured xylem. The fungus can disperse to the greater area of the bark, often the whole circle, girdling the tree and causing its death. In some cases, the mycelium disperses longitudinally and bark necroses occur in the form of narrow bands. Callus tissue is formed around the bands and the bark becomes rough. Callus rings block the parasitic fungi, so further development of the disease is checked. Numerous perithecium stromata form on the bark of such trees and the bark turns reddish. The secondary symptoms of beech bark disease occur also on the leaves, which turns yellow and usually stays on the tree during the summer and the crown is thinned. In the final stage of the disease development, on the dead part of the bark, the fungus forms fructifications. *N. coccinea* forms the typical perithecia in the reddish stromata, diameter 0.5-1.5 mm (5 - 35 perithecia are formed in each stroma). The perithecia are oval, egg-shaped or hemispheric and with a short acicular ostiole at the top. Young perithecia are light red, and with age they become darker and coarser, diameter 250 – 350 μm. Asci are formed in perithecia, they are cylindrical, with a globular end, size 75-100 x 10 μm. Ascospores are elliptic, 2-cellular, slightly narrowed at the level of the wall, colourless when young, but later they become light brown, size 12-15 x 5-6 μm. Fungus *N. coccinea* forms also the imperfect form described as *Cylindrocarpon candidum* (Link) Wollenw.They are small whitish sporodochia emerging below the bark before the appearance of perithecia. Macroconidia are formed on sporodochia, size 20-80 x 5-7 μm. Sporodochia can be found from mid summer to autumn and they remind of isolated colonies of lice.

After the infection with the fungus *N. coccinea* beech wood in the zone of necrotic bark is soon infested by wood decaying fungi, bark beetles and wood-boring insects. The process of tree decline due to the attack of these secondary organisms is relatively fast, the value of beech stand decreases heavily and considerable quantities of technical wood are lost. The first fungi which penetrate the dead bark and colonise sapwood are *Fomes fomentarius* (L. : Fr.) Fr. and *Trametes* gibbo*sa* (Pers.: Fr.) Fr. *F. fomentarius* is widely distributed, causes a white mottled rot of beech. Although it decays chiefly sapwood and heartwood of dead timber, it occasionally causes heart rot of living trees and also attacks living sapwood. Wood in the incipient stage of decay is brownish in color, firm, and seemingly not altered. Wood with advanced decay is yellowish white, soft, and spongy, with narrow dark-brown to blackzone lines, and often with frequent small radial cracks filled with yellowish mycelium, which give the wood a mottled appearance. The decay usuall begins in the upper part of the bole and progresses down-ward. Infection of living trees takes place through dead part beech bark (bark killed by *Nectria coccinea*). On the trees the most often the infected palaces are from 2 to 6 m height (average height infected trees were between 25 and 30 m, and diameter about 35-40 cm). The most infection on the trees was on the south side. *T. gibbosa* is present also very frequently on the trees with beech bark disease. The most often the infected palaces are from 1 to 2 m height. The decay usuall begins from the basis of trees tand progresses to get up. Infection of living trees begin through dead part beech bark (bark killed formerely by *Nectria coccinea*). *T. gibbosa* is widely distributed, causes a white rot of beech. Although it decays chiefly sapwood and heartwood of dead timber, it occasionally causes heart rot of living trees and also attacks living sapwood.

Figure 1. ***Nectria coccinea***: A-slime flux of tarry spot exudate on bark tree, B-fruiting bodies of fungus; C - ***Fomes fomentarius***- conk of fungus on dead portion of a living beech trees, D - ***Trametes gibbosa***- conks of fungus on dead portion of a living beech trees

After fungi *Fomes fomentarius* and *Trametes gibbosa* also some other wood decaying fungi penetrate the dead bark and colonise sapwood. The most oftent are: *Bjerkandera adusta* (Fr.) Karst., *Hypoxylon* species, *Trametes versicolor* (Fr.) Pil., *T. hirsuta* (Wulf. : Fr.) Pil. *Stereum* spp., *Auricularia auricula-judae* (Bull. ex St-Amans) Wettst., *Pleurotus ostreatus* (Jacq. ex Fr.) P. Kumm., *Polyporus squamosus* Fr. and sometimes *Ganoderma applanatum* (Pers. ex Wallr.) Pat. and *Ustulina deusta* (Hoffm.) Lind.The presence of the fungus *Armillaria mellea* (Vahl. Ex Fr.) Kummer was also recorded on the infected trees and it also plays a definite part in the fast decline and dying of individual trees.

3.3. Control measures

All the measures applied against beec bark diseases can be grouped in three groups: biological, silvicultural and chemical.

It was reported that several species of predators occur on *C. fagisuga* colonies. The larvae of some *Diptera* are very frequent, then *Neuroptera* (*Chrysopa spp.), Coleoptera* (some *Coccinellidae*). *Chilocorus stigma* Say*, C. Remipustulatus* Scriba are especially frequently reported as predators. Although these predators are sometimes very abundant, it is considered that their influence on the reproduction of *C. fagisuga* populations is not great. A number of insects develop as saprophytes on dead females of *C. fagisuga* and their fixed larvae, and recently some acari have been recorded which parasitise scale-insect eggs. It was also observed that the fungus *Nematogonium ferrugineum* (Pers.) Hughes parasitises *Nectria* species.

As *C. fagisuga* occurs sporadically on individual trees, and as they are mainly the trees above 30 up to 80 cm in diameter, the trees should be marked for felling as soon as possible in order to utilise the quality wood. If such trees are left in the forest, they are soon infested by wood rotting fungi through the wounds in the bark and consequently the timber value will be lost.

Chemical measures should not be implemented in natural stands. However, they may be implemented on the infested trees in parks. In that case, various insecticides can prevent the dispersal of *C. fagisuga*. If the insect pest is eliminated, the potential later infections by the fungus *N. coccinea* will be prevented.

4. DISCUSION

Beech bark disease was reported for the first time in mid 19th century from the British Isles (Mc Intosh 1849, cit. Ehrlich 1934). Till 1914 it was thought that *Cryptococcus fagi* Baer. was the agent of beech bark decline. Later on also the fungus *Nectria ditissima* was reported to infest the trees previously attacked by the insect. *C. fagisuga* was accidentally introduced to North America in 1890, and the first serious attack of beech bark disease was recorded in 1920 (Nova Scotia). Since that time, the research of beech bark disease has become more intensive. Probably the most significant step in understanding the causes of beech bark disease was the monograph by Ehrlich (1934). In his study, Ehrlich proved that the cause of beech bark disease, and also tree dying was the joint attack by the insect *Cryptococcus fagisuga* and the fungus *Nectria coccinea.* The majority of researchers who study beech bark disease nowadays agree with this stand point.

Results of our investigations are demonstrited that *Cryptococcus fagisuga* may simple be one of many possible predisposing stressors that alow for infection by *Nectria coccinea*. Many other harmful factors (drought, damages of frost, mechanical damages, other insects which colonized beech bark, other parazitic fungi and so on) can also alow infections by *Nectria* species. It mean that *Cryptococcus* is only one from many a necessary predispsing factors for *Nectra i*nfection*.* In many cases *Nectria* was found infecting weakened trees. Similary with our investigations agree Cale et al. (2011) and Kasson and Livinston (2011).

The damage caused by beech bark disease world-wide is very serious, especially on European beech (*Fagus silvatica* L.). After Shigo (1970) in USA in individual beech stands there were more than 50% of dead trees, and many survived trees were also not promising producers of good quality wood. According to Houston and O'Brien (1983), beech bark disease is widely distributed in the Maritime Provinces, Maine, east parts of Massachusetts, Quebec, New England, New York, New Jersey and Pennsylvania, and in 1981 the disease was recorded over 28,000 ha in north-east West Virginia. Great damage caused by beech bark disease was recorded in Great Britain (Parker 1982), France (Perrin 1977; 1982) and West Germany (Lang 1982).

Lang (1982) reports that in north parts of Bavaria in 1979 and 1981 averagely 25,000 cubic metres of beech were felled because the trees were damaged by beech bark disease. Based on our observations in the field, it seems that *Fagus moesiaca* is more resistant to beech bark disease than *Fagus silvatica.*

5. CONCLUSION

A long standing hypothesis states that *Cryptococcus fagisuga* and the fungus *Nectrta coccinea*, caused „beech bark disease". Results of our investigations are demonstrited that *Cryptococcus fagisuga* may simple be one of many possible predisposing stressors that alow for infection by *Nectria coccinea.* It mean that *Cryptococcus* is only one from many a necessary predispsing factors for *Nectra i*nfection. Many other harmful factors (drought, damages of frost, mechanical damages, other insects which colonized beech bark, other parazitic fungi and so on) can also alow infections by *Nectria* species.

„Beech bark disease" was recorded for the first time from Serbia in 1983 in the region of Majdanpečka Domena. During investigations in 2011 and 2012.years the disease was discovered on many places. The fungus occurs endemically and a greater damage was recorded on Majdanpečka domena, National park „Djerdap", National Park „Fruška Gora", Mountain Goč, at several places in beech stands in the region Južni Kučaj (the sites: Igrište-Tekuća bara; Kločanica, Kapatanske livade itc.). The most greates damages are observed in the beech stands of copice orgin on locality G.J. Igrište- Tekuća Bara (Š.U. Paraćin). Also, the latest surveys in the field indicate that the disease has the tendency of gradually spreading. The damage is greater in the beech stands of coppice origin.

After the infection with the fungus *N. coccinea* beech wood in the zone of necrotic bark is soon infested by wood decaying fungi, bark beetles and wood-boring insects. The process of tree decline due to the attack of these secondary organisms is relatively fast, the value of beech stand decreases heavily and considerable quantities of technical wood are lost. The first fungi which penetrate the dead bark and colonise sapwood are *Fomes fomentarius* and *Trametes gibbosa.* After fungi *F. fomentarius* and *T. gibbosa* also some other wood decaying fungi penetrate the dead bark and colonise sapwood. The most oftent are: *Bjerkandera adusta, Hypoxylon* species, *Trametes versicolor, T.hirsutua, Stereum* spp., *Auricularia auricula-judae, Pleurotus ostreatus, Melanopus squamosus* and sometimes *Ganoderma applanatum* and *Ustulina deusta.* The presence of the fungus *Armillariella mellea* was also recorded on the infected trees and it also plays a definite part in the fast decline and dying of individual trees.

In cases of heavier infections, silvicultural measures are recommended, consisting of felling and conversion of attacked trees, especially at the beginning of the disease development.

Some predators have been identified on *C. fagisuga* colonies, but their significance in the reduction of *C. fagisuga* populations has not yet been determined.

Chemical measures of control (e.g. suppression of *C. fagisuga* with insecticides) are recommended only for the protection of old beech trees in the parks.

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PRESENT STATE OF BEECH BARK DISEASE IN SERBIA

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Summary

Beech (*Fagus moesiaca* /Domin. Maly/ Czeczott) is the most widely distrubuted tree species in Serbia. The significances of beech in Serbia's forest economy is great. However, wider use of Beech wood is limited by its durability. Beech wood is an excellent medium for ther development of many parasite and saprophyte organisms primarly fungi. KRADŽIĆ et al. (2002) describe 147 fungi on beech.

In the beech forests an specially great damage can be caused by the fungi causing bark necrosis and canker. „Beech bark disease" is currently regarded ae the most serious disease of beech. The cause is considered to be a combination of an insect known as the beech scale (*Cryptococcus fagisuga* Lind.) and a pathogenic fungus (*Nectria coccinea* /Pers.ex Fr./ Fries). „Beech bark disease" was first discovered in the beech forests of Serbia in 1983 (MARINKOVIĆ and KARADŽIĆ, 1985). Detailed surveys of the most beech stands in Serbia show that this disease is widely distributed. The disease occurs endemically and a greater damage was recorded on Majdanpečka domena, National park „Djerdap", National Park, „Fruška Gora", Mountain Goč, at several places in beech stands in the region Južni Kučaj (the sites: Igrište-Tekuća bara; Kločanica, Kapatanske livate itc.). The most greates damages are observed in the beech stands of coppice orgin on locality G.J. Igrište- Tekuća Bara (Š.U. Paraćin). Results of our investigations are demonstrited that *Cryptococcus fagisuga* may simple be one of many possible predisposing stressors that alow for infection by *Nectria coccinea*. Many other harmful factors (drought, damages of frost, mechanical damages, other insects which colonized beech bark, other parazitic fungi and so on) can also alow infections by *Nectria* species. In many cases *Nectria* was found infecting weakened trees.

After the infection with the fungus *N. coccinea* beech wood in the zone of necrotic bark is soon infested by wood decaying fungi, bark beetles and wood-boring insects. The process of tree decline due to the attack of these secondary organisms is relatively fast, the value of beech stand decreases heavily and considerable quantities of technical wood are lost. The first fungi which penetrate the dead bark and colonise sapwood are *Fomes fomentarius* and *Trametes gibbosa.* After fungi *F. fomentarius* and *T. gibbosa* also some other wood decaying fungi penetrate the dead bark and colonise sapwood. The most oftent are: *Bjerkandera adusta, Hypoxylon* species, *Trametes versicolor, T. hirsuta, Stereum* spp*., Auricularia auricula-judae, Pleurotus ostreatus, Melanopus squamosus* and sometimes *Ganoderma applanatum* and *Ustulina deusta.* The presence of the fungus *Armillariella mellea* was also recorded on the infected trees and it also plays a definite part in the fast decline and dying of individual trees.

Based on our observation in the field, it sems that *Fagus moesiaca* is more resistant to beech bark disease than *Fagus sylvatica*, and for this reason the damages in beech stands in Serbia are notably lower.

In cases of heavier infections silvicultural measure are recommended, consisting of felling and conversion of attacked trees especially at the beginning of the disease development.

SOME PHISIOLOGICAL CHARACTERISTICS OF THE TWO PATHOGENIC FUNGI FROM *Ophiostoma* GENUS

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Abstract: *This paper presents the results of the study of the same phisiological characteristics of the two species of pathogenic fungi from Ophiostoma genus (Ophiostoma piceae (Munch) Syd. & P.Syd., and Ophiostoma ulmi (Buisman)Nannf). We have tested the influence of different temperatures and different nutritive media to the mycelia growth of this fungus, than fungal fermenting activity, firstly, production of oxidase and reductase.*

In the laboratory conditions we tesed the effect of different temperatures (6°C, 10°C, 11°C, 17°C, 18°C, 20°C, 23°C, 24°C, 26°C, 27°C, 31°C) and two different media: Malt Extract Agar (MEA) and selective media (MEA with actidion and streptomycin) on the growth rate and morphological shape of mycelium of fungi. The fungal fermenting activity was analyzed by testing the influences of isolated fungi on the media oxidation degree.

According to the results of our test fungi exhibited physiological activity at temperatures ranging from 6°C to 31°C, while the best conditions for growth of mycelium in the temperature range from 20°C to 27°C.

Our results show that better daily and weekly mycelial growth of O. picea was recorded on MEA nutritive medium, while O. ulmi had better growth on a selective medium MEA.

On media with gallic and tannic acid isolates showed slower growth, but the recorded oxidation of these substrates in all the samples.

Key words: *O. picea, O. ulmi,* temperatures**,** nutritive medium, growth of mycelium, fermenting activity

1.INTRODUCTION

Pathogenic fungi of the genus *Ophiostoma (Ascomycotina, Sordariomycetes, Ophiostomatales)* develop as parasites in the consignment courts and cause diseases known as "vascular infection". Vascular infection caused by a dry conductive xylem elements (vessels and trachea) and with colonization of the host parenchyma, which is gradually dying out. They may be present in different plant species (Hutchison and Reid, 1988; Sieber, 1989; Brasier, 1993; Kile, 1993) and cause their decline and dying, but the biggest damage they can cause on tree truncks of elm and oak trees (Brasier, 1988; Brasier and Kirk, 1989). Laboratory studies were carried out on species *Ophiostoma piceae* (Münch) Sydow, which colonizes the implementary vessels of oak and *Ophiostoma ulmi* (Buisman) Nannf that are the elm tree pathogen

The fungus *Ophiostoma ulmi* (Buisman) are responsible for the "Dutch elm disease" that in the 20 th century has destroyed most of the elms native to Europe and North America (*Ulmus minor, U. glabra, U. procera, U. americana,* and *U. rubra*) (Gibbs, 1978; Brasier, 1988; Brasier and Kirk, 1989). By Brasier (1993) *O. ulmi* is devasting pathogen of elm, invading the xylem where induces a vascular wilt. Among the species of elms that are growing in Serbia, the most

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sensitive is, *Ulmus carpinifolia*, just under *U. effusa*, and least sensitive to *U. montana* (Karadzic, 2010).

The fungus *Ophiostoma piceae* (Münch) Sydow was isolated and identified from the oak trees affected by the process of drying in the area of northeastern Serbia. During the years of research into the causes of drying oak trees at various locations a number of authors noted that an important role in this process have fungi that grow in the consignment courts (Djordjevic, 1926, 1930; Petrescu, 1974; Glavas, 1984; Gogola and Chovanec, 1987; Hesko, 1987; Marinkovic et al., 1987, 1990, 1992; Golubović Ćurguz and Karadžić, 2000). By Brasier (1993) *O. piceae* is a ubiquitous sapstain fungus on a wide range of coniferous and hardwood trees.

For the purpose of better understanding the properties of these fungi, ceratain laboratory testings were performed of some physiological properties of different strains of fungi of the genus Ophiostoma. These results may be important in the fight against these dangerous pathogens that cause drying and deterioration of important tree species.

2.MATERIALS AND METHODS

Laboratory researches – Laboratory researches were conducted in the laboratory of Faculty of Forestry in Belgrade. The pure cultures of isolates of pathogenic fungi *Ophiostoma* genus (*Ophiostoma piceae (*Munch) Syd. & P.Syd., and *Ophiostoma ulmi* (Buisman)Nannf). were preserved on the nutritive medium at 23 ± 1^0C in the dark.

The influence of medium on the growth of mycelium – The influence of the nutritive media on the growth of mycelium of fungi was determined by the sowing on two nutritive media: One standard nutrient media MEA (malt-extrakt agar, nutritive media which contained 20 gr of malt (Sigma-Aldrich, USA) and 20 g of agar (Torlak, Belgrade, Serbia).) and selective media (MEA with 0,2gr of actidion and 1gr streptomycin (Brasier,1986)). Cycloheximide (also known as actidione) is used as an selective antibiotic. Bacteries are sensitive to low concentrations of cycloheximide. In contrast, those in the group *Ophiostoma* by Weijman and Hoog (1984) tolerate high concentracion of this antibiotic. Both the prepared media were poured in Petri dishes (the 90 x 10mm diameter), and upon the sowing by the fragments of mycelia they were put in thermostat, in the dark at 23 ± 1^0C. The pH value of all media was 6.

The influence of of different temperatures on the growth of mycelium – Isolates were grown at temperatures of 6–33^0 C at for 30 d in the dark.The growth of mycelium was monitored for four weeks, and two cross-sectional diameters were measured every other day during this period.

Morphological changes of mycelium were monitored once a week through the following parameters: colony texture and colour, border appearance and colour,reverse color, medium coloration and exudates.

The fungal fermenting activity – The fungal fermenting activity was analyzed by testing the influences of isolated fungi on the media oxidation degree. The Bavenndamm's method, later on elaborated by Davidson et al (1938), was used for testing oxidase. The MEA medium, to which was added 0.5% of gall or tannic acid, was used as a medium. This experiment was repeated five times. The diffusion zone size, color and tone were used as a criterion for grading the oxidase secretion. The oxidase degree, according to Davidson et al, was expressed in the following way:

- negative, lack of brown agar coloration under or around inoculum;

+ light to dark brown diffusion zone, created under the inoculum in colony center visible from the bottom side of the Petri dish; when the colony is not formed the zone under the inoculum receives brown coloration;

++ light to dark brown diffusion zone, formed beneath the largest part of the colony, but not reaching its borders;

+++ light to dark brown diffusion zone spread on a short distance from the colony edge visible from the upper side;

++++ dark brown diffusion zone, opaque, considerably spreading across the line designating the inoculum zone;

+++++ highly intensive diffusion zone, dark brown, opaque, forming a wide wreath around the colony; usually this strong reaction have those species not grown on the medium with gall acid added.

According to the colony growth rate on malt-agar medium with 0.5% gall or tannic acid added, we have determined on the basis of key by Davidson et al the relation to fungi group in the following way:

Negative or non-reacting fungi

Group 1 – mycelia growth in gall or tannic environment is nearly equal;

Group 2 – growth in gall environment good, colony diameter longer than the one in tannic acid environment;

Group 3 – good growth in gall acid environment, there is no growth or is found only in traces in tannic acid environment;

Positively reacting fungi

Group 4 – not growing or growing only in traces on both media;

Group 5 – not growing or growing only in traces in gall acid environment, mycelia diameter up to 25mm in tannic acid environment;

Group 6 – not growing or growing only in traces in gall acid environment, growth 25-50mm (after 7 days) in tannic;

Group 7 – mycelium with aproxiametly same diameter on both media

Group 8 – clear growth in gall acid environment, good growth in tannic acid environment;

Group 9 – good growth in gall acid environment, not growing or growing only in traces in tannic acid environment; most frequently these fungi are vaguely reacting and for definite results it is necessary to wait 14 days;

Fungi having negative or positive reaction depending on the environment

Group 10 – negative reaction on gall acid environment, positive in tannic acid environment, with good growth in both.

The statistical analysis – All the experiments are set in five repetitions (4 colony radius values in each one). The average values and average errors were determined, whereas the statistically significant differences among the variances were determined by the analysis of variance (ANOVA) using SAS v.9.1.3., and averages were compared using Tukey test ($P<0.05$).

3. RESEARCH RESULTS AND DISCUSSION

The influence of medium on the growth of mycelium

The growth of mycelium on different nutritive media (MEA and selective MEA) is presented in the Table 1-2. The growth of mycelia of studied species of fungi was reported on both media. Fungi grow best in carbohydrate rich media that have a slightly acidic pH (Seifert et al., 1993).

Table 1. *Mean radial growth (cm) of Ophiostoma piceae cultures, in the presence of different culture medium, along time of inoculation*

Medium	Weeks after inoculation			
	I	II	III	IV
MEA	0.54±0.02[a]	0.62±0.03[a]	0.69±0.02[a]	0.81±0.15[a]
sel. MEA	0.41±0.03[b]	0.57±0.04[a]	0.64±0.07[b]	0.75±0.020[b]

Each value is expressed as mean ± standard deviation (N=5). In each row different letters mean significant differences (P<0.05)

Table 2. *Mean radial growth (cm) of Ophiostoma ulmi cultures, in the presence of different culture medium, along time of inoculation*

Medium	Weeks after inoculation			
	I	II	III	IV
MEA	0.64±0.09[a]	0.72±0.05[a]	0.79±0.11[a]	0.90±0.04[a]
sel. MEA	0.61±0.04[a]	0.71±0.0[b]	0.76±0.06[b]	0.88±0.02[b]

Each value is expressed as mean ± standard deviation (N=5). In each row different letters mean significant differences (P<0.05)

Mycelium *O. piceae* do start its growt in the first week on both media, and from the second week there were significant differences in the growth of mycelium. The best medium for this species (P<0.05) is MEA, on which mycelium filled all Petri dishes as early as in the five week.

In regard of *O. ulmi* both nutritiv media provide the favourable conditions for the growth of mycelium. The radial growth of the mycelium of this pathogenal fungus was reported on both media throughout the experiment. The growth is significantly better (P<0.05) on MEA media than on the sel. MEA medium.

Measuring of the growth of mycelium

According to the data in Table. 3 can be observed that the isolates demonstrated physiological activity in the temperature range of 6-31^0 C. The fastest growth in micelium *Ophiostoma piceae* was at 25^0 C, and at this temperature and the conidia were formed. The results of research on the effect of different temperature on mycelial growth of *O. picea* are slightly different from the results of other researchers who state that the optimum temperature for mycelial growth of fungus *Ophiostoma piceae* 23-27^0 C, and determined the optimum pH value is 5-7(Kile, 1993).

Table 3. *The radial growth of mycelium (mm) Ophiostoma piceae on different temperatures*

Temp. °C	Weeks after inoculation				
	I	II	III	IV	V
6	0,00	2,78	3,32	3,32	3,32
10	0,00	3,52	4,70	6,91	7,39
11	0,00	3,64	5,10	7,30	7,80
17	2,41	5,40	7,35	8,81	9,00
18	2,87	6,45	8,01	8,41	9,00
20	3,21	6,82	8,74	9,00	9,00
23	3,83	7,69	8,41	9,00	9,00
24	3,66	7,56	8,74	9,00	9,00
25	6,57	9,00	9,00	9,00	9,00
26	3,65	7,45	8,36	8,70	9,00
27	3,56	6,93	8,34	9,00	9,00
31	0,00	3,00	3,15	3,15	3,15
33	0,00	2,02	2,02	2,02	2,02

Results of temperature on mycelial growth of *O. ulmi* are given in Table 4. Physiological activity of the fungus is in the range of 6-31^0 C. Isolates measured is the best mycelial growth in the temperature range 20-24 ^{0}C. The rate of growth of O. ulmi is significantly greater on all temperatures then the rate of the growth of *O.picea*.

Table 4. *The radial growth of mycelium (mm) Ophiostoma ulmi on different temperatures*

Temp. °C	Weeks after inoculation			
	I	II	III	IV
6	1,65	2,55	3,98	4,70
10	2,76	4,74	8,32	9,00
11	2,97	5,30	8,50	9,00
12	6,38	7,87	8,90	9,00
17	4,07	7,18	8,55	9,00
18	5,09	8,06	9,00	9,00
20	5,26	8,50	9,00	9,00
23	5,09	8,44	9,00	9,00
24	6,02	8,80	9,00	9,00
26	7,39	8,26	8,50	9,00
27	7,29	8,00	8,40	9,00
31	0,00	2,40	2,60	2,70

The morphological description of the mycelium

The morphological description of the studied fungi is presented in the Table 5.

Table 5. *Morphological description of the mycelium of O. piceae and O. ulmi*

Species	Mycelium texture	Mycelium color	border	Medium coloration	exudates
O. piceae	cottony	white	clear	-	-
O. ulmi	wooly on concentric rings	whitish beige	diffuse	-	-

O. piceae – the texture of the mycelium is compact (cotton), with the clearly differentiated white limit.
O. ulmi – the well-formed mycelium of this species has the smallest morphological differences during the growth on the media. Colonies on 2% MEA were first white and gradually turned beige. The texture is wooly, the limit of growth of the mycelium is not clearly formed. Concentric rings formed on the surface of the colonies.

The fungal fermenting activity

The fungal fermenting activity was analyzed by testing the influences of both isolated fungi on the media oxidation degree.

Table 6. Oxidation degree of gallic and tannic acid

Medium		Reaction	Size of diffusion zone (mm)	Size of mycelia (mm)	Davidson 's group
Gallic acid	7thday	+++	3,6□-4,07	3,07-□3,47	7.
	14thday	++++	7,94-□8,2	5,9-□6,54	
Tannic acid	7thday	+++	4,62-□4,77	4,13□-4,25	7.
	14thday	++++	8,11-□8,5	6,5□-7,24	

The research degree of gallic and tannic acid oxidation degree in these media 7 and 14 days after incubation are presented in table 6. The isolates showed a slow growth in the medium with the addition of tannic and gallic acid. Oxidation of these medium showed both of the isolates. The isolates showed an approximately equal growth in both medium and belong to 7th group at Davidson. Fungi causing intensive oxidation of gallic and tannic acid are grouped among fungi which are intensively secreting ferments from oxidase group, proving their ability to oxidize lignin and decompose wood (Karadzic, 1986), which facilitates the penetration of the fungus directly across cell walls (Lagerberg,et all 1927; Gobbs, 1993).

After 7^{th} day isolates show slow growth in gall acid oxidizing it during the process. Tannic acid is faintly oxidized by this fungus and shows faint mycelia growth. After 14 days this fungus shows faint mycelia growth in both gall and tannic acid. The oxidation intensity of gall acid is slightly pronounced. The most intensive medium coloration is beneath inoculum, gradually reducing toward the rim of diffusion zone.

4.CONCLUSION

The results of these researches have led to the following conclusions:

During the years of research into the causes of dry oak and elm trees in different localities in Serbia, it was noted that a significant role of parasitic fungi (primarily tracheomycosis). Laboratory studies of physiological traits pathogenic fungus *Ophiostoma piceaea* and *O. ulmi* we found that tolerance to environmental conditions. Both species of fungus are grown on standard (MEA) and a selective nutrient medium (MEA medium with added antibiotics to the growth of bacteria had been eliminated). Physiological activity of the both fungus is in the range of $6\text{-}31^0$ C. This fungus has shown oxidation of gall and tannic acid

The results of our *in vitro* studies of some physiological characteristics of of the two species of pathogenic fungi *O. piceae* and *O. ulmi* serve as a base for the future researches on the influence of some factors on the development of these fungi, as well as on the possibility fight against these dangerous pathogens present in our forests .

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IMPACT OF THE PRINCIPAL CHARACTERISTICS OF SOIL ON THE ABUNDANCE AND DISTRIBUTION OF THE *Entomophaga maimaiga* RESTING SPORES AND SOIL MICROORGANISMS

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Abstract: *Cadavers of older Lymatria dispar (gypsy moth) larvae (from L_4 to finish instar) killed by the fungal pathogen Entomophaga maimaiga predominantly contain resting spores (azygospores). These cadavers frequently remain attached to tree trunks for several weeks before they detach and fall to ground.*

In spring of 2011, in the culmination phase of the new outbreak of the gypsy moth in Serbia, the higher mortality rate of the older gypsy moth larval instars was reported in the forest complexes of Belgrade region. In two sample plots, located at the site of Hungairan Oak and Turkey Oak forest (Quercetum frainetto cerris) and at the site of montane beech forest (Fagetum montanum), the principal characteristics of soil – a natural development environment for certain stadia of entomopathogenic fungi E. maimaiga and other microorganisms, were analysed. Physical and chemical properties, as well as the abundance and distribution of fungal pathogen and principal physiological groups of soil microorganisms, were examined. The existence of similarity in soil physical properties was revealed at both sites, whereas the differences between chemical properties were far more significantly pronounced. The differences in chemical properties of the soil and the organic layer resulted in manifestation of differences with respect to abundance and relations among principal physiological groups of soil microorganisms, but not for E. maimaiga.

Key words: *Entomophaga maimaiga*, soil properties, soil microorganism abundance

INTRODUCTION

A large number of beneficial entomopathogenic microorganisms, such as entomopathogenic fungus *Entomophaga maimaiga Humber, Shimazu & Soper,* spend one period of their development cycle in soil. Soil properties (soil solution reaction, nature of organic matter, presence of mineral plant assimilatives, humidity, aeration and oxidisability of pedochemical environment, as well as thermal conditions), to a large extent determine the species of soil microorganism that inhabit the soil, as well as their activity. Allelopathic relations of symbiosis and antagonism are established within a microorganism community that inhabits one pedochemical environment. That is performed through creation of matters by means of which microorganisms act upon each other, such as antibiotics, fungistatics, etc. The survival of entomopathogenic and other beneficial microorganisms, which spend only a part of their development cycle in soil, depends on such relations established within a soil microorganism community, as well as on physical and chemical properties of the environment in which they are active.

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This paper presents the results of the author's survey of the interactions between diferent tipes of soil and their physical and chemical properties, soil microorganisms community and resting spores of *E. maimaiga*.

MATERIALS AND METHODS

Characteristics of the sample plots

In the spring 2011, in the Belgrade region, sample plots were established at two sites in which a mass perishing of gypsy moth was observed. The first sample plot was located in the area of Barajevo, while the other was set up in a montan beech forest at Kosmaj.

First sample plot: Even-aged (about 65-year-old), well-preserved *Quercus cerris* L. (80%) and *Quercus frainetto* Tenore (20%) coppice stands. The sample plot is located at the altitude ranging from 120 meters to 170 meters. The slope is southeast-exposed, evenly and gently inclined from 0 to 5 degrees. Ground and bushy vegetation is very thick. In regard of coenology, this stand belongs to the Hungarian oak and Turkey oak association (Quercion frainetto) on Luvisol.

Second sample plot: Approximately even-aged (up to 67-year-old), mixed coppice *Fagus moesiaca* (Domin, Maly) Czeczott. (80%) and *Quercus cerris* L. (20%). The sample plot is located at the altitudes ranging from 410 meters to 450 meters. The slope is north-northwest-exposed, evenly inclined from 6 degrees to 15 degrees. The ground vegetation is frequent, whereas the bush layer is not present. In regard of coenology, the stand belong to the montain beech forest association (Fagenion moesiacae submontanum), on Cambisol dystric.

Pedological research

Pedological profiles were created in sample plots, the type of soil was determined and the samples, according to pedogenetic horizons, were taken for laboratory analysis.

The analysed soil properties are the following:

- Active and substitution acidity (pH u H_2O i pH u KCl), - potentiometrically ;
- The total humus content was determined by wet combustion in the potassium dichromate ($K_2Cr_2O_7$) and sulphuric acid (H_2SO_4) compound, by Tjurin method (Škorić and Racz, 1966);
- The total nitrogen content, by Kjeldahl method (Džamić, 1966);
- Soil particle size composition was determined by a sedimentation method with the application of Na- pyrophosphate as a peptisation agent. Removal of organic matter, carbonates and gypsum was not performed during the process (Racz, 1971). Based on the soil textural composition, a textural class was determined, according to a Ferre's triangle.

Examination of soil microorganisms

For the purpose of examination of the abundance of soil microorganisms, samples of the horizon organic layer and the humus-accumulative horizon were taken. The determination of soil microorganism abundance was performed on samples in natural wetness condition. Nutrient media were sown by soil suspension 0.1 ccm in 10^{-3} dilution. The sowing was repeated three times, and the number of microorganisms was calculated per 1g of absolutely dry soil. Four different media were used: Čapek's agar (3 gr. N_a NO_3, 1 gr. KH_2PO_4, 0.5 gr. KCl, 0.5 gr. $MgSO_4$, 0.01 gr. $FeSO_4$, 20.0 gr. agar, 3.0 gr. sucrose, distilled water up to 1000 ml), MPA (meso-peptonic agar- 41.3 gr. nutrient agar, distilled water up to 1000 ml), Erzbi's agar (0.2 gr. KH_2PO_4,. 0.2 gr. $MgSO_4$, 0.2 gr. NaCl, 0.1 gr. K_2SO_4, 5.0 gr. $CaCO_3$, 20.0 gr. agar, 20.0 gr. malt sugar (glucose), distilled water up to 1000 ml) and synthetic agar with sucrose (0.5 gr. KH_2PO_4, 0.5 gr. $MgCO_3$, 0.50 gr. NaCl, 1,0 gr. KNO_3, 0.01 gr. $FeSO_4$, $CaCO_3$ in excess, 20,0 gr. agar, 25 gr. sucrose, distilled water up to 1000 ml). The media were sterilised in an autoclave at the temperature of 120°C, pressure of 1.5 at, in duration of 20 minutes. Following the autoclaving, the media were poured in Petri dishes. After sowing, all Petri dishes were placed in a thermostat at the temperature of 22±1°C. The determination of the total number of fungi, bacteria and actinomyces, developed on nutrient media, was performed after 5 and 10 days. The obtained measurement data were presented in graphs and tables, according to their site of origin.

The following physiological groups were determined:

- The number of ammonifying microorganisms on meso-peptonic agar;
- The number of oligonitrofilic microorganisms on Esbhi's agar;
- The number of actinomyces on synthetic agar;
- The number of fungi on Čapek's agar;
- The total number of microorganisms on soil agar.

Entomophaga maimaiga (Zygomycetes: Entomophtorales) – main characteristics

The life cycle of *E. maimaiga* closely parallels the life cycle of the gypsy moth. The fungus overwinters in the soil in the form of dormant resting spores (azygospores). As springtime temperatures and moisture levels reach appropriate levels, the resting spores germinate and begin to forcibly release fragile, short-lived conidia (active, infectious spores). Gypsy moth caterpillars are infected by coming in contact with soil borne resting spores or the germinating conidia. An enzyme helps the fungus penetrate the larva´s body. The disease develops in the caterpillar, resulting in death within 7-10 days. After death, fungal hyphae form in the gypsy moth caterpillar´s body, producing conidia (outside the larval body) and/or resting spores (inside the larval body). The conidia produced at this time can infect other caterpillars. Some dead larvae will fall from tree trunks in next two or three weeks, while some will remain attached throughout the autumn and winter. Resting spores from dead larvae are eventually leached back to the soil (Hajek, 1999).

Soil collection protocol

Soil was collected 20 March 2012. *Lymantria dispar* populations in the semple plots had been sampled the previous May and June 2011 and high levels of *E. maimaiga* infection had been documented in the first site (Tabakovic-Tosic et al., 2012). In this site, all of sampled *L. dispar* cadavers containing *E. maimaiga* resting spores. Presence of the resting spores in cadavers from second site was reported, but the number of them was considerably smaller.

According to Hajek et al. (1998), soil was sampled from the four cardinal directions around the bases of five *Quercus cerris* in the first plot, or *Fagus moesiaca* trees in the second plot. In each direction, samples were taken 0-50 cm from the base of tree. For each collection location, samples were taken at a variety of depths. First, loose leaves were brushed from the surface. Then, a sample was taken from the dark, high organic content layer containing roots. To take this sample a trowel was used to remove this layer over a 5 x 5 cm area. A standard soil corer was used to extract cores from 0-8 cm (mixture of A and B horizons). Samples were placed in plastic freezer bags and were stored at 4-6ºC in the refrigerator.

Bioassays: After two month, in June 2012, sampled soil were sprinkled over the surface of the soil in the 15 (5 for each site and 5 for control) containers with a four-year-old oak seedlings. Soil in the each container was watered with 2 l water and placed outdoors. After ten days on each seedling were applied 30 fourth instar gypsy moth larvae reared under controlled laboratory conditions (temperature 21°C, light regime 14/10 hours day/night). Prevent migration, as well as the predator and parasitoid effect on their mortality, containers were placed in cages (Figures 1 and 2).

Figure 1. *Gypsy moth caterpillar on the seedling in cage.*

Figure 2. *Cages.*

The larval mortality was controlled 3, 6, 9 and 12 days after the establishment of the experiment. The dead larvae were placed in Petri dishes with wet filter paper. They were kept 7 days in the laboratory and then stored in the refrigerator. After the storage in the refrigerator for 3 months, the detailed microscope survey of the dead gypsy moth caterpillars was done. The evaluation of *E. maimaiga* infections was recorded as positive when azygospores and conidiospores were detected in the cadavers of dead gypsy moth larvae. The species identification was based on the size, shape and structural characteristics of different life forms of the fungus – azygospores, conidiospores and mycelia.

RESULTS AND DISCUSION

The soil type in the sample plot 1 is luvisol, which is a soil type typical of oak forests. The physical properties of this soil are characterised by a large depth of solum, which in the analysed profile amounts to 100 cm (Table 1).

This is a deep soil of a high capacity for absorption and retention of water. The skeleton is completely absent in the entire depth of solum. The humus-accumulative horizon belongs to a silty loam textural class. It is well water-permeable and aerated. As the soil depth increases, so does the content of clay, while the textural class in the eluvial horizon transforms into clay loam, and in the illuvial horizon it changes into clay. Such profile differentiation, based on textural composition, causes blocking of gravitational water runoff into the deeper layers of soil.

At the sample plot at Kosmaj, in a montane beech forest, a brown loessed soil was identified. The solum depth is 100 cm. According to the textural composition, the humus-accumulative and cambic horizon belong to a loam class, while the illuvial horizon is composed of clay loam. Although signs of ilimerisation are present in the soil profile, the clay transition index is less than 1.5, which classifies this soil as cambic (Škorić et al., 1985). The soil is weakly skeletal, well-structured and well-aerated. The water-absorption and retention capacity is high.

Table 1. *Soil particle size composition and textural class*

Horizon	Depth	Coarse sand	Fine sand	Sit	Clay	Total sand	Total clay	Textural class
	cm	%	%	%	%	%	%	
Ilimerised soil – Luvisol								
A	0-5	3.70	49.90	25.20	21.20	53.60	46.40	Silty loam
E	5-20	0.60	27.30	34.00	38.10	27.90	72.10	Clay loam
Bt	20-100	0.40	26.10	32.00	41.50	26.50	73.50	Clay
Brown loessial soil – ilimerised cambisol								
A	0-2/8	1.00	32.00	42.60	24.40	33.00	67.00	Loam
E	2/8-30	0.90	28.40	44.80	25.90	29.30	70.70	Loam
(B)/Bt	30-100	1.10	28.10	39.00	31.80	29.20	70.80	Clay loam

In both soil types, the water absorption and retention capacities are high. The high capacity of the retention of available water at both sites provide the sufficient reserve of soil water for the undisturbed physiological processes of the forest trees over longer dry periods between two rounds of precipitation. In Hungarian-Turkey oak forest the soil is more differentiated in depth, owning to which the gravitation water is preserved in the soil profile, so the forest trees can also use the gravitational water. It leads to the slower drying-out of the soil than in the case of well-drained solums.

At the submontane beech site the soil is considerably more permeable, which is the result of the lighter texture. The surplus of the gravitational water drains away by the descendant flows. Due to the lesser differentiation of the soil profile regarding the texture, the pause in the drainage of the gravitational water is not as intense as in the case of the luvisol in the observed oak stand. The physical characteristics of the analyzed illimerised dystric cambisol enable the faster drying-out of the soil in the comparison with luvisol. Although the physical characteristics of the cambisol enable the faster drying-out of the solum in the comparison with luvisol, the humidity regime is not necessarily less favourable. The montane beech site is considerably more humid than the Hungarian and Turkey oak site. It is mainly the result of the northern exposure of the terrain and of the higher altitude. These orographic factors reduce the potential evapotranspiration, thereby reducing the water discharge from the soil.

The chemical properties of the analysed luvisol are characterised by moderately acid reaction of the humus-accumulative horizon. As the depth of solum increases, so does the pH value and in the eluvial horizon active acidity of soil solution is in transition between moderately acid and highly acid. In the illuvial horizon the acidity slightly decreases.

The humus-accumulative and eluvial horizons of the ilimerised cambisol are characterised by a very high acidity of soil solution, whereas the acidity of illuvial horizon is high. According to the content of total humus in the humus-accumulative horizon, the soil belongs to a class with a low content of humus. The amount of total nitrogen is high in relation to such a low humus content, which results in a narrow carbone nitrogen ratio (Table 2).

Table 2. *Soil chemical properties*

Horizon	Depth	pH		Total humus	Total N	C/N
	cm	H_2O	KCl	%	%	
Ilimerised soil – luvisol						
A	0-5	5.96	5.38	20.92	0.96	12.58
E	5-20	4.46	3.39	1.18	0.21	5.73
Bt	20-100	4.79	3.54	0.91	0.18	5.15
Brown loessial soil – ilimerised cambisol						
A	0-2/8	4.70	3.59	2.10	0.20	10.54
(E)	2/8-30	4.88	3.52	0.84	0.28	3.03
Bt(B)	30-100	5.06	3.60	0.53	0.19	2.81

In the organic layer of beech forest, the abundance of ammonifying microorganisms is nearly equal to the total number of microorganisms on soil agar (Table 3). The equal number of mineralogenic and ammonifying microorganisms indicates that the processes of organic matter decomposition occur in the organic layer, with a part of decompositon inter-products entering into mutual synthesis by creating humus matter, and a part of them is decomposed to final products, whereby plant assimilatives are released in easily soluble and plant accessible forms. In the humus-accumulative horizon of the identical profile, mineralogenic organisms significantly prevail over ammonifying microorganisms. Oligonitrophile microorganisms are weakly represented, both in the organic layer and in the humus-accumulative horizon. Actinomyces are not identified in the organic layer, i.e., fungi are dominant in dehumidification processes. That indicates that the decomposition of hard-degradable matters, such as lignin or humus, is not performed to the final products and that the decomposition products have an acid reaction. Decomposition processes of hard-degradable matters take place more intensely in the humus-accumulative horizon, where actinomyces, capable of decomposing humus matters, appear in more significant numbers. Decomposition of hard-degradable organic compounds is performed already in the organic layer, where more significant abundance of actinomyces was observed.

Table 3. *Abundance of soil microorganism principal groups (1000 units/1gr dry soil)*

Horizon	Soil agar	MPA	Erzbi's agar	Synthetic agar		Čapek's agar	
	Total number of microorganisms	Ammonifiers	Oligonitrophiles	Actinomyces	Fungi	Actinomyces	Fungi
OP 1- Oak forest							
O lfh	57,761	57,760	17,205	-	31,952	-	3,686
A	151,920	40,902	9,089	5,194	19,477	5,843	25,320
OP 2 - Montane beech forest							
O lfh	11,464	93,078	25,280	4,596	29,877	-	16,087
A	71,666	28,779	63,201	-	12,415	-	10,722

In the organic layer horizon of the sample plot at Kosmaj in a montane beech forest, the number of ammonifying microorganisms significantly prevails over the total number of microorganisms on soil agar. That means that a large amount of mineral forms of plant assimilatives are not released in processes of decomposition of organic matter in the organic layer. In the humus-accumulative horizon, the total number of microorganisms on soil agar significantly prevails over the ammonifying microorganisms. This is a result of a higher presence of soil mineral component in surface layers of soil. In comparison to the first sample plot, the total number of microorganisms on soil agar is significantly lower in the beech forest, both in the organic layer and in the humus horizon. That indicates a lower soil fertility in the second sample plot and a lower amount of plant accessible forms of nitrogen, phosphorous and potassium. Fungi prevail in the humus horizon, while actinomyces are not identified either on a synthetic or Čapek's agar. This is a result of a significantly lower humus content in comparison to the first sample plot.

Numerous and diverse microbe populations play the role in a large number of processes, primarily in the processes of organic matter transformation, creation of plant assimilatives, maintaining a soil structure, degradation of pollutants, but also in biological control of plant and animal pathogens.

The results of testing the presence of resting spores of *E. maimaiga* in soil sampled from two sample and one control plots and its entomopathogenicity are presented in Table 4.

Table 4. *Direct effect of soil with E. maimaiga resting spores from sample plots on the mortality of gypsy moth larvae in the experiment.*

Variant of treatments	Exposure (days)	Average number of dead larvae per repetition				
		I	II	III	IV	V
With soil from first plot	3	2	1	1	0	2
	6	11	15	13	10	17
	9	26	23	25	27	29
	12	30	30	29	28	30
With soil from second plot	3	0	0	3	0	1
	6	12	16	11	13	10
	9	28	30	29	30	27
	12	29	30	30	30	28
Control - soil without spores	3	0	0	0	0	0
	6	0	0	0	1	0
	9	1	0	0	1	0
	12	1	2	0	1	0

Table 5. *Variance analysis of the direct effect of E. maimaiga on the mortality of gypsy moth larvae.*

Source	Sum of squares	Degree of freedom	Mean square	F- ratio	p - value
Between groups	1817.86	2	908.928	1286.22	0.0000
Within groups	7.06667	10	0.706667		
Total	1824.92	12			

No differences in infection level were detected among larvae caged on the soil from both semple plots (LSD $_{0.05}$) (Table 4 and 5). Based on the differences of the mean rates at the level $p < 0.05$, the experimental groups were divided into two homogenous groups (Table 5).

The detailed microscope survey of the dead gypsy moth larvae from experiment showed in all of them, without any exception, the presence of the numerous resting spores of the entomopathogenic fungus *E. maimaiga*. In addition, the presence of the conidia of this pathogen species was reported, but the number of them was considerably smaller (Figure 3).

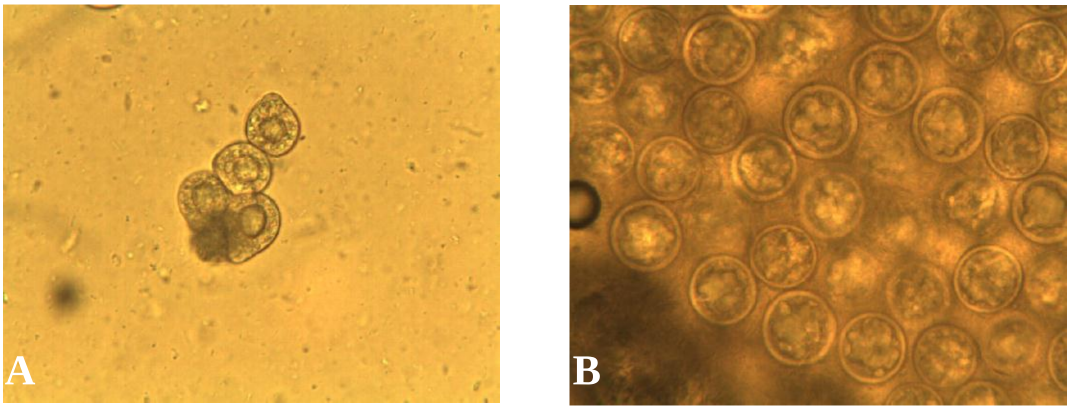

Figure 3. *Conidia (A) and resting spores (B) isolated from dead gypsy moth larvae.*

The soil moisture plays an important role in the anticipation of the effectiveness of *E. maimaiga*. Like most fungi, its spores need moisture and high humidity to germinate (Hajek et al., 1990, 1996; Hajek and Soper, 1992; Smitley et al., 1996; Weseloh and Andreadis, 1992; Weseloh et al., 1993). Frequent watering during the experiment contributes to the start and spread of *E. maimaiga* through a gypsy moth larvae in the cages. The temperature around 20-25ºC greatly enhanced fungal growth.

CONCLUSION

Based on the conducted investigations, it can be concluded that there are certain similarities, but also differences, in the soil characteristics at the sample plots.

Both investigated soils are characterised by a great depth of solum, high capacity for water absorption and retention, good aeration and favourable oxidising conditions of surface layers. A profile differentiation according to the textural composition is evident in both investigated soils, which is more intensive in luvisol, and less intensive in the illimerised cambisol. The physical characteristics of the illimerised cambisol enable the faster discharge of the soil water in the comparison with luvisol, but in the case of cambisol, due to the humid conditions of the site, the water discharge from evapotranspiration is less.

The chemical properties of soils differ significantly. The acidity of soil solution is particularly pronounced in both sites, but the total content of humus and nitrogen is significantly higher in the oak forest in comparison to beech forest.

The differences in chemical properties of the soil and the organic layer resulted in manifestation of differences with respect to abundance and relations among principal physiological groups of soil microorganisms, but not for *E. maimaiga*.

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INFLUENCE OF GYPSY MOTH FOOD ON THE BIOLOGICAL EFFICACY OF THE TESTED INSECTICIDES

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Abstract: *One of the steps on the path towards obtaining the permission for putting into circulation and for application of some insecticide is the study of the biological efficacy of it, i.e. of its ability to reduce a number of economically harmful insects to the normal level, which is considered to be safe. The study of the biological efficacy in forestry, by contrast to the same researches in agriculture, is faced up with many difficulties and problems, the biggest of which lies in the fact that in the natural conditions it is only possible to perform it when the outbreak of the target species occurs on a huge area of land. As a result, the study of the biological efficacy of the selected insecticide should be done simultaneously with the registration of it for this purpose and with the application in the suppression of the outbreak of the harmful insect. It is not possible to perform all of these activities simultaneously. The preliminary studies of biological efficacy are mainly conducted in the laboratory conditions, when the natural food of the gypsy moth larvae is not available, so prior to the experiment and during it the gypsy moth is fed on the synthetic food, specially adapted for the basic nutritional needs of this insect. Therefore, these studies are aimed at checking whether there are any statistically significant differences in the levels of the biological efficacy of the selected insecticides when they are applied on synthetic or natural food. In the experiments carried out in the semi-controlled laboratory conditions the levels of biological efficacy of some insecticides are mainly significantly different. In regard to the factor – type of food, i.e. nutrition by the natural or synthetic food, the maximum biological efficacy of all insecticides achieved when they applied on Pedunculate oak leaves can be explained by the tendency of larvae to prefer the natural food to the synthetic one, regardless of the fact whether it contains the feeding stimulators.*

Key words: Key words: gypsy moth, insecticides, laboratory, biological efficacy

INTRODUCTION

In the Serbian forestry the certification based on the principles of the sustainable forest management was adopted in 2006. During the preparation of it, the FSC Criteria (FSC-STD-01-001, 2004), relating to pesticide use (Criterion 6.6, 10.7, 10.8), proved to be particularly interesting. FSC has a list of chemicals that are prohibited. A company applying for certification would normally have to stop using these chemicals before it can receive an FSC certificate.

In Serbia broad-leaf forests, which are particularly endangered by the outbreaking insect species from the group of defoliators, cover 1988800 hectares, or 88.3% of the area covered by forests (Banković et al., 2009), and almost all previously registered and applied chemical insecticides are on the list of prohibited ones.

One of the steps on the path towards obtaining the permission for putting into circulation and for application of some insecticide is the study of the biological efficacy of it, i.e. of its ability to reduce a number of economically harmful insects to the normal level, which is

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considered to be safe. The study of the biological efficacy in forestry, by contrast to the same researches in agriculture, is faced up with many difficulties and problems, the biggest of which lies in the fact that in the natural conditions it is only possible to perform it when the outbreak of the target species occurs on a huge area of land. As a result, the study of the biological efficacy of the selected insecticide should be done simultaneously with the registration of it for this purpose and with the application in the suppression of the outbreak of the harmful insect. It is not possible to perform all of these activities simultaneously. The preliminary studies of biological efficacy are mainly conducted in the laboratory conditions, when the natural food of the gypsy moth larvae is not available, so prior to the experiment and during it the gypsy moth is fed on the synthetic food, specially adapted for the basic nutritional needs of this insect. Therefore, these studies are aimed at checking whether there are any statistically significant differences in the levels of the biological efficacy of the selected insecticides when they are applied on synthetic or natural food.

MATERIAL AND METHOD

The main characteristics of the observed insecticides

In the period of two years, the biological efficacy of the two biological (Foray® 48B, Wormox®) and four chemical insecticides (Dimilin® SC-48, Avaunt® 15 SC, Coragen® 20 SC, Alverde® 240 SC) and their mixtures, were tested in laboratory and field conditions.

Based on the technical documentation, Wormox® and Foray® 48 B potencies are 16.000 and 10.600 IU/mg. They are highly-selective microbiological insecticides active by ingestion. Their pathogenicity is based on the character of *Bacillus thuringiensis* ssp. *kurstaki* to produce crystalline proteins with toxic effects (causing the host toxicosis and septicaemia).

Dimilin® SC-48 (active ingredient – diflubenzuron), Avaunt® 15 SC (active ingredient – indoxacarb), Coragen® 20 SC (active ingredient - chlorantraniliprole) and Alverde® 240 SC (active ingredient - metaflumizone) are modern chemical non-systemic pesticides of the third generation, active by ingestion, less by contact.

Dimilin is restricted use pesticide, due to toxicity to aquatic invertebrate animals. Treatment of susceptible larvae with this insecticide generally results in an inability to moult. The larvae are unable to escape from the exuviae and often lethally injure the weak new cuticle in the attempt. Even when moulting is successful they usually die soon afterwards.

Indoxacarb and metaflumizone inhibits the sodium ions entry into nerve cells, which paralyses the larvae and causes the cessation of feeding and insect death (US EPA, 2009; Klein and Oloumi, 2005**)**. This mode of action requires no metabolism for toxicity to target insects. Chlorantraniliprole is a diamide insecticide. The mode of action of chlorantraniliprole is the activation of insect ryanodine receptors. This activation stimulates the release of calcium from the internal stores of smooth and striated muscle which causes impaired muscle regulation, paralysis and insect death (Ioriatti et al., 2009).

After foliar applications, most of the active ingredients remain on the leaf surface and a small amount penetrates into the leaf tissue. They are highly potent and active at low rates on target species, which are mainly Lepidoptera and also some Coleoptera and Diptera. The Reduced Risk Committee categorized indoxacarb, chlorantraniliprole and metaflumizone as the “reduced risk” pesticides.

Studies of biological efficacy of insecticides on the gypsy moth

The laboratory experiment of biological efficacy of pesticides presented in Table 1 was established in the two-year-period, during the third larval instar of the gypsy moth. From the beginning of feeding till the end of the experiment the caterpillars were fed with the natural (Pedunculate oak leaves) and synthetic food (Gypsy Moth Diet produced by MP Biomedicals, LLC – Aurora, Ohio, USA), but from the third instar the food was shortly soaked in water solutions of the analysed doses of the preparation. During the experiment, temperature and light conditions were constant (temperature 21°C, light regime - 10 hours a night, 14 hours a day) The potency was controlled 72, 144 and 216 hours after the establishment of the experiment.

Table 1. *Variants of the applied preparations in the tests of their biological efficacy*

Code	Name	Dose
A_1	distilled water	1000 l/ha
A_2	Foray® 48B	3000 ml/ha Foray + water up to 1000 l/ha
A_3	Wormox® SC	2000 ml/ha Wormox + water up to 1000 l/ha
A_4	Dimilin® SC-48	150 ml /ha Dimilin + 850 ml/ha white oil + water up to 1000 l/ha
A_5	Avaunt® 15 SC	250 ml /ha Avaunt + 750 ml/ha white oil + water up to 1000 l/ha
A_6	Coragen® 20 SC	200 ml /ha Coragen + 800 ml/ha white oil + water up to 1000 l/ha
A_7	Alverde® 240 SC	100 ml /ha Alverde + 900 ml/ha white oil + water up to 1000 l/ha
A_8	Foray® 48B + 10% Alverde® 240 SC	3000 ml /ha Foray + 10 ml/ha Alverde + water up to 1000 l/ha
A_9	Forey® 48B + 10% Coragen® 20 SC	3000 ml /ha Foray + 20 ml/ha Coragen + water up to 1000 l/ha
A_{10}	Forey® 48B + 10% Avaunt® 15 SC	3000 ml /ha Foray + 25 ml/ha Avaunt + water up to 1000 l/ha

During the assessment of the biological efficacy Abbott's formula (Abbott,1925) was used, since there was the constant number of the inviduals of the target insect in some elementary units and repetations.

Plan and method of the statistical analysis of the experiment

The factorial experiments (plans of the experiment in which two or more factors are introduced at the same time with all combinations, and each factor have two or more treatments, i.e. levels of observation) was used for this study. The factorial combinations are repeated in the blocks or Latin squares. They are frequently used in the biological researches, and particularly in agriculture and forestry (Jeffers, 1960; Hadživuković, 1977).

The experiment set in order to study of the biological efficacy of the selected insecticides and their mixtures had three factors with the different number of treatments, repeated in four blocks (repetitions):

Factor A – preparation (A_1 – A_{10} from the Table 1);

Factor B – type of food (B_1 – synthetic food, B_2 – natural food (Pedunculate oak leaves)

Factor C – exposure of the larvae to the harmful effect of the preparations (C_1 - 72 hours, C_2 - 144 hours, C_3 – 216 hours).

The experiment which was set is the combination of the qualitative (insecticides, type of food) and quantitative (exposures) treatments and can be abbreviated as 10 x 2 x 3 treatments. The research lasted for two years, and the number of the survived gypsy moth larvae, i.e. of their combinations, was registered upon the application of the above treatments.

The statistical analysis of the factorial experiment was conducted in the laboratory of the Institute of Forestry in Belgrade. The program STATGRAPHICS, version 5.0, was used. By dividing the total sums of the squares of variance of the observed characteristic into the sums of the squares of the treatment variance, i.e. their combinations and the sums of the squares of the experiment error, the direct influence of the observed factors and treatments (A, B, C) on the survival of the larvae was determined, as well as the influence of their interaction of the first (AB, AC, BC) and second levels (ABC). F-test was used for the assessment of the statistical importance of these influences and t-test for the assessment of the statistical significance of the differences between the treatment mean rates, i.e. the least significant difference (LSD) (Hadživuković, 1991).

RESULTS AND DISCUSSION

In the two-year-period, the biological efficacy of the biological (Foray®, Wormox®) and modern (third generation) chemical insecticides (Dimilin®, Avaunt®, Alverde®, Coragen®) and their mixtures, was studied in the Institute of Forestry in Belgrade, in the aim of their registration for use in the certificated forests in Serbia. The study results are presented in Table 2.

Table 2: *Biological efficacy of the tested insecticides and their mixtures in the control of the third larval instar of the gypsy moth*

Combinations of treatments			Average number of alive larvae per repetition for the period 2009-2010				X_{mean}	E (%) by Abbott
			I	II	III	IV		
A_1	B_1	C_1	14.85	14.35	14.65	15.00	14.71	
		C_2	14.70	14.20	14.65	15.00	14.64	
		C_3	14.70	14.20	14.65	14.85	14.60	
	B_2	C_1	14.85	15.00	14.85	14.00	14.67	
		C_2	14.85	15.00	14.85	14.00	14.67	
		C_3	14.85	15.00	14.85	14.00	14.67	
A_2	B_1	C_1	5.70	4.65	4.15	4.65	4.79	67.44
		C_2	1.35	1.00	0.70	1.00	1.01	93.10
		C_3	0.35	0.15	0.15	0.15	0.20	98.63
	B_2	C_1	1.15	0.50	0.00	0.35	0.50	96.59
		C_2	0.00	0.00	0.00	0.35	0.09	99.39
		C_3	0.00	0.00	0.00	0.00	0.00	100
A_3	B_1	C_1	12.00	11.70	10.70	9.70	11.02	25.08
		C_2	1.30	0.70	0.00	1.00	0.75	94.88
		C_3	0.70	0.70	0.00	0.70	0.52	96.44
	B_2	C_1	1.35	1.15	1.15	0.70	1.09	92.57
		C_2	0.00	0.00	0.15	0.35	0.12	99.18
		C_3	0.00	0.00	0.00	0.00	0.00	100
A_4	B_1	C_1	10.30	13.35	13.65	12.50	12.45	15.36
		C_2	4.15	5.50	9.35	5.65	6.16	57.92
		C_3	0.00	1.00	0.65	0.85	0.62	95.75
	B_2	C_1	8.50	5.35	4.85	6.70	6.35	56.71
		C_2	0.15	0.00	0.35	0.00	0.12	99.18
		C_3	0.00	0.00	0.00	0.00	0.00	100
A_5	B_1	C_1	11.15	12.20	10.15	10.00	10.87	26.10
		C_2	6.50	5.50	7.00	5.65	6.16	57.92
		C_3	0.65	0.85	0.65	0.65	0.70	95.20
	B_2	C_1	4.85	5.35	4.65	6.00	5.21	64.48
		C_2	0.00	0.00	0.15	0.00	0.04	99.73
		C_3	0.00	0.00	0.00	0.00	0.00	100
A_6	B_1	C_1	13.65	12.50	13.15	13.35	13.16	10.54

		C_2	1.20	2.50	4.20	2.85	2.69	81.62
		C_3	0.00	0.65	0.50	0.00	0.29	98.01
	B_2	C_1	5.85	6.70	6.65	8.50	6.92	52.83
		C_2	0.15	0.15	0.35	0.15	0.20	98.64
		C_3	0.00	0.00	0.00	0.00	0.00	100
A_7	B_1	C_1	12.50	14.85	13.50	13.50	13.59	7.61
		C_2	4.85	6.85	6.80	6.80	6.32	56.83
		C_3	0.70	0.50	0.35	0.30	0.46	96.85
	B_2	C_1	5.50	6.00	0.65	4.35	4.12	71.91
		C_2	1.15	1.15	0.00	0.65	0.74	94.95
		C_3	0.00	0.00	0.00	0.00	0.00	100
A_8	B_1	C_1	5.65	5.80	5.85	5.65	5.74	60.98
		C_2	1.20	0.65	1.35	0.65	0.96	93.44
		C_3	0.00	0.15	0.50	0.15	0.20	98.63
	B_2	C_1	3.15	1.65	2.50	2.00	2.32	84.18
		C_2	0.85	0.00	0.00	0.00	0.21	98.57
		C_3	0.00	0.00	0.00	0.00	0.00	100
A_9	B_1	C_1	5.15	6.35	6.35	6.35	6.05	58.87
		C_2	0.35	1.35	0.80	1.00	0.87	94.06
		C_3	0.00	0.00	0.35	0.15	0.12	99.18
	B_2	C_1	3.35	4.20	2.70	3.50	3.44	76.55
		C_2	0.00	1.00	0.30	0.65	0.49	96.66
		C_3	0.00	0.00	0.00	0.00	0.00	100
A_{10}	B_1	C_1	8.85	6.50	9.65	8.50	8.37	43.10
		C_2	2.15	2.00	1.20	2.30	1.91	86.95
		C_3	0.15	0.15	0.15	0.65	0.27	98.15
	B_2	C_1	5.85	6.65	7.00	7.50	6.75	53.99
		C_2	1.85	2.65	1.35	1.65	1.87	87.25
		C_3	0.00	0.00	0.00	0.00	0.00	100

Legend:
A – insecticides (Table 1)
B – type of food (B_1 – synthetic food, B_2 – natural food (Pedunculate oak leaves)
C – exposure (C_1 – 72 hours, C_2 – 144 hours, C_3 – 216 hours)

During the first assesment of the biological efficacy, 72-hours upon the application of the treatment, the highest rates, ranging from 52.83% (Coragen®) to 96.59% (Foray®), were reported in the phase of the experiment where the observed preparations were applied on the natural food of the gypsy moth – Pedunculate oak lives. Somewhat lower rates were reported when the preparations were applied on the synthetic food for the gypsy moth (ranging from 7.61% for Alverde®, to 60.98% for its mixture with the biological insecticide Foray®).

When the larvae were grown in the semi-controlled laboratory conditions and the preparations were applied on the natural food of the gypsy moth, 144-hour exposure to the observed insecticides and their mixtures were sufficient for all of them, without exception, to achieve absolute, maximum efficacy (100%).

The results of the study of the biological efficacy of the selected insecticides presented in the Table 1 show that all of them can be used for the control of the gypsy moth larvae in the forest ecosystems, but the attention should be paid to the fact that the application of Dimilin, i.e. of its active ingredient, is still prohibited in the certificated forests. As the remaining three chemical preparations (Avaunt®, Alverde®, Coragen®) achieved the maximum rates of efficacy and are not on the list of the prohibited ones, it is recommended that the possibility of their registration for the control of some economically significant harmful species of the defoliating insects in the broadleaf forests should be studied.

The results of the study of the biological efficacy of the mixtures of the biological insecticide as the bearer (Foray®) and lowest doses of the selected chemical insecticides, aimed at the highest possible increase of the biological efficacy in the control of the outrebreak of gypsy moths (*Lymantria dispar* L.), in the case when owning to their number the use of the first mentioned preparation does not give the satisfactory results, showed that they were compatible, i.e. their mixture did not cause the inactivation of the spores and protein crystals of the bacterium *Bacillus thuringiensis* ssp. *kurstaki*, bearer of insecticide activities. The biological efficacy of the study mixture was the same with the cases when microbiological preparation are applied independently.In order to get more accurate answer to the main question which is defined in this paper (whether there are statistically significant differences in the rates of the achieved biological efficacy when the insecticide is applied on the synthetic or natural food of the target insect species), the mean rates of the survival of the gypsy moth larvae in the experiment conducted over the two years period, presented in the Table 2, were subject to the detailed statistical analysis.

First, the variance analysis, in which the direct effect of the three above factors (A,B,C) and the effect of the blocks (D) was studied, was conducted. F-test showed that the effect of the blocks was statistically random ($p>0.72$), whereas the effect of all factors was statistically significant at the level $p<0.01$. In the further analyses the blocks were regarded as the usual repetitions. Afterwards the variance analysis, with the interaction of factors of the first and second levels, aimed at the determination if the statistically significant interactions between the observed factors occurred, and at which level, i.e. the possible reduction of the error of the experiment, was conducted. The results of the variance analysis are presented in the Table 3.

Table 3: *Variance analysis of the direct and combined effects of factors on the survival of larvae*

Source of variance	Sum of squares	Degree of freedom	Mean square	F- ratio	p - value
A - insecticide	3276.21	9	364.023	698.39	0.0000
B - food	379.765	1	379.765	728.60	0.0000
C – exposure	1568.37	2	784.185	1504.49	0.0000
AB	167.458	9	18.6065	35.70	0.0000
AC	408.912	18	22.7173	43.58	0.0000
BC	213.764	2	106.882	205.06	0.0000
ABC	137.574	18	7.64298	14.66	0.0000
Error	93.8213	180	0.52123		
Total	6245.87	239			

The result of F-test shows that the separate or combined influence of all factors on the number of the survived larvae in the experiment is of the high statistical significance. The variance of error is S^2 =0.52123, and its standard deviation or error of experiment is S_p=0.72196. By including the interaction of factors in the analysis, the error of experiment was reduced by 65.97%. All combinations of insecticides with the type of food and duration of exposure of the larvae are statistically significant.

The differences in the mean rates of the survived larvae for the factor – preparation are $LSD_{0.05}$=0.41125 and $LSD_{0.01}$=0.54259.

Out of 45 possible comparisons of the mean rates, in the first instance 39 or 86.7% are significant, and in the second instance 36 or 80%. Based on the differences of the mean rates at the level $p<0.05$, the preparations were divided into seven homogenous groups, and at the level $p<0.01$ in six groups (Table 4).

Table 4: *Homogenous groups of insecticides based on LSD and Dunkan's Tests*

Code*	Mean	Homogeneous groups																									
		$p < 0.05$														$p < 0.01$											
		LSD Test							Dunkan's Test							LSD Test						Dunkan's Test					
A_2	1.09792	x							x							x						x					
A_8	1.57292		x							x						x	x					x	x				
A_9	1.82917		x							x							x	x					x	x			
A_3	2.25208			x							x							x						x			
A_{10}	3.19792				x							x							x						x		
A_5	3.83125					x							x							x						x	
A_6	3.87708					x	x						x	x						x						x	
A_7	4.18125					x	x						x	x						x						x	
A_4	4.28542						x							x						x						x	
A_1	14.6625							x							x						x						x

* Legend in Table 1

The differences of the mean rates of the survived larvae for the factor of the type of food are $LSD_{0.05}$=0.18265 and $LSD_{0.01}$=0.24043, but for the factor of exposures are $LSD_{0.05}$= 0.22370, and $LSD_{0.01}$= 0.29447.

The mean rates of survival for the factor of type of food are: B_1=5.33667 and B_2=2.82083. By comparing the difference of mean rates and LSD, it was determined that the difference between two types of food of the larvae was statistically significant at the level $p<0.01$, and the higher in the comparison with the treatment B_2 – natural food. The mean rates for the factor of exposures of larvae are the following: C_1=7.60750, C_2=2.99500 and C_3=1.63375. By comparing the differences of the mean rates and LSD, it was determined that the difference between all three durations of exposures of the larvae was significant at the level $p<0.01$.

Based on the Dunkan's test, at the level $p<0.05$, preparations were divided into seven homogenous groups, and at the level $p<0.01$ in six groups (Table 4). Out of 45 possible comparisons of the mean rates, in the first instance 39 or 86.7%, and in the second one 36 or 80.0% were significant.

During this study no significant difference in the determination of the statistical significance of the difference between the mean rates of the treatments based on the LSD and Dunkan's test was reported. Other authors came to the same conclusion during the experimental studies of the different tests for the stimultaneous comparison of several mean rates (Hadživuković et al., 1973).

The statistical analyses of the results of the experiments set in order to study the biological efficacy of the selected biological and chemical insects on the gypsy moth larvae as the test insect, undoubtedly showed that all above factors (type of insecticide, type of food and duration of exposure) to a greater or lesser extent affected the achieved rates (Table 3). In regard to the first factor – insecticide, the mechanism of action had the crucial influence on the efficacy of the mechanism of action, i.e. considerably longer time was needed to pass from the moment of their introduction of the biological preparations in the organism of the target insect to their action to start than in the case of the observed chemical insecticides. In addition, Foray and Wormox, the active ingredient of which is *Bacillus thuringiensis* ssp. *kurstaki*, were most efficient on the younger larvar instars (L_1 and L_2), whereas for the older ones (experiment performed on L_3) the higher lethal dose from the applied one or the longer exposure were needed, by contrast to the selected chemical insecticides (Tabaković-Tošić, 2005-2006). In this way the influence of the third observed factor – duration of exposure of the larvae to the harmful effect of the preparation is also explained.

Table 5: *Homogenous groups of combinations insecticide-type of food based on LSD Test*

Code*	Homogeneous groups											
	(C1)*											
A_2B_2	x											
A_3B_2	x	x										
A_8B_2		x	x									
A_9B_2			x	x								
A_7B_2				x	x							
A_2B_1				x	x	x						
A_5B_2					x	x	x					
A_8B_1						x	x	x				
A_9B_1						x	x	x				
A_4B_2							x	x				
$A_{10}B_2$								x				
A_6B_2								x				
$A_{10}B_1$									x			
A_5B_1										x		
A_3B_1										x		
A_4B_1											x	
A_6B_1											x	
A_7B_1											x	x
A_1B_2												x
A_1B_1												x

Code*	Homogeneous groups					
	After 144 hours (C2)*					
A_5B_2	x					
A_2B_2	x					
A_4B_2	x					
A_3B_2	x					
A_6B_2	x					
A_8B_2	x					
A_9B_2	x					
A_7B_2	x					
A_3B_1	x					
A_9B_1	x	x				
A_8B_1	x	x	x			
A_2B_1	x	x	x			
$A_{10}B_2$		x	x	x		
$A_{10}B_1$			x	x		
A_6B_1				x		
A_4B_1					x	
A_5B_1					x	
A_7B_1					x	
A_1B_1						x
A_1B_2						x

Code*	Homogeneous groups				
	(C3)*				
A_5B_2	x				
A_6B_2	x				
$A_{10}B_2$	x				
A_4B_2	x				
A_9B_2	x				
A_3B_2	x				
A_8B_2	x				
A_7B_2	x				
A_2B_2	x				
A_9B_1	x				
A_2B_1	x	x			
A_8B_1	x	x			
$A_{10}B_1$	x	x	x		
A_6B_1	x	x	x		
A_7B_1		x	x	x	
A_3B_1			x	x	
A_4B_1				x	
A_5B_1				x	
A_1B_1					x
A_1B_2					x

* Legend in Table 2

In regard to the second factor – type of food, i.e. nutrition by the natural or synthetical food, the maximum biological efficacy of all insecticides achieved in the semi-controlled laboratory conditions when they applied on Pedunculate oak leaves. It can be explained by the tendency of larvae to prefer the natural food to the synthetic one, regardless of the fact whether it contains the feeding stimulators. Namely, when the factor B2 (natural food) is observed, the type of the preparation does not have a significant influence on the levels of the biological efficacy, in contrast to the factor B2 (synthetic food), where the observed preparations form a greater number of homogeneous groups (Table 5).

CONCLUSION

The results of the studies of the biological efficacy of the selected chemical insecticides of the third generation, which are not on the list of the preparations that are prohibited in the certificated forests, have showed that they have all the necessary properties (high biological efficacy, mechanism of action, resistance to watering and a small amount of application) for the use in forest ecosystems. Also, they are compatible with the biological insecticides the active ingredient of which is *Bacillus thuringiensis* ssp. *kurstaki* (Tabakovic-Tosic, 2008), so they can be safely mixed in the aim of the increase of the biological efficacy and safe application.

In spite of the fact that the experiments set in order to study the biological efficacy of insecticides, aimed at obtaining the permission for their use in the forest stands, can be conducted in the laboratory conditions, but the attention should be paid to the fact that the results are mainly significantly different. In regard to the factor – type of food, i.e. nutrition by the natural or synthetic food, the maximum biological efficacy of all insecticides achieved when they applied on Pedunculate oak leaves can be explained by the tendency of larvae to prefer the natural food to the synthetic one, regardless of the fact whether it contains the feeding stimulators. In laboratory experiments, preference should be given to natural food because, upon the registration, the preparations will be applied on the trees in the natural condition.

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INVESTIGATION OF *Cydia splendana* Hübner AND *Cydia amplana* Hübner AS PESTS OF PEDUNCULATE OAK ACORN

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Abstract: *In order to ensure sustainable management of penduculate oak forests it is necessary to provide enough supplies of high quality acorn for natural or artificial regeneration. In this purpose, at Forest estate Sremska Mitorvica were established two seed orchards of penduculate oak. In first years at seed orchard Banov Brod was observed that greatest share of acorns is destroyed before ripening of acorns, where dominant cause is addressed to acorn feeding insects. Investigations showed significant share of damages caused by Cydia splendana and Cydia amplana what initiated study of their biology and damage intensity. Research was conducted at seed orchard Banov Brod and laboratory of the Institute of Lowland Forestry and Environment.*

Results showed that C. splendana swarming spreads from beginning of July until end of August, with highest intensity in first half of August. Swarming of C. amplana was recorded from start of July until end of August. First caterpillars bored into acorns was observed in July with maximum number recorded in August for C. splendana and in September for C. amplana. Start of emerging of caterpillars from acorns was recorded in September and for C. splendana it ended in mid October, while for C. amplana it lasted until the end of October. Both species hibernate in the form of cocoon. Damages made by C. splendana and C. amplana were relatively high and in 2003 affected was 29,4% of yield, and 26,6% in 2004. Most of the damage was done by C. splendana .

Key word: pedunculate oak, acorn, *C. amplana*, *C. splendana*

1. INTRODUCTION

Aimed at producing quality seed of pedunculate oak at the locality "Banov brod" located in the vicinity of the Bosut in Srem, the Forest estate from Sremska Mitrovica used vegetative propagation to establish a seed orchard during the 1979 to 1987 period (Erdeši & Radivojević, 1996). In this seed orchard the greatest percentage of acorn fall before it reached maturation was observed during the early years of fruit-bearing. In this case the insects feeding on acorns were identified as the dominant factor in acorn reduction. The investigation proved that the following five insects caused the yield reduction: *Curculio glandium* Marsh., *Curculio elephas* Gyll., *Cydia splendana* Hb., *Cydia amplana* Hb. and *Andricus quercuscalicis* Burgsd. (Drekić, 2006). The acorn yield was intensively affected by the insect and the damage was 78% in 2003, and 76,8% in 2004. Other authors also reported about damages caused to the acorn yield by the insects (Fitze, 1959; Maksimović, 1982; 1983; Mikloš, 1991; Hrašovec, 1993). It was determined that a significant part of damages in seed orchard was caused by acorn moths *C. amplana* and *C. Splendana* and these harmful insects of oak acorn are mentioned by numerous authors: Spuler, 1910; Nüsslin & Rhumbler, 1927; Escherich, 1931; Fitze, 1958; Воронцов, 1962; Patočka, 1980; Земкова, 1980; Maksimović i dr., 1982; Mihajlović, 1992). Elements of biology

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mentioned by some authors differed to some extent, which was probably due to the various environmental conditions under which their studies were conducted. Due to intensive damages and the fact that for successful protection of the cultivated plants from the harmful insects it was necessary to have a good understanding of the insects biology, studies on biology and harmfulness of these two species were conducted.

2. MATERIAL AND METHODS

The studies were carried out in the pedunculate oak seed orchard at the locality of " Banov brod" and in laboratory. In order to breed insects under laboratory conditions the oak acorn attacked by insects was collected on 16th September 2003 and placed into two 20 l plastic containers with removed bottoms replaced by metal grating. These containers were placed above other two of 30 l filled with soil taken from the seed orchard at Banov brod. The metal grating placed at the bottom of the upper container was of such mash size as to allow undisturbed caterpillar transition into the container with the soil, and to prevent acorn from falling down. Containers were kept outside for most part of the year, during the period of insect growing, and in the basement facilities only during winter. The facilities were not heated, but the temperature within them never dropped below zero. The soil in the containers was occasionally watered in order to prevent complete drying. During 2004 through 2005 containers were regularly inspected once a week and emergence of insects recorded.

Observation of *C. splendana* and *C. amplana* swarming was performed in the seed orchard using wooden frames. The height of wooden frames was 40 - 50 cm, and they covered the area of 1m^2. The frames were buried at 15 to 20 cm below the soil. On the upper side the frames were covered by appropriate hinged lids and covered by a dense net. Total of 13 frames was placed in the orchard. Five of them were placed on 16th Septemeber 2003, and the other eight on 28th March 2004. In March of 2005 all frames were slightly moved to the side to occupy new area. The inside of the frames was regularly and thoroughly inspected approx. every two weeks from April through the beginning of November 2004, and from beginning of April to the end of October 2005 and occurrence of *C. amplana* and *C. splendana* butterflies was recorded.

The presence of the insect larvae in the acorn attached to the tree was determined by colecting of 200 acorns from the tree approx. every 14th day, and by inspection in the laboratory over the period from the end of July through mid October 2003, and from mid June through mid September 2004 at least once every 14 to 19 days. A sample of 200 acorns was taken from greater number of trees.

To observe the dynamics of the occurrence of caterpillar from the attacked acorns over the period from beginning of August through the end of October 2004 the acorn in seed orchard was collected approx. every 15 days from the area of 8 m^2. The acorn was placed into plastic containers covered by dense net. Containers containing collected acorns were inspected and number of caterpillars emerged from the acorn recorded over the period from mid August through mid December 2004.

Acorn was collected from the total of 24 surfaces of one square meter placed under the oak tree crowns aprox. 1 m apart from the tree base. Prior to acorn collection the surfaces were cleaned from the litter and branches and marked with permanent markings. In 2003 the collection of the fallen pedunculate oak acorns was performed from the end of July till the beginning of November, and in 2004 from mid June to the beginning of November every 14 to 19 days. The collected acorn was thoroughly inspected in the laboratory to determine the cause of its fall.

3. RESULTS AND DISCUSSION

Cydia splendana Hübner

Occurrence of the butterflies was observed at the beginning of July in 2004 in the laboratory where they were grown and kept in containers with soils above which the containers with the gnawed acorns were placed. The eclosion of the greatest number of butterflies of this species was observed during the period of August 3 - 10, and the last butterflies were observed on August 24th. No butterflies occurred in the growing containers the following year. The beginning of butterfly swarming in the seed orchard at Banovo Brdo in 2004 was observed in mid July, while the greatest number of adults of this species was found during inspection of wooden frames performed in mid August, when the last butterfly was observed (Drekić, 2009). At the beginning of August of 2005 only one butterfly of this species was found in the wooden frames. Reduction of the population could be explained by the low acorn yield on the trees under which frames placed in 2004. From the above mentioned it can be concluded that butterfly swarming took place during July and August, and that the swarming of this species was the most intense during the first half of August.

According to Patočka, J. (1980) the swarming took place from June to August, while Grbić, (1999) determined that the swarming in sessile oak forest on the area of Majdanpečka Domena started at the end of June and lasted until the mid August. Земкова, (1980) observed swarming in July and August.

Females lay their eggs on the acorn, and young newly emerged caterpillars make their holes through the acorn cap and pericarp. Results obtained from the acorn harvested from the trees at approx. equal intervals indicated that in 2003 the first caterpillars atack the acorns in the second half of July, while the greatest number developed in mid August, and in the following year the first drilled caterpillars were observed in mid July, while the greatest number was observed at the beginning of September. The above mentioned findings coincide with the citations of Patočka (1980) who claimed that caterpillars begin to develope in July. Maksimović et al. (1982) also concluded that the beginning of the caterpillars development in the acorn started in the second half of July, but they also mentioned development starting from June, which was not confirmed by our investigation.

Upon completion of development the caterpillars created elongated oval shaped exit holes in the acorn that can be clearly distinguished from the exit almost completely round shaped holes created by the larvae of *Curculio* sp. Exit of caterpillars with completed development was observed during the period from beginning of September to mid October with the largest number of exiting caterpillars observed in mid September. Determined period of caterpillar leaving the acorn coincided with the conclusion made by Patočka (1980), while it differed from that made by Bovey et al. (1975) that caterpillars began to leave the fruit of chestnut at the end of September, the most intensely during October, and it continued during November and December. Caterpillars overwinter in cocoons in the soil surface layer, in leaf litters or under cracks in the bark on tree trunks. *C. splendana* has a one-year generation which coincided with the citations of other authors (Spuler, 1910; Escherich, 1931; Patočka, 1980; Земкова, 1980; Maksimović i sar., 1982; Grbić, 1999).

Cydia amplana Hübner

Occurrence of the first butterflies in the laboratory was observed at the beginning of July in 2004. The last butterflies were observed on 24th August, and in 2005 no butterfly of this species occurred. The beginning of swarming was determined by collecting of butterflies in the wooden frames placed in the seed orchard in 2004 in mid July, while the last butterflies were observed during the frame inspection in mid August. During the following year the inspection of frame revealed no butterflies of *C. amplana*, which could be explained, as in the *C. splendana*, by the low yield in the previous year, which caused the reduction in the insect population. The above mentioned results indicated that swarming of *C. amplana* butterflies took place during July and August. According to Земкова (1980) swarming began at the end of June or beginning of July under Ukrainian conditions, while Spuler (1910) claimed that swarming took place during June and July.

Females lay eggs near the fruits, in leaves, and in on fruits (Земкова, 1980). Emerged caterpillars create their way into the immature acorn through its cap and pericarp. Inspection of the acorn harvested from the tree indicated that in 2003 and 2004 the first caterpillars created their way into the acorn at the mid July, while in both years the largest number of caterpillar developed inside the acorn was at the beginning of September. Upon completion of development the caterpillars created the elongated oval shaped exit hole in the acorn pericarp. Exit of caterpillars from the fallen acorns was observed during the period from the beginning of September to the beginning of November, with the greatest number of caterpillars leaving the acorn in the second half of September. Caterpillars overwinter in the cocoons in the soil surface layer or in leaf litters. Occurrence of butterflies was determined by growing in the laboratory in 2004, while in the following year butterflies was not observed and consequently was concluded that *C. amplana* has a one-year generation, which coincided with the claims of other authors (Maksimović, 1982; Grbić, 1999; Земкова, 1980), but Escherich (1931) concluded that it sometimes could have a two-year generation, and Воронцов, (1962) mentioned that in the Caucasus, there are two to three generations per year.

Damages caused by C. splendana and C. amplana

The influence of *C. splendana* and *C. amplana* on yield reduction was significant and in 2003 it was 29,4% from the total yield, and in the following year 26,6% of the acorn yield. In addition to that, 3,4% of acorn was destroyed in 2003, and 1,3% in 2004 by simultaneous feeding of *Curculio* spp. and *Cydia* spp. inside the same acorn. In regard to individual participation of these species in yield reduction some conclusions can be drawn based on determination of caterpillars present in the acorn at the time of inspection of the fallen acorn. During 2003 in the moths infested acorns 87,4% were caterpillars of *C. splendana*, and 12.6% of *C. amplana*. In the following year the ratio of determined caterpillars of these two moths was similar - 82,5% were caterpillars of *C. splendana* and 17.5% were caterpillars of *C. amplana*. This indicated that *C. splendana* was dominatnt and caused major damages. Falling of acorn damaged by *Cydia* spp. began in July, and continued until October.

4. CONCLUSION

Swarming of *C. splendana* took place during the period from the beginning of July, the most intensively during the first half of August, ending in the second half of August. Swarming of *C. amplana* during the research years was determined from the beginning of July to the end of August. Both species of the genus Cydia began to create their holes into the acorns in July, and maximum number of caterpillars of *C. splendana* developed inside the acorn in mid August and beginning of September, and that of *C. amplana* in the beginning of September.

Larvae of both species began to leave the acorn at the beginning of September, and those of *C. splendana* finished it in mid October, and of *C. amplana* at the beginning of November.

The influence of *C. splendana* and *C. amplana* on yield reduction was significant and in 2003 it was 29,4% from the total yield, and in the following year 26,6% of the total acorn yield. *C. splendana* was dominant and caused major acorn damages.

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BOTRYOSPHAERIACEAE FOUND ON DECLINING WOODY HOSTS IN SERBIA

Milica ZLATKOVIĆ[1,2], Nenad KEČA[1]

Abstract: *Species of Botryosphaeriaceae have been isolated as endophytes and canker pathogens from numerous hosts in many parts of the world and have been implicated in the decline of* forest, plantation and some ornamental trees. *These fungi have been associated with different symptoms such as shoot blights, stem cankers and dieback that have also recently been observed in Serbia. In the present study, botryosphaeriaceous fungi were isolated from both healthy and diseased plant tissues and fruiting bodies of a wide variety of native and introduced woody plant species (Cedrus spp., Picea spp., Abies spp., Pinus spp., Aesculus hippocastanum, Fagus sylvatica, etc.) planted in urban forests, parks, along streets, poplar and pine plantations and natural forest stands.*

Widespread dieback of trees in the cities of Serbia from which Botryosphaeriaceae (Diplodia, Fusicoccum, Dothiorella, etc.) were isolated may be due to unsuitable environmental conditions such as high temperatures, drought stresses, flooding, frost and insect damage observed during the last years. Imported nursery stock may also be an important source of this pathogens. Impacts of Botryosphaeriaceae could be even greater because of a high concentration of possibly highly susceptible trees in urban forests, managed parks and monocultures along roads planted in stressful conditions.

Key words: Botryosphaeriaceae, dieback, urban forests, parks, monocultures

1. INTRODUCTION

Botryosphaeriaceae Theiss. & P. Syd. (Botryosphaeriales, Ascomycota) is a species-rich family with 79 genera (www.MycoBank.org). Species in the family Botryosphaeriaceae are found in temperate and tropical climates worldwide as saprophytes, endophytes, primary or opportunistic pathogens in a wide range of both annual and perennial host plants (Sinclair et al., 1987; Slippers and Wingfield, 2007). Several botryosphaeriaceous species are well known pathogens and endophytes of woody perennial plants of important crops (Michailides, 1991; Slippers et al., 2007), forest, plantation and ornamental plantings and nursery plants including oak (Sánchez et al., 2003; Dreaden et al., 2011), beech (Vajna, 1999), ash (Bakys et al., 2009), pine (Bihon et al., 2010; Santamaría et al., 2011), juniper (Stanosz and Moorman, 1997; Alves et al., 2006), cypress (Abdollahzadeh et al., 2009; Li et al., 2010) and giant sequoia (Worral et al., 1986; Rooney-Latham et al., 2012). To date, species in the anamorphic genera such as *Diplodia* Fr., *Dothiorella* Sacc., *Fusicoccum* Corda, *Lasiodiplodia* Ellis & Everh, *Neofusicoccum* Crous, Slippers & A.J.L. Phillips, *Phaeobotryon* Abdollahzadeh, Zare & A.J.L. Phillips have been associated with forest, plantation and landscape trees. Species of Botryosphaeriaceae infecting

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woody ornamentals, forest stands and monocultures cause a broad variety of disease symptoms, such as shoot blights, dieback, bleeding necrosis and cankers (Ciesla, 1996; Sánchez et al., 2003; Kehr, 2004; Li et al., 2010). Massive diebacks and significant economic losses to the forest industry as a result of Botryosphaeriaceae species infection have been reported in oak stands in Spain and Portugal (Sánchez et al., 2003) as well as in eucalyptus and pine plantations worldwide (Nicholls and Ostry, 1990; Slippers et al., 2009; Rodas et al., 2009).

In recent years, there has also been a noticeable dieback of trees planted in the urban areas of Serbia and Botryosphaeriaceae have constantly been isolated from diseased parts (Zlatković et al., 2011a, b). Since then, new hosts, both native and introduced have been recorded from various ornamental plantings, forest stands, nurseries and plantations all over the country and Botryosphaeriaceae have been found associated with both diseased and healthy tissues. Thus the aim of this study was to examine the possible reasons for sudden prevalence of botryosphaeriaceous fungi in Serbia, focusing on the ongoing trade and environmental changes.

2. MATERIALS AND METHODS

2.1. Sample collection and fungal isolation

Botryosphaericeae isolates were collected from trees with various disease symptoms in urban forests, public greens, parks, private gardens, nurseries, natural forest stands and forest plantations all over Serbia, during the period of 2009-2012. Isolations were made from the margin between necrotic and apparently healthy tissue, healthy tissues of the same host, resin-soaked wood, twigs and/or needles or fruiting bodies. Small segments were rinsed in sterile distilled water, surface sterilized (1 min in 70% ethanol), again rinsed with sterile distilled water, dried on sterile paper towels, shortly flamed and placed on 2% malt extract agar (MEA) (2% malt extract, 1.5% agar; Merck KGaA, Darmstadt, Germany) supplemented with 2.5 ml/l of a 25% (vol/vol) solution of lactic acid to suppress bacterial growth. Piceases of tissue with fruiting bodies found on cones or necrotic stem and/or branch lesions were surface sterilized in the same manner and placed on Petri dishes containing MEA. The Petri plates were sealed with Parafilm [Pechiney plastic packaging, Chicago, USA] and incubated at room temperature in dark for 2 weeks. Colonies resembling species of the Botryosphaeriaceae (fast growth, mycelium white originally, turning dark greenish-gray or grayish within few days) were transferred to new Petri containing MEA and stored on MEA slants at 4^0C. Isolates are maintained in the culture collection of the Laboratory of Forest Pathology (Chair of Forest Protection) at the Faculty of Forestry, University of Belgrade.

2.2. Morphological characterisation

To induce sporulation, isolates were grown on 2 % water agar to which triple sterilized pine needles had been added as a substrate. The plates have been incubated at room temperature under near UV-light in a 12 h light-dark regime for 4-7 weeks to induce the formation of fruiting bodies. Morphological features of the resultant fruiting bodies were observed using a light microscope, digital camera and XliCap V17 software (Ceti, England, UK). Fruiting structures were sectioned by hand and mounted in sterilised distiled water.

3. RESULTS AND DISCUSION

Since 2009 fungi belonging to the Botryosphaeriaceae have been isolated from thirty one hosts all over the country mostly from trees in urban forests, managed parks, along road verges, but also from natural stands, plantations and nurseries. They have been found on both native and introduced host trees and in both healthy and diseased tissues of the same host (Table 1).

Table 1: *Tree hosts of Botryosphaeriaceae from Serbia*

	HOST	INTRODUCED
1.	*Abies alba* Mill.	-
2.	*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr	+
3.	*Aesculus hippocastanum* L.	+
4.	*Cedrus atlantica* (Endlicher.)Manetti ex Carriére	+
5.	*Cedrus deodara* (Roxb.) G.Don.	+
6.	*Chamaecyparis lawsoniana* (A.Murray) Parl.	+
7.	*Chamaecyparis obtusae* (Siebold & Zucc.) Endl.	+
8.	*Chamaecyparis pisifera* (Siebold & Zucc.) Endl.	+
9.	*Cryptomeria japonica* (L. f.) D. Don	+
10	*Cupressus arizonica* Greene	+
11.	*Fagus sylvatica* L.	-
12.	*Forsythia europaea* Deg. Et Bald.	-
13.	*Juniperus horizontalis* Moench	+
14.	*Ligustrum vulgare* L.	-
15.	*Liriodendron tulipifera* L.	+
16.	*Magnolia grandiflora* L.	+
17.	*Picea abies* (L.) Karst.	-
18.	*Picea omorica* (Pancic) Purk.	-
19.	*Picea pungens* Engelm.	+
20.	*Pinus halepensis* Muller	+
21.	*Pinus nigra* Arnold	-
22.	*Pinus sylvestris* L.	-
23.	*Prunus laurocerasus* L.	+
24.	*Pseudotsuga menziesii* (Mirb.) Franco.	+
25.	*Quercus petraea* (Mattuscha) Liebl.	-
26.	*Quercus robur* L.	-
27.	*Sequoiadendron giganteum* (Lindl.) J.Buchh	+
28.	*Sequoia sempervirens* (D.Don) Endl.	+
29.	*Thuja occidentalis* L.	+
30.	*Thuja plicata* Donn ex D.Don	+
31.	*Viscum album* L.	-

Botryosphaeriaceous species have been isolated as endophytes and canker pathogens from numerous hosts in many parts of the world and have been implicated in climate driven tree declines (Desprez-Loustau et al. 2006; Dakin et al., 2010; Piškur et al. 2011). A particularly dangerous feature of these fungi is that they can live as endophytes in plant organs, in a latent phase, without producing clear symptoms, and diseases only emerge following the onset of unfavourable conditions to the tree (Smith et al. 1996). The latent, dormant or quiescent infections (without visible symptoms) are due to the parasitic relationship during which the pathogen remains in a quiescent stage until, under specific circumstances, it becomes active (Verhoeff, 1974). Quiescence may occur during any of the processes from fungal germination to colonization (Swinburne, 1983). Plant material infected with a latent pathogen is a potentially primary source of inoculum for the incidence and spread of the diseases. Furthermore, endophytic isolates of Botryosphaeriaceae obtained from healthy material have been shown to cause disease symptoms in greenhouse trials (Pavlic et al. 2007; Slippers et al., 2007; Piskur et al., 2011). This implies that with increased movement of people and products these fungi can easily and unnoticed be introduced into new environments with seeds, cuttings and even fruit causing potentially serious damage to tree hosts (Slippers and Wingfield 2007).

Since commercial movement of living plants is a pathway of highest risk, incursions of plant material infected with a latent disease are being restricted using a number of measures.

Identification of fungal pathogens from apparently healthy tissues (including seeds) based on cultural characteristics requires a long time to yield results and may be influenced by conditions under which the tests are performed. Also, fast growing saprophytes overgrow the fungal pathogen, posing considerable difficulty in the isolation of the pathogens in pure cultures (Narayanasamy, 2006). Chemicals, especially paraquat and freezing methods have been utilized for the detection of some latent postharvest pathogens present in plant parts or in harvested produced, e.g. *Botryosphaeria dothidea* Cesati & De Notaris. on apple fruit (Biggs, 1995). Serological tests like ELISA have been designed for some botryosphaeriaceous crop pathogens such as *Macrophomina phaseolina* (Tassi) Goid. and could be employed to also detect pathogens in asymptomatic tissues (Afouda et al., 2009). Detection of plant pathogens using molecular techniques is based on nucleic acid sequences of the pathogen genome and is preferable because of greater sensitivity and reliability. Nucleic acid based techniques using specific DNA probes have been employed for the detection of fungal pathogens in seeds, propagative materials, plants, or soil. This technique is rapid; the results may be obtained within few hours, whereas the conventional methods need several days or weeks even. Furthermore, molecular diagnostic methods depend on characteristics of pathogen genoms and hence they can be applied for identification of all fungal pathogens, including those that have been difficult to differentiate based on morphological characters alone (like Botryosphaeriaceae, for example) and obligate pathogens which cannot be isolated on cell-free artificial media (Narayanasamy, 2006; Denman et al. 2000; Zhou and Stanosz 2001; Pavlic et al., 2007; Slippers et al., 2009). Moreover, microarrays are nowadays being used to simultaneously analyze for the presence of thousand nucleotide sequences and are being designed to test for the presence of all known fungi within a few hours (Narayanasamy, 2006).

However, these techniques involve considerable expense and are still beyond the reach of most developing countries (Brasier, 2008), especially when large scale seed or plant testing is needed. Furthermore, phytosanitary services rely on a visual inspection of plants and are not trained to deal with the latent pathogens. Plants are been sent to laboratories only in certain circumstances, mostly when unfamiliar pattern of symptoms is been observed during inspection (Slippers and Wingfield, 2007; Articles 35 and 36, paragraph 2 of the Law on Plant Health of the Republic of Serbia, 2009; Rulebook on plant health checks of consignments of plants in trade across the state border, 2011). Given the limitation of visual inspection potentially infected material can be imported into Serbia and latent pathogens can cross the border easily together with their apparently healthy hosts. Moreover, international movement of living plants, especially rooted nursery stock, semi-mature and even mature trees, which represents the greatest biosecurity risk has recently exploded into a high volume industry (Brasier, 2008; Wingfield et al., 2011). And although plants are regularly been propagated in the nurseries, they are also being imported into Serbia mostly from Netherlands, but also directly or indirectly (imported by Netherlands and exported into Europe) from Africa (especially Kenia), South America, Japan, China and other exotic places, with good climatic conditions and a cheap labor force (European Commission, 2006). Latent pathogens, including Botryosphaeriaceae are also known as seed born (Cilliers et al., 2003; Gure et al., 2005) which adds a higher level of complexity into the global trade problem. There has therefore always been a tension between a conservation and environmental responsibilities of horticulturists, foresters, garden designers and landscape architects and their desire for novel material or (these days) cheaper plants and instant mature trees (Brasier, 2008).

If a latent pathogen enters a new environment together with its host plant, it may find suitable climatic conditions for establishment, stressed hosts that might have no co-evolved resistance and absence of its natural enemies (Slippers and Wingfield, 2007; Brasier, 2008). In Serbia, the widespread dieback of trees from which Botryosphaeriaceae were isolated has mostly been reported from urban areas where trees are highly disturbed and, as such predisposed to insect or pathogen attack. Ornamentals are frequently planted in unfavorable sites such as parking lots or other areas where they experience stress from pollution, soil compaction or damage from human activities, including pruning. Pruning wounds provide a major entry point for Botryosphaeriaceae (Kim et al., 2001) and, together with possible insect damages (Glavendekic and Mihajlovic, 2006) also contribute to tree stress. And although are ornamental plants considered to be adapted to the stressful environment of urban areas those trees are mostly introduced (Table 1) and planted in settings with environmental conditions which often differ from those in their country of origin, making them more susceptible to the diseases as it has been observed for *Sequoiadendron giganteum* (Lindl.) J. Buchh and *B. dothidea* (Kehr, 2004). Furthermore, plant species that have been introduced with the host may disrupt the balanced microecology of the host (Johnson 1997), this may then reduce the plant defense system, resulting in increased colonization of locally adopted endophytes and increasing the potential for a pathogenic lifestyle of latent pathogens (Kogel et al., 2006; Redman et al., 2001) both naturally occurring within the host and acquired from the surrounding environment. Also, large residential or business developments or roadside plantings in urban areas are often composed of a single shade tree species. Monoculture planting can lead to the quicker spread of the diseases, where a uniform tree species is susceptible to a pathogen (Wingfield et al., 2001). Those trees represent a substantially more uniform genetic base than those that occur in the surrounding native forests, which can have a significant effect on epidemic development (Drenth, 2004). Similar situation can be found within Serbian plantation trees. Such plantations have the advantage of reducing the highly undesirable practice of logging native and old-growth forests that still too often supply timber mills, but are also often susceptible to various diseases (Wingfield et al., 2001).

Successful infection of botryosphaeriaceous fungi and susceptibility of trees is closely linked to environmental conditions, where high temperatures, water logging, freeze and other forms of stress favor infection (Ahimera et al. 2003). Thus, the incidence of diseases worldwide caused by or associated with these fungi and other endophytes has been steadily increasing and climate change is seen as the driving force in the apparent range expansion of these normally minor diseases (Desprez-Loustau et al. 2006; Slippers and Wingfield, 2007; Kliejunas et al. 2008; Dakin et al., 2010; Piškur et al. 2011). A pool of both native and introduced endophytic botryosphaeriaceous fungi can become serious pathogens when higher temperatures and drought conditions occur (Slippers and Wingfield, 2007; Piskur et al., 2011). The heat wave and the severe drought that Europe experienced in 2003 had serious consequences of the health and productivity of forests (Annals of forest science, special issue 63 (6), 2006). Similarly to the other parts of the world, Serbia has been confronted with changes in climatic conditions. Climatic extremes and natural disasters such as drought, flooding, forest fires, “heat” and “cold” waves have been regularly observed during the last years. Extremely high summer (44.9°C in July 2007) and extremely low winter (-28.9°C in February 2011) temperatures have been measured and high amounts of snow recorded, making everyday human activities impossible and causing floods in the spring (data obtained from RHMZ of the Republic of Serbia; www.hidromet.gov.rs). These natural disasters had severe economic impacts. For example, damage from floods in 2006 had been estimated at 35.7 million EUR (Milanovic et al., 2009). Current climate models indicate further rise in temperature and reduction in rainfall in this region (Vukovic et al., 2009), possibly making trees susceptible to botryosphaeriaceae opportunistic infection.

It has also been shown that botryosphaeriaceous fungi are capable of growth and their conidia can germinate in a broad range of temperatures, including those that have been considered extremes (Úrbez-Torres et al., 2010). Optimum temperature for in vitro mycelium growth of most Botryosphaeriaceae is in a range between 25°C and 30°C, with observed growth at 40°C (Kohn and Hendrix, 1983; Úrbez-Torres et al., 2006; Begoude et al., 2010; Mehl et al., 2011; Zlatković, unpublished). Conidial germination of Botryosphaeriaceae is also significantly affected by temperature with an optimum between 25°C and 35°C but 40°C for pigmented conidia of *Lasiodiplodia theobromae* (Pat.) Griffon & Maubl. (Pennycook and Samuels, 1985; Sutton and Arauz, 1991; Úrbez-Torres et al., 2010; Laturre et al., 2012), suggesting that these pathogens are well adapted and have potential to grow under high summer temperatures. For instance, *Diplodia pinea* (Desm**.**) J. Kickx f. is a thermophilic species with an optimum temperature for growth near 30°C (Keen and Smits, 1989; Desprez-Loustau et al., 2007) and its growth should be favored by climate warming (Desprez-Loustau, 2011).

In conclusion, widespread dieback of trees from which Botryosphaeriace were isolated and thus might be involved in could be due to native endophytic pathogen populations that became pathogenic because of unsuitable environmental conditions such as high temperatures, drought stress, flooding, frost or insect damage observed in recent years in Serbia or those are pathogens which might came on “healty“ imported nursery stock into new habitat where they have been exposed to already stressed hosts and suitable climatic conditions that would have occured within their endemic range. Impacts of Botryosphaeriaceae could be even greater because of a high concentration of possibly highly susceptible trees in urban forests, managed parks and monocultures along roads planted in stressful conditions. A possible resolution to the question lies in molecular identification to the species level of Botryosphaeriaceae and population genetic studies (using microsatellite markers, for instance) on the patricular pathogen.

Awareness of the potential threat of endophytic and latent pathogens within Serbian horticulturists and foresters is needed as it should be applied to future quarantine and plant health management practices.

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MOST COMMON HORSE CHESTNUT DISEASES (*Aesculus hippocastanum* L.)

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Abstract: *Horse chestnut (Aesculus hippocastanum L.) is an endemic species of the south part of Balkan Peninsula, which grows naturally only in the basin of the river Drina. Owing to its ecological characteristics and decorative quality, it is frequently used as a park tree and for formation of tree lines. As a result of increased exposure to harmful actors in urban environment, it weakens physiologically and becomes predisposed to attacks of harmful organisms. This paper presents the results of a two-year study of diseases that occur in all development phases of the horse chestnut. Furthermore, the paper presents for the first time a study of species of genus Phytophthora in horse chestnut in Serbia. The most commonly identified fungus in assimilation organs is Guignardia aesculi, which causes an occurrence of leaf spots. The most substantial harm on adult trees is caused by decay causing fungi. Among all identified decay causing fungi, the most harm is caused by* Inonotus hispidus, Ganoderma *adspersum and Ganoderma applanatum.*

Key terms: horse chestnut, pathogenic fungi, diseases, *Guignardia aesculi*, *Phytophthora*

INTRODUCTION

Common horse chestnut *(Aesculus hippocastanum* L.), according to Fukarek (1983) is naturally represented only in south-east Europe (Greece, Albania, Macedonia and Bulgaria). It is a relict species of tertiary flora. In natural stands, it grows jointly with walnut, narrow-leafed ash, maple tree, Norway maple and alder. There are several varieties, which differ in height, flower colour and leaf shape. In addition to common horse chestnut, red horse chestnut, horse chestnut with yellow flowers *(A. glabra* Wild.) and a hybrid created by crossbreeding between red and common horse chestnut, are also used for plantation in parks and tree lines.

(A. carnea Hayne). Owing to its ecological characteristics and decorative quality, it is frequently used as a park tree and for formation of tree lines. The adverse impact of urban environment represents a limiting factor to its growth and creates a predisposition to attack by various deseases and pests. The most substantial harm (physical weakness, attack by secondary parasites and pests, and reduction of decorative quality) on horse chestnut is infested by a fungus *Guignardia aesculi* (Peck.) Stew. and a horse chestnut leaf miner *Cameraria ochridella* Deschka & Dimić.

Guignardia aesculi causes appearance of leaf spots on horse chestnut. The spots first appear on leaf apices and edges and they are covered by a yellow margin. On their edges, the infested leaves fold longitudinally towards the upper side and fall off prematurely.

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A horse chestnut leaf miner was first discovered in 1984, in the surroundings of Ohrid in Macedonia, on account of characteristic mines on horse chestnut leaves (*Aesculus hippocastanum* L.) (Simova-Tošić, D. and Filev, S., 1985). Soon after it had been discovered, it rapidly spread to the north and occupied the entire territory of Serbia (Dimić, N. and Mihajlović, Lj. 1993). Today, it is present in many European countries, reaching the north as far as the Czech Republic. Under a strong attack, leaves become dry and fall off.

Guignardia aesculi and *Cameraria ochridella* frequently occur jointly, and in that case horse chestnut is at particular risk, losing completely its assimilation organs in August. Those trees foliate and blossom anew in September and October, which additionally weakens them. Decay causing fungi and, in recent years, *Phytophthora* species frequently occur in horse chestnut in parks and tree lines.

MATERIAL AND METHOD

The studies of the most common horse chestnut diseases were conducted in tree lines and parks in Obrenovac and Zemun. A presence of disease was first established by an ocular examination. If the cause of disease could not be identified in that manner, samples were taken for laboratory analysis, where, based on symptoms and fungi fruit-bodies, their identification was conducted. If the cause was not identified even after the laboratory analysis, the isolation from a horse chestnut tissue was performed in the following manner:

The tissues, from which isolation was performed, were firstly rinsed by running water for not less than 30 minutes. For isolation of fungi from diseased parts of horse chestnut, freshly infested parts were selected and cut into pieces of size less than 5mm. From older, infested tissues, saprohytic species were isolated. Cut down fragments of tissue were surface sterilised for 2 minutes in a sodium hypochlorite solution (2-6% of active chlorine) or for several seconds in 70% ethanol, and then rinsed in a sterile distilled water. After that, they were transferred, under aseptic conditions, to appropriate nutrient substrates. Petri dishes were placed into a thermostat to appropriate temperatures, where a suitable time for identification of fungi was determined by means of an everyday observation. Fungi cultures most frequently increased at the temperature between 21 and 25 ^{o}C, however, occassionally, depending on an isolated fungus, they were incubated at lower temperatures below 15 ^{o}C, or on higher temperatures above 34 ^{o}C.

In cases when pure cultures were not obtained, a repeated screening was performed until pure cultures were produced. Formation of fruit-bodies was facilitated by change of external conditions (temperature, light regime), changes in fungi nutrition (change of substrates rich in nutrient matter by a water-agar substrate) or a protracted development of culture.

Following the study of the above-mentioned characteristics, identification was performed by use of a relevant literature, namely: Hawksworth et al (1995), Sutton (1980), Webster and Weber (2007), Dennis (1978), Božac (2008), Pidopličko and Miljko (1971), Carmichael et al (1980), Arx (1974), Bondarcev (1953), Bondarceva and Parmasto (1986), Bondarceva (1998), Novotelnova (1974).

Isolation and identification of species of genus Phytophthora

The isolation of species of this genus was performed according to methods proposed by Jung (2009). Samples with disease symptoms (diseased trunk or branch tissues with rusty exudates) were taken and left in a distilled water until being taken to a laboratory. The water was regularly changed for three days in order to remove the excessive polyphenol. After that, in sterile conditions, parts of infested tissue were cut from various lesion depths, wiped off by filter paper and transferred to the PARPNH agar (V8-agar,10 μg/mL pimaricin, 200 μg/mL ampicillin, 10 μg/mL rifampicin, 25 μg/mL pentachloronitrobenzene (PCNB), 50 μg/mL nystatin i 50 μg/mL hymexazol) substrate. The samples with no clearly distinct symptoms were immersed into plastic dishes, into which distilled water was added. Oak or chestnut leaves, which served a role of the decoy, were placed on water surface. In these dishes water was also changed daily in order to protract the development of bacteria and remove excessive polyphenole.

Samples of soil with roots were taken from around trees in four directions, at the distance of 50-150cm. Three to five soil samples of size 20 x 30 x 30 cm were taken from around one tree. Out of these samples, after a removal of organic part, a new sample was formed. Nearly 300g of soil and root prepared in this manner was placed in plastic dishes, poured with 500 ml of distilled water, while 10-15 young oak leaves (aged 7 days) were placed on a water surface. The dishes were left in a laboratory at the temperature of 18-20^o C, kept under daylight conditions, without being closed. The leaves were inspected and, after the appearance of brownish spots, a presence of sporangia was identified by microscope. The leaves were wiped off with filter paper, cut into small pieces and transferred to the PARPNH agar substrate. Petri dishes were incubated at 18-20^o C under dark conditions, where, following a development of a colony, screening onto the V8-agar (100ml/l multi-vitamin juice, 3 g/l CaCO3 and20 g/l agar) substrate was conducted. Identification of species was performed based on a colony growth rate, as well as appearance of sporangia, oogonia, antheridia and chlamydospores.

STUDY RESULTS

During the course of a two-year study of horse chestnut leaves, fruits, roots, branches and trunks, a presence of several parasitic and saprophytic fungi was established. The results of these investigations are presented in the table 1.

Table 1. *The most common fungi on horse chestnut trees*

Name of fungus	Affected part of tree	Type of damage	Significance
Phytophthora citricolaSawada	Root and Stem	Root rot and bark canker ("Bleeding canker")	+ + +
Phytophthora cactorum (Lebert & Cohn) J. Schröt.	Root and Stem	Root rot and bark canker ("Bleeding canker")	+ + +
Phytophthora cambivora (Petri) Buisman	Root and Stem	Root rot and bark canker ("Bleeding canker")	+ + +
Armillaria spp. (Fr.) Staude	Root and Stem	Root rot (White rot)	+ +
Pythium spp.	Seeds and seedlings	Damping-off	+ +
Guignardia aesculi (Peck.) Stew.	Leaf	Leaf blotch	+ + +
Septoria hippocastani Berk. & Broome.	Leaf	Leaf spot	+ +
Uncinula fraxini Miyake.	Leaf	Powdery mildew	+ +
Alternaria alternata (Fries) Keissler	Leaf	Saprophyte on leaves	+
Epicoccum nigrum Link	Leaf	Saprophyte on leaves	+
Mucor mucedo L.	Seed	Mold	+
Rhisopus nigricans Her	Seed	Mold	+
Trichoderma viride Pers.	Seed	Mold	+
Trichotecium roseum (Persoon) Link	Seed	Mold	+
Epicoccum nigrum Link	Seed	Mold	+
Alternatia alternata (Fries) Keissler	Seed	Black mold	+
Fusarium spp.	Seed and seedlings	Damping-off	+ +
Penicillium spp.	Seed	Mold	+
Aspergillus spp.	Seed	Mold	+
Hypoxilon fragiforme (Pers.ex Fr.) Kickx	Bark of branches	White rot	+ +
Nectria cinnabarina (Tode ex Fr.) Fr	Bark of branches	Necrosis on the bark	+ +
Inonotus hispidus (Bull. ex Fr.) Karst.	Trunk and branches	White rot	+ + +
Ganoderma adspersum (Schulzer) Donk.	Root and Collar	White rot	+ + +
Ganoderma applanatum (Pers,exWallr.)Pat.	Root and Collar	White rot	+ + +
Trametes versicolor (L.: Fries) Pilát	Trunk and branches	White rot	+ +
Schizophyllum commune Fr.	Trunk and branches	White rot	+ +
Trametes hirsuta (Wulf.:Fr.) Pil	Trunk and branches	White rot	+ +
Chondrostereum purpureum (Pers.: Fr.) Pouzar	Trunk and branches	White rot	+ +
Laetiporus sulphureus (Bull. ex Fr.) Murill	Trunk and branches	Brown, cubical rot in the heartwood	+ +
Auricularia mesenterica (Dicks.: Fr.) Pers.	Trunk and branches	White rot	+ +
Auricularia auricula-judae Bull.:Fr.)Wettstein	Trunk and branches	Saprophyte on bark	+

+ = fungi develop saprophytically and do not inflict serious harm to horse chestnut;
+ + = fungi develop as weakness parasites (inflict harm only when the attack is strong);
+ + + = fungi develop as parasites and inflict severe harm

The table 1 shows that 29 species of fungi were identified during the course of investigations. Two species were also identified on both leaves and fruits (*Epicoccum nigrum* and *Alternatia alternata*).

A total of five species were identified on root and lower part of trunk, out of which 3 belong to a genus *Phytophthora*. A presence of five species was established on leaves, whereas nine species were identified on fruits. Twelve species (ten out of which cause decay) were identified on branches and trunk.

The most substantial harm on horse chestnut root and lower part of trunk is caused by species of genus *Phytophthora*, namely *Phytophthora citricola, Phytophthora cactorum* and *Phytophthora cambivora*. They occur very frequently, and symptoms ('Bleeding canker'), indicating their presence (a rusty brown bark and exudates oozing), were identified on as far as 48 horse chestnut trees in Obrenovac. The table 2 presents the main characteristics of species of genus *Phytophthora,* isolated from diseased tissues on trunk or from root or soil.

Table 2. *The characteristics based on which the species of genus Phytophthora were identified (Ho, H. 1981; Barzanti et al.2001; Brasier,et al.1999)*

Characteistich	***P. citricola***	***P. cactorum***	***P. cambivora***
Sporangium			
Lenght (μm)	30–50	30-50	> 50
Width (μm)	20–35		
Papile	semipapillate	papillate	non-papillate
Form	ovoid, obpyriform	globose	ovoid, limoniform or obpyriform
Oogonium			
Form	globose, spherical	globose, spherical	spherical, narrowing abruptly to a tubular stalk
Diameter (μm)	20-30	< 40	35-45
Oospore	Plerotic	Plerotic	Plerotic
Anterheridium	Paragynous	Paragynous	Amphigynous

During the course of investigations on horse chestnut leaves, a presence of the following fungi was established: *Guignardia aesculi, Septoria hippocastani, Uncinula fraxini, Alternaria alternata* and *Epicoccum nigrum*.

Among the above-mentioned species, *Guignardia aesculi* causes the most substantial harm on leaves, whereas species *Septoria hippocastani* and *Uncinula fraxini* were isolated only in individual cases. *Alternatia alternata* and *Epicoccum nigrum* occur on leaves as saprophytes and do not inflict any harm to healthy leaves.

Guignardia aesculi is a disease accompanying horse chestnut, first identified in Europe in 1950. It also occurs in *A. glabra*, *A. pavia,* as well as in *Aesculus* × *carnea* (hybrid *A. hippocastanum* x *Aesculus pavia*). As a result of an attack, a premature defoliation occurs, causing physiological weakness of plants, reducing their decorative quality and facilitating an attack of secondary parasites and pests. It is harmful to young plants in seedling nurseries and in the first year following the plantation. Primary infestations are caused by ascospores in spring, during a leaf development period. Conidia, which, released from pycnidia, cause secondary infestations during summer, are of greater importance for spreading of the disease. A progressive spreading of the disease is performed by conidia under favourable weather conditions (favourable humidity and temperature).

In summer, large, irregular, dark brown necrotic spots develop on leaves. The spots first appear on leaf apices and edges and they are covered by a yellowish margin. On their edges, infested leaves fold longitudinally towards the upper side and fall off prematurely.

S. hippocastani causes occurrence of leaf spots. Numerous small, brown, round spots are formed, scattered on the entire leaf area. Pycnidia are formed on live and dead leaves where several pycnidia, of 180 μm diameter, are formed on each spot. Spores are thread-like, folded on edges, and have three septa, of 30-57 x 2-5-3 μm size.

In addition to ash, which is a primary host, *Uncinula fraxini* also occurs in horse chestnut. It has appendages, which are simple or dichotomously branched, uncinately or spirally bent at the tip. It was identified only in one horse chestnut tree, while the attack was mild.

Species identified on horse chestnut fruit are the following: *Mucor mucedo*, *Rhisopus nigricans*, *Trichoderma viride*, *Trichotecium roseum*, *Epicoccum nigrum*, *Alternaria alternate* along with species of genera *Fusarium*, *Penicillium* and *Aspergillus*. Among the above-mentioned species, fungi of genus *Fusarium* can inflict the most substantial harm to fruit. If they penetrate into the inside parts of a fruit, the infested fruit does not germinate at all, and even when it manages to sprout, wilting of such plants will most probably occur. Other above-mentioned species mainly cause mould in horse chestnut fruit. They can be of importance only as a disease causing agent in storages, and under the following conditions: If fruit storages are humid and unaired; if fresh fruits are dried in overly thick layers; if not sufficiently dry fruits are stored; if fruits were damaged when collected, processed or have a damage inflicted by insects. In the above-mentioned instances, mould can penetrate inside fruits and germination of such fruits is significantly reduced. (Lazarev et al 2005).

Species *Hypoxilon fragiforme* and *Nectria cinnabarina* were identified on the branch and trunk bark. A presence of *Hypoxilon fragiforme* was recorded on dry branches and twigs of horse chestnut. It is most harmful to beech, in which it causes a mosaic decay of plant (Karadžić, 2010). *Nectria cinnabarina* was most frequently identified on dry branches, and far more rarely, on branches of live horse chestnut trees. It attacks bark, vascular system and the tree. A characteristic disease symptom is occurrence of stromata with numerous perithecia. Conidial stromata are formed in early spring, their diameter is 0.5-2 mm, and height 1.5mm. Conidia are of cylindric shape, unicellular, colourless, of 5-8 x 1,5-3 μm size. In temperate zones, conidia are formed throughout a year, but they can cause infestation only during a vegetation period at the temperatures 10-27 ^{O}C (Semenkova and Sokolova, 2003).

In winter, perithecia are formed on the same stromata. Perithecia are clustery, of 350-400 μm size, formed on a common stroma, of red colour which is getting dark with the age. Asci of 70-90 x10-12 μm, ascospores bicellular, lined in two rows, narrowed in the centre and with a separation. They are colourles, of size (13,2)16-20 (24) x 4-6 μm (Vasiljeva, 1998).

The most important among the fungi causing decay in horse chestnut are species *Inonotus hispidus*, *Ganoderma adspersum* and *Ganoderma applanatum*. *Inonotus hispidus* is the most commonly identified decay causing species. It is developed as a parasite on live trees and causes a yellow-white central decay of trunk. Infestation is passed through injuries on trunks and branches. It forms one annual carpophores in the period July-December.

Among species of genus *Ganoderma*, a presence of *Ganoderma adspersum* and *Ganoderma applanatum* was established during the course of investigation. Fruit-bodies of these species are most often found on stumps of cut down trees and, slightly more rarely, in lower parts of trunks of live trees.

These two species most often attack the ground part of a tree and the root, in which they cause multi-coloured-white decay of heartwood, and partially of sapwood. As a result of the heartwood and sapwood deterioration, trees lose their hardness, which leads to frequent windbreaks. Infestation of trunk and veins is passed through injuries. Decaying process begins in the centre of heartwood and then, more or less regularly, spreads toward sapwood, which eventually becomes partially affected itself. *G. adspersum* more often occurs in urban areas and parks, and more seldom in a closed forest canopy. It is considered that it begins its development as a parasite, while later develops saprophytically (Petersen,1983). Trees infested by species *G. adspersum* have a poorer long-term prospects in comparison to trees infested by *G. applanatum*.

With respect to other decay causing fungi, a significant harm can be inflicted only by a species *Laetiporus sulphureus*, however, it was identified only in one, old, semi-dry horse chestnut tree.

DISCUSSION

At present, horse chestnut is increasingly more seldom used for plantation in parks and formation of tree lines. The main reason for that is the early defoliation, which occurs already in August, and it is caused by a fungus *Guignardia aesculi* and a horse chestnut leaf miner *Cameraria ochridella*. Additionally, a substantial harm is inflicted by species of genus *Phytophthora,* as well as by certain decay causing fungi.

Brasier i Strouts (1976) first pointed out to a problem affecting horse chestnut, caused by species of genus *Phytophthora*. While studying the causes of horse chestnut dieback on roots of dead trees with symptoms of chlorosis and defoliation, as well as the causes of a branch dieback, they isolated a species *Phytophthora megasperma* var. *megasperma* and a non-identified species of genus *Phytophthora,* similar to species *P. cambivora*. Furthermore, they isolated a species *P. citricola* from a soil around the dead tree roots, with symptoms of marginal leaf necrosis.

In addition, Cerni et al (2007), who, in the region of Bohemia in the Czech Republic, isolated a species *Phytophthora cactorum* from injuries with exudates in horse chestnut, beech and poplar trees, also pointed out to this problem

According to investigations conducted by Robin and Piou, (2010), in Europe, *P. cambivora* was isolated from the following hosts: *Acer* sp., *Aesculus hippocastanum*, *Alnus cordata*, *Castanea sativa*, *Chamaecyparis lawsoniana*, *Chamaecyparis* sp., *Fagus sylvatica*, *Juglans regia*, *Juglans* sp., *Malus sylvestris*, *Nothofagus* sp., *Prunus avium*, *Prunus mahaleb*, *Prunus* sp., *Pyrus communis*, *Quercus petraea*, *Quercus robur*, *Taxus baccata* and *Ulmus* sp..

As the most important disease-causing agents on horse chestnut leaves, Horst (2008) specifies the following fungi: *Guignardia aesculi*, *Cercospora aesculina*, *Macrosporium baccatum*, *Monochaetia desmazierii*, *Micosphaerella maculiformis* var. *hippocastani*, *Septoria glabra*, *S. hippocastani*, *Phyllactinia corylea*, *Uncinula flexuosa*, *Glomerella cingulata* and *Taphrina aesculi*.

According to the above-mentioned author, cancer wounds on horse chestnut are caused by *Phytophthora cactorum* and *Nectria cinnabarina*, a root decay is caused by *Armillaria mellea* and *Phymatotrichum omnivorum*, whereas a branch and trunk decay is caused by *Ganoderma applanatum*, *Collybia velutipes* and *Polyporus* spp.

Snieškienė et al. (2011) in their investigations state that the most substantial harm to horse chestnut in Lithuania is inflicted by *Guignardia aesculi*, *Erysiphe flexuosa* and *Schizophyllum commune*.

Sutton, (1980) recorded the presence of species *Coryneum cesatii* and *Diplodina aesculi* on the horse chestnut bark, as well as the presence of *Fusicocum aesculi* on horse chestnut branches.

According to the results our investigations, the most substantial harm to horse chestnut was inflicted by species *Guignardia aesculi*, species of genus *Phytophthora*, whereas among decay causing fungi, the most harmful are *Inonotus hispidus*, *Ganoderma adspersum* and *Ganoderma applanatum*. A presence of *Guignardia aesculi* was identified in all localities, and the intensity of attack was very strong. As it is the case with a horse chestnut leaf miner (*Cameraria ochridella*), already in August, trees are deprived of assimilation organs. In late August and in the beginning of September they foliate and blossom anew, which additionally weakens them. A severe harm to horse chestnut trees, particularly in tree lines in Obrenovac, is caused by *Phytophthora citricola*, *Phytophthora cactorum* and *Phytophthora cambivora*. They cause root decay and lead to cracking, drying and dropping off of bark on large areas of trunk. By means of their activity, they prevent a regular flow of mineral matter, which is manifested through drying off of certain branches in the crown and withering of leaves.

CONCLUSION

By studying the most common disease causing agents in horse chestnut, we have arrived to the following conclusions:

A total of 29 species of fungi were identified in horse chestnut. Two species were recorded on both leaves and fruits (*Epicoccum nigrum* i *Alternaria alternata*).

A total of five species were identified on the root and a lower part of trunk. The most harm on the horse chestnut's root and lower part of trunk was caused by species of genus *Phytophthora*, namely *Phytophthora citricola*, *Phytophthora cactorum* and *Phytophthora cambivora*. The above-mentioned species had been recorded for the first time in horse chestnut in Serbia.

Five species were identified on leaves, whereas a presence of nine species was recorded on fruits. Twelve species were identified on branches and trunk (ten out of which are decay causing species).

Among the above-mentioned species, the most substantial harm to leaves is inflicted by *Guignardia aesculi*, which, as well as a horse chestnut leaf miner (*Cameraria ochridella*), causes defoliation already in August.

Among the fungi causing decay in horse chestnut, the most important species are *Inonotus hispidus, Ganoderma adspersum* and *Ganoderma applanatum*. *Inonotus hispidus* is the most commonly identified decay causing fungus.

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CONTRIBUTION TO THE KNOWLEDGE OF FAMILY *Phytoseiidae* (ACARI) ON OAK TREE OF THE MOUNTAIN AVALA

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Abstract: *The paper presents the results of previous studies of diversity of species of fam. Phytoseiidae in coppice, high and artificially established Avala mountain oak stands. The study encompassed the period 2011-2012 and involved five autochthonous plant species of genus Quercus L.: Q. cerris L., Q. robur L., Q. frainetto Ten., Q. petraea Liebl and Q. pubescens Willd. A presence of only three species of family Phytoseiidae - Euseius finlandicus (Oudemans 1915), Kampimodromus aberrans (Oudemans 1930) and Amblyseius (Amblyseius) andersoni (Chant 1957), was established in the investigated oak samples.*

Key words: Phytoseiidae, Quercus, mountain Avala, Serbia

INTRODUCTION

Predatory mites of family Phytoseiidae Berlese have been a subject of numerous studies worldwide, owing to their increasingly important role in integral protection of cultivated plants. Phytoseiidae most commonly feed on phytophagous mites of superfamily Tetranychoidea and Eriophyoidea, but also on small insects of orders Thysanoptera and Homoptera.

The diversity of predatory epiphyllous mites of family Phytoseiidae in Serbia has been only fragmentary investigated on forest plant species. Forests, on account of diversity of plant species and stable environment conditions, represent a natural source of Phytoseiidae populations, colonisation potential of which, with respect to agro-ecosystems, depends on proximity of natural vegetation (Tixier et al., 1998). More than 2,250 species of this family have been described worldwide (Moraes et al., 2004), out of which more than 20 are used commercially for biological control of phytophagous mites and certain insects. Until now, a presence of only 28 Phytoseiidae species in Serbia has been established (Kropczynska and Petanovic, 1987; Stojnić, 1993, Petanovic and Stojnic, 1995; Stojnic et al., 2002; Mladenović at al., 2010).

The problem of mites as pests occurred as recently as in mid-twentieth century, due to a change of ecological conditions, which took place as a result of the impact of anthropogenic factor, and are particularly apparent in agro-ecosystems and urban areas.

A number of papers indicate that an area rich in non-cultivated plant species represents a reservoir of these natural enemies (Boller at al. 1988; Duso and Fontana 1996; Tixier at al. 2000a, b; etc.).

Forest ecosystems have a considerable importance for conservation of Phytoseiidae. The importance of Avala forests, as a natural reservoir of these predators, is manifested in the fact

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that the forests are located in an immediate proximity of agricultural areas of Belgrade outskirts and urban greenery of city municipalities.

A typical oak distribution areal is a temperate zone of the northern hemisphere. The genus *Quercus* comprises 450 tree and bush species, out of which about ten are represented in Serbia (Vukićević, 1996). Oaks constitute one of the most important forest plant groups in Serbia.

MATERIAL AND METHOD

A collection of oak samples was performed during a vegetation period, in the mountain Avala, which belongs to the Forest Management Unit Avala, governed by State Enterprise for Forest Menagement Srbijasume, Forest Estate Belgrade, in autochthonous and artificially established communities in the period 2011-2012.

The Forest Management Unit Avala consists of a forest complex, covering a surface area of 835.05ha. Two natural entities can be distinguished on that territory: the mountain Avala, a so-called 'cone', and forests along the Beograd-Ralja road. The Avala forests are situated at the foothill of northern Šumadija. Avala is only 25km away from the centre of Belgrade. The Avala's highest summit, at the altitude of 506m, is situated at the spot called 'Tomb of the unknown soldier'. In 2004, the mountain Avala was designated 'an area of extraordinary characteristics' at the proposal of the Institute for Nature Protection, and represents a rich source of both autochthonous and allochthonous plant species.

This area is characterised by a temperate continental climate, influenced by the Mediterranean Sea and Atlantic Ocean, as well as by a cold continental air from north and north-east parts of Europe.

Forests and forest land of this management unit belong to the Sava-Danube forest area. In terms of geographical position, these forests are located between 44°42'05" and 44°36'40" of north geographic latitude and 20°30'02" and 20°34'06" of east geographic longitude.

The Avala forests were formed under a strong impact of anthropogenic factor. With respect to the origin, these forests are mainly coppice, artificially regenerated, high and mixed.

The present vegetation of Avala largely consists of coppice oak forests. The highest represented oak species is Turkish oak, whose representation in the total volume accounts for 48%, followed by pedunculate oak, accounting for 11% and Hungarian oak, accounting for 10%. In addition to these three oak species, sessile oak and red oak occur sporadically, accounting for 1% each, whereas the lowest represented species is downy oak (SE Srbijasume, 2008).

The collected samples included five different autochthonous oak species: *Quercus cerris* L., *Q. robur* L., *Q. frainetto* Ten., *Q. petraea* Liebl and *Q. pubescens* Willd.

Sampling of oak leaves was performed on the following localities of the Forest Management Unit Avala:
Locality 1: Department 2, section a
Locality 2: Department 3, section a
Locality 3: Department 7, section d
Locality 4: Department 13, section e
Locality 5: Department 20, section d
Locality 6: Department 25, section r

The samples contained 100 leaves each. The collection was performed during a vegetation period. Extraction of Phytoseiidae was conducted in a laboratory, by exposing leaves to the effect of ethyl acetate for 20 minutes, which was followed by a shake-off and extraction of mites under stereomicroscope. Isolated mite units were immersed into an ethyl alcohol and lactic acid solution (Evans and Browing, 1955). After illumination, permanent preparations were made by using the Hoyer's medium (Baker and Wharton, 1964).

For determination of Phytoseiidae relevant keys were used (Begljarov, 1981; Karg, 1993). Permanent preparations were kept at the depot of the Department of Entomology and Agricultural Zoology of the Faculty of Agriculture, University of Belgrade.

RESULTS AND DISCUSSION

Predatory mites of family Phytoseiidae were found in all five investigated oak species: *Q. cerris, Q. robur, Q. frainetto, Q. petraea* i *Q. pubescens*.

By investigation of epiphyllous oak fauna in the mountain Avala, a presence of only three mite species of Phytoseiidae family was established. The identified Phytoseiidae species are the following: *Euseius finlandicus* (Oudemans 1915), *Kampimodromus aberrans* (Oudemans 1930) and *Amblyseius (Amblyseius) andersoni* (Chant 1957) (Table no. 1).

Locality 1: Department 2, section a, artificially established pedunculate oak stand, of 6.50ha surface area, aged 57 years, declination 6^0-10^0, altitude 200-250m, south-east exposure. In addition to pedunculate oak, a presence of black and white pine, other hard broadleaves and black locusts was identified in the stand. In a sample *Q. robur,* a presence of ***K. aberrans*** and ***E. finlandicus*** was identified.

Locality 2: Department 3, section a, artificially established mixed pedunculate oak stand, of 3.92ha surface area, aged 57 years, declination to 5^0, altitude 220-260m, eastern exposure. In addition to pedunculate oak, a presence of Turkey oak, Hungarian oak, black pine, other hard broadleaves and black locust was identified in the stand. In a sample *Q. frainetto,* a presence of ***A. andersoni*** was established.

Locality 3: Department 7, section d, coppice mixed Turkey oak and Hungarian oak forest, of 2.63ha surface area, aged 57 years, declination to 5^0, altitude 220-240m, south-south-east exposure. In a sample *Q. cerris* and a sample *Q. frainetto,* a presence of ***E. finlandicus*** was identified. In a sample *Q. frainetto,* a presence of ***K. aberrans*** was established.

Locality 4: Department 13, section e, artificially established sessile oak stand, of 1.58ha surface area, aged 65 years, declination to 5^0, altitude 230-260m, south-east exposure. In addition to sessile oak, a presence of Turkey oak was identified in the stand. In a sample *Q. petraea* and in a sample *Q. cerris*, a presence of ***E. finlandicus*** was established.

Locality 5: Department 20, section d, high forest of Turkey oak, sessile oak, Hungarian oak, downy oak and hornbeam, of 0.31ha surface area, aged 65 years, altitude 270m, with no pronounced exposure. In addition to the above-mentioned woody plant species, a presence of Douglas-fir, white pine and other hard broadleaves was identified in the forest. In a sample *Q. cerris*, a sample *Q. frainetto,* and a sample *Q. pubescens*, a presence of ***E. finlandicus*** was identified. In a sample *Q. petraea*, a presence of representatives of Phytoseiidae family was not established.

Locality 6: Department 25, section r, coppice Turkey oak and Sessile oak forest, of 1.05ha surface area, aged 52 years, declination to 5^0, altitude 370-400m, with no pronounced exposure. In addition to the above-mentioned woody plant species, a presence of lime, flowering ash and Hungarian oak was identified in the coppice forest. In a sample *Q. cerris* and a sample *Q. petraea*, a presence of ***E. finlandicus*** was identified. In a sample *Q. frainetto,* a presence of representatives of Phytoseiidae family was not established.

Table 1: *Species of family Phytoseiidae found in Q. cerris L., Q. robur L., Q. frainetto Ten., Q. petraea Liebl and Q. pubescens Willd.*

Phytoseiidae type	oak type
Euseius finlandicus	*Q. cerris* *Q. robur* *Q. frainetto* *Q. petraea* *Q. pubescens*
Amblyseius andersoni	*Q. frainetto*
Kampimodromus aberans	*Q. robur* *Q. frainetto*

Euseius finlandicus (Oudemans 1915)

A species that is a distinct cosmopolite. The distribution areal includes Europe, Asia, Africa, North and South America. Its presence in Serbia was recorded in numerous hosts (Radivojević and Petanović, 1984; Kropczynska and Petanović, 1987; Stojnić, 1993; Stojnić and Petanović, 1994; Stojnić, 2001; Mladenović at al, 2010b, Mladenović at al. 2011). It might be said that this species is dominant at Phytoseiidae habitats. It is present in a number of plants. On this occasion, it was identified in all five oak species: *Q. cerris, Q. robur, Q. frainetto, Q. petraea* and *Q. pubescens* ,in all six investigated localities.

Worldwide, *Euseius finlandicus* (Oudemans 1915) has been identified in *Q. robur* in England and Germany, whereas *Quercus sp.* has been recorded in Canada, Japan, the Netherlands, the USA, Armenia, Azerbaijan, Belarus, Crimea and Ukraine (de Moraes et al., 1986).

Kampimodromus aberrans (Oudemans 1930)

A species found in Europe, Algeria, Israel, Iran, Canada, the USA and in the region of the Commonwealth of Independent States. Its presence has been also established in Serbia (Radivojević and Petanović, 1984; Kropczynska and Petanović, 1987; Stojnić, 1993; Stojnić and Petanović, 1994; Mladenović at al, 2010b, Mladenović at al. 2011). This species is present in a large number of woody and herbaceous plants. During the course of this study, it was identified in oak species *Q. robur* and *Q. frainetto,* in two investigated localities.

Worldwide, *Kampimodromus aberrans* (Oudemans 1930) has been identified in *Quercus sp*. in Italy, Azerbaijan and Moldavia (de Moraes et al., 1986).

Amblyseius (Amblyseius) andersoni (Chant 1957)

A species present in the largest part of Europe, Algeria, Canada, the USA, the region of Commonwealth of Independent States. Its presence has been also recorded in Serbia (Radivojević and Petanović, 1984; Kropczynska and Petanović, 1987; Mladenović at al, 2010b, Mladenović at al. 2011). It was found in a large number of woody and herbaceous plants. During the course of this study, its presence was confirmed in *Q. frainetto,* in one investigated locality.

Worldwide, *Amblyseius (Amblyseius) andersoni* (Chant 1957) has been identified in *Q. robur* in Moldavia, whereas its presence in *Quercus sp* has been recorded in Algeria, Azerbaijan and Ukraine (de Moraes et al., 1986).

By examination of available literature data (De Moraes et al., 1986) on worldwide records of Phytoseiidae species in five oak species encompassed by this study, only meagre information was obtained. Until present, Phytoseiidae have not been identified in species *Q. cerris* and *Q. frainetto.* In species *Q. robur,* twelve Phytoseiidae species have been found worldwide, namely: *A. andersoni* in Moldavia, *E. finlandicus* in England and Germany, *Neoseiulus masseei* (Nesbitt, 1951) in England, *N. umbraticus* (Chant, 1956a) in England, *Amlydromella bakeri* (Garman, 1948) in England, *A. clavata* (Wainstein, 1972b) in Moldavia, *A. rapida* (Wainstein and Arutunjan, 1968) in Moldavia, *Paraseiulus soleiger* (Ribaga, 1902) in

England, *P. incognitus* Wainstein and Arutunjan, 1967 in Moldavia, *Phytoseius macropilis* (Banks, 1909) in England, *Seiulus simplex* Chant, 1956a in England and *Typhlodromus tiliae* Oudemans, 1929a in England. Two Phytoseiidae species in *Q. petraea* have been identified worldwide: *Neoseiulus astutus* (Beglyarov, 1960) in Moldavia and *A. rapida* in Crimea. Four Phytoseiidae species in *Q. pubescens* have been identified worldwide: *Amblydromella commenticia* (Livshitz and Kuznetsov, 1972) in Crimea, *A. intercalaris* (Livshitz and Kuznetsov, 1972) in Crimea, *S. simplex* in Crimea and *Typhlodromus cotoneastri* Wainstein,1961 in Moldavia.

As it was noted in previous studies, and it was also confirmed on this occasion, the species *E. finlandicus* is the most frequently present Phytoseiidae in Serbia. Its presence was identified in all investigated oak samples: Turkey oak, pedunculate oak, Hungarian oak, sessile oak and downy oak, in all six localities. *K. aberrans* is a less represented species, a presence of which was confirmed only in pedunculate oak and Hungarian oak, in two investigated localities. A species *A. andersoni* was identified only in Hungarian oak, in one investigated locality.

CONCLUSION

The paper has presented the preliminary studies of diversity of mites from family Phytoseiidae in various autochthonous oak species in the mountain Avala.

The study involved five oak species: *Quercus cerris* L., *Q. robur* L., *Q. frainetto* Ten., *Q. petraea* Liebl and *Q. pubescens* Willd, represented on the territory of the Forest Management Unit Avala, governed by Forest Estate Belgrade.

By investigation of the mountain Avala epiphyllous oak fauna, a presence of only three mite species of family Phytoseidae was established. The identified Phytoseidae species are the following: *Euseius finlandicus* (Oudemans 1915), *Kampimodromus aberrans* (Oudemans 1930) and *Amblyseius (Amblyseius) andersoni* (Chant 1957). A species *Euseius finlandicus* (Oudemans 1915) is the most frequently represented Phytoseidae species in our country. Its presence in all investigated oak species and in all investigated localities, can be explained by its belonging to IV trophic group of generalist predators (McMurtry and Croft, 1997) which feed primarily on pollen, and then on mites and insects.

A number of identified species of family Phytoseiidae in coppice, high and artificially established oak stands of the mountain Avala is relatively low in comparison to the results obtained worldwide. The reason for a low diversity that was established is an insufficient study of forest ecosystems, therefore, new recordings of this mite group are expected in future. Spontaneous flora has a considerable importance for conservation of Phytoseiidae. In natural environment conditions, a significant harm to plants is seldom inflicted by phytophagous mites, as their population figure is limited by numerous enemies.

The forests of the mountain Avala represent a natural source of Phytoseiidae, predators to numerous harmful mite and insect species.

An area rich in non-cultivated plant species represents a reservoir of these natural enemies to phytophagous arthropods, therefore, it is necessary to focus further investigation of diversity of predatory mites in Serbia more closely on forest plant species.

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RELATIONSHIPS BETWEEN POWDERY OAK MILDEW AND WEATHER VARIABLES

Miroslava MARKOVIC[1] and Snezana RAJKOVIC[1]

Abstract: *The occurrence of mass dieback in oak forests is a consequence of the presence of powdery mildew, caused by the pathogenic fungus Microsphaera alphitoides Griff. et Maubl., which particularly affects new, young foliage susceptible to infections. The occurrence and development of oak powdery mildew are closely related to weather conditions during the year. This paper presents the incidence of the disease in relation to outdoor temperature and humidity in Serbia from 2003 to 2009, with a forecast of potential focal centres of infection in the coming period in relation to weather conditions, which is important for the purpose of protection.*

Key words: oak powdery mildew, weather variables

1. INTRODUCTION

Serbia is considered a medium forested country. According to the latest data by the National Forest Inventory for the year 2009 [1], 29.1% of the total land area of Serbia is under forests (of which portion 37.6% of the area is located in central Serbia, while 7.1% is located in Vojvodina). Generally, Serbia comes close to the global average percentage of forested area (30%), yet it is still significantly below the European average (46%).

The total forested land area in Serbia amounts to 2,252,400 ha, with oak forest area of 720,800 ha. Out of these,Turkey oak forests (*Quercus cerris* L.) cover 345,200 ha and Sessile oak forests (*Quercus petraea* /Mattuschka/ Liebl.) cover 173,200 ha, whereas Hungarian oak (*Quercus farnetto* Ten.), English oak (*Quercus robur* L.) and Downy oak trees (*Quercus pubescens* Willd.) populate 159,600 ha, 32,400 ha and 10,400 ha respectively [1, 2].

Information on the key factors affecting the health of forests determines certain activities within the framework of feasible forest management as the basis of various national and international policies. Such information is collected through extensive, long-term and intensified monitoring conducted within *ICP Forests* (*the International Co-Operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests*) and *the Convention on Long-Range Transboundary Air Pollution (CLRTAP)* of the EU. The Republic of Serbia has been involved in the *ICP Forests* since 2003 [3, 4].

One of the most widespread pathogens which endanger the survival of forests as well as the process of feasible forest management in Serbia, fungus *Microsphaera alphitoides* (Syn. *Erysiphe alphitoides* Griffon & Maublanc 1912), causes powdery oak mildew. Without implementation of proper protective measures, this disease can destroy all seedlings in a nursery or significantly reduce their height growth due to dieback of shoots [5, 6, 7]. In adult trees,

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powdery oak mildew is a major cause of English oak forest drying up, alongside gypsy moth (*Lymantria dispar* Linnaeus, 1758) and honey fungus (*Armillaria mellea* (Vahl.) P. Kumm. 1871).

2. MATERIALS AND METHODS

Monitoring of the tree crown condition is conducted in over 30 countries in Europe at more than 6,000 sample plots. In Serbia this monitoring is conducted at 131 sample plots encompassing the total of 2,756 tree trunks of all species. Out of the 131 sample plots, oak trees appear at 74 plots with 1,115 trees that are the subject of the health assessment and powdery oak mildew monitoring. At these sample plots, the share of oaks amounts to 71.2% of all trees.

On the satellite image map of Serbia (Fig. 1) the sample plots where English oak trees as the most vulnerable oak species in this region are found are marked yellow, the sample plots with other oak species are marked white, and the sample plots with other tree species are marked blue.

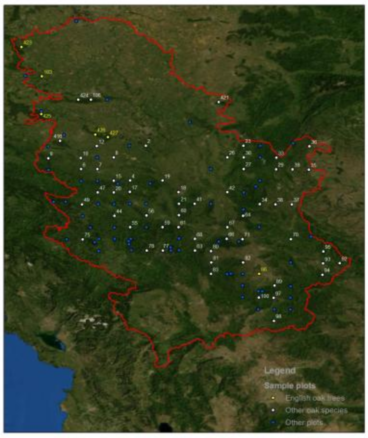

Figure 1 – *Cartographic image of the spatial distribution of the sample plots on the territory of the Republic of Serbia (the situation from 2009)*

Turkey oak trees are found at 51 sample plots; Hungarian oak trees are found at 39 plots; Sessile oak trees are found at 19 plots; English oak trees and Downy oak trees appear at 7 and 3 plots respectively. At some of these sample plots two oak species concide: Turkey oak and Hungarian oak trees share 26 sample plots; Turkey oak and Sessile oak trees share 4 plots; Turkey oaks and English oaks as well as Turkey oaks and Downy oaks share 2 sample plots; Hungarian oaks and Sessile oaks share only 1 sample plot. Moreover, up to three oak species sometimes coincide at certain sample plots – Hungarian oak, Turkey oak and Sessile oak trees are found together at 3 sample plots whereas the combinations of Hungarian oak, Turkey oak and English oak as well as Hungarian oak, Turkey oak and Downy oak occupy 1 sample plot each. A single oak species occurs at each of the remaining 34 sample plots (Turkey oak occurs at 12 plots, Sessile oak occurs at 11 plots and Hungarian oak occurs at 11 plots).

The method of sample plot marking includes the establishment of quadrats either within 16-kilometre or 4-kilometre grid by means of GPS. The central point is permanently marked with a metal stake and the trees for the crown condition assessment are selected systematically as clusters of trees around the 4 loci, which are at a 25-metre distance in 4 cardinal directions from the centre marked with a stake. In this way the nearest 6 trees in each direction are selected (24 in total) and defined as samples for assessment.

Every year, during the vegetation period, the selected trees are observed for the assessment of chlorosis and defoliation and damages are recorded and classified according to the types and species of causing agents. In addition, the exact tree part where damage is observed is recorded (foliage, branches, bark, part of the trunk, etc.). Chlorosis (decolourisation) is measured by indices ranging from 0 to 3, and branch drying (defoliation) is measured by indices ranging from 0 to 4 (Table 1).

Table 1 – *Methods of assessing chlorosis and defoliation at sample plots in Serbia*

Foliage chlorosis (decolourisation)		**Branch drying (defoliation)**	
Indices	Symptoms for foliage chlorosis indexing	Indices	Symptoms for branch drying indexing
0	Change in foliage colour 0 to10%	**0**	Branch drying 0 to10%
1	Change in foliage colour 11 to 25%	**1**	Branch drying 11 to 25%
2	Change in foliage colour 26 to 60%	**2**	Branch drying 26 to 60%
3	Change in foliage colour over 61%	**3**	Branch drying over 61%
		4	Completely dried up trunk – 100%

Monitoring of the occurrence and development of powdery oak mildew in folaige was conducted ocularly and expressed in percentages of the total number of trees at a sample plot.

3. RESULTS

3.1. Helath condition of the Q. cerris trees

Turkey oak forests comprise approximately a half of all oak forests in Serbia, i.e. about 48%. Fig. 2 shows chlorosis indices ranging from 0 to 3, defoliation indices ranging from 0 to 4 and the occurrence of powdery oak mildew from 2003 to 2009 expressed in percentages.

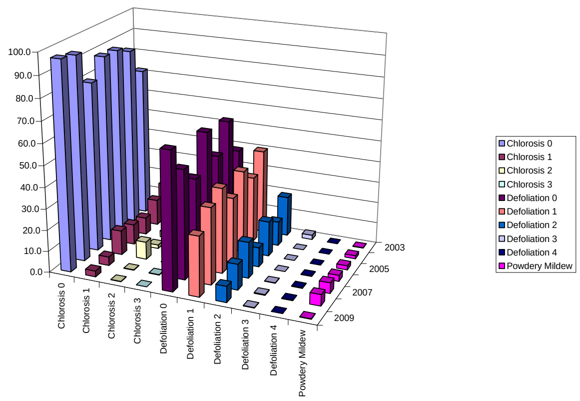

Figure 2 – *Health condition of the Q. cerris trees and the occurrence of powdery oak mildew at sample plots in Serbia from 2003 to 2009*

Turkey oak trees displayed a very good health condition compared to the other oak species monitored (second best to that of Downy oaks). During the whole period of assessment, 71.8% to 97.0% of Turkey oak trees belonged to the chlorosis 0 category. Similarly, Turkey oak featured the largest percentages of trees in defoliation categories 0 and 1 – 64.2% and 28.1% respectively. The least favourable year for chlorosis in Turkey oak was the year 2003, and the least favourable year for defoliation in Turkey oak was 2007.

During the whole assessment period the powdery oak mildew attacks on the monitored Turkey oak trees were rather weak – between 0.2% and 5.3% of the trees were infected, i.e. 2.41% on average. The largest numbers of Turkey oaks affected by powdery mildew were recorded in 2007 and 2008 (5.0% and 5.3% respectively). This is due to the fact that during 2007 and 2008 the weather conditions in the region populated by Turkey oak were most favourable for the pathogen (average annual precipitation sums ranged from 700 to 1100 mm and mean maximum temperatures were 15 to 19^{0}C). However, as a species relatively resistant to the powdery mildew attack,Turkey oak did not suffer a more massive infection during this period.

3.2. Health condition of the Q. farnetto trees

Hungarian oak forests comprise about 22% of all oak forests in Serbia. According to the health condition assessed, they came third (Fig. 3). The largest percentages of the Hungarian oak trees had chlorosis 0 (from 64.8% in 2003 to 96.4% in 2009). Considering the worst defoliation categories, 3 and particularly 4, there was a marginally small percentage of Hungarian oak trees (up to 2.7% in defoliation category 3 in 2004). The largest percentages of the trees belonged to the defoliation categories 0 and 1, ranging from 27.1% up to 60.1% during 2009. Based on the results stated, it is clear that the years 2008 and 2009 were the most favourable for the health condition of Hungarian oak trees, while the least favourable was the year 2003.

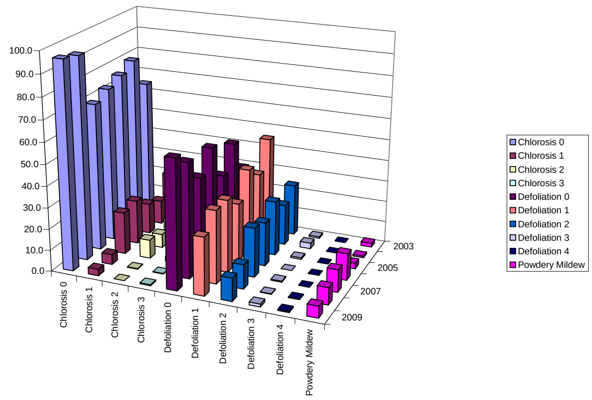

Figure 3 – *Health condition of the Q. farnetto trees and the occurrence of powdery oak mildew at sample plots in Serbia from 2003 to 2009*

During the whole assessment period the powdery oak mildew attacks on the monitored Hungarian oak trees were fairly weak – between 0.7% and 12.6% of the trees were infected, i.e. 5.99% on average. The strongest powdery mildew attacks on Hungarian oaks were recorded in 2006 and 2007 (12.6 and 10.6% respectively). This is due to the fact that during 2006 and 2007 the weather conditions in the region populated by Hungarian oak were most favourable for the pathogen (average annual precipitation sums ranged from 800 to 1100 mm and mean maximum temperatures were 14 to 19^{0}C), and, although being a species less susceptible to powdery mildew, Hungarian oak still suffered a medium powdery mildew attack.

3.3. Health condition of the Q. petraea trees

Sessile oak forests comprise about 24% of all oak forests in Serbia. Sessile oak – *Quercus petraea* came fourth according to the health condition assessed in the monitored region of the Republic of Serbia. The largest percentages of Sessile oak trees had chlorosis 0 and 1, which indices refer to relatively healthy trees, yet these percentages are lower than those of the above described oak species (Fig.4).

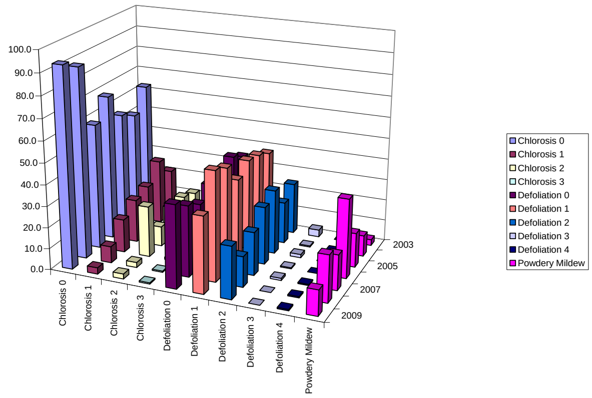

Figure 4 – *Health condition of the Q. petraea trees and the occurrence of powdery oak mildew at sample plots in Serbia from 2003 to 2009*

Larger percentages of Sessile oak trees than the above described oak species had chlorosis 2 and 3, which indices refer to weakened or diseased trees. Considering the worst defoliation categories, 3 and particularly 4, as with the above described oak species, there were marginally small percentages of Sessile oak trees; however, they were more evenly distributed across the categories 0, 1 and 2, which means that there were more Sessile oak trees with defoliation 2 than those of the above described oak species. In terms of chlorosis and defoliation, Sessile oak displayed the best health condition during the year 2009.

During the assessment period the powdery oak mildew attacks on the monitored Sessile oak trees ranged from 2.8% to 37.2% of the trees infected, i.e. 16.7% on average. Weak powdery mildew attacks were recorded in 2005 and 2009 (16.2% and 12.0% respectively). A medium magnitude powdery mildew attack was recorded in 2008, when 22.1% of the trees were infected whereas a strong attack affecting 37.2% of the trees was recorded in the year 2006. During 2006 the weather conditions in the region populated by Sessile oak were most favourable for the pathogen (average annual precipitation sums ranged from 800 to 1000 mm and mean maximum temperatures were 13 to 18^{0}C), which stimulated the occurence of powdery mildew and caused severe infection.

3.4. Health condition of the Q. pubescens trees

Downy oak forests comprise only 1.5% of all oak forests in Serbia. *Quercus pubescens* (Downy oak) displayed the best chlorosis and defoliation results of all the oak species monitored for health assessment. Nearly all the trees had chlorosis 0, while not one tree had defoliation categories 3 and 4 (Fig. 5).

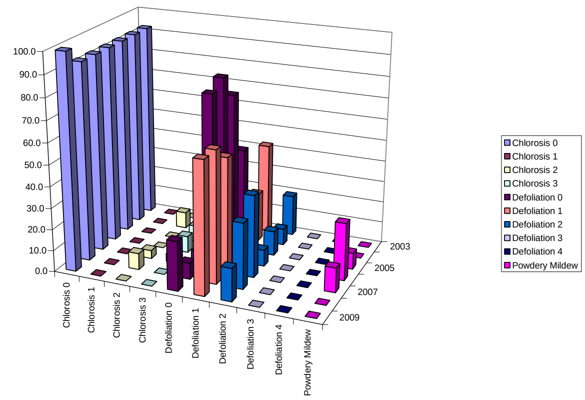

Figure 5 – *Health condition of the Q. pubescens trees and the occurrence of powdery oak mildew at sample plots in Serbia from 2003 to 2009*

During the assessment period the powdery oak mildew attacks on the monitored Downy oak trees ranged from 0% to 26.9% of the trees infected, i.e. 6.59% on average. Weak powdery mildew attacks were recorded in 2005 and 2007 (7.7% and 11.5% respectively). A medium magnitude powdery mildew attack was recorded in 2006, when 26.9% of the trees were infected. During 2006 the weather conditions in the region populated by Downy oak were favourable for the pathogen (average annual precipitation sums ranged from 800 to 1000 mm and mean maximum temperatures were 14 to 19^0C), which led to the medum magnitude infection. To a certain extent, the magnitude of the infection was a consequense of the general vulnerability of Downy oak as a species.

3.5. Health condition of the Q. robur trees

English oak forests comprise 4.5% of all oak forests in Serbia. *Quercus robur* displayed the worst health conditions of all the oak species monitored for health assessment in Serbia. Considering chlorosis, this oak species also had the largest percentage of trees with chlorosis 0; however, large percentages of trees belonged to categories 2 and 3, particularly in 2008 and 2009 (Fig. 6).

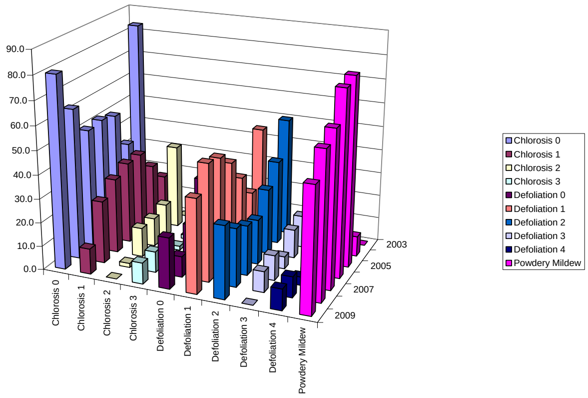

Figure 6 – *Health condition of the Q. robur trees and the occurrence of powdery oak mildew at sample plots in Serbia from 2003 to 2009*

Considering defoliation categories, the health condition of English oak trees was even worse. The largest percentage of the trees belonged to defoliation category 2 (from 19.0% in 2006 up to 50.0% in 2003). In the year 2009, 8.9% of the trees featured defoliation index 4 (which refers to completely dried up tree trunks).

The year 2003 was generally unfavourable for English oak health condition considering chlorosis and defoliation as parametres, which led to the occurrence of powdery mildew on foliage in 8.6% of the trees the following year. During the year 2003, the lowest average annual precipitation sum was recorded in the sample plot areas populated by English oak. According to the data published by the Republic Hydro-Meteorological Service of Serbia [8], it amounted to 500-600 mm. The culmination of the infection was recorded the following year (2004). During the assessment period, the magnitude of the infection decreased gradually to 51.8% in 2009. Over the years 2004 and 2005, the highest average annual precipitation sums were recorded in the regions populated by English oak (700-900 mm). The highest mean maximum air temperature (19^0C) was recorded in this region in 2004, which, combined with the high relative humidity, resulted in the most massive powdery mildew infection.

During the assessment period the magnitude of powdery oak mildew attacks on the monitored English oak trees was 49.16% on average. Thus, of all oak species trees attacked by powdery mildew, the largest percentage were English oak trees. The strongest attacks were recorded in 2005 and 2006, affecting 79.3% and 77.6% respectively. During 2006 the values of the average annual precipitation sum (600-800 mm) and mean maximum air temperature (approximately 17^0C) in the region were exceptionally high, which directly influnced the large magnitude of the infection. The following years (from 2007 to 2009), the values of the average annual precipitation sums (500-700 mm on average) and mean maximum air temperatures (16^0C on average) decreased, which lead to a gradual subsidence of the infection.

4. DISCUSSION

The magnitude of the powdery mildew infection depends on numerous factors, most of all climate factors and susceptibility and age of the host plant.

With regard to their susceptibility to powdery mildew, the oak tree species monitored at sample plots in Serbia (according to Karadzic and Milijasevic, 2005 [9]) are classified as follows: *Q. robur* – English oak (the most susceptible), *Q. pubescens* – Downy oak (susceptible), *Quercus farnetto* – Hungarian oak (fairly resistant), *Q. petraea* – Sessile oak (resistant) and *Q. cerris* – Turkey oak (the most resistant).

Younger trees – seedlings in nurseries and young cultivated plants – require special attention as they are particularly susceptible to powdery mildew and suffer most severe damages caused by this pathogen. Unless prompt measures against powdery mildew are taken, the magnitude of the infection increases and after several years of successive attacks, the mildew physiologically weakens, stunts and eventually dries the host plants.

The magnitude of the infection with the same sort of powdery mildew in the same host plant varies significantly across countries, even across different regions within the same country. The magnitude of the infection is influenced by climate features of the region and by the geographical distance of the susceptible host plant from the source of infection [10].

In the reference works cited a number of authors from different climatic reagions of the world confirm and prove that the magnitude of the powdery mildew infection in different plant species is directly dependent on the environmental conditions, primarily the air temperature and humidity [11, 12, 13, 14, 15, 16], as well as the fact that negative effects on the pathogen by one of the two factors (air temperature and humidity) may be reduced significantly by positive impact of the other.

As for the cause of powdery oak mildew, each population of this fungus is characterised by great genotype variability and great polymorphism, so that a specialised research of each particular case is required. That is why, for the purpose of protection against powdery mildew, new active substances are constantly being tested and introduced into practice, together with combinations of the existing ones with different mechanisms of action in order to enhance their scope and obtain synergic effect [17].

Relative air humidity need not be exceptionally high to facilitate germination of the spores. The pathogen is therefore markedly present in dense plantings with poor air circulation and in dark and humid places. The incidence of the infection increases with the increment of the relative humidity up to 90%; however, the infections do not occur when the leaf surfaces are wet, i.e. when it is raining. Torrential rains wash away the inoculum from foliage and reduce the magnitude of the infection since the pathogen is epiphyte. On the other hand, long periods of high air temperatures facilitate the development of the pathogen. Favourable periods for powdery mildew infections come following the rains, when leaf surfaces have dried and air humidity is still high.

During the vegetation period there are a number of conidial generations of powdery mildew. Cleistothecium formation occurs toward the end of the vegetation period of the host plant, while the ascospores mature physiologically during autmn and winter. The most favourable period for the occurence of severe mildew infections in Serbia is in the first half of July due to the simultaneous effects of the optimum values of the relative air humidity and temprerature during a prolonged period of time, which is very important for the purpose of effective protection. In other words, unless protective measures are applied prior to the outbreak of massive infection, all actions taken afterwards will have little effect.

5. CONCLUSION

In Serbia, English oak is most endanagered by powdery mildew. The strongest mildew attacks were recorded in 2005 and 2006, affecting 79.3% and 77.6% of the trees respectively. During the whole assessment period, the attacks of mildew on the English oak trees monitored were very strong, except in the year 2003, when the disease was not recorded. From 2004 to 2009, the magnitude of the infection ranged from 8.5% to 79.3% of the trees. During the whole assessment period of powdery mildew on English oak trees at sample plots in Serbia, the mildew attacks affected 49.16% of the trees on average.

For the purpose of conducting integrated forest protection, the monitoring of the health condition of forests and population levels of the major diseases and pests continues within Level 1 at the sample plots in the territory of the Republic of Serbia. Furthermore, Level 2 observation will be introduced (which, among other things, involves very thorough examination of forest health status and continuous monitoring of the environmental conditions – air temperature and humidity, which directly influence the occurrence and development of the disease) in order to provide very precise diagnostics as well as the forecasts of the disease development at the most endangered sites in the years to come.

It should be emphasised that a well-timed implementation of prevention measures is of great significance for the health of forests. These measures are aimed at elimination of the conditions that facilitate the development of the disease and provision of satisfacrory resistnace and vitality of the forest trees. Prevention measures involve timely restoration and nurturing of forests and forest plants, maintenance of biodiversity, expert habitat identification and proper choice of the species suitable for planting new forests, selection of plant species with genotypes resistant to major diseases and pests, usage of healthy seeds and seedlings, proper seedling manipulation, etc.

Over the years of dry weather, when the average annual precipitation sums are below normal values and air temperatures in summer months are exceptionally high, the risk of the occurence of mildew infection is reduced so that special protective measures need not be conducted. In all other cases, it is necessary to create a prudent protection programme for the endangered species, particularly for the plants in nurseries and young cultivated plants.

Acknowledgements

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THE PROSPECT OF A SHORT-TERM PRESERVATION OF THE OAK LOGS AT THE FOREST STORAGES USING ENVIRONMENTALLY FRIENDLY PRESERVATIVES

Milenko MIRIĆ[1], Snežana IVKOVIĆ[1], Melita VUKOVIĆ[1]

Abstract: *The problem of log-protection at the forest storage emerges instantly after the timber fall and is especially important for prolonged period of storing, due to the surrounding conditions. Numerous pests as xylofagous insects and decaying fungi attack trunks in order to provide nutrients for their growth. The possibility of short-term protection of Oak logs (Sessile Oak - Quercus petraea agg.) has been tested at the two different geographical sites, using four wood preservatives based on chrome/copper/boron salts, chlorinepiriphos /dichlorinefluanid, Cu– naphthenate and antiseptic paste. Treated logs were artificially inoculated at the surface, using developed dicariotic mycelia of five Oak wood-rotting fungi. The separate control series of log-samples have been exposed to the spontaneous infection in the forest. The test results showed that those wood preservatives provided satisfactory protection of Oak trunks just for the short period of time (four weeks). The most frequent cause of log-sapwood deterioration has been spontaneous infection by sporas of fungus Stereum hirsutum at the forest sites. That was the outcome of the high level of Stereum hirsutum inoculum, as well as the microclimate conditions and pioneer character of fungus itself. Taking into consideration the unsatisfactory effects of the applied protection, one can recommend only the organisational and technical measures. The proper transport of logs out of the forest is the most recommending one.*

Key words: *Stereum hirsutum*, CCB, chlorinepiriphos/dichlorinefluanid, Cu–naphthenate, log-protection;

Izvod: *Problem zaštite trupaca na šumskim stovarištima pojavljuje se odmah nakon obaranja stabala i naročito je važan pri produženom vremenu lagerovanja, zbog uslova sredine. Brojne štetočine kao ksilofagni insekti i gljive truležnice napadaju trupce da bi obezbedili hranu za svoj rast. Mogućnost privremene zaštite trupaca hrasta kitnjaka (Quercus petraea agg.) ispitana je na dva geografski različita lokaliteta, korišćenjem četiri preparata za zaštitu drveta na bazi soli hroma, bakra i bora (CCB), hlorpirifosa i dihlorfluanida (C/D), Cu-naftenata i antiseptičke paste. Zaštićeni trupci su na veštački način površinski inokulisani, korišćenjem razvijene dikarione micelije pet gljiva truležnica hrasta. Posebna, kontrolna serija uzoraka trupaca izložena je spontanoj infekciji u šumi. Rezultati ispitivanja su pokazali da su korišćeni preparati za zaštitu drveta obezbedili zadovoljavajuću zaštitu hrastovih trupaca samo u kratkom periodu (četiri nedelje). Najčešći uzrok degradacije beljike trupaca bila je spontana infekcija sporama gljive Stereum hirsutum u šumi. To je posledica visokog nivoa inokuluma vrste Stereum hirsutum u šumi, kao i mikroklimatskih uslova i pionirskom karakteru same gljive. Uzimajući u obzir nezadovoljavajuće efekte primenjene zaštite, mogu se preporučiti jedino organizaciono-tehničke mere. Blagovremeno izvlačenje trupaca iz šume je najpreporučljivija mera.*

Ključne reči: *Stereum hirsutum*, CCB, hlorpirifos/dihlorfluanid, Cu–naftenat, zaštita trupaca;

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INTRODUCTION

Wood decaying fungi, depending to their enzymatic activity, can utilize each cellulose, lignin and hemicelluloses, causing brown-, soft- or white rot (Schmidt, Kerner - Gang, 1986).

Among this group extremely important are those species with the both parasitic and saprophytic mode of nutrition. A numerous stereoide fungi can behave as facultative parasites or parasites of weakened trees (Mirić, Schmidt, 1992).

After felling, and during storaging of logs on forest or industrial storages, they behave as a saprophytes, causing anatomical, aesthetical, mechanical and other changes of wooden material (Mirić et all. 2012). Their deteriorating activities can start in stems and continue (or start) in logs (Schmidt, 1994).

Some pioneer-species of Stereoide fungi that are commonly present in the Oak-stands, are as follows: *Stereum hirsutum* and *Chondrostereum purpureum* (cause of white rot*), Stereum rugosum* (cause of cancer wounds) and *Xylobolus frustulatu* (cause of heartwood white pocket rot – Partridge wood) (Swift, 1978). They colonize Oak wood after felling causing its'deterioration (Montgomery, 1982; Mirić, Schmidt, 1992).

Sessile Oak (*Quercus petraea agg*) is very widespread Oak species in Serbia. For woodworking industry it acts very valuable row material for production of wide range of quality wood products as like furniture, parquets, boats, constructions etc.

Regarding that there are favourable microclimate conditions for developing of wood decaying fungi in forests, the logs are the most endangered just in this phase of exploration (Rayner, Boddy, 1998), and that is why one has to pay attention to those protection. Organisational and technical measures are certanly of main importance, but in the case of prolonged storaging of logs in forest during period of active vegetation, usage of chemical preservatives for their temporary protection is necessarly. When choosing preservatives to protect lying logs in the forest, the most important step is to test their efficacy against decaying fungi. To protect forest land and the total ecosystem from pollution it is necessary to use such chemical formulations that are not hazardous to the environment if it spreads into the atmosphere, water or land. Testing the effectiveness of preservatives consist of two steps: laboratory experiments as well as field tests. The results of both kind of experiments, together with proven ecologicaly friendly character of preservative, should be of invaluable importance in making decisions about the formulation, concentrations and doses of preservatives that should be applied for the protection of timber during prolonged temporary lying of logs on the forest storages.

MATERIAL AND METHOD

Possibility of protection of Oak wood from decay was tested during prolonged retention of logs directly in forest. Experiments were set up at forest sites with logs protected by preservatives that have showen effectiveness in laboratory tests, and then artificially inoculated with four stereoide- as well as one control fungus – *Trametes versicolor*. Unprotected logs were used as control group.

One of the most important species of Oak in climate region of Serbia, Sessile Oak – *Quercus petraea* (Matt.) Liebl. (Jovanović, 1991), has been used in this research. The wide prevalence of this Oak-species in Serbia and its' endangering under the influence of harmful mycoflora, were the decisive reasons for choosing of this wood-species. Following the issue of protection capabilities of Oak logs in the forest, during the most sensitive stage in terms of susceptibility to biodegradation processes, we chose to test several protective products that have previously been successfully tested in laboratory conditions against some decaying fungi.

The main assumption was that the most sensitive phase is the time from the trees-harvesting till pulling them out from forest-sites to the industrial processing storages. The possibility of practical application in forest conditions, the range of effects on harmful organisms and those availability on the market, have been taken in to consideration in choosing preservatives for testing. Tests were carried out with the next wood-preservatives (trade names omitted from the text):

1. CCB: Salt based on chromium, copper and boron;
2. SP: antiseptic paste for covering the fronts of logs;
3. C/D: based on 1% chlorinepiriphos ($C_9H_{11}Cl_3NO_3PS$) and 1.5% dichlorinefluanid ($C_9H_{11}Cl_2FN_2O_2S_2$);
4. Cu-N: based on salts of copper and naphthenic acids (Cu naphthenate).

In field trials all these products were used in produced concentrations (undiluted), except the products CCB that was used as a 10% aqueous dilution. In laboratory experiments, during testing of the toxicity-limit, all these preservatives were diluted to lower concentrations to determine their effect against decaying fungi in pure cultures.

Experiments have been conducted at two sites in stands of Sessile Oak *(Q.petrae agg)* allocated to localities Slačina (Majdanpek domain) and Krčanik (Goč). The first experimental plot was at an altitude of 540 o.s., on the southern exposition. Experimental plot on Goč was at an altitude of 980 meters on the north north-east exposition.

Test wood-samples were cut out from completely healthy Oak trees. Each six loggs of 60 cm in length, were laid on wooden coasters, and covered and protected from the rain-leaching by using poles and plastic sheeting. Considering that some of used preservatives were based on organic solvents and as such unsuitable for application on moist surfaces, tested logs have been left 10 days for partially drying of fronts. Ten days after cutting test-logs were treated with preservatives. Preservative CCB was used as 10% aqueous solution, while antiseptic paste SP and preparations C/D and Cu-N were used in manufactured concentration (without dilution). Application of preservatives was carried out using hand-held sprayer, in the amount of 0.3 l per each tested log, except antiseptic paste that is inflicted in a three-layer coating. Treated test- logs were left the following four weeks in the covered stack, to stabilize the protective compounds in wood.

After this period all test-logs were placed in groups, in the upright position and the free cross sectional areas were inoculated with mycelium of tested stereoide fungi. As inoculum, we used previously prepared plates of poplar wood (50 x 50 x 5 mm), that were in plastic Petri dishes (D = 90 mm) owergrown by the mycelium of tested fungi in laboratory under standard conditions of humidity (70 ± 5%) and temperature (21 ± 1°C).

After complete ingrowth of poplar plates by mycelium, Petri dishes were transferred to the forest and after surface sterilization of cross-sectional areas of test-logs with ethanol, their upper part, together with the developed mycelium covered with poplar, eccentrically placed (opening down) over the cross sections of test-logs to cover areas of sap- and heartwood. Petri dishes were attached to the surface of wood with inert gumo-plastic mass, and in this way inoculums were protected against rapid dehydration and superinfection. All test-logs were kept in conditions of overshadow during the whole experiment. This series of experiments were placed in the same way on both experimental plots. The first group of logs (group A) was neither treated with a preservative nor inoculated with mycelium of tested fungi, but left to spontaneous infection - as control.

The second group of logs (group B) was also formed from unprotected, but artificially inoculated logs, as described above. Groups C, D, E and F were protected by CCB SP, Cu-N and C/D and inoculated with all tested fungi, as described above. Each one protected log from each of the previous four groups, have been left (without artificial inoculation) to the spontaneous infection in forest-stand conditions (control group H).

The experiment was conducted in the summer, with a time difference of 10 days at both sites and in the same way. Monitoring and review of experiments were conducted on the occurrence of changes at the surface of test-logs (splitting, detachment of bark, appearance of subcortical mycelium or carpophores etc.). Samples from the heartwood and sapwood zones have also been colected for laboratory testing of mycelial occurrence inside the wood.

RESULTS AND DISCUSSION

The results of examination of protected and artificially inoculated logs with stereoide fungi are shown in Tables 1 and 2.

Table 1: *Overview of the health status of protected and unprotected Oak logs (Q.petraea) 16 weeks after inoculation at the site Slačina (Majdanpek domain)*

Tested logs →		Control A (untreated, uninoculated)	Control B (untreated, inoculated)	Group C Preservative CCB (10%)	Group D Preservative SP	Group E Preservative Cu-N	Group F Preservative C/D
Fungus	**Wood-zone**						
Stereum hirsutum ***(Str. 1)***	sapwood		1	0	0	0	0
	heartwood		0	0	0	0	0
Stereum hirsutum ***(Str. 2)***	sapwood		1	0	0	0	0
	heartwood		0	0	0	0	0
Chondrostereum purpureum	sapwood		1	0	*S.h.Sch.c. 2*	0	0
	heartwood		0	0	0	0	0
Stereum rugosum	sapwood		1	0	*Sch.c. 2*	0	0
	heartwood		0	0	0	0	0
Xylobolus frustulatus	sapwood		1	0	0	0	0
	heartwood		0	0	0	0	0
Control H (treated, uninoculated)	sapwood	*S.h.* 1		*B.p. 1*	*Sch.c. 1*	0	*B.p. 1*
	heartwood	0		0	0	0	0

0 = Unattacked/undestroyed;
1 = Early stage of decay;
2 = Advanced stage of decay;

S.h. = Fruit bodies of fungus *S.hirsutum*;
Sch.c. = Fruit bodies of fungus *Schizophyllum commune;*
B.p. = Fruit bodies of fungus *Bulgaria polymorpha;*

From the results related to the wood of Sessile Oak (*Q.petraea agg),* which are shown in Table 1, for the site Slačina (Majdanpek domain) one can conclude the next:

Control logs (group A) which were neither protected nor inoculated with stereoide fungi, were covered with fruit-bodies of *Stereum hirsutum* due to spontaneous infection in the stand itself. A darkened sapwood (the initial stage of decay) occured, while the heartwood was unattacked, which has been confirmed by laboratory analysis (incubation of samples at artificially nutritive medium).

These results were also reported with the other control group (group B) despite the fact that the test-logs were artificially inoculated, suggesting that the level of inoculum of fungus *S.hirsutum* in the forest-stand was very high and that the spontaneous infection (by spores) exceeded ability of used strains of stereoide fungi in competition on the wood as a nutritive substrate. Suitability of fungi to forest- stand conditions is also very important, as the strain that caused the spontaneous infection showed markedly greater virulence (ability to provoke infection).

Besides the fact that the spontaneous infection provoked by spores occurred at a much greater area in comparison with artificially inoculated one, it is known so far that the pace of expansion of mycelium of *S.hirsutum* in longitudinal direction inside the Oak tree, after the moment of infection is slowly, and then accelerates in accordance with the time-length of incubation. In some other wood species, however, the case is reversed (Rayner, 1979).

In a period of sixteen weeks there were no symptoms of decay neither in sap- nor in heartwood zone on the logs in groups C,E and F. In group D (treated with antiseptic paste), on the logs inoculated with *Ch.purpureum* and *S.rugosum* appeared fruit-bodies of *Sch.commune* and *S.hirsutum* as a result of spontaneous infection in the forest, with obvious symptoms of advanced stages of sapwood decay. The fungus *Schizophyllum commune* is also well known as a pioneer species that is always present in forests and escorts physiologically weakened or/and fallen trees.

On the logs treated with antiseptics, but not artificially inoculated afterwards (group H), as a result of spontaneous infections appeared the fruit-bodies of species *Bulgaria polymorpha* Wett. (logs protected with CCB and C/D), and *Sch.commune* Fr. (logs treated with paste SP), where the sapwood had signs of discoloration, while the heartwood was unattacked.

Based on these results, in general, one can conclude that the ability of performance of succesful artificial infection in forest-stand conditions is limited by many factors, including the level of inoculum of microorganisms and other climatic factors, which certainly are of crucial importance (Montgomery, 1982). This statement opens many questions like as the problem relating to evaluation of methods for conducting tests *in vivo* in this area.

Based on the results and also bearing in mind the previous remarks, one can come to certain conclusions regarding the efficacy of tested preservatives. Aniseptics CCB, Cu-N and C/D meet the preservative function during 16 weeks and provide protection of sap- and heartwood of Oak logs in the given test conditions. Slightly weaker effect was obtained with antiseptic paste SP, certainly because of its paramount purpose to protect the fronts of logs from drying and splitting.

In the control groups (group A, B and G) in the period of 16 weeks occured discoloration or complete degradation of the sapwood with appearance of fruit-bodies of decaying fungi. By comparing, one can see the positive effect of tested preservatives on this site.

Table 2 shows the results of testing the possibilities of protection of Oak logs (*Q.petraea*) at the site Krčanik (Goč).

In control group A, 17 weeks after cutting it was found mosaic rott of sapwood and fruit-bodies of fungus *B.polymorpha*, while the heartwood zone was unattacked. Under the bark of control logs appeared galeries and larvas of an dangerous xylophagous insect – *Plagionotus arcuatus* L.

On control logs of group B, inoculated with mycelia of fungus *S. hirsutum*, there were found fruit-bodies of *S. hirsutum* located on the surface and crevices of the bark and the sapwood zone of the cross sections of logs, while the sapwood was in an advanced stage of decay. Under the bark of logs there were found galeries and larvas of *P. arcuatus* and *Agrillus* -like larvas. In the sapwood zone of logs inoculated with mycelia of fungi *Ch. purpureum* and *S. rugosum*, was observed phenomena of wood discoloration, what could indicate early stage of decay (Rayner, Boddy, 1988). The presence of fungi has not been detected in heartwood zone even in serie inoculated with a fungus *X. frustulatus*.

The reason could be due to the method of taking samples for analysis of logs on the presence of fungi. From each side of logs it was cut discs with thickness of 5 cm, and samples were taken from the remaining part of log. Based on this method of sampling, if the presence of fungi is not stated, one can conclude that the mycelium did not penetrate from the surface more than about 5 cm from the place of inoculation.

In the case of test-logs from group C protected with preservative CCB (10%), heartwood zone was unattacked, while the sapwood was at an advanced stage of decay in all cases. Under the bark of logs in this group, *Agrillus*-like larvas were found, while on the logs inoculated with mycelia of test fungus *X. frustulatus*, occurred a numerous stromas of pioneer fungus *H. multiforme* Fr.

The logs protected with antiseptic paste SP (group D) after 17 weeks had a healthy heartwood, while the sapwood was in an advanced stage of white rot, with numerous fruit-bodies of fungus *S.hirsutum* on the surface and in crevices of bark.

Table 2: *Overview of the health status of protected and unprotected oak logs (Q.petraea) 17 weeks after the inoculation at the site Krčanik (GOČ)*

Tested logs →		**Control A** (untreated, uninoculated)	**Control B** (untreated, inoculated)	**Group C** Preservative **CCB (10%)**	**Group D** Preservative **SP**	**Group E** Preservative **Cu-N**	Group F Preservative C/D
Fungus	**Wood-zone**						
***Stereum hirsutum** (Str. 1)*	sapwood		*S.h.* 2 * **	2 **	S.h. 2	0	2
	heartwood		0	0	0	0	0
***Stereum hirsutum** (Str. 2)*	sapwood		*S.h.* 2 *	2 **	S.h.2 *	1	2
	heartwood		0	0	0	0	0
Chondrostereum purpureum	sapwood		1 **	2 **	*S.h.;H.spp.2*	2	2
	heartwood		0	0	0	0	0
Stereum rugosum	sapwood		1 **	2 **	*2*	2	2
	heartwood		0	0	0	0	0
Xylobolus frustulatus	sapwood		2 *	*H.spp*.2 **	*H.spp.* 2	2	2
	heartwood		0	0	0	0	0
Control H (treated, uninoculated)	sapwood	*B.p. 2 **		2 **	*H.spp.* 2	2	*2*
	heartwood	0		0	0	0	0

0 = Unattacked/undestroyed;
1 = Early stage of decay;
2 = Advanced stage of decay;
***** = Larvas of *Plagionotus arcuatus* under bark;
S.h. = Fruit bodies of fungus *S.hirsutum*;
H.spp. = Fruit bodies of fungi *Hypoxylon spp*.;
B.p. = Fruit bodies of fungus *Bulgaria polymorpha;*
****** = *Agrillus*-like larvas under bark;

On the logs from this group that haven't been artificially inoculated, as well as on those inoculated with mycelia of fungi *Ch.purpureum* and *X.frustulatus*, appeared a lott of stromas of *Hypoxylon spp*., while in sapwood zone appeared a white-mosaic type of rot. A numerous factors affect process of infection of *Ch. purpureum* on the wood, so that spontanous infection due to other "stronger" fungi in forest is always present (Spiers, Hopcroft, 1988).

In group E, on the logs protected with preservative Cu-N, the symptoms of decay was not observed only on logs inoculated with strain1 of fungus *S.hirsutum*. In other cases, the white mosaic rot was found in sapwood zone, and in those inoculated with isolate 2 of fungus *S.hirsutum* occured symptoms of discoloration. In all cases the heartwood was unattacked, and the surface of bark had not formed carpophores.

In logs protected with preservative C/D (group F) there was appearance of white mosaic rot of sapwood and detachment of the bark in all cases, while the heartwood was unattacked, and completely healthy.

When comparing the results obtained for the sites Slačina (Majdanpek domain) and Krčanik (Goč), it can be concluded that in the first case, the protection effects were more favorable.

Since the experiments were installed and guided by the same method at both sites, the reason of the various successes of protection may be sought at different levels of inoculum in the above localities, since in all cases the spontaneous- in relation to artificial infection, had the dominant influence on the occurrence of decay of sapwood. One of the reasons may be different natural resistance of Sessile Oaks from these two sites, but also different micro-climatic conditions in parts of the forest-stands where the experiments were conducted.

At both sites it has been observed the white mosaic rot of Oak-sapwood caused by spontaneous infection by fungus *S.hirsutum*. It is well known so far that *S.hirsutum* plays important role in decomposition of Oak wood in forests especially during long term of exposition of wood to this fungi (Swift, 1978). According to Todd and Rayner (1979) (source: Frankland et all. 1982), the dark line between the zones of decayed wood are the consequence of somatic incompatibility or intraspecies- antagonism on the same nutritive substrate, due to different origin of the mycelium in separate zones of wood (different strains of the same species) (Rayner, 1978). In the forest-stand conditions with a high concentration of spores of this fungus in the air (level of inoculum), originating from different fruit-bodies, this assumption can be taken as correct. In many cases this was confirmed by laboratory tests, by breeding, so-called, mixed cultures (Rayner, 1976.; Frankland, et all., 1982).

In general, regarding to appearance of decay of the Oak-sapwood caused by fungus *S.hirsutum* and uneven success of logs protection, used application methods or tested preservatives can not be recommended for practical application with confidence. The problem of preserving the sapwood of oak in terms of maximum quantitative and qualitative utilization of raw materials, should be solved by their proper transport out of forest at least four weeks after trees-felling. In the case of prolonged storage of logs at forest-sites due to organizational, technical and/or some other reasons, one can aplicate some efficient chemical preservatives, but just some environmenally friendly one.

CONCLUSION

During the field tests, one can conclude that there were methodicaly problems relating on performance of succesful artificial infection in forest-stand conditions. This operation was limited by many factors (level of inoculum of other competitive microorganisms and other climatic factors). This statement opens question of evaluation of methods for conducting tests *in vivo*.

Based on the results of the efficacy of tested preservatives, one can conclude that aniseptics CCB, Cu-N and C/D meet the preservative function during 16 weeks and provided the protection of sap- and heartwood of Oak logs in the given test conditions. Slightly weaker effect was obtained with antiseptic paste SP, certainly because of its paramount purpose to protect the fronts of logs from drying and splitting.

The results obtained for the site Slačina (Majdanpek domain) showed that protection effects were more favorable in comparison with those for site Krčanik (Goč). All experiments were installed and guided by the same method at both sites, so that the reason of the various successes of protection lays in different levels of inoculum. Spontaneous- in relation to artificial infection, had the dominant influence on the occurrence of sapwood-deterioration in all cases. One of the reasons may be the different natural resistance between trees of Sessile Oak from these two sites as well, but also the micro-climatic conditions in parts of the forest-stands where the experiments were conducted.

At both sites occurred the white mosaic rot of Oak-sapwood caused by spontaneous infection provoked by fungus *S.hirsutum* (natural strain from forest itself). It is obvious that fungus *Stereum hirsutum* plays important role in decomposition of Oak wood in forests, especially during prolonged exposition of logs to this fungi.

In general, regarding to appearance of decay of the Oak-sapwood caused by fungus *S.hirsutum,* as well as the fruit-bodies of some other pioneer fungi like as *Hypoxylon spp*., *Bulgaria polymorpha* and *Schizophyllum commune*, one can conclude that tested preservatives should not be recommended for practical application with confidence.

The problem of preserving the sapwood of Oak in terms of maximum quantitative and qualitative utilization of raw materials, should be solved by their proper transport out of forest or testing and implementation of some more efficient preservatives, in the case that due to organizational, technical and/or other reasons there is a prolonged storaging of logs at forest -sites.

This approach provides sustainable forest management and utilization in future because healthy and unpoluted environment is of the crutial importance for growth and development of healthy trees, and finaly for good wooden row material for woodprocessing industry.

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SURVIVAL OF FIVE WOOD DECAYING FUNGI TREATED WITH THE CERTAIN ENVIRONMENTALLY FRIENDLY WOOD-PRESERVATIVES *in vitro*

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Abstract: *Wood preservatives based on the chrome/copper/boron (CCB) -salts, chlorinepiriphos / dichlorinefluanid and Cu-naphthenate were evaluated according to its effect on the following wood-decaying fungi: Stereum hirsutum, Chondrostereum purpureum, Stereum rugosum, Xylobolus frustulatus and Trametes versicolor. Fungal cultures were grown on the Malc-agar media containing 0.1, 0.5, 1, 5, 10, and 20% of the antiseptic. The lowest concentration with the lethal impact and the highest concentration with the fungistatic effect were estimated. With the Cu-naphthenate preparation the best results were achieved, while the other two were a little less effective. Wood-preservation at the forest storages can be based on these results. Nevertheless, lab-experiments (in vitro) can be used only as a start position for the experiments in a living environment (in vivo), because the outcomes do not correspond very often. That is, alteration of just one of the influential factors in the natural surrounding can cause entirely different micro-organisms reactions on the tested agents, comparing to the lab-originated results. The reason lies in the inevitable simplification of the experiments in vitro, comparing to the ones in vivo. Still, prior to a large-scale application of any wood-preservative stand lab-experiments. They are placed before the tests at the forest-storage, as to assess the area of outdoor application, especially for the freshly fallen stems, that are of the highest risk when it comes to the wood-decaying fungi.*

Key words: lethal concentration, *Stereum*, CCB-salts, chlorinepiriphos/dichlorinefluanid, Cu-naphthenate.

Izvod: *Preparati za zaštitu drveta na bazi hroma, bakra i bora (CCB), hlorpirifosa i dihlorfluanida kao i Cu-naftenata ocenjeni su na osnovu efekta na sledeće gljive truležnice: Stereum hirsutum, Chondrostereum purpureum, Stereum rugosum, Xylobolus frustulatus i Trametes versicolor. Kulture gljiva rasle su na Malc-agarnoj podlozi sa sadržajem antiseptika od 0.1, 0.5, 1, 5, 10, i 20 %. Utvrđene su najniža koncentracija sa letalnim dejstvom i najviša koncentracija sa fungistatičnim efektom. Najbolji rezultati postignuti su sa preparatom na bazi Cu- naftenata, dok su ostala dva preparata bila malo manje efikasna. Zaštita drveta na šumskim stovarištima može se bazirati na ovim rezultatima. Međutim, laboratorijska ispitivanja (in vitro) samo mogu biti upotrebljeni kao polazna pozicija za eksperimente u živom okruženju (in vivo), zato što često rezultati* ne korespondiraju jedni sa *drugima. Ovo stoga što promena samo jednog uticajnog faktora u prirodnom okruženju može izazvati potpuno različitu reakciju mikroorganizma na ispitane agense u poređenju sa rezultatima poreklom iz laboratorije. Razlog ovome leži u neizbežnom uprošćavanju eksperimenata in vitro u poređenju sa onima in vivo. Ipak, pre šire primene bilo kog preparata za zaštitu drveta, stoje laboratorijska ispitivanja. Ona prethode ispitivanjima na šumskim stovarištima, da bi se pristupilo široj primeni na otvorenom prostoru, naročito za sveže posečena stabla koja su najugroženija od gljiva truležnica.*

Ključne reči: letalna koncentracija, *Stereum*, CCB-soli, hlorpirifos/dihlorfluanid, Cu-naftenat;

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INTRODUCTION

In process of dying-back of Oak forests, fungi have the most significant role. By attacking the healthy trees, parasitic fungi have an extraordinary importance, but significant role in that process have also those species that behave as weakened-trees' parasites and after felling of trees as a saprophytes. These species colonize the wood through different injuries on the surface of the bark and continue their destructive activity after trees' felling, inducing the decay (Cartwrigt, Findlay, 1946; Frankland, Hedger, Swift, 1982).

Decomposition of wooden mass causes enormous losses in the row material as well as in the sense of finance. These particular species of fungi, which are commonly present in the Oak-stands, are as follows: *Stereum hirsutum* and *Chondrostereum purpureum* (cause of white rot*),* *Stereum rugosum* (cause of cancer wounds) and *Xylobolus frustulatu* (cause of heartwood white pocket rot – Partridge wood) (Swift, 1978).

Sessile- (*Quercus petraea agg*) and Pedunculate Oak (*Quercus robur L.*) are two widespread species of noble broadleaved trees in Serbia (Jovanović, 1991). For the wood processing industry, they represent a very valuable raw material for production of a wide range of quality wood products, from furniture, boats etc., to flooring and other items.

Mentioned fungi are the pioneer species that colonize the Oak after felling and cause its destruction (Robinson, 1978; Montgomery, 1982; Mirić, Schmidt, 1992). Feeding on wood mass, decaying fungi cause anatomical, structural, aesthetic and mechanical changes in the wood (Mirić et all. 2012). Due to the prevailing forest conditions favorable for the development of decaying fungi, logs are very sensitive at this stage of exploitation (Rayner, Boddy, 1998), and an adequate attention must be given to its rescue from degradation. Organizational/technical measures are of paramount importance, but if the logs remain some time in the forest during the growing season, it is necessary the implementation of chemicals for their temporary protection against decaying fungi.

When choosing products to protect logs lying in the forest, the most important step is to test their efficacy against decaying fungi. To protect forest land and the total ecosystem from pollution it is necessary to use preparations that are not hazardous to the environment if it spread into the atmosphere, water or land. Testing the effectiveness of preservatives for the protection of wood always goes in at least two steps: laboratory experiments as well as field tests (Muntaňola - Cvetković, 1987). The results of experiments *in vitro* should be of invaluable importance in making decisions about concentrations and doses of preservatives that should be applied in field tests. Only the results of the both experiments can provide recommendations for practical application in the protection of wood raw-material during prolonged storage of logs in the forest besides stumps.

MATERIAL AND METHOD

The effect of different concentrations of antiseptics on the mycelium of tested fungi was studied under laboratory conditions by placing the inoculums on Malt-agar substrate containing the appropriate concentration of protective preparations and monitoring the growth of mycelium. Studies were performed with the lignicolous fungi: *Stereum hirsutum, Chondrostereum purpureum, Stereum rugosum*, *Xylobolus frustulatus* and *Trametes versicolor,* which are frequent companions of Oak wood at forest- and industrial storages (Schmidt, Kerner - Gang, 1986; Schmidt, 1994). For the experiments it have been used dicariotic mycelia of tested fungi, isolated from the fruit-bodies of fungi collected from the surfaces of Sessile Oaks. As a control, the fungus *Trametes versicolor* has been used.

The aim of this study was to determine the minimum concentration of antiseptics, which is toxic to the fungus during his presence in the nutritive substrate (fungicidal concentration), as well as the maximum range at which stops the growth of fungi but retains vitality (fungistatic concentration).

The next concentrations of tested wood preservatives have been tested:

Preservative:		**Concentration:**			
CCB	/	0.1	0.5	1.0	5.0%
C/D	0.5	1.0	5.0	10.0	20.0%
Cu-N	0.5	1.0	5.0	10.0	20.0%

**CCB= chrome/copper/boron; C/D=chlorinepiriphos/dichlorinefluanid; Cu-N= Cu-naphthenate;*

Nutritive media (2% Malt, 2% agar) was prepared so that previously it has been taken out a certain part from the required amount of water , and thus obtained a little more concentrated solution of Malt-agar solution. Deprived of water was sterilized separately and then mixed in aseptic chamber with the appropriate amount of certain protective preparations, and then added to the prepared Malt-agar media (of slightly higher concentrations) with continuous stirring using magnetic stirrer. All substrates were prepared in this way, except the one with the preparation CCB, which is like water solution also sterilized by autoclaving (20 min. /121 $^{\circ}$ C). In this way we obtained a standard substrate concentration of 2% Malt, 2% agar, and the desired concentration of antiseptics.

Before pour the medium in Petri dishes, the pH values for all tested concentrations of antiseptics have been measured to control the possible limiting effects of this factor on the growth of fungi. As these values ranged from 4.0 to 6.8 within the values that do not limit the growth of tested fungi, one can consider that change of pH values had no significant impact on results.

For faster cooling and consolidation it have been poured each 15 ml (instead of standard 20 mm) of prepared substrate into Petri dishes (D =90 mm), so that good dispersion has been achieved even with preservatives based on organic solvents (C/D and Cu-N). Inoculums of the tested and control species (D = 10 mm), taken from the growing zone of mycelium, were placed along the edge of the Petri dish, with the covered side facing upwards, i.e., without direct contact of mycelium of the inoculums with a toxic substrate. All fungi were incubated at a temperature of 21 +/- 1°C, and for each fungus and each preservative or tested concentration, each 3 replications were used. All experiments were repeated three times, with the identical results of all three tests.

Mycelia growth was monitored and have labeled every 48 hours. In the cases where even after 10 days a fungus did not begin to grow, inoculates were transferred to non-toxic, fresh Malt-agar media of standard composition. If the fungus continued to grow on the fresh substrate, the maximum concentration of toxins that the fungus was previously exposed was marked as fungistatic concentration. In cases where even after 30 days on fresh media fungus did not continue to grow, the corresponding concentrations were indicated as lethal ones (fungicidal).

RESULTS AND DISCUSSION

Discovered fungicidal-, fungistatic- and non-toxic concentrations of tested preservatives against the Stereoide fungi and *T.versicolor* (control) are shown in Tables 1, 2 and 3. Out there it is visible their impact on certain fungi.

It should be noted that the results were obtained in laboratory conditions, so that they are not directly applicable in practice. In this we take into account the influence of many environmental factors (temperature, wind, weather, rain etc.) on the treated wood in the outdoor area. Such environment requires the use of larger concentration, due to possibility of leaching or evaporation of a certain amount of applied preservative.

From Table 1 it is obvious that preservative CCB added in Malt-agar substrate at a concentration of 0.5% was lethal to all tested fungi, while at the same time in media containing 0.1% of CCB all fungi succeeded to develop mycelium.

From these results one can conclude that the exact toxic concentration of this preservative for the tested fungi lies in the range between 0.1 and 0.5%, if it was directly added in the nutritive media. For practical application, the manufacturer recommends 20 to 25 times higher concentration than lethal ones obtained by these tests, depending on application method, species, condition of wood and assortments and the intended use of a protected wood.

Table 1: *Effect of different concentrations of CCB preservative in Malt-agar substrate against mycelia vitality of tested stereoide fungi and control-fungus T. versicolor*

fungi	**Concentration of preservative CCB (%)**			
	0.1	0.5	1.0	5.0
Stereum hirsutum	+	-	-	-
Chondrostereum purpureum	+	-	-	-
Stereum rugosum	+	-	-	-
Xylobolus frustulatus	+	-	-	-
Trametes versicolor	+	-	-	-

+: *non-toxic concentrations;* ***0****: fungistatic concentrations;* -: *fungicidal concentrations;*

Preservative C/D if added at concentration of 5% to nutritive medium was fungistatic for the mycelium of fungus *S.hirsutum*, while 10% concentration was lethal (Table 2). Fungi *Ch.purpureum* and *S.rugosum* stopped their growth at 1 and 5%, but they continued to grow by transfer to fresh nutritive substrate, suggesting that these two concentrations were fungistatic for the aforementioned fungi. Since the both fungi lost viability at next higher concentration (10%), the exact toxic concentration of preservative C/D for these two species was between 5 and 10%. For the fungus *X.frustulatus* fungistatic concentrations were 0.5 and 1%, while 5% had already been lethal. Control fungus *T.versicolor* had mycelia growth on media containing 0.5% of preservative C/D, whereas 1% on this fungus has had lethal effect because mycelium did not continue development after transfer to fresh nutritive media. From the foregoing it can be concluded that mycelium of fungus *S.hirsutum* showed the highest resistance against preservative C/D, and then *Ch.purpureum*, *S.rugosum* and finally *X.frustulatus*. The lowest examined concentrations were fungistatic for fungus *X.frustulatus*. The most sensitive to this preservative was fungus *T.versicolor*.

Table 2: *Effect of different concentrations of C/D preservative in Malt-agar substrate against mycelia vitality of tested stereoide fungi and control-fungus T. versicolor*

fungi	**Concentration of preservative C/D (%)**				
	0.5	1	5	10	20
Stereum hirsutum	+	+	0	-	-
Chondrostereum purpureum	+	0	0	-	-
Stereum rugosum	+	0	0	-	-
Xylobolus frustulatus	0	0	-	-	-
Trametes versicolor	+	-	-	-	-

+*: non-toxic concentrations;* ***0****: fungistatic concentrations; -: fungicidal concentrations;*

Preservative Cu-N seems to be the most toxic among the tested antiseptics (Table 3). All tested concentrations proved to be toxic, since all fungi have lost their vitality by the concentration of just 0.5% preservative in substrate.

In laboratory tests, preservative Cu-N proved to be the most toxic of all tested preservatives against stereoide fungi as well as against control fungus *T.versicolor*.

Table 3: *Effect of different concentrations of Cu-N preservative in Malt-agar substrate against mycelia vitality of tested stereoide fungi and control-fungus T. versicolor*

fungi	**Concentration of preservative Cu-N (%)**				
	0.5	1	5	10	20
Stereum hirsutum	-	-	-	-	-
Chondrostereum purpureum	-	-	-	-	-
Stereum rugosum	-	-	-	-	-
Xylobolus frustulatus	-	-	-	-	-
Trametes versicolor	-	-	-	-	-

+: *non-toxic concentrations;* **0**: *fungistatic concentrations; -: fungicidal concentrations;*

CONCLUSION

It has been determined the toxicity of the investigated treatment with wood preservatives against stereoide- and control fungus and consequently one can conclude the following:

The most toxic against the mycelium of stereoide fungi was preservative Cu-N based on copper naphthenates. Directly mixed in the nutritive media at a concentration of 0.5% it appeared to be lethal to almost all tested fungal strains.

Preservative CD based on chlorinepiriphos / dichlorinefluanid, added to nutritive media at a concentration of 10% was lethal against all tested fungi.

Preservative based on chromium, copper and boron (CCB), directly mixed in the nutritive media at a concentration of 0.5% was lethal to all fungi.

These statements relate to the results of the toxicity tests of preservatives in laboratory conditions, while the use of these antiseptics in field conditions probably require the use of stronger concentration in order to provide secure protection effects in outdoor conditions and to achieve the expected results.

Methods for testing the toxicity of wood preservatives in the laboratory and in the field are necessary to be evaluated and adjusted, due to differences of testing conditions. However, the results of laboratory analysis are certainly a solid guideline for further investigations of the efficiency of treatment with wood preservatives in the open.

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ESTABLISHMENT OF HYMENOPTEROUS ENTOMOFAUNA ON INDIGO BUSH *Amorpha fruticosa* L. IN REPUBLIC OF SERBIA

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Abstract: *During six years research studies of aggressive invasive host plant Amorpha fruticosa L. and its entomofauna, significant number of hymenopterous species had been recorded. Data analyses were done from statistically significant samples collected around the country. Primarily, the paper presents results of the parasitoid complex established on introduced monophagous indigo bush weevil Acanthoscelides pallidipennis Motschulsky. Coleoptera: Bruchidae: Bruchinae feeding in its pods. Special attention was on assessing and monitoring of new formed inter species relations between autochthons parasite wasps and herbaceous seed weevil beetle. As cosmopolitans, two subgenera species of Eupelmus and Anastatus (Chalcidoidea: Eupelmidae) were found commonly feeding on weevil larvae and pupa with ectoparasitoid status. The evidence of hyperparasitism existence as a phenomenon was established by specimens eclosion of Proctoptrupoidea: Diapriidae and species of genera Torymus (Chalcidoidea: Torymidae) and Tetrastichus (Chalcidodea: Eulophidae). One specimen from family Scelionidae (Hymenoptera: Proctoptrupoidea) appeared from pods sample, with status of fresh beetle egg parasite. Material was stored and exposed to outside weather conditions, and available to infestation. The most frequently insects found feeding on stem bark was scales. At least two scale species were recognized as A. fruticosa common pests. Mulberry scales, or Pseudaulacaspis pentagona Targ. Homoptera: Diaspididae and False plum scale Parthenolecanium corni Bouche. Homoptera: Coccidae were also monitored in different development stages. Adults of Chalcid wasps from families Aphelinidae, Eurytomidae, and Mymaridae (Hymenoptera: Chalcidoidea) and Braconidae (Hymenoptera:Ichneumoidea) appeared, living emergence holes after, on scale female mature shields. Leaves and branches material collecting in a goal of detecting damage caused by Metcalpha pruinosa Say (Hemiptera: Flatidae) on Indigo bush resulted with apterous specimens appearance-family Dryinidae (Hymenoptera: Chrysidoidea). Innitial hypoteses that genera Oedaule (Chalcidoidea:Pteromalidae) is zoophagous weevil larvae parasitoid, was rejected after studious laboratory work and confirmed as endophagous herbivore feeding in seeds also as the most common one.*

Key words: Pods, *Amorpha*, Weevil, Scales, parasitoids, parasitic wasps

INTRODUCTION

False indigo or indigo bush *Amorpha fruticosa* L. (Fabaceae: Papilionaceae: Astragalae) is the woody shrub plant introduced in Europe in 1724 and in the Balkan Peninsula at the beginning of the twentieth century, precisely in 1900 (Petračić, 1938). This invasive species colonized native alluvial forests, ecosystems and habitats in large lowland river valleys areas with serious threatened influence to the natural ecological balance maintaining (Tucović & Isajev, 2000). Due to fundamental changes in the rare oases of relatively undisturbed wetlands

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nature and direct influence to continual shrinking and disappearance of open water surfaces (water mirrors), there is a concern and importance of international scientific cooperation under frame of such cosmopolitan aggressive species spreading topic, (Šefrová & Laštůvka, 2005; Hulme et al. 2008). Observations of candidates for biological measures of weed control were started in a goal of preserving indigenous floristic (Bobinac, 1999) but also indirectly and fauna diversity of this vulnerable nature settlements from its drainage and eutrophication caused by weed growth - indigo bush populations abundance increasing (Tomović et al. 2008).

MATERIALS AND METHODS

Collected seed was in the paper bages at exterior temperature. In February the seed was placed in the cardboard light eclectors with flacons. February to March, 100 pods from each locality were dissected and 100 pods from each locality were places in the test tubes for growing (**Figure 1 and 2**). All adult insects appeared during April and May from pods collected during the three winter periods, of total five. In order to obtain the parasitoids more easily, 50-100 g of the seed from each localities were transported in the plastic transparent bages so that it they could be recorded more easily. All the material is prepared and is being preserved in the Entomological Laboratory of the Faculty of Forestry and Institute of Forestry.

Figure 1 *Tubes for growing*


Figure 2 *Pods from each locality were dissected*

RESULTS AND DISCUSSION

Primarily, the paper presents results of the parasitoid complex establishment on introduced monophagous indigo bush weevil *Acanthoscelides pallidipennis* Motschulsky. Coleoptera: Bruchidae: Bruchinae feeding in seed of indigo bush on territory of Republic of Serbia (Mihajlović, 2008a). Special attention was on assessing and monitoring of new formed and detected inter species relations (Mihajlović, 2008b) between autochthons parasite wasps fauna (Hymenoptera: Chalcidoidea) and herbaceous seed weevil beetle. As cosmopolitans, two subgenera species of *Eupelmus* (Tuda et al. 2001) and *Anastatus* (Chalcidoidea: Eupelmidae) were found commonly feeding on weevil larvae and pupa with ectoparasitoid status. The evidence of hyperparasitism existence as a phenomenon was established by specimens eclosion of Proctoptrupoidea: Diapriidae and species of genera *Torymus* (Chalcidoidea: Torymidae) and *Tetrastichus* (Chalcidodea: Eulophidae). One specimen from family Scelionidae (Hymenoptera: Proctoptrupoidea) appeared from pods sample, with status of fresh beetle egg parasite. Material was stored and exposed to outside weather conditions, and available to infestation. After seed predation, the most frequently insects found feeding on stem bark were scales. At least two species of scales were recognized as *A. fruticosa* common pests during this period. Mulberry scale – *Pseudaulacaspis pentagona* Targ. Homoptera: Diaspididae and False plum scale *Parthenolecanium corni* Bouche. Hemiptera: Coccidae field generations were also monitored in different development stages. In second half of june during two seasons, adults of Chalcid wasps from families Aphelinidae, Eurytomidae, and Mymaridae (Hymenoptera: Chalcidoidea) and Braconidae (Hymenoptera: Ichneumoidea) appeared, living emergence holes after, on scale female mature shields. Emergence holes were photographed in laboratory, the parts of stem for *P.corni*, and root for *P. pentagona* were taken by the axe or saw. Leaves and branches material collecting in a goal of detecting damage caused by *Metcalpha pruinosa* Say (Hemiptera: Flatidae) on Indigo bush resulted with apterous specimens appearance-family Dryinidae (Hymenoptera: Chrysidoidea).he attacked trees were present in all localities. Hymenopterous specimens also appeared from stem and branches material kept in cylinder collectors set up for bark-beetles, or wood boring and xylophagous insects collecting. Adults of wasps emerged from dry and rot wood during 18 months from seting up in collectors. Specimens needs to be determinated and connect with potential host (bark beetles, wood boring or long horn beetles. Innitial hypoteses that genera *Oedaule* (Chalc.:Pteromalidae) is zoophagous (Gagić & Mihajlović, 2009) and weevil larvae parasitoid, was rejected and after studious laboratory work it was confirmed as endophagous herbivores feeding in seed-pods also as herbaceous insect (Tuda & Morimoto, 2004) and also the most common one. Established host plant-seed predator linkage (**Diagram 1)** was observed in correlation with different environment parameters, especially water level fluctuations in bank corridor formation stands and riparian cultures.

CONCLUSIONS

Main results paper gives is the native parasitoid complex diversity showed according their adults cached after emergence from laboratory cultures of bruchid beetle feeding in pods of indigo bush (**Table 2**). The hypothesis of interspecies relations and the status of parasitoids were set, citing the biology of the described species of determinate genera, how parasitic wasps were following appearances of endophagous weevil, and existening hyperparasitism possibility (Gagić et al. 2008). A specimen needs to be determinate, with zoogeographical indicators, within comparing to other species from the regions, using keys for confirmation. Under the framework of six years research studies of aggressive invasive host plant *Amorpha fruticosa* L. and its entomofauna (**Table 1and Table 3**), significant number of hymenopterous insect species had been recorded, related to indigo bush insect-pests. During research dated in period 2006-2011, data analyses were done from statistically significant samples from about 30 locations around the country (3 experimental host plants by site).

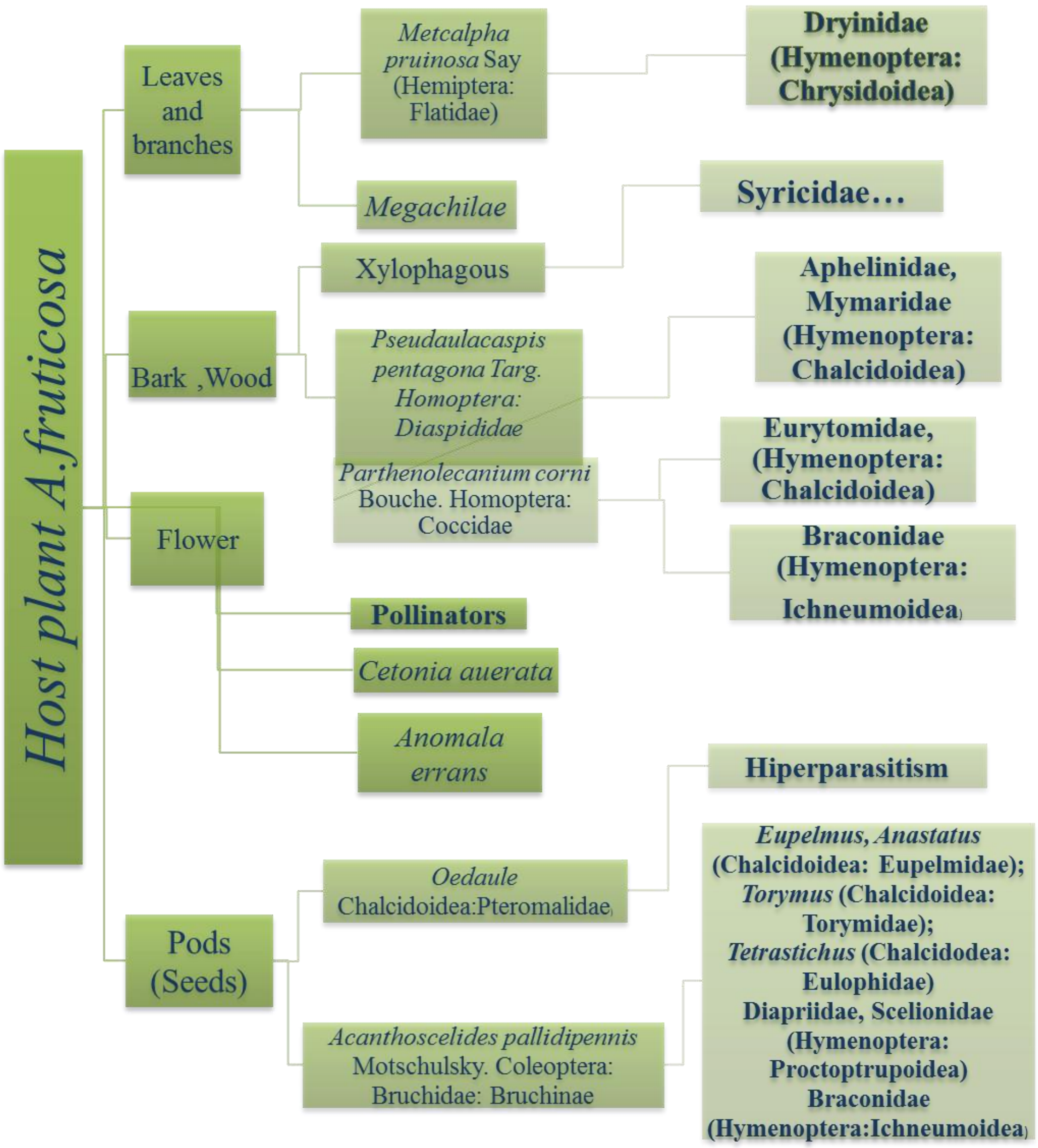

Diagram 1 Indigo bush as host plant - and its pests with trophic chains (plant organs, localized entomofauna and its parasitoid complex)

Table 1 *Research Sampling Periods, Localities, Plant communities, Water Regimes, Infested seed (in %) and Presents of Parasitoids*

No	Locality	2006/07	2007/08	2008/09	2009/10	2010/11	2011	Flooded Area	Infested pods in %	Emerged parasitoids
1	Ada Ciganlija, Taložnik,Oak-Elm-Ash forest		Oct.07	Oct. 08	Dec.09	Mar.10	Mar.11		34	
			25.Mar.08							*Eupelmus* sp 3♀+3♂
			10.Apr.08							*Tetrastichus* sp. Two specimens
				5.May.09						*Oedaule* sp 7♂+4♀
2	Kovilj, Swamp			Dec.08	Dec.09	Jun.10	May.11	✓	22	*Eupelmus* sp

No	Locality	2006/07	2007/08	2008/09	2009/10	2010/11	2011	Flooded Area	Infested pods in %	Emerged parasitoids
	Bank, Willow-Poplar forest									
			10.Nov.07							*Eupelmus* sp 1♂
				2.May.09						*Oedaule* sp 1♂
				5.May.09						*Oedaule* sp 2♀
3	Obedska bara A (Matijevica-Kadionica) Kupinovo, Pedunkulate Oak Young Forest (20 years old)		Nov.07		Nov.09				26	
				10.Apr.09						*Oedaule* sp 2♀
4	Obedska bara B (Obreške širine) Kupinovo Mixture Pedunkulate Oak-Ash Forest (50 years old)		Feb.08	Feb.09			Apr.11		25	*Anastatus* sp
				24.Apr.09						*Oedaule* sp 3♂+2♀
				2.May.09						*Tetrastichus* sp
5	Obedska bara C (Kupinske grede 39, 40) Kupinovo, Pedunkulate Mature Virgin Oak Forest (100 years old)		Dec.07	Dec.08		May10		✓	16	
				2.May.09						*Eupelmus* sp 1♀
6	Čortanovacka Forest, Danube Bank, Willow-Poplar forest		Nov.07	Dec.08	Dec.09			✓	17	Scelionidae ♀
			1.Nov.07							*Oedaule* sp 1♂
					01.Dec.09					*Eupelmus* sp 1♂
7	Obrenovac, Road Buffer greenery		Jan.08		Dec.09				44	
			25.Mar.08							*Oedaule* sp 1♂
8	Šabac, River Sava Bank, Willow-Poplar-Ash Forest	Dec.06	Nov.07	Nov.08	Jan.10			✓	10	*Torymus* sp.
			Nov.07							*Eupelmus* sp 1♀
				2.May.09						*Eupelmus* sp 1♀+1♂
				2.May.09						*Oedaule* sp 1♂
9	Bačko Gradište, DTD Channel Bank, Willow forest		Nov.07	Jan.09	Jan.10			✓	2	*Anastatus* sp
				22.Mar.09						*Oedaule* sp 1♂
				1.May.09						*Eupelmus* sp 2♂
				3.May.09						*Oedaule* sp 3♂+1♀

No	Locality	2006/07	2007/08	2008/09	2009/10	2010/11	2011	Flooded Area	Infested pods in %	Emerged parasitoids
10	Ostružnica, Bridge Sava River Bank Greenery		Feb.08	Aug-08					31	
			8.Apr.08							*Eupelmus* sp 1♀+2♂
			10.Apr.08							*Eupelmus* sp 1♀
			10.Apr.08							*Tetrastichus* sp. 1
				3.May.09						*Oedaule* sp 3♂+3♀
				3.May.09						*Eupelmus* sp 1♀
11	Vračev Gaj, Lake Shore Greenery		Nov.07	Dec.08		May10		✓	4	*Tetrastichus* sp.
12	Ašanja, Lošinjci, Coppice Pedunkulate Oak Stand		Nov.07	Nov.08		May10	Apr.11		20	*Tetrastichus* sp.
				20Nov.08						*Oedaule* sp 1♀
13	Makiš, Devastated Pedunkulate Ash Elm Stand	Jan.07	Nov.07		Dec.09				32	
				25.Apr.09						*Eupelmus* sp 1♀+1♂
				3.May.09						*Eupelmus* sp 1♀
14	Bački Monoštor,Siga Pedunkulate Ash Virgin forest		Feb.08	Mar.09	Feb.10			✓	19	*Eupelmus* sp.
				10.Apr.09						*Oedaule* sp 1♂
				25.Apr.09						*Oedaule* sp 2♂
				4.May.09						*Eupelmus* sp 1♀ Dryinidae
15	Carska bara, Perlez, Swamp bank,		Nov.07					✓	28	
			25.Mar.08							*Oedaule* sp 1♀+3♂
16	Borkovac, Lake Shore Greenery		Mar.08	Feb.09	Feb.10	Feb.11		✓✓	2	
17	Ada Ciganlija Lake Shore Greenery.	Nov.06	Nov.07	Nov.08		Mar.10			36	*Tetrastichus* sp.
			15.Mar.08							*Oedaule* sp 4♀+2♂
18	Zasavica I - Mačv. Mitrovica, Swamp Bank Vegetation		Mar.08	Jan.09	Jan.10	Jan Mar-11	Apr.11	✓	20	*Tetrastichus* sp.; Scelionidae, *Anastatus* sp
			10.Apr.08							*Eupelmus* sp 1♀+1♂
			10.Apr.08							*Tetrastichus* sp. 1
			15.Apr.08							*Oedaule* sp 1♀+1♂
			25.Apr.08							*Oedaule* sp 3♀+2♂
			28.Apr.08							*Oedaule* sp 1♂
			28.Apr.08							*Eupelmus* sp 5♀+3♂

No	Locality	2006/07	2007/08	2008/09	2009/10	2010/11	2011	Flooded Area	Infested pods in %	Emerged parasitoids
			9.May.08							*Oedaule* sp 2♂
19	Ada Ciganlija, Willow-Poplar Bank Forests, Sava River		Nov.07	Nov.08		Mar.10			24	*Eupelmus* sp
			21.Mar.08							*Oedaule* sp 3♀+2♂
			25.Mar.08							*Oedaule* sp 1♀
20	Senajske Bare, Klenak, EA Poplar Culture	Nov.06	Nov.07					✓	11	
			25.Mar.08							*Oedaule* sp 1♀+1♂
21	Šimanovci, Ruderal Vegetation	Feb.07		Nov.08	Nov.09	Nov.10			41	Eupelmus sp
				25.Apr.09						*Oedaule* sp 1♀
				26.Apr.09						*Oedaule* sp 1♂
				30.Apr.09						*Oedaule* sp 1♀+1♂
22	Opovo, Banat; EA Poplar Clone 214 Culture			Dec.08					17	
23	Đerdap Gorge, Dobra, Road Buffer greenary(Black Locust)			Sep.08	Aug-10				15	
24	Grabovačko-Vitojevačko ostrvo,Klenak Pedunkulate Oak Ash Young Culture Stand	Jan.07		Feb.09	Dec.09	May10	May11	✓	4	*Eupelmus* sp
				26.Apr.09						*Oedaule* sp 1♂
				2.May.09						*Tetrastichus* sp
				5.May.09						*Eupelmus* sp 2♀
25	Futog Adica, River Danube Bank- Willow-Poplar forests			Oct.08	Dec.09	Dec.10		✓	15	*Torymus* sp *Anastatus* sp(5.♀)
26	Zoljevo, Jelašnica and Korbevačka rivers, Bank-Willow-Elm Beech, latitude ≈≈1000m		Jul.08	Oct.08	Aug09				16	
27	Vlasina river bank, Vlasotince,Willow		Jul.08	Oct.08	Aug09				21	
28	Predejane, Leskovac, Road Buffer greenary (with Black Locust)		Jul.08	Oct.08	Aug09				25	
				26.Apr.09						*Oedaule* sp 1♂
29	Sremska Rača, Višnjićevo, Mature Pedunkulate Oak-Ash Forest		May.08	Jan.09		Aug.10		✓	18	
30	Barunovac, 0,5					Nov.10	I-XII 11		32	

No	Locality	2006/07	2007/08	2008/09	2009/10	2010/11	2011	Flooded Area	Infested pods in %	Emerged parasitoids
	ha Homogenous Stand of *A.fruticosa*									
31	Topčiderska reka, Ruderal Vegetation					Nov.10			27	
32	Kamenjar, Danube river bank, Oak-Elm-Ash forest					Mar.11			12	Diapriidae, *Anastatus* sp
33	Klenak, Dobreč, *Juglans nigra* Mature (50 years old) Culture Stand					Sep.11			37	

Table 2 *Average infested seed percentage (with causer of infestation detected by dissection in March, during six years of research) for three main different types of sampling surfaces categorized by water fluctuation regimes*

Infested seed \ water regime	Flooded *(%)*	Periodically flooded *(%)*	Dry *(%)*
# bruchid larvae	1,83	13,14	21,12
# bruchid pupa	2,56	2,62	2,62
# bruchid adult	3,11	5,05	5,31
# parasitoid adult	1,17	0,05	0,08
# parasitoid larvae	0,11	0,14	0,04
# emergence holes	1,89	5,38	1,58
# parasitoid pupa	0,11	0,10	0,08
Oedaule sp. all dev. stages	0,61	0,62	0,42

Table 3 *Parasitoid and predator complex of Indigo bush weevil (or of Pteromalid endophagous wesp) as potential biological threatening agents for this introduced legume seed pests*

Insect	*Biology and host preference of A. fruticosa pod pests*
***Eupelmus* and *Anastatus* (Hymenoptera: Chalcidoidea: Eupelmidae)**	**ectoparasitoids of weevil larvae**
***Syntomaspis* sp. and *Torymus* sp. (Hymenoptera: Chalcidoidea: Torymidae)**	**possibility of seed predation and hyperparasitism, both need to be proven**
***Tetrastichus* sp. (Hymenoptera: Chalcidoidea: Eulophidae)**	**known to encompass parasitoids of the first and second order, so it is needed to proceed the research in order to determine their status -hyperparasitism phenomena demands experimental "tricks"**
(Hymenoptera: Proctotrupoidea: Scelionidae),	**Reared one specimen as fresh bruchid beetle egg parasite. Investigation needs to be continue in a goal of getting more specimens, data, status confirmation and species determination**
(Hymenoptera: Proctotrupoidea: Diapriidae),	**Hyperparasitoid of *Eupelmus* and *Torymus* genera, until now one specimen had been reared and prepared**
Acari, Pyemotidae	**Predators of weevil larvae and pupa**
***Pyemotes* spp. (=*Pediculoides*) verticosus, National Academy of Sciences 1978**	

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SECTION VII

FOREST POLICY

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International Scientific Conference
FORESTS IN THE FUTURE – SUSTAINABLE USE, RISKS AND CHALLENGES
4-5 October 2012, Institute of Forestry, Belgrade, Republic of Serbia

ECOLOGICAL AND ECONOMIC EVALUATION OF "URBAN TREES" IN PART OF PARTIZANSKE AVIJACIJE STREET IN BELGRADE – USING CTLA METHOD

Ana A. MALETIĆ[1]

Abstract: *Trees that are growing in urban city areas are one of the most important natural resources of Belgrade.*

Without investment in tree management, the health and functionality of trees deteriorates.

As more and more people live in urban areas we need to raise awareness about natural capital in urban areas. Urban forests, rivers, and other green areas of cities can be considered as natural capital. Values of urban natural capital are improvement of water quality, air, providing habitat to many species of plants and animals, acceptance and retention of storm water, prevention of erosion, reduction of temperature extremes, etc. a large number of trees in Belgrade has reached its decrepit age. The functionality of these trees is very low, so their significance is reduced more to the psychological function. The cause of this is the old trees and poor investments in their proper maintenance.

The aim of this study was to determine the ecological and economic values of urban trees. Specific method was used as an example of calculating the value of trees growing in alley which is located in Partizanske avijacije street in the city of Belgrade. This was accomplished by the empirical analysis of the collected data and the valuation of urban trees using the CTLA method for calculating the monetary value of trees.

The results of evaluation of the urban street trees and their comparison with the funds that are invested in maintaining existing and planting new trees can provide the basis for a new approach to maintenance, protection and management of urban trees as part of urban natural capital of Belgrade

Value of urban trees, expressed in monetary value, is an additional and very strong argument for the systematic greening of city streets, the preservation of existing trees and improvement of their condition.

Key words: urban trees, evaluation, economic value

INTRODUCTION

Street can be defined as spatial, social or cultural concept. It is one of the most important factors of functioning in any city or town. Streets are defined by the activities at the city level, but also functions of the street itself- infrastructure (transport, energy, water features, and telecommunication functions).

From the aspect of urban ecology city streets help the achievement of harmony in the functioning of all the zones in the city. Street greenery is the base for the environmental protection. Green street is usually related to a tree or avenue.

Trees provide benefits that vary, depending on the location in which they are located. Forests provide natural conditions for plants and animals for those whose it is a living space and its benefits for people that are very important.

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The nature of benefits of trees in urban environments and their classification are explored, explained, classified and documented in the literature. Forestry profession values as an investment, which returns the timber, biomass, etc.. For some people trees are an environment in which they can engege in recreation, walking, hiking, hunting, fishing. For residents in the cities trees that grow in the urban environment enhance productivity, and create a comfortable and invigorating environment. (S.Radovanović, 1994)

Significant efforts have been made to describe and categorize the different uses of trees planted in urban areas. Many researchers have identified a specific set of benefits arising from the "urban trees" such as a favorable impact on the climate, aesthetic experience, energy saving, noise reduction, reduction of wind impact, pollution and social benefits as the primary benefits of urban greenery. (Anastasijević N., 2006)

METHODS

The survey held place in an outskirt district of Belgrade. Belgrade climate is temperate continental, with four seasons. The average annual temperature is 11.90 ° C. Winter is not so severe, with an average of 21 days with temperatures below freezing. January is the coldest month with an average temperature of 0.40 ° C. Spring is short and rainy. Summer is coming quickly. The hottest months are July (21.70 ° C) and August (21.30 ° C). The average of 139 rain days, include 27 days of snow. The most intense rainfall in May and June, and the lowest in February. The average amount of annual rainfall is 667.9 mm. (Sekretarijat za zaštitu životne sredine, 2009.) A particular problem is the increased air pollution. In the vicinity of Belgrade are situated extremely big polluters – Obrenovac and Kolubara power plants and nitrogen fertilizer plant and oil refinery in Pancevo. Because of all this a large metropolitan area is exposed to pollution.

Partizanske Avijacije street, is a major corridor for communication with highway Zagreb-Belgrade-Nis, as well as with other parts of Belgrade. Traffic along this street is heavy, and there are 4 lines of public transport. Street contains residential facilities for individual and collective housing, two shopping malls and industrial center. Nearby sports facilities SRC "11 April" are located.

Street has tree alleys formed on both sides. This work has considered part of the alley on the left and right side of the street, from the beginning of the street (TC "Mercury") to the intersection with the Stojana Aralice street.

Method used in the preparation of this paper is based on the available literature, available plans and legal documents from the company PUC "Zelenilo Beograd", and specific calculation of urban trees value.

The method is a combination of:

a) abstract-theoretical work on the basis of the study of literature
b) a critical analysis of existing documents (situation, dynamics, and other planning and legal documents);
c) The empirical part, through the analysis and evaluation of tree alley at the Partizanske Avijacije Street in Belgrade.

Formulation of the thesis is done with the use of good practices and experiences of developed countries (mainly U.S.), which can be applied to the Serbia, and especially the city of Belgrade. These are the achievements of some countries which are reflected in the various methods for valuation of urban trees, especially in the application and implementation of the evaluation results.

Information obtained from interviews with the PUC “Zelenilo Beograd " employees in charge of maintenance of existing trees and the planning of new alley in Belgrade, are also used in this paper, and will correspondent with the main topic of the work.

VALUATION OF URBAN TREES IN PARTIZANSKE AVIJACIJE STREET

CTLA (Council of Tree & Landscape Appraisers, 2000.) method of calculating the value of trees is used in the process of assessment of the real value of urban trees in New Belgrade.

This method was published in the publication "Guide for plant appraisal"-International society of arboriculture. The method is based on measuring the cross-sectional area of the trunk at a height of 1.3 m, which is multiplied by the monetary value of tree per square inch. The resulting value is the maximum value of the tree, which is then reduced by the quality factors for type, condition and location of the tree (values can range from 0.0 to 1.0 for each of these factors). The value of trees per square inch is defined on the basis of price and superior examples of largest trees of the same species can usually be purchased at local nurseries.

A simplified representation of CTLA formula method (Council of Tree & Landscape Appraisers, 2000.) would be:

(C) = (P) x (B) x (C) x (K) x (L)

Where:
(C)-Estimated tree value ($)
(P)-cross-sectional area (cm^2)
(B)-cost /cm^2
(V) - species class
(K)-tree condition
(L)-value of tree locations

This approach is based on the valuation of plant mass which is the product of assimilation and other physiological processes in the plant life at the particular location. This is a common method of evaluation that results in reliable financial structure in the formation of the ornamental plant price. This estimation method is used in most of the U.S. countries, Germany and throughout Europe. The method is based on biomass, which is defined by the trunk size. It is also based on the condition of the tree, and is therefore more objective, but also more complex. It takes knowledge and experience to estimate the health and overall condition of a tree.

The primary, nursery value of appropriate tree type shall be determined as follows:
The cross-sectional area of the trunk is an indicator that can be easily calculated and the field. Using this value we can determine the price of each centimeter in diameter of the appropriate tree type. Diameter can be calculated by dividing the circumference, measured at breast height (1.30 m) using flexible measuring tape. The cross-sectional area of the trunk is calculated mathematically as the amount of the corresponding circuit volume.

$O=2r\pi$

$(P=r^2 \pi)$

Although the intersection of the tree trunk is never a regular circle, geometric deviation has very little influence on the accuracy of the results. This value should be compared with the value of the cross section value of plant species that are in the same group of plants based on the classification by quality of the plant of the highest quality in the nursery. This aspect ratio of the measured tree, tree from the nursery and multiplication of the price per unit with appropriate monetary value establishes base value of the tree. Base value should then be corrected by financial expression of spices quality, nursery estimates (some plants are rare and difficult to produce), assessment of tree condition (healthy plants have a higher value), and the valuation of the site where the tree is located (visual, decorative and aesthetic qualities of each plant has its own price).

This financial structure can be expressed as the product of multiplication of tree base value (B), species value (V), condition (K) and the location (L), where the plant grows: C=B xVx K x L as described above in the text.

When calculating monetary value of the trees in the alley using this formula several problems can occur. The first is related to coefficient that is used to adjust the base value (B), as well as those which determine the importance of qualitative indicator (V), condition (K) and, in particular, the value of location (L). (Anastasijević-Vratuša, V.,1987) For example, the value of species is estimated by forest practice in classification of trees according to the quality of wood (hardwood or softwood deciduous trees, fast-growing or slow-growing species, resistance to pests and diseases, etc.), the relation between some species is very difficult to express quantitatively. How much is hardwood worth compared to softwood deciduous trees? When we assess the condition of the tree there is a question how much more is the healthy plant worth tan the one which has some kind of disease. Finally, there are questions related to the valuation of a location, because no one can accurately determine the market value of the place where the tree is planted in the exact amount, without relying on the land price in the vicinity, or the price of real estate.

Species class

In the western countries practice gave answers to these questions. It suggests that the best quality trees should get the highest score (1). The value of poor quality trees should be reduced by multiplying with coefficients of 0.8 and 0.6, depending on the category. (Council of Tree and Landscape Appraisers, 2007)

CTLA method proposes a table which is a listing of species class values for many common landscape trees.

Condition class

Condition Class is a factor indicating the health, vigor and life expectancy of a tree. This value can be any percentage from 1% to 100%, but is most commonly expressed as one of five percentage categories (100, 80, 60 to 40, 20, 0). (Council of Tree & Landscape Appraisers, 2000) The rating is based on determinating of defects such as wounds, decay, storm damage, insect or disease damage, and poor form. Very few trees are perfect specimens. The accuracy of the value assigned for tree condition is dependent on the expertise of the appraiser. Damage to the trunk, for example, may significantly reduce a tree's life expectancy, or the damage may be superficial. During these corrections base value cannot be exceeded, and at best will remain unchanged.

Value of tree location

The value of tree location is based on the functional and aesthetic contribution, which the tree makes to the site. This factor can be rated at any percentage from 1% to 100 %. When assessing site factors the functional, aesthetic and spatial dimensions should be to taken into account.

The elements of location class are:

1. Site location-Two identical trees on two different locations may be valued differently. A large, healthy plane tree in a remote location would not rate as highly as the same tree in a center of the city in Kralja Milana street.
2. Functional and aesthetic value(contribution to the site). – evaluation of the tree's role in the city landscape.
3. Plant placement – plant's value may be diminished by a location, if there is conflict with utility lines, or is a safety hazard.

Since the avenue that is the subject of this research is in a residential area on the outskirts of New Belgrade, the value assigned to the location of all trees will be 4, or 80%.

The actual value of the trees in the avenue should be harmonized with the adopted value in the market of the country whose professional associations (Council of Tree and Landscape Appraisers) presented the proposed method for calculation. Average value of treeson the territory of the U.S. is $ 28 per square inch of cross-section area of the trunk at breast height . This value is useful because of the constant changes in the value of the dollar relative to the value of the dinar.

The value of 28 $ / in^2 cross-section at breast height of the tree should be the starting point of the calculation process, and all final monetary values are calculated relative to this initial value.

Calculating the base value of urban trees is done as described below:

1 in^2 = 6,4516 cm^2

6,4516 cm^2 = 28 $ (value of 1 in^2 cross secton at breast hight)

28 /6,4516= 4,34 $

1 cm^2 = 4,34 $ $ (value of 1 cm^2 cross secton at breast hight)

Base value should be multiplied in each case- (for each particular observed tree) with condition class factor. Condition factor can range from 1% to 100%. Species class factor (by which the corrections are made based on categorization by species) in this case for high quality trees would be a factor of 0.95 for the Plane tree, for Hawthorn 0.85 and 0.75 for the Birch, as plane tree can be classified as valuable tree species because of wood quality and it's environmental attributes.

Deformations of the tree trunk which are caused mainly by rough pruning, tumors, rot and partially healed damages are present in a very small percentage. These deformations were noticed in 9 trees. For a number of trees presence of diseases or damage to the bark have been noticed. The cause of these damages is tree pruning, which leads to the deformation of the trunk, and severe environmental conditions as a result of the street traffic, which is primarily related to pollution. (McPherson, 2007.)

The average condition rating of 55 observed trees is 4.15 or 83%. Table below displays the monetary value of each individual tree of observed part of the alley of the left and right sides of Partizanske avijacije street, from "Merkur" shopping center to the intersection of Partizanske avijacije and Stojan Aralice streets.

The total value of these trees at the time of observation according to the results of this research is: $ 109,054.40**.**

In the proces of collecting data in the field, for easier reference and calculation special table was used for each tree. (Watson, G., 2002.)

Every tree was marked by number, species and it's location. Then the circumference at breast height was measured for each tree. Mathematical calculation then leads to tree diameter, and by further calculation the fundamental (base) value of the trees was established (Table 1.). Condition factor was determened by scoring individual tree elements . In the end, the value of each tree is calculated using a formula described earlyer in the text.

Table 1. *Single tree monetary values in the observed part of an alley.*

No.	Species	Circumference	Trunk diameter	Cross-section area (cm2)	Base value	Species factor	Condition factor	Location factor	Monetary value
1	*Crategus monogyna*	85	14	575	2497	0.8	0.8	0.8	$1,278.23
2	*Crategus monogyna*	77	12	472	2049	0.8	0.8	0.8	$1,048.94
3	*Platanus x acerifolia*	180	29	2580	11196	0.95	1	0.8	$8,508.61
4	*Crategus monogyna*	69	11	379	1645	0.8	1	0.8	$1,052.88
5	*Crategus monogyna*	67	11	357	1551	0.8	1	0.8	$992.73
7	*Crategus monogyna*	57	9	259	1123	0.8	0.6	0.8	$431.10
8	*Crategus monogyna*	60	10	287	1244	0.8	0.8	0.8	$636.90
9	*Crategus monogyna*	82	13	535	2323	0.8	0.6	0.8	$892.19
10	*Crategus monogyna*	86	14	589	2556	0.8	0.6	0.8	$981.36
11	*Platanus x acerifolia*	193	31	2966	12871	0.95	1	0.8	$9,782.01
12	*Crategus monogyna*	71	11	401	1742	0.8	0.8	0.8	$891.84
13	*Crategus monogyna*	62	10	306	1328	0.8	0.8	0.8	$680.07
14	*Crategus monogyna*	68	11	368	1598	0.8	1	0.8	$1,022.58
15	*Crategus monogyna*	77	12	472	2049	0.8	1	0.8	$1,311.18
16	*Crategus monogyna*	31	5	77	332	0.8	1	0.8	$212.52
17	*Crategus monogyna*	47	7	176	763	0.8	0.8	0.8	$390.81
18	*Crategus monogyna*	74	12	436	1892	0.8	0.6	0.8	$726.60
19	*Crategus monogyna*	62	10	306	1328	0.8	1	0.8	$850.09
20	*Crategus monogyna*	49	8	191	830	0.8	0.8	0.8	$424.78
21	*Crategus monogyna*	50	8	199	864	0.8	1	0.8	$552.87
22	*Platanus x acerifolia*	161	26	2064	8957	0.95	1	0.8	$6,807.15
23	*Platanus x acerifolia*	139	22	1538	6676	0.95	0.8	0.8	$4,059.13
24	*Crategus monogyna*	55	9	241	1045	0.8	0.8	0.8	$535.17
25	*Crategus monogyna*	63	10	316	1371	0.8	1	0.8	$877.73
26	*Crategus monogyna*	70	11	390	1693	0.8	0.8	0.8	$866.89
27	*Platanus x acerifolia*	178	28	2523	10948	0.95	0.8	0.8	$6,656.47
28	*Platanus x acerifolia*	156	25	1938	8409	0.95	0.8	0.8	$5,112.73
29	*Platanus x acerifolia*	163	26	2115	9181	0.95	1	0.8	$6,977.32

No.	Species	Circumference	Trunk diameter	Cross-section area (cm2)	Base value	Species factor	Condition factor	Location factor	Monetary value
30	*Platanus x acerifolia*	151	24	1815	7879	0.95	1	0.8	$5,987.80
31	*Platanus x acerifolia*	122	19	1185	5143	0.95	0.4	0.8	$1,563.48
32	*Platanus x acerifolia*	121	19	1166	5059	0.95	0.8	0.8	$3,075.92
33	*Platanus x acerifolia*	160	25	2038	8846	0.95	1	0.8	$6,722.85
34	*Platanus x acerifolia*	134	21	1430	6205	0.95	0.8	0.8	$3,772.36
35	*Platanus x acerifolia*	111	18	981	4257	0.95	0.8	0.8	$2,588.51
36	*Platanus x acerifolia*	117	19	1090	4730	0.95	1	0.8	$3,594.89
37	*Platanus x acerifolia*	97	15	749	3251	0.95	1	0.8	$2,470.91
38	*Platanus x acerifolia*	142	23	1605	6967	0.95	0.2	0.8	$1,059.06
39	*Platanus x acerifolia*	99	16	780	3387	0.95	0.6	0.8	$1,544.31
40	*Crategus monogyna*	69	11	379	1645	0.8	0.8	0.8	$842.30
41	*Crategus monogyna*	52	8	215	934	0.8	0.8	0.8	$478.38
42	*Crategus monogyna*	61	10	296	1286	0.8	0.6	0.8	$493.73
43	*Crategus monogyna*	54	9	232	1008	0.8	0.8	0.8	$515.89
44	*Crategus monogyna*	58	9	268	1162	0.8	0.6	0.8	$446.36
45	*Crategus monogyna*	56	9	250	1084	0.8	1	0.8	$693.52
46	*Crategus monogyna*	66	11	347	1505	0.8	1	0.8	$963.31
47	*Crategus monogyna*	63	10	316	1371	0.8	1	0.8	$877.73
48	*Crategus monogyna*	52	8	215	934	0.8	1	0.8	$597.98
49	*Crategus monogyna*	54	9	232	1008	0.8	0.8	0.8	$515.89
50	*Crategus monogyna*	56	9	250	1084	0.8	1	0.8	$693.52
51	*Crategus monogyna*	68	11	368	1598	0.8	0.8	0.8	$818.07
52	*Betula alba*	80	13	510	2211	0.75	0.8	0.8	$1,061.50
53	*Betula alba*	76	12	460	1996	0.75	0.8	0.8	$958.01
54	*Betula alba*	81	13	522	2267	0.75	1	0.8	$1,360.26
55	*Betula alba*	62	10	306	1328	0.75	1	0.8	$796.96

SUMMARY

Streets as the most dynamic areas in the city. They carry heavy traffic, communal and urban activities, electric and water supply, sewerage systems and telecommunication networks. There are a number of factors that need to be considered in case of determination of urban tree values.

The value of trees that were an object of this research, according to the results is: $ 109,054.40.

The monetary value of trees rises with their good condition, which is resulted by proper, professional and forehand maintenance. Value of the trees in crowded and polluted urban areas is higher than in a small settlement. Value of trees decreases if there is any kind of conflicts with urban infrastructure.

Some tree spices are more valuable than others, so this should be considered when planning of tree alleys.

This evaluation could be used as a very strong argument to justify the amount of funds needed for planning, planting, and for the proper care of urban trees.

There is an obvious disproportion between the monetary value of trees and their current status as well as the way they are treated and maintained. These trees are still undervalued. This conclusion is supported by a large number of certifies in practice. The removal of mature trees is often easily allowed to make room for a variety of installation, expansion or providing access to urban infrastructure. During construction, road reconstruction, pipeline placement, water and sewage installation protection of trees is not provided, so they often suffer severe damage from which they cannot recover.

Evaluation of trees and determination of the exact monetary value of damage can be used increase awareness of the need for preservation of urban trees both with citizens and the authorities.

Urban street trees are very important resource of a community and an important part of the urban landscape. Lately, many other values, such as environmental and economic benefits have been recognized.

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ENTRANCE FEES AS REVENUE SOURCE FOR NATURE PROTECTION IN THE NATIONAL PARK KOPAONIK

Predrag ŠUMARAC[1], Biljana SAKOVIĆ[2]

Abstract: *Although human civilization and the mankind continue to develop, protected areas as backbone of nature protection are still facing almost the same problems. Managements of protected areas around the globe reports the problem or issue of money deficiency for their proper functioning. This problem is more prominent in the countries whit preserved nature, rich biodiversity and distinguish transition process like Serbia is. Different models of protected areas financing are practiced among the countries but the same line underline all financing models - needs for further diversification of revenue sources in favor of accomplishment of sustainable financing strategies. Diversified funding portfolio is one among other four key principles or building blocks which define and determine sustainability of financing strategy for particular protected area. Protected areas are, as one of last existing wilderness areas, defined as public goods which establish, to the certain limits, responsibility of wider public to participate in their financing. After all resources that protected areas provide are from crucial significances for present and future generation.*

This paper will explore legal and formal prerequisites for establishing the system of entrance fees and valuate in monetary terms the potential of entrance fees as revenue source for future financing of management activities related to nature protection in the National park Kopaonik.

Key words: protected areas, financing, entrance fees

INTRODUCTION

Protected areas present the best possible tool for biodiversity and nature protection. Problem of improper and insufficient financing of protected areas is old almost the same as concept of protected areas itself. Different kinds of financing models are practiced among the countries in the world and mechanism like state funding, public private partnership, resource extraction, tourism, payment for ecosystem service etc. are widely excepted and performed with different level of success. Diversification of revenue source with appropriately formulated sustainable strategy of financing is general solution for above maintained problem.

Because nature protection and biodiversity preservation and conservation which are performed throughout various models of protected areas are not isolated but interconnected and multiply depended part of the human activity system, proper combination of funding sources depend of particular social-political, legislative, institutional, economical and natural condition in which certain protected area exist and function. Accordingly widely excepted, uniform solution do not exist and proper mix of financing mechanisms for particular protected areas, which is based on diversification model and sustainable financing principle, highly depend on

[1] Public enterprise National park Kopaonik
[2] Public enterprise Srbijasume Nature park Golija

management ability to recognize possibilities and together with other institution in charge capture those possibilities as revenue source.

National park Kopaonik is one among five national park is Serbia. It is founded in 1981. With 12 000 ha of territory National park Kopaonik is placed on the same name mountain. National park territory is divided between two municipalities: Raska and Brus with 80:20 percentage rate.

National park Kopaonik is also a place with high tourism activity which have strong seasonal attribute. Most of the tourist visit national park during the winter period. This trend in past 30 years positioned National Park as well recognize winter tourist center. Entrance fees as one of the possible way for capturing part of the revenue made from tourist activities will be examined as potential revenue source for National park Kopaonik.

Materials and methods

This paper will provide information about legislative framework that influence on tendency of National park's Kopaonik management to introduce entrance fees as revenue source in the overall financing strategy. Important part of this paper will be also estimation of entrance fees' total amount based on the frequency of the entrance traffic in the National park Kopaonik and officially adopted decision on charges for usage of National park's Kopaonik protected area.

Applied research as model or template is used for this paper because researchers wishes *...to address specific concerns or to offer solutions to a problem of their employer, a club or organization they are affiliated with...(* Lawrence 2006,page 25).

Since researchers will provide detail picture of related legal framework or prerequisites for establishing the entrance fees as revenue source and explore the monetary potential and contribution of entrance fees to overall financing of the National park Kopaonik this research will be both descriptive and explorative.

The research will be conducted as a case study because *the logic of the case study is to demonstrate a causal argument how general social forces shape and produce results in particular settings* (Walton, 1992:122). Also this type of study provide potential to examine one more cases (in this paper National park Kopaonik) for across multiple period of time.

In order to assess the total annual monetary potential of entrance fees and to point out all cost related with this activity cost benefit analysis is used. *Cost benefit analysis provide applicability and profitability assessment of project proposal or project in its early phase of development* (Cupic, 2009).

Secondary data both internal like management decisions and reports, accounted service reports (and other related documents from Public Enterprise National park Kopaonik) and external like official legislation, governmental decision and regulation are used in this paper.

Result and discussion

In Serbia 6,6 % of total territory is under some level o protection. Five national park in Serbia occupied around 30% of that amount or 159 000 ha. Among them national park Kopaonik is the smallest (occupied territory of around 12 000 ha)one but also one with the highest potential for introducing the entrance fees as revenue source.

Although an entrance fee can be a very important part of the NP Kopaonik revenue system this possibility, due to legislative constrains, is not used. In the past years management of all national parks in Serbia together with the responsible ministry have not succeeded to solve this problem (Sumarac, 2009).

Since 2009 lot of effort from all stakeholders have been done in order to change this undesirable[1] legislative framework. As a result of altogether engagement, starting from nationals park management, Public enterprise Roads of Serbia and Directorate for Serbian road, public

[1] undesirable in the sense of possibilities to introduce entrance fees

servant in the responsible ministry for environment, ministry of the environment and the Serbian government following outcome was accomplished (timely sorted):

1. Request for approval (number 690/09 from 01.07.2009 year) for putting in work entrance gate Josanička Banja (Djorov most) and Brzece sent to general director of Public Enterprise Roads of Serbia
2. Consent of Public enterprise Roads of Serbia to National park Kopaonik about possibilities to introduce entrance fees (from 29.07.2009 year)
3. Government Regulation about precise criteria, tariffs and collection procedure of fees for usage of protected areas ("Official Gazette of RS", No. 43/10)
4. National park's Kopaonik steering committee decision about fees tariffs (No. 1481/2010)
5. Consent of responsible ministries (No. 353-02-2049/2010-03).

Resistance of Public enterprise Roads of Serbia towards initiative of all national parks about putting into operation entrance gates as prerequisite for entrance fees was huge. This kind of attitude of public enterprise Roads of Serbia was grounded in Law on public Roads ("Official Gazette of RS", No. 101/205, 123/07, 101/2011) especially in the following articles:

- article number 7 which define public roads management (which above all include usage of roads, control over collection of road use tax, safety...)
- article number 8 which define public enterprise (in this case Public roads of Serbia) to be fully in charge for public roads management
- article number 15 which define reasonability of public road manager to provide durable, continual and quality maintenance and protection of public roads as well as smooth and safe traffic flow.

Very important public road in Serbia are passing throughout territories of all five national park in Serbia. Granting permission for establishing entrance fees will, by opinion of Public enterprise Roads of Serbia seriously diminish the safety and flow of the traffic on public roads.

Understanding the situation and standing point of Public enterprise Roads of Serbia and also having in mind that throughout territory of national park goes one regional road whit low transit traffic frequency, management of National park Kopaonik changed the strategy towards above mentioned public enterprise for roads. Instead in group management of National park Kopaonik in the process of getting approval performed individually (document number one from the list above) which was very fruitful approach resulting in obtaining necessary consent (document number two from the list above).

Law on Nature Protection ("Official Gazette of RS", No. 36/2009 and 88/2010) article 70 allowed possibilities that management of protected areas charged and collect fees from tourist that visit particular protected areas. Although this article of above mentioned law stipulate not only possibilities to charge entrance fees but also and other kind of fees for usage of protected area national park managers have unsuccessfully strive to establish the entrance fees. In order to underline and to stress its commitment to article 70 of Law on nature protection Serbian government at session held on 17th June 2010 proclaim regulation (form of bylaw) about precise criteria, tariffs and collection procedure of fees for usage of protected areas. This was clear message not only for national park managers but also and for other stakeholder that Serbian government fully support nature protecting principle and needs for further diversification of protected areas funding portfolio.

After couple mounts and several meeting of protected areas management with representatives of Ministries for nature protection, mining and spatial planning all five national parks mutually harmonized its tariffs for fees for usage of protected areas with article 4 of governmental regulation[1]. Steering committee of the National park Kopaonik with its decision

[1] About precise criteria, tariffs and collection procedure of fees for usage of protected areas ("Official Gazette of RS", No. 43/10)

from the session held on fully supported this fees tariff agreement. Article 4 define rates between highest and lowest payment amount in relation to same payment base or payment unit. In accordance to article 6 of the same bylaw entrance fees will be calculated by the vehicle and collected only if the entrance gate is properly arranged and organized.

Based on this article 6 management of the National park Kopaonik formulated proper project proposal, applied and from responsible ministry received fund for renovation of two from possible four entrance gates[1].

It is important to stress fact that National park Kopaonik despite all above mentioned efforts, consent and invested money still haven't established entrance fees system. It is planned that entrance gates and entrance fees collection system starts at the end of this year when skiing session starts.

National park Kopaonik during the first four mounts in 2012 conducted the research of traffic frequency at the potential entrance gates. Methodology of determining the frequency of traffic was very simple and it was based on simple vehicles counting. Result of that research are presented in table 1. below.

Table 1. *Total entrance traffic frequency for January, February, Mart and April*

CAR	BUS	TRUCK
46 871	1 925	1 609

Potential financial effect from introducing entrance fees will be:

1. For cars – 59.828[2] €
2. For buses – 8.190[3] €
3. For trucks – 6.846 €

Total sum for entrance fees collection will be 74.864 €. This calculation must me revised because the evidence of traffic frequency haven't take into consideration places of vehicles registration (local population and visitors from other parts of Serbia). In the National park's Kopaonik steering committee decision about fees in the article number 8 it is stated that local population can be totally excused from entrance fee payment or amount for entrance fees can be decreased. If we adopt assumption that one third of all traffic in observed period represents traffic from the local communities (Raska and Brus municipality) then total amount of excepted fees collection will reached the sum of 49.860 €.

The use of cost-benefit analysis as a method of estimating the efficiency of investment is very widespread in developing countries. Its application in addition to the financial effects of the investment project, include both economic and social effects (Penev,1994).

Cost benefit analyses is used as tool before any investment in question is made. It is very helpful as method for estimating economic impact of certain project or policy measure. In this work this analysis will be used to present estimation of economic impact of introducing entrance fees system in the National park Kopaonik (cost side and expected revenue side) as well as influence to nature protection principle and social effects.

[1] Entrance gate Josanicka Banja and entrance gate Brzece

[2] Base for calculation - National park's Kopaonik Steering committee decision about fees tariffs (entrance fee are following: car - 1,3 €; buses and trucks - 4.25 €;

[3] Base for calculation is average exchange rate between euro and dinars on the 01.08.2012 by National bank of Serbia: (1 €=117,5139 RSD)

Table 2. *Ex post Cost benefit analysis*

Cost	Benefits
Reconstruction of entrance gates - 23.675[1] €	Entrance fees revenue - 68.490 €
Maintenance cost (hitting and electric power) - 1.136 €	
Cost of employees (annually) - 5.956 €	
Cost of video control system - 8.000 €	
Total calculated cost **38.767 €**	Total calculated benefits **68.490** €

Several assumption are adopted as prerequisite for above cost - benefit analysis, Table 2.:

- total number of new employed staff for entrance gates is 14 with
- total monthly salary per person will is 50.000 RSD (about 425 €)
- number of visitors in the December will be equal to the 1/2 February visit (around 6.000 cars entries, 280 bus entries and 240 trucks entries)[2]
- monthly average numbers of visits for May to November will be equal to 1/5 of the April visits (around 600 car entries, 40 bus entries and truck 30 entries)

One of the basic financial rules states:"Without previous discounting it is possible to compare only cash flows that are incurred in the same time"(Cupic,2009).

Cash flows compared here are made in close time period. Time distance is one year. Based on the calculation in table above it is more than clear that entrance fees have more than good potential to become respectable revenue source. Payback period of investment is less than a year.

This revenue could considerably change the relations among present revenue sources and provide much needed financial means for investment for strengthening biodiversity related efforts (Sumarac, 2009). If we have in mind fact that total revue or total budget of National park Kopaonik in one year is approximately about 1 million euro than statement above gets it full importance. Revenue source from entrance fees will present about 10 % of total annual budget of national park.

The entrance fees system in addition to aforementioned revenue source will have and other benefits:

- Strengthening activities to protect biodiversity and national park territory with the system of integrated control
- Enhancement the PR activities
- Improvement of first contact with the visitors
- Introducing the more diversified tourist services and nature friendly activities

CONCLUSION

Managers of the National park Kopaonik in the last three year period have invested lot of time, efforts and financing in order to fulfill all of the needed requirements for the establishment of the entrance fees system.

Applying the proper strategy in approaching to relevant institution (individual approach rather than group) managers of national park have obtained all necessary constant and governmental regulation. Together with all internal documents (mutually harmonized tariffs with other national park and Steering committee decision) national park managers have succeeded to create entrance fees favorable legislative framework.

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[1] Base for calculation are Report of National park Kopaonik about fulfillment the obligation by the contract No.401-00269/2011(singed between Ministry for nature protection, spatial planning and mining and National park Kopaonik) and average exchange rate between euro (€) and dinar (RSD) for the period 01.09. - 15.12.2011 by the National bank of Serbia

[2] Based on the Report about traffic frequency at two entrance gates from January - April 2011 period

Entrance fees can be very important part of National park Kopaonik funding strategy. Calculation done for ex post cost benefit analysis presented the real money figure that can be expected to collect from entrance fees system. Almost 10% (or 70.000 €) of average annual budget of National park Kopaonik is respectable amount of new funding from entrance fees.

At the end of this year national park Kopaonik will introduced the entrance fee payment for visitor and with that fact will become first national park in Serbia that have performed this kind of activity as revenue source.

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THE POLICY OF FINANCING PUBLIC SERVICES IN FORESTRY

Viera PETRÁŠOVÁ[1]

Abstract: *The current period of economic crisis in Europe provokes problems of funding of ecosystem (public) services in forestry. National support in forestry of SR almost does not exist any longer. The Support from EU Structural Funds does not cover the costs associated with the protection of nature within the regulation adopted by NATURA 2000. This paper consists of the analysis of current situation in EU support ecosystem services for society and the proposal for the support options at national level of policies at different levels of land management. It concerns the policy of the nature conservation in a specific fund, agriculture and regional policy.*

Key words: public ecosystem service, forestry, support in forestry

INTRODUCTION

The current period is influenced by the complex macro-economic situation in the EU due to the global economic crisis. It is important to prepare the discussion about the new support policy in the EU. Requirements for quality of the environment are growing, even though the owners of certain natural resources are expected in particular, income from property (rent). Therefore, the owners of the support of the EU expect compensation for their property through the use of ecosystem services of the entire society. In case of forests (Papánek, 1983, Petrášová, 2012), they carry out their basic functions as the part of the ecosystem (biodiversity, production of wood and other products influenced by the climate of the country ...) which can be classified on the basis of existing knowledge into following three groups:

- landscape function (having the influence on the climate of the country, flood mitigation, water purification and air ...)
- production function (timber, water, forest products ...)
- social functions (aesthetic and spiritual values, recreational values, jobs ...).

The performance of these functions is derived from ecosystem services that are currently the most discussed. These services are accessible to the target group but these are benefits to landowners. Therefore the question whether the landowner or the society should pay for following services:

- to restore and maintain the provision of such services,
- to protect the environment and natural resource management.

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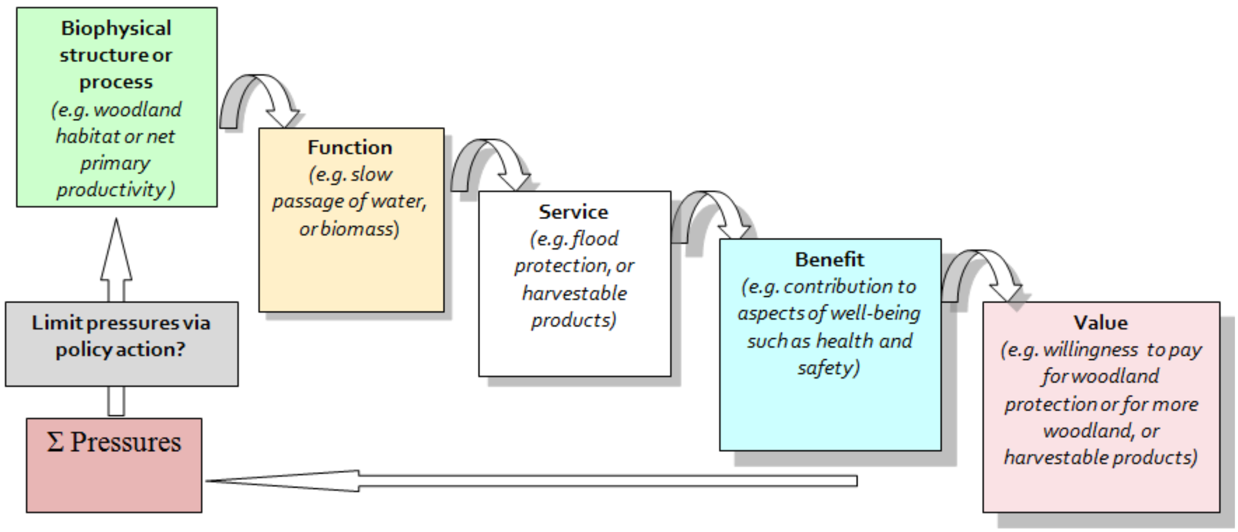
Fig. 1 describes the system of ecosystem functions, services as well as describes the economic value of ecosystems. This division is currently the most frequent. Ecosystem services are reflected in socio-economic benefits. These benefits may be public or private.

Their value is divided into the following groups:

- the primary value (products and services), externalities, rent,
- Macro-economic values (tourism, water management, air protection ...)
- Non-value private &collective benefits

Ecosystems services shall be managed in order to create a synergic effect for the society as well as the landowner.



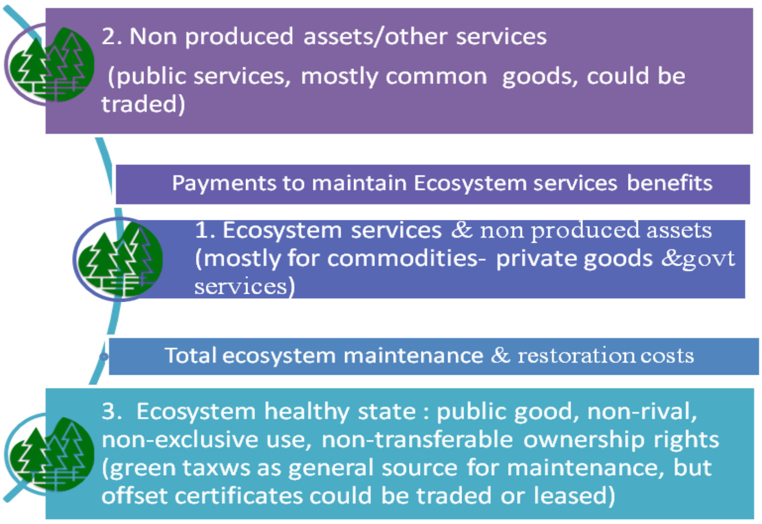
Source: Haines-Young and Potschin, 2010; modified de Groot et al. 2009

Figure 1: *Defining ecosystem functions, services and benefits, and the context for common international classification of ecosystem goods and services (CICES)*

Ecosystem services can be the part of a trade market and they are valued and received payments for services (e.g. recreation - fees for parking, entrance to the forest ... payments for air pollution and water abstraction ...). Valued ecosystem services (eco-filling services) maintain supportive conditions for payment of ecosystems through restoration and protection of ecosystems (ecosystem potential). Non rated public services are associated mainly with the implementation of public interest services. In this case, the use of valuation of marketable benefits or valuation rights should be used in portable ecosystem services. Relations and the payment between these 3 types of ecosystem services are shown in Fig. 2.

Implementation of ecosystem services in Slovakia is provided for in the specific legislative protection. Forests are divided into three categories. Each category reflects a relationship between the performance of functions and services of forest ecosystems. These are economic forests, protective and of specific purpose. Forest management must be the subject of certain category and it is ensured regardless of the ownership.

The whole system of nature protection and conservation of biodiversity is currently being considered by the NATURA 2000. Environmental policy instruments for the assessment of environmental services will be derived from the NATURA 2000. The article contains a description of the current situation in the financing of environmental services within the NATURA 2000.

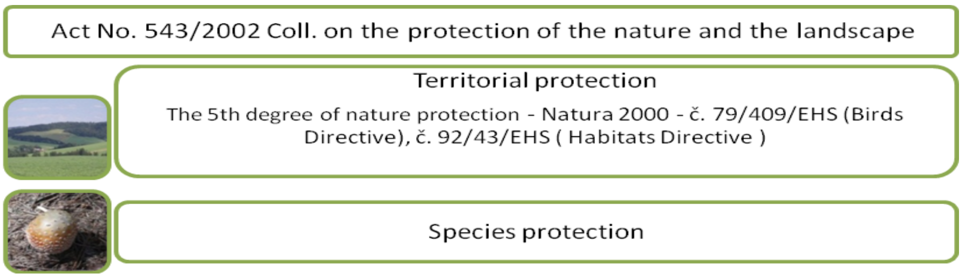


Source: Weber, J.-L. (2009) Land Cover Classification for Land Cover Accounting. Paper presented to 14th Meeting of the London Group on Environmental Accounting, Canberra, 27 – 30 April 2009, Session 4 – Asset Accounting, Point 11 – Land classification, LG/14/9 and own data

Figure 2: *Assets, services and values: 3 dimension*

CURRENT SITUATION IN THE SUPPORT POLICY FOR THE NATURA 2000

The specific nature protection in Slovakia was carried out from 1955 to 1994. It mainly dealt with specific laws - the Forest Act, the Hunting Act, the Tatra National Park and Protection Act and other farmland regulation. It should be observed that the legislation from 1993 was not harmonized and consolidated any longer. Firstly in 1994, the new law was adopted on the protection of landscape and nature. This was not aligned with specific laws and caused confusing interpretation of environmental legislation. Secondly in 2002, there was adopted a new law that had to be revised following the accession to the EU because it ignored the requirements of the Slovak Republic regarding the adoption of an European network of protected areas NATURA 2000. FIG 3 describes the current situation in the legislation of nature and landscape protection in the Slovak Republic (Petrášová et al., 2011).



Source: Own data

Figure 3: *The current legal situation in landscape and nature protection in Slovakia*

NATURA 2000 is a coherent European network of protected areas and the EU Member States are building it under the Birds Directive and Habitats Directive in accordance with the Accession Treaty. It consists of SPAs and Sites of Community Importance, which defined itself on the basis of professional criteria. The inclusion of territory in NATURA 2000 is not yet excludes economic activities or other land use. In order for economic activity in the region of NATURA 2000 sites should be conducted for each individual project authorizations. In it for the planned activities to assess the possible effects of preserving the integrity of NATURA 2000 sites. Human activity in the NATURA 2000 be referred to in Article 6 of the Habitats approve if the assessment shows that will have a significant negative impact on the integrity of the NATURA 2000 network. In most cases, are parts of a project called mitigation measures (e.g. change the time to implement some work activities, treatment technologies for industrial production and construction, etc.). In the event of the conflict of interest as the public. For construction of highways, tourism, mining mineral resources and some others coming up compensation measures.

Measure RDP – ***Rural Development Programme of the SR 2007 – 2013*** **: NATURA 2000 payments– forest land**

Rationale for intervention

The NATURA 2000 areas defined according to Directives 79/409/EEC and 92/43/EEC are declared in compliance with rules of the Act No. 543/2002 Coll. on the protection of the nature and the landscape in Slovakia. The Government of the SR approved, by its resolution No. 636/2003, a national list of 38 locations of Special Protection Areas (SPA) and, by its resolution No. 239/2004, a national list of 382 locations of Sites of Community Importance (SCI). In terms of mentioned SR legislations, the restricted forest activities in the individual areas in compliance with the legislation of the SR and levels of territorial protection are concerned. The support should be provided to the private owners of forests and their associations to overcome disadvantages in the affected areas within the 5th degree of nature protection in which it is prohibited to intervene into forest coppice and to damage vegetal cover, to exploit the woody matter by clear cutting method, to apply the chemical agents and fertilizer.

The support of individual forest management method in territories of NATURA 2000 should contribute to sustainable development with objective to protect environment and landscape, in particular biodiversity and high nature value areas. The measure is designated in compliance with National Forest Programme of the SR.

Objective To help the private owners of forest and their associations in the process of solving the specific disadvantages resulting from implementation of the Directives of NATURA 2000 network (5th degree of nature protection).

Subject of the support The cultivation of forest land in NATURA 2000 territories covered under 5th degree of nature protection according to conditions of support.

Conditions for the support Applicant for the support within NATURA 2000 network for forest land (5th degree of nature protection) must:

- To own at least 1 ha of forest land in NATURA 2000 declared territories.
- To enter the measure with at least 1 hectare of forest land in NATURA 2000 territories.
- To adopt commitments to manage the forest activity for at least 5 years period since the first payment of compensatory allowance, except force major cases[8], in scope of the minimum acreage for the entrance into measure.
- To farm within entire holding in compliance with Good Agricultural and Environment Condition (GAEC) according to Article 5 and Annex IV of the Council Regulation (EC) No. 1782/2003. (This condition relates to subjects, who owned agricultural land as well).
- To farm within entire holding in compliance with the relevant mandatory standards Pursuant to Article 4 and Annex III of the Council Regulation (EC) No. 1782/2003 (SMR).
- The prohibition of interference into forest coppice and damage of vegetal and land cover.

NATURA 2000 and ecosystem services in forest

The defining principles of forest management NATURA 2000 sites are the most often these activities or factors affecting the economy:

- Method of production: clear cut (size), the strip mining, mining group, selection system exploration, exploitation, any territory unprincipled
- Replacement of equipment: planting, vegetative propagation, natural regeneration (with additional measures to influence species composition), transfers and conversion of forests for example stool
- Use of non-native versus native trees, plants use the original songs based on site conditions, origin of the material on forest regeneration
- Plowing or other practices which jeopardize the land, here is mainly in the Záhorie
- The intensity of tending and thinning;
- Hunting and grazing management;

These factors are important for the biodiversity and this is the reason why they should be taken into account in the implementation of NATURA 2000. Area of NATURA 2000 should be funded. Therefore, it is a change of these factors. This change can also be voluntary but the land owners argue that the changes are in the interests of society.

Generally, we can conclude that the management of the site must be negotiated with the owners of these topics:

1. Where the current method of forest management does not in terms of conservation of species or deterioration of habitats and is not contrary to the principles of a Member State for the protection of nature, then this may continue forest management.
2. Where the current methods of forest management to protect the leads nature to degradation of the species or habitat protection for which the site is designated or is contrary to the principles of a Member State for the protection of nature, then it should be involved in Article 6 of the Habitats Directive and must be revised forest management objectives.

The example from the literature can be given the protection of capercailzie (Tetrao urugallus), a species listed in Annex I of the Birds Directive. Where these species occur in "Forest" NATURA 2000 sites, the management must be a forestry measures that are tailored to the aim at maintaining or improving the conditions of the locality for these species. Capercailzie is one of the few species whose population meets the forestry operation, if carefully planned, it may happen on the contrary that the forest does not serve no longer for the economical to use. In most European countries, capercailzies are not yet in the local grouse population decline because of forest management is not sufficiently focused on the requirements of this kind.

Actions for recovery, treatment and exploitation of the forest should be carried out at the time and manner that does not lead to a reduction in production capacity sites, as would be prevented to damage of the remaining vegetation and the soil and should be used by appropriate methods (Petrášová, 2009).

In present, the biodiversity and its maintenance is the important problem. The conservation of biological diversity at forestry sites is recommended to follow these procedures:

- to ensure the protection of individuals, adults, dead and decaying trees which are suitable habitats for woodpeckers, raptors, insects and many lower plants (fungi, ferns, bryophytes, ...);
- to ensure the protection of trees with cavities that can be used for nesting birds and small mammals in burrows;
- to ensure the protection of large trees and their immediate surroundings, where they provide the opportunity for nesting raptors;

- to preserve lakes, springs, streams and other small wetlands such as bogs and fens in the state, which allows them to play a role in propagation of fish, amphibians, insects and so on.,
- to prevent large fluctuations in water levels, damage to natural shores and water pollution;
- to appropriate zoning large areas of forest area in terms of forestry, and tourism / recreation, under different degrees of forest management interventions;
- The Natural "disasters" such as major storms and fires, to take decisions which take into account the possibility of promoting biological diversity through natural succession in areas of potential interest;
- to customize timing of planting and harvesting of interventions so as to avoid their impact on "sensitive" species of animals, especially during periods of breeding, nesting and spring care of young wild birds;
- to maintain the adequate distance so as to avoid disturbance of rare or endangered species, whose presence was confirmed in the field;
- If it does not conflict with applicable laws and regulations, to consider leaving for the planting of a small afforested natural habitats other than forest, such as grasslands, such as limestone, heaths, bogs, meadows, and others.

CONCLUSION

All these measures are criticized by owners of forest land especially because the best may be implemented on large forest holdings and not to small land holdings. For those owners of land, then compensation for restrictions on land management are low. In the Slovak Republic under the Forest Act, it is required for each owner of forest land to finance activities of a professional forest manager. The work of the expert is not valued and the owner of the refinancing. The support for NATURA 2000 occurs only in 5th degree of nature protection but the entire territory is protected. This contradiction between the need to protect landscape and wildlife interests of the landowner and is therefore not a satisfactory solution.

The current period is characterized by various types of economic instruments in environmental policy. Examples of these economic instruments are processed in Table 1.

Table 1. *Type of current payments and type of financial and economic instruments in environmental*

Type of payments	Type of financial instrument	Type of economic instruments
Additional payments stated policy targets needed to restore ecosystem capacity up to	State	corporate and public accounting norms, environmental laws and regulation, international conventions
Payments to maintains Ecosystem services benefits	Public-private	actual protection expenditure embedded into prices, insurance premiums, annuities and interest of loans, green taxes, green subsidies
Payments to get usage of commodities and assets embedding Ecosystem services	Private	purchaser price, lease, fee & royalties

Source: WEBER, J.L.: Beyond GDP, *Ecosystem services as components of progress, wealth and well-being,* Solutions for Sustaining Natural Capital and Ecosystem Services International Conference and Workshop – Salzau Castle and Kiel University June 7th 2010 – June 11th 2010 and own data

The proposed measures in forestry activities are very expensive. For the society, ecosystem services can be considered as a public service. In Slovakia there are two funds Environmental and Recycling fund) to support environmental activities. Ecosystem services will not support them.

About Environmental fund

The Environmental fund was established by the Act on waste in 2004. The mission of the Fund is to promote environmental stewardship. Fund has a defined activity-branches codes CPV 2007: 75111000-7 Executive and legislative services and 90700000-4 Environmental Services.

About Recycling fund

The Recycling fund was established by the Act on waste in 2001 and it became a new element in the system of waste disposal in the Slovak Republic. One of the aims of its establishment was material provision of ecological and economic treatment with designed products and materials after the end of life-span, following the principle “The polluter pays”.

The Recycling and Environmental Fund income resource consists of:

- Donations and contributions of national and foreign legal entities and natural persons,- Incomes from agreed penalties,
- Rates coming from credits supplied by the Recycling and Environmental fund,
- Incomes from the return and withdraw of financial means of the Recycling fund, which were used in an un law way,
- Profits from the property of the Recycling and Environmental fund,
- Rates from the financial means of the Recycling and Environmental fund kept in banks,
- Other resources if stipulated by a special law.

The Funds shall provide services to the state in the areas of waste, air protection resource alternative energy and also in environmental education. Funds do not fulfill the role of environmental services. Funds should play an important role in the field of public environmental not valued services. This is a major challenge for policy makers in forestry and agriculture. Support from the EU and national funds (Environmental and Recycling Fund) may help the development of environmental services. Support measures should be aimed at achieving synergy effect.

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BASIC PROJECTIONS OF THE ACTION PROGRAMME OF SUSTAINABLE DEVELOPMENT OF SERBIAN FORESTS

Predrag ALEKSIĆ[1], Zoran TOMOVIĆ[2], Predrag JOVIĆ[3]

Abstract: *The Action Programme of Sustainable Development of Serbian Forests originated within the reform process of the forestry sector. According to the analysis of the present forest condition and the organization and functioning of forestry sector institutions, necessary measures, activities, processes and financing methods have been defined with the aim of meeting developmental objectives set in the Forest Strategy. Developmental processes are based on the following principles: (1) sustainability of forest and forestry development, (2) multifunctionality (by accepting all the forest functions, not only the economic functions), (3) development of rural areas, (4) participation of stakeholders in the decision-making process, (5) publicity of information about forests and forestry, (6) increase of area covered by forests and their productivity, (7) commitment to accepted international obligations, (8) preservation of the forest health condition, (9) prevention of degradation and assessment of environmental influences, (10) enhanced research, education and staff training.*

Within the Action Programme, support has been defined to be necessary for the development of institutions of public forest management, inspection and public forestry services, as well as for the development and enhancement of forests, as follows: economic functions of forests, raising and tending of new forests, biological reproduction of existing forests, recovery of damaged stands, provision of forest seeds and planting material and preservation of the gene pool in forest trees, construction and maintenance of forest roads, marketing and the use of wood and non-wood forest products, sustainable development of wood industry and forestry planning.

Within the Programme, financial needs are represented, as well as the sources of funding of the projected development of forests and the forestry sector.

Key words: Action Programme, Serbian forests, sustainable development

1. INTRODUCTION

The Forest Directorate of The Ministry of Agriculture, Forestry and Water Management, started (2003) the process of drawing up the National Forest Programme (NFP) of the Republic of Serbia, with the aim of reforming the forestry sector.

The development of the NFP was supported by the Food and Agriculture Organization of the United Nations (within the Technical Cooperation Programme FAO/TCP/JUG/2902 "Institutional Development and Capacity Building for the National Forest Programme of Serbia") and the Government of the Republic of Finland (within the project entitled "The development of the forestry sector in Serbia ").

The main results of the NFP definition are the following documents: "The Forestry Development Strategy of the Republic of Serbia", Law on Forest Reproductive Material, Forest Law, Law on Hunting; Proposal for Restructuring State Forestry Enterprises, Forestry

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[2] Public Enterprise „Vojvodinaforests“ Novi Sad
[3] Ministry of Agriculture, Forestry and Water Management, Belgrade, Forest Directorate.

Administration Reforms; Supporting the Organization of Private Forest Owners and Capacity Building at different levels; National Forest Inventory and Forest Financing Study.

The Forestry Development Strategy, based on a detailed analysis of the problem, provides a framework for the future of the forestry sector in Serbia. In this context, it proclaimed creation of the National Forest Action Programme (NFP), and an action plan for the implementation of the Forestry Development Strategy. Accordingly, in May 2007 the Forest Directorate of the Ministry of Agriculture, Forestry and Water Management started the development of the NFP, whose final version was entitled The Action Programme for Sustainable Development of Forests in Serbia for the period 2011-2020 (but not adopted by the Government of the Republic of Serbia).

2. MATERIAL AND METHOD

The development of The Action Programme for Sustainable Development of Forests in Serbia is based on: Forestry Development Strategy of the Republic of Serbia, National Forest Inventory, Forest Financing Study as well as Substudies of the Programme which involved a large number of professionals who made a significant contribution to the formulation of the Serbian forestry development projections.

The method of work included the following elements: analysis of the current state, problems, needs (of the forests) and interest (of forest owners), definition of objectives and strategic directions, definition of necessary measures, explanation of the planned activities and necessary financial resources.

3. DEVELOPMENT RESULTS AND PROJECTIONS

3.1. Public forest management, inspection and public forest service

The Forestry Development Strategy of the Republic of Serbia defines the strategic goals and the overall framework for the organization of modern public forest management, service and inspection. The concept of public forestry management in Serbia has regulatory, inspection / supervisory, administrative and ownership functions. They are carried out by the Ministry of Agriculture, Forestry and Water Management – Forest Directorate, the Provincial Secretariat of Agriculture, Water Economy and Forestry and regional offices.

The supervision over the implementation of Forest Law, Law on Forest Reproductive Material, Plant Protection Act, and relevant acts is in the jurisdiction of The Forest Inspection.

The work of The Public Forest Service (including the forest warden services), whose aim is to increase the general public interest and which is pursuant to the Law on Forests, are carried out by public forest management enterprises and national parks.

The Forest Council is organized for the purpose of providing supreme technical and advisory support in the process of making the most important decisions in forestry. The Chamber of Forestry Engineers of Serbia is also planned to be established. Its aim would be to improve the conditions and define the criteria for performing expert activities in the field of forestry.

3.2. Economic forest functions

The use of forest timber products is harmonized with the current state of forests and the needs for the implementation of silvicultural measures. The present state of Serbian growing stock reveals an unsatisfactory state of its production potentials, which is reflected in the low values of timber volume (161m3/ha) and average increment (4.0m3/ha); unfavorable structure of origin and silvicultural form (64.7% of coppice forest); unfavorable conservation structure (29%

of the area is covered by thinned and devastated forests), unfavorable age structure (ripening and mature forests make up 42% of the natural high forests), significant lack of natural regeneration; sporadically poor health; unfavorable assortment structure; insufficient density of the forest road network and insufficient use of other resources of forests and forest sites.

The attainment of the overall goal of sustainable use (enhancement of biological stability, renewable use, productivity and socio-cultural effects) is feasible only by achieving specific objectives: increase the forest cover (from 29.1% to 41.4%) increase the current growing stock (161 or m^3/ha to 250 m^3/ha), increase the percentage of high forest area (from the current 35.4% to 55-60%), improve the age structure and the health status, increase the density of forest road network, protect the genetic resources and biodiversity.

The possible scope of forest use, estimated on the basis of the present state, set goals and silvicultural needs, is presented in Table 1.

Table 1: *Possible scope of forest use in the planning period in m³*

State forests			Privately owned forests			Total		
Main increment	Thinning increment	Total	Main increment	Thinning increment	Total	Main increment	Thinning increment	Total
2.187.371	783.193	2.970.564	2.322.256	1.113.721	3.435.977	4.509.627	1.896.914	6.406.541

The optimal use of forest production potentials involves implementation of the following measures for the improvement of the current state of forests: establishment of new forests on an area of 5 000 hectares per year (1/3 on state and 2/3 on private land) with the dynamics of 4 000 ha in the first half-period and 6 000 ha in the second and the ratio between environmental and commercial functions of 96: 4 (4,800 ha : 200 ha), tending newly established plantations on 69 258 ha per year (14 400 ha of new forests, 25 284 ha of direct conversion, 1 000 hectares of rehabilitated stands damaged by biotic and abiotic factors, 1092 ha of degraded high forest reconstruction, 7 892 hectares of burnt forest rehabilitation and 19 590 hectares of high even-aged stand regeneration); tending high even-aged forests (thinning, sapling clearing, thinning stands of middle age and tending intensive plantations) on 55 456 hectares per year, or 31 597 ha in state, and 23 859 ha in private forests; regeneration of uneven-aged (beech and spruce) forests and performance of selection cutting (in of fir-spruce-beech forests) on an area of 17 439 ha per year (12 317 ha in state and 5122 ha in private forests), regeneration of even-aged forests on 6 508 ha per year, or 3 790 ha in state and 2718 ha in private forests; reconstruction of devastated high forests on 273 ha per year (205 ha in state and 68 ha in private forests); indirect conversion of coppice forests on 65 984 ha per year, with natural regeneration carried out on 6 211 ha (2 117 ha in state forests and 4 094 ha in private forests), and tending - thinning on 59 773 ha (17 237 ha in state forests and 42 536 ha in private forests); direct conversion of devastated coppice forests on the area of 6 321 ha per year, or 1 884 ha in state and 4 437 ha in private forests; introducing tending measures into stands with individual trees dying (sanitary cuttings) on an area of 11 250 ha per year (4 477 ha in state and 6773 ha in private forests); rehabilitation of stands severely damaged by abiotic and biotic factors on 250 ha per year, or 150 ha in state, and 100 ha in private forests, rehabilitation of burnt stands on an area of 1 973 ha per year, or 513 ha in state, and 1460 ha in private forests.

The use of non-timber forest products has been insufficient so far. It has also been badly organized. The increased use of non-timber forest products is planned to be achieved by developing an objective approach and evaluating non-timber forest products in forest planning documents as well as in the practical application of these documents, by increasing the revenue that public companies get from non-timber products to the level of 5% of the total revenue and by realization of 90% of the approved quotas for the use of non-timber forest products at the national level.

Conservation of the genetic resources of autochthonous wildlife species and improvement of the economic benefits of hunting and hunting tourism will be carried out by establishing the optimal population size and composition of trophy wildlife and by sustainable wildlife management based on the principles of wise and rational use of space with the appropriate inter-sectoral cooperation and multi-functional approach. The optimal herd of the major game species is estimated to be at the following level of abundance:

European deer 20 000; doe 155 170, wild boar 25 000, rabbit 702 400, pheasant 463 425 and field partridge 392 150.

The provision of forest seed is affected by revision of all seed facilities in the next three years, which will provide 96 seed plantations or 608.55 ha per year. Based on the planned scope of reforestation, direct conversion of coppice forests and artificial regeneration of high forests, the estimated annual demand for forest seed is 0.6 tons of conifer, 5.2 to 8.2 tons of broadleaved and 200 tons of pedunculate oak seed. Planting material should be supplied according to the scope of afforestation to be carried out. The estimated annual volume of planting stock amounts to 45 million seedlings (28 million of conifer and 17 million of broadleaved seedlings) mainly with protected root systems. Furthermore, The Seed Center in Pozega should be equipped and nursery production reorganized and improved in this period.

The Plan for construction and maintenance of forest roads is based on the present unfavourable state of the forest road network density, which ranges from 9.09 m / ha ("Vojvodinaforests") to 11.86 m / ha ("Serbiaforests"), which is significantly behind the optimal state estimated at 30 m / ha. There is a need to increase the density of forest road network to 15m/ha in PE " Serbiaforests " and to 11m/ha in PE " Vojvodinaforests " while private forests need an increase of 1.5 to 2.0 m / ha (in the period from 2011 to2020). About 218.5 km of solid truck roads per year should be built in state and 40 km in private forests. At the same time it is necessary to reconstruct the major roads through the forest management units (to enable the transport of assortments by trucks and trailer trucks). It is necessary to restore 111.5 km of hard and 92 km of soft roads annually in state forests. Private forests should have approximately 18.5 km of soft roads restored every year. The maintenance of forest roads should be adjusted to the actual needs and at least ½ of the existing communication lines should be maintained in a year. About 2.950 km of hard and 3.070 km of soft roads should be maintained in state forests every year. Private forests should have on average of 149.5 km of soft roads maintained annually.

The adoption of the new forest law imposes an obligation to introduce modern forestry planning, which requires fulfillment of certain preconditions: provision of digitalized thematic maps of management units; updating forest registry and forest land in terms of land use changes, establishment of owner-based cadastral database, creation of methodology for evaluation and ranking of forest functions, etc.

In order to support the development of marketing and the use of timber and non-timber forest products, it is necessary to provide the following basic preconditions: to establish a marketing information system, to establish monitoring and transparency of the operations carried out by the institutions within the forestry sector; to certify sustainable management of state forests; to launch the chain of custody certification (CoC) of wood processing enterprises and promote the PEFC model for private forest certification; to increase the current degree of forest product use in Serbia by changing the existing attitudes, prejudices and habits of consumers in terms of using natural materials, and finally to increase exports.

3.3. Ecological and social forest functions

The use of land for reforestation should be directed towards creating a necessary basis for the establishment of new forests in line with the projections of The Action Programme for Sustainable Development of Forests in Serbia (2011-2020). In order to prevent the change of forest purpose, it is necessary to develop and consistently apply the methodology for the evaluation of all functions of forests and forest land, as well as for compensation for the lost forest functions.

Consolidation of forest properties, sustainable management of the forests in private ownership and an increased contribution of private forestry to the development of the forest sector and national economy implies association of owners of small private forest properties.

The impact of forestry activities on forest ecosystems and protection of forests and forest land, as natural resources of common interest, from the negative impacts of other activities requires the creation and application of the regulation for determining the compensation for denied and limited rights to use forests and forest land.

The measures for the conservation of forest biodiversity should be directed towards improving the protection of wildlife and plant habitats in accordance with the Resolution for their protection with prior preparation and implementation of the projects for the establishment of Natura 2000 and EMERALD networks.

The measures for the protection of forests against biotic factors and forest fires will be achieved by controlling and preventing damage caused by biotic and abiotic damaging factors and implementing various actions to: a.) improve the efficiency of the diagnostic-forecasting reporting service, b.) establish a permanent forest health monitoring (ICP) for the level I, based on ICPF international methodology (within the pan-European forest monitoring programme), c.) establish permanent stations for forest health monitoring for Level II (according to the methodology of ICPF), d.) protect forests against encroachment and illegal exploitation.

The preservation and enhancement of forest water functions assumes definition of the policy for the management of water resources in forest ecosystems; harmonization of the policy for the management of forest and water resources through the National Forest Programme and Integrated water management plan at the appropriate levels.

Carbon balance determination and development of guidelines for the mitigation of climate change include the following activities: a.) developing a study to define the conditions and potentials for the implementation of CDM projects in the forestry of Serbia; b.) developing models of anticipated changes in vegetation and forest conditions as a result of potential future climate change. Special significance is attached to promoting the use of wood biomass for energy production, and its possible contribution to reducing greenhouse gas emissions.

In the interests of conservation and sustainable management of forests within protected areas, it is necessary to perform the following tasks: a.) establish criteria (parameters) for the calculation of the compensation to be paid to the owners and users of forests and forest land for denied and limited rights to use forests and forest land, b.) select and protect representative ecosystems of all forest types; c.) select and protect forests that are characterized by high species diversity and abundance of endemic and relict species; d.) select and protect forest areas with landscape diversity.

Sustainable management of forests with social functions involves definition and elaboration of functional requirements, policies and guidelines for achieving the goals set by them. Functional requirements can be biological, biotechnical and technical and they are locally determined, depending on the type of (recreational) use.

3.4. Support to building capacities for the implementation of the forest sector development projections

The field of higher education should provide: a.) consistent harmonization of study programmes and curricula with the Bologna Declaration, b.) change of the current way of higher education funding to meet the needs of the curricula and c.) training the staff in line with the needs and opportunities for their employment

In the field of secondary education, it is necessary: a.) to improve the status of existing specialized secondary school of forestry to the level of schools of national significance, c.) promote the education of forestry technicians, with constant adaptation of study programmes to meet the requirements of modern forestry practices.

Staff training within additional education is also essential in many professional areas to meet the requirements of modern forestry practices.

Education and training of private forest owners should include the training of forest owners for responsible and skilled private forest management, performance of forest operations, setting and running of small and medium-sized forest enterprises, organization of owners and implementation of all other activities in private forests.

In order to improve the quality of education, it is planned to establish a National Training Center on the mountain of Goc. It would be specialized for education and training of forestry workers at all levels from vocational training to education of experts with highest degrees.

4. FINANCING

Having in mind the current state of forest funds and a number of existing problems, as well as the policy of forest management defined by the Forestry Strategy, the establishment of the Forest Fund Budget and Provincial Forest Fund Budget (not institutional) was a pressing need. It seemed impossible to solve the conflict between the ownership and general interests, as well as all other forestry problems without adequate financial support. Different forms of supporting the maintenance and improvement of forests that have existed since the end of World War II (FUS /State Directorate of Forest/ funds, Budget Incentive funds, SIZ /National Employment Service/ funds, the Social Fund, the State Fund) indicate the need for the establishment of a permanent, independent financial source of forest funds.

The help provided by people who are not owners shows that the real owner of forests is man. Law on Forest should ensure participation of all community members in the protection and improvement of forests. The existence of the budget fund for forests and the provincial budget fund is based on the principles of sustainable forest management, various man-oriented forest functions and numerous interests of both forest owners and non-owners.

In accordance with the aforesaid, forest products should be the main financing sources, which means that a forest itself charges for its products (timber, forest fruits, herbs, stones, peat, CO_2 and other numerous functions and values) from different direct and indirect beneficiaries. Forest Law stipulates that the budget funds are used to introduce measures, established by development programmes (Forestry Development Programme of Serbia and the plans for forest region development), and by annual funds utilization plan.

When distributing the total budget funds resources, priority is given to the funds necessary for the preparation of plans and programmes and to finance forest protection measures (against fire, insect outbreak, etc) envisaged by a medium-term plan for fire protection, or a medium-term plan for the protection of forests against plant diseases and pests.

Budget funds are used by local municipal units (part of the resources comes from fees charged for the use of forests and forest land in the amount of 30%) for the establishment of new forests.

The statement of the financial resources necessary for the implementation of the Forestry Development Programme in Serbia (2011-2020) was carried out on the basis of the planned volume of work and the applicable unit prices for the work and all related activities. The total funds required for the implementation of all planned activities and measures for the 10-year planning period, amount to 897 979 euros, or an average of about 90 million per year. If we take into account the planned forest utilization working activities, the total value of the planned work is 1 623 million (Table 2).

Table 2: *Funds necessary for the 10-year planning period in euros*

Measures	State	Non-state	Common	TOTAL
Reforestation	26 644 329	55 432 181		82 076 510
Regeneration of even-aged high forests	51 112 391	73 44 901		58 457 292
Tending of even-aged high forests	25 268 130	1 496 273		26 764 403
Reconstruction of degraded high forests	3 825 383	1 268 908		5 094 291
Indirect conversion of coppice forests	8 017 502	15 504 797		23 522 299
Direct conversion of coppice forests	35 156 205	82 796 221		117 952 426
Rehabilitation of severely damaged stands	2 799 061	1 866 041		4 665 102
Rehabilitation of burnt areas	16 277 698	46 623 393		62 604 091
Construction of forest communication lines	91 550 000	16 175 000		107 725 000
Reconstruction of forest roads	25 137 500	3 237 500		28 375 000
Maintenance of forest roads	23 993 000	463 450		24 456 450
Enhancement of forest auxiliary goods production			4 224 000	4 224 000
Forest certification	450 000	450 000		900 000
Expenses of the public forestry service	161 874 696	31 978 950	13 284 640	207 138 286
Reforming and capacity building of the public forestry service	8 520 000	4 000 000	480 000	13 000 000
Supporting private forest owners			6 318 000	6 318 000
Supporting small and medium-sized enterprises			6 530 000	6 530 000
Development of an integrated information system			600 000	600 000
Preparation of planning documents			794 880	794 880
National Forest Inventory			730 000	730 000
Forest Protection and Monitoring	4 477 800	468 150	10 385 067	15 331 017
Education in Forestry			6 695 000	6 695 000
Research (capacity building)			1 535 000	1 535 000
Research (Project Implementation)			92 490 000	92 490 000
TOTAL	**485 103 695**	**268 808 765**	**144 066 587**	**897 979 047**
%	54.02	29.93	16.04	100.00
Forest utilization	395 781 600	329 575 702		725 357 302
% (of the total)	44.93	55.08		44.68
TOTAL (with utilization)	**880 885 295**	**598 384 466**	**144 066 587**	**1 623 336 348**
% (with the use)	54.26	36.86	8.88	100.00

5. CONCLUSION

The current state of the growing stock in Serbia is unsatisfactory. This state can be improved by: raising the percentage of forest cover, increasing the stock of standing timber volume, increasing the percentage of high forests in the total forested area; improving the forest age structure, health and road network density, protecting biodiversity and genetic resources.

Based on the current state, defined objectives and silvicultural needs, the potential annual scope of forest use is 66.406.541m^3.

By executing the planned actions to improve the state of forests we can achieve a number of positive effects, such as: increasing the total timber volume by 27 million m^3, a significant improvement of forest quality (assortment structure), successful economic management, climate change mitigation (reduction of greenhouse effects, carbon binding and oxygen production), a favorable impact on agriculture, promotion of nature conservation and environment protection, provision of favorable conditions for human health, preservation of biodiversity and genetic resources, integrated and sustainable management of forests, etc.

The current scope of forest utilization measured by timber production amounts to 50% of the scope which will be possible if the planned measures to improve the condition and productivity of forests are implemented.

Implementation of the planned works on the construction and maintenance of forest roads would enable efficient execution of forest works, management cost reduction, effective protection of forests, etc.

By raising awareness about the importance of forests and forest ecosystems we would significantly contribute to the improvement of the private forest management, conservation and protection of forests, improvement of social functions and development of rural areas.

Forests are an irreplaceable natural resource of common interest, whose main function is to protect and improve the environment. Since their multiple environmental functions are vital to the protection of air, water and soil, forests, as the most important component of the environment, cannot be replaced by any technical instrument.

The improvement of the public forest service and education in forestry are fundamental prerequisites for the successful implementation of the measures planned to improve the state of forests and forestry in general.

The total funds required for the implementation of all planned activities and measures for the planning period of 10 years amount to 897 979 euros, or an annual average of about 90 million. Taking into account the planned works on the use of forests, the total value of the planned works is 1, 623 million euros. If we take into account the planned forest utilization activities, the total value of the planned work is 1 623 million

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THE BASIC CHARACTERISTICS OF NTFP$_S$ – BASED ENTERPRISES' BUSINESS IN MACEDONIA AND SERBIA

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Abstract: *The forests in Southeastern Europe (SEE) region are characterized by extremely high species richness. The wealth, in terms of biodiversity, is mirrored in the abundance of non-timber forest products (NTFPs) collected from the forests by local populations. Among the NTFPs in SEE region, mushrooms, medicinal herbs, berries and honey stand out as of particular importance - both in terms of subsistence value and potential for generating cash income at the village level.*

The main objective of the paper is to analyze basic characteristics of NTFPs - based enterprises' business in Serbia and Macedonia. In this paper is presented part of the results from the FOPER II CRRT project "Entrepreneurship, markets and marketing of non-timber forest products in SEE region". The methodology used for this research is quantitative analyses of collected data. Door-to-door survey, with 36 SMEs from Macedonia and 91 from Serbia was conducted. The questionnaire consisted of 51 questions, from which 17 are analyzed and presented in this paper.

The presented results refer to the basic characteristics of analyzed enterprises, theirs business and elements of marketing mix (product, price, promotion and place).

Key words: Non-timber forest products, small and medium enterprises, Macedonia, Serbia

1. INTRODUCTION

The forests in Southeastern Europe (SEE) region are characterized by extremely high species richness. The wealth, in terms of biodiversity, is mirrored in the abundance of non - timber forest products (NTFPs) collected from the forests by local population. Following new trend in forest management towards sustainability, NTFPs are inseparable part that can provide significant sources for income to local population. Taking into account that the significance of NTFPs has been seen lately, there are still discussions on what NTFPs are (Ahenkan, Boon, 2011). Hence, many different definitions have been developed for Non Timber Forest Product (NTFP). On that basis, United Nations Food and Agriculture Organization (FAO), in a document prepared by Chandrasekhar in 1992, proposed the following definition: "*Non-timber forest*

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products included all goods of biological origin, as well as services, derived from forest or any land under similar use, and exclude wood in all its form." This definition was revised in 1995 and again in 1999. Based on a series of internal, regional and global consultations, FAO adopted new definition on NWFPs: "*Non-wood forest products consist of goods of biological origin other than wood, derived from forest, other wooded land and trees outside forests"* (1999).

Among the NTFPs in SEE region, mushrooms, medical and aromatic plants and berries and other fruits stand out as of particular importance - both in terms of subsistence value and potential for generating cash income at the village level. The forestry management in Serbia and Macedonia is still traditionally oriented and it is more focused on timber. The main income sources are from the fuel and technical wood. Even so, the forestry contributes to the national GDP with 0.3 in Macedonia and with 0.2 in Serbia.

Local, regional, national, and international trade of NTFPs can significantly contribute to community and household economies in this region. As a result, marketable NTFPs can provide an important means for economic growth and sustainable forest management in local communities. Much has been studied about timber productivity; however, NTFPs have not been studied up to this point despite their apparent high value and diversity. Aspects of NTFP trade must be examined before NTFPs can be developed as a means of economic growth and forest resource conservation (Collier *et al*., 2004; Essmann *et al*., 2005; Delang, 2006).

The **main goal** of the paper is to analyze basic characteristics of NTFPs-based enterprises' business in Macedonia and Serbia. In order to achieve this goal, the following objectives will be analyzed:

- To identify the problems that influence the NTFP business sector
- To analyze marketing mix tools (price, promotion, place and product)
- To provide recommendations for improvement

Therefore, the main research question is: **Which are the basic characteristics of NTFPs based enterprises and its marketing mix elements in Macedonia and Serbia?**

2. METHODOLOGY AND METHODS

This paper is a mix of descriptive and exploratory research. Descriptive because collected data are used for description of the relevant issues about the current situation of the NTFPs sector. Exploratory because it explores problems which impede or foster NTFPs business sector in both countries (Macedonia and Serbia).

As research technique, door-to-door survey was conducted. Primary data were collected from 36 SMEs from Macedonia and 91 from Serbia were conducted. The survey was part of the FOPER II CRRT project "*Entrepreneurship, markets and marketing of non-timber forest products in SEE region*". The sample size was determined according to the list of registered small and medium enterprises (SMEs) gathered from Governmental institutions in both countries and all SMEs, whose representatives were willing to cooperate, were approached.

The project questionnaire consisted of 51 questions, but for the paper aims 17 questions were further analyzed and presented more comprehensively in this paper. Questionnaire included close, open-ended, multiple answer and Likert scale questions. As well, questions analyzed in this paper, have been divided into 3 groups: general data about enterprises, enterprises business and marketing mix elements.

The collected data were quantitatively analyzed in SPSS and presented in this paper.

3. THEORETICAL FRAMEWORK

According to Kotler (1994), marketing is the process of satisfying customer needs and wants by the exchange methods. In general, marketing is the process of satisfying customer wants and needs while meeting organizational objectives. Marketing refer to the research and business analysis, plan distribution, promote sales, creating marketing plans and strategies to approach the marketplace.

The marketing concept is a management philosophy and management enterprises that meet the needs of consumers and users, to take over and coordinate marketing activities (Bennett, 1997; Baker, Saren, 2010). That means that essence of marketing, the starting point is realized through the market concept. One of the tools of marketing theory is marketing mix model 4Ps (Product, Price, Place and Promotion).

The **marketing mix** principles are used by business as tools to assist them in pursuing their objectives. The marketing mix principles are controllable variables, which have to be carefully managed and must meet the needs of the defined target group.

The 4Ps (product, price, place, promotion) should work together in marketing mix. Often, decisions on one element will influence the choices available in others. Selecting an effective mix for market will take time and effort, but these will pay off as one satisfies customers and create a profitable business.

Product refers to the goods and services offered to customers. Apart from the physical product itself, there are elements associated with your product that customers may be attracted to, such as the way it is packaged. Other product attributes include quality, features, options, services, warranties, and brand name. Product's appearance, function, and support make up what the customer is actually buying. When an organization introduces a product into a market, they must ask themselves a number of questions. They must decide about the product design, package and added value to the product. Organization also should know for whom the product is aimed; what benefit will customers expect; how to position the product within market and advantage of the product over product competitor

Price is one of the most important elements of the marketing mix, as it is the only mix, which generates a turnover for the organization. The remaining 3p's are the variable cost for the organization. The price point of the product or service is the essential element to the marketing mix. On a similar note, the price has to be just right in proportion to the other elements. It should be high, low or in between, depending on the market to which product is pitching and the message sent out by the other elements of the marketing strategy. Therefore, "Price" refers to how much is charged for product or service. Determining product's price can be tricky. Pricing approach should reflect the appropriate positioning of product in the market and result in a price that covers cost per item and includes a profit margin. The result should be neither greedy nor timid. The former will price out of the market; pricing too low will make it impossible to grow.

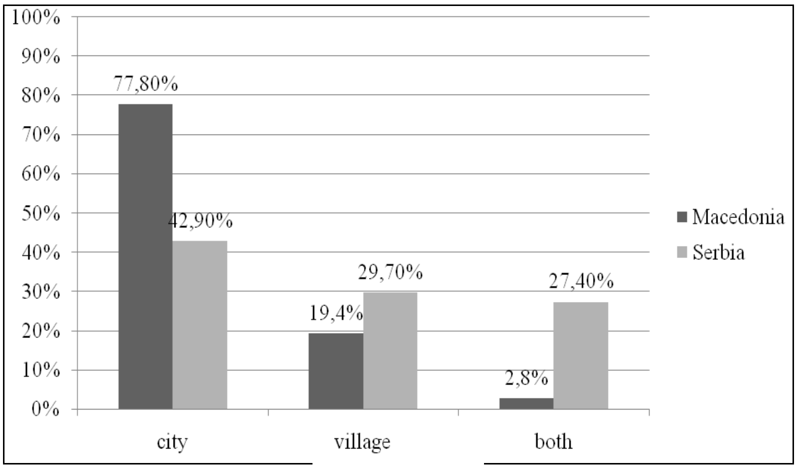
Place refers to how an organization will distribute the product or service they are offering to the end user. The organizations must distribute the product to the user at the right place at the right time. Place (i.e. Distribution) means ensuring that the product is in the right place for the customers to buy it. Businesses that create or assemble a product will have two options: selling directly to consumers or selling to a vendor.

Promotion refers to the advertising and selling part of marketing. It is how someone let people know what they got for sale. The purpose of promotion is to get people to understand what your product is, what they can use it for, and why they should want it. A successful product or service means nothing unless the benefit of such a service can be communicated clearly to the target market. To be effective, promotional efforts should contain a clear message targeted to a specific audience reached via an appropriate channel. Promotion may involve advertising, public relations, personal selling, and sales promotions. Promotion is perhaps the most traditional of the 4Ps.

4. RESULTS AND DISCUSSION

4.1. General data about NTFPs based enterprises

General data about enterprises in Macedonia and Serbia refers to the location and establishing on the enterprises, number of employee and seasonally hired workers, and main activities of the examined SMEs. According to the answers, most of the SMEs in both countries are located in the city. However, it should be noted that almost 1/3 of SMEs in Serbia and less than 5% of them in Macedonia are located both in urban and rural areas (Fig. 1).



Source: original

Figure 1: *Location on the SMEs in Macedonia and Serbia*

Furthermore, most of the SMEs (52.8%) in Macedonia are established after 2000 year, while 47.2% are formed to 2000 year. On the other hand, most of the SMEs (54.9%) in Serbia are established to 2000, while 45.0% from the SMEs are established after 2000 year.

The number of employees in the SMEs in both countries is different, but usually varied from 1 to 10, or 80.6% of SMEs have such a number of employee in Macedonia, while more employees, from 11 to 50 have 16.7% of SMEs. Exception from this in the number of employees is a company that represents outlier in this study because the number of employee in the company is 2500 or 2.8%, which largely differs from the number of employees of other SMEs in the survey. The number of employees in the SMEs in Serbia varied from 11 to 50, or 49.4% of SMEs has so employee. Little bit less employee, from 1 to 10 have 31.8% of SMEs, from 51 to 250 employees have 18.6%. The SMEs has seasonal hired workers, which mean number in the SMEs in Macedonia was 26 workers, while in Serbia was 36 seasonal workers.

In Macedonia, all SMEs dealing with the same activity from the very beginning of their formation and their performance, from the establishment, is associated only with NTFPs, while, in Serbia most of the SMEs (87.9%) deal with NTFPs from the beginning of their formation, remaining 12.0% do not deal with NTFPs since their establishment.

Activities of the analyzed enterprises in both countries were collecting, buying, processing and selling NTFPs. Therefore, the main activities of the SMEs in Macedonia, (100%) are buying and selling, 94% of the SMEs are buying, selling and processing, while 36% of them are collecting, buying and selling NTFPs. Very small part of the SMEs (6%) are dealing with other activities (cultivation of medicinal and spicy plants) at the same time. On the other hand, the main activities on the SMEs in Serbia in the highest percentage were buying (95.6%) and processing (94.5%) of NTFPs, 68.1% are engaged in selling NTFPs and 50.5% occurs as collectors of NTFPs despite the buying, processing and selling.

4.2. Business analysis

Further is presented SMEs equipment that SMEs in Macedonia and Serbia possess at the time when the survey was conducted. All SMEs in Macedonia and almost all in Serbia (94.5%) have weighing machine. Majority of SMEs in both countries have drying machine, 83.3% in Macedonia and 65.9% in Serbia. After that follows van without refrigerator 72.2% in Macedonia and 60.4% in Serbia, while van with refrigerator have 44.4% from SMEs in Macedonia and 42.9% in Serbia.

On the first place, the main problem in business, by the respondents in both countries, was unfair competition with 86.1% in Macedonia and 60.4% in Serbia. After that, with same percentage share (41.7%) followed by insufficient labor and payment in Macedonia and with same percentage share (39.6%) followed by insufficient labor, payment and underdeveloped domestic market in Serbia. Respondents in Macedonia (27.8%) think that underdeveloped domestic market was main problem in business in this sector. The majority of respondents in Macedonia (30.6%) in comparison with respondents in Serbia (22%) think that unskilled labor force was one of the main problems in business in NTFPs sector. In addition, 22.2% in Macedonia said that there was a lack of the training course of collectors, while 14.3% in Serbia think that lack of the training course of collectors was main problem. On the other hand, the highest percentage from respondents in Serbia (27.5%) in comparison with respondents in Macedonia (11.1%) think that not efficient use of facilities was main problems in business in this sector.

4.3. Marketing mix elements

Stability on the market of NTFPs, at the moment, by the respondents in Macedonia was assessed as stable 38.9% of respondents, while little bit less, 26.4% of respondents in Serbia think that market was stable at the moment.

According to the question with which **products** SMEs in Macedonia are dealing, 80.6% from the respondent's answer that they are engaged in the buying of mushrooms, 34.3% are engaged in the buying of aromatic and medicinal plants and 63.9% dealing with the buying of berries and other fruits. On the other hand, the equal percentage 62.6% from the respondents answer that SMEs in Serbia are engaged in the buying of mushrooms and berries and other fruits, while 35.2% are engaged in the buying of aromatic and medicinal herbs (Tab. 1).

Table 1: *Total average quantity of NTFPs*

	Macedonia		**Serbia**	
Products quantities	**Frequency**	**%**	**Frequency**	**%**
Mushrooms	29	80.6	57	62.6
Aromatic and medicinal herbs	12	34.3	32	35.2
Berries and other fruits	23	63.9	57	62.6

Source: original

The most of enterprises in both countries (61.1% in Macedonia and 53.8% in Serbia) said that in the previous period did not have changes to its products. The largest percentages (78.6%) of the change in the products in SMEs in Macedonia is noted in packaging of product, while the change in the product in SMEs in Serbia, is most visible at the assortment of product (36.5%). According to the answer by respondents in Macedonia followed change on the product in assortment with 64.3% and 50% in type of production. On the second place in Serbia was type of production with 34.1% and packaging of product with 29.4%.

The **price** of NTFPs varies widely and depending on the weather, the quantity of representation and collection of NTFPs, and the quality of NTFPs. This phenomenon is mostly noted with mushrooms because they have big differences in prices depending on the time of collection, whether it is a spring collection of mushrooms or autumn collection of mushrooms and certainly also from the quality that mushrooms have been associated with time when gathering mushrooms itself. Therefore, the price of all NTFPs is calculated with weighted average of all prices that have been given in response to the respondents (Tab. 2).

Table 2: *The prices of NTFPs in Macedonia*

Type of NTFPs	**Average buying price per kg in EUR**	**Average selling price per kg in EUR**
Mushrooms	4.02	5.58
Aromatic and medicinal plants	2.44	7.18
Berries and other fruits	1.54	1.95

Source: original

As shown in Table 2, difference between buying and selling price of mushrooms is 39%, aromatic and medicinal plants 194% and berries and other fruits 27%. Respondents from Serbia stated that there is 20% of difference between buying and selling prices of mushrooms and aromatic and medicinal plants and 15% of prices of berries and other fruits.

Change in the price of products in the last period (year) have been noted in 75% of response from SMEs in Macedonia, which answered positively on this question, while the remaining 25% responded negatively to the question, did not have change the price of products. This change in the price of products in the last period (year) is most visible in the answers on respondents from SMEs in Serbia, where 85.7% answered positively, they have changed the price of products, while the remaining 14.3% responded negatively to the question, did not have change the price of products.

Furthermore is an assessment on importance of **promotion** marketing tools in NTFPs sector. The majority of the respondents (86.1% in Macedonia and 75.8% in Serbia) in both countries think that the developed channels of distribution are very important and important as a marketing activity in this sector. On the other hand, 11.1% of respondents in Macedonia and 17.6% in Serbia think that developed distribution channels are unimportant and unimportant at all as a promotion marketing tool. Similar situation is with next marketing tool that was offered to evaluate. 69.5% of respondents in Macedonia and 66% in Serbia think that familiar product/name (brand) is very important and important marketing tool. Moreover, 19.5% in Macedonia and 22% in Serbia think this is unimportant and unimportant at all marketing tool. There are differences between countries, when it comes to advertising as a marketing tool in NTFPs sector. The majority of respondents in Macedonia (55.5%) consider it as very important and important marketing tool and 41.7% as unimportant and unimportant at all. Nevertheless, respondents from Serbia have different opinion, because only 33% consider advertising as very important and important marketing tool and 50.6% as unimportant and unimportant at all.

In Macedonia, 41.2% of respondents consider advertising and PR as most successful promotion marketing tool. In Serbia, this marketing tool is considered as the most successful only by 20.9%. According to the respondents from Macedonia, branding is the second most successful promotion marketing tool (19.6%), while, in Serbia, only 11% of respondents think this is successful marketing tool. Larger percentage of respondents from Macedonia (15.7%) than from Serbia (5.5%) see developed marketing channels as the most successful promotion marketing tool. Almost the same percentage of respondents in both countries (13.7% in Macedonia and 11% in Serbia) stated that direct communication with costumers is the most successful promotion marketing tool. It is noteworthy to mention that the highest percentage of all respondents from Serbia (28.6%) thinks that no promotion marketing tools are successful.

The large percentage of the SMEs in both countries (94.4% in Macedonia and 75.8% in Serbia) has web - site and e - mail address.

In terms of **place**, SMEs in Macedonia distribute most of the buying products to other processors in the country (58.3%) and export it to the international markets (55.6%). The remaining small part was sold in own shops (8.3%) and retail (5.6%). SMEs in Serbia in the highest percentage were exported to the international markets (61.5%) and selling to other processors in the country (58.3%). In addition, the remaining small part they sold in own shops (4.4%) and retail (7.7%).

5. CONCLUSION AND RECOMMENDATIONS

Following conclusion can be drawn from conducted research:

- Most of the SMEs in both countries are located in the city, almost 1/3 of SMEs in Serbia and less than 5% of them in Macedonia are located both in urban and rural areas;
- Most of the SMEs (52.8%) in Macedonia are established after 2000 year, while most of the SMEs (54.9%) in Serbia are established to 2000 year;
- The number of employees in the SMEs in Macedonia varied from 1 to 10, or 80.6%, while the number of employees in the SMEs in Serbia varied from 11 to 50, or 49.4%. Seasonal hired workers in the SMEs in Macedonia was 26 workers, while in Serbia was 36 seasonal workers;
- In Macedonia, all SMEs dealing with the same activity from the very beginning of their formation, while in Serbia most of the SMEs (87.9%) deal with NTFPs from the beginning of their formation;
- Activities of the analyzed SMEs in both countries were collecting, buying, processing and selling NTFPs. Therefore, the main activities of the SMEs in Macedonia, (100%) are buying and selling, 94% of the SMEs are buying, selling and processing, while the main activities on the SMEs in Serbia in the highest percentage were buying (95.6%) and processing (94.5%) of NTFPs;
- All SMEs in Macedonia and almost all in Serbia (94.5%) have weighing machine. Majority of SMEs in both countries have drying machine, 83.3% in Macedonia and 65.9% in Serbia;
- The main problem in business by the respondents in both countries was unfair competition with 86.1% in Macedonia and 60.4% in Serbia. After that, with same percentage share (41.7%) followed by insufficient manpower and payment in Macedonia and with same percentage share (39.6%) followed by insufficient manpower, payment and underdeveloped domestic market in Serbia;
- Stability on the market of NTFPs at the moment in Macedonia was assessed as stable 38.9% of respondents, while 26.4% of respondents in Serbia think that market was stable at the moment;
- 80.6% from SMEs in Macedonia are engaged in the buying of mushrooms, while equal percentage 62.6% from SMEs in Serbia are engaged in the buying of mushrooms and berries and other fruits;
- The largest percentage of SMEs in both countries (61.1% in Macedonia and 53.8% in Serbia) does not change the product in the previous period;
- Difference between buying and selling price of mushrooms is 39% in Macedonia and 20% in Serbia, in price of aromatic and medicinal plants 194% in Macedonia and

20% in Serbia and in price of berries and other fruits is 27% in Macedonia and 15% in Serbia;

- Change in the price of products in the last period (year) has been noted in 75% of response from SMEs in Macedonia, and 85.7% in Serbia;
- According to the respondents in Macedonia, 47.2% believe that the developed channels of distribution were very important as a marketing activity in this sector, while the highest percentage in Serbia (56%) think that the developed channels of distribution were also very important as a marketing activity in this sector;
- 38.9% of respondents stated that familiar product/name (brand) was important for the marketing of this sector, while the highest percentage (40.7%) from the respondents in Serbia have similar opinion. They think that familiar product/name (brand) was very important as a marketing activity in this sector;
- Advertising as a marketing tool in NTFPs sector in Macedonia was considered an important 47.2% of respondents, while respondents in Serbia have opposite opinion. The highest percentage from them (29.7%) thinks that advertising as a marketing tool was considered an unimportant for NTFPs sector;
- The most successful marketing tool in NTFPs sector in Macedonia was advertising (25.5%), while the highest percentage 28.6% from the respondents in Serbia thinks that there was no successful marketing tool for this sector**;**
- The most of the SMEs in Macedonia (94.4%) and Serbia (75.8%) have web - site and e - mail address;
- Most of the buying products, SMEs in Macedonia distribute to other processors in the country (58.3%) and exported to the international markets (55.6%). SMEs in Serbia in the highest percentage were exported to the international markets (61.5%) and selling to other processors in the country (58.3%).

To overcome the situation in this sector, SMEs should accept the new market conditions and rules and adjust them according to the customers` needs. It is the result of the transition period, in which two countries still are. On the other hand, the state should facilitate and support the whole process for development of small and medium enterprises in this sector through subsidies and favorable loans.

Because as a major problem in business in both countries was pointed unfair competition, the state also needs to find an appropriate mechanism for dealing with this problem. This would facilitate the work of already established SMEs, while, at the same time, it will create the opportunity for opening new enterprises in this sector, which is not so attractive for investment in both countries at the moment.

In addition, use of marketing tools in NTFPs sector should be increased. Use of marketing tools in NTFPs sector should be more focused on promoting of enterprises, promoting enterprises' products and the quality of the products of enterprises. At the same time, marketing tools are also success for better sales of products and better communication and cooperation as between enterprises and with consumers at the same time, and reliable buyers and growing number of consumers.

The state should introduce a mechanism to overcome the irregularities and gaps that exist in this sector and harmonization of existing laws, cross - sectored collaboration and cooperation for sustainable management of NTFPs. Furthermore, this harmonization will lead to more efficient and effective work of enterprises and it would contribute to promoting the NTFPs sector by self and NTFPs as economically important products.

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SITUATION OF ILLEGAL GRAZING IN TURKISH FOREST FROM PAST TO PRESENT

Oguzhan SARIKAYA[1]*,Ahmet Alper BABALIK[2]

Abstract: *A total of 21.2 million hectares that constitute 27.7 % of the land in Turkey are forests. 54.4 % of the forests in Turkey are constituted by needled trees and 45.6 % are by broad-leaved trees. Forest fires are the main factor which threatens forest. Besides that, several abiotic and biotic factors affect Turkish forests. One of the most important factors of them is goat damage and illegal grazing. Goat is a natural element of the Mediterranean ecosystem in Turkey by vegetation, topography and climatic conditions. Especially, stony, sloping and uneven areas don't enable any animal except goat. Grazing is very important factor in shaping vegetation types in the Mediterranean ecosystem. Grazing of rangelands cause reduced 2-3 times over their yields. For this reason, openings in the forests and maquis areas are preferred for grazing by shepherds. These stands are grazed mostly by hair goats and important damages occur on vegetation by this feeding.*

Rangelands consist 18.8 % of total area in Turkey and most of them are located on sloping and uneven stands and also 90 % of them are on degrade areas. It is easily seen that rangeland areas are becoming less year by year. Turkey had 44.3 million hectares rangeland areas in 1935, it reduced to 14.6 million hectares were in 2009. Recently years, this ratio was estimated less. Large forest stands are potential for forest products, however insufficient of high quality rangelands become an obstacle for stockbreeding in rangelands. For this reason, overgrazing pressure occurs in forest and maquis stands. Forest ecosystem and maquis areas are damaged by illegal grazing. According to official records, since 1954 till 2011 284.558 illegal grazing crime recorded and approximately 31 million animals were included related these crimes. It is seen that contrary to increasing of population, ovine (sheep or goat) number is decreasing year after year. Relating to this decreasing, number of crimes about illegal grazing is also becoming less. In this study, situation of illegal grazing and changes from past to present were defined by tables and figures.

Key words: Illegal grazing, hair goat, Turkish forests.

INTRODUCTION

A total of 21.2 million hectares that constitute 27.7 % of the land in Turkey are forests. 54.4 % of the forests in Turkey are constituted by needled trees and 45.6 % are by broad-leaved trees. 51 % of Turkish forests are productive. 60% of forest areas are constituted by coniferous forests and 40 % of them are broad leaves trees. Most of broad leaves trees are oak species (*Quercus* spp.) and also most of coniferous trees are Brutian pine (*Pinus brutia* Ten.) and Black pine (*P. nigra* Arnold) (OGM, 2006).

Forest fires are the main factor which threatens forest. Besides that, several abiotic and biotic factors affect Turkish forests. One of the most important factors of them is goat damage and illegal grazing.

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Today in Turkey, grazing is called as breeding of animals in rangelands or in forests. Agriculture, stockbreeding and forestry have not reached to good level. So that, grazing became traditional usage. Productivities and vegetation values of rangelands in Turkey were reduced and some of them can not satisfy fodder requirements (Canakcioglu, 1993).

Arid rangelands which have inadequate yield are suitable for sheep and goat. The terrain has rocky, rough character and mostly covered with short and long lasting broad leaved plants. For this reason, goat breeding became more popular (Kucukaydin, 2005).

Goat is a natural element of the Mediterranean ecosystem in Turkey by vegetation, topography and climatic conditions. Especially, stony, sloping and uneven areas don’t enable any animal except goat. Grazing is very important factor in shaping vegetation types in the Mediterranean ecosystem. Grazing activity of rangelands are 2-3 times over than their grazing capacity. For this reason, openings in the forests and maquis areas are preferred for grazing by shepherds. These stands are grazed mostly by hair goats and important damages occur on vegetation by this feeding (Koc et al., 1994).

In this study, illegal grazing problem, reasons of grazing and situation of grazing from past to today emphasize and precautions for preventing illegal grazing were put forwarded.

REASONS OF FOREST GRAZING

Grazing is very important factor in shaping vegetation types in the Mediterranean ecosystem (Naveh and Whittaker, 1979; Davis and Goetz, 1990). Nowadays the number of animals grazing on Turkey’s rangelands is 2-3 times more than their grazing capacity. This also caused to reduction in yield of rangelands. For this reason, stockbreeders don’t confine with rangeland grazing. They also use openings of forests and maquis stands which have very important in the Mediterranean ecosystem for grazing. These stands are grazed mostly by hair goats and important damages occur on vegetation by this feeding (Koc et al., 1994).

In Turkey, irregular settlements are an important problem. There are conflicts between forest villagers and forest directorate about permitting of grazing in forest stands. Agricultural applications are not well developed yet in Turkey. Shepherds prefer forests for grazing. Traditions and habits caused a belief that grazing in forests as connatural and compulsory. This also triggered to damage on forests. Most of forest villagers think that grazing in forests is natural rights for them (Canakcioglu, 1993).

Most of rangelands in Turkey are located in semi-arid regions. Therefore, fodder plants dried fast in the mid of summer season when temperature increase, they easily consumed so that grazing are preferred in forest rangelands and in forests (Yazici and Babalik, 2011).

Another reason is that forest villagers are low income people. So, it is not possible to bind to engagement for business based on financial strength. Therefore, they think that livestock is very appropriate way which they can handle nature with very little capital without loss (Canakcioglu, 1993).

SITUATION OF ILLEGAL GRAZING IN TURKISH FORESTS

Grazing in Turkish forests can be seen as free public right and significant activity for rural communities. Thus, it can be considered that the grazing also is a type of the positive externalities for forest villagers. (Ozturk et al., 2009).

There are a lot of discussions about goat that has large spreading in the Mediterranean Belt of Turkey, owing to negative effects on forest ecosystems and damages. Goat is a natural element of the Mediterranean ecosystem in Turkey by vegetation, topography and climatic conditions. Especially, stony, sloping and uneven areas don’t enable any animal except goat. Grazing is very important factor in shaping vegetation types in the Mediterranean ecosystem.

Goats are very active animals. They can move easily in very steep slopes and rocky areas. They are the best animals for evaluating of young shoots and thorny plants of shrubs and woody tree species.

Goats are considered to be dominant species even in areas where rangeland conditions are not good. They also are feeding by woody vegetation and thorny species with high nutritional value. The terrains are mostly rocky and rough and also covered with short and long lasting broad leaved plants. Therefore, goat breeding is more popular and it is seen more in the Mediterranean and South-eastern part of Turkey.

Large forest stands are potential for forest products, however insufficient of high quality rangelands become an obstacle for stockbreeding in rangelands. For this reason, overgrazing pressure occurs in forest and maquis stands. Forest ecosystem and maquis areas are damaged by illegal grazing. According to official records, since 1954 till 2011 284.558 illegal grazing crime recorded and approximately 31 million animals were included related these crimes (Figure 1) (Anonymous, 2010; Elvan, 2010).

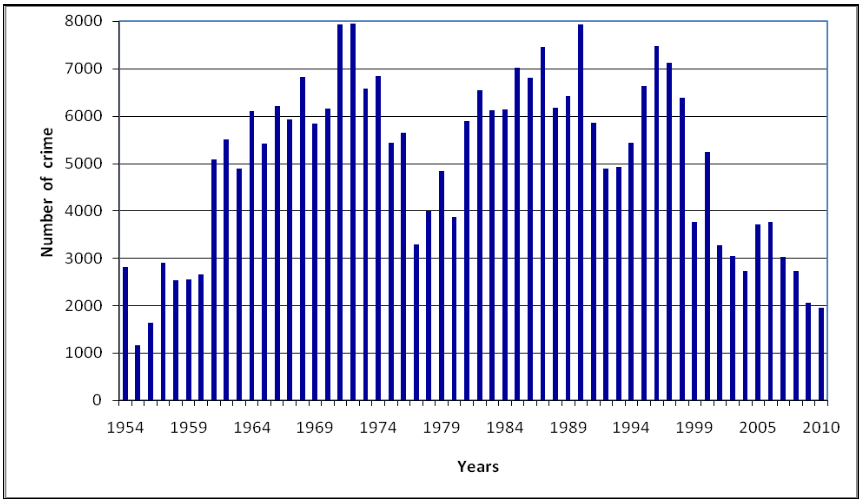

Figure 1. *The crimes of illegal grazing (1954-2010).*

It is seen that contrary to increasing of population, ovine (sheep or goat) number is decreasing year after year. Relating to this decreasing, number of crimes about illegal grazing is also becoming less.

Comparisons about population and livestock numbers between 1935 (the first Forest Law entered in the force) and today, show that goat number was nearly 6 times, sheep number was 2.5 times much more tan present (TUIK, 2008; Elvan, 2010). Forest law played important key role on this reducing in goat breeding (Elvan, 2010).

On the other hand, the reason of hard line of forest directorate for sheep and cattle grazing is serious damage in forest areas where uncontrolled and illegal grazing can be seen. Recently years, number of grazing crime showed that this crime is seen in regions where livestock is density. It is very important indicator for planning of forestry and livestock. For this reason, these important factors should be protected and pursued together for economy and welfare.

THE SITUATION OF RANGELANDS

Rangelands are the most fodder resources where roughage is provided for livestock. Rangelands composed to 18.8% (14.6 million ha) of total area. Rangelands were constituted 59.8% of total area in 1950 and this ratio reduced 31.1% in 1984, 27.9% in 1998 and 18.8% in 2009 (Figure 2) (Altin et al., 2011).

It is easily seen that rangeland areas are becoming less year by year. Turkey had 44.3 million hectares rangeland areas in 1935, it reduced to 14.6 million hectares were in 2009. Grazing activity of rangelands are 2-3 times over than their grazing capacity (Koc et al., 1994). Therefore, their performance is not at the desired level. It is estimated that productivity became more less in recently years. Areas with covered vegetation in rangelands of Turkey are varied between 10-27%.

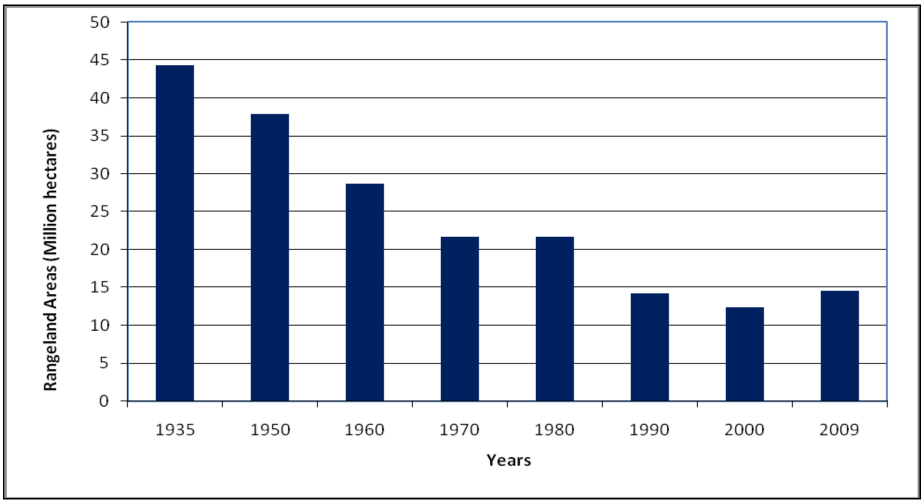

Figure 2. *Changes of rangeland areas belonging to years (1935-2009).*

Rangelands in Turkey receive less than 900 mm annual precipitation and generally suffer from heavy grazing. Heavy grazing causes not only destruction of range vegetation but also degradation of the soils by erosion. Vegetation of heavily grazed rangelands in arid and semiarid regions has a tendency towards conversion to shrublands (Koc, 2000). Rangelands lose their productivity owing to over and early grazing and some of them cannot require fodder for livestock. Most of rangelands lose their natural vegetation because of improper applications and erosion problem reached very seriously danger level. Estimation of rangeland hay yield in Turkey is between 450-1200 kg/ha (Ozudogru, 2000). Annual yield is approximately 700 kg/ha and this value is 1/3 of global average level (Babalik, 2008).

Rangelands where located in forest areas reduced or stopped pressure on forests by supplying fodder demands for forest villagers. If this is not, villagers use fresh shoots and leaves for this aim and this kind of usage cause important economic losses in wood producing.

Also, reducing of grazing pressure is very important for plantation, reforestation and erosion controlling studies. The most important condition for this aim, hay yield of rangelands should be in enough level.

CONCLUSION

Irregular and overgrazing which continue for a long time, cause serious damage on forests in Turkey. For all that, livestock is very important livelihood job for forest villagers. Especially, goat breeding is a considerable alternative for ecological farming.

Some precautions must be taken for preventing damages of overgrazing in forest stands. For this aim, borders between forests and rangelands must be determined certainly. Forest and forest rangeland areas should be separated. Also, forest directorate should allow the use of forest resources by villagers. Provisions about grazing of goats should be taken place in forest management plans.

Cultivation of fodder should be implicated for reducing grazing pressure on forest areas. In addition to this, versatile job possibilities should be provided for villagers. Establishing of cooperatives is a good way to villagers for assessing property much better and providing fodder and fertilizer cheaper. Hair goat breeders should become organize and grazing management should be carried out by this organization.

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INSTITUTIONAL, LEGAL AND ORGANIZATIONAL FRAMEWORK OF NATURE PARK GOLIJA

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Abstract: *Protected natural area is a preserved part of nature, which is characterized by specific natural values and has multi level significance (ecological, scientific, cultural, education). Natural areas under protection are: national park, nature park, landscape of exceptional quality, nature reserves (general and special), natural monument and natural rarities. In Serbia, natural areas, which are characterized by great biological diversity, are protected whit different protection regime in order to preserve these special natural values. Protected areas are declared by a competent authority on the proposal of the Institute for Nature Protection of Serbia. State Enterprise for Forest Management "Srbijašume", Belgrade was founded in 1991 with the primary activity in management of state forests, promotion and utilization of all forest functions, including also and management of protected areas. In Serbia under certain level of protection is 5.86% of its territory and State Enterprise "Srbijašume" is responsible for managing 94 protected areas or almost 42% of the total protected areas in Serbia. The main objective of protected areas management is to preserve, protect and improve natural resources, biodiversity, quality of natural resources and landscapes and geo-heritage. This paper will present institutional and legislative framework of Natural Park "Golija" and its organizational and management model under the State Enterprise "Srbijašume".*

Key words: protected area, legislative and organizational framework

INTRODUCTION

Golija belongs to inside zone of the Dinaric mountain system. It extends in the direction of east-west length of about 32 km (in the form of passing the Latin letters "S"). It stretches in the form of curve between the Ibar, Moravice Radocelo and Pestar. The western part is curved to the south, and east side to the north. The dominant peaks are Jankov kamen (1833 m) and Crni vrh (1795 m). It is surrounded by mountains Jelica in north, Kopaonik in the east, and Cemernim, Radočelom, Javor in the west, Zlatar, Jadovnik and Pester plateau in the south.

General characteristics of the Natural Park "Golija"

The Nature park Golija surface covers area of 75.184 ha out of which 53.804 ha belongs to „Golija – Studenica" Biosphere.

Natural Park "Golija" is a mountainous area, which within its borders and includes mountain Golija and Radočelo, and a small part of the mountain Čemerno. Golija National Park is of particular importance as a center of genetic and ecosystem diversity in the Balkans and in Europe.

[1] State Enterprise for Forest Management "Srbijašume" – Nature park Golija
[2] National park Kopaonik

The total surface area of 75.183 ha belongs to the Mount Golija Natural Park, out of which 39.528 or 53% are covered in forests, out of which 18.460 or 46, 70% are in the private property and 21.068 ha or 53, 30% belong to social sector.

Not a single city or urban settlement is located within the boundaries of the Nature Park. There are 32 local villages, out of which 30 within the limits and two on the both sides of the border (Medovine, which belongs to the Municipality of Ivanjica and Muhovo which belongs to the Municipality of Novi Pazar). In addition, there are about 150 hamlets within the area of mentioned local villages

Table 1 – *Nature park territory by the municipalities*

	Surface area (ha)	**%**
Nature Park	75.183	100
Municipality of Ivanjica	41.755	55,5
Municipality of Raška	12.623	16,8
Municipality of Kraljevo	12.049	16,1
Municipality of Novi Pazar	5.891	7,8
Municipality of Sjenica	2.865	3,8

Source: Nature Park Golija

In the By-law proclaimed by the government of the Republic of Serbia („Official Gazette of the Republic of Serbia“, No. 45/2001 dated July 20, 2001) it is that:

„The Mount Golija and Radocelo areas are protected under the name „Golija“, and are classified as area with I category of protection, being the natural resource of the significance.“

Nature Park Golija is a set of natural, cultural and functionally related landscape units, which are due to more efficient planning and implementation of protective measures divided into several sub-areas or locations. The park has three levels of protection (I, II, III). Under the regime of protection degree is covered 18 locations (554 ha or 0.7%), under the protection regime and the degree of 20 locations (3.883 ha or 5.2 %) and under the III regime of protection is 70.746 ha or 94.1 %).

Part of the Natural Park with its natural resources is allocated and fully met the criteria for nomination for Biosphere Reserve by the MAB program ("Man and Biosphere"). Commission of UNESCO with its Decision from October 2001. year, proclaimed part of the Nature Park Golija as the Biosphere Reserve "Golija - Studenica".

LEGISLATIVE FRAMEWORK

Legislative framework defines the right and duty of a guardian to protect and improve the environment in accordance with the law.

Following Law and sub laws are defining and stipulating the work of management in the Nature Park Golija:

- The spatial Plan for special purpose Nature Park „Golija “(Official gazette of RS, No.16/09)
- Law on Environmental protection“(Official gazette of RS, No.135/04 and 36/09)
- Law of Nature Protection“(Official gazette of RS, No.36/09 and 88/10)
- Law on forestry“(Official gazette of RS, No.30/10)
- Law on protection and sustainable usage of fish stock (Official gazette of RS, No.36/09)
- Law on hunting and game management (Official gazette of RS, No.18/10)
- Regulation on internal order in the nature park "Golija" (Official gazette of RS, No.63/03)

- Regulations on the declaration and protection of strictly protected and protected wild species of plants, animals and fungi(Official gazette of RS, No.36/09)
- Rules on determining the amount and method of calculation of fees for the use of natural resources and services in the nature park "Golija" (Official gazette of RS, No.63/03)

The basic principles of protection and enhancement of nature are prescribed by the Law on Environmental Protection. Pursuant to the Act on the Protection of the Environment it has been determined that the funds for the protection and development of the protected natural resources are to be provided from:

- the state budget,
- income gained from the activities taken up by the enterprise - management,
- compensation for the utilization of natural resources
- and other sources, in accordance with the Law.

The same Act envisages that the usage of the natural resources by the other legal entities and citizens – users, should be compensated to the organization which manages the resource. The funds gained from the fees are to be used for the protection and development of the protected natural resource.

Law on nature protection (2009.) clearly defines the obligations of the protected area.

INSTITUTIONAL FRAMEWORK

Following institutions are from high importance for proper function of Nature Park Golija:

- Ministry of Environment, Mining and Spatial Planning – performing public administration activity in relation to the protection and sustainable use of natural resources. This Ministry jurisdiction is over preservation and improvement of biodiversity and protected areas, monitoring and sustainable use of biodiversity and landscapes, domestic and international trade of endangered and protected species of wild flora and fauna.

- Ministry of Agriculture, Forestry and Water Management has responsibilities relating to the protection of nature which are carried through the Forest Directorate, Directorate of Plant Protection, Department of Rural Development and National Directorate of water.

- Ministry of Economy and Regional Development includes the sectors of industry, tourism and complementary activities.

- Institute for Nature Protection of Serbia performs professional tasks in relations to protection of natural resources, research and study with order to implement the measures of protection, monitoring of endangered natural resources and recommend measures for their protection, establishing the conditions and providing data on protected areas in process of formulation of the spatial and other plans then performed other duties prescribed by the regulations, conduct study on protection of biological and geological diversity of Serbia, supervise and provides technical assistance in the management and improvement of protected areas.

Above aforementioned ministries and institutes certain functions relating to the protection of nature are transferred to the Public Enterprise "Srbija".

Public company “Srbijašume” performs activities of protection and development of protected areas. This public enterprise is organized as General direction with 17 regional forest management units, 67 management units and 13 working units.

Within General Direction of Public company Srbijašume in the sector for forestry and environmental protection there is department that controls the activity of management of the Nature Park Golija.

Nature Park Golija represent one working unit which includes part of territory of three regional forest management units ("Golija" - Ivanjica, "Sumartsvo" –Raska and "Stolovi"-Kraljevo).

Internal organization of Nature Park Golija is following:

- General manager of the Nature park Golija
- Independent officer for nature protection
- Executive of management unit that are within the borders of nature park
- Forest engineers
- and forester which monitor assigned territory

CONCLUSIONS AND RECOMMENDATIONS

Public company "Srbijašume", as guardian, in performing the protection and development of the Nature Park on a commitment to conservation and development program, the implementation of the prescribed regime of protection and conservation of natural resources, implementation of internal order and security guard service, scientific research, cultural, education and training, information, publicity and other activities set out in the National Strategy for Sustainable development of Serbia.

The basic assumptions for the successful realization of the protection and development Program for the Mount Golija Nature Park and "Golija – Studenica" Biosphere Reserve lies in the organization on the high level of expertise, suitable equipping, and in the presence of exceptionally capable technical staff in the Enterprise. It means that on the outset of the program period and after it, all the services and departments of the Enterprise must constantly be on the highly operational level and functionally organized, in the first place the services and departments for the protection of nature and environment at all levels (Direction, Forest Management, Forest Estate).The Service is operationally interconnected, and well equipped in technical and human resource sense to carry out the required activities.

In order to fulfill its obligations and secure the realization of fundamental functions of Nature Park and Biosphere Reserve, the Management of the Park must be based on the up-to-date broadly accepted concepts. Its work and decision making should include all interested subjects, from local and regional communities to state institutions and authorities as well as governmental and Non-Governmental organizations.

The coordinated, joint work and co-operation of all competent entities or those interested in protection, utilization and development of particular resources of the area is of utmost importance if the protection and development Program for the Mount Golija Nature Park and "Golija-Studenica" Biosphere Reserve is to be successfully executed. Also, execution of particular obligations, regulations, creation of plans, foundations, and investments in the development of the area is equally important. Therefore, the Enterprise shall make effort to promote, draw the attention, organize and coordinate all the interested parties.

Improvement of the protection system of the Park will allow for the following:

- Harmonization of the methods of operation and presentation of the results on internationally accepted criteria,
- Establishing full scale co-operation with home and international associations operating in the relevant field of activity,
- Establishing the co-operation with the authorities of the local self-government.

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THE ANALYSIS OF TRENDS IN ESTABLISHMENT OF PROTECTED AREAS ON THE TERRITORY OF REPUBLIC OF SERBIA IN THE PERIOD 1948-2009.

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Abstract: *The concept of nature protection on the territory of Republic of Serbia has a long tradition, which has been accompanied by a number of legislative regulations, adopted in the period from 1930 to present. The first regulation on nature protection dates back as far as XIV century, whereas the first regulation in modern history was introduced in 1930. More than ten laws, directly relating to establishment of new protected areas, as well as a number of indirect legal regulations fostering this activity, have been passed since that time. The main objective of this paper is the analysis of the trend in establishment of protected areas from 1948 to present, through several observed periods, with a view to obtaining an insight into the extent of impact the laws had on establishment of new protected areas in those periods. Furthermore, the paper analyses all legal and sub-legal regulations adopted in those periods. The study data have been collected by means of a non-reactive method. The studies indicate that establishment of protected areas in the period from 1948 to present has followed a positive trend, and that this trend has been most intensive in the most recent period of observation, prompted by the legislation enacted in this period, increasing interest of institutions involved in this field and a growing need for sustainable management of certain areas, in conformity with the nature protection concept.*

Key words: protected areas, establishment, legislative framework

1. INTRODUCTION

Nature protection represents a concept that was founded long ago, as a need of the society to detach certain areas, either afforested or not, from regular use and to assign them for a partially or entirely limited use. In the beginning, nature protection was developed as a need of aristocracy to enjoy their privacy in certain areas, most commonly related to hunting activities. Many forests in Europe enjoyed precisely that type of protection and were used as hunting areas (Martinić, 2007). One of the oldest protected areas on the territory of Serbia is Obedska bara (*Obedska Marsh*), protected in 1874, presently under the strictest protection regime. In that period, Obedska bara was a part of Austro-Hungarian Empire and it was protected primarily on account of its abundant flora and fauna. The oldest form of nature protection in the world is the Yellowstone National Park, founded in distant 1872. Its purpose in that time was quite different, as it was related to education and commercialisation of this form of service. In the first half of 20th century, two legislations on nature protection were enacted. The first was the 1930 Regulation on protection and maintenance of facilities of historical, scientific and artistic value, natural beauty and rarities, and the 1938 Regulations on national parks. There are no data on establishment of protected areas in that period, probably due to a lack of implementation of those

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legislations and a turbulent political situation (Sekulić, 2011). During the course of second half of 20th century, a rapid expansion of nature protection took place. One of the first laws of that period on nature protection in the Republic of Serbia dates from 1948, establishing three protected areas (Ostrozub, Mustafa and Felješana) on a small area of 400ha. The following legislation, which designated Fruška gora the first national park, dates from 1960, whereas the law of 1977 clearly defined the boundaries of this National Park (Đorđević I. 2009). One of the principal purposes of this park was related to recreation, as the areas within the National Park were intended precisely for that purpose. If the concept of nature protection is considered in terms of prevention of excessive felling and use of a certain area, then the origins of protection date back to 14th century, for the Emperor Dušan' Codex, in paragraph 123, prohibited Saxon ore miners to cut wood in the proximity of mines and also imposed an obligation to afforest the already felled areas.

The first legal regulations relating to protected areas date from 1930 and 1938. However, there are no data on establishment of protected areas in that period, hence the establishment of protected areas in the Republic of Serbia will be analysed in the period from 1948 to present. Nine legal regulations, directly relating to establishment of protected areas, have been enacted in this period. The first legislation dates from 1945 and it defined a form of protected area entitled 'natural rarity'. The following legislation was enacted already in 1948, under the title Law on protection of cultural monuments and natural rarities. This law did not define protection categories, however, the State Institute for Nature Protection (established in 1946, by a law passed in 1945) applied three categories: strict nature reserve, natural monument and area of exceptional natural beauty (Sekulić, 2011). The first national park was established by a 1960 law, but only the regulation of 1977 defined the boundaries of the National Park 'Fruška gora'. The Law on nature protection, adopted in 1961, first seriously defined nature protection categories and determined who can establish certain protection categories. Consequently, the establishment of national parks requires a separate law, whereas designation of other protection categories depends on local governments. This law set up three basic protection categories: nature reserves, natural monuments and memorial natural monuments. The law had not been changed for fourteen years, until the 1975 law defined two basic protection categories; area of exceptional natural values and natural attraction. In addition to these two basic protection categories, another eight sub-categories were defined (strict natural reserve, special nature reserve, national park, regional nature park, forest park and important observation points). The subsequent 1981 amendment to the law introduced two new sub-categories: area of exceptional natural features and natural area around cultural monuments, whereas the amendments in 1986 were related to introduction of the system of zoning of protected areas. As a result, three protection zones were formed. In the zone one, any form of activity was prohibited and this zone represented the strictest protection level. For the remaining two zones, regimes of use were not defined, except for national parks (Sekulić, 2011). The Law on environmental protection in 1991 regulated system of environment protection and improvement, as well as protection measures, the procedure for placing under protection and management of protected areas. This law actually integrates the field of environmental protection and nature protection (Sekulić, 2011). The Law on environmental protection, passed in 2004, did not bring any changes in the context of establishment and management of protected areas, as it did not change anything in this segment. Provisions of the Law on environmental protection of 1991, relating to protected areas, remained unchanged. The last legislative document that was enacted, directly relating to establishment and management of protected areas, was the Law on nature protection, adopted in 2009. Following a long period of use of a term 'protected natural area, which comprised several terms and was related to both protection of species and protection of nature, this term was divided into three terms: protected areas, protected species and movable protected natural documents.

In addition to direct legislative documents that regulate establishment and management of protected areas, the Government of Republic of Serbia adopted two indirect regulations relating to establishment of new protected areas. The Republic of Serbia Law on spatial planning 2010-2020 defined placing 12% of the territory of Republic of Serbia under protection by 2020, as well as preparation of an efficient management system in those areas while National strategy of sustainable development[1] defines extension of protected area network to 10% of the territory of Republic of Serbia

2. METHOD

This study belongs to a group of applied investigations, aimed at presenting the current situation in protected areas. The primary target group is the decision-makers within state administration (competent Ministry and the Institute of Nature Protection), managers of protected areas, local self-governments and other stakeholders involved in work of protected areas. The investigation method is at the same time descriptive and explorative, since it presents a true picture of current situation in protected areas, including historical facts that led to the current situation, and explains the trends in establishment of this property. Data collection was performed by means of a non-reactive method (Neuman, 2006). A non-reactive investigation is such investigation where a subject of investigation is not aware of this fact. This method includes investigation that does not involve a direct data collection from investigation subject, and it is contrasted to investigation methods such as interviews, surveys and experiments. As a non-reactive technic, the analysis of existing statistics, document-secondary analysis, was employed. The main source of data for the analysis of existing statistics and documents is the state and international institutions, as well as private sources (Neuman, 2006). The methods of analysis of existing statistics and documents are suitable for the analysis of data of longitudinal character. Longitudinal analyses investigate how the subject of investigation changes during time, that is, it can be observed during a longer time period. This analysis is particularly suitable owing to a fact that data are collected during a longer period and it is possible to analyse them in form of trends and possibly link to certain social changes.

The study subject of this paper is various forms of protected areas, established since 1948 on the territory of Republic of Serbia (including two autonomous provinces). The underlying bases, used in order to determine the trend in establishment of protected areas in Serbia, are legal regulations, introduced in the period from 1948 to present, relating to nature protection. From 1948 to present, approximately 454 various forms of protected areas have been established. The first established category was a Nature Reserve (1948), followed by the category National Park (1960). Presently, following a recent change of legal regulations and adoption of a new law on nature protection (2009), there are 7 categories of protected areas: a) Strict Nature Reserve b) Special Nature Reserve v) National park g) Natural Monument d) Protected Habitat đ) Area of Exceptional Features and e) Nature Park.

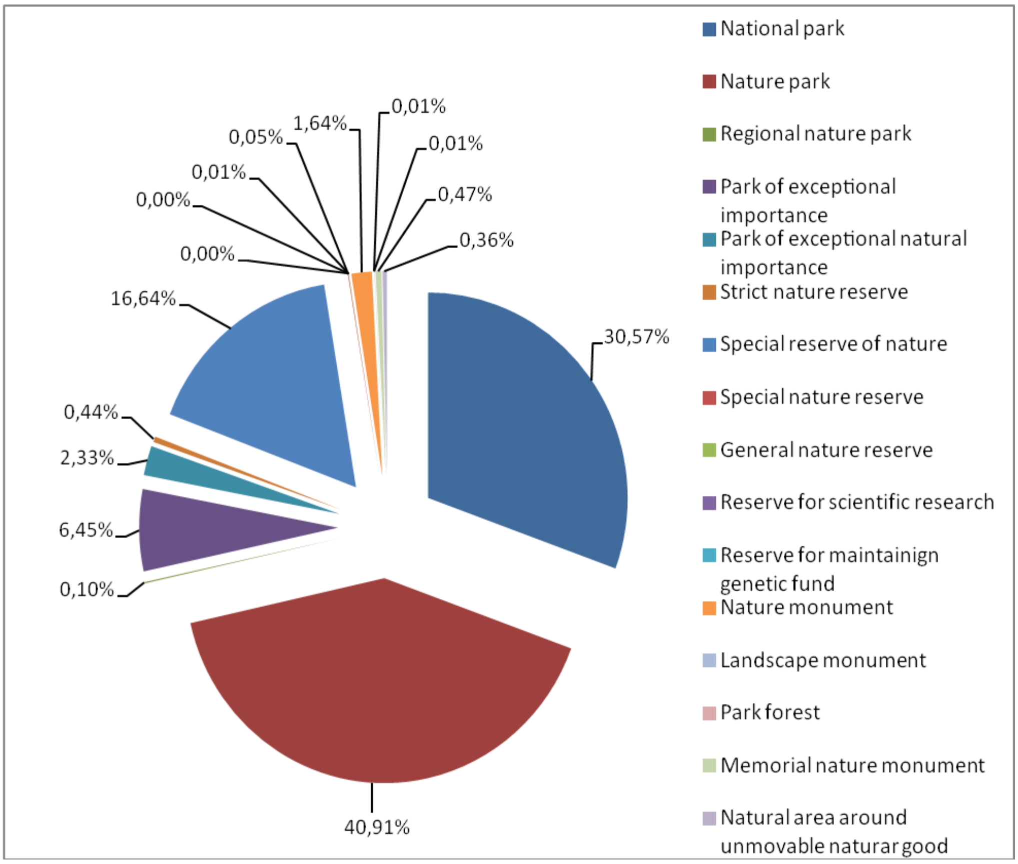
3. RESULTS AND DISCUSSION

The total surface area of protected areas in the Republic of Serbia amounts to 520,092 ha, which accounts for 5.89% of the total surface area of the territory of Republic of Serbia. There are various sources, which estimate that protected areas account for 5.8-6.6% of the territory. The representation of 5.89% is a result derived from a data base of protected areas, which was created for this purpose. It involves citations from the Institute for Nature Protection (IZP), Public Enterprise (JP) 'Srbijašume', Public Enterprise 'Vojvodinašume', literature citations,

[1] National sustainable development strategy of the Republic of Serbia ('Official Gazette of RS', no 55/od, 71/05 and 101/07)

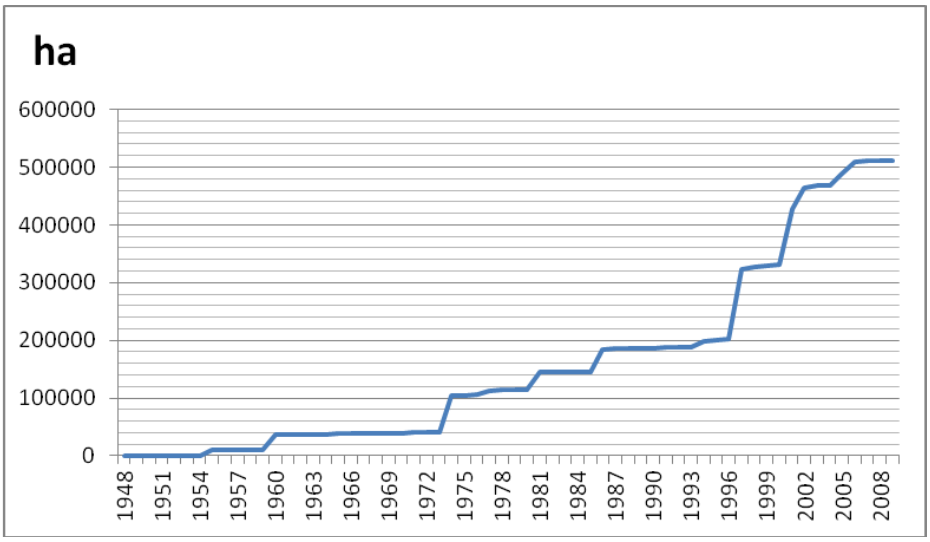
citations of various strategies at national and regional level and data obtained from other secondary sources. Data from different sources are used in order to obtain the most representative data on representation of protected areas and, consequently, to enable the use of the most authentic source of information. The territorial scope encompasses the Republic of Serbia and its two autonomous provinces. The paper examines, according to certain periods, the impact that the legislative framework had on establishment of new protected areas (the analysis did not include a category 'natural monument', due to a lack of data with respect to the date of establishment of this category, and the area it covers is small, only 1.64% of the total surface area of protected areas).

The data obtained in this manner classify protected areas into 16 different classifications. They are: a) National park; b) Nature park; c) Regional nature park; d) Park of exceptional importance; e) Park of exceptional natural importance; f) Strict nature reserve; g) Special nature reserve; h) Special reserve of nature; i) General nature reserve; j) Reserve for scientific research; k) Reserve for maintenance of genetic fund; l) Memorial natural monument; m) Natural area around an immovable cultural property, n) Natural monument and i)Landscape monument.. As can be seen from the above-mentioned, the current classification does not coincide with the classification defined by the new law on nature protection and it is a result of overlapping with the classification of the Law on environmental protection (1991), as well as with previous classifications adopted in the period before 1991. The Graph 1 presents all categories of protected areas, existing at present in the nature protection system of Republic of Serbia.



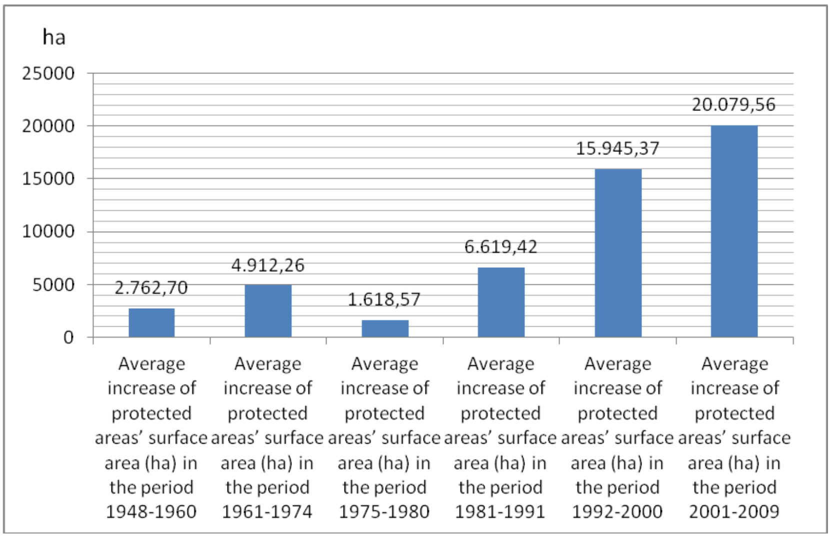
Graph 1. *Categories of protected areas in the Republic of Serbia*

The graph below presents cumulative trend in establishment of protected areas, from 1948 to present.



Graph 2. *Cumulative trend in establishment of protected areas in the Republic of Serbia from 1948 to 2009.*

As can be seen from the graph, certain years saw more significant changes in establishment of protected areas in comparison to others. These years are 1955, 1960, 1974, 1977, 1981, 1986, 1996, 1997 and the period after the year 2000. That change, i.e. an increase of protected areas, is related to the laws adopted in those periods, as well as legal regulations introduced after the year 2000. On account of the above-mentioned, the period of analysis of establishment of protected areas will be the period 1948-1960 (I period). A considerable increase of the protected areas' surface area occurred in this period, which represented a significant step ahead, considering that nature protection as a new concept only began to assume importance. In the period 1961-1973 (II period), a modest increase of protected areas occurred, whereas a sharp increase of protected areas' surface area was seen in 1974. The next period encompasses the period from 1975 to 1980 (III period), which is characterised by a constant, but moderate intensity increase, in comparison to II period. A more significant increase occurred in the period 1981-1991 (IV period), as well as in the period 1992-2000. The last period encompasses the period between 1992 and 2000. The graph below presents the average increase in the above-mentioned periods.



Graph 3. *The average increase in given periods*

In the first period of observation, an increase of protected areas' surface area by 35,915.15ha, or 2,762.70 ha at an annual level, occurred. 19 protected areas were established, while the largest protected areas were Fruška gora and Resava. In addition to the Law on protection of cultural monuments and natural rarities, the Law on establishment of the National Park Fruška gora, adopted in 1960, had a significant impact on this increase. In the following period, the establishment of protected areas was under a strong influence of the new law on nature protection, adopted in 1961. This law defined three basic categories, along with four sub-categories. 37 new protected areas, covering the surface area of 68,771.64ha, were established in that period. The annual increase was nearly doubled in comparison to the previous year and amounted to 4,912.56ha. The following observation encompasses the period 1975-1980 and it is considerably shorter in comparison to previous periods. This period was separated as distinct, largely on account of the introduction of two new categories and a number of sub-categories, with 23 protected areas, covering the surface area of 9,711.43ha (1,618.57ha on average) established during this period. By means of amendments to the 1961 Law on nature protection, a zoning system was introduced into national parks in 1981, which increased the speed of establishing new protected areas and, hence, the extent of the surface area they covered. In the period 1981-1991, 27 protected areas were established, covering the surface area of 72,813.59ha. At the annual level, 6,619.42ha were established, largely as a result of the establishment of National Parks Tara, Kopaonik and Šar Planina. The Law on Environmental Protection of 1991, considerably changed the attitude towards protected areas and significantly improved this segment of nature protection. In the period until 2000, 21 protected areas were established, on the surface area of 143,508.35ha. In comparison to previous periods, a major increase of protected areas was experienced, given that 15,945.37ha of new areas per year were established in this period. In the last observed period, 2000-2009, 27 protected areas were established, covering the surface area of 180,716.06 ha, which amounted to 20,079.56ha.

4. CONCLUSION

It can be clearly seen from the above-mentioned that legislative and institutional framework provides a sufficient scope for establishment of new protected areas. Strategies and legislative framework define the surface area of over 10% of the territory of Republic of Serbia, whereas it presently accounts for slightly less than 6%. Regulations introduced in the period 2000-2010, defined the increase of these areas to 10% of the territory of Republic of Serbia, while the Law on Spatial Planning postpones this term to 2020.

The first regulation, defining some form of protection, originates from 1930, however, there had been no establishment of protected areas before 1948. Only in 1948, the first protected area on the territory of Republic of Serbia was established. From that time to present, a constant establishment of new protected areas has been recorded, with the average value for the entire period of 8,248.97ha. At the beginning, this trend was of low intensity, the I period accounted for only 33.5% of the entire period's average value, in contrast to the II period, when it accounted for 59.5%. The basis for formation of new protected areas in the I period of observation was provided by the State Institute for Nature Protection, established in 1946, which applied three new categories, not defined by the Law of 1948. The Law on Nature Protection of 1961 defined three basic categories and, within the framework of the first category - nature reserve, three new sub-categories: national park, strict nature reserve, reserve for scientific research and area of particular natural beauty. Such legal regulations and proposed categorisation soon nearly doubled the establishment of new protected areas in the period before 1974. In the period 1975-1980, establishment of new areas accounted for only 19% of the entire period's average value. Despite the fact that a number of new categories were formed by the 1975 amendments to the law, these values are far lower than those previously observed. The reason for that is probably a short observation period, however, it must be pointed out that these changes in categories provided a strong stimulus for the following period, when a rapid establishment of new protected areas took place. In the IV observation period, from 1981 to 1991, the highest increase of new protected areas occurred. 72,813.59ha of new protected areas were established in that period, which, in comparison to period since 1948, accounts for 63.6% of protected areas, whereas in comparison to the entire period's average, it constitutes 80.2%. In fact, most new protected areas were established in this 11-year period, which was largely due to the establishment of three national parks (Tara, Kopaonik and Šar Planina). In the IV and V observation period, after 1992, and adoption of the Law on Environmental Protection of 1991, the establishment of new areas became more rapid and, in comparison to the entire period's average, this increase accounted for 193.3% (that is, 93.3% above the entire period's average). In comparison to the surface area of protected areas established by 1991, 76.7% of protected areas were established in this period. The period after 2000 is particularly interesting, as the increase, in comparison the entire period's average, accounted for 243.42% (that is, 143.42% above the average). The largest number of protected areas were established in this period, covering the surface area of 180,716.06ha.

Given the fact that the Law on Spatial Planning (2010) defines an increase of protected areas' surface area of up to 10% of the territory of Republic of Serbia, new areas should be assigned for that purpose. That means that it is necessary to assign new 36,3454.3ha of protected areas in the following period. If the trend of average increase for the entire observation period is maintained, a period of 44 years will be required to attain this value. On the other hand, in the last observed period, from 2001 to 2009, the average increase of new protected area amounted to 20,079.56ha. If this trend of establishment continues, 18 years will be required to attain the 10% level of representation of protected areas on the territory of Republic of Serbia. Therefore, the establishment of new areas should be intensified in the following period, accompanied by a relevant legislation and state support. It is necessary to assign appropriate budgetary resources on the part of the Institute for Nature Protection at the republic and provincial level, to support this activity in the process of formation and definement of new areas, as well as the resources for their functioning. A possible measure that could facilitate this, is the establishment of a Nature Protection Fund, similar to the Forest Fund, which would have a continuous source of financing through collection of relevant charges, that is, fees. This could be also made feasible through thes present Fund for Environmental Protection, in the framework of which funds could be assigned, at the annual level, solely for this purpose.

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USE OF SOCIAL NETWORKS IN SE ”SRBIJAŠUME“

Jovana ANTIĆ, Milka ZELIĆ, Gordana JANČIĆ[1]

Abstract: *From the scientific, technological and sociological standpoint, the Internet and social networks have made a breakthrough in understanding of the functioning of everyday life and work. The social network is one of the most democratic medium because it allows diffuse and two-way communication.*

The economy of every country is a driving force of society. Today's market environment requires increasing use of information technologies that companies need to ensure greater efficiency.

Environmental problems are complex and global. The current way of life is unsustainable. Our common planetary home will be saved if the forest protection is good.

For the survival of future generations, the Planet's population is informed and warned about these problems every day,

Online social networks such as Facebook, LinkedIn, Twitter, MySpace and LiveJournal are an integral part of modern business: marketing, PR, promotion of healthy lifestyles and environmental protection, and other business segments. Nowadays one may constanly be online, wherever one is, due to modern telecommunications infrastructure. One can at any time surf the Internet portals, access e-mail, watch and listen to multimedia content in HD format on YouTube.

Social networks have become an integral part of our lives, we are often faced with the delicate problem of choosing the content set on the social network. Facebook, LinkedIn, Twitter as a communication media that have been accepted by a wide range of users. These networks allow the use of all types of content, including video-content information.

SE "Srbijašume", ready to confront the new challenges of modern communication and business communication is directed to a specific target group, has included the application of social network Facebook. Social responsibility of ”Srbijašume“ requires a careful choice of professional content, as appropriate interactive communication with users.

Key words: Social networks, SE ”Srbijašume“

1. INTRODUCTION

Global changes have caused changes in the business environment and development of IT firms. The most important changes were made in the transition from industrial economy to economy based on information technologies.

With the advent of virtual shops on the Internet and virtual advertising space, a new "online" market knowing no boundaries has been created. More than 500 million people worldwide access the global computer network now. No matter what you do, you can not ignore 500 million people on the Planet. The Internet market, since the emergence of market in general, is one of the world's largest markets. It is only the individual or business entity that will condition which part of this market will belong to them. Even if you do not have the ambition to

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do business in the international market, the Internet will provide this for you, and social networks will make your marketing visible at the global level. This is the result of strong development of electronics, wireless telecommunication networks and miniaturization of technical components. It is worth mentioning that only two decades have passed since the appearance of the Internet up to wireless computers and handheld devices (such as mobile phones, iPod, iPhone and others), and remote access to virtual networks containing stored information.

The economy of every country is a driving force of society. Today's market environment requires increasing use of information technologies that need to enable companies to do their work more efficiently.

Over the past few decades, the economy is rapidly transforming from its traditional base to a new, information-based economy. In this kind of environment, the work moves from the creation of material goods to the flow of information, and companies are redesigning their business processes towards integrating Internet technologies into all segments of work.

2. ELEMENTS OF THE ENVIRONMENT

Due to rapid deterioration of the environment throughout the world, now this issue is being paid very much attention. Rapid demographic expansion, industrialization, intensive urbanization, the overall process and human activity have resulted, due to irrational use of the natural environment, in disturbed ecological balance with the appearance of intensive processes of destruction and degradation of ecosystems.

It is widely understood that the problem of environmental pollution is a a technical issue, so it often comes down to precise measurements of pollution and finding various technical solutions to stop pollution and possibly reduce it. Modern production techniques and technologies are considered the main cause of environmental degradation if not used properly under human control.

Environmental crisis is not only technological, but also a social crisis, because the relation of man to nature is an essentially social relationship, as the production always has a social character. Thus, the natural environment in modern conditions is becoming an integral part of the productive forces of society. Processes of degradation and environmental pollution are taking place constantly and continuously, and their intensity is dependent on adverse natural processes and events (natural disasters), human activities and technical-technological development.

The issue of environmental protection is a contemporary and topical issue in all the countries of the world. Therefore, it became a common starting point for all considerations of the country's national and economic development. No matter which segment of society is talked about and which social position it is observed from, the constantly present argument is the unacceptably poor state and a high degree of degradation and pollution of natural resources, as well as pointing to the need for emergency rehabilitation of water pollution, air and land and revitalization and protection of natural ecosystems. But all the indications and current activities so far have not allowed the establishment of a complex and efficient system that could stop long-term negative trends of ecological imbalance and degradation, even the loss of natural resources.

The stability of the environment is influenced by many elements, and the forests are one of the important factors. There is a general understanding that the forests are very important for environmental protection, especially for the preservation of soil quality, water and air.

The population in urban areas is faced with major pollution of the environment. Therefore, the protection of man's environment and its physical space becomes more and more prominent, increasingly gaining importance while the city, as the most complex creation of human civilization expands horizontally and vertically. In developed western countries, huge amounts are already being invested in preventive environmental protection in urban areas.

The role of man in the environment is large, significant and specific, unlike all other organisms. He is an integral part of nature and as such, acts decisively on changes in all aspects of the environment. He uses, changes and adapts nature according to his needs, often to the point when unknowingly jeopardizing his existence and survival. The influence of man in the environment is dominant. By his activities in the environment, large and crucial changes are made in its balance and stability.

Environmental problems are global, complex, and both acute and chronic nature. Future generations will feel the hardest consequences. The current way of life and work as a whole is unsustainable.

The most important scientific field today, which is important for both the scientists and worldwide population, is the information and communication technologies (ICT) field, energy sources, environment and human health.

The development of ICT is important for improving our living environment, but information and communication technologies, which is especially important, "approach" the general population in a qualitatively new way.

3. IMPORTANCE OF FORESTS

The forest has significantly influenced the development of man and civilization and represents an important factor in man's survival and development. The world's forests cover an area of about 4 billion hectares (30% of the total area of the globe), and in Europe, 193 million hectares or 34% (without Russia).

Total forest area in Serbia is 2.252.000 ha (1.194.000 ha or 53.0% are state- owned, and 1.058.400 ha or 47.0% privately-owned). Serbia is considered a medium- wooded country. Of the total area of its territory, 29.1% (7.1% in Vojvodina, 37.6% in central Serbia) is under forest. The forest cover is similar to the world's forest cover which is 30%, and significantly lower than the European, which is 46%. In relation to the reference year of 1979, forest cover had increased by 5.2%, which had a positive impact on the situation and environmental quality. A major contribution to increasing the forest coverage in Serbia has been made by companies managing forests in the past and now.

Forest protection is as old as human community. Man has protected forests in order to preserve the source of his survival, and during his development he has lived in harmony with nature, using natural resources for his basic needs.

In the last three centuries, forests of Central Europe have mainly been managed based on the principle of permanence of yield. Serbia, as a country rich in biodiversity (particularly forest ecosystems), has adopted the concept of permanent sustainable forest management (based on the coordinated development of ecological, economic, social and cultural functions of forests).

Forests have ecological, economic and social importance. Ecological effects of protection, promotion of forests and establishment of new forests are much more important than economic ones. The boundary between environmental and economic effects is difficult to determine, since the forest simultaneously exerts both an ecological and economic function. Forests play a leading role in the accumulation of solar energy (large amounts of oxygen are released and carbon dioxide is bound at the same time, which practically enables life on earth) and they are the most productive, cost-effective and largest producers of biomass on the planet.

Forests have a positive impact on the soil formation and the increase in soil fertility, they protect soil from erosion, prevent the occurrence of landslides, avalanches, water and wind erosion. They protect agricultural land, rivers, reservoirs and lakes against drifting. Forests mitigate climate change and positively influence the climate, the increase in precipitation, the air flow, the circulation of nitrogen, they protect from the wind, prevent air pollution (absorb pollutants-emissions), retain a variety of pollutants, chemicals, soot, smoke, dust, solid particles, redue the spreading of radioactivity and ionizing and non ionizing radiation and mitigate noise.

Forests have a positive impact on reducing water runoff, improving water quality, saving water and water sources (including healing springs), but they also keep us safe from water (floods). Ecological effects of forests are classified as follows: a balanced flow of water in the reservoir (prevents removal of earth and mud, and also increases the length of time using hydro reservoirs, as Serbia has little space for storage and if they are strewed, water supply will be jeopardized); retention-protection function (achieved by afforestation of steep slopes of land affected by erosion, and reclamation of degraded forests in similar orographic conditions, thus reducing the negative impact of torrential flows that cause enormous material and environmental damage each year); increase in forest area (has immeasurable significance for the environment); increase in agricultural; health function; scientific educational function; development of sport and recreation; sanitary hygienic functions, holiday function; diversity and beauty of landscape, art, protection of cultural and natural monuments; creating conditions for greater use of wood-based fuels as a substitute for fossil fuels and maintenance of ecological balance in nature.

In the forest there is a large number of plant and animal species and forests are a crucial factor in the preservation of biodiversity and genetic resources. A general characteristic of biological diversity in Serbia is the genetic, species and ecosystem diversity. Out of 6.600 plant species that are found in the Balkan peninsula, almost half are in Serbia.

The forest is a source of raw materials, primarily wood (as well as mineral - stone, gravel, sand, humus, etc.). whose consumption and use value is constantly increasing. Wood is used in wood industry, chemical industry, engineering, construction, transportation, shipbuilding, mining, handicrafts, agriculture, household, packaging materials, arts, education and others. Wood is an important carrier of energy production for the commercial and industrial development. Wood-based energy is the dominant source of energy for over two billion people in the world. Production and consumption of wood in the world are increasing, forecasts show this trend will continue because it is the safest and cleanest wood fuel. The forest is a source of food (fruit, berries, mushrooms, medicinals, herbs, etc..). Almost half of the drugs produced by modern pharmaceutical industry is of plant origin. Forests are an important source of raw materials for cosmetics.

Game management, hunting tourism, mountain tourism, mountain farming, fishing and rural development are impossible without the forest. Forests protect the settlements, roads and various other objects and they have military-strategic importance.

The economic effects of forests (as well as environmental) may be perceived more realistically by implementation of long-term plans. Increase in the contribution of forestry to economic development of Serbia would be met on a long-term basis through increasing the forest area, increasing the productivity of forests, rational use of the total forest potential, protection of forests against biotic and abiotic factors, construction and maintenance of optimal quality and density of forest roads (which would reduce migration of rural population in mountainous areas i.e. the abandonment and closing of villages).

The social significance of forests is reflected in their overall impact on the development of man, society and civilization in general. States rich with forests have better conditions for faster social and economic development and healthy environment.

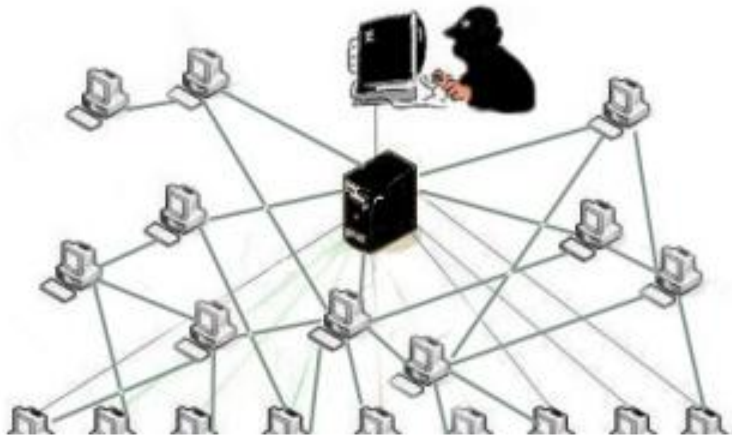
4. INTERNET – MODERN COMMUNICATION MEDIUM

The Internet is one of the most democratic medium because it allows diffuse and two-way communication. The Internet has made a breakthrough in understanding and functioning of everyday life and work. Technical improvement of the Internet in Serbia has the potential to achieve significant economic benefits to our country (e-administration, e-health, e-education, e-ecology, etc.).

Multiple, diverse information (recorded in the form of text, photo, audio or video), via web presentations and associated applications have become available for learning, update and exchange to hundreds of millions of people around the planet. Such a virtual-information connection was the inspiration and basis for the creation and implementation of what we now call the social media, among which certainly the most famous are Facebook, Twitter, Linkedin, MySpace, and LiveJournal.

5. SOCIAL NETWORKS - FORM OF BUSINESS COMMUNICATIONS

Social networking is a form of communicating and connecting people with no direct contact. What distinguishes social networks from other websites, is a cause and effect relationship between the content of the website and its users. In fact, users are the ones who form and widen the scope and coverage of social networks and they themselves are the essence, purpose and means of creation and existence of social networks, rather than passive observers, as is the case with other web pages.



Picture 1. *Global Networking*

These facts have made it to social networks rapidly evolve from a virtual place to meet and communicate, to the space in which ideas and campaigns are promoted, people motivated and grouped for the implementation of specific social needs and desires. In addition to informative and entertainment features, websites of this type also have psychological-emotional contours, because members of social networks are active participants in their creation.

The social network is, therefore, a fast and efficient medium for exploring, cooperation and gathering of a large number of people. These properties of social networks can serve the motivation of members to generally useful activities, to encourage the involvement of members in a practical action to improve environmental quality and improve the health of members of social networks, and society as a whole.

6. SOCIAL NETWORKS AT SE "SRBIJAŠUME”

An integral part of business communication, directed at a specific target group, is also the application of so-called social networks. Social networks are a significant phenomenon of our time, because it is the largest virtual community and an endless source of information and updates about various topics. This is why in the social networks almost all businesses are present.

Scientists predict that by 2030 the biggest problem will be the irrational use of natural environment, biochemical storage and the fact that 20% of the entire population, by 2030, will be older than 65, which will have a huge impact on the health care system.

Predictions of possible future development of information and communications technology (ICT) are made by using relevant statistical data and the most important development trends whose requirements are becoming more and more extensive every year. These predictions are taken, of course, in consideration of global trends in population development, migration, life expectancy and health, urbanization-development of the so-called smart cities, as well as globalization in connecting of companies and the formation of "business networks" as the basic form of cooperation among companies. All this mentioned above affects the national economy, so the information and communication technologies must be carefully studied in each and every segment .

Electronic communication facilitates the exchange of information, reduces business expenses, saves time and resources. Tools such as the Internet, intranet, e-mail, conferencing, video conferencing and others, form the basis for good modern communications.

Social networks, as a modern and inevitable form of communication today, carries a wide array of media options. In recent years, social networks are becoming an indispensable element in the work of businesses and socio-political players around the world, including our country. Social networks are used by almost everyone: individuals, businesses, politicians. "The Social Network Twitter gives people the ability to communicate and say what they think," said Minister Oliver Dulic, adding: "I think it's very good for politicians and would recommend to any politician to be involved in any of the social networks." German Chancellor Angela Merkel has 100.000 Facebook friends. German Foreign Minister Guido Westerwelle has 12.000 friends, and Frank-Walter Steinmeier, 13.700 friends.

State Enterprise for Forest Management "Srbijašume" has readily entered the "E-Society" which arose and developed due to the development of ICTs. Modern management of SE for Forest Management "Srbijašume" has conveyed the possibilities of communications technology into practice through implementation of new technologies in daily work.

Picture 2. *"Srbijašume" on Facebook*

In order to fulfill all of the objectives, it is necessary for SE for Forest Management "Srbijašume" to use the potential of new communications such as the social networks Facebook, LinkedIn, Twitter. These networks allow the use of all information, including video information. Facebook, LinkedIn and Twitter are a communication medium accepted by a wide range of users. In "Srbijašume", there is a practical realization of the corporation's multimedia contents to raise the importance of forest conservation. Social responsibility requires a careful and professional choice of content (Pic. 2), as well as appropriate interactive communication with users.

Nowadays one may constanly be online, wherever one is, due to modern telecommunications infrastructure. One can at any time surf the Internet portals, access e-mail, watch and listen to multimedia content in HD format on YouTube.

Given that social networks are an integral part of business communication, we are faced with the delicate problem of selecting the content set on the social network, because environmental health represents the condition of the Planet's existence. Environmental crisis is not only technological, but also a social crisis, because the relation of man to nature is essentially social, and production always has a social character. Natural environment in modern context is becoming an integral part of the productive forces of society. This information is best delivered to a large number of people due to no other than the social networks.

The salvation of the common planetary home to a considerable extent leads across forest protection, improvement of existing forests and establishing of new forests, for which"Srbijašume" is in charge. Today, the State Enterprise for Forest Management "Srbijašume" Belgrade, is the leader in forest management, hunting and protected areas in Serbia. SE for Forest Management "Srbijašume" controls or manages state forests and forest land on an area of 854.541.12 ha and performs professional work in private forests on 1.029.022.00 ha.

SE "Srbijašume" manages 96 protected areas, with a total of 216.804.88 ha, which represents 41.52% of the total protected areas in Serbia. As Manager, "Srbijašume" is obliged to ensure protection and sustainable use of protected areas.

7. CONCLUSION

The salvation of our common planetary home, to a large extent, leads across forest protection, improvement of existing forests and establishing new forests, for which "Srbijašume" is the responsible company in Serbia. On a daily basis, the world population is informed and warned about aforementioned problems through interactive communication on social networks.

Environmental problems are of a global, complex, and both acute and chronic character. The most serious consequences will be felt by future generations. The current way of life and work as a whole is unsustainable.

Given that social networks are an integral part of business communication, we are faced with the delicate problem of selecting the content set on the social network, because environmental health represents the condition of the Planet's existence. Environmental crisis is not only technological, but also a social crisis, because the relation of man to nature is essentially social, and production always has a social character. Natural environment in modern context is becoming an integral part of the productive forces of society. This information is best delivered to a large number of people due to no other than the social networks.

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SOME OF NON WOOD FOREST PRODUCTS IN THE LAKES DISTRICT OF TURKEY AND THEIR USAGE FIELDS

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Abstract: *Increasing of human interests was observed on natural resources by population rearing and developing of life quality. Turkey has three different floral regions by geographical situation like a bridge between Asia and Europe. For this reason, it has approximately 10.000 plant species and 3500 of them are endemic. All vegetal and animal products which are growing up inside and edge of forests are utilized by people for using or trading. These products are called "Non Wood Forest Products". The Lakes District of Turkey which is located in the south-western part of country and famous for having a lot of big lakes and watersheds, are very rich by non-wood forest products. These products are used as food, medical, spice, natural herbal tea, dye, perfume, decorative articles and ornamental plants. In this study, some of considerable non wood forest products like cone of semen pine (Pinus pinea), linden (Tilia platyphyllos), carob tree (Ceratonia siliqua), sumac (Rhus coriaria), thyme (Thymus spp.), French lavander (Lavandula stoechas), kantaron (Hyperium montana), laurel (Laurus nobilis), hawthorn (Crateagus monogyna), chesnuts (Castanea sativa) etc. and information about their usage fields were put forwarded.*

Key words: Non-wood forest product, the Lakes District, Turkey, usage.

INTRODUCTION

Considering the benefits of forests that comes to mind is that the oxygen supply lives. Natural vegetation in forest takes up carbon dioxide through photosynthesis provides oxygen as. The air we breathe is 21% oxygen. %56 of them is produced by forests. 1 hectare of pine forest produces oxygen for us 30 tons per year. Forests protect and organize the presence of water in nature. They keep order in the form of snow and rain precipitation in the earth, prevent floods and overflows. Also, forests conduce to consisting of groundwater and their protection. They also extend the economic life of dams by preventing erosion and natural disasters. A mature beech tree can reserve 10 tons water by its roots. Therefore, forests prevent negative effects of precipitation and damaging of soil.

Forests are resources for the most basic needs of mankind for firewood and timber which is used for demands. Production of these demands without damaging and planning according to technique are required. Otherwise, faulty productions cause degradation of natural balance and damage people. Therefore, reasons of many natural disasters and environmental disasters are arising from inaccurate usage of forests. Due to their natural beauty and structure of protect the environment, forests are the most important recreation areas for people. In this century, owing to increasing urbanization and expanding industrial areas, forests constitute the major recreation

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areas. 250 meter wide forest area reduces noise by 50%. Because of increasing on life quality and employment opportunities, forests villages have very dense migration. This migration process can be seen as a positive in terms of reduction of forests and human pressures. However, the negative impacts of migration as being dense and unstable, labor force are becoming less in forests.

Increasing of job opportunities has an important role in preventing of unemployment and negative effects of migration on urban areas. Sources of income are very limited in Turkish forest villages. For this reason, forest villagers and cooperatives have rights. According to these legal rights, forest villages and cooperatives have priority in forest works (Ornek, 2010).

The benefits from forests are not limited. Another important issue is non-wood forest products (NWFP). In these forests and wood products produced outside

THE SITUATION OF NON-WOOD FOREST PRODUCTS (NWFP) IN TURKEY

Increases on people interest on natural resources were seen by increasing population and development of life quality. Turkey has three different floral regions because of its location like a bridge between Asia and Europe. Therefore, there are approximately 10000 plant species in Turkey. 3500 of them are endemic plants. However, only 2650 endemic plant species exist in whole European continent. Many products are produced from root, trunk, branches, leaves of trees as raw material for medical, cosmetic, chemical and paint industry (Ege Orman Vakfi, 2012).

Over 100 plant species are used in medicine, food, paint, cosmetics and leather industry. Besides these benefits, forests are limited areas for living conditions and livelihoods. In many countries, particularly developed countries, including special programs for the forest villagers living in these areas are applied All kinds of vegetable and animal products which grow in forest and forest openings are evaluated for usage and commercial purposes. These products are called non-wood forest products-NWFP. Although, the framework of this definition is very large, the main products in Turkey are mainly balsamic oils, and other non-wood forest products which are derived from leaves, flowers, fruits, cones, seeds, bark and roots of thousands of woody and herbaceous plants.

Usage of plants for people in nature is as old as human history. Since the beginning of life, people used plants for food, fuel and construction of weapon and housing. Plants are sources of food. Also, plants are used as medicine. The most of the people in Turkey is interested in wild plants. For this reason, plants are classified as food, medical, spice, natural tea, paint, perfume, pleasure and decorative ornamental plants.

SOME IMPORTANT NON WOOD FOREST PRODUCTS AND THEIR USAGE IN THE LAKES DISTRICT OF TURKEY

The Lakes District is located in the South-western part of Turkey and it is called for many lakes like Beysehir, Acigol, Burdur, Egirdir, Kovada, Kestel and Salda lakes. This region includes Antalya, Isparta and Burdur cities with a total area of 36672 km². Beysehir, Egirdir, Acıgol, Burdur, Ilgin (Çavuşçu), Aksehir, Eber, Salda and Kovada lakes are main lakes. Grain, fruit and vegetables and also sugar beet are cultivated. Other economic activities are brimstone, rose and rose oil producing, carpet weaving, animal husbandry (particularly for sheep and goats), forest products, and sugar industries.

The Lakes District is a rich region in non-wood forest products. Some important non wood forest products and their usage fields are given in Table 1.

Table 1. *Non-wood forest products of the Lakes District of Turkey and their usage*

Plant	Features	Usage Field	Usage Type
Achillea millefolium L.	The leaves are hairy and fragmented the flowers in white, pale yellow or golden yellow in color. The plant is a herbaceous perennial.	Blood-cutter, preventive migraine and ovarian inflammation. It is used in treatment of hemorrhoids and rheumatism.	Used as an ointment and sits baths, and also herbal tea.
Agropyron repens L.	It is a perennial plant. Its roots are used.	Calcification inhibitor, diuretic and blood cleanser.	Dried and used for boiling in water with their roots.
Arbutus andrachne L.	It is a plant with orange or bright red fruit and white flowers.	Jam, marmalade, jelly, and even used in making perfumes.	It is used in food and cosmetic purposes.
Arbutus unedo L.	Green leaves, white flowers, red fruit.	It is used as germicidal against dermatitis and urinary tract, arteriosclerosis and against liver disease.	Herbal tea.
Artemisia absinthium L.	This plant is grayish or whitish-green color, split leaves. It has red flowers.	Intestinal worm remover, pain reliever and It is used in making liquor.	It is used for food and herbal tea.
Berberis vulgaris L.	Yellow or orange flowers, red fruits.	Appetizing, prevents vomiting, thirst expectorant, digestive disorders, removes cough cuts, tension regulator, and improve oral wounds	It is used for food and herbal tea.
Castanea sativa Mill.	The leaves are elliptical, and flowers are yellowish.	It is used in therapy of pertussis disease and constipation, as blood pressure regulator and in confectionary.	The leaves bark and fruits are used. It is used for food. It is eaten as raw, by boiled or fried in fire.
Ceratonia siliqua L.	Greenish-yellow flowers, fruits are brownish purple color.	It is used against diarrhea, making spirits, rum and molasses.	Its fruit and seeds are used. Also, It is used for producing drink and food.
Cistus creticus L.	The upper side of leaves is hairy green. It has pink flowers.	It is used as expectorant and raw material in perfume industry.	Shoots flower and leaves are used. It is used also in cosmetic industry.
Crataegus monogyna Jacq.	It has green leaves and red fruits.	It is used as a regulator of heart disease and high blood pressure.	It is used as herbal tea. Fruits can be eaten.
Cotinus coggygria Scop.	Green leaves and yellow flowers	It is used against throat and gum disease, as yellow paint for fabric and leather and against diarrhea.	The leaves and fruits are used as mouthwash, herbal tea and paint material in textile industry.
Erica arborea L.	Flowers are pink colored.	Diuretic	Herbal tea. Its root is used in making tobacco pipes.
Glycyrrhiza asymmetrica Hub-Mor	Flowers are in blue color. Fruits are reddish-colored in the form of bean. The roots are used.	Sputum relievers and diuretic. Reduce to effect of nicotine.	Roots and rhizomes are used. It is used in the manufacture of coke and beer.
Hypericum perforatum L.	Flowers are yellow colored.	It is used in therapy of burns and wounds and also against depression, asthma and bronchitis.	Flowers and buds are used. Its oil is used and drink as tea.
Juglans regia L.	It has core and juicy fruit. The leaves are aromatic odor.	It fixes digestive disorders, constipation and anorexia. It is blood stopper, intestinal worm remover and regulates cholesterol.	Fruits and leaves are used. Fruits are eaten and leaves are used as tea.
Juniperus oxycedrus L.	Small cones are round or pear shape. The seed is composed of bright brown-red colored stamps. The needle leaves are jagged.	It improves skin diseases.	Its wood is used in medicine and perfumery industry. Oil is extracted and external use. The plant itself is used for decorative purposes.
Laurus nobilis L.	The leaves are dull and light green. It has bluish black-colored fruits.	Diuretic and diaphoretic. It prevents fatigue, and indigestion It used as a sweetener and in manufacturing of soap.	The leaves and fruits are used. It is used as spicy and in cosmetic industry.
Lavandula stoechas L.	It has pink and purple color flowers.	It relieves pain and stops sputum production, removes drowsiness.	Flowers and leaves are used. It used as herbal tea.
Malva neglecta Wall.	Each side of the green leaves and leaf stalks are covered with feathers. Flowers are purple color.	It is good for respiratory tract dermatitis. It curatives common cold and cough. It is good for skin diseases and mouth sores.	Seeds, roots, flowers and leaves are used. It is used as herbal tea. The leaves are eaten porridge made..
Matricaria chamomilla L.	The leaves are thin pieces. Middle part of the flower is yellow. It has white colored flowers.	It reduces fewer, kills pain and solves spasm, calms the nerves. It resolves inflammation of throat, tonsils and gums.	Flowers are used as herbal tea. It is used in cosmetic industry.
Menta longifolia L.	Toothed edges, and a thin light green leaves are covered with feathers. Flowers are lilac in color.	It is used as nausea relief, diarrhea preventer.	Leaves are used as spicy and herbal tea. It is used in producing of mints and gum. It is used in soap, toothpaste and creams in perfumery industry.
Myrtus communis L.	It has different colored leaves and fruits and dark green color leaves.	It heals wounds. It is good for the spider and scorpion stings.	Leaves, shoots with flowers, fruits and seeds are used. It is

			used as spicy in cosmetic and perfumery industry.
Origanum minutiflorum O.Schwarz Et P.H.Davis	It has small shrublet of many spikelets with grayish and hairy leaves, and also pale pink flowers .	It is stopper of stomach and head pains, It is cholesterol and blood sugar reducer. It is good for the respiratory and digestive system disorders.	All above-ground organs are used. It is used as a spice. Oil is extracted. It is used as herbal tea.
Rhus coriaria L.	It has red color fruits.	It is used in dyeing of leather and fabric. It is used for skin diseases, reducing fever, relieving intestinal regulator.	The leaves bark and fruits are used. It is used as spicy, coloring matter and herbal tea.
Rosa canina L.	Flowers are pale pink in color. Fruits are yellowish-red color.	It is used as tan article in paint and leather industry and external sugar in some parts of the pharmaceutical industry.	Fruits and crown leaves are used. It is used as herbal tea and marmalade.
Rubus caesius L.	Flowers are pink and white color. These flowers become fruit similar to a reddish-black color mulberry.	It is used as cancer prevention, blood purifier, wound and burn healing, relieve diarrhea and against mouth and gum diseases.	Fruits and leaves are used as food and herbal tea.
Salvia officinalis L.	Leaves are long-necked, hairy gray-silver color. Flowers are purple colored.	It is curative for dental inflammation and mouth sores. It is used as pain killer and relieving stomach diseases.	Leaves and flowers are used as spicy and herbal tea. Oil is used.
Tilia platyphyllos Scop.	It has white and yellow flowers. Fruits are small and round shape.	Calming the nerves, intestinal worm reducer, and cough reliever. It is used in skin cleaner.	The leaves, flowers and barks are used as herbal tea and for making skin cleansing lotions.
Urtica dioica L.	The leaves are dark green color and shine. It has burning plume. It has brown color and nuts type fruits.	It is effective evacuation of the urinary tract, flushing and rheumatic edemas.	The leaves are used as herbal tea.
Viscum album L.	It has two opposite leaves at the end of the branches, similar to the olive leaf. There are yellowish-white small flowers at the ends of branches. Fruit is white and sticky.	It reduces high blood pressure. It is used for calming the nerves, removing nervous spasms It relieves palpitation. It regulates the metabolism and useful against atherosclerosis.	Leaves and young shoots are used. It is used as herbal tea. Fruits should not be used

CONCLUSION

The importance of non-wood forest products and forest resources management benefits provided by these sources and emphasis on the necessity of awareness and interest has increased in recent years. As a result of this, it is seen that non-wood forest products make more contribution than forest products in some countries and some regions of countries. Also, in some countries it is among the main sources of revenue in foreign trade (DPT, 2001).

Usage fields of medicinal and aromatic plants are rapidly expanding and consumption is rapidly increasing in around of the World and also in Turkey (Baydar, 2009). Approximately 60 medicinal plants are naturally present in the Lakes District. Annual revenue from NWFP is about 60 million dollars for Turkey. Also, the amount of wood and wood products exports per year is average 2.1 billion dollars in recent years. Forest villagers who harvest the gain is achieved by only 7% of revenue. Unconscious harvest works cause damage on natural resources od NWFP. This faulty application threatens of plants generation. In addition to this, smuggling of plants is big problem (Genc, 2008).

The importance of non-wood forest products is increasing day by day. As its location, the Lakes District has very rich species diversity. There are a lot of plants which have not investigated yet. Benefits of these plants should be investigated and also they should be planned by without threaten of their existence. It is very important to preventing of plant smuggling. Non-wood forest products are valuable for the economies of both countries and of humanity.

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ORGANISATION OF FOREST ENTERPRISE AND IT S INFLUENCE ON CAPACITY TO MANAGE NATURE PROTECTED AREAS

Zoran PODUŠKA, Ilija ĐORĐEVIĆ[1]

Abstract: *Nature conservation is of strategic importance for Serbia. Nature is protected in order to preserve biological, geological and landscape diversity and the sustainable use of natural resources in accordance with human activities, social and economic needs and plans.*

This paper analyzes the state of organization in nature protection and its capacity to manage in protected areas. The analysis included all type of organizations that manage nature protected areas. The aim of this study was to determine the capacity of organizations for manage the protected areas. The purpose of this research was to determine the most appropriate form of management of protected areas. The survey was conducted using structured questionnaires.

It was found that the management of protected areas affecting state institutions and enterprises, local governments as well skills and experience of employees. Competencies and needs of the parties involved in the management are often confronted toward expectations that natural resources should contribute to the successful management of the company and a better life for the population in the areas under protection, in the same time on the same place.

Key words: organization, improvement, state enterprise, diversification, services

INTRODUCTION

The success of organizations in management of protected areas is in their capacity to acquire new business opportunities as well as new knowledge in all domains. According to Drucker, jobs in the organization, regardless of size, must be managed in an entrepreneurial way for the company. More and more companies, regardless of size, financial strength and ownership relations, begins to behave entrepreneurial, adopting the basic principles of business and entrepreneurship using entrepreneurial management. Nature protection is from strategic importance in management of natural resources, therefore organizations which manage protected areas are faced with demand to "strive for the best possible economic results from the resources currently employed or available" (Drucker, 1963).

Historically forest sector in Serbia has been an important industry for national economy, particularly for purpose of reconstruction of country after wars as well as for wellbeing of rural population. Industrialization and migration people from rural to urban areas open space for changing in functions of nature ecosystems. Many ecosystems became protected areas by function instead of production but still economic important areas in a way of resources utilization. Even in protected areas some management objectives like tree harvesting have importance in sustainable use of resources. Similar results are shown by Eagles, McCool and

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Haynes who claim that biodiversity protection in protected areas is far from purely purpose of protected areas and often not a primal goal in management of protected areas (Eagles, 2002. p. 10)

Concept of capacity in management of protected areas has been used in several contexts: governance in forestry (Secco, Da Ra, Gatto, & Tasso, 2011) as well analysis of protected area management effectiveness (Leverington, Costa, Pavese, Lisle, & Hockings, 2010). In governance analyze Secco used capacity as one of seven key dimensions of good governance, defining it as: “Actors’ competences and experiences. Impartiality and professionalism by public sector. Collaborative learning. Capacity and willingness to transfer experience, competences and knowledge to interested actors. Experts systems included in decision making. Government’s social, educational, technological, legal, institutional ability to provide public access to decision-making (autonomy, independence, resources availability); ability of the civil society to make use of such access (analyze the issues and participate effectively)“ (Secco, Da Ra, Gatto, & Tasso, 2011).

Leverington and associates in analyze of management effectiveness in protected areas argued that financial and logistical support, especially in poorer countries, is an important component of increasing management capacity. They suggested that protected areas stuff have inadequate skills and training. In a context of organizations and institutions that manage with protected areas it is conclude that inputs, processes and outputs influence on capacity to manage with protected areas (Leverington, Costa, Pavese, Lisle, & Hockings, 2010). Inputs in management process on the organization level means: adequacy of staff member, adequacy of professional training, adequacy of current funding.

Organizations which manage protected areas need to have capacity for effective conservation. Protected areas are considered to be an effective conservation strategy if there are no gross ecological changes or destruction of habitat, or if these changes are less in protected areas than in comparison. This statement does not exclude tree harvesting rising the at least two questions: If forests are not harvested, to what extent is this due to good management? and Has the protection of some areas led to more clearing in other places? Proposed questions is analyzed from the point of forest enterprises who manage with protected areas (Avdibegović, 2006). Avdibegović proposed several scenarios for successful operating of forest enterprises in protected areas according to the multifunctional forest management: The first scenario assumes separating protected areas from the forest management area system and forming special public authorities responsible for their management. The second scenario assumes that forestry companies will remain to manage protected areas, but with radical change in forest management concept and business philosophy in general. Intermediary alternatives are also applied worldwide and they mean joint management of protected areas on the basis of coordinated activities of public authorities and forestry companies (Avdibegović, 2006).

It can be assumed that satisfactory capacity for management in protected areas rely on several conditions. Conditions are based on consideration that social and environmental issues go together with economic ones.

Compound of above mentioned theoretical and empirical statements lead to set of conditions for organizational capacity to manage in protected areas:

1) skills and expertise (present know-how plus confidence to be able to obtain know-how needed in the future)
2) adoption of new technologies, processes and procedures
3) improvement of existing products and services
4) a supportive environment (conditions and policies that provide comfort and support to the organizations).

Individual characteristics and personal goals of managers are influential factors that play a major role in business performance and organization capacity to manage with protected areas. Coherence between political decisions and individual indicators are essential condition for effectiveness in management of protected areas.

METHODOLOGY

This study compares characteristics of the general population of managers in nature protected areas in Serbia. Study was carried through three phases. In the first phase a review of literature is conducted. In the second phase survey questionnaire has been constructed and pretested with employees in forest organizations which manage protected areas. Questionnaire was pretested face to face and corrected according to respondent suggestions. Capacity to manage nature protected areas is measured by:

Employees performance
- training needs,
- professional training,

Opportunity recognition
- business opportunities,

External factors
- political influence.

Attitudes, perceptions and behaviors of respondents was measured according to the answers in structured questionnaire. In the third phase sample was chosen from target population. The target population included all nature protected areas in Serbia. The sample consisted of one representative of organizational unit which manage with protected areas. Questionnaires were sent by mail on the 109 addresses. Before sending all organizations were announced about research goals and kindly asked to participate in the research. After three weeks to all non respondents was sent reminder about questionnaire. At the and 41 usable questionnaire was received. Response rate is 38%.

All responses were uploaded in the appropriate data base constructed for that specific purpose. At the end of the third phase all attitudes of respondents was analyzed in descriptive statistics regarding each measurement scale.

RESULTS

Origins of the legal nature conservation in Serbia reach far into the past, and the first regulations to protect nature and preserve natural resources date back to the fourteenth century. The first area, which is under protection in the territory of Serbia was Obedska bara, even under the protection of the 1874th year. The forest reserves Ostrozub, Mustafa and Felješana around Majdanpek town was proclaimed in the year 1948. The first national park in Serbia was Fruska Gora, declared in the1960th. On the basis of concrete measures of institutional protection of nature for more than six decades, the size of protected areas in Serbia is currently at 522,789 ha, or 5.92 percent of the territory of Serbia. Spatial Plan of the Republic of Serbia (RS, 2010), it is envisaged that by the year 2015. to be protected about 10% of Serbia, and that by 2021. around 12% of Serbia's territory need to be under some form of protection.

Under the protection of natural resources there are 464 sites:

- 5 National Parks;
- 16 nature parks;
- 16 areas of outstanding features;

- 68 nature reserves;
- 1 protected habitat;
- 42 areas of cultural and historical significance;
- 316 monuments of nature.

The total area of all National parks is 158986,40 ha or 29, 0% of the total area of protected areas in Serbia about 7% of the total growing stock in Serbia. Nature and other protected areas in Serbia include 280256,40 ha or 51,2% of the total area of protected areas. For general and special natural 94323,60 ha or 17, 2% of the total area of protected areas in Serbia, and the cultural and historical landscapes 106,31 ha, respectively, 0,07% (Ostojić & Vukin, 2007).

Protected areas are managed by different kind of organizations. Organizations for management of nature protected area are established by government or dedicated by government to manage specific area. Organizations types are: State enterprises, Non-government organizations, Public organizations established by municipality/town, Commercial organizations, Other state organizations like hospitals, army, and Church too. Organizations are of different sizes, number of employees and its education, attendance of professional training. Protected areas are dedicated to different organizations for future management on different area under protection. Distribution of protected areas per different type of organizations and area under protection are shown in Table number 1.

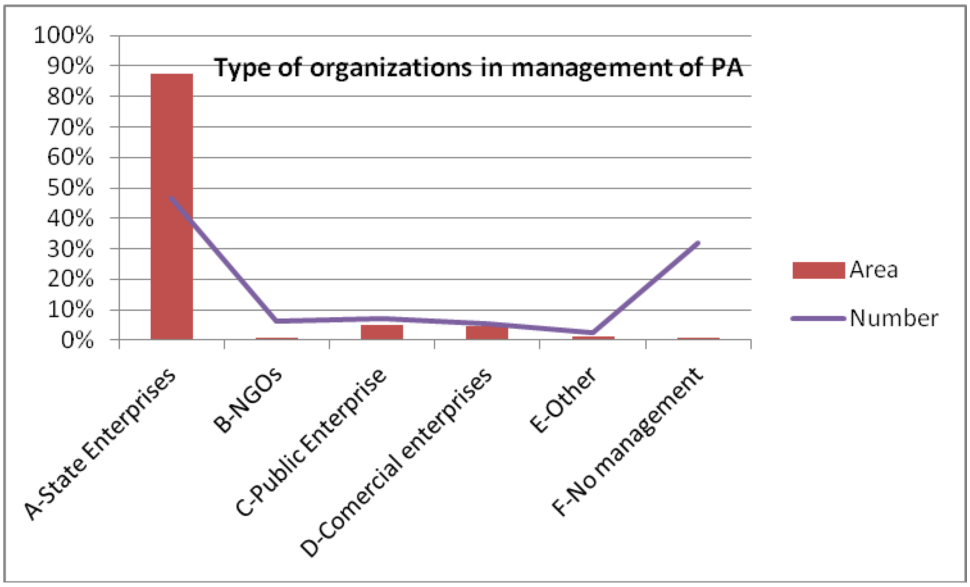

Table 1. *Distribution of number and area of protected areas per type of organizations*

Management of protected areas in most cases is responsibility of State enterprises. State enterprises manage all national parks and other protected areas in 47% of total number of protected areas. Under direct management control of state enterprises there are 88% of protected areas. Non government organizations is dedicated to manage with 1% of protected areas with 6% of total number of management organizations. Public enterprises established by local administration managed with 5% of total protected area with 7% of all organizations. Commercial enterprises manage with 4% of total area under the protection with 6% from total number of organizations. Other organizations like hospital, army as well as church manage with 1% of areas under the protection with 2% out of all organizations. For 32% protected sites there are no organizations dedicated to manage. Those protected areas without management occupy 1% of all areas under protection.

In order to measure adequacy of professional trainings respondents are asked about frequency of attending in professional trainings. They can choose between tree answers: never attend professional trainings, rarely attend professional trainings and normally. Frequency of attending professional trainings is shown in Table number 2.

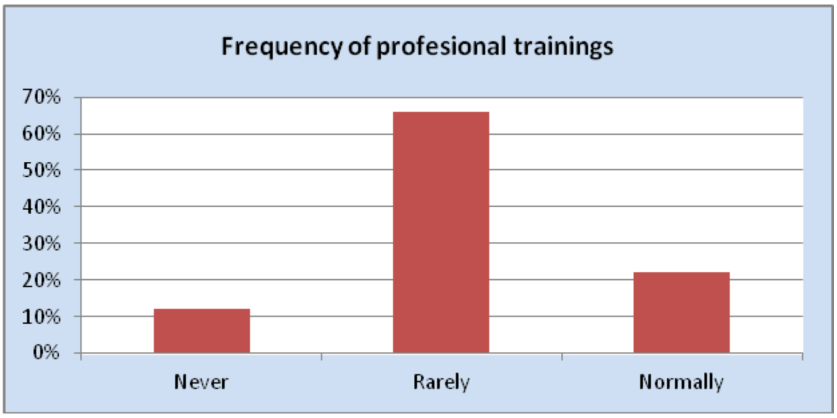

Table 2. *Frequency of professional trainings in organization for management Protected Areas*

The 66 % of respondents claims that rarely attend professional trainings. On regular basis 22% of respondents attend professional trainings and 12% never attend it.

On question about training needs assessment respondent could choose between six answers: trainings in computer skills and information technologies, foreign languages, seminars and exhibitions, professional journals, new vocational information and other trainings. Multiple answers was possible. Training needs assessment for employees in organizations for management protected areas is shown in Table number 3.

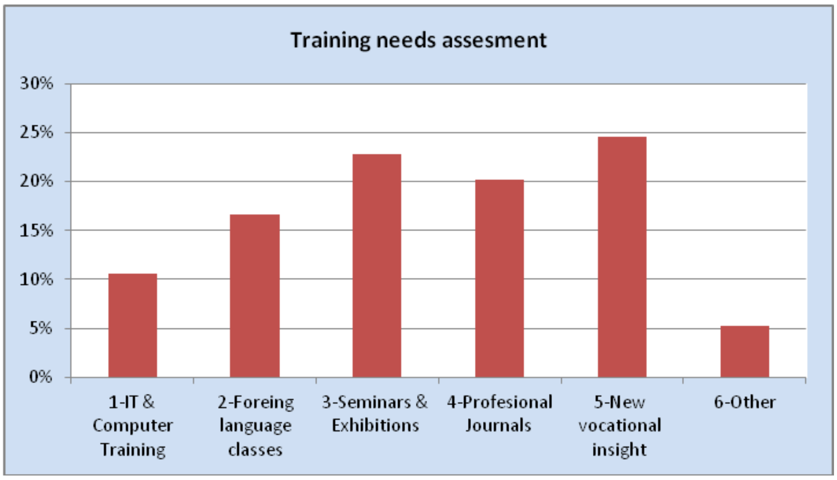

Table 3. *Training needs assessment for employees in organizations for management Protected Areas*

Computer training needs 11% of respondents, additional education foreign language needs 17% of respondents. Attendance of professionals seminars and exhibitions 23% of respondents consider as important for training, 20% of respondents needs professional journals as a tool for training New vocational insight as way of gaining new knowledge specific for they job is important for 25% of respondents, 5% of respondents choose other ways of professional trainings . They ask for trainings in writing a project proposals and exchange of knowledge and experience with colleagues from other protected areas.

Influence of policy and political parties on management in protected areas has been measured according to opinions of respondent. Respondents are asked do policital parties have influence on management in protected areas. They can choose if influence occur, if influence neutral or if influence doesn't occur. Frequency of respondents opinion about influence of political parties on management in protected areas is shown in Table number 4.

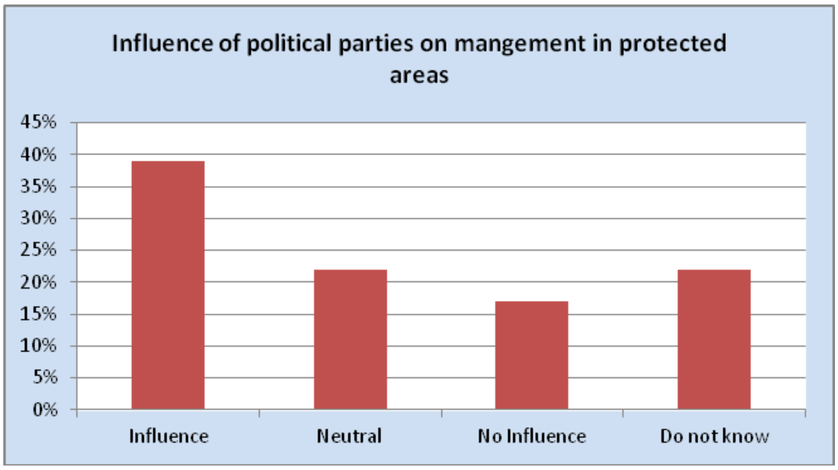

Table 4. *Influence of daily policy and political parties on business operation and management in protected areas*

Influence from daily politics perceive 39% of respondents, neutral attitude toward political influence have 22% of respondents. Seventeen percents of respondents think that there are no influence from political parties on management in protected areas, 22 % of respondents have attitude that they do not know about influence from political parties on management in organizations who manage in protected areas.

Respondents are asked for attitude how they perceive future of their organization. On question about opportunities for business development in organizations for management of protected areas respondents have opportunity for multiple choices. Frequencies of respondent opinion about best way to business in organization for management of protected areas are shown in Table number 5.

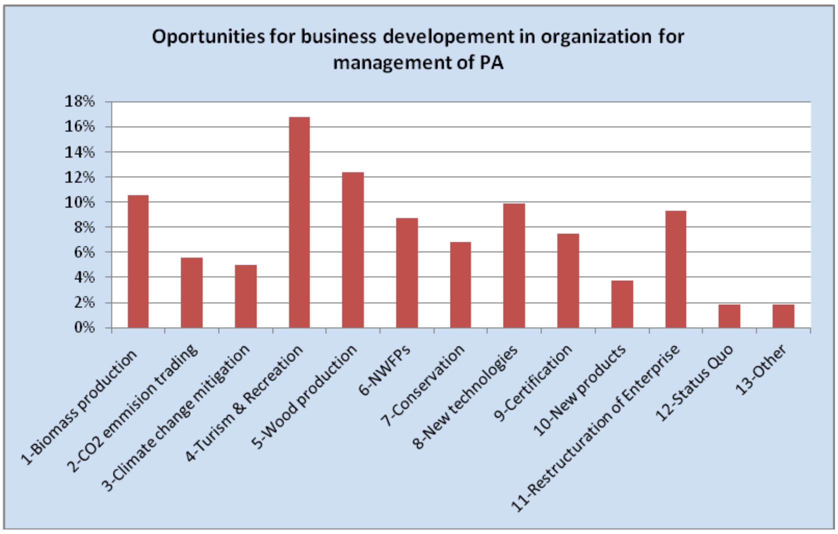

Table 5. *Opportunities for business development in organization for management of Protected Areas*

Biomass production other than wood production is an option for 11% of respondents, 6% claim that future of organization for management of protected areas is in CO_2 emission trading and 5% have attitude that influence of trees and biodiversity on climate change mitigation could be the best business orientation. Tourism and recreation services have been seen as opportunity for organizational development from 17% of respondents. Still 12% of respondents rely on wood production and 9% of respondents think that production, collection and trade with non wood forest products is option. Conservation without any production function in protected areas is option for 7% of respondents. Adoption of new technologies is option for 10% of respondents, certification for 7% , development of new products 4 %. Restructuration of enterprises 9% and opinion that nothing need to change is 2%. Other as opinion is 2% of all respondents.

Respondents are asked for attitude how different sources of financing influence on organizations capacity to manage in protected areas. They can chose between six sources of financing: Donations, revenues from Tourism and recreation, Collection and trade with Non wood forest products (NWFP), Revenues from Wood trade, Finances from municipal level and finances from Ministries. Respondent could choose if financing have influence, if financing neutral or without any influence on management of protected areas. Do not know was the option, too. Influence of financial sources on capacity to manage in protected areas is shown in Table number 6.

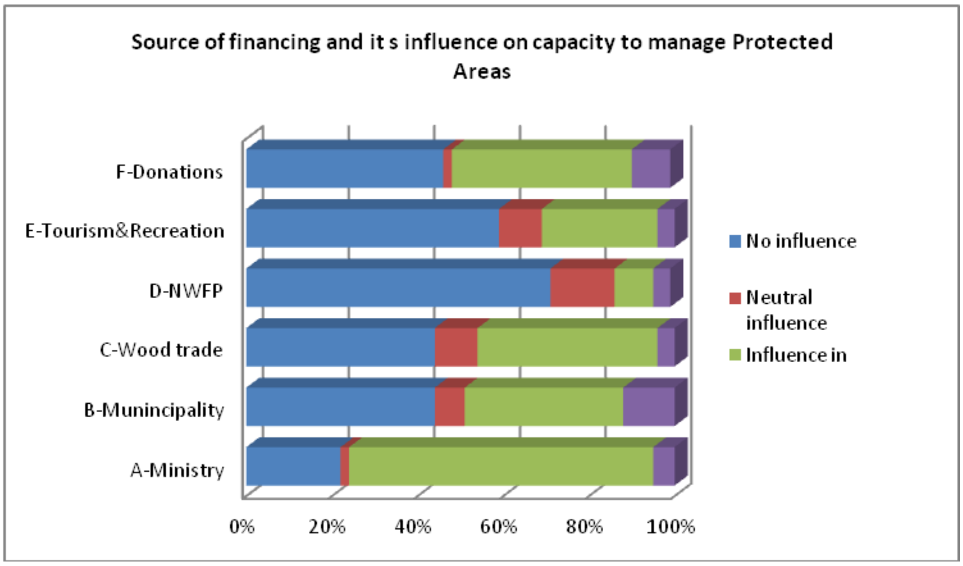

Table 6. *Source of financing and it s influence on capacity to manage Protected Areas*

International donations: have no influence for 46% of respondents, influence is neutral for 2% and influence is important for 42% of respondents on 9% claim that they do not know does donations have influence in capacity to manage in protected areas. Revenues from tourism and recreational services: have no influence for 59% of respondents, influence is neutral for 10% and there is some influence claim 27% of respondents, 4% claim that they do not know does tourist and recreation service have some influence on capacity to manage in protected areas. Collection and trade with non wood forest products: have no influence on organizations capacity to manage in protected areas for 71% of respondents, for 15% of respondents it is neutral for 42% it is influential in managing of protected areas. Four percents claim that they do not known if there is any influence from NWFP. Wood trade has influence according to 42% respondents, no influence in 44% and influence is neutral in 10% out of all respondents. Four percents claim that they do not known if there is any influence from wood production. Financing from municipal level have influence in 37%, no influence in 44% and neutral influence in 7% out of all responses. Twelve percents of respondents claim that they do not know how financing from municipal level influence in their organization. Financing from Ministry have influence in 71% of responses and no influence in 22% , 5 % respondents have attitude that they do not know how financing from Ministry level influence in their organization, 2% thing that influence is neutral.

DISCUSSION AND CONCLUSIONS

Nature protected areas are established to fulfill demands toward conservation of biodiversity as well as variety of social functions like tourism, recreation, cultural and amenity functions. Beside biological and ecological importance, a number of authors emphasizing economical importance of protected areas. Capacity to manage cannot be summarize by one value (Tomićević & Milovanović, 2006) and in one contexts. It need to be measured in a context of governance of protected areas, including multiple dimensions. Similar statements have been presented by Hocking were dimensions for capacity to manage was broadly discuses and it include: political support, community support, stuff resources, adequacy of funds and similar (Hockings & Phillips, 1999).

In this research capacity to manage protected areas regarding professional training indicate that 78% of staff never or rarely attend professional training i.e. they miss professional training. Influence from political parties on capacity to manage is felt by almost forty percent of management staff were only 17% doesn't feel political influence. Management stuff behaves very entrepreneurially while finding opportunities for future management. They plan activity in protected areas in a more diverse way. Employees see diversification of activity mostly into tourism and recreational services. But still reality is that main income in a most of protected areas comes from wood production. More diverse activity could be biomass production and collection and trade with non wood forest products. Organizational changes like restructuration of enterprise and adoption of new technologies encounter is in 9 and 10% of answers. Just 2% of management stuff thinks that nothing needs to change. Financing from different sources have strong influence on capacity to manage in protected areas. Most important source of financing is from Ministry. On the second place is financing from municipal funds and from wood production and trade. Still there are no influential financing from tourism and recreation for most of the organizations with promising plans that recreation services should future business orientation for majority of organizations.

In analyze of management of protected areas from organizational level the point is made that responsible entrepreneurship can play a major role in improving the efficiency of resource use. This point is in under attention from Rio conference and Agenda 21 were efficient and responsible entrepreneurship put into the context of sustainable use of natural resources.

Organizing of management in protected area is of strategic importance for each country. There are several scenarios where organizations involved in management of protected areas operate. State forest enterprises manage protected areas in a sustainable way using wood as a main and most frequent product. On this scenario Avdibegović assumes that forestry companies will remain to manage protected areas, but with radical change in forest management concept and business philosophy in general (Avdibegović, 2006). Same author proposes separating protected areas from the forest management area system and forming special public authorities responsible for their management or joint management of protected areas on the basis of coordinated activities of public authorities and forestry companies.

All of these scenarios have been used in Serbia but still capacity to manage in protected areas lack in funds and employees training. Sample organizations show that many employees lack in professional trainings. Respondents feel that attending of seminars and exhibition needs them to improve their capabilities to manage protected areas in a more efficient way. The most of respondents need new knowledge and experiences in their specific business area. There is lack in computer and IT fluency as well as in foreign languages. On the other hand daily policy is very present in top level management with questionable results in gaining of capacity to manage.

Having in mind difficult economic situation, traditionalality of forest sector and demands of society it can be proposed at least one strategic orientation for organizations which manage protected areas. Strategies should go in a way of diversification into tourism and recreational services. Recreational services are part of environmental services and need to be planed by each organization in protected area management. Beside planning in activities, valuation of recreational services is still open issue and need to be performed in a future (Ranković & Keča, 2007). Diversification into recreational services will lead to financial autonomy of organizations as well as multifunctional management of protected areas which imply harmonising numerous benefits from the protected areas. The requirements for such organization which have capasicty to harmonise numerous of benefits rely in competencies and needs of the employees and managerial stuff and need to be in line with expectations that natural resources should contribute to the successful management of the company and a better life for the population in the areas under protection, in the same time on the same place.

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THE RISE AND FALL OF THE PRIVATE FORESTRY SECTOR INITIATIVE IN CROATIA

Konrad KIŠ[1]

Acronyms:
CEPF - Confederation of European Private Forest Owners
CUPFOA - Croatian Union of Private Forest Owners Associations
GWFF - general welfare forests function
GWFFF - general welfare forests function fund
PFO - private forest owner
PFOA - private forest owners' association
FES - Forest Extension Service
JLO - Joint Labour Organization

Abstract: *This paper shortly describes the development and failure of the private forestry sector initiative in Croatia regarded through the aspects of contemporary political situation and inherent sectors (agriculture, nature protection), giving a short history of the development of forest policy regarding private forests and describing how policy makers are still, to a very high extent, influenced by the general politics.*

It was not before the 3rd millennium that private forestry sector in Croatia started to develop. This changes were driven by the general transition process accompanied by the process of integration to the EU and, of course, personal interests of the parties involved (their leaders, to be more precise). In the period 2005-2007, two important forestry institutions were founded (Forestry Chamber and the Forestry Extension Service) as well as numerous PFO organizations. These organizations were later gathered under the umbrella organization of the Private Forest Owners' Union, which set an ambitious goal of joining the CEPF in near future.

As part of the anti-recession measures, the Government shut down the Forestry Extension Service by the end of 2010 and the Parliament amended the Forest Act in a way that declared the monopoly of the state forest company over all jurisdictions in private forests. The PFO Union ceased with all activities and was simply snuffed, which brings the question if it represented the interests of PFOs in the first place. These events by the end of 2010 definitely marked (hopefully, only temporarily) the failure of the private forestry initiative in Croatia.

In other words, the pre-requisites for the beginning of a sound forestry policy-making process in Croatia have not yet been acquired.

METHODOLOGY

This paper was designed as a review article based on the analysis of two decades of forestry and inherent sectors legislation changes since the founding of Croatia as an independent state and their effects to the wider forestry sector. Due to zero budget and insufficient temporal resources, no official research has been conducted on this matter – the analysis consisted of literature review, comparison of former and contemporary Forest Acts and inherent acts as well as peers' articles, informal discussions with colleagues and PFOs, qualitative assessment of

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Internet forum discussions regarding this topic, official data obtained on demand and, above all, personal experience. For these reasons, this is not in any way a scientific article because it, in the first place, lacks scientific scrutiny and methodology. Its intention was not, however, to be a scientific article but to encourage forest policy makers, scientists and students to endulge in one, since author is currently not in the position to conduct extensive or any other scientific research whatsoever.

This fact does not, however, lessen the importance of the topic since it deals with major political decisions and global changes which could affect the Croatian forestry sector greatly and which are, by all means, knocking on the door as we speak.

INTRODUCTION

The intention of this paper is to describe, in short terms, the development of Croatian forest policy since the country's independence till nowadays, with a special emphasis on private forestry sector.

Croatian forestry in general emerged as a phenomenon shortly after the founding of Croatia as an independent state. Two major steps were the enactment of the first Forest Act in December 1990 and founding (by the very same Forest Act) of "Hrvatske šume" (=Croatian Forests) stock company - a state-owned company in charge of managing the state-owned forests and forest lands[1]. Until the disintegration of Yugoslavia, public forests were managed by forest districts which were conceptualized as the so-called "joint labour organizations", a legal entity typical for communist Yugoslavia, very much alike the nowadays forest districts (apart from the fact that the latter are only organizational units of a company, while JLOs were independent profit centres, i.e. they behaved as individual companies).

Not much had happened during the 90ies; the war that occurred in the early years halted the development of any policy, not just forestry, and the issue was put aside for the next decade - one third of the country was occupied for almost five years and many afforested land is still covered with mines. The only change in Croatian forest policy arena that occurred in the 90ies was the amending of the Forest Act: once in 1991 and twice in 1993, as well as the enactment of the Forest Regulation Ordinance in 1994 and 1997. These changes, however, considered merely technical details regarding forestry production and did not drive any major political changes - this had to wait until the beginning of the 3rd millennium when the situation has ripened and conditions for the emergence of a sound, integrative forest policy were finally fulfilled.

CHANGES IN CROATIAN FOREST POLICY IN THE 3RD MILLENNIUM

Generic changes in global politics regarding European integrations, i.e. continuous trend of new countries joining the European Union was the major political current which triggered changes in forest policy, rural development, agriculture policy and many others. The issue of Croatian forest policy development cannot be observed separately from other primary sources utilization sectors as well as the quarterly - nature and environment protection, which all consist of a variety of stakeholders with often conflicting interests and wide range of political power. At this stage, it is interesting and important to notice that joining the EU was an essential future goal for both major political currents in Croatia - Christian - Democratic Croatian Democratic Union as well as the left-oriented Social Democratic Party. Apart from their differences as two major opposing Croatian parties, what they have in common is a humiliating, poltroon and submissive pro-European politics *a priori* proclaimed as the "millennium target" and "everlasting aspiration" of Croatian nation. This politics started the process of adapting national legislation with the EU

[1] In 2002, "Croatian Forests" was reregistered as "Croatian Forests" Ltd., i.e. the company of shareholders with limited liability. It has, however, remained under state ownership all along.

policies and was firmly set by the enactment of the Law on Confirmation of the Stabilization and Accession Agreement Between the Republic of Croatia and the European Communities and Their Member States from December 2001. Croatia started drafting its forestry documents on a national level: the first document to be published was the National Forestry Policy and Strategy from 2003 which, among other things, recommends the founding of two very important new actors (parties) in the Croatian forestry arena: Forest Extension Service and Forestry Chamber. Forest Extension Service was founded by the Government's decision from June 2006 while the Forestry Chamber was founded by the Parliament, i.e. by the enactment of the Law on Croatian Chamber of Forestry and Wood Technology Engineers from February the same year. These two institutions were the main driving forces of changes in Croatian forestry, particularly regarding the private forestry sector.

Forest Extension Service was actually the Government's agency in charge of supporting the PFOs through advisory support, seminars, conducting of professional tasks in private forests, initiating founding of PFOAs and active participation in the international private forestry arena. Its activates were almost entirely financed from the General Welfare Forest Functions Fund, while state budget was burdened only by employees' salaries, offices rent and telecommunications bills.

Croatian Chamber of Forestry and Wood Technology Engineers is, like all chambers, a professional association aimed towards the consolidation of mostly chaotic state in Croatian forestry, particularly regarding illegal harvesting, licensing of legal and natural persons (entrepreneurs) in the forestry sector as well as conducting professional exams and authorizing of forestry engineers. Despite the strong political opposition from conservative foresters, the Chamber withholds and performs its duties even nowadays, although its achievements are highly obstructed by various external factors, i.e. institutional insufficiencies of the Forestry Inspectorate and extremely high level of corruption. Although the Chamber should, by definition, be independent, its performance is still highly influenced by the current strongest political actors ("Hrvatske šume" Ltd. and the state forest administration). The president of the Chamber is also an employee of "Hrvatske šume" Ltd. which is, to a certain extent, a conflict of interests since there is a great dispute between state and private forestry companies.

GENERAL WELFARE FORESTS FUNCTION FUND

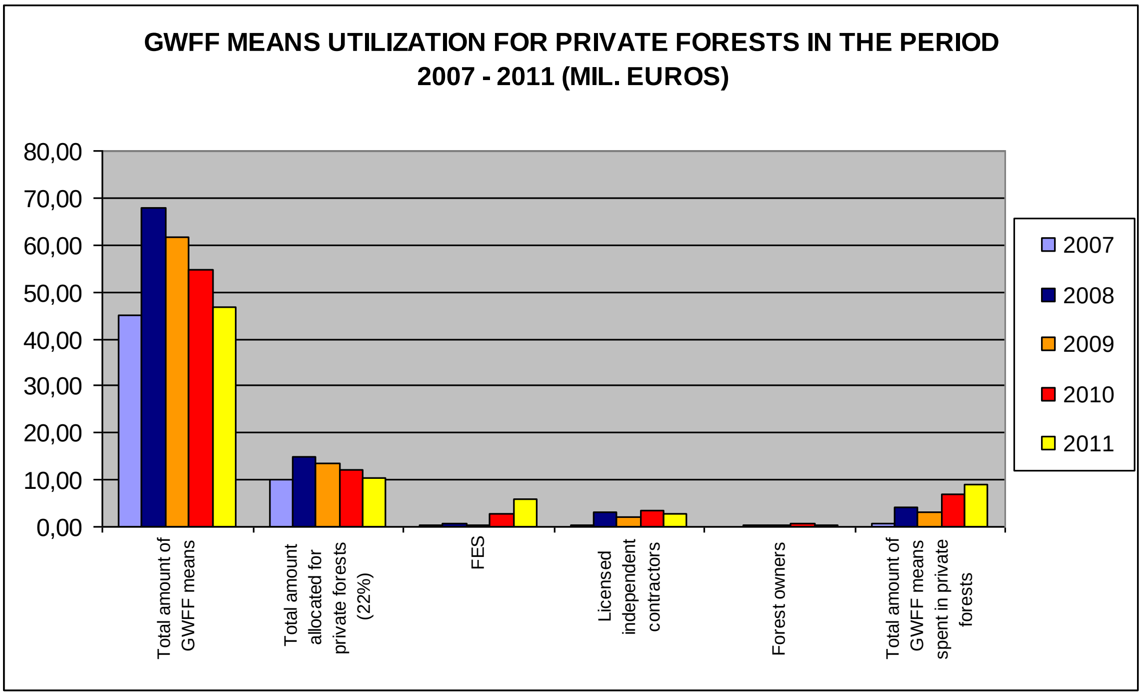
At this stage, it is very important to describe the GWFF levy, a non-tax revenue prescribed by the enactment of the first national Forest Act in 1990. This fund is meant for the management of all economically nonviable forests which cover a substantial amount of forest land in Croatia (mostly karst areas). By the first Forest Act, all legal and physical persons that perform economic activity in Croatia are obliged to pay this tax in an amount of 0,07% of their gross income. The means from this fund are strictly earmarked, as prescribed by Article 64. of the Forest Act: forest protection, biological rejuvenation, karst forests management, forest roads construction, mine cleansing, production of seeds and seedlings, drafting of management plans for private forests and financing of scientific research. This article has remained as it is through all the amendments of the Forest Act. The means from the GWFFF should have been divided proportionally between private and state forests, regarding the land coverage. However, the portion of the money intended for private forests was never fully utilized due to institutional insufficiencies in the private forestry sector (22% of means or, approximately, 90 million kunas or 12 million euros). The means from this fund were, and still are, the main factor of political dispute and struggle in Croatian forestry sector.

RISE OF THE PRIVATE FORESTRY INITIATIVE

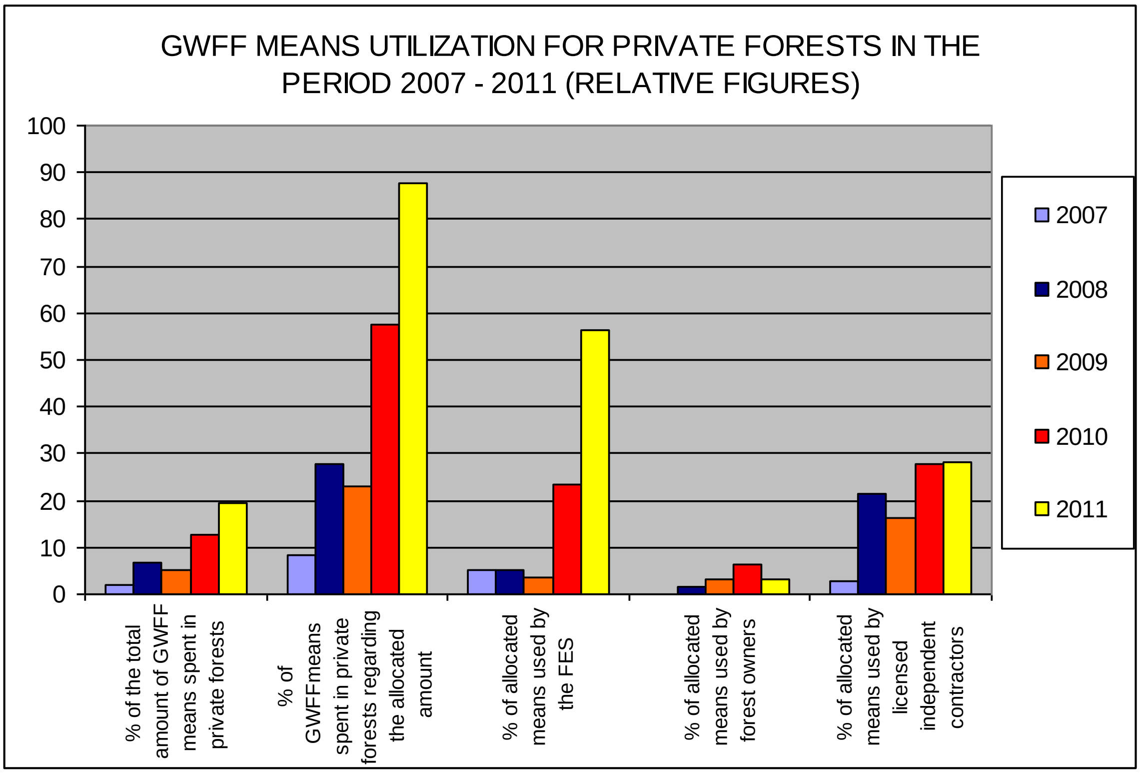
The major challenge for FES was to strengthen and consolidate private forestry sector in Croatia. Although with significantly limited resources, the Service managed to trigger substantial positive changes during the three years of its existence - it initiated the founding of PFOAs, intervened between the PFOs and state administration in drawing the incentives for biological rejuvenation (afforestation, reforestation and nursing) and made a series of contacts on the international level with various organizations/institutions whose primary area of interest is private forestry. When FES has become fully operational in 2007, it supported the extensive founding of PFOAs. The first three PFOAs in Croatia were founded in 2004., probably encouraged to a certain extent by the National Forestry Policy and Strategy and also by the introduction of private forestry department in the former ministry in charge of forest management. The founding of FES boosted this process to a large extent: in 2007 when 11 PFOAs were founded, while today this number had increased to the amazing 42.

When talking about the PFOAs, however, the issue of motivation is highly disputable. Although any PFOA president will state that her/his motives are pure and aimed strictly towards increasing the benefits for PFOs and improving private forestry, common sense teaches us otherwise. The motivation for engagement in the work of PFOAs is always, in various amounts, a mixture of declared interests, self-driven motives and a variety of political factors. Since heads of all government bodies (FES not being an exclusion) are appointed exclusively on the principal of political competence, the question is to what extent did the Service have a political influence in the founding of PFOAs and particularly in the process of appointing their leaders, as was indicated in several forestry Internet forums. The blatant example that supports this theory is the case of the umbrella organization of PFOAs, the Croatian Union of Private Forest Owners Organizations founded in 2008. The first head of this organization was a member of the Croatian Peasants' Party, the only party which went into coalition with the mainstream Croatian Democratic Union and won the elections in 2007. After the disintegration of FES by the end of 2010, this association ceased all activities and simply faded out from the forestry arena. The role of the main PFO leader was taken over by the former regional association of private forest owners (namely: *Alliance of Private Forest Owners, Forest Rights Holders and Private Forest Owners' Associations*) which later grew up to the national level and is nowadays *de facto* the main leader of Croatian PFOs.

Having a limited influence by the very definition (non-profit associations), the PFOAs couldn't do much to enhance the situation in Croatian private forestry sector. It was the FES that managed to draw the attention of PFOs and motivate them to start managing their forests in a more efficient way and begin the consolidation of private forestry in general. Direct incentives for PFOs were drawn from the GWFFF by recording PFOs forest holdings into the PFOs registry established by the Ministry and performing rejuvenation works in their forests. One type of regulatory policy instruments was, for instance, the provision of FES' internal ordinance on forest roads construction in private forests (later adopted by "Hrvatske šume" Ltd.) which gives advantage to PFOAs when applying for forest road reconstruction, maintenance or projecting. The data on utilization of GWFFF means spent for private forests best describe the progress achieved in Croatian private forestry sector:



Graph 1: *GWFFF means utilization for private forests in the period 2007 - 2011 (million euros)*



Graph 2: *GWFF means utilization for private forests in the period 2007 - 2011 (relative figures)*

These data clearly show positive trend in the development of private forestry, despite the fact that the amount spent by private licensed contractors and FES vary - the sudden increase in GWFFF means utilization regarding FES that happened in 2011 was due to takeover by "Hrvatske šume" Ltd. Final users, the PFOs, who are supposed to be the main beneficiaries of the GWFFF means intended for private forests have slowly but constantly started utilizing their share of money from the Fund. It is important to notice that the GWFF levy was collected not by the respective ministry but by the state-owned forest company, which later distributed the share allocated for private forests to FES who then paid for a part of its activities, private licensed contractors for their works as well as subsidies for PFOs. The share of money allocated for private forests which wasn't spent was not reimbursed to the tributaries, but rather spent illegitimately by "Hrvatske šume" Ltd. for state-owned forests, as Croatian Employers' Association – Association of Forestry, Game Management and Ancillary Activities pointed out in several occasions (this issue is still, quite justifiably, one of the main causes of dispute among the opposing parties in the forestry arena). For the purpose of this text, the figures represent only the amount that has been collected by "Hrvatske šume" Ltd. and not the amount that should have been collected according to the Forest Act (namely Article 62).

Even a cursory overview of the data shows that these means were highly under-utilized (the last column of Graph 1 which shows the total amount actually spent in private forests). Since the most financially demanding investments in forestry are drafting of management plans and construction of forest roads, it is not a surprise that most of the means were spent by the licensed independent contractors. The lowest and the most troublesome value in this graph is the amount used by the very forest owners (subsidies for rejuvenation works in their forests). These amounts have been gradually increasing from 2007 till 2010, followed by the drastic decline in 2011 - a fact which is very indicative in this story.

DRAMATIC CHANGES IN CROATIAN FORESTRY SECTOR - RECESSION OF 2010 AND THE BEGINNING OF FALL OF THE PRIVATE FORESTRY INITIATIVE

Global recession that took place in the period 2007 - 2012, by some analysts considered the worst economic downturn after the great depression from 1929, struck its peak in Croatia in 2010. The country's economy was falling apart, unemployment rate almost broke the record of 2003 and drastic saving measures had to be undertaken in order to cut the expenses in the public sector. Part of these measures was the Government's decision to abolish, reorganize, merge or in some other way change the existent array of agencies, public departments and institutions. Among the agencies that were abolished was also the FES. As it was previously mentioned, FES burdened the State budget with a negligible amount of approximately 10 million kunas per year which equals the amount of roughly 1,32 mil. euros, while all other activities consisted of merely directing the money from GWFFF allocated for private forests, i.e. helping the PFOs and other parties to use these means, thus improving the entire private forestry sector. FES was abolished by the end of 2010 and all employees and assets were taken over by "Hrvatske šume" Ltd. If it were private entities who were involved, this act would probably had been characterized as "hostile takeover". Most of the employees were brutally degraded, but none complained since salaries in "Hrvatske šume" Ltd. were much higher than those in FES, so any major resistance of FES employees to this decision lacked, although such treatment was the obvious violation of the ILO provision 111 and Principle 4.1.3. of the Forest Stewardship Council, which are one of many prerequisites for obtaining and maintaining the FSC certificate.

The decision to abolish FES marked the beginning of downfall of the private forestry initiative in Croatia which lasts ever since.

MAJOR PARTIES IN THE FORESTRY ARENA AND THEIR INTERESTS

In order to fully comprehend how the decision of abolishing of FES combined with the amendments to the Forest Act from October 2010 influenced the parties in this process, one has to know who the primary, secondary and peripheral parties are.

Primary parties in Croatian forestry arena are the state company for management of state forests - "Hrvatske šume" Ltd., public forest administration and private forest companies whose number has increased significantly since the beginning of the millennium. FES, being the Government's institution which ceased to exist cannot be considered as a party in this analysis.

Secondary parties are all PFOs who, due to the very low level of power, cannot be grouped as a primary party, all authorized forestry engineers who are not the employees of "Hrvatske šume" Ltd., forestry inspectorate, Faculty of Forestry whose interests traditionally converge with those of "Hrvatske šume" Ltd., which is one of its greatest financial supporters, as well as licensed independent contractors.

Peripheral parties are all people or entities who are in some way connected to forestry or forestry activities and can benefit or loose profit regarding the changes in forest policy. Most of these parties often dance on the edge of law and more often than not cross that edge, but are not directly involved into the drafting of forest policy. A peripheral party is also Croatian Forest Research Institute, since its interest in this matter is purely scientific.

The most disputable issue after the abolition of FES is the amendment of Forest Act from October 2010 which in Article 68 prescribes to "Hrvatske šume" Ltd. the jurisdiction over all professional works in private forests, regardless to the fact that there are many licensed private forestry companies - during FES' existence, all capital works in private forests (particularly drafting of management plans and road construction) were a matter of public procurement, i.e. these jobs were distributed via public tenders. The amendment, basically, legalized the monopoly of a state-owned company over private property which was a practice from times that were thought long gone and forgotten.

Of course, the main opposing party in this matter - licensed private forestry companies, lead by the Croatian Employers' Association – Association of Forestry, Game Management and Ancillary Activities – immediately triggered the dispute process, followed by a series of legal charges against "Hrvatske šume" Ltd. and even a constitutional complaint. The success of these initiatives was partial: the constitutional complaint was declined, but the Croatian Competition Agency has issued an affirmative decision regarding the Association's complaint on monopoly position of "Hrvatske šume" Ltd. (*http://www.aztn.hr/uploads/documents/odluke/TN/031-022010-01171.pdf*). This decision states that there is a state monopoly in this matter, since "Hrvatske šume" Ltd. are conducting all works in private forests and it is up to them to decide whether they will pass these jobs to some other licensed forestry company or not. The monopoly also shut the door to all authorized forestry engineers who are not the employees of "Hrvatske šume" Ltd. making it impossible for them to even appear on the job market. Furthermore, the state company has the exclusive right to make decisions on the amount of money that shall be allocated for private forests - allegedly, no means at all were planned for private forests in 2012 (*http://www.vecernji.hr/vijesti/hrvatske-sume-lose-poslovanje-krpale-drzavnim-novcem-clanak-383280*), and since the beginning of 2012 numerous lawsuits had been filed against "Hrvatske šume" Ltd. regarding the illegitimate utilization of the GWFFF means. Graph 2 best describes this situation where it is obvious that in the year 2011 most means allocated for private forests have been spent, but to what purpose and to whose benefit? Series of articles in the press and legal charges against "Hrvatske šume" Ltd. indicate that there is a possibility that the GWFFF means were spent illegally for covering financial losses generated by bad business decisions. State company, as the most important and most powerful party in the process, has all the means (money, employees, equipment) for conducting all works in private forests which they were so generously awarded by the Forest Act. This part of the GWFFF represents the company's income generated by conducting these works and, of course, charging them as they seem fit, since there is no public competition. Drastic decline of means spent by forest owners as subsidies for rejuvenation works in their forests best describe how much the state company actually represents interests of PFOs. This situation is, actually, quite grotesque since one party is legally in charge of taking care of its direct competitors.

When it comes to PFOAs, their influence is quite negligible. The question is to what extent did the founding of these associations help to serve and promote the interests of PFOs and to what extent was it politically driven, i.e. by the pursuit of personal rather then general interests. As it was mentioned earlier, the declarative leader of PFOs - CUPFOA - simply faded out after the FES was abolished. The Union's head was the member of the Croatian Peasants' Party, the only party that went into coalition with the mainstream Croatian Democratic Union and won the elections of 2007, which clearly shows that politics had influenced even the seemingly opposing parties in this process. Attitudes of the current PFOs leader in Croatia are highly ambiguous since they neither supported or opposed the decision of shutting down of FES, although they started an initiative for drafting of the National Strategy for Private Forests which eventually also diminished.

There are numerous non-licensed forestry entrepreneurs and craftsmen who operate illegally throughout the country and are hard to trace due to insufficiencies of the Forestry inspectorate, lack of political will and police force or because of a high level of corruption inside the forestry sector. Peripheral parties are simply waiting for the development of the situation which will drive them to adjust their course of action - once the Croatian private forestry sector is placed on solid foundations, these parties should vanish from the forestry arena or turn into licensed private forestry companies, i.e. become secondary parties.

CONCLUSIONS AND DEBATE

The issues presented in this article are only some of the very complex and rather diverse problems and relations inside Croatian forestry sector. Detailed analysis of the situation is necessary in order to get a sound, holistic and clear view on the situation, scientifically scrutinized and justified. Nevertheless, it is a tribute to the development of Croatian forest policy which has never been so turbulent and chaotic as it is nowadays, when drafting of the new Forest Act is soon expected where all parties shall be involved in the pursuit of their interests.

The initiative aimed towards the promotion and enhancement of private forestry in Croatia has its origins in three basic documents: the Law on Confirmation of the Stabilization and Accession Agreement Between the Republic of Croatia and the European Communities and Their Member States from December 2001, National Forestry Policy and Strategy from July 2003 and the EU Council's Regulation on Support for Rural Development by the European Agricultural Fund for Rural Development (EAFRD). The measures taken afterwards (founding of FES and Croatian Chamber of Forestry and Wood Technology Engineers) were entirely in concordance with these documents and reflected fully Croatia's aim to adjust its forest policy with the EU guidelines, which cannot be said for any of the major political decisions which followed in 2010, starting with the abolition of FES. Although there was a need for serious cut of expenses in the public sector, the question is was it really necessary to abolish a service which only very slightly burdened the state's budget, thus cancelling all the positive effects that contemporary forest policy brought so far? As in many other things, the answer is strictly political: diversification of parties in the forestry arena was not in the interest of the major party who is, even nowadays, *a priori* considered to be the only relevant forestry authority in Croatia. Anticipating the almost certain loss on the following elections which took place a year after, contemporary political set did not pay too much attention to the consequences of their acts: their only aim was to convince voters that they are trying to do their best, thus desperately trying to win the battle that was already lost. The tributaries to the GWFFF, on the other hand, made constant and hard pressure towards the Government in order to reduce the amount of levy for general welfare of forests. The Government eventually did reduce the levy in two occasions, not paying too much attention what the levy was actually about and what did it stand for.

The political battle was lost as expected - the Croatian Democratic Union together with their coalition ally Croatian Peasants' Party suffered their ultimate defeat on elections from December 2011. The new political set, led by the left-oriented Social Democratic Party, didn't so far do anything to improve the situation regarding forestry sector - on the contrary, the Government reduced the amount for the GWFFF from previous 0,07% of gross income of all legal economic entities in Croatia to 0,525% by the amendment from June 2010 (although the decision for first reduction was brought by the old political set), and then additionally to 0,0265% by the amendment from February 2012. Altogether, the non-tax levy for the general welfare forest function was decreased to 38% of its original amount.

When it comes to politics, everything is about power and money, and Croatian forestry sector is not an exclusion. The consequences of this reduction will be devastating and manifold: even before the first reduction of the GWFF levy, "Hrvatske šume" Ltd. could barely make even a minor profit, the fact which falls beyond the scope of this text and should be the matter of a separate study. No market mechanisms have ever been present in the forestry sector - wood prices are set directly by the Government and the majority of wood is being sold to wood processing industry through long-term contracts (except for smaller part that is sold on auctions). The reduction of the GWFF levy, however, makes such situation unsustainable: "Hrvatske šume" Ltd. cannot operate positively if the prices remain on their current level due to the fact that majority of forest-covered land in Croatia is karst area, i.e. economically nonviable, and GWFFF means were so far covering this imbalance. On the other hand, wood processing industry overwhelmed with problems cannot sustain further rise in wood prices. The impression is that one of the reasons for the abolition of FES was to get control over the entire GWFFF, since the first reduction took place in June 2010 - the most powerful players anticipated today's situation and, greatly aided by the Government's decision on reorganization of the entire public sector, succeeded to silently push through the decision of shutting down of FES. At that point no one, of course, considered the interests of the least powerful actors, i.e. the PFOs. The figures presented in Graph 2 clearly show the decrease of PFOs interests for managing their forests after the takeover by "Hrvatske šume" Ltd. Although "Hrvatske šume" Ltd. had embraced all duties of the former FES, it is absurd to position one party in charge of performing all professional tasks for the other party which is its direct competitor! Another fact which supports this statement is that there were no representatives of PFOs in the working group which made the draft proposal of the contemporary Forest Act.

The final conclusion is that there is a general failure in Croatian forest policy, especially regarding integrative approach and decision-making process. Croatian forestry participates in the country's GDP with only approximately 1,5%, a fact which puts the whole profession on political and economic margin. In such a situation, it is clear that the conditions for sound and integrative forest policy process had not yet been acquired - the actual decision-making system resembles more the era of planned economy of the Soviet Union than modern, market-oriented forest economies of the developed world. There are, however, numerous other parties (stakeholders) who emerge in the field, and the overall political imperative - joining the EU in July 2013 - will only enhance their power. In conclusion of this article, I shall stress one major fact which puts additional weight to the issue: prior to the World War II, only one quarter of Croatian forests was state-owned[1]. The nationalization that happened in the communist era drastically changed this ratio, but the restitution process is far from finished, if it ever seriously began: for example, neighbouring Slovenia has greatly advanced in this process and their private forests share now

1 Avdibegović, M., Petrović, N., Nonić, D., Posavec, S., Marić, B., Vuletić, D.: "Readiness of Private Forest Owners in Croatia, Serbia and Bosnia-Herzegovina to Cooperate in Forest Roads Construction and Maintenance ", original scientific papers, Šumarski list br. 1–2, CXXXIV (2010), 55-64

amounts 70%. If the restitution process finally starts, which is a matter of a separate political debate, the question is how it will end and what the ratio private - state forests will be? This issue is hard to predict since it is a purely political question and falls beyond the scope of this article, but is nevertheless one of the major issues that will influence the development of private forestry sector in Croatia. Hopefully, it is not too pretentious to expect that the enactment of the new Forest Act shall anticipate these trends and set path to historical changes in Croatian forestry arena by resurrecting private forestry initiative and positioning private forestry in Croatia to its rightful place - in other words, when policy finally overrides politics.

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INTERPERSONAL AND INTERORGANIZATIONAL COMMUNICATION DURING THE TRANSPOSITION PROCESS OF HABITAT DIRECTIVE IN CROATIA

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Matija LANDEKIĆ[2], Dijana VULETIĆ[1]

Abstract: *The Council Directive 92/73/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (the EC Habitats Directive) is, alongside the EC Birds Directive, the legislative basis upon which the EU-wide network of protected areas (Natura 2000) is built. The first step in the implementation of the Network is the national proposal of Sites of Community Importance (pSCI), which should be based just on scientific criteria. Croatia is now in the process of designating pSCI's, and has formed a working group dealing with forestry section of Natura 2000 under the leadership of State Institute for Nature Protection. This working group is composed of representatives of many organizations coming from nature protection and forestry sectors, which also have a task of setting management guidelines for the conservation of these species and habitats. The designation process is characterized by strong need for improvement of scientific knowledge on the consequences that different forest management regimes have on the conservation status of forestry species and habitats. Another momentum is a policy learning process on the legislative framework of Natura 2000 and on its implementation practices. Although primary based on science, the process is best characterized as a participatory policy negotiation process, in which parties are approaching to a common-ground decision. The objective of this paper is to explore the non-scientific elements of the transposition of the Habitats directive and its influence on the decision making process.*

Two main variables that set the "position" of the decision in the process are the policy learning process and the power relations among stakeholders, which are based on former cooperation, organizational interests, resource dependencies and communication networks. These elements are structured into organizational network of resource dependencies and individual (members of the working group) networks of communication and influence. The parameters of the influence network of individuals shows similarities with the resource dependencies network of their organizations. The strength of the relations among organizations shows relation to the similarity of their interests. This indicates that the interorganizational relations are a reference framework in which the discussion of the working group is set. Such network model can facilitate the policy formulation process by giving new insights to all the parties, which would help them to assess the claims of other parties. This would also increase the "ease" of the implementation of the decision, since it would be more embedded in the context of the policy subsystem. However, disclosure of the parameters of these interorganizational relations during the policy formulation should be done with great prudence, as it would be an intervention to the process.

Key words: social network analysis, interorganizational relations, communication network, influence network, Natura 2000

INTRODUCTION

Natura 2000 is the ecological network of the European Union which encompasses areas important for the conservation of endangered species and habitat types. The legal bases of the Network are the Birds directive (2009/147/EC) and the Habitats Directive (Council Directive

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92/43/EEC). Each EU member state contributes to the Network by designating Special Areas of Conservation (SAC) according to the article 4 of the Habitats directive. These areas should be chosen in a manner that they secure the favorable conservation status of the habitats and species listed in annexes I and II of the Habitats Directive. According to the Birds Directive Special Protection Areas (SPA) are designated for the annexed birds. SAC and SPA areas together make the Natura 2000 network. For every of those areas it is need to define and implement management measures that will secure the favorable conservation status of those habitats and species for which those areas are proclaimed as protected. On the EU 27 level the Natura 2000 network consists out of 26 406 sites that span onto 17.9% of its land surface (Sundseth, 2012). Although the responsibility for the implementation of the Network is on the member states there are numerous EU funding instruments (Miller and Kettunen, 2007). The most important funding instruments for the Network is the LIFE programme, which has from its establishment in1992 co-funded 3104 projects with a contribution of approximately 2.2 billion €.

NATURA 2000 AND ITS NATIONAL IMPLEMENTATIONS

Before joining the European Union in July 2013 Croatia must submit a draft version of proposed Sites of Community Importance (pSCI), which after multilateral negotiations in the Biogeographical seminars and after bilateral negotiations with the Commission become SAC. Although member states have certain discretion when drafting the pSCI, according to the rulings of the European Court of Justice (C-67/99, C-71/99 and C220/99; in European Commission, 2006) this designation process should be based just on scientific criteria.

Habitats Directive was adopted in a very top-down fashion with relatively little consultation involving stakeholders and policy actors on the ground that had to implement the Natura 2000 measures. It was based on the experiences from Dutch National Ecological Network, and with the background of these experiences the DG Environment and non-governmental organizations have formed a coalition that pushed Natura 2000 (i.e. Habitats Directive) through (Weber and Christophersen, 2002). In the beginning of the implementation of the Network the same top-down approach was also used by the member states (science, no politicians or stakeholders), and this had almost halted the implementation of the network due to the resistance of stakeholders. The subsequent “opening up” of the process enabled the continuation of the implementation of the Network, but also brought dissolution of strict nature protection goals, and introduction of partly ambiguous results (Engelen et al. 2008).

Although the Netherlands had a reputation of a pioneer in the formulation of Habitats directive, its national implementation was characterized by significant delays, mostly which can be attributed to the national government which believed that the Network could be implemented with limited changes of the current situation (Van der Zouwen & Van den Top, 2001). As the transposition of Natura 2000 legislation focused more on the formal and less on the substantive aspects (Directives were literally translated, but no guidelines on how to practically implement them were made) ENGO`s were able to block development project by taking the developers to court for the lacks of the project documentation (i.e. appropriate assessments) related to Natura 2000 (Ferrantia et al., 2010). This attitude led Netherlands to delays in transposition of EU legislation, consultation processes and designation of pSCI`s and SCI`s, whose designation was not completed until the end of 2010.

In the French case of the implementation of the Network the implementing agency – Ministry of Environment “had overestimated their strengths” (Alphandéry and Fortier, 2001) when it came to financial and human resources. The scientific arguments on the biological demands of habitats and species of Community interest brought about a national proposal of Natura 2000 which spanned onto ¼ of forestland and on 7 mil. ha (13%) of France`s land surface. This proposal created an opposition formed out of stakeholders to the process that were not consulted previously. The core of the opposition was based private forestry sector which raised the support of agricultural and game and fish breeding sectors. The usage of “top-down” approach decreased the credibility of experts in the later phases of the implementation of the Network, and they were partly replaced by representatives of stakeholders. This change subsequently led the 13% proposal from 1996 to a reduction on the level of 7% of land surface in 2002.

As in France, the Polish initial proposal covered 20% of land surface, but was reduced by half due to the pressure by local authorities, foresters and water management authorities (Chmielewski & Krogulec, 2008). Similar development of the implementation of the Natura 2000 network happened in Bulgaria – the scientific proposal was also cut by half, due to the pressure from landowners, local developers and tourism business sector (Keulartz, 20009. Plachkova, Z., 2007). Although all EU Member States have chosen different ways of identifying, designating and communicating the designation of Natura 2000 sites, most of them have in common the late “opening up” of the process to stakeholders, which may be perceived by ENGO`s as a negative development that impedes the implementation of the Network (Walder and Schnell, 2006). An argument in the favor of such a claim is the fact that half of EU 15 were taken before the European Court of Justice by the Commission for not designating pSCI in accordance with the Habitats Directive (with a major reason being not respecting the deadlines; Paavola 2004). The entire process can be however put under question by the prevalence of scientific conservation over societal needs both in the legislation behind the network (Weber and Christophersen, 2002) and in its national implementation (Bennett & Ligthart, 2001)

IMPLEMENTATION OF NATURA 2000 IN CROATIA

The preparations for the Natura 2000 network in Croatia span onto 2001, when a pilot project for the Emerald network began (Lovrić and Lovrić, 2012). These preparations are characterized by a series of internationally founded projects that were run by the State Institute on Nature Protection (SINP). These projects focused on the Emerald Network, the National ecological network and directly on the Natura 2000 network. The projects that were directly related to Natura 2000 network have resulted with the transposition of the basic elements of Natura 2000 into the national legislation and with adequate background knowledge needed for the establishment of the Network. With this information SINP has made a first draft version of the Natura 2000 sites in 2009 which encompassed 44.83% of the land surface. Currently there are two ongoing projects, one of which (“Capacity building for preparation of management plans and strengthening of nature protection inspection for proposed NATURA 2000 sites”) focuses on creating management plans for six potential Natura 2000 sites. The other project (“EU Natura 2000 Integration Project”) focuses on infrastructural investments, information system and capacity building needed for the management of the network. Through these activities the County level (regional) public institutions for the management of protected natural values should be prepared for the management of the Network, while the expert activities related to the Network would be performed by SINP.

The 2009 proposal of Natura 2000 pSCI`s and SPA`s has been made through usage of extensive participation of stakeholder, which were consulted through a series of regional and two rounds of sector-specific workshops (forestry, water management, agriculture, physical planning, nature protection, science, non-governmental sector). The biggest lack of this proposal was its marine part, as there was not enough background data to define it in appropriate manner. The situation had improved through the findings of 2010-2011 “Identification and setting-up of the marine part of Natura 2000 network in Croatia - Marine NATURA 2000” project. In 2010 a working group has been formed with a task of designating forest Natura 2000 forest areas. The working group is comprised out of representatives of many stake-holding organizations from the sectors of forestry and nature protection. The topics that were covered by the working group are: designation of forestry related protection measures for the protection of birds, designation of Natura 2000 areas for forestry habitats , designation of measures for the protection of forest habitats and designation of forestry related measures for the protection of other species. Until June 2012 the working group had nine meetings. The organizations which have representatives in the working group are: State Institute for Nature Protection, Croatian academy of sciences and arts (CASA), Croatian forests Ltd. (CF; State forest management company), Croatian Natural History Museum (CNMH), Croatian Forests Research Institute (CFRI), Croatian Union of Private Forest Owners Associations (CUPFOA), Croatian Forestry Society (CFS), Ministry of Culture – Directorate for Nature Protection (MCDNP), Ministry of regional development, forestry and water management with its Department for Hunting (MDH) and Department for Forestry (MDF), Alliance of Private Forest Owners and forest Owners Associations (APFOA), Forest Extension Service (FES) and Faculty Of Forestry, University of Zagreb (FOF). No other working group that would cover the implementation of the Network into other sectors has been formed.

MATERIALS AND METHODS

The object of research is the working groups` effort to define forest habitat sites of the national Natura 2000 proposal and the conservation measures for protection of forest habitats and forest-related species. The basic premise of the research is that the meetings of the working group are regarded as a policy formulation process as seen from the classical perspective of policy sciences (Dahl, 1961., Bachrach and Baratz, 1962), which is characterized by power relations among stakeholders.

Power on the level of individuals is seen as the “decision making power” (first face of power), with focus on the observable political decision making process and its outcomes, which are rational and based on interests (i.e. policy preferences). The focus on observable conflicts and exercise power in this context equates power with influence (Dahl, 1961). This conceptualization of power – influence relations is in contrast to Bachrach and Baratz (1970) political science`s view of influence as power without threat or social-psychological perspective of power as potential influence (French and Raven, 1959.), but is line with Foucault`s (1982) that power exists only when it is put into action. In this context interpersonal influence is operationalized as issue-related interpersonal influence (Friedkin, 1993), whose variables are interpersonal visibility of alter`s opinion on ego (OPIS) and salience of alter`s opinion on ego (OPIS). Influence is treated as a finite value scaled from 0 to 1.

The interpersonal influence relations set within the working group are embedded in a broader structure of interorganizational relations from which the members of the working group are coming from. The interorganizational relations are operationalized in the context of Resource dependence model (Pfeffer and Salacnik, XXX). The variables that describe the interorganizational relations are dependencies of focal organizations on the informational, material, human and financial resources with respect to other organizations which are represented in the working group (OPIS). The power on the organizational level is operationalized according to the Casciaro`s and Piskorki`s (2005) reformulation of resource dependence theory where interorganizational power is characterized by an imbalance of resource dependencies among organizations on a dyadic level (if organization A is more dependent on organization B, than organization B has power over organization A). This view is in line with the microsociological view of Emerson (1962) that “… (interpersonal) power resides implicitly in the other's dependency” (p.32) .

Based on non-participant observation of the meetings and prior knowledge eight specific topics on which policy preferences were tested have been chosen. The night question regarding policy preferences has been added, which questions the general inclination of the respondent on will the Natura 2000 network improve the management of forests in Croatia or not.

The data was collected in March 2011, when a one third of the meetings of the working group have passed (total of 10 meetings). The questionnaires were distributed electronically by e-mail, and all the members of the working group have fulfilled the questionnaires. Questions on interpersonal and interorganizational relations were made on a five-point rating ordinal scale. Questions on policy preferences were made on a nine point Lickert scale (from totally disagree to totally agree). Following the arguments of Reips and Funke (2008) the points were distributed evenly along a horizontal line in order to approach the form of questions to a visual analogue scale.

RESULTS AND DISCUSSION

Figure 1. shows the interpersonal influence relations among the members of the working group. Received influence is treated as a finite value scaled from 0 to 1, where the total received influence (i.e. in-degree) has value of 1 in all the actors. Layout of the network is based on the similarity of the strengths of ties, and the more central an actor is, the more influence he/she has distributed in the network. Ties are directed, and the width of a line and the size of the arrow head show the strength of the influence. White squares represent members of the working group coming from the sector of forestry, and black squares represent the members of the working group coming from the sector of nature protection. Two groups of actors can be seen; one group formed mostly out of actors from the forestry sector ("forestry group"), and another group formed mostly out of members of the nature protection sector ("nature protection group"). One third of actors does not belong to any of the groups and the actor MCDNP2 acts as a broker between the two groups. Actor SINP2 which is embedded in the forestry group has forestry education. The largest value of out-degree (i.e. distributed influence) is of the actor SINP5 (3.04) who is also the leader of the working group. The second largest value of out-degree belongs to actor CF1 (2.33), who is the most influential member of the forestry group. It is has to be noted that a certain part of the position of actor SINP5 in the network is defined by being the leader of the working group, so the comparison of his attributes with the rest of the network has to be done with prudence.

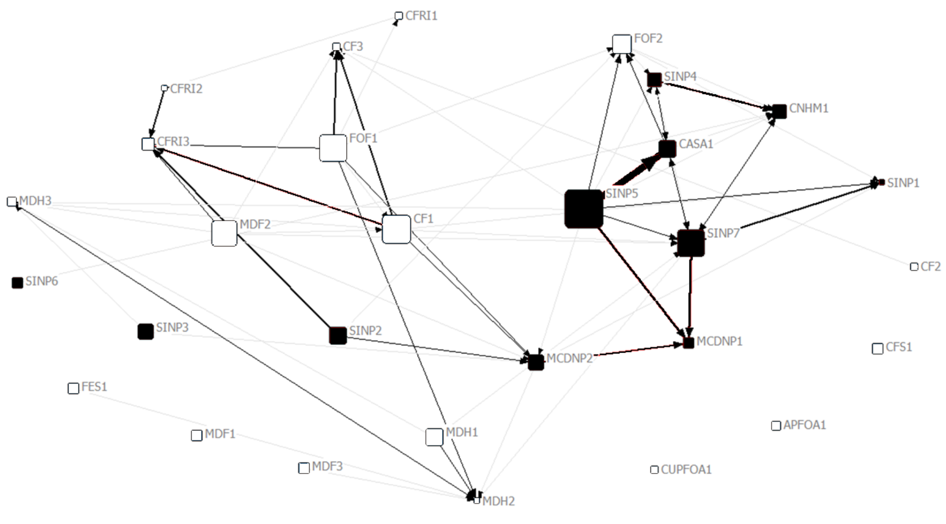

Figure 1. *Network of interpersonal influences within the working group*

Figure 2. shows the network of organizations that have representatives in the working group. The lines represent the level of resource dependencies among the organizations (i.e. the

organizations that are resource dependent are receivers of a tie). On dyadic (relation between two actors) level resource dependencies have been scaled to a range from 0 (no dependency) to 20 (total dependency). All other characteristics of Figure 2 (layout, color and size of the quadrants, thickness of a tie…) are equivalent to those from figure 1. The interorganizational network shows clear demarcation of organizations into forestry group and nature protection group. The dominance of Croatian forest is even more pronounced (out-degree 50.38), and is followed by FOF (35.78), MDF (34.48) and SINP (30.17). The ratio of dependencies between CF and MDF is 1, and between CF and MDH is 4. This indicates in the context of resource dependencies CF has superior position to the part of the state administration that controls it. The same ratio in the relation SINP-MCDNP is 0.43, indicating that in the context of resource dependencies SINP has a subordinate position to the part of the state administration that controls it.

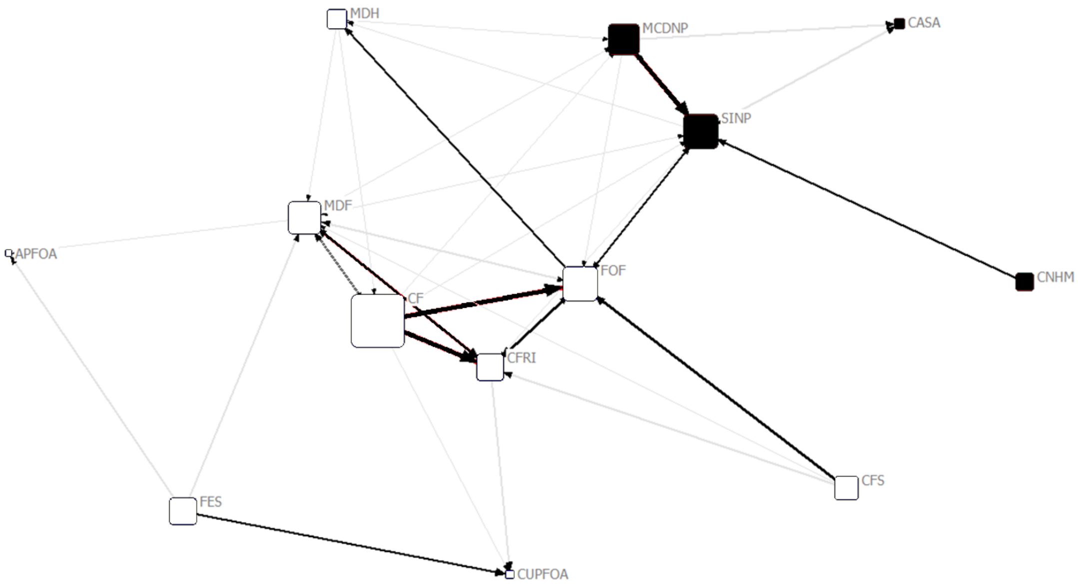

Figure 2. *Network of interorganizational resource dependencies*

Following the model of Friedkin and Johnsen, 1997, the nine questions posed to the members of the working group regarding the policy preferences have been processed with respect to interpersonal and interorganizational relations. The idea of the analysis it to calculate the final policy preferences (at the end of negotiations – T2) based on the initial opinions (i.e. the ones collected with the questionnaires – T1) and the relations among actors that exist on individual and organizational level. The calculations are performed with the assumption that all the change that occurs in the policy preferences is caused by the observed relations among the actors in the network. The relations among the actors in the individual and organizational level are scaled to a range from 0 to 1, with 0 indicating to relation, and 1 indicating maximum strength of relation. The positions of the actors are scaled from 0 to 1, with 0 indicating the position most leaned to the forestry position and 1 indicating the position most leaned to nature protection (with 0.5 value of having a neutral position).

Figure 1 provides results of the calculation of the change of policy preferences from T1 to T2 in a summarized for all nine questions. The initial opinions for the actors in the forestry and nature protection are equally apart from a neutral position. In the interpersonal model the change of opinions by actors from the forestry sector (12%) is two times higher than the change of opinions among the actors from the sectors of nature protection (6%). In the interorganizational model the change of opinions is approximately the same for both sectors (4%). Position of CF and SINP at T 1 are further away from a neutral position than the positions of MDF and MCDNP are, which is line with the theory of Advocacy coalition framework

(Sabatier, 1988), by which the implementing agencies have more “extreme” position than their administrative counterparts have. According to the interpersonal model of calculation the key organizations from the forestry sector will change their opinion more than the key organizations from the nature protection sector will do; and in the interorganizational model the situation is the opposite. The biggest difference in between the two models of calculation is the expected change of position of CF, which by the interorganizational model should be zero, as there is no organization in the network that has “net positive” ratio of resource dependency towards CF (i.e. in every relation in this network CF is the more powerful actor). In the interpersonal model of calculation the mean opinion in the working group will shift towards the position of nature protection by 4.6%, and in the interorganizational model the mean position will change towards the position of forestry by 2.2%. As the majority of influence and communication exchange has happened between several members from key organizations, it is expected that the changes of their opinions will have more impact on the conclusions of the working group than will the mean opinion of the group have. Both models show consistency by predicting the decrease in the standard deviation of opinions, which is an expected result.

	Interpersonal level		**Interorganizational level**	
Sectors	**Positions at t1**	**Change**	**Positions at t1**	**Change**
Forestry	0,4042	0,1276	0,4042	0,0419
Nature protection	0,60132	-0,0604	0,60132	- 0,0418
Key organization	**Position at t 1**	**Change**	**Position at t 1**	**Change**
CF	0,3003	0,1977	0,3003	0
MDF	0,3906	0,3385	0,3906	0,0087
SINP	0,6324	-0,1356	0,6324	-0,1141
MCDNP	0,5625	-0,0027	0,5625	-0,0313
Time	**Sum. opinion**	**S.D.**	**Sum. opinion**	**S.D.**
T 1	0,4789	0,2733	0,4789	0,2733
T 2	0,5248	0,1543	0,4565	0,1633

Figure 3. *Results of calculations of policy preferences in interpersonal and interorganizational model*

The interpersonal influence network presented in this paper is just one way of presenting the relations among the members of the working group. Interpersonal communication (as a number of dyadic conversations measures on five point rating list) was used as one of the explanatory variables for interpersonal influence. Most of the communication in the working group happened between actors MDF1, CF1, SINP5 and SINP7, and these relations show much more similarities to the network of interorganizational relations than does the network of interpersonal influences.

Another bias to the analysis is that only 9 specific questions were asked, and the underlying policy beliefs have not been taken into consideration. This could be improved by performing qualitative interviews with the members of the working group in which policy beliefs according to a certain theoretical framework (such as Advocacy coalitions framework).

It is also presumed that all the change of policy preferences can be explained by the relations among the actors. Such assumptions is not probable in reality, and Friedkin and Johnsen (1997) have introduced the α parameter which determinates the extent to which the final policy preference in determined by the initial opinion, and to what extent it is set by the relations in the network. Such parameter also does not fully depict reality, as it introduces the assumption that all the actors have the same degree of inclination towards being influenced by other actors.

In the case of interpersonal network this issue could be resolved by differentiating the α parameter among actors based on the differences of their social status. One way of differentiating the social status in this context would be a phonetic analysis of interviews with the members of the working group based on speech accommodation theory (Giles and Smith, 1979), similar to the work of Gregory and Webster (1996). Another suitable would be discourse analysis of interviews with the members of the working group based on the concepts of social power from a appropriate theoretical framework (such as the one in Brauer and Bourhis, 2006). In these ways the α parameters of the members of the working group would be calculated on a basis of differential of social status and social power of the interviewer and the individual members of the working group. A less "demanding" calculation of α parameter could be based on "classical" socio-demographic parameters such as age, education and position in the organizational hierarchy.

In the case of interorganizational network this issue could be resolved by differentiating the α parameter with respect to the embeddedness of actors in the network (based on in-degree)

A test of validity of the claims produced in the analysis of the models presented above would be a comparison of the calculated policy preferences with the actual policy preferences. If the actual policy preferences would follow the results from the interorganizational model, then such findings would mark the observed process as policy formulation that is significantly shifted away from a discursive negotiations based on scientific knowledge, which according to international legislation it should be. The alignment of the interorganizational model with the actual policy preferences would have repercussions also on all future policy formulations that would happen within the presented network, and in order to diminish the impact of these interorganizational power relations the procedural elements of the policy formulation processes should be changed.

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NON-WOOD FOREST PRODUCTS-BASED ENTERPRISES IN WESTERN SERBIA: ORGANISATION OF EXTERNAL SUPPLY CHAIN

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Abstract: *The use of non-wood forest products (NWFPs) provides multi-functionality of forests, as natural resources. Also, it is an important opportunity for the development of entrepreneurship and gaining additional income for local people in rural areas, which are largely dependent on forest resources. The subjects of this paper are NWFPs-based small and medium enterprises (SMEs) in the region of Western Serbia, which includes 4 forest areas: Podrinjsko-kolubarsko, Tarsko-zlatiborsko, Limsko and Golijsko. The objective of this paper is the analysis of basic characteristics of SMEs and its business, organization of NWFPs external supply chain elements, as well as the analysis of possibilities for SMEs cooperation within the supply chain. The purpose of the paper is to point out the advantages that could be gained by more successful organizing of SMEs in the NWFPs supply chain in selected forest areas. In the paper is given part of the results of the project "Research on development of entrepreneurship in private forestry sector in Serbia: NWFPs-based enterprises". The research was conducted in 2011 and included 28 NWFPs-based enterprises, in the region of Western Serbia. The questionnaire consisted of 65 questions, of which are 21 analysed in this paper. The research results show that the cooperation between enterprises exists, but, generally, only during purchasing and placement.*

Key words: organisation, small and medium enterprises, non-wood forest products, supply chain

1. INTRODUCTION

The pursuit of the nature and its original values, which is increasingly present, requires the use of available resources in accordance with the principles of sustainable development. This concept implies continuous economic growth that, beside economic efficiency and innovations, involves optimal use of natural resources, while preserving biodiversity (2008/b).

In the framework of national sustainable development policy objectives, clear need for support to small and medium enterprises (SMEs) and entrepreneurship, both in urban and rural areas, is emphasized. In this way could be ensured balanced regional development in Serbia. Measures to achieve these goals are related to "*promotion of use of local knowledge and resources with a specific geographical origin*" (2008/b).

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Non-wood forest products (NWFPs) and entrepreneurship based on them can have a positive impact on sustainable development and gaining additional income for rural population. On this way, the development of local economies and preservation of ecosystems and biodiversity of rural areas are encouraged (O'Brien Mee, 2009; Pettenella *et al.,* 2009; Saha, Sundriyal, 2012).

Consequently, an organized collection, purchase, processing and placement of NWFPs can help to achieve the objectives of national sustainable and regional development policies, since the use of wild medicinal and aromatic plants (MAP), berries and mushrooms has a long tradition in Serbia.

Under the present conditions of market globalization, the progress of individual enterprises has been greatly hampered. Innovation, i.e. constant introduction of new products, development of organizational and management structures and successful new market penetration are becoming the most important factors of sustainable competitiveness and commercial success. This can be accomplished by providing higher value of products with low costs of ensuring that value (Rapajić, 2010).

If all enterprises participating in the supply chain operated separately and performed their own business strategies, the sum of their costs would exceeded the costs arising from integrated operations of these enterprises within the supply chain. Due to this fact, the product, which would be the result of integrated operations within the supply chain, would be more competitive in the market in the relation to the product that is result of cooperation between enterprises outside of the supply chain (Rapajić, 2010).

The supply chain is, actually, an integrated "network" of different business entities, which are connected by information and capital flow and involved in the process of designing, processing and placement of products and services (Van der Vorst, 2006; Swink *et al*., 2011). In addition, supply chain also includes "*... all transfers of physical goods and services needed to produce goods and assess in the market, i.e. to reach the final consumer*" (2008/a).

However, it is necessary to distinguish between two types of supply chain (Hicks, 2001; Li, 2007; Sweeney, 2007; Sweeney, 2010):

1. internal (micro) supply chain includes functions, departments and/or business units within the enterprise that are related to purchasing, production, storage, transport and distribution;
2. external (macro or *business-to-business*) supply chain, which includes the other enterprises.

Previously conducted studies in Serbia, in some of its segments indicate that commercialization of NWFPs in our areas is mostly unorganized, uncontrolled and incompetent and that it requests the appropriate support (financial and non-financial) of state, scientific, educational and professional organizations (Vukomanović, Bogdanović, 1991; Milanović, Bučalina, 2010; Maletić *et al*., 2011).

Previous studies also show that insufficient social understanding of these activities and lack of state orientation towards the development of this sector, lack of economic measures for its development, the low level of organization of actors in the supply chain, as well as lack of knowledge of local people about the possibilities of generating additional income from NWFPs contributed to the unfavourable situation of this sector in Serbia (2003/a; 2008/a; Katić *et al*., 2008; Milanović, Bučalina, 2010). It is also emphasized that NWFPs are, to large extent, marketed as unprocessed raw materials and semi-products (2008/a).

In Serbia, so far, any significant socio-economic researches on NWFPs-based enterprises have not been conducted and, because of this, there is lack of data on organization of both internal and external supply chain.

For that reason, the **subjects** of this paper are NWFPs-based small and medium enterprises in the region of Western Serbia, which includes 4 forest areas: Podrinjsko-kolubarsko

(PKFA), Tarsko-zlatiborsko (TZFA), Limsko (LFA) and Golijsko (GFA). The **objective** of this paper is the analysis of basic characteristics of SMEs and its business, organization of NWFPs external supply chain elements, as well as the analysis of possibilities for SMEs cooperation within the supply chain. Accordingly, the **purpose** of the paper is to point out the advantages that could be gained by more successful organizing of SMEs in the NWFPs supply chain in selected forest areas.

The research was conducted within the framework of the project: "*Research on development of entrepreneurship in private forestry sector in Serbia: NWFPs-based enterprises*", which is funded by the Ministry of Agriculture, Trade, Forestry and Water Management – Directorate for forests. Data collection was conducted during 2011 and included 14 forest areas in the territory of Serbia, without Autonomous Provinces of Vojvodina and Kosovo and Metohija. In the paper are presented the results of research in territory of 4 forest areas in the Western Serbia, which were chosen primarily because of the great wealth of forest resources, and, therefore, the NWFPs (2004; 2003/b; 2010). Also, all chosen forest areas have favourable geographic position and the transport position, which provides them good opportunities for economic development.

2. METHODS

In the research are used different scientific methods and research techniques. Comparative method "*area studies*" (Milosavljevic, Radosavljevic, 2008) was used in order to determine the similarities and differences in the attitudes of representatives of NWFPs based enterprises in the selected forest areas.

As a basic method for the quantitative research of mass phenomena, statistical method was applied in data processing. Also, in the research are used methods of analysis and synthesis, and induction and deduction (Mihailović, 2008; Milosavljević, Radosavljević, 2008).

Door-to-door survey (Neuman, 2006) was applied as research technique. The questionnaire consisted of 65 questions: open-ended, closed, multiple-answer and Likert scale questions (Fishbein, Ajzen, 1975). For the purposes of this paper, 21 questions, related to the basic characteristics of SMEs and its business, organization of NWFPs purchasing, processing and placement within the supply chain and the existence of cooperation between enterprises and with relevant ministries, were chosen.

The main source of information on SMEs was internal documentation of the Ministry of Environment, Mining and Spatial Planning. The data on the liquidity of NWFPS based enterprises were obtained through telephone contact with SMEs, whose contact details were available in internal reports of the Ministry, as well as through the checking the database of Serbian Business Register Agency and the National Bank of Serbia. On that basis is defined the final number of active SMEs. In the selected forest areas, 28 representatives of NWFPs based enterprises were surveyed: 11 in the GFA, 9 in the TZFA, 7 in the PKFA and 1 in the LFA.

In the first phase of data processing, questionnaires were coded and the data base in Excel program was established. In the second phase, after importing data from Excel into SPSS program (*ver. 20*), statistical analysis was done.

3. RESULTS AND DISCUSSION

3.1. Basic characteristics of SMEs and its business

Most SMEs in the PKFA, TZFA and GFA are **located** in urban or both in urban and rural areas. The only enterprise that is located only in rural area is from LFA. Such a distribution of companies is a consequence of the decrease of labor force in the rural areas and poor traffic infrastructure.

Most companies (60.71%) in all forest areas were **established** prior to 2000. Results of previous research on SMEs in the forestry sector show that most of these enterprises were founded after 2000, as a result of the reforms, which, in accordance with the political and economic changes, also occurred in the forestry sector (Ranković *et al.*, 2012). However, this is not the case in NWFPs sector, considering that here presented results indicate that most of the companies were founded before 2000.

Most enterprises have 11-50 **employees**. It is noteworthy that only one enterprise, located in the GFA, has 50-250 employees and, by this criterion, in accordance with the Law on Accounting and Auditing (2006), belongs to the group of medium enterprises. The average number of seasonal workers for all surveyed companies is 21. Largest numbers of seasonal workers (50) engage 1 enterprise from the GFA and 1 from the LFA. The number of seasonal workers is greatest in summer and autumn, when the primary processing operations (cleaning and grading) mostly occur.

Almost all SMEs (92.86%) **base its business on NWFPs** since establishment. However, when it comes to business activities, there are differences in responses (Table 1).

Table 1. *Business activities of NWFPs based enterprises*

Forest area / Business activity	Podrinjsko-kolubarsko		Tarsko-zlatiborsko		Limsko		Golijsko		Total	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
NWFPs collection	6	26.1	6	22.2	0	0	4	12.1	16	57.1
NWFPs purchasing	5	21.7	9	33.3	1	100	11	33.3	26	92.9
NWFPs processing	6	26.1	7	25.9	1	100	11	33.3	26	89.3
NWFPs placement	6	26.1	5	18.5	1	100	7	21.2	19	67.9

Source: Authors

In the PKFA, 4 from 7 companies do collection, purchase, processing and placement. In the TZFA, less then half enterprises (4 from 9) perform all of these activities and similar situation is in the GFA, where also 4 SMEs (36.4%) perform all these activities.

In the Western Serbia, NWFPs are predominant or sole **activity** for the majority of surveyed companies (78.6%), i.e. for all companies in the GFA and LFA and most companies in the PKFA (71.4%) and TZFA (55.6%).

Question about **types of purchased NWFPs** was a multiple answer question. In the Table 2 can be seen differences between some forest areas. In the GFA and PKFA, most companies are engaged in purchasing mushrooms, while the majority of the SMEs in the TZFA are engaged in berries purchasing. This situation is most likely due to differences in biodiversity of forest areas.

Table 2. *Types of purchased NWFPs*

Forest area / Type of NWFPs	Podrinjsko-kolubarsko		Tarsko-zlatiborsko		Limsko		Golijsko	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
mushrooms	4	57.1	6	42.9	1	100	11	61.1
MAP	2	28.6	0	0	0	0	0	0
berries	1	14.3	8	57.1	0	0	7	38.9

Source: Authors

Most enterprises in the Western Serbia are engaged in purchase of mushrooms (55%) and berries (40%), while only 2 companies, based in PKFA purchase MAP.

Business conditions are similar in all analysed forest areas. The SMEs greatly depend in their business on weather conditions (53.5%), but there is also influence of inadequate legislation (41.9%). Objections on the inadequate legal framework mostly arise because permits for purchase shall be obtained before the season starts, and no one can know what the year will be, in terms of quantity of raw materials.

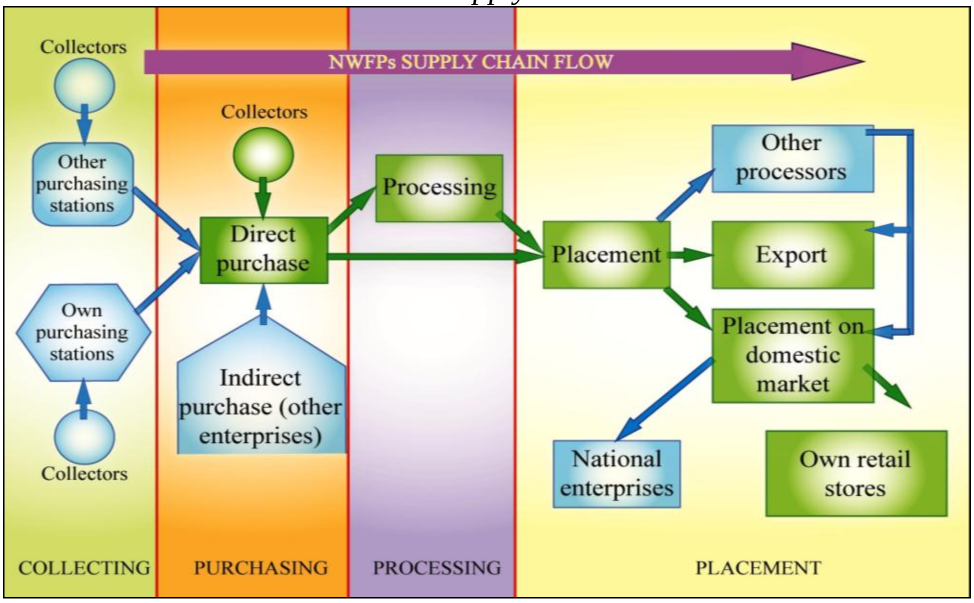
Problems in business are, as well, similar in all analysed forest areas. The most common are: unfair competition and lack of labor. Unfair competition (27.3%), especially during the purchase (mainly mushrooms), is manly because of non-registered companies. By encouraging the NWFPs market development and increasing of competitiveness of SMEs, this negative characteristic can be mitigated. Another problem is lack of labor force (18.2%), especially in TZFA, where the SMEs are located in villages, so this, due to the outflow of population, emerges as a business problem. As well, as significant problems arises payment (12.1%) and insufficient capacity utilization (12.1%).

3.2. Organization of NWFPs purchasing, processing and placement within the external supply chain

Most companies add value to products and have a complete supply chain. In the Western Serbia, 15 of 28 enterprises have **complete supply chain**, i.e. NWFPs purchase, process and placement. Some of these enterprises (9 SMEs) are also engaged in NWFPs collection. However, most of these companies do not have its own collectors, and, on that basis, one can assume that training of collectors, which is prescribed by the law, is not done. Lack of trained collectors may threat the sustainability of NWFPs

In Scheme 1 is shown the **organization of the NWFPs external supply chain** in the territory of selected forest areas in the Western Serbia. It is followed by the analysis of elements of the NWFPs external supply chain and of attitudes of SMEs representatives towards the importance of certain elements for business efficiency.

Scheme 1. *NWFPs external supply chain in the Western Serbia*



Note: Elements of MAP supply chain are presented with green frames
Source: Authors

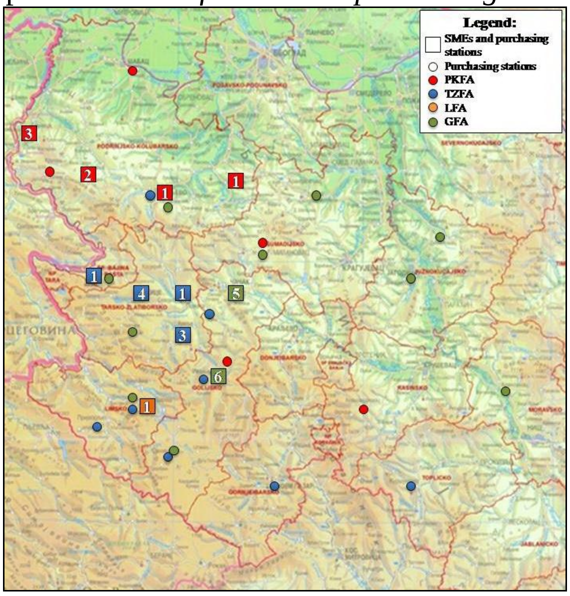
As shown, mushrooms and berries supply chain have the same organization. Differences in MAP supply chain organization are caused by the existence of final products, in the forms of teas, tinctures and supplements.

Purchase of NWFPs is mostly done through own purchasing stations (26.8%) or by collectors coming directly to the enterprise (25.4%). Consequently, the transport of the products can be organized by own means of transport (56.8%) or by collectors (43.2%). In addition, the companies organize visits to the villages (18.3%), in order to purchase products, and, as well, use other purchasing stations (15.5%).

Purchasing stations are, mostly, on the territory of the forest area where enterprises are located. However, purchasing stations of the SMEs from the PKFA are also located in the GFA, Rasinsko and Šumadijsko forest area. Similarly, purchasing stations of SMEs from the TZFA are located in the LFA, PKFA, GFA, Gornjeibarsko and Topličko forest area. Purchasing stations of SMEs from the GFA are located in the LFA, TZFA, PKFA, Šumadijsko, Južnokučajsko and Moravsko forest area.

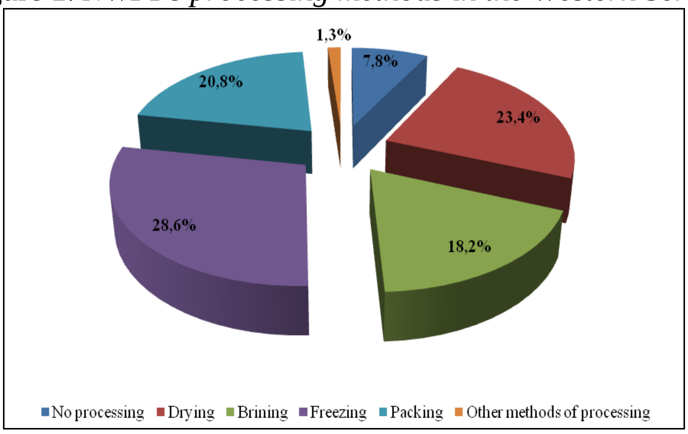
In Map 1 are shown locations of SMEs and its purchasing stations that are marked with a square and a number of SMEs on certain location.

Map 1. *Location of SMEs and purchasing stations*



Depending on the SMEs capacities and equipment, **processing** of raw materials is done in several ways (Figure 1). However, SMEs generally do not have final products, but only semi-products.

Figure 1. *NWFPs processing methods in the Western Serbia*



Source: Authors

Representative of only one SME stated that there is no processing, but the products are marketed immediately after purchase. Other SMEs, too, in some cases, market unprocessed products, but also do some processing (drying, brining, freezing, and extraction)

NWFPs are **marketed**, in processed or unprocessed state, to the local or foreign enterprises, and, sometimes, to other processors, which, after processing, carried out further placement.

Due to the high demand and good quality of NWFPs, Serbian SMEs easily market products in foreign markets. The studies previously conducted in Serbia show that quality of products and lower labor costs have impact on price competitiveness (Keča *et al*., 2009).

In terms of **placement**, there are, as well, differences between analysed forest areas (Table 3).

Table 3. *NWFPs placement*

Type of product placement \ Forest area	Podrinjsko-kolubarsko		Tarsko-zlatiborsko		Limsko		Golijsko	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Own retail shops	3	33.3	0	0	0	0	0	0
Retail shops (grocery shops)	0	0	0	0	0	0	0	0
Domestic supermarkets	0	0	0	0	0	0	0	0
Export	4	44.4	4	80	1	100	7	0
Other	2	22.2	1	20	0	0	0	0

Source: authors

After processing, the products are mainly exported (16 SMEs). As well, products are marketed through its own retail shops (3 SMEs) or on some other way, usually through wholesale (3 SMEs). Analysed SMEs do not market their products through grocery shops or supermarkets.

Such small placement of products directly to consumers is caused by its insufficient finalisation and lack of small, commercial packages (final products), primarily mushrooms and berries, as well as insufficient consumption of NWFPs in Serbia. That is why SMEs export, primarily, fresh mushrooms, often at the price that does not provide a great earning, but also does not create any loss (Keča *et al*., 2009).

Question about organization of transport of goods was, as well, multiple-answer. Frequently customers organize transport (17 SMEs) and 10 SMEs do it with their own means of transport. The enterprises specialised in transportation of goods is hired by 8 SMEs.

Most representatives of surveyed SMEs (35.7%) believe that the purchase, as an element of supply chain, has the greatest **impact on achieving efficient business**. The importance of good organization and alignment of all tree elements of supply chain is highlighted by 25% of SMEs representatives.

However, there are differences in the attitudes of SMEs representatives in certain forest areas. In the PKFA, SMEs representatives believe that well-organized placement of products has the greatest impact on achieving efficient business (42.8%). The SMEs representatives from the TZFA (55%) and the only one representative from the LFA state that the purchase is the most important element of supply chain.

On the other hand, majority of the SMEs representatives from GFA (45.4%) consider good organization of all tree elements of supply chain as the most important for successful and efficient business. Only one SMEs representative from the TZFA and PKFA stressed the importance of all the elements of the supply chain.

3.3. Cooperation between SMEs within the NWFPs supply chain

All SMEs have different kinds of cooperation with **other enterprises**. In the Western Serbia, as well as in the PKFA, TZFA and GFA, SMEs mainly cooperate during purchasing and placement of products. As well, the common way of cooperation is consulting and knowledge exchange. The only surveyed SMEs representative from LFA stated that they cooperate with other enterprises only when purchasing products. Most surveyees see cooperation between enterprises as one of the most important factors in business. Majority of SMEs representatives (85.8%) assess this cooperation as "very important" and "important" for business success, 7.1% as "neither important nor unimportant" and 7.1% as "unimportant".

Less than 1/3 of surveyed SMEs representatives stated that they have cooperation with **Ministry** of Agriculture, Trade, Forestry and Water Management and there is no significant difference between the forest areas. In the level of Western Serbia, 5 SMEs representatives evaluated this cooperation as "good", 2 as "neither good, nor bad" and 1 as "bad". All surveyed representatives stated they have cooperation with Ministry of Environment, Mining and Spatial Planning. Most SMEs representatives (46.5%) consider this cooperation as "very good" and "good", 32.1% as "neither good, nor bad" and 24.1% as "bad" and "very bad".

4. CONCLUSIONS

After the analysis of data on NWFPs based enterprises in 4 selected forest areas in the Western Serbia, following conclusions, which are of importance for this research, are drawn:

- 15 from 28 SMEs has complete supply chain, i.e. perform purchasing, processing and placement. In addition, 9 of these SMEs are engaged in NWFPs collection;
- most SMEs are engaged in the purchase of mushrooms (55%) and berries (40%) and only 2 SMEs are engaged in the purchase of MAP;
- the purchase of products is done in several ways, but mostly through own purchasing stations (26.8%) or by collectors coming directly to the SME (25.4%). Also, SMEs organize visits to villages (18.3%) and often use the other purchasing stations (15.5%);
- most enterprises have purchasing stations on the territory of the forest area where there is a SMEs headquarter. However, it is not uncommon that purchasing stations are located in the territory of other forest areas;
- placement, without any kind of processing, is performed only by 1 SMEs. Other SMEs market part of its products on this way, but also do some processing. The most common way of NWFPs processing is freezing (28.6%) and drying (23.4%);
- the processed products are mainly exported (16 SMEs), but placement of products is also done through own retail shops (3 SMEs) or in the other ways, mostly through wholesales (3 SMEs). It is noteworthy that none of analysed SMEs market their products through grocery shops or supermarkets;
- 25% of SMEs representatives believe that good organization and alignment of all tree elements of supply chain is important for achieving efficient business. However, most respondents (35.7%) believe that the purchase is the most important element of the supply chain, when it comes to effective and efficient business;
- SMEs generally cooperate during purchase and placement. As well, SMEs do consulting and knowledge and information exchange. About 50% of SMEs representatives believe this cooperation is "very important" for business success;
- 28.6% of SMEs have cooperation with Ministry of Agriculture, Trade, Forestry and Water Management. Most SMEs representatives evaluate this cooperation as "good";

– all analysed SMEs have cooperation with Ministry of Environment, Mining and Spatial Planning and little less than one half of surveyees evaluate this cooperation as “good” and “very good”.

SMEs that were subject of this research belong to the group on small enterprises and they are, in strategic documents, recognized as a pillar of economic development of Serbia. Accordingly, mutual cooperation between enterprises should be stimulated and promoted by various financial and non-financial support measures.

So far, the most important cooperation is during purchase and placement of products, which may indicate that SMEs tend to form an association, which would improve SMEs business.

Cooperation is also highly expressed in consulting and education, which indicated a need for further involvement of professional institutions, in order to improve all business elements.

Improving cooperation between all actors in the NWFPs supply chain in the Western Serbia would provide easier introduction of new technologies, representation of joint interests, common procurement and use of equipment and machinery, purchase and processing of sufficient quantities of NWFPs, in order to be able to perform “just-in-time” business strategy etc. This would reduce costs of production and transport of goods, while increasing efficiency and competitive advantage of enterprises.

Effective networking of all participants is essential for the successfully functioning of the external supply chain of NWFPs, especially if one take into account the specific characteristics of these products (such as bulkiness and perishability), as well as the fact that these are food products and that they are not available during all year.

With the favourable geographic location of selected forest areas, successful cooperation of SMEs could have positive impact on development of domestic market. In this way, problems of unfair competition, grey market and excessive price fluctuation could be solved. As well, use of NWFPs on the domestic market could be promoted in this way. Since most of the SMEs representatives stated they do not have small, commercial packages, the result of mutual cooperation, with positive impact on development of domestic market, could be greater finalisation of products. In addition, the improvement of mutual cooperation could lead to the greater competitiveness of enterprises and increase the number of employees, which would also have positive impact on domestic market development.

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RUSSIAN VIEW ON THE BOLOGNA PROCESS

Anatoly CHUBINSKY, Maxim CHUBINSKY[1]

Abstract: *In 2010, the leading Russian Universities have been developed Federal State Educational Standards and the creation of which took into account the basic principles of the Bologna Declaration, including the competence-based approach to assessing the quality of specialist training, increased academic freedom of Universities for curriculum development, the presence in the educational program of disciplines at the student's choice, increase in self-study, taking into account labor discipline in credit units. From September 1 st 2011, all Russian universities switched to a two level system of training: Bachelor - Master.*

However, this time related to the Bologna process in the society has undergone several changes, including because most teachers do not see improvements in the life of the Universities, which have passed in the mid 90s of last century, on new system of training. Education funding was not enough for successful development. Employers are not on demand bachelors who have the competence and level of education lower than the engineers because of the reduced period of study, unsupported introduction of modern methods and teaching aids, including IT, that certainly require additional financies

Not interested in the promotion of education business community:

- *low interest of employers to the content of educational materials of bachelor's and master's degrees and their practical training in the workplace;*
- *virtually no sponsorship institutions of higher education;*
- *not received the system of continuing professional education, including Adult education.*

Analysis of the views of employees of higher education, public authorities, employers, shows a large spectrum of views on the Bologna process - from excellent to negative.

Keywords: Bologna process, education, bachelor's and master's degrees, Russia

INTRODUCTION

The fundamental principles of organizing the higher education in Europe were laid down in the end of XIX century and took a stable share by the middle of XX century, reflecting the level of the societal development of the time. Tremendous growth of economy, its globalization, scientific-technical progress and creation of information technologies required changes both of the content and organization of higher education, distance learning as an example. This was reflected in the Bologna declaration aimed at creation of the common education space and elimination of barriers to mobility of both students and teachers. This is also promoted by a number of other factors: development of interstate relations, simplification of the procedure for obtaining permits to study in universities, higher accessibility and speed of receiving information, knowledge of foreign languages, development of the Internet and its use for educational purposes, development of international collaboration of higher education institutions,

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and creation of networks of universities training students in the same field of expertise / Alekseev A.S. 2010, Shalaev V.S. 2009, Kritskaja V.V. 2010/

Bologna process in Russia

Occurred in the last decade of the past century in the former Soviet Union, political and socio-economic changes have also led to significant changes in the higher education system.

In 1994, 50 universities of Russia taken part in experiment of introduction two-level system of education: Bachelor - Master, while maintaining the existing form of engineering training. At that time, these changes did not cause a high school educational community of serious adverse reaction, especially because so focused on the convergence of Russian and foreign educational systems, an active exchange of students and teachers of higher education, teaching methods and scientific cooperation. The reforms of the time did not anticipate the rejection of engineering training. Economic situation inside the country was very difficult and changes in education and perceived as a change for the better in life high schools of Russia.

Many Russian Universities are beginning to actively participate in international programs and projects, including the programs funded by the European Union.

St.Petersburg State Forest Technical University (former St. Petersburg State Forest Technical Academy) was among first 50 Russian University which transfered to the two level system of education.

RESULTS

In academy was created this time ICFFI , based on the order of the Ministry of Education, the main idea of which was international cooperation between Russian forest education system and forest Universities of other countries.

Integration of European forestry higher educational institutions started from organization of the SILVA network in the middle of 90-ies of the last century. It should be noted that the history of international collaboration of Universities in the forestry area is longer: it existed both in the prerevolutionaly Russia and during the Soviet period. The St. Petersburg State Forest Technical University named after S.M. Kirov has been an active participant of collaboration with forestry Universities around the globe.

Since 1995 SPbFTA has been taking an active part in the events organized by the SILVA and in cooperation based on bilateral and multilateral agreements.

The next stage of international cooperation was the participation of academy projects Tempus-Tacis, coincides with the active transition on a multilevel system of education in accordance with the basic principle of the Bologna Declaration. Sequential execution of three EU-funded projects: Continuing Education in Economics for the St. Petersburg Forest Technical Academy (1998-2000); North-West Forest Trainer (2002-2005); Developing MSc Curriculum in Forest Policy and Economics (2007-2010) , allowed not only to adapt quickly to a two-level system of higher education, but also to create, and to initiate an international master's educational program FORPEC, developed by the Universities of Germany (Dresden Technical University), Sweden (Swedish University of Agriculture Sciencies), Estonia (Tartu University of Life Sciences).

In 1999 in Italy Bologna Declaration was adopted, aimed at creating a common European educational space, which proclaimed a number of important principles for Russian education, including the need to increase the mobility of students and alumni, improve qualification of graduates to the labor market requirements in September 2003, at the Berlin Conference of Education Ministers of the member states, the Russian Federation joined the Bologna process, committing themselves to the cause in 2010 the higher education system in Russia in a accordance with the basic principles of the Bologna Declaration.

In 2010, the leading Russian Universities have been developed Federal State Educational Standards and the creation of which took into account the basic principles of the Bologna Declaration, including the competence-based approach to assessing the quality of specialist training, increased academic freedom of Universities for curriculum development, the presence in the educational program of disciplines at the student's choice, increase in self-study, taking into account labor discipline in credit units. From September 1 st 2011, all Russian universities switched to a two level system of training: Bachelor - Master.

However, this time related to the Bologna process in the society has undergone several changes, including because most teachers do not see improvements in the life of the Universities, which have passed in the mid 90s of last century, on new system of training. Education funding was not enough for successful development. Employers are not on demand bachelors who have the competence and level of education lower than the engineers because of the reduced period of study, unsupported introduction of modern methods and teaching aids, including IT, that certainly require additional finances.

Not interested in the promotion of education business community:

- low interest of employers to the content of educational materials of bachelor's and master's degrees and their practical training in the workplace;
- virtually no sponsorship institutions of higher education;
- not received the system of continuing professional education, including Adult education.

Analysis of the views of employees of higher education, public authorities, employers, shows a large spectrum of views on the Bologna process - from excellent to negative. It seems possible to combine these views into three groups (Fig. 1)

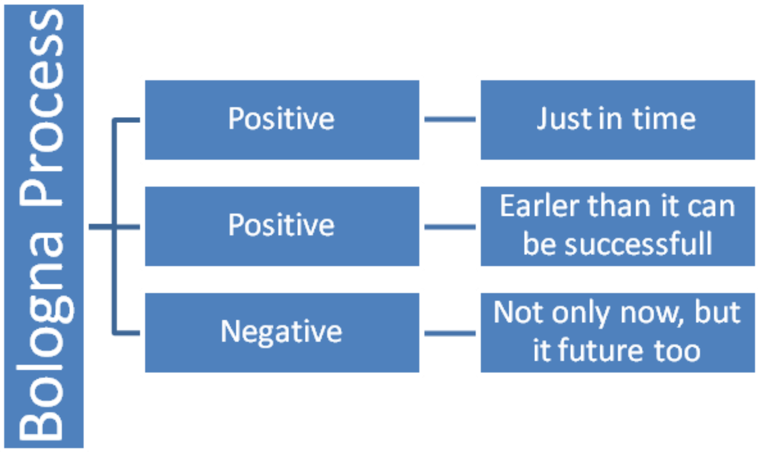

Fig. 1 *Three groups of relations Russians to the Bologna process.*

Supporters of positive evaluation of "just in time", based on the experience of Russian universities in the basic principles of Bologna Declaration, show the benefits of new forms of organization of educational process and student learning, stressing the timeliness of their implementation.

A key issue Magna Charta Universatum is a quality of education by a complex of activities, including competence-based approach to conducting educational activities, the effective functioning of the system of quality management education and teachers research activities, etc.

Competence-based approach to a greater extent than traditional, aims at developing the students' needs constant self-education, the ability to use knowledge and skills in emergency situations. Its application involves the development of students' not only professional but also instrumental (the ability to analyze and synthesize, decision making, communication in the native and foreign languages, etc.), interpersonal (the ability to work in a team, including the international, the ability to criticism and self-criticism, etc.) and system (the ability to self-education, application of knowledge in practice, initiative, creativity, etc.) skills / Baidenko 2009 /. These competencies are developed through the inclusion in the educational process of modern forms of education as business games, presentations by students independently studied sections of discipline, the use of other interactive forms of learning. An important element of this system is international cooperation, including both exchange students (training included), and teachers to deliver lectures.

CONCLUSION

Experience of implementation of the FORPEC MSc program shows that the use of competence-based approach to the formulation and implementation of educational programs increases students interest in learning, stimulates the production of new knowledge, which, in turn, positively affect the quality of development disciplines. This also contributes to the organization for FORPEC students inclusive education in various universities in Finland.

Higher education in Russia was in need of reform, because such changes in the world and the country, and the transition to the principles of the Bologna process given new impulse its development. Supporters believe a positive view of inadequate pace of reform since, and their views are embedded in the 2011 educational standards are not directed at the development of self education, do not allow to increase the level of academic mobility, there is little freedom of choice of subjects by students.

For a number of positions of their point of view coincides with the supporters of a second look at the Bologna process - «positive, but earlier that it can be successful», who believe that the current level of development of university education in Russia does not allow to implement the basic principles of the Bologna Declaration. In the system of vocational education of the forest science sphere are poorly developed information technology training, including distance learning, electronic books have not been developed, methods of teaching as a mode of «on-line», and «off-line», and low pay wages and high average age of university teachers do not encourage the creation and application of innovative training techniques.

Small amount of public funding does not allow to upgrade laboratory facilities, its technical level below the level of processing tools used in the industry. One of the major barriers to implementation of a multilevel system of education is the lack of understanding or unwillingness to understand the employers (the consumers of university graduates), to receive an engineering education, skill level of competence of bachelors and masters and their ability to implement their knowledge and skills in the workplace.

For enhanced implementation of key provisions of the Bologna process, given strict government control over the activities of public educational institutions need to be developed by the Ministry of Education and Science, a series of documents on international student mobility. Training of students aiming of receiving two diplomas of partner Universities does not involve many difficulties when the student studies for some time at Russian University (not less than 90-ty credits for Bachelor and 30-ty for Master training) and in one European University for the other part of time. In this case there is no problem of studing obligatory subjects within the bachelor or master training curriculum. The situation gets complicated when Russian and/or foreign students who studied in the master's degree courses of one University want to receive a diploma on the grounds of preparation and presentation of Master's thesis in two partners Universities. This problem has not been reflected in regulatory acts of Russian Ministry of Education and Science.

Proponents of the third point of view "negative: not only now but in future too" believe that much easier and more cost-effective to improve the existing system of technical education, which has many advantages over the two-level"bachelor-master", one of which is the fundamental education: curriculum includes a large amount of natural sciences and engineering disciplines. Indeed, the main objective of the Bologna process is the preparation of specialist skills relevant to the labor market. But vocational education is always late, new knowledge are created not only in Universities and in research institutions and industry, too. Vocational education is delayed and the training of engineers who produced the Russian universities and in the preparation of bachelors and masters, which produce foreign Universities, so there is no need to change the form and terms of training, you need to improve education technology.

A strong argument for the third view of the Bologna process is the clear successes of the Russian engineering education, which gave the world many talented scientists and engineers.

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SECTION VIII

ENVIRONMENTAL PROTECTION

CHAIRMEN – MODERATORS

Jan Tucek

Dragana Dražić

CONSERVATION VALUE INDICATORS OF FORESTS AND FOREST-LIKE HABITATS IN HISTORIC AGRICULTURAL LANDSCAPES

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Abstract: *The major challenge in forest biodiversity conservation lies in the loss of the high quality habitats. A solution can be in finding substitution habitats for forest-dwelling species. The cultural and aesthetic importance of old manor (castle) parks is widely known, but their biodiversity value is still insufficiently estimated. We explored whether densely wooded parks can be considered as forest-like habitats suitable for forest specific species. We surveyed old densely wooded parks around manors and compared their complex of structural and biodiversity indicators with neighbouring forest stands, and surveyed forest-corridor transects in central and southern Estonia. Studied indicators described stand structure, dead wood types and forest related biodiversity.*

We found that the studied park fragments do resemble old deciduous stands. In fact, park stands have higher estimates for various indicators and their compound indices except for dead wood index which is higher in forests. The latter can be expected due to the more intensive management of park stands. Forest species richness and the proportion of common forest species were almost the same in parks and forests. We conclude that old closed-canopy stands in parks can function as semi-natural forest habitats, but over-intensive management of these parks can jeopardize the continuation of their special biodiversity conservation service. In forest land, broad-leaved and mixed stands should be restored instead of secondary post-clear-cut stands and mono-species conifer plantations.

Key words: biodiversity indicators; broad-leaved forest; stand structure

1. INTRODUCTION

Historical rotational use and the management intensification of forests and, particularly, the conversion of forest into arable land, have caused forest biodiversity to decline (Bengtsson et al 2000, Riitters et al 2012). Another threat is the change of stand composition during silvicultural management and plantations after clear-cuts (Brunet et al. 2011). Contemporary mature forests in Estonia, i.e. the boreo-nemoral vegetation zone, consist mostly of evergreen conifers and tree species of secondary deciduous forest (*Betula* spp. and *Populus tremula*), planted or grown after clear-cuts (the Statistical Forest Inventory on Estonia; Adermann, 2009). In Estonia, nearly 50% of the territory is forest land, but only 2–4% of forests are in a near-natural status and have old-growth stand structure (Adermann, 2009). Therefore attention should be paid on improving the conservation of forest biodiversity in fragmented agricultural landscape.

In order to preserve forest biodiversity in fragmented landscape, the improving of connectivity between forest patches has been proposed, and the creation or maintenance of woody corridors can be seen as a solution (Baudry et al 2000, Oprea et al 2009, Gilbert-Norton et al 2010). Hypothetically, forest species dispersal patterns should proceed in the landscapes

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according to the theory of patch–corridor–matrix system (Forman, 1995; Opdam, 1990), i.e. linear woody habitats or small forest patches may act as dispersal corridors or stepping-stones. Field observations, however, provide contradictory data on the role of linear woody habitats for forest species (Deckers et al, 2004; Wehling and Diekmann, 2009; Aavik and Liira, 2010;) and therefore, the generalized theory on the role of woody corridors for forest-dwelling species remains inconsistent (McCollin et al 2000, Davies and Pullin, 2007). Alternatively, the dispersal of forest species in the landscapes can follow the general theoretical framework of island biogeography (MacArthur and Wilson, 1967), from patch to patch. Some indications for that have been emerged even for sessile organisms, such as plants (Jüriado et al 2011; Liira et al 2012).

In addition to linear woody habitats the creation of alternative habitat patches for forest specific species is another possibility to preserve forest biodiversity. In Estonia, rural parks were created between the 17th and 20th century, and during the last 50–100 years, many of them have been under-managed or abandoned, which has caused semi-open areas to become overgrown and become closed-canopy habitats with dense understory (Abner et al 2007). The cultural and aesthetic importance of old manor (castle) parks is widely known, but their value as habitat islands supporting biodiversity is still insufficiently estimated (Cranz & Boland 2004).

Forest inventories and monitoring schemes use a wide range of structural characteristics and lists of indicator species to estimate habitat quality for conservation (Noss, 1999; Lindenmayer et al 2000; Liira et al 2007). Several stand structural characteristics, bryophyte and lichen species are defined as habitat quality indicators. Also bats, although they can be expected to be highly adaptive to landscape changes, can be used as indicators of forest quality (Hayes & Loeb 2007). Because many studies have been concentrating on within stand value of indicators and less have been considering landscape as a driving factor, raises the question, which anthropogenic driver plays the main role on the change of forest indicators – whether the habitat loss in landscape or the degradation of specific habitat patches.

In this study we explored whether densely wooded parks and corridors can be considered as forest-like habitats suitable for forest specific species, in the context of structural modifications in contemporary forests and forest landscapes. The aims of our study were to: i) determine the ecological role of human created old stands via their structure in the mosaic of human affected forest landscape; ii) estimate how successful are forest-dwelling species in their dispersal, and iii) estimate the relative ecological importance of stand structure and habitat type on selected biodiversity indicators.

2. METHODS

Estonia is located between the boreal and nemoral/temperate forest zones – in the hemiboreal vegetation zone of Northern Europe, where broad-leave deciduous forest change into Nordic mixed forests (Ahti et al 1968). The main characteristics of the climate are average annual precipitation varying between 600 and 700 mm year^{-1}, average temperatures ranging from 16.5 to 17 °C in July and from -5 to -7.5 °C in February (Aunap, 2011). The main soil types in agricultural areas are podsols, luvisols and various gleysols. The study was carried out during the summers of 2008-2011 in central and south-eastern Estonia, in an area of 200x200 km (the coordinates of the central point were 58°27’1’’, 26°29’50’’) in locations with flat terrain 30-100 m a.s.l. The age of woody habitats was estimated using historical maps and aerial photos provided by the Estonian Land Board. Maps were available for the periods since mid of the 19th century.

In order to estimate the ability of old parks to function as alternative forest habitat we surveyed 74 densely wooded and closed-canopy parts in old manor parks and compared the complex of structural and biodiversity indicators with neighbouring forest stands (93 stands). Studied indicators described stand structure, dead wood types and forest related biodiversity.

The study of corridor habitats included transects with historically continuous forest area with a mature stand and with a minimum area of 1 ha. The corridor part of the transect consisted of shrubs and/or trees of at least 2 m height and had a more or less perpendicular position to the forest margin. In total 47 forest-to-corridor transects were sampled.

Plant species richness was analyzed in terms of emergent sub-groups of species of common forest species. The common forest species were defined as species observed in at least 10% of the sampled forests (analogue to Aavik et al 2009, Liira et al 2012). Within common forest species we classified species according to their dispersal profiles along the corridors accordingly: ‘forest-restricted species or F-response type species’ – plants showing maximum frequency in forests and other widely dispersed forest species - ‘generalist species s.l. or G-response type species’.

The ecology of forest bats was studied using acoustic survey in natural forests and old parks. We recorded bat activity and species richness in 26 landscape windows with SM2 recorders (Wildlife Acoustics Inc).

3. RESULTS AND DISCUSSION

Parks vs. forest

We found that the studied park fragments do resemble old deciduous stands. In fact, park stands have higher estimates for various indicators. Some of the indicators, e.g. management indicator or species richness of various taxa and the proportion of common forest species, were almost the same in parks and forests. For instance, overall in both habitat types, we recorded much of bat species known for Estonia, and the park-forest difference in species richness was minor. Only dead wood abundance was larger in forests, with the exception of large diameter dead wood and branches being more common in parks. The higher abundance of small and medium diameter dead wood in forests can be expected due to the more intensive maintenance of park stands. We conclude that old closed-canopy stands in parks can function as semi-natural forest habitats, but over-intensive management of these parks can jeopardize the continuation of their special biodiversity conservation service. The major ecological factor for sessile organisms was the qualitative suitability of stand structure, resembling broad-leave forest, while for well dispersing organisms, the landscape factor-complex became more dominant. Therefore, plants and other sessile organism can be seen as indicators of stand quality, while for mobile taxa, e.g. bats, should be considered as indicators of forest landscape.

Corridors

The dominant tree species in the surveyed forest-corridor transects were *Alnus incana*, *Betula pendula*, *Salix spp* and *Tilia cordata*, and in the understorey *Alnus incana*, *Salix* spp, *Prunus padus*, *Picea abies* and *Sorbus aucuparia*. Within 89 common forest species we defined 60 species restricted to forests. The use of woody corridors by plants was low, because the species richness of common forest species dropped to the lowest value already at the distance of 15 m from the forest edge.

The results hint on the incomplete knowledge about the true ecological profile of species, i.e. the underestimation or biased estimation of the niche breadth. Expectedly dispersal limited functional group of forest-dwelling plants or epiphytic cryptogams have an active dispersal pressure out from forests, but the dispersal success can be characterized as stochastic and with low probability, mostly limited by establishment success. Highly mobile organisms, e.g. bats, instead, make use of diverse structure of landscape. The underestimation of ecological niche breadth of forest species is easy to occur in regions, where broad-leaved woodland habitats have been lost. Habitat historic continuity and age of newly formed forest habitats is limiting for many forest-dwelling species. Only habitats with long continuity and sufficient structural quality support forest restricted species, and suppress generalist species.

4. CONCLUSIONS

Indicators used in our study showed that all studied habitats are far from the theoretically idealistic status, which can be compared to old-growth forests, showing that much of effort should be paid to attain biodiversity supporting targets in both natural and artificial stands. Optimal shade conditions, seen as average level and seasonal pattern, are vital for many forest species, because over-intensive shade, usually generated by conifers and dense understory, caused resource limitation and decline in biodiversity. We suggest that intermediate canopy closure should be set as target in the management planning of park stands as well forests. The recovery of broad-leaved deciduous stands should be promoted to improve habitat quality in future forests. With increasing proportion of broad-leaved trees, the habitat quality (spatial and seasonal) will be improved for many forest-dwelling species within a stand and, also, in forest landscape. Such retargeting of silvicultural objectives in forestry will also provide substrate for epiphytic species and animals that largely depend on broad-leaved trees.

Our survey results imply that woody-corridor-type landscape features cannot be considered as primary alternative habitats for forest-dwelling species, whereas forest-like patches, e.g. old park stands, can function as alternative forest habitats for many species groups. However, the ecological restoration and plantation of broad-leave forest should be seen as the primary goal in forestry for sustainable future.

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FUNCTIONAL TERRAIN CLASSIFICATION IN THE SPATIAL DECISION SUPPORT SYSTEM ENVIRONMENT

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Abstract: *The differentiated forest management focusing the integrated forest functions and keeping the principles of sustainability is based also on a rational (economically and environmentally appropriate) use of machinery - logging technology. For this purpose, we have developed a model for the selection of an optimal logging technology. The model is based on an evaluation of environmental, economic and ergonomic criteria for each technology. So far, it is possible to choose the optimal technology variant (machinery system) based on the evaluation of set of environmental and technological criteria (terrain accessibility, skidding distance, logging erosion, cutting method , soil bearing capacity, structure and parameters of trees, the location of loading points). The inclusion of other economic, ergonomic and energetic criteria is in preparation.*

Appropriate or optimal technology for each forest stand shall be selected from a wide range of commonly used technologies and devices used in Slovakia as well as advanced technologies and equipment described in the literature. Knowledge on environmental and technological evaluation criteria and parameters of technology and machinery from various sources (literature, own research results) are converted into formalized knowledge base using fuzzyfication and object approach. Created networks of dependencies are applied to the content of relevant information layers and databases, stored in GIS and database system. For their construction, we used NetWeaver software environment, directly linked to the EMDS system, which is a technological extension of the ArcGIS. The functionality of the proposed solutions was verified on large areas in belonging under management of the Krivan enterprise, an organization branch of the Slovak State Forests.

Key words: Functional terrain classification, decision support system, knowledge base, network of dependencies

1. INTRODUCTION

Compared with the most other European countries, Slovakia forests are characterized by high diversity. The relatively small area has a high diversity of geographical conditions, geologically and climatically differentiated, which are reflected in the pedological and vegetation conditions. Natural forest conditions are also the production conditions of forestry.

Although in the more detailed assessment the other factors also have their specific effects, for tree species composition as well for the terrain properties, the altitude can be considered as the most important factor (Štaud et al, 1963). Tree species distribution, or their division to deciduous and coniferous and basic characteristics of the terrain - slope, soil bearing capacity and presence of obstacles, are subsequently recognized as the most important factors influencing the use of logging and transport technologies in the forestry.

Efforts to systematic terrain classification for forestry purposes began after the World War II. in the northern countries, especially in Norway. Gradually, the specific systems were

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created for scientific and practical purposes in many European countries - Norway, Sweden, United Kingdom, Italy (Löffler, 1979, 1984), but also in Czechoslovakia (Štaudt, 1963, and Haláth and Roško, 1975). In the 70's and 80's there were even attempts internationally to accept unification or at least comparison of approaches used, unfortunately without success more prominent. The results of the consultation and the proposals put forward by experts from different countries were published in a report prepared by Löffler (1984).

Technical possibilities of logging technologies or equipment using are limited by machine accessibility, typically by the most crucial, the most important means of mechanization and/or machine of the technology. This is then reflected in the cost of logging activities. According the Samset (1971, 1975), the accessibility is influenced by the traffic conditions and transport infrastructure on the one hand and field conditions between transport routes to the other.

Terrain classification for forestry needs can be understood as a description and clustering of forest areas regarding their accessibility or also regarding the degree of difficulty and/or implementation possibilities and implementation constraints of forestry operations.

Systems for terrain classification can be divided into descriptive or primary and functional or secondary. Descriptive systems describe and classify forest areas according to the elements / features that affect the difficulty of forestry operations. Functional or secondary describe and classify forest areas taking into account the possible use and limitations of used / proposed procedure or equipment. A typical routine is to establish a functional system on terrain accessibility by skidding equipment or on the workability of the soil. Different regional and local requirements are often included. They are also time-dependent on the evolution and change in the parameters of logging equipment and its working methods, so require adaptation and modification.

Practical forestry is more interested in functional systems as in the descriptive ones (Putkisto, 1964, Haarlaa and Asperstahl, 1972). In view of the above reasons it is difficult to find a general consensus on the highly variable local and regional needs as well as to cope with the time limitation of the proposal given by the technological development of conditional parameters of machines and equipment. The shift from a descriptive to a functional system therefore always requires to take into account the future use in defining the categories of parameters in the description field.

The breakthrough in terms of transfer problems to the computing environment can be considered in the work of Davis and Reisinger (1990). These authors also report the operational assessment of the proposed functional (secondary) system that assesses and classifies the terrain based on slope, soil bearing capacity and the presence of obstacles. Interesting is the use of GIS tools and environment in the integrated decision-support tool for the planning of logging.

The efforts to transfer the process of description, documentation of terrain features and means of mechanization using computing environments, are documented also in the works of other authors Ziesak (2003), Bydgén, et al. (2003), Nugent et al. (2000), Saarilahti (2002) or Pentek et al. (2008). There is a relatively large group of applications, in which the authors propose, verify and assesses a wide-designed systems which in addition to the functional classification of the terrain are used for the selection, planning and / or optimization of the harvesting and transport technology. Creation of matrices of parameters for the selection of systems for each category of terrain as published by Rowan, 1977 a Mellgren, 1980. Multi criteria evaluation method for assessing suitability of areas for application of harvesting, transport technology used Krč (1996) and Stampfer and Lexer (2003). Different ways and extent whilst using technological tools - database systems, GIS and data structures were published.

Therefore, recent developments in this area results in the efforts to create specific means to support the (spatial) decision making. This trend requires not only to manage these means and their tools as well, but also to learn new approaches to data structuring, and formal description of knowledge and decision rules.

In addition to structural and functional requirements for such systems, this discussion is also heavily dependent on technology. Keenan (1997) regards the GIS as a generator of spatial decision support system - SDSS. According to him, GIS can play a key role in building the SDSS so than the generator to create a general decision support system (DSS) - that function means for development and define the data model (Bhagrava, et al, 1999) as a user-friendly environment. Feick a Hall (1999) identified two known approaches to integrate the tools on multicriteria evaluation and GIS - the addition of such instruments to the current GIS (Idrisi, Spans) or the implementation of these tools along with GIS functions in a suitable user interface - a domain specific SDSS. Yeh a Qiao (1999) identified this problem as a "modeling inside and outside the GIS".

As an example of modern means for creating the knowledge bases in the space-based applications the NetWeaver may be mentioned, which is a part of the decision support system for managing the ecosystems - SDSS called Ecosystem Management Decision Support (EMDS). Knowledge representation in the system is based on object-oriented networks, using application of the fuzzy logic (Reynolds, 1999). In addition to these complex and integrated solutions can be assumed that with the support of object-oriented programming (especially COM) and techniques on integrating systems is possible to create a dedicated system, which will include the basic functions of GIS, database system, managing technology and knowledge base models to support the overall modeling and decision-making process.

The issue of the application of decision support systems in the forestry is paid much attention. There have also been published several bibliographies and technical reports, e.g. Mowrer (1997). An excellent review on the state of decision support systems in managing of ecosystems was published by Rauscher (1997). In the area of logging – from planning to logistics supplies, Harstela (1997) performed a detailed analysis. The review of recent developments with emphasis on the utilization of decision support in sustainable and adaptive forest management was provided by Reynolds (2005). The paper finds significant results, but also problems in all areas evaluated. The second level of evaluation of his work is the suitability and usability of the most common means (LMS, NED, EMDS). Wide-ranging analysis of published knowledge in the broad field of planning of logging, together with the proposal of the rule-based system, states Lubello (2008).

Objective of the presented paper is to briefly analyze the current state of the systems for functional terrain classification, to design such a system using GIS and SDSS environment and tools and finally to introduce main results of the practical evaluation of the system on model forest area of the Krivan enterprise.

2. MATERIAL AND METHODS

In preparation phase of geographical database creation, available data resources were imported - mainly raster, vector and image layers and databases - a digital elevation model with a resolution of 10 m, the forest typological maps, the forest soil types maps, digital ortho photo with a resolution of 0.5 meters, ownership of forest land and finally forest stand map with database containing a description of vegetation, natural conditions and proposed management measures. Data were obtained in a format compatible with ArcGIS (ArcGIS raster, shape-file, geo referenced image file), so that could be directly inspected and included in the geographic database.

Given that under current law a forest road network database is not created in Slovakia, we conducted verification of the content of forestry thematic maps and verify practically the procedure for creating such database. Quality and timely information on forest roads and hauling places are limiting inputs for assessing the technological parameters of the territory under consideration. Their location and properties have particular influence on skidding and transportation distance, applicability of logging technologies or their key machinery. Data on the slope, slope length, slope shape and their orientation (aspect) were derived from digital elevation model in GIS environment, using standard analytic tools for raster data processing.

Applicability of machinery and equipment in the particular soil, stand, and technological conditions represents their technical and technological characteristics. Therefore, we created a database of forest logging machinery. We have included booth the one time commonly used equipment and new equipment including multi operational machines with different types of chassis (wheeled, tracked, split strip, wheel-walking, walking). The database will be updated as necessary together with the dynamically changing technical and technological parameters, techniques and types of bogies.

Terrain accessibility by machinery and equipment, respectively the rate of the negative consequences of their actions in the particular soil and forest stand conditions was assessed based on slope accessibility, risk of soil compaction and risk of logging erosion.

Slope accessibility of different means of mechanization was determined on the basis of technical parameters, as indicated by its producer. For geographical analysis of accessibility we used raster of the terrain slope in a given area derived from the digital terrain model (DTM). These data were supplemented by the location of obstacles (rocks, ravines, swamps), respectively micro relief sudden changes located in the database of description of natural conditions and a detailed field survey.

Soil compaction has negative consequences not only for environmental but also production function of forests. However, it is less visible, such as erosion, and therefore it is generally received less attention. Our proposed solution, however, allows the assessment of local conditions and in this respect, taking into account the bearing capacity of the soil. For this purpose, we adapted the classification drawn by Adámek (1982), based on grain size and content of the soil skeleton. Unsupervidsed classification was used for moving machinery on unpaved forest roads. For movement of the machinery in the field (common stand area), we introduced corrections taking into account soil conditions, especially moisture content (dry, frozen, wet, muddy).

Logging erosion is also evaluated based on several factors – functional forest type, slope, slope length, slope shape, slope aspect, micro relief, skeleton occurrence, organic layer thickness, bedrock type, soil depth, soil particle size, shell content, soil moisture, average annual precipitation, soil bearing capacity, ground vegetation presence. For its determination we used the procedure published by Šach (1988) and the index methodology described by Klevanik (1984). The starting point for the application is to compile a set of quantitative and qualitative characteristics conducting mechanism of logging erosion. Mutual conditionality or overlapping might not be excluded.

In skidding distances calculation, we used all the knowledge about the possibilities of modeling of this important parameter, using standard or special tools in a GIS environment (Koreň et al., 2007). Skidding distances for forest stands were calculated using the distance over the terrain surface for the three key technology variants – cable skidding, tractor and mountain processor. For each technology was calculated skidding distance in the gravity and upper the gravity orientation. The result therefore was the set of six grids of skidding distances (two for each technology variant).

Creation and verification of the system for functional terrain classification on the basis of GIS and SDSS was performed on the territory of the Krivan enterprise, which is a part of the Forests of the Slovak Republic, S.E.. Cadastral acreage of forest plant is 164 327 ha. Forest covered area is 41.5% with 29% representation of conifers and 71% representation of deciduous trees. The territory of the Protected Landscape Area Polana – Biosphere Reserve belongs to it with area of 20,079 ha.

3. RESULTS

The Ecosystem Management Decision Support (EMDS) environment was successfully applied for the complex of functional terrain classification. This technology works as an extension of ArcView, ArcGIS. It provides the means for knowledge base formalization and implementation lacking in GIS environment, stressing the unique orientation on space applications and employing common GIS data structures (coverages, databases, raster layers).

The proposed solution allows variable use of the system. The basic option is to use it as a primary, descriptive system, respectively to perform terrain classification for particular territory. The terrain in this application is assessed against four criteria – slope and the obstacles occurrence, the soil bearing capacity and risk of compaction and the potential of logging erosion risk.

For the existence of appropriate data sources, the GIS environment can provide rich possibilities of slope setting for the selected location, real or projected path of machinery and equipment movement, surfaces or objects. In relation to the processed data sets of model territory we used a median value of inclination for each forest stand calculated from individual raster cells values of the compartment area from digital terrain model. In addition to the possibilities of interactive questioning, searching, sorting and aggregation, the slope maps and the tables of aggregated values (median, average, minimum, maximum, etc.) are typical results of analyses application for individual stands.

To evaluate the potential of terrain accessibility by machinery and equipment for harvesting and skidding, respectively for afforestation, tending and protection work are useful data on the occurrence of rocks, cliffs, boulders, debris, or ravines and potholes introduced in the database of natural conditions description. From the spatial point of view, the data on the occurrence and location of these barriers are important – the standardized options used in the database of natural condition description offers either its entire area distribution or in space designated part of the area localization. Another possibility is performing special data survey using mobile GNSS/GIS applications.

The primary source of information for defining of the soil bearing capacity as described in the methodology is a digital map of soil types. Spatially localized soil type is combined with knowledge of the grain size distribution of soil types and the assumed water content in them, respectively season of the applications. A typical result of the application might be either map of spatial distribution of soil bearing capacity or tables of its aggregated valuesfor individual stands (minimum, maximum, mean, median).

Significantly comprehensive is nature of the parameter of logging erosion potential. Inputs from relevant spatially localized information layers (especially digital elevation model, digital soil map, digital map of forest types, a digital map of precipitation totals) are combined with a database containing descriptions of natural conditions and literary sources of knowledge. The result is a map of spatial distribution of the logging erosion potential or tables of its aggregate values for individual stands (minimum, maximum, mean, median).

Higher level of use is the application of the system for functional terrain classification, thus the assignment or selection of a suitable means of mechanization to different geographically defined territory, typically to the forest stands. Descriptive or primary system will then change to the functional or secondary one. According to the understanding of decision support it can be used for choosing – identification of all eligible equipment or technology that are applicable in the specific circumstances (or there are barriers to their use), or a selection of different aspects of optimal or best value option. Analysis of the accessibility of each terrain part by each machine, and/or the possibility of their use in terms technologically relevant properties of trees growing there (tree species, diameter), is the key issue in this functionality widening.

In terms of the parameters can be considered technology assessment still divided into two groups. First, limiting of the equipment applicability is based only on accessibility evaluation using all the parameters previously commented – hence the slope, presence of obstacles, soil bearing capacity and soil compaction risk and logging erosion risk. In the second variant, skidding distances and basic technological properties of stand vegetation (performed operations, tree species, age, size of trees, assortment production, etc.) are taken into the consideration.

Target application of tools of the Assessment environment (specific part of EMDS) for evaluation of the relevant factors and conditions by changing parameters in the evaluation network nodes can perform the collection of all allowable equipment or technology or the most appropriately defined, optimal resources and technology options. Selection heuristics, taking into account the total amount of score (suitability), of a machine or technology, provides assessment of the factors. Although the proposed system allows individual assessment of the suitability of any equipment contained in the database regardless of the operation it performs, most attention was given to a skidding machinery, respectively to the type of skidding operation. The rating is possible to make for six groups of technology variants for which the system was filled with data, while still working on the extension of it (universal wheel tractor with conventional and flotation tires, wheeled skidder with conventional and flotation tires, cable system in gravity direction and anti-gravity direction).

Generalize this principle, it can be assumed the execution of arbitrary choice of equipment or technology to the selected production, economic, and ecological factors. It is also possible to perform optimization of machinery, or its groups in the form of integrated technologies, conditioned by different considerations. The planned deepening of the approach of detailed technological, economic, environmental, ergonomic and safety considerations and implementation of sources for the multi criteria evaluation can be assumed overgrown described system in a complex environment for the selection and optimization technologies, their planning as well as simulations of the whole chain of equipment or technology.

4. CONCLUSION

As the above knowledge, the current means of geo-information technology and data structures developed allows to resolve the problem of the functional terrain classification implementing new approaches. On the other hand, it is necessary to use a broad base of theoretical and practical as well as application knowledge on this subject, that has already published.

Compared with the approaches published before – e.g. Krč, (1999 a 2006) or Pentek, et al, (2008), the solution proposed in this paper features several new approaches to quality increasing, which results in the design of the functional terrain classification system as a flexible, open system for spatial decision support filled by the necessary data - spatial designated coverages and raster layers describing space variability of parameters and terrain characteristics, databases, knowledge bases and tools for their assessment rather than a static description of the structure of the evaluation criteria, even in digital form, respectively. This approach can avoid repeating time consuming dose evaluation of large areas with fixed parameters and criteria.

It is also the first application of the knowledge on the relationships, the conditions and criteria in functional terrain classification and technology optimization, which previously existed in analogue form as tables, text, literary knowledge, research results, and statistical functional dependency etc. into machine-readable form of knowledge base on this problem domain. Application of fuzzy logic allows to assess quantitative characteristics (especially the slope and skidding distance) in model containing manner very close to human understanding. Suitability of land for the implementation of some equipment and machinery in the territory is interpreted taking this model in to the account. At the same time there is a qualitative change in the system. The rule-based reasoning is replaced by a flexible managing and using the open knowledge base.

Acknowledgment

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LAND DEGRADATION AND INCREASING POVERTY IN RURAL AREAS OF SERBIA

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Abstract: *Land is one of the basic elements of the environment and multi-functional versatile resource, which is particularly threatened by natural processes, and actions of human activities. Although it is difficult to assess the extent of land degradation problems, there is no doubt that people around the world feel the consequences of its effects. Loss of productive land has a direct impact on agriculture in rural communities, primarily in the form of reduced yields and revenues are based on this exercise. Serbia has recorded a significant reduction of arable land, primarily because of damage to land and conversion of the most fertile agricultural land into construction and other non-agricultural purposes. Socially marginalized population groups directly affect the decline in soil quality and reducing the fertile fields. The aim of this article is point to a direct causal link between living standards and population and environmental quality, as well as finding possible solutions in the form of preventive action, and "healing" environmentally degraded areas. As one possible alternative to the revitalization of environmentally damaged areas of Serbia forestation "vulnerable" land and the terrain. The purpose of this study is evaluation of the current state of land in Serbia, and the formulation of possible solutions of action to improve, then revitalized and use of land resources for economic development, primarily in agriculture, where the most pronounced effects of soil degradation. The case of the demographics of rural areas, in terms of population, their share in total population, data regarding the standard of living and the number of households. In addition, it has been analyzed data on the level of land degradation, its prevalence and forms of manifestation in the surveyed areas.*

Key words: land degradation, poverty, Serbia, rural areas

INTRODUCTION

Land is not only a basic factor of production of basic foodstuffs, but also one of the most valuable natural resource from which crucially depends on the development of rural communities and the survival of rural families. It has a specific social function, determined by its role as a space for human activities (Subić et al., 2005). The problem of environmental degradation, particularly soil as a very important multifunctional resources in recent years takes on a significant level and difficult estimable. The consequences are not only ecological, but also largely economic. Reduction in quality and productivity of land directly affects mainly the rural areas, that is existentially dependent on agriculture. Although the concept of rurality, variously interpreted, an internationally recognized OECD methodology suggests that the rural areas

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(locally) one with a population density below 150 inhabitants per km², with agricultural activity as primary, while at the regional level based on the percentage share of the population living in these areas. By this criterion, rural areas comprise 85% of Serbian territory and 55% of the total population of the country (Bogdanov, 2007). In The National Programme of Rural Development of Serbia 2011-2013 year was found that rural poverty is more pronounced in the eastern and southeastern parts of the country, which are distinguished by unfavorable demographic indicators. The assessment presented in the Poverty Reduction Strategy in Serbia in 2003 year indicates that the population of these areas twice at risk of poverty than the average population. It is estimated that there are about 25.000 ha of degraded land (Trumbulović-Bujić et al., 2008). The link between poverty and use of natural resources is traditional. Namely, in order to provide arable land, on that basis and the creation of living conditions for many households, is the intense pressure on the environment. In terms of land such action results in permanent loss of agricultural land, their conversion into other uses and the disruption of their quality. In addition, inadequate treatment of soil resources by human actions and natural factors contributing to the erosion process, adverse changes in salinity, acidity and alkalinity, and changes in the chemical structure of soil. In the Republic of Serbia, the representation of land which are suitable and not suitable for processing is almost identical (2012/a).

Geomorphological characteristics of Serbia are strongly connected to the problem of soil erosion, where wind erosion is prevalent in the northern plains, while the water erosion present in the southern region (Petković et al., 1999). Increased erosion is one of the main causes of land degradation and its subsequent degraded quality. It is estimated that the erosion (to varying degrees) affects up to 80% of agricultural land in Serbia (Corine Land). The major factor of accelerated erosion is human activity (Zlatić et al., 2002).

The aim of this paper is to stress the relationship between the proportion of poverty in rural areas and levels of degradation of land resources in these areas. The main purpose of this paper is to understand the usefulness of agricultural land in Serbia, and finding opportunities for recultivation and use of land with the aim of agricultural development of agricultural areas. The case of the demographics of rural areas, in terms of population, their share in total population, data regarding the standard of living and the number of households. In addition, we analyzed data on the level of land degradation, it's prevalence and forms of manifestation in surveyed areas.

MATERIAL AND METHOD

In order to study the development tendency of the studied phenomenon, the paper used in the formulation of methods of modeling and trend analysis. In order to define the strengths and weaknesses of rural areas and diagnose opportunities and threats which act as a stimulus, or repressive factors in the environment, SWOT matrix is constructed. SWOT has contibuted as the basis for the application of hybrid varieties called SWOT analysis. A'WOT analysis (Analytic Hierarchy Process in SWOT analysis), which is basically a combination of the analytic hierarchy process (AHP Analytic Hierarchy Process) and the classic SWOT analysis. Setting model was made by AHP Thomas Saaty (Saaty, 1980) through the formulation of conceptual and mathematical solutions to its application. The essence of this model is based on constructing a hierarchy of problems, then their evaluation by top-down system, where by a mathematical model defining the weights of each element of the hierarchy of decision-making hierarchy.

In the demographic analysis, with the aim of projecting the future trends of the population used the method of arithmetic progressions, which is the optimal method when it has data from two successive lists:

(1) $$s = \frac{bs2 - bs1}{x1}$$

(2) $$bs_n = bs2 + s * x_2$$

s - average annual population growth; $bs1$ - population in the first list; $bs2$ - population in the second list; bs_n - population of the n-th year relating to the relevant date; x_2 - number of years for which the prediction is.

Due to the nature of research, in addition to time series analysis, we used descriptive statistics through the collection of relevant data, then group them based on attribute, geographic, temporal, numerical characteristics. Plotting the data was carried out in tabular and graphical form. As a general scientific method applied to the analysis, synthesis, induction, deduction and dialectics. The survey was conducted in the territory of Serbia, within seven statistical regions. The total area of the territory of the Republic of Serbia is 88.361 km² and is characterized by the three territorial units with special features: Vojvodina, which is plain from the 21.506 km², the central part of the lowland-highland with 55.968 km² and Kosovo and Metohija as a highland-depression of the 10.887 km² (Hadzić et al., 2002). This research focuses on the approximate period of 2002-2010, Using demographic data, and in 1991 year. The study used secondary data of the Statistical Office (Survey on standard of living, Inventory of population, Inventory of agriculture Statistical Yearbooks), and internal documents of the Ministry of Physical Planning.

RESULTS

A significant level of poverty in rural areas is largely related to their reliance on the agricultural sector. Based on the data of the Serbian government is estimated to be 5.734.000 ha (0,56 ha per capita) of the total territory of the Republic of Serbia is under agricultural land, which is characterized by considerable heterogeneity in terms of usage, credit standing and representation. Contrary to Vojvodina, which is characterized by highly productive agricultural land in central Serbia and Kosovo are present to express ranges in terms of fertile land. Arable land consists of a category with the most important agrarian land resources, especially important for the rural population and make up about 63,9% of total agricultural land (Law on Spatial plan of Serbia 2010).

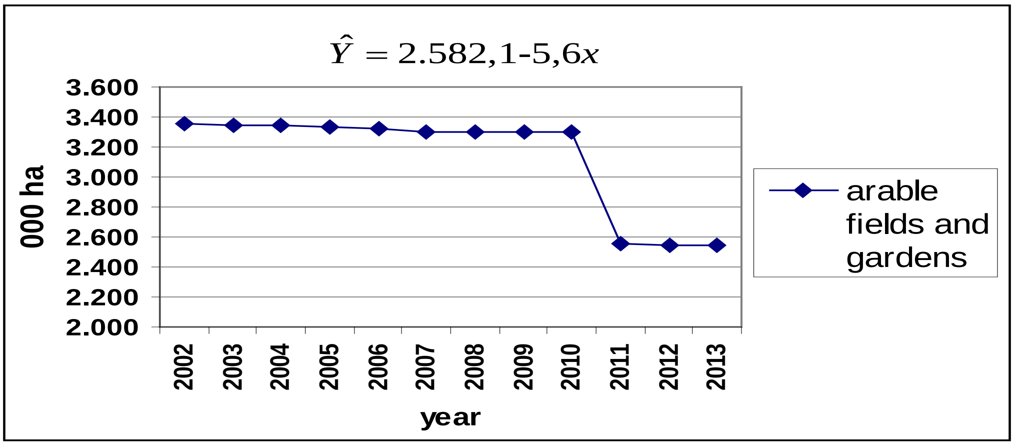


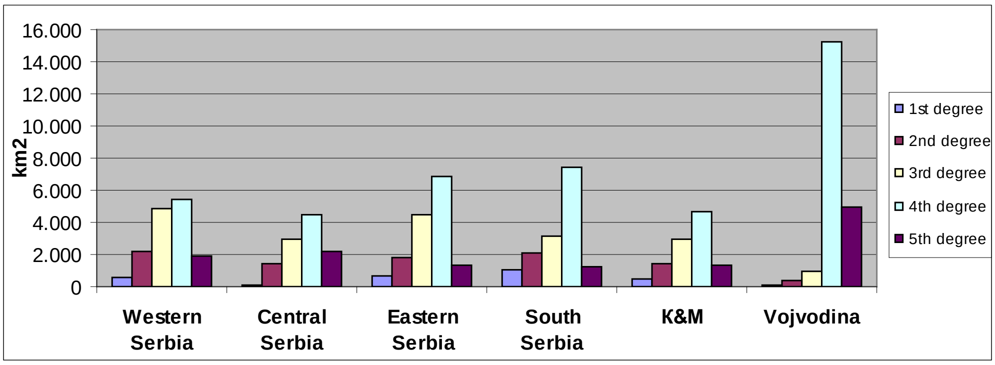
Diagram 1. *Reduction of arable land and garden in the overall structure of agricultural land*
Source: original, according to Statistical yearbook of the Republic of Serbia 2007, 2010, 2011

Linear trend of the reduction of arable and garden in the overall structure of agricultural land is presented by the function:

(3)
$$\hat{Y} = a + bx$$
$$\hat{Y} = 2.582{,}1\text{-}5{,}6x$$

In the period 2002-2010 the area under arable land and gardens are dramatically decreased (diagram 1). Based on the linear trend is estimated that in 2012 the total of arable land and garden will be 2.548.000 ha, and in 2013 year fall to 2.543.000 ha. The main causes of these changes are: the most fertile land for construction purposes, the ageing rural population and lack of motivation to become involved in agriculture.

The most represented form of degradation and compromising quality of soil erosion is a different level of intensity which included about 80% of agricultural land (2012/b). Erosion caused by the action of water, most pronounced in the central and mountainous regions of Serbia (diagram 2). The highest erosion (first degree) caused by the water present in South Serbia and operation 1.050 km², followed by areas of Eastern and Western Serbia, where affected by erosion 629 km² and 578 km ². Erosion second level is most pronounced in Western and Southern Serbia, where he represented the same level of 2.149 km² and 2.060km², while the erosion of the third degree dominant in western Serbia, where the procedure 4.870 km² and in Eastern Serbia, with 4.448 km². In the region of water erosion is the lowest level which can be explained by the fact that this type of erosion typical of the terrain with a higher slope.

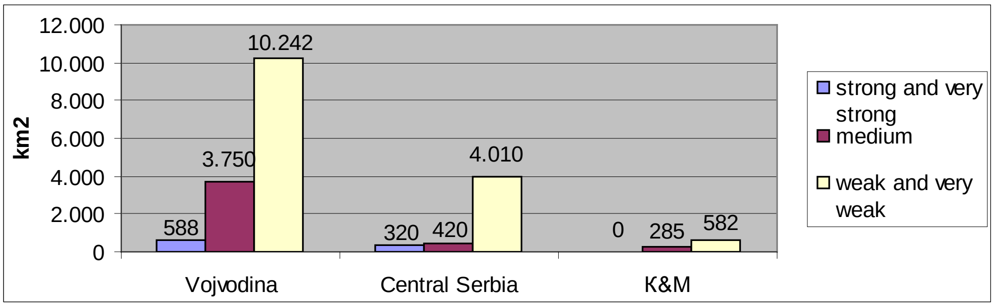


Source: original, according to (2012/a)

Diagram 2. *Coverage of water erosion (1st degree the strongest, 5th degree the weakest of erosion)*

In contrast under the influence of air mass movement, the area of AP Vojvodina is more exposed to erosion by wind in respect of all three analyzes the intensity (diagram 3). It is estimated that in this way annually loses about 0,9 t of material per hectare (Corine Land), resulting in degradation through the removal of surface layers which are largely concentrated in the highest quality plant nutrients. It is because of susceptibility to wind action and varying degree of intensity plot of Vojvodina is largely exposed to the degradation process eolian character. Also, the performance of the harvest before the drought leads to nakedness land, so that the crop can not be counted as a significant factor for erosion protection.

Due to AP Vojvodina is categorized as predominantly rural area with intensive production, an increase of eroded land and an annual reduction of arable land is in direct correlation with population movements from rural to urban areas. The explanation for these trends is the fact that erosion and other forms of land degradation compromised the quality of the environment is unfavorable for growing crops and reduced the possibility for intensive agricultural production.



Source: original, according to (2012/a)

Diagram 3. *Coverage of wind erosion*

Taking into account that rural areas comprise 85% of the entire territory of Serbia and to make the space in which the dominant land use as the primary source of income, it is important to emphasize decreasing trend in using it from 2004-2010 years (table 1 and diagram 4). The real use of agricultural land (Y) represents the original value of it's total use in the Republic of Serbia, published in statistical yearbooks. The parameter (X) is an independent variable that denotes the time unit, which is due to an odd number of years taken into consideration for the starting point selected central and 2007. Theoretical use of agricultural land ($\hat{Y}$) includes the value of the model formulated on the basis of a linear trend on which the interpolation is performed among the trend lines of the original data (diagram 5).

Table 1. *The use of agricultural land*

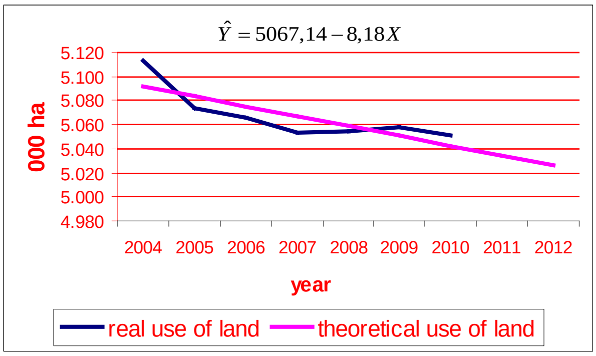
Year	Real use of land	Year label	Theoretical use of land
2004	5.113	-3	5.091,7
2005	5.074	-2	5.083,5
2006	5.066	-1	5.075,3
2007	5.053	0	5.067,1
2008	5.055	1	5.059,0
2009	5.058	2	5.050,8
2010	5.051	3	5.042,6
2011		4	5.034,4
2012		5	5.026,3
2013		6	5.018,0

Source: original, according to Statistical yearbook of the Republic of Serbia 2007, 2010, 2011

Lineaar function of the phenomenon is described by the following function:

$$\hat{Y} = a + bx$$
$$\hat{Y} = 5.067{,}14 - 8{,}18x$$

The parameter *a* value is a theoretical value of the linear trend in the source-year (x=0), in this case in 2007. This means that the linear trend model, the use of agricultural land in 2007. amounted to 5.067.000,1 ha. Parameter *b*, or the direction of the coefficient is negative (b<0), indicating an absolute decline in the occurrence, or, a gradual decline in the use of agricultural land in the period 2004-2010 year.



Source: original, according to Statistical yearbook of the Republic of Serbia 2007, 2010, 2011

Diagram 4. *Use of agricultural land*

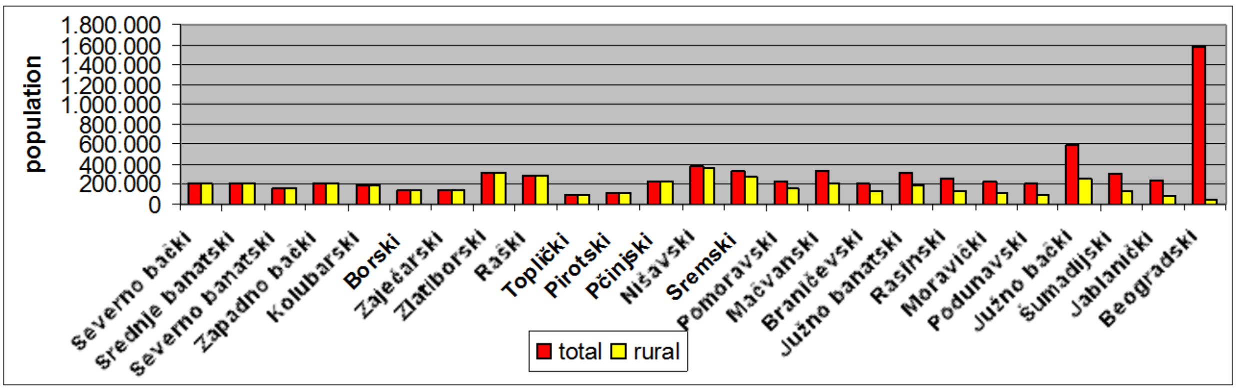
Using the model of a linear trend defined by the movement in the use of agricultural land from 2004-2010 and the projections made for this movement in 2012 and 2013. Based on the graphic display (diagram 4) notes the negative trends in the use of agricultural land in the period from 2004-2010 year. Provided that this trend continues the trend of the linear model, it is anticipated that the use of agricultural land in the Republic of Serbia in 2012 year amount to 5.026.000,25 ha and in 2013 year 5.018.000,1 ha.

Table 2. *Agricultural population by region*

Agricultural population				
Regions	All of the agricultural population	Participation of the agricultural population by region (%)	Area region (km²)	Agricultural population /km²
Beograd	35.629	4,4	3.224	11,1
Vojvodina	215.147	26,3	21.506	10,0
Šumadija and Western Serbia	343.988	42,1	26.483	13,0
South-Eastern Serbia	222.288	27,2	26.192	8,5
Total	**817.052**	**100%**	**77.405**	**10.06**

Source: original, according to Statistical yearbook of the Republic of Serbia 2011

In accordance with the territorial scope of the regions (table 2), is determined depending on the population of the largest agricultural area in Šumadija and Western Serbia, where the 1km² has nearly 13 farmers. Taking into account that the Belgrade region procedures is far less area than the other, has about 11 inhabitants per km² which may be claimed as agricultural, and Vojvodina has 10, and the area of southern and eastern Serbia, about 8 farmers per km².



Source: original, according to Bogdanov et al., (2006)

Diagram 5. *Participation of total in rural population*

Areas north of Bačka and South Banat district are categorized as predominantly rural, the Rasina to Jablanica areas of the transition levels of rurality, while Belgrade is the only region of predominantly urban character (diagram 5). Assuming that about 58% of all poor live in rural areas. In 2007 year (according to the Survey on standard of living 2007) the percentage of poor in rural areas, compared to the previous period has increased to over 61%, twice as much compared to urban areas (9,8%: 4,3%).

Table 3. *SWOT analysis*

Strenghts	Weaknesses
s1 - the fertility of the land (1-4 class makes 1/3 of total agricultural land) **s2** - suitable conditions for agricultural production **s3** - arable land per capita above the European average **s4** - available to fund land food security **s5** - significant areas of unused agricultural land **s6** - multifunctional character of the land **s7** - conditions for the development of organic production, medicinal herbs, forest fruits **s8** - ecologically clean environment **s9** - climatic predisposition **s10** - proximity to markets and urban centers	**w1** - high degree of land degradation **w2** - deagrarization **w3** - unplanned conversion of agricultural in non-agricultural **w4** - inadequate use and depletion natural resources **w5** - fragmentation of holdings **w6** - a marked erosion and flooding **w7** - underdeveloped infrastructure **w8** - obsolete machinery **w9** - using traditional methods and technologies of cultivation **w10** - lack of funds to investments
Opportunities	Threats
o1 - the implementation of amelioration and melioration of land **o2** - the preservation and agrobiodivesity soil qua **o3** - rational use of agricultural land **o4** - preventing land degradation **o5** - an increase of irrigated areas **o6** - consolidation of agricultural holdings **o7** - linking science with industry **o8** - infarasturcture improvement **o9** - development of organic farming **o10** - introduction of new production technologies ar modernization of agricultural holdings	**t1** - a lot of pressure on the environment and depletion of natural resources **t2** - reduce the total area of agricultural land **t3** - inadequate land management **t4** - agricultural production that improves soil erosion **t5** - weed infestation and loss of function agricultural land **t6** - pollution due to agricultural land improper use of chemicals **t7** – melioration measures are significantly lower compared to **t8** – conventional treatment of land **t9** - neglect of care for the environment **t10** - inadequate measures to protect the environment

Source: original

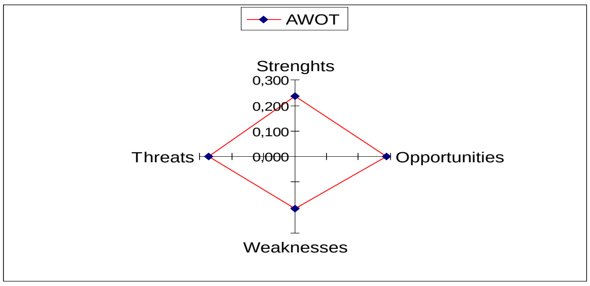
By bringing into the relationship strengths and weaknesses with external opportunities and threats, in terms of land as a resource of great importance for the existence of the rural population it can be concluded that significant power in the form of edaphic conditions, high quality land suitable for processing, ecologically clean area with good predispositions for development of organic production. Such a favorable constellation of factors is of particular importance for the rural population that has traditionally been the most dependent on agricultural production. The weaknesses are the high level of degradation (erosion affected 85% of land), land melioration issue and loss of agricultural lands, fragmented holdings (rural population that has no land or is less than 1 ha is most at risk of poverty). Chances are reflected in the implementation of amelioration and melioration of the land and the rational and sustainable use of agricultural land. In this way, contribute to reducing the depopulation of rural areas by creating opportunities for development of agriculture in re-cultivated fields. Threats are expressed through the intense pressure on the environment, loss of agricultural land, then its conversion into other uses, and insufficient implementation measures of recultivation. Poverty, especially rural character, promotes uncontrolled depletion of resources, but also the result of degradation and reduced land productivity.

Table 4. *Average values of factors of SWOT analysis*

Strenghts	Opportunities	Weaknesses	Threats
0,236	0,288	0,204	0,272

Source: original

Valorized elements of the SWOT matrix and analysis A'WOT results are shown in diagram 6.



Source: original

Diagram 6. *A'WOT analysis*

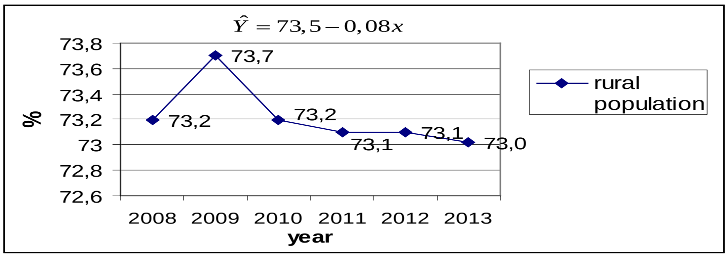
Approximate symmetry between all four SWOT element is explained by the high valuation of all elements, where the range between the lowest and highest values ranging from 0,0166-0,0339, which can be explained by a balanced approach to benefits, primarily caused by natural predispositions, as well as weaknesses and threats arising from the intense pressures on the environment.

Table 5. *Results of analysis of A'WOT*

S		W		O		T	
s1	0,0271	w1	0,0237	o1	**0,0339**	t1	0,0305
s2	0,0271	w2	0,0237	o2	**0,0339**	t2	0,0305
s3	0,0271	w3	0,0237	o3	**0,0339**	t3	0,0305
s4	0,0244	w4	0,0214	o4	0,0305	t4	0,0275
s5	0,0244	w5	0,0214	o5	0,0305	t5	0,0275
s6	0,0244	w6	0,0214	o6	0,0305	t6	0,0275
s7	0,0217	w7	0,0190	o7	0,0271	t7	0,0275
s8	0,0217	w8	**0,0166**	o8	0,0237	t8	0,0244
s9	0,0190	w9	**0,0166**	o9	0,0237	t9	0,0244
s10	0,0190	w10	**0,0166**	o10	0,0203	t10	0,0214

Source: original

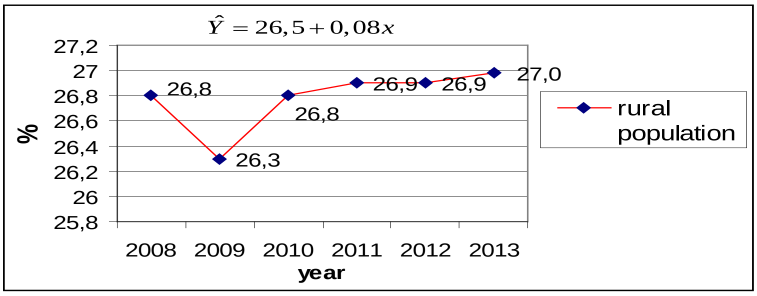
In relation to other elements, and the results A'WOT analysis (table 5), the highest value factors are categorized as likely (0,288) through the implementation of ameliorative and measures of recultivation of degraded areas with sustainable land use and preservation of their quality (0,0339) . Starting from the rural population in Serbia, classified as a predominantly agricultural population, these measures would significantly contribute to the creation of living conditions based on agricultural production. Threats (0,272) are reflected in the uncontrolled depletion of soil resources and its inadequate management, resulting in degradation and reduced agricultural area (0,0305). These are most directly affected by the rural agricultural population, where the reduction in land productivity increase directly in proportion to their poverty. In the weak emphasis on the proportion of degraded (especially land affected by erosion) in relation to the total area, deagrarization of certain areas and the conversion of agricultural land to nonagricultural (0,204). In this way creates a direct negative impact on the amount of production and, indirectly, the standard of the rural population. As opposed to these negative images of rural agriculture, as well as benefits (0,024) to allocate the land of high quality (1-4 class makes 1/3 of total agricultural land), arable land per capita that is above the European average and favorable natural predisposition for the development of agriculture (0, 0271). This suggests not that Serbia has potential and that if they are used rationally and sustainably, can be leverage to developing rural areas and by analogy with the team and reduce poverty levels.



Source: original, according to Survey on manpower 2008, 2009, 2010, 2011

Diagram 7. *The rural population in Central Serbia*

On the territory of Central Serbia contingent of the rural population increased by 0,5% in 2009 (diagram 7), then in 2010 year the percentage share of the rural population decreased to a value of 2008 year of 73,2%. In the 2011, there was a milder decline of 0,1%. Based on the model of a linear trend was performed to estimate in 2012 year will be at the same level as in 2010 of 73,1%, while in 2013 year in Central Serbia will be 73%.

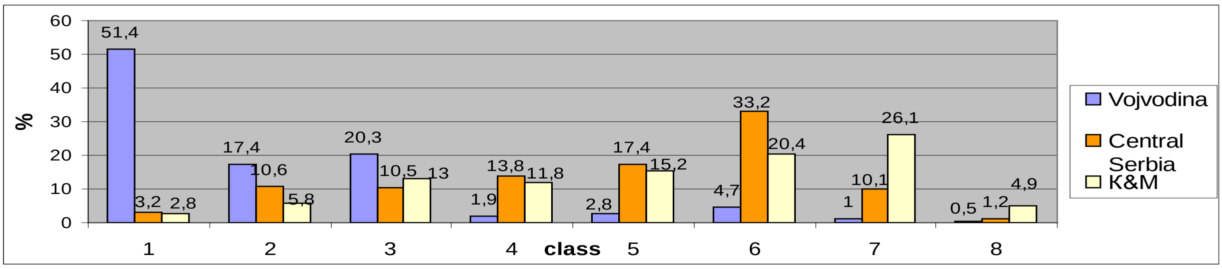


Source: original, according to Survey on manpower 2008, 2009, 2010, 2011

Diagram 8. *The rural population in Vojvodina*

In contrast to the tendency to reduce the rural population in Central Serbia, Vojvodina comes to its gradual rise (diagram 8). The exception in 2009 year when the proportion of rural population in Vojvodina decreased by 0,5% in 2010 year. Using the linear trend model, the conclusion is that the rural population in 2012 be on the same level and 2011 (26,9%), and in 2013 by 0,1% compared to the previous year.

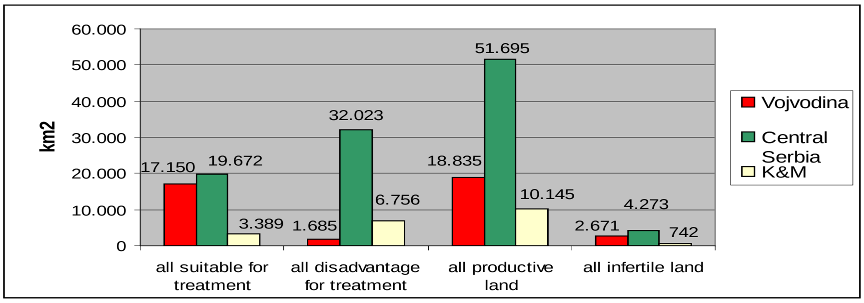
From the standpoint of its features can be noted that a significant part of arable land is acidified, primarily due to the irrational use of chemical agents. Thus, increased soil acidity makes 1,97 million ha (2012/a). In Vojvodina, the production possibilities of land greatly reduces the occurrence of salinization and it is estimated that in this way degraded about 150,000 ha. Excluding these factors affecting the decline in soil quality, with Vojvodina, Mačva is characterized by highly productive agriculture with favorable structure of farms. In terms of demographic characteristics is present in higher concentration of population with a lower degree of migration compared to other rural regions. This can be attributed to the highly productive land and relatively developed infrastructure, well equipped, which reduces the need to leave the farms and movements to urban areas.



Source: original, according to Spatial Plan of Republic of Serbia

Diagram 9. *Classification of land*

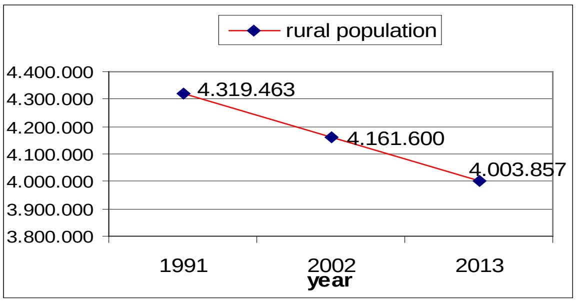
Based on the established classification of land quality classes at eight major prerequisites for intensive agriculture is the Vojvodina, where the soil is the 1-3 class much more than in other areas (diagram 9). Also, some high productive land is dominated by the lower classes in Vojvodina, while the lowest level of soil quality (5-8 classes) is largely represented in Central Serbia and Kosovo. Highly productive land in the rural parts of Vojvodina is brought into correlation with positive demographic trends, particularly in the period 1991-2002 and directing the population toward agricultural production, as well as existentially undisputed for most households. Land for slightly lower quality compared to the Vojvodina region is characterized by central Serbia, where demographic trends are highlighted. Pressure on natural resources in this area is largely industry. Mountainous rural areas, particularly South-East Serbia because of lower land quality is correlated with negative demographic trends and the low population density.



Source: original, according to Spatial Plan of Republic of Serbia

Diagram 10. *Productive land in Serbia*

On area of land suitable for processing is about 10 times higher than in non-arable land, while in Central Serbia and in Kosovo and Metohija, this ratio significantly worse, because disadventage area has nearly twice as many (diagram 10). Low productivity of land limits the latent agricultural production and, accordingly, encourages migration trends and the increasing depopulation of rural areas.



Source: original, according to Inventory of population 1991, 2002

Diagram 11. *The movement of rural population in the period of 1991-2013*

Inventory of population of 1991 in rural areas were 4.319.463 inhabitants in 2002 year 4.1616.000. Based on these data, the method of arithmetic progressions of population in rural areas declined by 14.346. Based on this negative demographic trends, and the list of available empirical data, it can be stated that in 2013 year in rural areas will be populated with 4.003.857 inhabitants (diagram 11). Expected population density in 2013 population is 60,7.

DISCUSSION

In the era of modernization of agriculture in particular insist on continually increasing the risk of loss of biodiversity, which are traditional farmers (the rural world) marked as protectors of the natural environment (Stojanović et al, 2009). Rural economy, traditionally based on agriculture provides sustainable only if the resources are managed properly. Otherwise there is a violation of the rural environment and degradation of natural resources. In contrast to the situation in developed economies where the soil contamination is due to significant livestock (Wossink and Wefering, 2003) in Serbia is the distortion factor of soil quality is relatively insignificant. Soil erosion is the most important problem of environmental degradation in developing countries (Ananda and Herath, 2003), to indicate the situation in Serbia, where the erosion of various degrees affected about 85% of the total territory, where practically the entire territory of Serbia attacked water erosion with different intensity, and wind erosion occurs in Vojvodina (Kostadinov et al., 2006). That the land degradation problem of global proportions, is the fact that the critical and growing in Africa, Asia and South America, and is an important and relatively stable in Europe and the former USSR, is critical to the decline in North America, while the low priority and relatively stable in the polar region (Soković-Djokic, 2004).

Distinct socio-geographic and socio-economic transformation over the past 30-40 years have led to changes of land utilization and the abandonment of agricultural land (mainly arable) and their healing in permanent grass and brush cover (Dragićević et al., 2009). Starting from the fact that Serbia is predominantly rural and predominantly agrarian economies, the role of soil resources is crucial for a large number of Serbian households. In the past few decades in Serbia it is expressed the trend of unbalanced regional development, which particularly affected the rural areas that differ in natural, economic, political and socio-demographic characteristics (Jelić et al., 2011). Rural poverty is most pronounced in the southeastern part of Serbia, which is characterized by low population density, population migration expressed as a result of extensive agricultural production and the negative relationship between favorable and unfavorable surface for processing. The link between environment, poverty and the population had the opposite interpretation. In a human population growth is a major cause of poverty and environmental degradation, while the other just takes a high poverty population growth and environmental degradation (2012/b). The number of rural population in the past (according to 1991 inventory of population and 2002 year) had a regressive movement of the design of the same negative trend in the future. Along with that, and use of agricultural land in the period from 2004-2010. The negative movement was recorded, with a significant reduction in arable land and garden as the most productive areas.

Agriculture is the primary activity of rural areas and as such it is an existential land base for a significant number of mostly poor households in Serbia. The reliance on natural resources, will inevitably lead to their exhaustion and consequent degradation. The weakening of the productive capacity of land next to the consequent lower yield reflects and reinforces the rural poverty, but in certain circumstances, primarily due to the lack of alternative forms of engagement outside of agriculture, and the poor themselves often destructive effect on the environment. Declining fertility and soil degradation phenomena in our country are due primarily to the application of conventional tillage and lack of application techniques and equipment for the melioration of land and rational processing (Raičević et al., 2006).

Rehabilitation of degraded areas, in addition to a number of general social environmental benefits, is one of the most important factors that could contribute to the economic prosperity of the agriculture-oriented rural areas. Properly designed and installed erosion control works have an impact on reducing the intensity of soil erosion (Kostadinov et al., 2008), however, processes are usually slow recovery and a significantly lower level compared to the real needs. As a form of melioration of degraded land stands out afforestation, which provides multiple positive effects. In addition to producing oxygen and absorbing CO_2 from the air, afforestation repressive effects on the degradation processes and contribute to ecological balance. Moreover, raising forest plantation-afforestation "vulnerable" land over time contributes to a raw material base for the wood processing industry, thereby creating opportunities for the development of this industry in rural areas, and thus accelerate the rural development (2008/c).

CONCLUSION

The total agricultural land in Serbia is 63,7% of its territory. In the period 2004-2010 year observed a negative trend in the use of agricultural land. According to the model of a linear trend is estimated that land use in 2007 year amounted to 5.067.000,1 ha, and that its use in 2012 year fall to 5.026.000,25 ha. It also reduces the area under arable land and gardens, so that the model of a linear trend in 2012 year they amount to 2.248.000 ha of land, and in 2013 year, 2.543.000 ha. Following the movement of rural population, also noticed a negative trend, which according to data from 1991 year (4.319.463 inhabitants) and 2002 year (4.161.600 inhabitants) showed an average annual reduction of 14.346 inhabitants in rural areas. In 2013 year is expected populated rural areas with about 4.003.857 inhabitants. Expected population density in 2013 year was 60,7 people per km². Šumadija and along the western Serbian km² on average have about 13 people involved in agricultural production, as compared to other parts of the country has most of the agricultural population. Of the 25 districts, 18 were categorized as predominantly rural, of which 12 districts in the rural part of the total population is 100%. Poverty in all its forms is widespread in all spheres of society but is most pronounced in rural areas, where, according to statistics from 2007. The rural poverty was twice higher than in urban (9,8%: 4,3%).

In Central Serbia in 2009 year rural population has increased by 0,5% compared to 2008 year when, then in 2010 year number of rural population increased to a level of 73,2%. In 2011 year, there was a milder decline of 0,1%. Based on the model of a linear trend was performed to estimate in 2012 year will be at the same level and 2010 year of 73,1%, while in 2013 year in Central Serbia will be 73%. In respect of agricultural holdings Central Serbia, Vojvodina leading to a gradual increase share of rural population. The exception in 2009 year when the proportion of rural population in Vojvodina decreased by 0,5% and was at the level of 26,3%. U 2010 year of the rural population was the same percentage level as in 2008 year (26,8%). Using the linear trend model, the conclusion is that the rural population in 2012 will be on the same level and 2011 year (26,9%), and in 2013 year 0,1% more, so it will reach a level of 27%.

Serbia has very favorable natural predisposition for the development of agricultural production with high quality land, where the first four classes of land made 1/3 of total agricultural land. Land of the 1-3 class dominates in Vojvodina, while the land is low and full of low quality (5-8) class largely represented in central Serbia and Kosovo. As a result of increased urbanization, unplanned occupation of land for construction purposes, depletion of land resources in agriculture, which is the only source of income for marginalized social structure, there is growing Degradation and analogous to that film production and reduced the ability of the land. Precisely, the condition of poverty is causing a negative effect on the environment which is primarily manifested through excessive exploitation of resources of public importance.

Erosion, degradation of vision as the most widespread, affected about 80% of the entire territory. Wind erosion is most pronounced in Vojvodina, where she described as "very strong" covers 588 km², moderate erosion is present on the 3.750 km², while the "weak" erosion represented at 10.242 km². Water erosion caused largely covers the central part of the country, where erosion of the first and second degree strongest in southern Serbia which covers 1.050 km², or 2.060 km². Based on the analysis A'WOT as valuation variant SWOT matrix, the most valued element of the chances (0,288), followed by threats (0,272), benefits are measured with a 0,236 to 0,204 and weaknesses.

Chances are expressed through the remediation and melioration of degraded areas and erosion risk, sustainable and rational use of land resources, increasing the irrigated areas, the return of abandoned agricultural land to its original use, consolidation agricultural holdings are factors that can greatly affect the development of rural agriculture. In addition, reforestation of degraded areas to achieve multiple positive effects, both from an environmental point of view through, and as a potential opportunity for economic prosperity in terms of industry development and analogous to that development and socially marginalized areas. State can support agriculture and rural development, with comprehensive public funds and coordination with the ministry, which could be instruments that will in the future defining to act on reducing rural poverty.

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BIOSPHERE RESERVE "GOLIJA-STUDENICA"

Predrag ALEKSIĆ[1], Gordana JANČIĆ[1]

Abstract: *The area of the mountains Golija and Radočelo was designated by the Decree of the Republic of Serbia Government (2001) as the Nature Park "Golija" (75.183 ha) and SE "Srbijašume", as the trustee, performs the management. Nature Park "Golija", with its natural and man-made values, satisfies completely the criteria for the Biosphere Reserve nomination by the MAB (Man and Biosphere) Programme.*

The base of the MAB Programme, which was established in 1971 within the United Nations Educational, Scientific and Cultural Organization (UNESCO), is the harmony of man and nature.

As proposed by the Institute for Nature Conservation of Serbia, and in harmony with the objectives of the Spatial Plan of the Republic of Serbia (1996), supported by MAB National Committee, a part of the Nature Park "Golija" under the name "Golija-Studenica" (53.804 ha) was nominated as biosphere reserve. By the decision of the MAB International Coordinating Council (ICC) for UNESCO MAB Programme, in September 2001, Biosphere Reserve "Golija-Studenica" was designated as the first biosphere reserve in Serbia and it became a part of UNESCO's World Network of Biosphere Reserves (to date, 598 biosphere reserves in 117 countries have been included in the World Network of Biosphere Reserves - WNBR). The designation of the reserve was based on the well-preserved nature with a great number of plant and animal species, among which there are many endemic and relic species. The area includes the Monastery Studenica which has been on the World Heritage List since 1986.

Biosphere reserves are sites of terrestrial and coastal/marine ecosystems which are internationally recognized by the UNESCO MAB Programme and they should solve one of the most important issues faced by the world today: how to reconcile the biodiversity conservation with the need for economic and social development and for the maintenance of pertinent cultural values. An effective biosphere reserve denotes mutual actions by professionals for natural and social sciences, groups for protected area conservation and development, institutions responsible for reserve management and local communities.

The effectiveness of the reserve organization was analysed in the First Report on the occasion of the tenth anniversary of the Biosphere Reserve "Golija-Studenica" (2001-2011).

Key words: biosphere reserve, Golija, management.

1. INTRODUCTION

Biosphere reserves are sites of land and coastal/marine ecosystems which are internationally recognized by the UNESCO MAB Programme and they should solve one of the most important issues faced by the world today: how to reconcile biodiversity conservation with the need for economic and social development and for the maintenance of pertinent cultural values.

Nowadays there are 598 biosphere reserves in 117 countries. Eighteen new ones were included in 2011 and twenty more were nominated for inclusion into the World Network of Biosphere Reserves (WNBR) in 2012.

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The Seville Strategy (adopted at the UNESCO International Conference on Biosphere Reserves in 1995): gives guidelines for the development of effective biosphere reserves and sets conditions for the functioning of the WNBR; defines the specific role of biosphere reserves in expanding a new vision of the relationship between conservation and development; proposes the level (international, national, individual biosphere reserve) on which each of the proposals will be the most effective and emphasizes the contribution made by biosphere reserve to the implementation of the Convention on Biological Diversity.

The part of “Golija“ Nature Park under the name of “Golija-Studenica“ (53.804 ha) was granted biosphere reserve status in 2001 and thus became part of the UNESCO’s World Network of Biosphere Reserves (the first and only biosphere reserve in Serbia to date).

The First Periodic Report on “Golija-Studenica” Biosphere Reserve (2001-2011) was submitted to the International Coordinating Council of UNESCO's MAB Programme in Paris in 2011.

2. WORK METHODOLOGY

In the study, data have been used, analyzed and synthesized from the following sources: the Spatial Plan of the Republic of Serbia (2010-2020), the Biosphere Reserve Nomination Form for “Golija-Studenica“ and “Golija“ Nature Park Management Plan. International conventions, declarations, resolutions and strategies in the field of biosphere reserve management have been studied.

3. CONCEPT OF BIOSPHERE RESERVES

A Biosphere Reserve is determined by the national government and must meet certain criteria and defined requirements to be admitted into the network of internationally recognized biosphere reserves within UNESCO's Man and Biosphere Programme (MAB Programme is a legal framework for the World Network of Biosphere Reserves).

In order for an area to be designated as biosphere reserve, it is necessary that it: represents a larger biogeographic region, including varying degrees of human intervention in it; covers landscapes, ecosystems and protected species; enables the implementation of the principles of sustainable development; is of a size which enables the fulfillment of the three functions and has an appropriate zoning system.

A Biosphere Reserve must fulfill three complementary functions: conservation function (to conserve landscapes, ecosystems, species and genetic diversity); development function (to foster economic and social development which is socio-culturally and ecologically sustainable) and logistic function (to support scientific research, monitoring, education and information exchange related to issues of nature and environmental protection and development on the local, national and global levels).

Physically, each biosphere reserve should cover three areas (zones): the central area (*core area*), which must be legally protected at national level, in which long term protection of landscape and biological diversity is provided and the size of which depends on the objectives of protection (there may be one or several small central areas and eligible activities are: scientific research, monitoring and activities that are consistent with the objectives of protection of the central area); protection area (*buffer zone*) surrounding the central area (clearly defined boundaries), with activities that have to be consistent with the objectives of protection of the central area and in the function of preventing impacts that may compromise the protection (eligible activities include: research aimed at improvement and rehabilitation of degraded areas, sustainable use of natural resources (forestry, fisheries, land, etc.). with maximum preservation of natural processes and biodiversity) and the transition area (*transition zone*), which can have major economic and social importance for the development of the region and may include agricultural areas, villages and areas of other purposes (in this zone, various agricultural activities can take place or it can be used for other purposes, in which case local communities, management agencies, scientists, NGOs, cultural groups, economic organizations and other interested parties can work together to organize the management and sustainable development of resources in this area).

These three zones were originally conceived as concentric rings, but in practice they have been implemented in various ways to meet specific local requirements and conditions of each biosphere reserve. In fact, one of the strongest features of the concept of biosphere reserves is the flexibility and creativity with which this concept can be realized under different conditions.

Some countries have adopted specific laws introducing the institution of biosphere reserves. In many countries the central areas and protection zones are designated (in whole or in part) as zones protected by special laws. A number of biosphere reserves also includes areas that are protected by other systems (such as national parks, nature parks and nature reserves) and other internationally recognized areas (such as the World Heritage areas and Ramsar sites). In Serbia, the institution of Biosphere Reserves is not legally defined, but the Spatial Plan of Serbia, as a strategy document, defines the areas in Serbia to be nominated for biosphere reserves.

The ownership structure of areas in the WNBR can vary. The central area of the biosphere reserve is mostly state-owned (may be privately owned or owned by NGOs), the ownership of the protection zone is private, state and public, and that is also the case with the transition zone. The main objectives of biosphere reserves are: conservation of biological diversity, preservation of healthy ecosystems, learning about natural systems and their changes, acquisition of knowledge about traditional ways of land use, acquisition of knowledge about the use of natural resources in a sustainable manner and cooperation in solving problems related to natural resources. What makes the idea of a biosphere reserve complex in its realization is the necessity of local communities to recognize it and actively participate in its implementation. For the functioning of biosphere reserves, more important than the actual declaration procedure is the willingness of local communities to recognize their environment as an area with special values, and develop it in that light.

4. SEVILLE STRATEGY AND MANAGEMENT OF BIOSPHERE RESERVES

Biosphere reserves should solve one of the most important issues faced by the world today: how to reconcile the biodiversity conservation with the need for economic and social development and for the maintenance of pertinent cultural values. An effective biosphere reserve denotes mutual actions by professionals for natural and social sciences, groups for protected area conservation and development, institutions responsible for reserve management and local communities.

The idea of biosphere reserves is related to the year 1974 (UNESCO Man and Biosphere Programme or MAB). The World Network of Biosphere Reserves (WNBR) was initiated in 1976 (in 1995 it included 324 reserves in 82 countries, and in May 2012 the network comprised 598 reserves in 117 countries) and is crucial for the MAB Programme objectives which are: achieving a sustainable balance among the sometimes conflicting goals of conserving biological diversity, promoting economic development and maintaining cultural values. Biosphere reserves are sites where these objectives are tested, demonstrated and implemented.

The First International Congress on Biosphere Reserves was held in 1983 in Minsk (Belarus), organized by UNESCO and UNEP, in collaboration with FAO and IUCN. The Congress launched the initiative "Action Plan for Biosphere Reserves" which is, in its greater part, still in force today. The context in which biosphere reserves operate changed significantly after the adoption of the Convention on Biological Diversity (Rio de Janeiro, 1992), whose main goals are: conservation of biological diversity, sustainable use of its components and fair and equitable distribution of benefits arising from the use of genetic resources. Biosphere reserves promote this integrated approach and are good examples for the implementation of the Convention.

In the decade after the Minsk Congress, reflections upon protected areas as a whole and biosphere reserves developed along parallel lines. The link between biodiversity conservation and development needs of local communities (a central component of the approach brought by biosphere reserves) is now recognized as a key factor in successful management of most national parks, nature reserves and other protected areas. At the Fourth World Congress of National Parks and Protected Areas (Caracas, 1992), the world's planners and managers of protected areas adopted many of the ideas (engagement of local communities, links between conservation and development, importance of international cooperation) which are essential aspects of biosphere reserves. The Congress also adopted a resolution in support of biosphere reserves.

Important innovations in the management of biosphere reserves themselves have also been introduced. New methods for stakeholder involvement in decision making and conflict resolution have been developed, and increased attention has been given to the need to implement regional approaches. New types of biosphere reserves, such as group cluster and cross-border reserves, have been devised, and many biosphere reserves have evolved considerably from the original focus of conservation to a greater degree of integration and development of the conversation through intensive cooperation among stakeholders. In addition, new international networks enabled by technological innovations have significantly contributed to better communication and cooperation between biosphere reserves in different countries. In this context, the Executive Board of UNESCO decided in 1991 to establish an Advisory Committee for Biosphere Reserves. The Advisory Committee concluded that the time had come to review the effectiveness of the 1984 Action Plan, to analyze its implementation and to develop a strategy for biosphere reserves for the next century. In this context, UNESCO organized the International Conference on Biosphere Reserves in Seville (1995) which adopted the Seville Strategy.

Seville Strategy objectives (recommended at the international level, national level and the level of individual biosphere reserve) are: **to use biosphere reserves for the conservation of natural and cultural diversity** (promote biosphere reserves as a means of implementing the objectives of the Convention on Biological Diversity; to establish, strengthen or extend biosphere reserves; to encourage the establishment of transboundary biosphere reserves as a means of preserving organisms, ecosystems and genetic resources that cross national boundaries; to include biosphere reserves in strategies for biodiversity conservation and sustainable use of resources, plans for protected areas and action plans); **to utilize biosphere reserves as models illustrating spatial management and sustainable development** (to incorporate biosphere reserves into plans for implementation of the objectives of sustainable use provided in Agenda 21 and the Convention on Biological Diversity; to establish, strengthen and extend biosphere reserves so as to include areas practicing traditional lifestyle and indigenous use of biodiversity; to examine the interests of individual stakeholders and engage them in planning and decision-making regarding the management and use of reserves; to provide that each biosphere reserve has an effective management policy or plan and the appropriate authority or mechanism for their implementation; to establish a local advisory network which will integrate all parties with economic and social interests on the reserve, with the inclusion of all kinds of interest (eg. agriculture, forestry, hunting and collection, water and energy supply, fisheries, tourism, recreation, research, etc.); to include biosphere reserves in spatial planning policy and regional land-use planning projects); **to use biosphere reserves for the purposes of research, monitoring, education and training** (use biosphere reserves for basic and applied research; encourage the participation of biosphere reserves in international networks and programmes, promote exchanges in education and raise awareness of the general public; encourage the involvement of local communities, school children and other stakeholders in education and training programmes, as well as research and monitoring within certain biosphere reserves; prepare information for the visitors about the biosphere reserve, its importance for the conservation and sustainable use of biodiversity, its socio-cultural aspects and recreational and educational programmes and resources; promote environmental education centres in the field within certain reserves, intended for school children and other groups); **to implement the concept of biosphere reserves** (ensure that each biosphere reserve has an effective management policy or plan and an appropriate authority or mechanism for their implementation; provide the involvement of local communities in planning and managing the biosphere reserve; encourage initiatives from the private sector to initiate and maintain environmentally and socially sustainable activities in the reserve and surrounding area; provide adequate resources for implementation of the Strategic Framework of the WNBR; allow periodic review of biosphere reserves in each country, as instructed by the WNBR Legal Framework and assist individual countries in taking steps to make their biosphere reserves functional; ensure to the reserves greater presence in the public and distribution of information materials, develop communication strategies; monitor, evaluate and support the implementation of the Seville Strategy, with the use of implementation indicators and analyze the factors that help in achieving these indicators, as well as those preventing their achievement).

5. BIOSPHERE RESERVE "GOLIJA-STUDENICA"

Golija is the highest mountain in southwest Serbia, stretching in a length of 32 km in the form of an S-shape curve. The highest peak is Jankov kamen (1833 m). By the beauty and variety of landscapes and preservation of original, natural and cultural values, it is one of the most attractive mountains in Serbia which, for this reason, was placed under protection as Nature Park "Golija" with an area of 75.183 ha (2001). The Serbian Government entrusted the State Enterprise "Srbijašume" with managing Nature Park "Golija" by performing activities, through the Administration of NP "Golija", that are aimed at its protection, sustainable use and development.

Nature Park "Golija" was placed under protection in order to preserve: the value of forest ecosystems; diversity of landscapes and their extraordinary beauty; cultural heritage and their surroundings (Studenica and Gradac monasteries); durability and quality of basic natural resources (water, soil and plant cover) , biodiversity; rare, endemic and relic species; geo-heritage, represented by unusual and attractive relief forms and numerous water objects and phenomena such as mountain springs, streams and peat bog lakes.

Golija is embellished by a spacious forest cover, with a great presence of beech forest. Some parts of these forests are of virgin character. Golija is now the mountain with the highest forest cover percentage in the country, with the greatest and best forest complexes. Its south slopes are overgrown with spacious meadows and pastures. In its spruce forests, peat bogs have been preserved, as specific and vulnerable ecosystems. In Nature Park "Golija", whose total area is 75.183 ha, forest cover is found on 39.528 ha (53% of the Park area), of which 18.460 ha (46.7%) are privately-owned and 21.068 ha (53.3%) are state-owned.

Together with Mt. Tara, Golija represents a refuge of the Tertiary flora in Serbia and it is a significant centre of genetic, species and ecosystem diversity in the Balkans and in Europe. The floristic biodiversity of Golija consists of about 900 plant taxa, of which are 729 species of vascular fungi, 40 species of mosses and 117 species and varieties of algae. Endemic and relic species are especially important in flora, as well as threatened species. Among the conserved natural rarities is the relic and endemic woody species of Balkan maple (Acer heldreichii) which is the synonym for the flora of Golija. Golija is a mountain massif of high biological diversity i.e. one of the important European centres of ornithological and genetic diversity. On Golija, there are 45 recorded bird species which belong to the group of natural rarities and about 90 candidate species are registered for the Red Book of Birds in Serbia.

An exceptional cultural-historical value of Golija is the Studenica Monastery. It was founded in late 12th century, as the main endowment of the founder of the Nemanjić Dynasty, Stefan Nemanja. With time, it became the most significant spiritual centre of the new medieval Serb state, with the greatest influence on the social and cultural development of the country. It was frequently destroyed and restored. In the 12th and 13th century, the Monastery complex consisted of 13 churches and supporting buildings, only two of which have been preserved until today: Church of the Holy Virgin and Saints Joachim and Ann's Church. The Studenica Monastery is undoubtedly one of the most valuable building designs of the Serbian nation and one of the most important centres of medieval events. As its value surpasses the borders of our country, it has been on UNESCO List of World Heritage Sites for over 25 years.

In 2001, "Golija" Nature Park was designated as biosphere reserve under the name "Golija-Studenica" and thus became the first biosphere reserve in Serbia. Preservation of nature with its abundant flora and fauna, among which there are endemic and relic species, as well as the presence of Studenica Monastery that has been on the World Heritage List since 1986, contributed to the proclamation of the reserve. The area of Biosphere Reserves "Golija-Studenica" covers 53.804 ha and comprises part of Nature Park "Golija" on the territories of Forest Estates Ivanjica and Kraljevo.

After the establishment of Biosphere Reserve "Golija-Studenica", the Government of the Republic of Serbia adopted the Decision on Forming a Coordination Committee for Protection and Development of Golija Region (2002), tasked with coordinating activities to prepare the programme and plan basis for socio-economic and environmentally sustainable development of the Golija Region, and in accordance with the criteria of preserving natural and cultural heritage of "Golija-Studenica" Biosphere Reserve, i.e. Nature Park "Golija", with the needs to improve quality of life for residents in the area and the development of appropriate activities.

The Coordination Committee for Protection and Development of Golija Region functioned until 2004, so that SE "Srbijašume", by managing Nature Park "Golija", performed tasks related to the functioning of Biosphere Reserve "Golija-Studenica". In the Report on Biosphere Reserve "Golija-Studenica" for the period 2001-2011 (drawn up by the Institute for Nature Protection of Serbia and SE "Srbijašume", in cooperation with the Ministry of Environmental Protection, Mining and Spatial Planning), the activities implemented by "Srbijašume" as the Manager were presented primarily.

The Manager has carried out the mid-term Programme on Conservation and Development of Nature Park "Golija" and, in accordance with the Law on Environmental Protection, issued a Protected Area Management Plan for the period 2011-2020 (consent given by the the Ministry of Environmental Protection), by which the following is determined: implementation method regarding protection, use and management of the protected area and guidelines and priorities for protection and conservation of natural values of the protected area.

In addition to designing and implementing planning documents, the Manager has also done the following: designed the trademark of Nature Park "Golija" and Biosphere Reserve "Golija-Studenica"; built the Visitor Centre at *Bele vode*, edited and marked the protected area; carried out projects in the field of monitoring of natural values in the protected area; carried out programmes and plans of sustainable use of natural resources; implemented programmes of cooperation with local people on sustainable use of NP "Golija" and eco-tourism etc..

The Manager of Nature Park "Golija" and Biosphere Reserve "Golija-Studenica" has recently sought to establish cooperation with local people, local government and other users of the area, so that local people would recognize the natural values of the area they live in and understand the importance of nature protection, as well as to accept the concept of protection and sustainable development of NP "Golija" and Biosphere Reserve "Golija-Studenica".

The Reserve area is characterized by a pronounced depopulation and underdevelopment, so that the Manager is faced with an extremely difficult task to achieve cooperation and education of the elderly population, and on the parallel to perform activities on the return of the population to the Golija area, which is naturally supported by state authorities, with a primary focus in the field of security and required funding for the management of the biosphere reserve (in the period 2002-2011, total costs of management activities of Nature Park "Golija" amounted to about 3.2 million euros, and co-financing by the Ministry of Environmental Protection amounted to only 465.853 euros, while the remaining funds were provided by the Manager partly from forestry activities and partly from the fees for the use of NP "Golija").

The Advisory Committee for Biosphere Reserves, considering the first periodic report for Biosphere Reserve "Golija-Studenica", recommended that, in order to accomplish all the functions of biosphere reserves, in the future more attention must be paid by the state to the following: improving the Reserve management (SE "Srbijašume", Manager of NP Golija", can not manage a biosphere reserve as it manages a protected area, but, according to world experience, should be done through collective bodies such as councils/committees/ coordinating bodies, comprising representatives of stakeholders, i.e. representatives of local communities, local governments, NGOs, the forestry sector, environmental protection, agriculture, businesses, etc..); creating conditions for greater involvement of local communities in the management of the biosphere reserve (building the necessary infrastructure, particularly transport, utilities and other) and providing conditions for rural development in the biosphere reserve area.

The management of Biosphere Reserve "Golija-Studenica" should be organized based on the model that works within the World Network of Biosphere Reserves, using examples of good practice in the management of the Biosphere Reserves Rhon in Germany and Entlebuch in Switzerland.

Priorities for the Biosphere Reserve "Golija-Studenica" should be: defining the management method of the biosphere reserve; preparation of biosphere reserve Management Plan; establishment of Municipal Boards, the Stakeholder Forum and the Biosphere Reserve "Golija-Studenica" Committee.

6. CONCLUSIONS

Biosphere reserves are sites of land and coastal/marine ecosystems which are internationally recognized by the UNESCO MAB Programme and they should solve one of the most important issues faced by the world today: how to reconcile biodiversity conservation with the need for economic and social development and for the maintenance of pertinent cultural values. Nowadays there are 598 biosphere reserves in 117 countries of the world.

The role of biosphere reserves is the promotion and demonstration of a balanced relationship between humans and nature. In order for an area to be designated as biosphere reserve, it is necessary that it: represents a larger biogeographic region, including varying degrees of human intervention in it; covers landscapes, ecosystems and protected species; enables the implementation of the principles of sustainable development; is of a size which enables the fulfillment of the three functions (conservation, development and logistic) and has an appropriate zoning system.

The Seville Strategy (adopted at the UNESCO International Conference on Biosphere Reserves in 1995): gives guidelines for the development of effective biosphere reserves and sets conditions for the functioning of the WNBR; it defines the specific role of biosphere reserves in expanding a new vision of the relationship between conservation and development; it proposes the level (international, national, individual biosphere reserve) on which each of the proposals will be the most effective and emphasizes the contribution that biosphere reserves can make during the process of implementing the Convention on Biological Diversity.

What makes the idea of a biosphere reserve complex in its realization is the necessity of local communities to recognize it and actively participate in its implementation. For the functioning of biosphere reserves, more important than the actual declaration procedure is the willingness of local communities to recognize their environment as an area with special values, and develop it in that light.

Nature Park "Golija" with its natural and man-made values fully met the criteria for a biosphere reserve nominee by the MAB Programme, and part of Nature Park "Golija" named "Golija-Studenica" (53.804 ha) was granted the status of Biosphere Reserve (September 2001) and became part of UNESCO World Network of Biosphere Reserves (the first and so far the only biosphere reserve in Serbia).

The first periodic report on Biosphere Reserve "Golija-Studenica" (2001-2011) was submitted to the Advisory Committee for MAB, UNESCO and the same was discussed in July 2012. The Advisory Committee for Biosphere Reserves, considering the first periodic report for Biosphere Reserve "Golija-Studenica", recommended that, in order to accomplish all the functions of biosphere reserves, in the future more attention must be paid by the state to the following: improving the Reserve management (as SE "Srbijašume", Manager of NP Golija", can not manage a biosphere reserve as it manages a protected area); creating conditions for greater involvement of local communities in the management of the biosphere reserve (building the necessary infrastructure, particularly transport, utilities and other) and providing conditions for rural development in the biosphere reserve area. The management of Biosphere Reserve "Golija-Studenica" should be organized based on the model that works within the World Network of Biosphere Reserves.

Priorities for the Biosphere Reserve "Golija-Studenica" should be: defining the management method of the biosphere reserve; preparation of biosphere reserve Management Plan; establishment of Municipal Boards, the Stakeholder Forum and the Biosphere Reserve "Golija-Studenica" Committee.

For effective operation of Biosphere Reserve "Golija-Studenica" it is necessary that required financial resources are provided by competent state authorities.

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CADMIUM ACCUMULATION IN *Ailanthus altissima* (Mill.) Swingle SEEDLINGS UNDER PHOSPHORUS AND IRON DEFICIENCY

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Abstract: *Potential plant nutritional disorders on carbonate soils are phosphorus or iron deficiency. Adapted calcicole plants, like Ailanthus altissima (Mill.) Swingle, have ability to change root microenvironment by increasing rhizosphere acidity and capacity of roots to uptake iron, zinc and phosphorus. Modified root microenvironment influences availability of toxic heavy metals, especially cadmium, which is among the most mobile in contaminated carbonate soils. Adaptation for efficient nutrients uptake also affects the process of Cd uptake into roots and translocation in shoots.*

To access influence of nutrients deficiency on Cd uptake and translocation hydroponic method was used to growth seedlings of Ailanthus altissima. Ten days after Cd contamination by adding Cd $(NO_3)_2$ at 20 µM in growing medium, accumulation of Cd was detected in roots and leaves of Fe-deficient, P-deficient and control plants. Results indicate that roots of P-deficient plants accumulate significantly less Cd (152.6±29.12 mg/kg) than control, well supplied plants (632.7±67.12 mg/kg) and Fe-deficient plants (621.6±56.24 mg/kg). Concentrations of Cd in leaves of P-deficient plants were a little bit higher than in control and Fe-deficient plants, but statistically insignificant. The iron and phosphorus deficiency decreased root and shoot biomass production of Ailanthus altissima seedlings. Cadmium contamination decreased root and shoot growth in control and additionally, in iron deficient plants, but in phosphorus deficient plants Cd treatment did not influence growth.

From presented data it seems that P deficiency in growing media is more limiting factor for Cd accumulation than Fe deficiency. This study could be important for improvement of phytoextraction efficiency on polluted soils, which are poor in phosphorous and iron available forms.

Key words: *Ailanthus altissima*, phosphorus deficiency, iron deficiency, Cd accumulation, phytoextraction, nutrition.

1. INTRODUCTION

Iron (Fe) and phosphorus (P) deficiency can be potential nutritional problems of higher plants on alkaline and carbonate soils. The absence of iron deficiency symptoms on plant species which growth on neutral and alkaline soils indicate that in those plants nutritional starvation triggers adaptation mechanisms for efficiently nutrient acquisition in the rhizophere. In Strategy I plants (dicots and monocots except grasses), Fe acquisition mechanisms are: rhizosphere acidification, reduction of Fe(III)-chelates by plasma membrane–bound enzymes (Schmidt, 1999, Marshner and Römheld,1994) and release of organic compounds such as phenolic compounds, amino acids and organic acids (Curie and Briant. 2003). Activation of these

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mechanisms increase root uptake of Fe from the rhizosphere, also increase uptake of other micronutrients (Zn, Cu, Mn) but also toxic metals such as Cd (Cohen, 1998).

Phosphorus deficiency is limiting factor for plant biomass production in calcareous soils. Typical P deficiency response is release of carboxylates in root microenvironment. It is postulated that increased exudation of organic acids is related to increased mobilization of sparingly soluble P (Neumann and Römheld, 2006). Increased concentration of organic acids in the rhizosphere can also influence availability of heavy metals and Ca.

In the papers published so far, the interaction of toxic metals and nutrient deficiency is mainly studied in annual crops (Larbi et al, 2002). In the present study, influence of induced Fe and P deficiency on accumulation on Cd is investigated in *Ailanthus altissima* (Mill.) Swingle, an invasive tree species (native to northern China) with very fast growth, high biomass production and high photosynthetic efficiency (Kowarik and Saumel, 2007; Marek, 1988; Hammerlynck, 2001). The native habitats of this species are lime-rich soils with a high potential risk of P and Fe deficiency, thus it colonizes such soils in the secondary range (Kowarik and Saumel, 2007).

The main objective of the work presented here was to elucidate whether induced Fe deficiency and P deficiency affects accumulation of Cd in seedlings of *Ailanthus altissima*, in order to investigate capacity of this plants for phytoremediation use on contaminated soils, poor in phosphorous and iron available forms.

2. MATERIAL AND METHOD

Seeds of *Ailanthus altissima* were collected from one mother tree and germinated in Petri dishes on filter paper moisturized with distilled water at temperature of 25°C. After germination, young seedlings were transferred to a nutrient solution containing (mM): 0.35 K_2SO_4, 0.05 KCl, 1.0 Ca $(NO_3)_2$, 0.25 $MgSO_4$, 0.05 KH_2PO_4, and (in µM): 5 H_3BO_3, 0.25 $MnSO_4$, 0.25 $ZnSO_4$, 0.1 $CuSO_4$, 0.005 $(NH_4)_6Mo_7O_{24}$. Iron was supplied as Fe^{III}EDTA at 20 µM. For every replacement, initial pH of solutions was adjusted to 6.5.

Plants were grown in a growing chamber with a photosynthetic photon flux density of 200 $\mu molm^{-2}s^{-1}$ at plant height, a photoperiod of 16/8h, temperature regime of 27/20°C and relative humidity of about 70%. The nutrient solutions were renewed completely every 5 days and continuously aerated. After three weeks the plants were divided and transferred in 1) phosphorous deficient nutrient solution (-P), 2) iron deficient solution (-Fe) and 3) in complete nutrient solution (control). After one week in all solution with plants (both treatments and control) 20 µM Cd $(NO_3)_2$ is added and plants growing in that solutions for a next 10 days.

Each replication was consisted of three *Ailanthus* plants of similar biomass and height.

After treatments plants were prepared for mineral analysis. The intact roots were washed in 0.5 mM Na_2EDTA for one hour, and then dried at 70°C for 72 h. After determination of root and shoot dry weight, the samples (0.2 g) were subjected to a microwave digestion with 3 mL HNO_3 + 2 mL H_2O_2, Mineral elements were determined by inductively coupled plasma optical emission spectrometry (ICP-OES).

Statistic: Data were subjected to analysis of variance (ANOVA) and means were compared by LSD test at $P < 0.05$.

3. RESULTS

The results, shown in Figure1, indicate that P deficient plants accumulate significantly less ($p \leq 0.05$) Cd in roots than control and Fe deficient plants. The Cd concentration in roots of control and Fe deficient plant are about 4 fold higher than in P deficient *Ailanthus altissima* seedlings. In leaves of P deficient plants (Figure 2) the accumulation of Cd is a little bit higher

(29.87 mg/kg) compared to control (19.87 mg/kg) and Fe deficient (11.55 mg/kg). Biomass parameters (dry weight of roots and shoots and root/shoot ratio) show significant decrease ($p \leq 0.05$) in root biomass in P deficient plants (0.43 g) compared to control plants treated with Cd (1.32 g). Cadmium treatment also significantly decreased ($p \leq 0.05$) shoot biomass in Fe deficient plants, but in P deficient plants Cd did not influence growth in Fe deficient and control plants. Compared to control plants Cd treatment did not influence growth when plants were supplied with all essential nutrients but biomass of roots and shoots was significantly lower when Cd toxicity was combined with nutrients deficiency (Table 1).

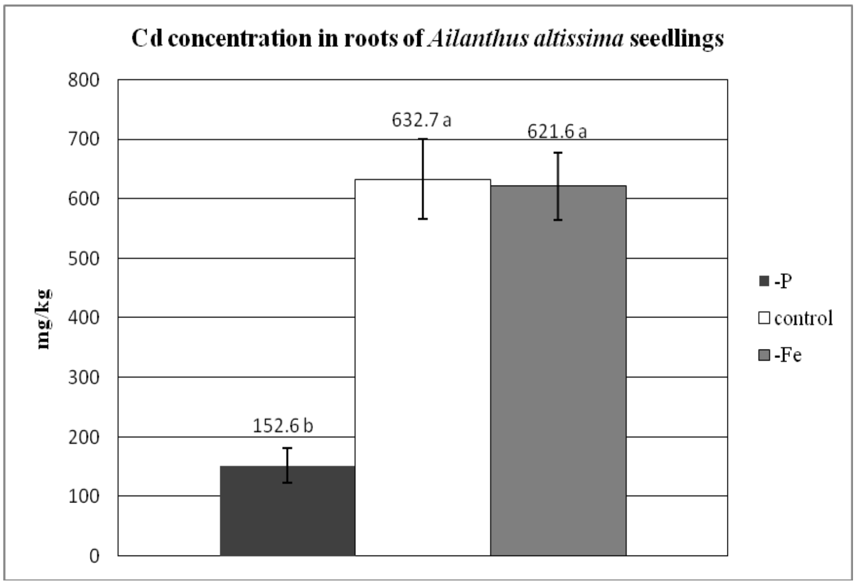

Figure 1. *Cd concentration (mg/kg) in roots of Fe deficient, P deficient and control Ailanthus altissima plants 10 days of Cd treatment (20µM Cd(NO_3)$_2$.*

The data are mean values of three replicates with standard errors. Statistically significant differences ($p \leq 0.05$) are indicated by different letters.

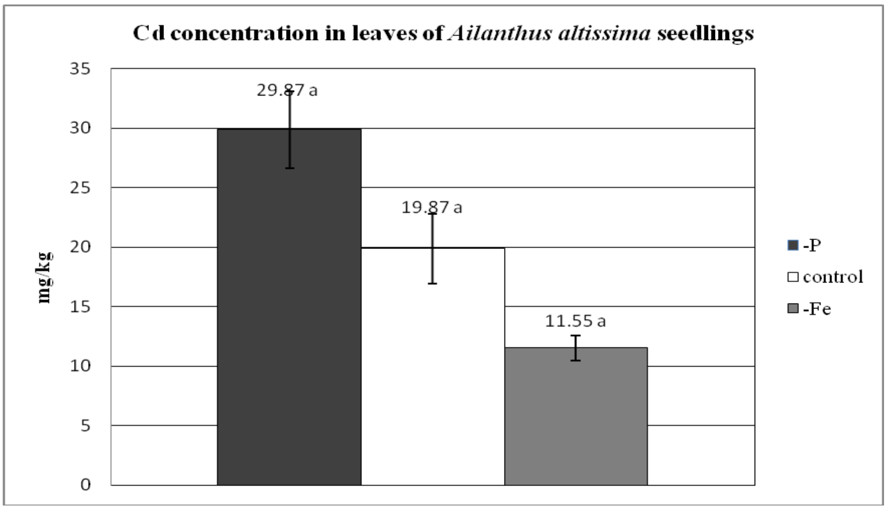

Figure 2. *Cd concentration in leaves of Fe deficient, P deficient and control Ailanthus altissima plants 10 days of Cd treatment (20µM Cd(NO_3)$_2$.*

The data are mean values of three replicates with standard errors. Statistically significant differences ($p \leq 0.05$) are indicated by different letters.

Table 1. *Root and shoot dry weight (gDW), root/shoot ratio and level of chlorosis after 10 days of Cd treatment (20µM $Cd(NO_3)_2$ of Fe deficient and P deficient seedlings of Ailanthus altissima.* The data are mean values of three replicates with standard errors. Statistically significant differences ($p \leq 0.05$) are indicated by different letters.

Treatment	(g DW)		Root/Shoot ratio	Visual chlorosis
	Root	Shoot		
control	1.45 a ± 0.51	3.82 a ±1.67	0.38	-
-Fe/+Cd	0.89 abc ±0.14	1.92 b ±0.2	0.25	+++
Control/+Cd	1.32 a b ± 0,12	4.80 a ±0.35	0.27	+
-P/+Cd	0.43 c ± 0,06	0.75 b ± 0.026	0.57	_

4. DISCUSSION

Removal of toxic metals from contaminated soils is one of the most important environmental issues. There are many different strategies to clean up contaminated soils, such as use of synthetic helators, microorganisms, and plants (phytoremediation). There are a lot of plant species characterized as efficient accumulators of toxic metals but usually they have low biomass production (Chang and al. 2003). Use of fast growing species which produce large amount of biomass is less investigated. Plant species with large biomass production especially in nutritionally poor soils can be considered as potential plant species for use in phytoremediation (Pan and Bassuk 1986; Dožić et al, 2010). Unfortunately, little is known about both metabolism and transport of toxic metals in tolerant plants. Also, little is known about interaction of nutritional acquisition mechanisms and toxic metal availability.

In this study we tried to elucidate is there an influence of induced Fe and P deficiency on Cd accumulation in seedlings of fast growing *Ailanthus altissima.* Our results indicate that P starvation is more limiting factor for Cd accumulation in *Ailanthus* plants while accumulation of Cd in Fe deficient plants is on the same level as in plants well supplied with essential nutrients (control plants - Figure1). Under condition of Fe deficiency, iron is transported via specific iron transport way which is induced in plants, while in Fe sufficient condition, plant transport iron via low-affinity transport system (Curieand and Briant, 2003). Several short-term uptake experiments show that metals such as Cd, Co, Mn, Cu and Zn may also be taken up as substrates by specific iron transporter (Cohen et al., 1998; Zaharieva and Romheld, 2000). Furthermore, the expression of specific iron transport system can facilitate accumulation of these heavy metals in plant tissue (Cohen et al., 1998) but long-term exposure to Fe starvation shows that energy support in the form of NAD(P)H reducing equivalents, seems to be more important for an efficient response (Siedlecka and Krupa, 1999; Đunisijević-Bojović et al., 2012). We can speculate that in this long term experiment (plants were exposed to Fe deficiency 7 days in pretreatment and further 10 days during Cd treatment - total 17 days), –Fe plants did not accumulate more Cd compared to control because specific iron transport system efficiency was decreasing during prolonged iron starvation. Under induced P deficiency *Ailanthus altissima* seedlings accumulate significantly less Cd than control and –Fe plants. Phosphorous is very important nutrient for plant growth, and frequently limiting factor for plant biomass production in many natural ecosystems. It is a vital component of ATP which forms during photosynthesis and participates in metabolic processes from the beginning of seedling growth through to the formation and maturity of seeds. It is involved in energy transfer, the activation of proteins and the regulation of metabolic processes. Phosphorous deficiency is limiting factor for energy support witch is required for active transport in roots. Decreased accumulation of Cd under P deficiency in our experiment is probably due to these metabolic changes under P starvation.

These findings could be important for improvement of phytoextraction efficiency on polluted soils, which are poor in phosphorous and iron available forms.

5. CONCLUSION

Presented data indicate that roots of P-deficient *Ailanthus altissima* plants accumulate significantly less Cd (152.6±29.12 mg/kg) than control, well supplied plants (632.7±67.12 mg/kg) and Fe-deficient plants (621.6±56.24 mg/kg).

Concentrations of Cd in leaves of P-deficient plants were a little bit higher than in control and Fe-deficient plants, but statistically insignificant. The induced iron and phosphorus deficiency decreased root and shoot biomass production of *Ailanthus altissima* seedlings. Cadmium contamination decreased root and shoot growth in control and additionally, in iron deficient plants, but in phosphorus deficient plants Cd treatment did not influence growth. It seems that P deficiency in growing media is more limiting factor for Cd accumulation than Fe deficiency.

This study could be important for improvement of phytoextraction efficiency on polluted soils, which are poor in phosphorous and iron available forms.

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AN UP-TO-DATE APPROACH TO ENVIRONMENTAL PROTECTION THROUGH FORESTRY PLANNING DOCUMENTS

Zvonimir BAKOVIĆ[1], Bratislav KISIN[2]

Abstract: *One of the basic human rights is the right to live and develop in a healthy environment. Sustainable management of natural values, preservation of natural balance, diversity and improvement of the quality of the environment are imperatives of modern society. The natural values of Serbia are its natural resources, and forests occupy a central place among them. The ecosystemic relationship between these natural values is multifaceted.*

Planning has been in use in Serbian forestry for the last two centuries. The society's need for productive functions provided by forest ecosystems was often not in accordance with their actual potentials. In those circumstances planning was exposed to constant changes, following the scientific achievements of modern forestry on the one hand, and legal compliance of various plans on the other.

This paper presents an up-to-date approach to environmental issues in planning, through the prism of protected natural areas (PNAs), taking into consideration the modern achievements of science and (national and international) practices in forestry, international conventions signed by the Republic of Serbia, applicable local provisions, national strategies etc. This paper has identified the conflict between commercial interests and the priorities of forest management, defined for specific areas and protection regimes. Also, this paper defines optimal forest management objectives and measures for their implementation for developing strategic and operational planning documents in forestry in the conditions of specific protection regimes, with the aim of preserving and improving the environmental quality. This concept is characterized by the harmonization of several factors, including achievable functional permanence, ecological balance, biological heritage, the diversity of biodiversity and sustainable forest management.

Keywords: forest, planning, environmental protection, biodiversity

1. INTRODUCTION

Sustainable management of natural values, preservation of natural balance and diversity and the improvement of environmental quality are imperatives of modern society. The natural values of Serbia are its natural resources that include forests, which occupy a central place among them. The ecosystemic relationship between these natural resources is multifaceted.

Planned forest management and planning in the forestry of Serbia have been in use for the last two centuries. During that period, planning was the link between the real possibilities of forest ecosystems and the needs of society for productive functions provided by forest ecosystems. In those circumstances, planning was subject to constant changes, following the scientific achievements of modern forestry on the one hand, and legal compliance of various plans on the other.

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At present, one of the highlighted strategic goals in Serbian policy is preservation, protection and improvement of natural areas, including forests.

According to previous research, Serbia has a large number of plant and animal species, and it represents a very important center of biodiversity. The diversity of the species of flora and fauna is manifested through genetic diversity (allelic variation, i.e. variation in gene forms), special diversity (special diversity in the Republic of Serbia is underresearched – inadequately documented) and ecosystemic diversity (almost all terrestrial biomes, representing four of the twelve terrestrial biomes of the world, are present in Serbia).

In the territory of Serbia there are:[1]

- 39% of the vascular flora of Europe;
- 51% of the fish fauna of Europe;
- 49% of the reptile and amphibian fauna of Europe;
- 74% of the bird fauna of Europe;
- 67% of the mammal fauna of Europe.

A large number of these species (of flora and fauna) inhabit the forest ecosystems of Serbia. Serbia adopted the concept of sustainable forest management, which is provided through a number of national laws[2], strategies, regulations, rule books and several bylaws.

By adopting and ratifying a number of international conventions and agreements[3] pertaining to protection and improvement of the environment, which directly or indirectly affect the development of the forestry sector, Serbia has also accepted the concept of conservation, improvement of the current state of forests and the concept of sustainable (permanent) forest management.

Due to the above, Serbia put a large part of its territory under various forms of protection. On the other hand, regular forest management continued in these areas, in accordance with the newly-defined purposes and functions of forests resulting from those purposes.

Planning in the forestry of Serbia was faced with the challenge of using a plan framework. On the one hand, it was supposed to ensure an optimal operational plan that will enable the achievement of sustainable and modern principles of sustainable forest management in protected areas in compliance with international conventions and treaties, national laws and regulations that affect forestry sector. On the other hand, it was supposed to provide and ensure

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[1] Biodiversity Strategy of RS (2011 - 2018), Belgrade, 2011;

[2] Legislation affecting the management of forest ecosystems: the Constitution of the Republic of Serbia (2006), Forest Law (Official Gazette of RS, no. 30/10), the Law on Environmental Protection (Official Gazette of RS, no. 135/04 and 36/09),the Law on Nature Protection (Official Gazette of RS, no. 36/09 and 88/10), the Law on Ratification of the Convention on Biological diversity (FRY Official Gazette, International treaties. 11/01), the Law on Ratification of the Convention on Biodiversity (Official Gazette of RS, International agreements 02/07), the Law on Strategic Environmental Impact Assessment (Official Gazette of RS, no. 135/04 and 88/10), the Law on Environmental Impact Assessment (Official Gazette of RS, no. 135/04 and 36/09), the Law on Forest Reproductive Material (Official Gazette of RS, no. 135/04), the Law on Hunting and Wildlife (Official Gazette RS no. 18/10), Water Law (Official Gazette of RS, no. 30/10), the Law on Planning and Construction (Official Gazette of RS, no. 72/09), the Law on Fire Protection (Official gl. Serbia no. 111/09), the Law on National Parks (Official Gazette of RS, no. 39/93), the Law on Ratification of the European Landscape Convention (Official Gazette of RS, no. 4/2011), the Biodiversity Strategy of Serbia (2011 to 2018), and other laws, regulations, strategies, programs and rule books.

[3] International conventions, agreements accepted (ratified) by Serbia affecting the management and forest ecosystems: Agenda 21 (1992), the UN Framework Convention on Climate Change (1992), the Convention on Biodiversity (1992), the Convention on the Transboundary Air Pollution at Large Distances (1979), the Convention on Wetlands (Ramsar) (1977), the Convention on International Trade in Endangered Species - CITES (1973), the Convention on the Protection of the World Cultural and Natural Heritage (1972), Resolutions of the Ministerial Conference on the Protection of Forests in Europe (1990, 1993, 1998, 2003), the Directive of the Council of Europe no. 43/92 on the conservation of natural habitats and wild flora and fauna (1992), the Directive of the Council of Europe no. 409/79 on the Conservation of Wild Birds (1979), the Directive of the Council of Europe no. 105/99 on the Market of Forest Reproductive Material (1999), the Directive of the Council of Europe no. 2158/92 on the protection of EU forests against fire (1992), the Directive of the Council of Europe no. 3528/86 on the protection of EU forests against atmospheric pollution (1986), the Directive of the Council of Europe no. 1615/89 on the Establishment of Information-Communication System of European Forests (1989), the Directive of the Council of Europe no. 89/68 on the Framework Law of the Member States in the Classification of Raw Material (1968), Natura 2000, the EU Forestry Strategy (1998), the EU Sustainable Development Strategy (2002), the EU Strategy of Sustainable Use of Natural Resources (2005) ., the International Plant Protection Convention (1951) and many other conventions and agreements.

economic autonomy of the manager of a specific forest that belongs to a certain protection regime.

Protected natural areas in forest planning documents (primarily in operational planning) mainly reflected the conservative principles of protection. This meant that they were mainly exempted from the regular system of utilization and management by decrees and decisions, and the protection implied preservation and conservation.

Also, it can be noticed that the protection acts do not define the aims of management (both general and specific) for certain PNAs and the measures for their implementation, so that the designers of planning documents have serious professional dilemmas of how to reconcile the newly-formed conflicts and regimes in forest management, when developing a particular plan.

2. MATERIALS AND METHODS

In this study the authors used literature related to this issue, analyzed the laws and bylaws, as well as a variety of strategies, conventions, regulations, decisions, etc., which are directly or indirectly related to the protection of nature and the environment and are important for forestry planning. All these regulations must be taken into account in the development of various planning documents at all levels. The production of a forest management plan as an operational planning document that includes all the activities scheduled in a particular management unit for a ten-year period, occupies the central place among these planning documents.

The scientific methods that were used most in the study of the research problem were: the method of analysis and synthesis, the comparative method, and finally the method of induction and deduction.

3. ENVIRONMENTAL PROTECTION THROUGH PNAs IN SERBIA

About 5.91% of the territory of the Republic of Serbia is currently under certain protection regime. In order to further improve the current state of the environment, the Spatial Plan of the Republic of Serbia envisages an increase of the protected area to about 10% of the territory by 2015, and to about 12% by 2021.

According to official figures[1], 463 natural areas are currently under protection, as given in Table 1.

Table 1 – *Protected natural areas in Serbia – July, 2012*

Type of protected natural area	**Number**	**Area (ha)**
National park	5	158.986
Nature park	16	213.302
Landscape of outstanding features	16	45.656
Nature reserve	67	92.972
Protected area of cultural-historical value	42	2.507
Natural monument	317	7.681
In total		**521.104**

The concept of sustainable forest management[2] should be fully applied in the management of forests within the protected natural areas. The support to this concept should be realized through clear defining and balanced determination of the priority functions of forests defined by a decree or decision. The economic potential of the state and the needs of the

[1] Source: Nature Conservation Institute of Serbia – July, 2012.
[2] Strategy of Forestry Development of the Republic of Serbia – Belgrade, 2007.

population in these mostly rural areas should also be taken into account in this process. The aim is to improve sustainable forest management in protected areas, on the basis of a harmonized development of the ecological, economic, social and cultural functions of forests.

4. GOAL OF PLANNING IN THE LEGISLATIVE FRAMEWORK

The applicable Forest Law ("Official Gazette of RS" no. 30/10) incorporates planning as a system in Serbian forestry. Forestry is directly or indirectly affected by legislation and other documents, as indicated in footnotes 4 and 5. Planning is one of the most important prerequisites for a permanent and sustainable forest management. It involves four levels of planning and the same number of planning domains.

General assessment of forest planning in Serbia reveals a correlation between specific plans and consistency within the sector, which is not the case for cross-sectoral cooperation. The level of cooperation among experts from different fields (involved in planning and design) is low, which complicates the application of participatory approach to the solving of specific problems.

Comprehensive polyfunctional planning is characterized by properly defined objectives and adequate measures for their implementation. It is very important for the objectives to be properly defined, achievable and measurable.

General forest management objectives are established by the Forest Law. According to this law (Articles 3 and 4), forests are common goods that have to be maintained, regenerated and used in a way that maintains and increases their value and multiple benefit functions, provides durability and protection, as well as a continuous increase in yield and increment.

Provisions of the Rule book[1] define the general and specific objectives of forest management.

Harmonization of measures for the achievement of objectives, priority ranking of the objectives, and spatial harmonization are supposed to resolve the conflicts among the objectives.

Forest ecosystems represent essential components of natural systems. In addition, their ecological functions substantially contribute to the biological and landscape diversity of the planet. They are of great importance for future survival and progress and crucial for environmental protection. An up-to-date approach to forest management planning involves a dynamic understanding of the theory of sustainable management of natural resources, and defining of the general and specific objectives of forest management in forests, in accordance with their purposes, which determine the functions of forests and the protection regime of a specific stand (complex) etc.

5. PROTECTION OF THE ENVIRONMENT, NATURAL RESOURCES AND VALUES THROUGH THE APPLICATION OF UP-TO-DATE PLANS

Environmental protection is reflected in the rational utilization and improvement of natural resources, including air, water, forests, mineral resources, biodiversity etc. A modern human impact on the appropriate use of spaces is possible through their integrated planned utilization. The environment affects people's health and the quality of life.

Bearing in mind the report on the state of forests and ways of their utilization (TBFRA 2000), we can see that polyfunctional utilization of forest ecosystems, observed both globally and locally, is strongly recommended. This certainly indicates planned use of forest ecosystems.

[1] Rule book on the content of forest management plans and programs, annual implementation plans and the temporary annual plan of forest management in private forests "Official Gazette RS "no. 122/03;

On the basis of available data[1] regarding the existing state of affairs in Serbia (without Kosovo), state-owned forests contain about 40 individual units used for different purposes. General and specific objectives of management as well as measures for their implementation have been defined for each of these individual purpose units.

High quality of environmental protection is, among others things, reflected in the quantity and quality of protected areas. In recent years, the number of protected natural areas is increasing, which, in turn, increases the total area under a certain regime of protection.

Poor intersectoral collaboration among the professionals involved in the production of spatial plans and detailed regulation plans and the experts involved in the drafting of various laws, strategies and regulations affecting the sector of forestry with the professionals engaged in sectoral planning (in this case forestry experts engaged in the development of strategic and operational planning documents) leads to a large number of uncertainties in the determination of forest management objectives and measures for their implementation in certain protection regimes. Here are a few steps leading to that aim:

1. Development of a framework for analysis
2. Analysis of the problem using SWOT analysis
3. Proposal of strategic and operational objectives of management
4. Specifying of measures for the achievement of these objectives

This paper is an attempt to provide a recommendation of a planned response to the new conditions of management, which are the result of the declaration of a certain part or complex of a forest a protected natural area (nature park, landscape of outstanding features, landscape of outstanding natural beauty, special nature reserve, natural monument, natural rarity etc.) These areas are integral parts of the plans being developed (development program, development plan, forest management plan and implementation design).

Step one – involves an analysis of the applicable domestic laws and by-laws pertaining to environmental protection, the forestry sector and the international obligations ratified by Serbia, which are directly or indirectly related to this field. This step also involves the analysis of a number of strategies (Spatial development strategy of Serbia (2009), Forestry Development Strategy of Serbia (2006), National strategy of sustainable development (2008), Expert plan for the development of NFAP[2] (2008), Analysis of the current state of private forestry sector in Serbia and its role in the process of defining the strategy for the development of forestry and the National Forest Action programme (2008), Biodiversity Strategy (2011) and other studies and valid strategic documents). An environment characterized by better conditions is certainly reflected through protected areas, and the way in which they are managed. This step involves the analysis of the PNAs of Serbia. In the aim of easier and more practical analysis, a conditional categorization by size (area) was made, as follows:

- I – Individual trees or groups of trees up to an area of 1 ha
- II – PNAs with an area of 1 to 100 ha
- III- PNAs with an area larger than 100 ha

This categorization is conditional and it was made for practical reasons. In order to define plans, goals and measures, it is first necessary to make a survey of the state in the field. In the areas of up to 1 ha (individual trees or groups of trees), it is necessary to measure all trees and collect all the elements, in order to be able to better define the plans and goals in a later phase. In NPAs with a size of 1-100 ha survey of the state can be performed using both total and partial measurement (depending on the importance). In this category, the basic purpose is determined, which serves as the basis for the plans at a later stage, i.e. the objectives and measures for the improvement of the current state. In areas larger than 100 hectares, there are usually several

[1] General forest management plans for forest areas and national parks, forest management plans and other applicable plan documents in forestry;

[2] NFAP- National Forest Action Programme of Serbia.

basic purposes arising from specific protection regimes. These purposes serve as the bases for the objectives and measures, i.e. forest management plans for the improvement of each specific-purpose entity in the future (ten-year) period. Data collection for the assessment and analysis of the current situation is performed using scientifically recognized methods of forest inventory supplemented with additional information relevant to the particular PNA.

Step two – SWOT analysis was used to analyze the specific problem, and its elaboration was an endeavour to find possible solutions and determine specific forest management objectives for each individual category. This step is represented by the following scheme:

SWOT matrix

INTERNAL FACTORS

STRENGHTS (advantages) **WEAKNESSES**(disadvantages)

EXTERNAL FACTORS

CHANCES (opportunities) **THREATS** (risks)

Step three – is the proposal of possible forest management objectives for the assumed three categories of protection regimes in PNAs. Defining of these management objectives served as the starting point for the next step.

Step four – Defining of the measures to meet the objectives of management. If the objectives and measures of forest management in the limited "protected" management regimes, defined in this way, prove as measurable and achievable, they can serve as a possible framework for their prescription through planning documents, at all four levels of planning in Serbian forestry.

6. ANALYSIS (SWOT analysis)

SWOT analysis was carried out for all three PNA categories. In order to obtain a simple and concise representation, three SWOT analyses were used to perform one SWOT analysis with some items in the internal and external factors pertaining only to certain PNA "categories".

The possible internal and external factors obtained by the SWOT matrix analysis are:

ADVANTAGES	***DISADVANTAGES***
➢ A proper legal framework for the declaration and establishment of PNAs; ➢ Arranged manager- user relations; ➢ Legally bound and defined protection regimes (controlled management established); ➢ Guidance and education of local authorities in accordance with the principle of conservation (leadership in education); ➢ Envisaged integrated	➢ Lack of information about the PNA for a proper determination of the current state; ➢ Incomplete methodology used for collecting, processing and presentation of the state of a PNA; ➢ Difficulty in realistic defining of management objectives and measures; ➢ Lack of harmonization and updating in documents adopted by the institutions engaged in determining the specific conditions of protection with planning documents in forestry (PNAs that include state forests whose documents were not revised); ➢ Mismatch between spatial divisions in forest planning documents and decisions pertaining to protection; ➢ Changed compartment numbers by the managers of PNAs (after the production of forest management plans); ➢ Difficulty in proper management and implementation of the plans proposed; ➢ Need for frequent inspection to ensure consistent implementation of management plans, which demands penalty provisions; ➢ Lack of strictly defined rules that prohibit changes in the forest division within PNAs; ➢ The protocol pertaining to the determination of management objectives and

resource monitoring regimes; ➢ Existence of an organizational structure.	measures in PNAs; ➢ Imprecise definition of the concepts of PNA user and PNA manager; ➢ Source of income for the implementation of the protection regime that is unstable in the short run; ➢ Source of income for the implementation of the protection regime that is unsustainable in the long run; ➢ Shortage of staff, including an unfavorable personnel structure; ➢ Insufficient supervision of the protection exercised; ➢ Medium-level accessibility and availability (roads, trails), unrestricted entry of people and vehicles; ➢ Small economic valorization from the visitors; ➢ Poor provision of information to visitors and inadequate spatial arrangement; ➢ Lack of cooperation on preservation and protection with the local population; ➢ Low degree of traditional utilization in the surrounding area (grazing, mowing, etc.) ➢ Unresolved property issues, multiple users; ➢ Poor road infrastructure leading to the PNA; ➢ Poor organization of the maintenance of public spaces around the PNA (garbage removal); ➢ Great pressure from other sectors to implement land-use changes within the PNA; ➢ Reduction of forest areas within the PNA; ➢ Difficulty in exercising permanent control and monitoring of the PNA state (which led to structural changes in the protected area, reduced overall biological diversity and appearance of regressive evolutionary changes in the stability of forest ecosystems).

OPPORTUNITIES	***RISKS***
➢ Development of planning in protected areas at the national level; ➢ Establishment of the management objectives within specific categories of protected areas; ➢ Business practices based on economic and ecosystem principles; ➢ A more precise identification and definition of the concepts of PNA user and PNA manager; ➢ Achievement of a better understanding of different categories of protected areas among all stakeholders in the system of PNA management; ➢ Adoption of new bylaws that will raise the level of protection to the next level; ➢ Introduction of regimes of active "permanent" protection; ➢ Introduction of a modern information system; ➢ Monitoring and stricter control using GIS; ➢ Modern technical equipment (in all services within the PNA); ➢ Increased and intensified participation of owners and local residents; ➢ Envisaged application of modern marketing in the plan (training and presentations on the importance of protection); ➢ Organization of events, workshops and camps to promote the importance of PNAs; ➢ Strengthening of the economic capacity for the protection of PNAs from national and foreign funds; ➢ Development of a complex study of management in PNAs that will contribute to easier planned defining of sectoral plans; ➢ Clear elaboration and adoption of a methodology for the assessment of all PNA functions; ➢ Encouragement of stakeholders participation, especially in rural areas, in decision-making and the allocation of responsibility regarding all important issues related to PNA management; ➢ Development of a single modern information system at the national level for all PNAs.	➢ Long-term unsustainable utilization of the PNA; ➢ Enormous pressure from other sectors on the forestry sector; ➢ A large number of conflicting objectives within the PNA that intersect with other sectoral objectives; ➢ Failure to maintain the PNA, which leads to isolation, overgrowth, spreading shrub and disappearance of certain species; ➢ Type of property as a limiting factor in the "realistic" determining of the protection regime (protection regime I-exclusively state ownership, and protection regimes II and III-combined with private ownership); ➢ Various PNA categories that have the same or similar content of decrees and regulations on the conditions and regimes of protection; ➢ Depletion of biodiversity; ➢ Changes in the use of spaces; ➢ Spread of invasive species in the vicinity of the PNA; ➢ Environmental pollution; ➢ Violation of the internal order; ➢ Low interest of local population in the protection; ➢ Lack of funds; ➢ Lack of intersectoral collaboration (poor compliance among plans), lack of inter-sectoral committees to control the exercise of established strategies; ➢ Lack of local plans for the arrangement of spaces.

7. PROPOSED MANAGEMENT OBJECTIVES AND MEASURES

On the basis of the two previous steps (analysis and SWOT analysis) management objectives and measures in PNAs are proposed. Their number is not final and they do not have to follow the listed order.

Management objectives in PNAs can be divided into general and specific objectives, in accordance with the Rule book.

The general objectives of management in PNAs are:

- Improvement of the state, management and protection of the PNA.

The specific objectives of management in PNAs are:

- Protection and improvement of the protection regime;
- Protection of biodiversity;
- Gene pool conservation;
- Provision of the aesthetic function;
- Provision of the conditions for scientific, research and educational work, training of personnel;
- Protection from climatic extremes;
- Protection against harmful effects of immission;
- Maintenance of roads and facilities serving to the PNA;
- Provision of funding for the protection and development of the PNA;
- Provision of a secure (scientifically recognized) method of data collection, analysis of the current state and defining of plans;
- Determination of the quantitative and qualitative measures and objectives to monitor the exercise of sustainable forest management in the PNA;
- Provision of support for communication and exchange of information on the conservation of the PNA at the international and national levels;
- Enabling of participation to local communities and other stakeholders in the planning and creation of the plan pertaining to the PNA;
- Development of specific guidelines for the concepts of PNA preservation and sustainable forest management;
- Rational utilization of natural resources in the PNA in line with the plans - an ethical attitude toward future generations;
- Future development of a specific system of planning, and the needs derived from the developed forest management system that puts the preservation of PNAs and their values in the first place;
- Creation of a new system of subsidies and compensations for the limited right of private forest owners to use forests, on the basis of clear criteria (parameters) for fee calculation to be developed;
- Adoption of sustainable international norms, standards and strategies related to PNAs and the environment in general;
- Raising of intersectoral cooperation to a higher level.

Measures for meeting the management objectives in PNAs shall be the following:

- Collection of more information (field data) on PNAs, using modern methods of forest inventory;
- A detailed analysis of the current state (of sites and stands), on the basis of the information collected in the field;
- Development of a modern poly-functional plan based on the established protection regime and the current state;

- Public preliminaries and panel discussions (participation of all stakeholders in the creation of a "better" plan) during the preparation of the planning documents pertaining to the PNA;
- Determination of economic parameters for sustainable forest management in the PNA defined by a plan;
- Development of criteria through an economic and financial analysis of PNA financing defined by a plan;
- Preparation of a study of forest management within the PNA, whose development will help easier defining of objectives and measures of sectoral planning;
- Defining of the physical PNA protection and stricter penalty provisions in the plan;
- Defining of bans on any activities in the area of the PNA that could jeopardize the area as a whole or any of its parts in the plan;
- Development of mechanisms of the modern planning principle: plan - implementation - control;
- Development of a protection program (development of biological and technical measures necessary for the conservation and improvement of the health and vitality of trees) defined by a plan;
- Permanent PNA monitoring (monitoring, protection from diseases, sanation of a potential disease outbreak, recovery of fire burned areas, etc.) envisaged by the plan;
- Education of the local population about the importance of protection envisaged by the plan;
- Ways of marking the PNA defined by the plan (with suitable plates and interesting basic information about it);
- Ways of maintaining the protected areas envisaged by the plan;
- Preparation of management plans (for a ten-year period);
- Production of a Management Programme (annual programme) on the basis of the Management Plan;
- Control of completed works;
- Deadlines for the implementation of the provisions of the plan defined by the plan;
- Modern technical equipment of the PNA manager that is included in the plan;
- Highest possible degree of participation of the managers and other stakeholders (local residents, local authorities, other institutions, various associations, and the like) defined by the plan.
- Additional mechanisms (loans, sponsorships, donations and the like) for providing funds for the protection and development of the PNA that are defined by the plan, in accordance with the legal framework;
- Participation of researchers in national and international fora on PNAs that is envisaged by the plan.
- Ensure that the development of the plan for the PNA (and the activities preceding it (data collection, etc.)) are performed by prestigious professional institutions in the field of forestry planning;
- Singling out of preserved representative forest ecosystems within the PNA, with a marked diversity of species, where there are endemic and relict species, in order to increase the PNA quality;
- Regeneration in liberal regimes of protection using the urgency criterion in prioritizing (first stands that differ with respect to the primary composition, poor quality, reduced stands, etc.), under constant supervision by state authorities;
- Carrying out of tending in liberal regimes, in accordance with the most up-to-date principles of stand tending, considering the plans and current state of the stand;
- Sanitation felling, light low thinning, moderate low thinning, light high thinning,

moderate high thinning and other types of thinning, which should be performed according to the rules established for the care of exceptional natural values;

- Establishment of new criteria for determining the continuity of yield through a continuous maintenance of optimal conditions in accordance with the intended use;
- Strict prohibition of uncontrolled utilization of secondary forest products (medicinal plants, fungi, humus, turf, opening of quarries, removal of rock masses, utilization of regeneration etc.;
- Establishment of intersectoral bodies that will supervise, monitor and update the adopted strategies, etc.

8. CONCLUSIONS

Sustainable forest management through forestry planning documents (at all levels of planning) implies consideration of the multifunctional approach to the development of planning documents, in accordance with all laws and bylaws that are directly or indirectly related to this area, as well as with a variety of strategies, conventions, international agreements, and the like.

On the basis of their size (area) PNAs can be classified into individual trees or groups of trees on areas of up to 1 ha (Category I), an area from 1 to 100 ha (Category II) and an area of over 100 ha (Category III). Category I usually involves monuments of nature, the second category includes areas whose basic purpose is defined in planning documents and category III involves the areas whose primary purposes are defined by specific protection regimes. It is necessary to produce plans, considering the objectives and measures for each specific type of PNA regardless of its area, on the basis of the surveyed (current) state. The central place in the planning domain of forestry certainly belongs to forest management plans, as operational planning documents with a10-year validity. The lower level planning documents (implementation design) and higher level plans (development plan of the forest area) draw the basic information about each area from a forest management plan.

When protected areas are concerned, the objectives and measures for the achievement of objectives in the management of forest ecosystems that are listed in forest planning documents have to reflect the essential meaning and purpose of protection which is not an end in itself. This paper proposes the objectives and measures that can be used in the development of forest planning documents for a specific PNA, depending on the current state and the established protection regimes. The protection through a PNA should provide improved environmental quality, which will be increasingly used in the future to measure the progress of society in a certain area and the country as a whole. Cooperation among institutions and organizations, and the multi-functional approach to planning (in forestry and other areas) are necessary, but when forest ecosystems are concerned, forestry as a sector must play the leading role. Therefore, in order to face this challenge, forestry must use an up-to date approach to the improvement of forest planning documents related to PNAs.

"The Chair of Sustainable Development", with its four pillars, i.e. the environmental, economic, social and cultural pillar, cannot be sustained and “used” if these are not fully balanced, and nature protection, with protected forest ecosystems, is a direct supporter of the environmental and cultural awareness in a society. Without these supporters the sustainable development and economic progress (we strive to) is nowadays incomplete (impossible).

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REVITALIZATION OF LANDSCAPES DEGRADED BY SURFACE MINE EXPLOITATION - CASE STUDY OF LANDSCAPE PLANNING AROUND FOOTBALL FIELDS IN CVETOVAC

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Abstract: *Surface mine exploitation of coal as a technological process cannot be completed without a significant impact on the environment and the landscape where works are carried out. Vast disturbed landscapes are left upon finished exploitation. These areas then require extreme care, caution and a great complexity in the planning and carrying of the work on the revitalization of the area. The landscape can never return to its original state because of the great loss of land mass by coal exploitation, geological disturbance and mixing of different layers of sedimentary formations and thus changing the groundwater regime. However, past experiences have shown that it is possible to plan degraded post mining landscapes in way to provide similar facilities of multifunction value, with modifications dictated by the emerging environmental conditions, method of exploitation, equipment and other moments. This paper presents an example of revitalization of areas degraded by surface mining. The area intended for landscape planning is located in surface mine pit „Tamnava-Istočno polje“, near "Strelište" in Cvetovac. The football fields have already been built in this area. The main goals of landscape planning were prevention of all types of erosion by forming plant cover, improving the visual appeal of the area and increase of forest cover percentage of Belgrade. The entire area includes two parts, which are planned differently. The green space around football fields is designed by free landscaping using trees, shrubs, climbers and lawn areas. The green windbreak in planned on slops toward surface mine pit. More appealing landscape was achieved by creating different types of plantings using a large number of deciduous, coniferous and fruit trees species which change the coloring of area when going through different phenophases. And a relatively stable forest ecosystem is established by a reforestation of slopes of surface mine pit thus creation of green windbreak will protect surrounding area from air pollution and erosion.*

Key words: surface mine exploitation of coal, degraded landscape, revitalization, green windbreaks

INTRODUCTION

Opencast coal mining, as a technological process, cannot be performed without a strong impact on the area and environment where works are conducted. In such places, degradation of the environment manifests through a disappearance of pastures, ploughland and forests, driving out of animals, displacement of settlements, roads and water-courses. When the exploitation activities end, an extensive disturbed area remains, which requires a particular care, utmost caution and complexity in planning and execution of works on revitalisation of that area. It is quite clear that the original condition can never be restored, since a large mass loss is incurred by extraction and removal of coal, disturbance of geological layers and mixing of various

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sedimentary deposits occurred and, in consequence, disturbance of the ground water regime (Dražić *et al.*, 2010).

A previous experience in the field of re-cultivation and land development (Schlattzer, 1973; Knabe, 1973; Jonaš, 1973; Lindley and Mansfild, 1979; Hage *et al.*, 1996; Hildmann and Wonsche, 1996; Bismarck, 2000; Dražić *et al.*, 2012) pointed out to the possibility of land development in lignite basin areas and creation of similar multi-functional facilities, with modifications dictated by the newly-created environmental conditions, method of exploitation, level of equipment and other aspects. In realisation of land development plans it should not be insisted on the authentic restoration of forms, facilities and functions that existed before the execution of mining works, but, considering changed ecological, social and other conditions, different ambient values of these areas can be created. By means of their relief, vegetation, existing and potential water areas, along with an appropriate planning of further re-cultivation and development works, these areas can provide all natural and other preconditions for various activities (Dražić, 2002). The above-mentioned transformations should contribute to accomplishing such state of post-exploitation areas where, despite drastic changes in landscape and ecosystems, they become attractive, rich in content and multi-beneficial for the inhabitants of the neighbouring inhabited places(Veselinovic *et al*.,2006).

The area of the opencast mine ’Tamnava-Istočno polje’ is located in the south part of the Posavsko-Tamnavska plain and territorially belongs to the municipality of Lazarevac. It constitutes a part of disturbed and nearly completely disturbed autochthonous and anthropogenic (agricultural) spatial entities and their original living and non-living contents. It is situated in the region of Šumadija, characterised by a distinct valley type of relief, with a mildly wavy terrain and the altitude ranging from 100 to 160m. As it is located in a flooded area of the alluvial plain of the river Kolubara and the river Kladnica, the *Querceto-Fraxinetum serbicum* Rudski forest communities in higher, and the poplar and willow communities in lower tailings, were present in this area prior to the exploitation period.

The area, which is the subject of this paper, is located within the opencast mine ’Tamnava-Istočno polje’, in the proximity of ’Strelište’ in the village of Cvetovac. It comprises two entities, planned in a different manner.

ESTABLISHMENT OF GREEN AREAS AROUND FOOTBALL FIELDS AND THE GREEN WINDBREAK

The primary aims of the land development project for establishment of green areas around the football fields in Cvetovac were: creation of a plant cover with a view to preventing all types of erosion (wind, water), enhancement of the visual aspect of the landscape and an increase of afforestation level of the city of Belgrade. For the purpose of fulfilling those aims, re-cultivation and the establishment of green areas within the above-mentioned degraded area, were performed.

The first entity, subject to landscaping, is located within the fence around the grounds and accompanying facilities; the green area was freely landscaped, with the use of trees, shrubs, climbers and lawns. The other entity was outside the fence, located in the direction towards the mine, with a green windbreak planned within it. The green windbreak will prevent the erosion of mine slopes on one side, and the spreading of various pollutants towards the sports fields. The newly-created green area, apart from its undisputed aesthetic contribution, also complements the architecture of the surrounding facilities. It also constitutes an integral part of the system of green areas and forests of the city of Belgrade and its surroundings, and, as such, has an impact on its integrity, functionality and aesthetics. The first entity covers the area of 2.4 hectares, whereas the green windbreak is 350m long and 20m wide.

Green areas around football grounds

The principal idea behind the establishment of green areas around the football fields and the facility was to create a pleasant atmosphere for stay of all types of visitors.

A selection of dendroflora species was performed based on the ecological conditions of the environment (climate, substratum, type of habitat), condition of the vegetation in the zone exposed to the impact of industrial facilities, and the established aims to provide versatile positive functions by means of biological measures. Solely woody types of species, envisaged for the afforestation of such categories of land by the Belgrade Area Afforestation Strategy (Ratknić *et al.*, 2009), were considered in the process of selection of species. Given that this document does not exclude use of allochthonous species with respect to this category of green area, the introduced species, which proved very resistant in the relevant environmental conditions, were also taken into consideration. In total, 6 species and forms of coniferous trees, 17 species and forms of broadleaved trees, 3 species and forms of shrubs and 1 species of climber were used for establishing the green areas on the degraded terrain.

Table 1. *Plant species on landscaped area around football fields and height of planting material*

Type of planting material	Height planting material (m)
Coniferous tree species	
1. *Abies concolor* (Gordon) Lindley ex Hildebrand - white fir	2.00 - 2.50
2. *Chamaecyparis lawsoniana* (A. Murray) Parl. 'Ellwoodii'	1.50 - 2.00
3. *Pinus nigra* J.F.Arnold - European black pine	2.50 - 3.00
4. *Pseudotsuga menziesii* (Mirb.) Franco - Douglas fir	2.50 - 3.00
5. *Thuja occidentalis* L. 'Globosa'	0.50 - 0.80
6. *Thuja occidentalis* L. 'Rheingold'	0.40 - 0.60
Broadleaf tree species	
7. *Acer ginnala* Maxim. - Amur maple	1.50 - 2.00
8. *Acer negundo* L. 'Variegatum' - Variegated box elder	1.50 - 2.00
9. *Acer platanoides* L. - Norway Maple	3.00 - 4.00
10. *Acer platanoides* L. 'Crimson King'	2.00 - 2.50
11. *Betula verrucosa* Roth.- Silver Birch	3.00 - 4.00
12. *Celtis australis* L. - European nettle tree	3.00 - 4.00
13. *Corylus avellana* L. 'Contorta'	1.00 - 1.50
14. *Corylus colurna* L.- Turkish hazel	3.00 - 4.00
15. *Crataegus laevigata* (Poir.) DC. 'Paul's scarlet'	2.00 - 2.50
16. *Liquidambar styraciflua* L.- American sweetgum	3.00 - 4.00
17. *Liriodendron tulipifera* L. - tulip tree	3.00 - 4.00
18. *Morus alba* L. 'Pendula'	2.00 - 2.50
19. *Prunus serrulata* Lindl.- Japanese cherry	2.50 - 3.00
20. *Prunus cerasifera* Ehrh. 'Pissardii'	2.50 - 3.00
21. *Quercus petraea* (Mattuschka) Liebl. - Sessile Oak	3.00 - 4.00
22. *Quercus rubra* L. - Northern red oak	3.00 - 4.00
23. *Sorbus aria* Crantz - Common Whitebeam	3.00 - 4.00
Shrubs	
24. *Berberis thunbergii* DC. 'Atropurpurea'	0.60 - 1.00
25. *Cornus alba* L. 'Sibirica'	1.00 - 1.50
26. *Lavandula officinalis* Chaix ex Vill. - Lavender	0.40 - 0.60
Climbers	
27. *Hedera helix* L. - Common Ivy	0.30 - 0.80

Figure 1. *Species on landscaped area around football fields (White fir, Thuja occidentalis L. 'Globosa', Acer platanoides L. 'Crimson King', Common whitebeam, Japanese cherry and Lavender)*

The landscaped areas around the football fields and the facility were formed by means of planting of groups of greenery, trees and shrubs of interesting colouring and high resistance to environmental conditions, pests and diseases. The whole area was separated from the Lazarevac-Tamnava road by tree-lines. The planting of trees around the car parking created a much needed shade. The use of a large number of various species complemented the colouring of the entire area. The figure 2 presents the appearance of green areas around the football fields.

Figure 2. *Model of landscaped area around football fields in Cvetovac*

A lawn was created on the entire green area, where a grass mix intended for the intensive-use sunny terrain lawns was applied. A sowing norm was 30 g/m^2.

Green windbreak

For the purpose of preventing the eolic erosion and reducing the adverse environmental impact of wind, a porous type green windbreak was established. It is characterised by an even distribution of openings throughout the whole length. Its wind-permeability between trees accounts for approximately 30%, whereas in crowns it is 30-70%. Its effect can be felt at the distance of 40-50 belt heights.

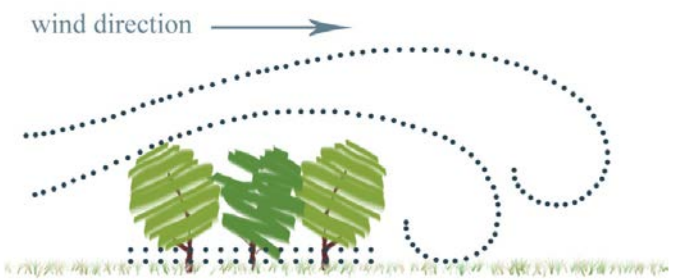

Figure 3. *A porous type green windbreak*

In the process of selection of species, the same requirements were observed as in the selection of species for establishment of the green areas around the football fields, along with a use of woody species, as envisaged by the Belgrade Area Afforestation Strategy (Ratknić *et al.*, 2009). Eight tree species, 2 coniferous and 6 broadleaved species were used for the establishment of the green windbreak. Out of the total number of broadleaves, 3 species are forest fruit-tree types. In addition to trees, three shrub species were planted.

Table 1. *Plant species in green windbreak and height of planting material*

Type of planting material	Height planting material (m)
Coniferous tree species	
1. *Pinus nigra* J.F.Arnold - European black pine	1.00 - 1.50
2. *Pseudotsuga menziesii* (Mirb.) Franco - Douglas fir	1.00 - 1.50
Broadleaf tree species	
3. *Quercus petraea* (Mattuschka) Liebl. - Sessile Oak	1.50 - 2.00
4. *Acer platanoides* L. - Norway Maple	1.50 - 2.00
5. *Betula verrucosa* Roth.- Silver Birch	1.50 - 2.00
Forest fruit tree species	
6. *Cerasus avium* (L.) Moench - Wild cherry	1.50 - 2.00
7. *Malus sylvestris* (L.) Mill. - European crab apple	1.50 - 2.00
8. *Pyrus pyraster* (L.) Burgsd. - European Wild Pear	1.50 - 2.00
Shrubs	
9. *Euonymus europaeus* L. - European spindle	0.30 - 0.50
10. *Forsythia europaea* Degen & Bald. - Balkan forsythia	0.30 - 0.50
11. *Prunus laurocerasus* L. - Cherry laurel	0.30 - 0.50

Figure 3. *Species planted in green windbreak (European black pine, Sessile oak, Norway maple, Wild cherry, Balkan forsythia and Cherry laurel)*

The porous green windbreak was established by means of a triangular planting of trees and bushes at a distance of 3x3m and 1x1m.

Seen from the position of the football grounds towards the opencast mine, shrub species were planted in the first and the second row. They were planted in form of a 30 m long one-species group, which is followed by a group of other species of the same length and so on repeatedly. The forest fruit-trees were planted in the third row. Their fruits can be used as food for birds and small animals that might return to this area. Moreover, some of the above-mentioned species are melliferous. The tree species changes after every 30 seedlings. The forest fruit-trees are followed by birch, whereas the Douglas-fir was planted in the fifth row. It is followed by another belt of conifers, i.e., black pine. The broadleaved species, sessile oak and Norway maple, were in the seventh and the eighth row. The green windbreak ends with two rows of shrubs, which were planted according to the same principle as the first and the second row. The appearance of the green windbreak is presented in the figure 5.

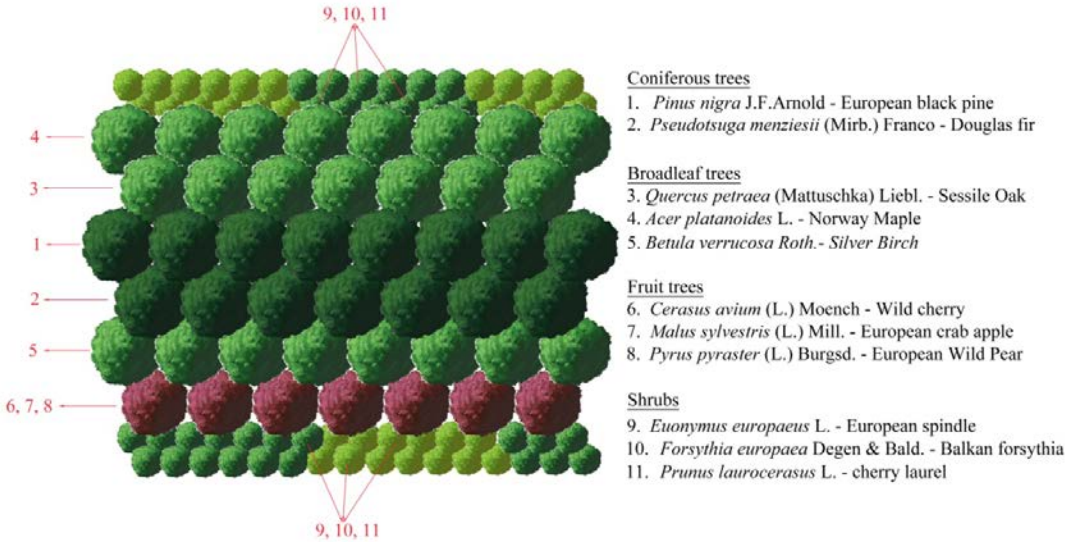

Figure 4. *Model of green windbreak*

TECHNOLOGICAL PROCEDURE FOR ESTABLISHMENT OF GREEN AREAS AND THE GREEN WINDBREAK

The Project envisages that the dynamics of works on plantation of the green windbreak and green areas around football fields correlates to the financial capacities of the Investor. It was recommended that the works should last one vegetation season, whereas it was best to plant shrubs in spring and trees in autumn.

Prior to the commencement of the plantation, the agro-technical preparation of the terrain was performed on the entire area and positions of planting holes were marked.

The planting material was obtained from a registered seedling nursery and care was taken that it was of even quality, a well-developed root system and the above-ground part, with no mechanical damage, or damage caused by insects or disease (Veselinović *et al.*, 2010). Apart from these requirements, the seedlings were of a first quality class according to the standard, with a certificate of health condition and the planting material origin (provenances).

The plantation of trees, shrubs and climbers was performed in accordance with a standard technological procedure. Well-tended and root-trained seedlings were planted. In this manner, an undisturbed initial growth was facilitated already in the first year of plantation, which enabled a good increment and functional development in a shorter time period.

Given that the soil is scarce in terms of available nutrient matter, along with the inability to provide the seedlings with sufficient amounts of water in the period of initial care, a mixture of hydro-absorbing and nutrient matter, substance that would activate the growth of the root and the supporting matters (product TerraCottem Univerzal) was added during the plantation. This product mixture will absorb water and gradually release it, along with the nutrient matter, in the most needed period of the plant development. The application of this treatment enables the reduction of the need for watering in a dry period by as far as 50%, since the efficiency of water retention is exceptionally high. Following the plantation, the trees were firmed up, in order to prevent swaying and movement in the zone of a root collar, which would lead to denudation. All plantation material was heavily watered.

Following the agro-technical preparation of the terrains intended for lawn formation, a product TerraCottem Turf was applied into the soil, in order to provide the future lawn with a sufficient quantity of nutrient matter and water. The sowing was performed manually in two opposite directions. The sown area was flattened by a spike and a regular lawn roller and after that heavily watered by sprinkler.

The implementation of care and protection measures was uniform for all trees, shrubs and creepers, regardless of whether they were located in the green windbreak or in the landscaped areas around the football fields. A period of initial care is considered a period of first two years following the plantation of trees and shrubs. Activities conducted in that period include watering, fertilisation, hilling, weed removal, mulching and pruning. Should a need arise, a protection against harmful insects and diseases is to be carried out.

A period of initial lawn care is considered a one year period after the lawn formation by sowing. The basic care and protection activity with respect to the newly-formed lawn involves watering, nourishing, first mowing and removal of the weed from the surface.

Following the expiry of the initial care period of the newly-established plants and the newly-formed lawn, the application of the above-mentioned measures should continue, but it could be of lower intensity. However, it should be carried out nevertheless, if the functions of the landscaped area are to be maintained.

CONCLUSION

The coal exploitation in the opencast mines of the Kolubara-Tamnava basin inevitably leads to a permanent disruption of the existing natural ecosystem. Excavation and non-selective disposal of overburden leads to a creation of tailing ponds, which usually have a biologically low active soil on their surface, once located in deeper layers, or a sterile sand which is susceptible to surface area washing away and gully erosion.

By re-cultivation of the area degraded by opencast mining, a relatively stable forest ecosystem can be established. By their existence, thus created forests have an ameliorative effect on soil, leading to the activation of the latent production potentials of the newly-created soils, which can be used for production of biomass. However, other beneficial functions of these plantings in the concrete environmental conditions are far more important.

The newly-established green windbreak on the post-exploitation area has, primarily, a protective function. Forest cultures and spontaneous grass growth will prevent further spreading of a surface and gully erosion, and will make the slopes of the former mines more stable. Additionally, trees and shrubs, thanks to their leaf mass, will assume an important role in cleaning the polluted air, both by decomposition of chemical air-pollutants, and sedimentation of hard particles, which is particularly important from the aspect of environmental protection in the area of neighbouring towns and villages.

By the use of a large number of broadleaved and coniferous species, along with forest fruit-trees, several types of plantations were created in the post-exploitation area in Cvetovac, enriching the newly created landscapes by their colouring in different phenophases. In that manner, following the end of coal exploitation works, the re-cultivated area will blend into a broader ambient of the surrounding area, thus enabling creation of a pleasant atmosphere for stay of all type of visitors.

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RESEARCH OF DEFOLIATION ON ICP FORESTS SAMPLE PLOTS IN THE REPUBLIC OF SERBIA

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Abstract: *Initial symptoms of forest stands drying are defoliation and discolouration of tree crowns. Therefore, the defoliation, with the changing of tree crowns color are accepted as the main parameters which estimate crown condition within forests state monitoring. This paper analyzes data for defoliation as part of the results of the monitoring of forests on ICP sample plots. Rating of defoliation is done regardless of the cause of leaves loss, and the results are not aimed at determining the cause-effect relationship. They are only represent the state of defoliation on sample plots processed in the period. Connecting these results with other indicators of environmental conditions will provide more specific information, and make conclusions about the vitality of plants depending on environmental conditions.*

Key words: defoliation, ICP sample plots, crown condition monitoring, Serbia

1. INTRODUCTION

Project of forests conditition monitoring under the framevork of ICP Forests Programme, operates as international European project. It consider annually observation of forests with recording data on defoliation, discolouration and other damage recorded on the trees, distributed in network of special purposed sample plots. The goal of this program is to collect data about the condition of forests in Europe using its unique methodology and to obtain information about the spatial and temporal variation of forest conditions in the countries of Europe.

On the territory of the Republic of Serbia first recording of forests health, harmonized about the programs, were conducted in 1988. In 2003 the network of theese sample plots has been reconstructed, with the numerous of them which had to be set up once again. In 2004, final network was established. That reconstructed set up sheme with 103 sample plots in the grid of 16 x 16 km did not fully represent the state of vegetation cover in Serbia, so that the new one had been set with 27 sample plots in the network 4 x 4 km. Over the past years at some sites of sample plots the clear cut were carried out making further observation impossible, and two sample plots became ureacheable because of technical reasons leading not to continuously collecting the necessary data. On all other sample fields recording were continued with monitoring forest conditions and all the field data necessary for further processing had been collected. According ICP forest program of forest state condition monitoring observations were conducted continuously at 121 Level I sample plots in Serbia.

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This paper proceed data analyzes of defoliation, as part of all gathered results of field assessment, for all new established plots grid after the revision.

2. MATERIALS AND METHODS

Within this project, the tree crown state classes are expressed by foliar mass or leaves (needles) losses, color changes and combined classes of damage. The assessment of the crown is done every year on permanent sample plots called bioindication point.

Permanent sample plots or bioindication point is made up of the center, based on the coordinates of sample field, and visibly marked with a metal bar. At 25 meters from the center, in the direction of four principal sides of the world, there are determined four experimental surfaces, where six trees marked with numbers from 1 to 6 are selected for permanent observations. The selected trees were durable marked with numbers, and if for any reason trees have been removed, they shall be replaced with new ones more selected trees.

Defoliation and loss of needles or leaves in the crown on the field are estimated at 5% of intervals, for each tree on permanent sample plots. This paper are utilized data from the forms-fill records by researchers made on site, within the tour on bio-indicator points. Based on this record, calculation were made as the mean defoliation for each previous year, for each sample plot and for individual most represented tree species. Moderate defoliation values for each plot were based on the individual values for each tree defoliation at sample plot regardless of the type of trees.

Mean values for individual defoliation of most represented tree species were based on individual values for total defoliation of appropriate species. This method provides possible to compare values of defoliation on particular plots and by the tree species.

Determination of mean values for this in each experimental area has allowed mapping of defoliation. By interpolation of defoliation mean values for surrounding -adjacent sample plots, the sample plots with the same values of defoliation were obtained with. With combining these - equal values of defoliation plots positions isolines were formed. Isolines, in this case, represent the same average annual defoliation on the territory of Serbia or for some regions of country.

3. RESULTS AND DISCUSSION

Monitoring of forest condition in the Republic of Serbia is conducted continually at 121 bioindication points. The field work on data collection (observation and measurement) in the previous period was performed between June and September.

The points were distributed in the 75-1,558m altitude zone, whereas the largest number of points, a total of 27, was located in the 400-600m altitude zone (table 1).

Table 1. *Distribution of bioindication points as per the respective altitude*

Altitude m	0 - 200	200 -400	400 -600	600 -800	800 -1000	1000-1200	1200-1400	1400-1600	Total
Number of points	17	24	27	16	9	13	11	4	121

The most represented species at bioindication points are *Fagus moesiaca, Quercus cerris, Quercus frainetto, Quercus petraea and Carpinus betulus.* The represented coniferous tree species are *Abies alba, Picea abies, Pinus nigra* and *Pinus silvestris.*

An estimation of defoliation level was performed at all bioindication points, while the summary results according to bioindication points are presented in table 2. The table indicates that oscillations of mean annual defoliation values were low and ranged between 11.0% (2011) and 15.5% (2007).

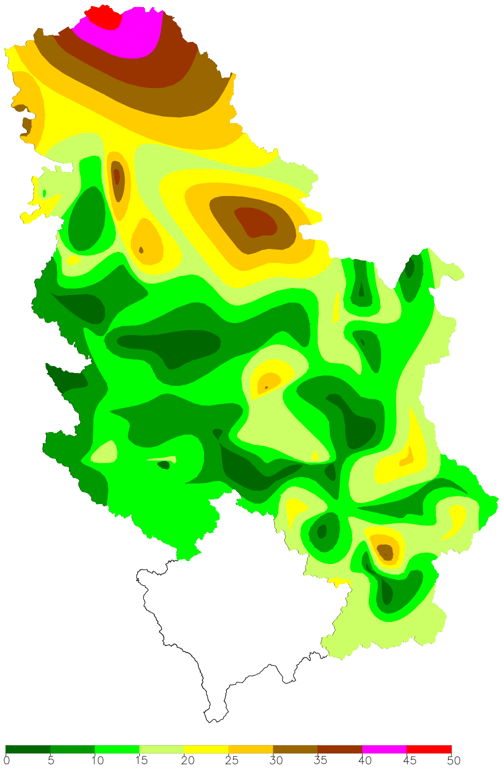
Table 2. *Average annual defoliation at bio-indication points*

BIT	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
2	30.8	25.8	14.0	17.0	14.6	16.3	16.5	11.1
3	5.4	16.9	9.2	10.0	10.0	9.6	2.5	2.7
4	10.4	11.7	7.1	13.8	9.8	12.9	4.2	2.9
6	8.3	15.0	10.0	10.8	13.1	8.8	2.1	0.6
7	15.4	15.8	6.7	15.4	17.7	5.0	15.4	13.3
8	12.9	12.1	7.5	7.9	13.3	5.8	9.8	9.2
9	0.2	7.1	7.9	0.4	5.2	12.6	5.4	
10	10.8	19.6	10.8	10.0	16.2	7.5	5.8	4.0
11	0.0	1.6	4.7	8.9	6.0	8.9	5.8	6.1
12	4.2	4.6	11.7	10.0	17.3	10.8	8.1	14.8
13	13.8	17.9	4.6	13.0	10.6	7.9	11.7	1.5
14	0.0	18.5	15.8	12.9	10.2	9.5	5.0	9.8
15	17.1	17.7	6.2	9.6	9.2	7.1	1.7	1.0
17	15.8	12.3	12.5	12.3	12.7	11.0	3.1	7.7
18	23.5	29.0	25.4	22.1	20.7	16.3	12.9	9.5
19	20.0	15.4	14.6	12.9	2.1	0.6	3.5	1.5
20	20.6	21.0	17.3	15.2	12.9	9.2	11.5	7.9
21	20.2	18.8	20.4	27.7	19.4	21.7	15.2	4.8
23	6.7	9.8	14.2	7.9	20.0	20.0	17.5	16.0
24	3.8	10.6	7.9	24.2	21.7	6.7	5.2	4.2
26	9.2	13.5	13.3	14.4	14.2	16.5	14.8	15.2
27	13.3	15.2	22.9	24.0	22.7	18.1	20.6	15.4
28	3.3	4.2	2.5	4.8	5.0	3.7	4.0	5.0
29	8.8	20.6	15.0	18.8	15.4	15.8	18.8	19.2
30	5.8	17.9	15.8	15.8	13.8	14.5	20.0	15.2
31	1.7	6.2	5.0	8.8	7.5	4.2	3.3	
32	5.8	13.3	12.1	11.2	15.0	2.5	7.1	2.9
33	10.8	39.2	22.9	13.3	20.4	15.0	19.8	25.0
34	7.9	10.4	14.2	18.5	16.7	18.5	11.7	8.5
35	10.4	31.2	12.9	24.2	13.3	16.3	15.4	14.0
36	8.3	34.6	25.4	20.0	9.6	4.6	15.0	15.6
37	13.8	25.8	39.6	22.1	23.3	10.4	17.1	8.0
38	10.4	14.6	13.3	16.2	19.2	9.2	12.9	12.9
39	8.8	19.6	13.8	17.9	12.5	10.4	13.3	15.4
40	1.2	2.3	1.7	7.1	17.1	15.8	11.3	9.6
41	23.3	29.4	18.1	27.5	30.4	34.6	30.8	18.3
42	16.1	13.9	9.7	11.1	12.2	22.9	13.3	17.2
44	14.6	17.3	15.8	12.1	10.0	3.3	5.8	6.5
45	29.6	30.4	22.5	23.1	21.0	21.5	11.0	10.2
47	27.5	27.1	25.2	25.0	20.5	10.0	12.6	5.2
48	15.0	15.6	15.6	10.6	6.9	10.0	15.2	10.7
49	26.0	25.0	22.7	32.0	14.4	17.3	9.0	9.0
50	22.9	17.5	14.2	5.2	16.2	6.3	4.6	5.4
51	27.1	23.8	23.5	17.9	16.0	11.3	16.3	16.5
52	18.3	14.2	9.2	7.1	11.5	13.1	15.0	10.6
53	14.7	13.3	7.8	8.3	8.3	10.6	11.7	10.3
55	17.9	13.8	13.7	11.0	7.1	12.9	9.0	8.5
56	24.0	24.4	17.7	16.9	11.5	6.1	8.3	9.8
57	24.0	19.8	15.8	16.8	11.6	5.8	10.9	7.7
58	15.4	12.7	12.5	13.1	12.5	11.0	10.4	7.7
59	15.6	15.4	14.6	11.5	6.5	1.9	3.5	2.1
60	29.8	24.8	24.8	23.8	0.0	11.3	9.2	4.4
61	18.8	17.5	16.5	13.5	11.7	3.8	17.7	8.8
62	0.0	3.8	7.1	1.0	0.4	1.0	3.3	4.6
63	1.7	2.5	7.1	2.9	2.1	1.7	2.5	3.3
64	0.4	0.8	6.7	6.7	5.8	4.2	7.1	8.3
65	12.9	13.5	1.7	4.6	4.8	5.0	3.3	1.9
66	16.7	13.3	10.8	10.8	12.5	45.0	23.3	21.7
67	10.4	10.0	12.5	11.7	14.2	8.8	14.6	19.2
68	12.9	7.9	12.5	21.2	12.5	12.9	11.3	17.1
69	10.0	10.2	10.0	11.9	8.1	7.7	4.8	7.7

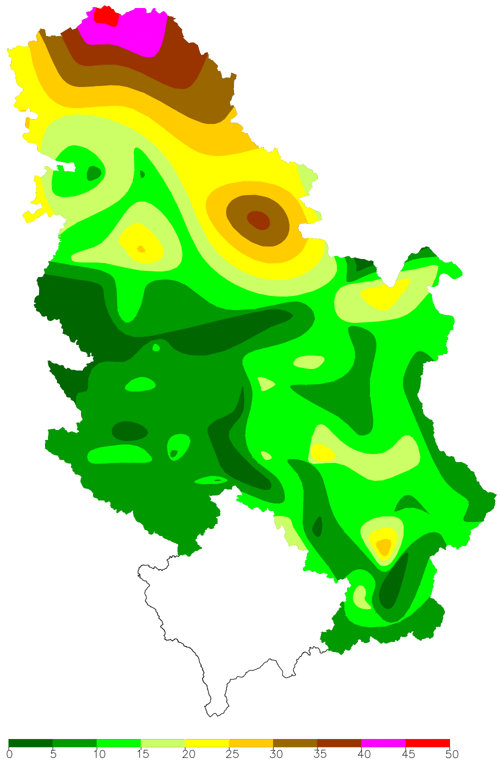
BIT	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
70	13.3	20.8	17.1	29.8	23.8	30.4	27.3	18.3
71	6.7	11.7	12.5	23.3	13.8	12.5	9.6	20.0
72	2.1	15.8	6.2	17.9	6.7	0.0	0.0	9.0
73	14.2	13.3	14.0	13.1	14.8	15.0	7.8	6.7
74	21.7	19.4	10.2	11.0	13.1	13.3	12.9	10.4
75	23.8	23.8	16.9	17.3	15.6	17.1	18.5	15.2
76	17.1	17.1	14.0	10.8	8.3	7.5	11.0	10.0
77	22.7	21.5	20.2	23.3	20.8	4.6	13.1	16.3
78	29.2	33.3	26.9	24.8	24.0	12.5	8.5	10.2
79	0.0	1.2	20.4	13.8	2.9	4.2	6.8	4.2
80	7.9	11.2	12.5	18.3	11.2	11.3	13.8	15.0
81	8.3	13.3	15.8	20.8	12.5	12.5	25.0	12.5
82	5.4	18.3	5.4	12.9	15.8	9.2	12.5	12.1
83	22.1	16.2	10.8	23.3	12.5	14.6	20.4	16.7
85	5.4	2.5	1.5	11.0	20.4	22.9	21.5	7.7
86	10.8	7.3	9.4	15.8	25.0	19.2	19.0	15.4
87	3.8	2.5	0.8	7.5	10.4	10.8	15.6	5.2
89	2.8	0.0	1.7	13.7	16.7	22.2	36.1	30.3
91	0.0	0.0	0.0	0.0	1.7	9.0	6.9	6.0
92	0.0	2.5	1.2	13.1	15.2	13.1	13.5	6.0
93	12.5	6.5	5.8	26.2	21.2	22.3	23.1	14.6
94	0.8	0.8	0.4	25.2	21.5	22.7	21.9	11.9
95	11.1	1.9	1.1	18.3	12.2	10.0	7.2	6.4
96	2.5	2.7	1.6	13.5	31.0	44.3	19.0	17.7
97	7.1	8.1	5.2	8.1	8.5	10.4	5.4	5.6
98	10.0	13.3	10.6	18.9	17.4	20.6	17.8	11.1
99	0.0	1.5	0.0	10.2	7.1	5.0	4.0	1.0
100	5.0	11.1	4.2	22.2	19.4	21.4	19.4	13.3
101	47.1	45.4	45.6	50.4	47.5	45.6	40.0	37.5
102	27.9	31.0	23.8	32.2	15.0	24.0	32.9	26.0
103	22.3	19.4	17.9	16.2	16.5	18.8	23.8	20.4
104	17.7	10.8	18.5	13.2	9.8	5.8	14.0	15.8
105	14.2	17.3	14.2	16.2	12.5	7.7	16.3	9.0
106	25.0	24.6	21.9	21.1	18.9	34.6	38.0	30.4
401	13.8	17.7	8.5	11.9	11.7	8.9	0.8	1.9
402	16.5	20.2	10.6	15.8	12.3	12.9	2.9	1.5
403	0.0	0.0	0.4	4.8	4.2	3.8	2.9	3.5
404	0.8	0.8	0.0	19.0	10.2	12.0	11.4	7.1
405	5.8	4.8	0.0	14.0	12.5	7.5	1.9	5.2
406	26.5	21.2	5.4	6.2	12.1	5.7	5.2	4.8
407	20.2	16.9	17.1	7.7	5.0	7.3	11.7	9.6
408	4.6	2.9	3.8	3.3	2.9	1.3	3.3	5.0
409	7.5	10.0	6.2	13.1	6.0	10.0	1.5	15.4
410	18.8	16.7	9.2	4.2	5.0	2.1	2.5	10.0
412	10.4	15.4	25.4	7.9	6.7	14.6	20.4	10.5
413	11.9	13.8	10.8	22.9	11.7	8.8	3.3	5.0
414	4.2	9.8	12.1	11.2	3.8	1.3	4.0	0.6
415	7.5	13.8	6.2	11.2	9.0	8.8	2.9	11.3
416	64.2	54.6	48.8	33.8	22.5	20.2	23.3	16.5
417	6.0	7.7	3.3	3.5	5.6	6.7	9.5	10.3
418	15.6	18.1	21.9	29.6	14.4	15.3	14.1	3.8
419	6.7	3.8	1.2	2.9	3.8	5.8	7.5	7.9
420	2.9	1.2	0.4	3.8	3.2	4.0	4.2	1.9
421	19.4	14.8	21.0	34.0	22.9	23.3	16.5	19.8
422	22.5	31.9	32.5	31.2	36.9	37.1	47.7	46.9
423	35.2	31.7	16.5	18.5	22.2	24.8	24.4	21.9
424	16.5	17.9	13.5	8.4	3.4	10.7	11.1	7.9
425	34.8	20.6	17.7	28.8	24.6	22.6	24.4	24.0
426	15.0	19.0	18.1	20.0	18.8	24.2	18.1	21.5
427	20.2	22.7	25.6	28.8	29.0	30.6	30.8	26.0
Sr.	**13.5**	**15.1**	**12.6**	**15.5**	**13.6**	**12.9**	**12.7**	**11.0**

The points no.101 (Deliblato, *Pinus nigra*) and no.416 (Petkovica, *Quercus frainetto*), were most frequently recorded as the points with the highest loss of assimilation organs in the previous period, three times in course of one year. When considering mean annual values, the species most resistant to defoliation processes were the trees at the point no.91 (Lake Vlasina, *Betula pendula*).

Based on the presented values, defoliation maps for the territory of Serbia were created (picture 1). These maps enable more plastic presentation of spatial variance of defoliation value.



2010



2011

Picture 1. *Defoliation map of forest tree species on the territory of Serbia*

The extent of exposure to defoliation processes among the most represented broadleaved and coniferous tree species is presented in tables 3 and 4. Considered summary, the most unfavourable year for broadleaved species in the observed period was the year 2007, whereas the most unfavourable year for coniferous species was the year 2005. The most favourable year for both broadleaved and coniferous species was the year 2011.

Among broadleaved species, beech and hornbeam proved to be species more resistant to defoliation processes in comparison to oak. Hornbeam's mean annual defoliation values vary between 6.4% and 13.5%, whereas values for beech vary between 6.9% and 10.6%. Among broadleaves, the most endangered species at bio-indication points is sessile oak, the mean annual defoliation value of which ranges between 19.1% and 23.8%.

Among coniferous species, spruce proved to be a slightly more resistant species, whereas black pine is by far the most endangered of all species recorded at the bio-indication points. Spruce's mean annual defoliation values range between 6.4% and 13.4%, whereas black pine's values vary from 26.8% to 30.6%.

Table 3. *Mean annual defoliation of the most represented broadleaves at bioindication points in the period 2004-2011*

Year	2004	2005	2006	2007	2008	2009	2010	2011
Total (broadleaves and conifers)	13.5	15.1	12.6	15.5	13.6	12.9	12.7	11.0
Broadleaves	13.3	15.0	12.6	15.8	13.6	12.3	12.5	11.1
Carpinus betulus	6.4	8.9	7.7	11.1	12.2	13.5	9.9	9.7
Fagus moesiaca	9.1	9.8	8.5	10.6	8.8	7.5	7.5	6.9
Quercus cerris	13.5	16.7	14.0	17.5	15.4	12.5	13.9	11.5
Quercus frainetto	18.9	20.7	17.0	18.6	14.9	14.5	13.9	11.9
Quercus petraea	19.1	23.8	19.8	20.4	18.8	19.3	20.3	20.8

Table 4. *Mean annual defoliation of the most represented conifers at bioindication points in the period 2004-2011*

Year	2004	2005	2006	2007	2008	2009	2010	2011
Total (broadleaves and conifers)	13.5	15.1	12.6	15.5	13.6	12.9	12.7	11.0
Conifers	16.0	17.6	13.0	14.3	13.9	13.8	11.9	10.5
Abies alba	12.9	15.3	11.9	16.7	12.9	10.4	6.0	4.9
Picea abies	13.4	12.2	6.6	6.8	7.9	8.4	7.2	6.4
Pinus nigra	26.8	29.9	27.1	28.6	29.5	29.6	30.6	28.4
Pinus silvestris	14.3	19.7	14.5	13.8	11.7	11.6	7.5	6.5

4. CONCLUSION

Project of forests conditition monitoring – ICP Forests Programme, operates as international European project which demand performing annually observation of forests with recording data on defoliation, discolouration and other damage recorded on the trees, distributed in network of sample plots with special purpose called bio-indicator points or BIT.

Paper analyzes the data of defoliation as part of the complete gethered results of the monitoring of forest on all BIT, after their network revision in the Republic of Serbia. Monitoring of forests is carried out continuously at 121 mantioned sample plots. Field work on data collection (observations and measurements), in the previous period were carried out in the period June – September each year.

Calculations of the defoliation mean values for previous years, for each sample plot and for the most common tree species, allowed the comparison of the values of defoliation in some regions and by tree species.

In deciduous forests beech and hornbeam are proven to be more resistant species, in a processes of defoliation than oaks. Sessile oak was the most endangered species among the broadleaved. Among the coniferous trees spruce proved to be a resilient species, while the black pine trees were far the most vulnerable to these processes of all registred species on sample plots.

Determination of defoliation mean values for each experimental field area has allowed mapping of defoliation. Such maps have allowed more plastic and much clearer image of spatial variations of defoliation.

At the sample plots assesment of defoliation were done regardless the cause of loss of leaves, and the results are not aimed to determinate the cause-effect relationship, only represent the state of defoliation on experimental fields for the processed period. The presented study is a baseline for monitoring of changes in forest conditions and connectivity of these results with other indicators of environmental parametres will provide more specific information, and making conclusions about the vitality of plants dependence on environmental conditions.

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FORESTS AS A BIOLOGICAL BASIS FOR TOURISM VALORISATION OF VELIKI JASTREBAC

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Abstract: *Forest ecosystems represent the most important ecological potential, whose considerable significance for human life arises from their resources and numerous functions. In recent years, preserved and protected nature and safe food received a particular worldwide attention, while regions able to provide such conditions have a particular importance in terms of tourism. The Republic of Serbia Spatial Plan for the period 2010-2014-2021 envisages a formation of spatial-functional complexes of mountain, spa, ecological, hunting and other forms of commercial tourism. The preference in the Serbian tourism offering is given to facilities whose construction has already been completed or initiated, or to centres that offer complex tourism services. One such complex is the region of Veliki Jastrebac. The paper outlines natural characteristics and specificities of this region, which, along with additional, created values, represent a tourism potential that can be subject to valorisation on various grounds.*

Key terms: forests, Veliki Jastebac, multi-functional valorisation, tourism

1. INTRODUCTION

A long-term development of the Serbian tourism offering is largely based on spatial-functional complexes of mountain, water, transit, city and spa tourism, which incorporate hunting, eco, ethno and other forms of tourism.

Natural characteristics and specificities of Serbian forest regions, along with additional, created values, represent a great tourism potential that can be subject to valorisation on different grounds. Forests exert a favourable impact on air, water, soil, climate, plant and animal world and space in general; protect settlements, facilities, roads and agricultural land from erosion, torrents, floods, avalanches, rockslides, wind, noise, etc. They reduce noise and radioactive radiation, whereas recreational-health and tourism function of forests is assuming ever-increasing importance, particularly given the constantly growing human needs for rest and recreation, especially in natural environment. Apart from numerous natural values, forest ecosystems in Serbia provide opportunities for realisation of potentials, such as large and small game, forest fruit, edible fungi, medicinal and aromatic herbs, that could leave a distinctive mark and distinguishing character to certain localities. High revenues, accompanied by relevant investments, can be generated by means of development of eco and hunting tourism, mass holiday, recreation and rehabilitation in nature.

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A draft of the 2021 Kruševac Municipality Spatial Plan envisages a special protection of Veliki Jastrebac, as a region of primarily recreational-tourism purpose, along with application of relevant ecological measures and standards.

2. THE OBJECT OF STUDY

The study area Veliki Jastrebac includes a territory of large state forests within management units ’Lomnička reka’, ’Jablanička reka’ and ’Srndaljska reka’.

The management unit ’Lomnička reka’ includes state owned forests and forest lands in the central part of the mountain massif Veliki Jastrebac. With respect to its geographic position, it stretches between 18°59’ and 19°05’ east longitude and 43°24’ and 43°28’ north latitude, at the altitudes ranging from of 300m at the Bukovica riverbed to 1,394m in the place called ’Stracimir’.

The management unit ’Jablanička reka’ is located in the western part of the mountain massif Veliki Jastrebac. With respect to its geographic position, it stretches between 18°51’ and 19°11’ east longitude and 43°21’and 43°29’ north latitude, at the altitudes ranging from 230 m to 1,124 m above the place called ’Maznice’.

The management unit ’Srnadaljska reka’ is located in the eastern part of the mountain massif Veliki Jastrebac. With respect to its geographic position, it stretches between 18°51’ and 19°11’ east longitude and 43°21’and 43°29’ north latitude, at the altitudes ranging from 310 m in the Dugački potok riverbed to 1,492 m at the place called ’Velika Đulica’.

In hydrographic terms, all three studied management units belong to a watershed of the river Rasina.

3. RESULTS OF THE STUDY

3.1. Environmental conditions

3.1.1. Relief

The mountain massif Veliki Jastrebac belongs to the Rodopi mountain system, while morphologically it belongs to a class of high and medium mountains with a clearly distinct relief. The relief is characterised by steep and very steep slopes with inclinations 20-40°. It stretches in east-west direction, with the altitudes ranging from 300 to 1,492 m. The most prominent summits are ’Đulica’ (1,492 m), ’Tri sestrice’ (1,482 m), ’Stracimir’ (1,394 m) and other lower summits. The altitude difference is 1,192 m.

Several reefs, belonging to a watershed divide of several most important watersheds that gravitate towards the Zapadna Morava river, stretch from the main reef in the north and north-east direction. The terrain is broken by streams of a steep descent, creating a clearly distinct relief.

3.1.2. Climate

The studied area is located in a temperate continental climate zone, which is characterised by a clear distinctiveness of all four seasons, high variability of weather conditions and quite even distribution of water sediment during a year. Data from the nearest meteorological station ’Kruševac’ indicate that the mean average air temperature amounts to 11.5°C. The extreme minimum air temperature is -26.0°C, whereas the extreme maximum temperature is 40.4°C. Fluctuation of temperature is high and it can reach 60°C during a year.

The mean annual precipitation amount of 601mm is evenly distributed per seasons, with maximum reached in May and June and minimum in February and September.

The mean value of relative air humidity is 74%.

Most common winds blow from north-east, east and south-east direction. The best known winds are *košava* (cold south-eastern wind), north and south wind.

According to a Thornthwaite classification, altitudes between 600 and 1,000 m have a climate ranging from temperate humid (type B2) to strongly humid (type B4). The climate in areas above the 1,000 m altitude is perhumid.

3.1.3. Geological substratum

The geological composition is diverse, dominated by low-grade metamorphosed shales, magmatic grandiorite and clastic sedimentary rocks. Most commonly they are granite, diorite, granodiorite, micaschists, gneiss, rocks of sedimentary origin and phyllite.

Quarternary formations are represented by alluvial, deluvial and proluvial genetic types, with corresponding morphological formations – river terraces, mountain cones and deluvial slopes. These formations are particularly developed in north slopes of Jastrebac.

3.1.4. Soil

Based on various pedogenetic factors – geological substratum, macro and micro climate, inclination, terrain aspect and vegetation coverage, the following principal types of soil have been recorded:

- *Brown forest soil*. It is formed on a parent substratum consisting of shales, sandstone and alluvial deposits. It is of a medium to deep depth, sporadically skeletal and dry, very porous and permeable. The water capacity is medium, physical characteristics are favourable, pH temperate acid to acid. Humification has a tendency of creation of acid humus, that is, formation of brown podzolic soil, which is particularly apparent in beech forests of a scarce and broken canopy, in south slopes exposed to sun.
- *Brown podzolic soil*. Most commonly, it is a brown forest soil with a tendency to variation towards acid podzolic soil. That is influenced by a wide range presence of beech forests or their various subtypes, characterised by their pedogenetic processes. The depth ranges from shallow to medium deep. According to the texture, it can be sandy to slightly loamy. It is well-aerated and water-permeable. According to recent studies (Knežević, M., Košanin, O. i Milošević, R., 2010.), it can be concluded that there are distinct differences in characteristics and production potential between podzolic soil and typically acid brown soil in the Veliki Jastrebac region. Deep, typically acid brown soil, on granodiorite, in a montane beech forest type, (*Fagetum moesiacae montanum typicum*), is characterised by highly favourable properties; large depth, developed A-horison, favourable mechanical composition, absence of skeleton, formation and accumulation of mul-humus and a high supply of nitrogen.

Podzolised acid brown soil, on grandiorite, in an acidophilus type of beech- wood-rush forest (*Luzulo-Fagetum moesiacae*) and an acidophilus type of beech-moss forest (*Musco-Fagetum*), can be classified as soil of low production potential. That is particularly a result of low solum depth, a higher or lower degree skeletalness, stronger acidification and destruction in the surface soil layer caused by podzolization, while the occurrence of surface soil layer erosion is frequent in high inclinations.

3.1.5. Vegetation

The flora of the Jastrebac region had been studied in detail since 1856, when Jastrebac was first visited by Josif Pančić, and then on two occasions in 1869 and 1874. More recent studies were conducted by Gajić, M. and Tucović, A with collaborators in 1965.

According to ***Flora of north part of Veliki Jastrebac*** (1992), 90 families, 285 genera and 537 species of plants have been recorded in this region. The real number of species is significantly higher, as only north, colder terrain aspects, mostly on silicate layer that reduces flora diversity, have been studied.

Presence of several forest phitocenosis has been established. When going from the foot of the mountain to the highest summits, the following forest species can be found:

- Ass. *Alnetum glutinosae* Jov., black alder forest community, azonal black alder forest community whose fragments are represented by rivers
- Ass. *Fraxino-Quercetum roboris* Rudski, pedunculate oak and ash forest community
- Ass. *Carpino-Quercetum roboris cerris* Jov. subas. aculeatetosum Jov., pedunculate oak, hornbeam and Austrian oak forest community with Butcher's broom
- Ass. *Quercetum frainetto-cerris* Rudski, Hungarian oak and Austrian oak forest community
- Ass. *Querco-Carpinetum* Rudski, sessile oak and hornbeam forest community
- Ass. *Quercetum montanum* Černjavski et Jovanović, sessile oak forest community, subasoc. *Carpinetosum orientalis* Gajić
- Ass. *Musco-Fagetum* Jov., beech forest community with moss
- Ass. Fagetum montanum Rudski subas. silicolum Jov., mountain beech forest community
- Ass. *Abieti-Fagetum* Jov., beech and fir forest community
- Ass. *Fagetum subalpinum* Grebenšćikov, subalpine beech forest community
- Ass. *Aceri-Helderichii-Fagetum* Jov., Balkan maple and mountain beech forest community

Typical forest of pedunculate oak and ash - *ass. Fraxino-Quercetum roboris* Rudski., was noted in area of Velike Lomnice. *Quercus robur* and *Fraxinus angustifolia* are present in tree floor and *Viola odorata, Helleborus odorus, Polygonatum latifolium, Asperula taurina, Galium cruciata, Ulmus carpinifolia, Evonymus europaea, Veronica chamedys, Galium aparine, Urtica dioica, Dactylis glomerata* and others are present in herbaceous plant floor.

Pedunculate oak, hornbeam and Austrian oak forest community with Butcher's broom - *ass. Carpino-Quercetum robori-cerris* Jov. *subass. aculeatetosum* Jov., was noted in area of Nauparima. *Quercus robur, Q. cerris, Carpinus betulus and Acer campestre* are present in tree floor, *Carpinus betulus, Acer campestre, Crategus momogyna* and others are present in shrub floor. and *Evonymus europaea, Geranium robertianum, Veronica hederifoia, Ruscus aculeatus, Cyclamen neapolitanum, Asperula taurina,* and others are present in herbaceous plant floor.

Hungarian oak and Austrian oak forest community - *ass. Quercetum farnetto-cerris* Rudski. Important species in tree floor are *Quercus cerris* and *Quercus farnetto*. *Pirus piraster, Malus silvestris, Acer campestre, Fraxinus ornus* and *Sorbus torminalis* are also present. *Crategus monogyna, Sorbus domestica, Viburnum lantana, Rhamnus cathartica, Acer tataricum* and others are present in shrub floor. *Silene viridiflora, Iris graminea, Tanacetum corymbosum, Lathyrus niger, Viola hirta, Trifolium alpestre, Carex tomentosa, Teucrium chamaedrys,* and others are present in herbaceous plant floor.

Depending on the exposure Hungarian oak and Austrian oak forest communities are followed by **sessile oak forest communities - *ass. Quercetum montanum* Čer. et Jov.**, that form **sessile oak and hornbeam forest community - *ass. Querco-carpinetum*** Rudski at lower altitudes in the valleys. Besides *Quercus petraea*, *Quercus daleschampi* is also present in tree floor. *Quercus petrea, Q. daleschampi, Acer platanoides, Corylus avellana, Fagus silvatica, Fraxinus ornus* are present in shrub floor. *Calamintha clinopodium, Festuca heterophylla, Lysimachia punctata, Dactylis glomerata, Luzula luzuloides, Poa nemoralis, Galium schultesi, Silene nutans, Scutellaria columne, Pteridium aquilinum, Lathyrus venetus, Melica uniflora,* and others are present in herbaceous plant floor.

Beech forest community with moss - *ass. Musco-Fagetum* is registered on severe slopes, small areas exposed north and northwest.

Besides *ass. Musco-Fagetum*, ***subass. Fagetum montanum silicolum*** is also registered, as well as **sessile oak forest communities - *ass. Quercetum montanum* Čer. et Jov**. Beside beech *Quercus petraea* and *Pirus piraster* are present in tree floor, *Fagus silvatica, Crateagus monogyna* and *Spirea chamaedrifolia* are present in shrub floor. *Campanula rapunculus, Carex digitata, Doronicum columnae, Asperula odorata, Vaccinium myrtillus, Lathyrus vernus, Sedum maximum, Lamium maculatum, Senecio rupestre, Saxifraga rotundifolia, Hieracium racemosum* and others are present in herbaceous plant floor.

Mountain beech forest - *ass. Fagetum montanum* Rudski represents very important forest community in this area. Within this community ***subass. silicolum*** was allocated as dominant for Jastrebac area because it is fully acclimatised on present environmental conditions. Besides beech *Betula pendula, Pirus piraster, Carpinus betulus, Ulmus glabra, Acer platanoides, Acer pseudoplatanus* are present in tree floor, and *A. heldreichii* and others are presented on higher latitudes. *Sambucus nigra, Crateagus monogyna, Corylus avellana* and *Quercus petraea* are present in shrub floor. *Viola silvestris, Salvia glutinosa, Asperula odorata, Arum maculatum, Euphorbia amygdaloides, Carex digitata, Poa nemoralis, Pulmonaria officinalis, Anemone nemorosa,* and others are present in herbaceous plant floor.

Beech and fir forest community - *ass. Abieti - Fagetum* Jov. occur above mountain beech forest on latitudes over 650 meters, on various types of soil and different reaction to the environment. This has influenced the development of various subassociation: ***drymetosum, polypodietosum, allietosum ursinae*** and ***muscetosum***. Beech and fir are important species in tree floor. Beside them *Betula pendula, Acer pseudoplatanus, A. platanoides* and others occur sporadically. Beside almost all mentioned species *Sambucus racemosus* and *Evonymus latifolia* are present in shrub floor. *Rubus hirtus, Salvia glutinosa, Luzula luzuloides, Asperula odorata, Oxalis acetosella, Epilobium montanum, Glechoma hirsuta, Asarum europaeum, Pulmonaria officinalis,* and others are present in herbaceous plant floor.

Subalpine beech forest communities occur above beech and fir forest communities, mostly on latitudes between 1200-1350 m in the form of belts. Beside beech *Acer pseudoplatanus* and *A. heldreichii* occur sporadically in tree floor. *Cardamine bulbifera, Asperula odorata, Rubus hirtus, Oxalis acetosella, Paris quadrifolia, Daphne mezereum, Anemone nemorosa* and others are present in herbaceous plant floor.

Balkan maple and mountain beech forest community - *ass. Aceri-heldreichii - Fagetum* Jov. ends forest cover at latitudes between 1350-1480 m. *Acer heldreichii* and *Fagus silvatica* are present in tree floor, and *Rubus hirtus, Geum urbanum, Asperula odorata, Cardamine bulbifera, Myosotis silvatica* and others are present in herbaceous plant floor.

A ceno-ecological group of mountain beech forest types covers the largest areas and forms a clearly differentiated and defined spatial-ecological complex - **clima-regional belt** in all mountain massifs in Serbia. The forests were created as a result of synergic effects of a number of factors. Therefore, they are characterised by ecological diversity, expressed through petrographic-edaphic, orographic, micro-climatic, cenological properties and typological position. The belt is characterised by a specific micro-climate, which has a favourable effect on an ecological and ceno-ecological optimum of most types of beech: higher precipitation, higher relative humidity, lower temperatures (which is particularly important in the period of summer droughts) and lower degree of temperature fluctuations.

Beside mentioned plant communities some conifer tree species were anthropologically introduced in Veliki Jastrebac area: Austrian pine (*Pinus nigra* Arn.), Scots pine (*Pinus silvestris* L.), common spruce (Picea abies (L.) Karst), common larch (*Larix decidua* Mill.) and Coast Douglas-fir (*Pseudotsuga menziesii* (Mirbel.) Franco). Common red oak (*Quercus rubra* L.) was one of broadleaf species anthropologically introduced in this area.

More than two hundred medicinal herbs have been recorded in the flora of Veliki Jastrebac, which creates exceptional opportunities for their use.

Protected and rare plant species

Beside Balkan maple (*Acer heldreichii* Orph.) which represent relict tree species, according to Jovanović (1951), Butcher's broom (*Ruscus aculeatus* L.) and English holly (*Ilex aquifolium* L.) also occur in this area as relict tree species, flora remains from the banks of the former Pannonian Sea. Noted relict species in Veliki Jastrebac area are also *Ruscus hippoglossum* L., *Staphilea pinnata* L., *Aremonia agrimonoides* L., *Carpinus betulus* L., *Carpinus orientalis* Mill., *Erythronium dens-canis* L., *Isopyrum thalictroides* L., *Tamus communis* L. and *Viscum album* L.

By the Decree of the Government of Republic of Serbia ('Off. Gazette of RS', no 93/2008), a part of the mountain Veliki Jastrebac region, at the place called Prokop, of the surface area of 5.91ha, was placed under protection as a **nature reserve** and defined as **natural protected area of exceptional importance**, that is, **natural protected area of I category**, with a first degree protection regime which prohibits use of natural resources and excludes all other forms of area use and activities on the protected area, except for scientific research and limited education. In this birch reserve (*Betula pendula* R o t h.) at Prokopačka kosa, birch-tree is largely mixed with beech (*Betula pendulae – Fagetum*), with a certain number of pure stands. It is well-known that birch has a broad ecological range and that it is spread in most parts of Europe, however, birch-tree in Serbia is in the south border of its areal.

Isolated seed stands or seed trees also represent floristic values that ought to be particularly highlighted and protected. Such are, for instance, seed stands of beech, ash, birch, horse chestnut, sweet chestnut, fir, tulip tree and other species.

Apart from the above-stated floristic rarities, all valuable forest and other eco-systems ought to be protected, enhanced and fully valorised.

Edible fungi

According to studies by Karadžić, D. (1992), *Flora of Veliki Jastrebac* lists a large number of fungi, out of which the following are of importance from the aspect of tourism potential: *Helvella crispa* Fr.- white saddle, *Leptopodia monachella* (Scop. Ex Fr.) Boud. - hooded false, *Morchella elata* Fries., *Agaricus campestris* L. ex Fr.- field mushroom, *A. macrosporus* (Moell. Et Schff.) Pilat., *A. silvicola* (Vitt.) Peck. - wood mushroom, *A. sylvaticus* Schaeff. Ex Secr. - blushing Wood Mushroom, *Lepiota procera* (Scop. Et Fr.) S.F. Gray - parasol mushroom, *Volvariella speciosa* (Fr. Ex Fr.) Sing. - stubble rosegill, *Kuehneromyces mutabili* Sing. Et Smit. sheathed woodtuft, *Calocybe gambosa* (Fr.) Donk. - St. George's mushroom, *Clytocibe gibba* Kummer, *Mycena halmatopus* Kummer - bleeding fairy helmet, *M. pura* Kummer - lilac bonnet, *Pleurotus ostreatus* Kummer - oyster mushroom, *P. cornicopicae* Rolland - branching oyster, *Cantharellus cibarius* Fr. - golden chanterelle, *Craterellus cornucopioides* Pers. - black chanterelle etc.

Forests by principal categories of use

Total surface area of the study area is 14281.19ha, out of which 97.3% is covered by forests and forests cultures. The remaining area (2.7%) is covered by forest, infertile land for other purposes and spatial occupation. Surface areas of overgrown and not overgrown land in the Veliki Jastrebac region are presented in Table 1.

Table 1. *Forests by principal categories of use in the Veliki Jastrebac region*

Area structure by overgrown land	**ha**	**%**
Forests	13479.62	97.0
Forest cultures	415.30	3.0
Overgrown land	**13894.92**	**97.3**
Forest land	70.80	20.7

Area structure by overgrown land	ha	%
Infertile land	239.82	70.1
Land for other purposes	31.59	9.2
Not overgrown land	**342.21**	**2.4**
Spatial occupation	44.06	0.3
TOTAL	**14281.19**	**100.0**
Extraneous land	282,63	

Forests by special purpose

According to a priority purpose in the forest management plan, forests in the study area are classified into the following special-purpose units: Special purpose unit 10 – technical wood production; Special purpose unit 14 – large game breeding centre; Special purpose unit 17 – seed stand; Special purpose unit 26 – I degree land protection; Special purpose unit 77 – outing spot; Special purpose unit 84 – strict nature reserve and Special purpose unit 97 – forests surrounding historical and memorial complexes. The overview of surface areas, forest volume and volume increment by special purpose units is presented in the Table 2.

Table 2. *Forests by special purpose in the Veliki Jastrebac region*

Special purpose unit	Surface area		Volume			Volume increment			
	ha	%	m^3	%	m^3/ha	m^3	%	m^3/ha	p_{iv}
10	13,028.40	93.9	4,071,114.0	93.7	312.5	89,694	93.5	6.9	2.2
14	367.51	2.6	155,821.6	3.6	424.0	3,533.2	3.7	9.6	2.3
17	17.90	0.1	10,127.0	0.2	565.7	329.9	0.3	18.4	3.2
26	352.74	2.5	75,706.0	1.7	214.6	1,469.9	1.5	4.2	1.9
77	79.94	0.6	27,647.6	0.6	345.9	731.4	0.8	9.1	2.6
84	5.91	0.0	2,599.9	0.0	433.1	49.9	0.0	8.4	1.9
97	42.52	0.3	10,425.3	0.2	245.2	201.4	0.2	4.7	1.9
TOTAL	**13,894.92**	**100**	**4,353,441.3**	**100**	**313.3**	**96,009.7**	**100**	**6.9**	**2.2**

As can be seen in Table 2, the study area is dominated by forests whose primary function is production of technical wood, their surface area amounting to 94%, while the remaining 6% are intended for fulfilling other forest functions. Such structure of special-purpose units is absolutely not in compliance with contemporary forest management principles and enhancement of forests as ecosystems by means of equal utilisation of all their functions, which would facilitate realisation of sustainable development and multi-functional forest use principles.

Forests by origin and conservation degree

High forests (Table 3) are a forest type that is most highly represented in the forest complex Veliki Jastrebac. The second largest are coppice forests covering (26% of the surface area) and with the share in the total volume accounting for 19.6%. Anthropogenically established stands cover the area of 11.1%, while their share in the total volume accounts for 8.7%.

Table 3. *Forests by origin*

Origin	Area		Volume			Volume increment		
	ha	%	m^3	m^3/ha	%	m^3	m^3/ha	p_{iv}
High	8,736.13	62.9	3,119,953.0	357.1	71.7	62,665.7	7.2	2.0
Coppice	3,614.92	26.0	853,914.5	236.2	19.6	20,256.7	5.6	2.4
Anthropogenically established	1,543.87	11.1	379,573.8	245.9	8.7	13,087.3	8.5	3.4
TOTAL	**13,894.92**	**100**	**4,353,441.3**	**313.3**	**100**	**96,009.7**	**6.9**	**2.2**

Conserved stands (Table 4), with a high degree of overgrowth and in good health, cover the largest area (80.7%). Sparse natural forests represent a form of a devastation stadium, particularly if these stands are located on steep slopes with no undergrowth, and if the soil is exposed to erosion.

Table 4. *Forests by conservation degree*

Conservation degree	Surface area		Volume			Volume increment		
	ha	%	m^3	m^3/ha	%	m^3	m^3/ha	p_{iv}
Conserved	11,211.68	80.7	3,572,191	318.61	82,1	83,471.6	7.4	2.3
Sparse	2,211.77	15.9	741,791	335.4	17,0	11,756.8	5.3	1.6
Devastated	471.47	3.4	39,460	83.7	0,9	781.4	1.7	1.9
TOTAL	**13,894.92**	**100**	**4,353,442**	**313.3**	**100**	**96,009.7**	**6.9**	**2.2**

Forests by mixture

Pure stands account for 53% of the Jastrebac region. Mixed stands cover 47% of the total overgrown area. Given the higher production capacity of mixed stands, their resistance to entomological damage and phytopatological disease, it is clear that our focus ought to be on maintaining mixed stands, depending on site conditions. The overview of stands by mixture is presented in the Table 5.

Table 5. *Forests by mixture*

Mixture status	Surface area		Volume			Volume increment			
	ha	%	m^3	m^3/ha	%	m^3	m^3/ha	p_{iv}	%
Pure	7,370.72	53.0	2,512,142	340.8	57.7	52,998.4	7.2	2.1	55.2
Mixed	6,524.20	47.0	1,841,299	282.2	42.3	43,011.4	6.6	2.3	44.8
UKUPNO	**13,894.92**	**100.0**	**4,353,442**	**313.3**	**100.0**	**96,009.7**	**6.9**	**2.2**	**100.0**

Growing stock and game

Situated within the study area, the hunting area 'Veliki Jastrebac' was established in 1995. The use of the hunting area is given over to the Public Enterprise 'Srbijašume', Belgrade, while the hunting area is run by a forest management 'Kruševac'. The hunting area 'Veliki Jastrebac' is located in the central part of the mountain massif, in the Lomnička reka valley. It is at a 20km distance from Kruševac, 30km from Niš and 210km from Belgrade. It is a mountain type hunting area, with the altitudes ranging from 200m to 1,510m, and covering the surface area of 29,731 ha. The number of game is presented in Tables 6.

Table 6: *Number of game in the hunting area 'Veliki Jastrebac'*

Species	Number	Species	Number
Large furry game			
Wild boar	172	Roe-deer game	123
Small furry game			
Hare	362	Squirrel	300
Fox	250	Dormouse	250
Stone marten	150	Badger	140
Pine marten	100	Ferret	80
Wild cat	60	Marbled polecat	15
Muskrat	15	Ermine	15
Feathered game			
Grey partridge	250	Eurasian woodcock	80
Comon quail	200	Northern goshawk	20
Mallard	60	Pheasant	100
Eurasian coot	40	Rock partridge	40
Rook	60	Hazel grouse	15
Grey heron	15	Eurasian jay	100
Common wood pigeon	60	Bean goose	60

The MU ’Lomnička reka’ includes a fenced rearing centre for breeding of autonomous large game species, such as red deer and wild boar.

A large game rearing centre, located in this management unit, is intended as a source of further population and propagation of this game in the entire hunting area of Veliki and Mali Jastrebac.

4. TOURISM VALORISATION OF VELIKI JASTREBAC FOREST AREAS

Veliki Jastrebac is regarded as one of the most forested and water abundant mountains in this part of the Balkans, while its slopes belong to a group of areas larger than 1,000 ha, with significant natural resources. It is characterised by a mostly beech forest coverage, with sporadic groups of other broadleaves and coniferous trees, which makes it particularly attractive for outing-goers. A white birch natural reserve in a spot called Prokop is of particular importance, covering the surface area of 5.91ha and placed under protection as a *nature reserve* and defined as a *natural protected area of exceptional importance*, that is, *natural protected area of I category*. Preserved natural ambiance of certain spatial complexes, abundance of forests, diversity of flora and fauna, public utility and road infrastructure and four accommodation facilities, represent a good underlying basis for development and enhancement of hunting, eco-tourism and other forms of tourism in the region of Veliki Jastrebac.

Table 7: *Accommodation capacities at the region of Veliki Jastrebac*

Facility	Number of rooms	Number of beds
Hotel „Trayal club“	17	35
Mountaineering refuge	-	55
Villa ’Merima’	19	55
Hunting lodge „Ravnište“	7	22
TOTAL	**43**	**167**

Source: 2021 Municipality Kruševac Spatial Plan (Draft)

Forest regions of Veliki Jastrebac provide opportunity for use of secondary forest products, such as game, fish, forest fruits (forest blackberry, forest strawberry, blueberry, European cornel, etc), edible fungi, (porcino, chanterelle), medicinal and aromatic herbs, which could leave a distinctive mark and distinguishing character to certain localities.

In the framework of the Republic of Serbia Spatial Plan for the period 2010-2014-2021, a formation of a regional nature park in Veliki Jastrebac has been proposed, on the surface area of 44.20 ha, as a region with preserved natural and aesthetic values, which would have a cultural-educational, scientific and tourism-recreational importance. In accordance with the above-stated, the local self-governments, in collaboration with a competent ministry, are supposed to: adopt tourism offering strategy/programmes for this region that are aligned with principles of environment protection and protection of existing natural values; enhance the level of transport and public utility infrastructure; establish and implement programmes related to development of the existing and building of new accommodation facilities; organise education of a local population and include it into tourism programmes; control the quality of service by issuance of relevant work licences, particularly in the field of production and sale of safe food.

5. CONCLUSION

It is possible to revitalise a number of attractive location in the entire region of Serbia, with the aim of enhancing the existing Serbian tourism offering, animating each individual visitor and providing a unique experience. By extending and enhancing tourism offering through inclusion of forest ecosystems, the Serbian tourism potentials could be far better exploited and economic effects increased. Such concept is, on the one hand, based on a contemporary world practice concerning protection of particular regions and biodiversities, but also on principles of integral use and sustainable development, on the other hand.

Veliki Jastrebac is considered one of the most forested and water abundant mountains in this part of the Balkans, while its slopes belong to a group of areas of significant natural resources larger than 1,000 ha.

The nature reserve 'Prokop' represents a unique and representative natural property. It has a particular scientific and expert relevance, since it provides an opportunity for monitoring of the process of natural vegetation succession.

Natural scenery, abundance of forests, diversity of flora and fauna, fenced hunting area, accommodation facilities, public utility and transport infrastructure, represent a good underlying basis for enhancement of hunting and development of eco-tourism in the region of Veliki Jastrebac.

Acknowledgements

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CONSERVATION PLANNING AND IMPROVEMENT OF A DEGRADED LANDSCAPE IN THE CITY MUNICIPALITY OF LAZAREVAC

Milijana CVEJIĆ[1], Jelena TOMIĆEVIĆ[2]

Abstract: *The area of City Municipality of Lazarevac, which consists of a flood plain of the Kolubara River's lower and central course and the Kolubara Coal Basin, was once a forested area with extensive farming. As a result of a large-scale coal mining, the Kolubara Coal Basin, the largest lignite coal deposit in the central part of Serbia, has undergone drastic changes with serious environmental consequences that caused a complete change of the landscape character.*

The analysis of secondary data, along with other study and technical documentation, relevant to the area of Lazarevac Municipality, as well as the assessment of a character and stability of the analysed part of the landscape, indicated a need for a proposing a plan for preservation and improvement of the degraded landscape's visual aspect and attributes.

The paper presents estimated values of the landscape character. They are a tool by means of which the spatial values are integrated into landscape planning. Networking and re-naturalisation of disrupted natural elements have been proposed, for the purpose of restoring their stability on the territory of Lazarevac Municipality.

Key words: planning documents, landscape character, conservation and enhancement of the landscape character.

1. INTRODUCTION

Coal ore in the Lazarevac region was discovered in 1875, since when this industrial sector has been developed in this area. At the beginning, coal was extracted from underground mines, until 1975, when they were substituted by opencast coal mines, when Kolubara 'black gold' became the major production-industrial sector of the region. Coal mines, (active and closed) presently cover the surface area of 600 km^2. On account of them, the course of the Kolubara River was changed, houses and households were displaced, while a dead land or 'moon landscape' remained in the mining areas (Cvejić et al., 2008).

The paper describes landscape elements that remained in the area of former mines in the region that has undergone substantial changes due to a mining activity.

The aim of the paper is an examination of attributes that describe a landscape's character and stability, identification of a level and type of degradation of natural flow of matter in the landscape and a proposal of a strategy for preservation and improvement of a degraded landscape's function and visual aspect.

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2. METHOD

2.1. Study Area

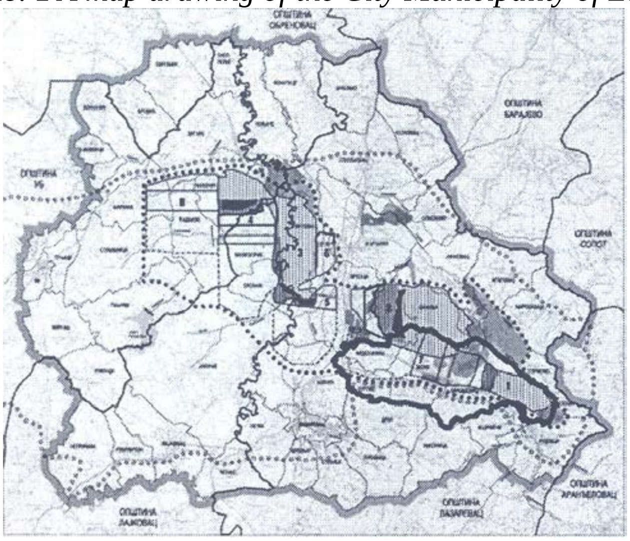
The Lazarevac Municipality is administratively located on the territory of City of Belgrade, covering the surface area of 379 km^2, with 33 inhabited places (8 towns and 24 villages). It is situated in the north-west part of the low Šumadija region, between alluvial plains in the valley of the Kolubara River's central course and the Tamnava River's lower course, and a hilly-mountain region of north Šumadija, with spot elevations ranging from 170 to 250m. Once a hilly terrain, today it is largely a plain, with a modified soil, which caused a drastic change of micro-climate.

The Municipality partly comprise the area along the Kolubara River, and partly mining areas (presently, this is the largest lignite deposit in Serbia) (Cvejić et al., 2008). The mining industry 'devours' villages and small settlements, which, following the end of mining works, are not re-inhabited and remain deserted.

Village households are abandoned and villages slowly disappear. Once cultivated, highly valuable agricultural areas are abandoned and left to a natural succession.

The paper analyses underlying indicators of assessment of nature degradation, for the needs of planning, preservation and improvement of landscape. The landscape analysis encompassed issues and conflicts that appeared in the area as a result of its use. Landscape planning in Serbia began to develop in the mid-1970's.

Picture no. 1 *A map drawing of the City Municipality of Lazarevac*



Source: Official Gazette of the City of Belgrade

The principles and objectives of that pioneering concept were advocated by Milinković, Čolić, Janković and others, according to Cvejić (1999). The adoption of the Law on Spatial Plan of the Republic of Serbia from 2010 to 2020, defined a landscape fragmentation and degradation as one of the key problems of landscape protection and development in the Republic of Serbia. The following operational objectives for protection, design and development of the Republic of Serbia's landscape have been defined: protection, preservation and improvement of all types of landscape by application of relevant measures in the areas where natural and aesthetical values were disturbed (The Law on Spatial Planning of the Republic of Serbia 2010- 2020)

2.2. Landscape Analysis Method

The landscape analysis method comprised the analyses of ecological data with respect to landscape attributes collected:

- by means of field observations
- from secondary sources and other study and technical documentation, creating a complete picture of the character and stability of the analysed part of the landscape. The collected data enabled creating realistic proposals for planning, preservation and improvement of a degraded or changed landscape.

3. RESULTS

3.1. The Law on Spatial Plan of the Republic of Serbia from 2010 to 2020 stipulates that:

The concept of protection, design and development of the Republic of Serbia's landscapes involves:

- minimising adverse and stimulating positive impact of new developments on a landscape's character and diversity in the areas with development priority;
- preservation and improvement of a characteristic structure and visual aspect of rural areas through preservation of a characteristic landscape pattern, based on use of land, a relation between constructed areas and open-air areas and a construction character.

The planning conception should provide:

- improvement/preservation of a visual aspect and structure of urban landscape through development of construction activities and landscape design that are in conformity with a landscape character and specificities of the development of the city at large and its parts, establishment of spatial order and preservation of elements of rural landscape (forests, agricultural areas)
- improvement and sustainable use of open air, green areas and elements, creation of a network of green areas and public areas, connecting natural and cultural values of settlements, peri-urban areas and a rural landscape.

3.2. Causes of Disturbance / Transformation of Landscape

3.2.1. Ore Exploitation in Opencast Mines

The exploitation of coal ore is conducted in opencast mines that stretch over the surface area of 600 km^2, at the depth of 40m. A specific industrial sector of the Lazarevac Municipality, ore exploitation, had an impact on change of a landscape character, as the technological procedure required removal of a layer of fertile plough land and displacement of river courses for the purpose of formation of opencast mines. A life cycle of an opencast mine depends on ore deposits it contains, and it might last for several years. Following a closure of one mine shaft, another opencast mine is opened in a different place. A degraded, so-called 'moon landscape' remains at an exploitation site.

Future of Settlements in the Opencast Mine Zone

Under a town of Vreoci in the vicinity of Lazarevac, there are 200 million tons of quality lignite, on account of which displacement of the town has been planned by 2014. A complete or partial displacement of another four villages, due to extension of coal mines, has been planned in the zone of opencast mine Tamnava-Zapadno Polje. Furthermore, an extension of mining works within a large area of the Kolubara Coal Basin has been envisaged (Official Gazette of the City of Belgrade, 2008).

3.2.2. Change of the Kolubara River Bed's Position/Development Dynamics

According to development plans by 2020, the most significant changes in the landscape are associated with the plans for further coal exploitation in the Kolubara Lignite Coal Basin, which involve opening of new open-cast mines.

A further intervention in the region involves change of the course of the Kolubara River and its tributaries, for the purpose of providing space for new open-cast mines, as well as for protection of mines against flooding. It is expected that the planned hydro-technical regulation will cause drastic changes in these areas (Official Gazette of the City of Belgrade, 2008).

3.2.3. Deforestation in the Area of Lazarevac Municipality

In addition to direct changes of the landscape, ore exploitation has led to abandonment of households, fertile lands and forests. On account of rapid changes, remaining agricultural areas are not cultivated. The results are abandon areas prone to erosion and further degradation, as can be seen in pictures 2, 3 and 4.

Pictures 2,3,4: *Abandoned agricultural land on the territory of Lazarevac Municipality*

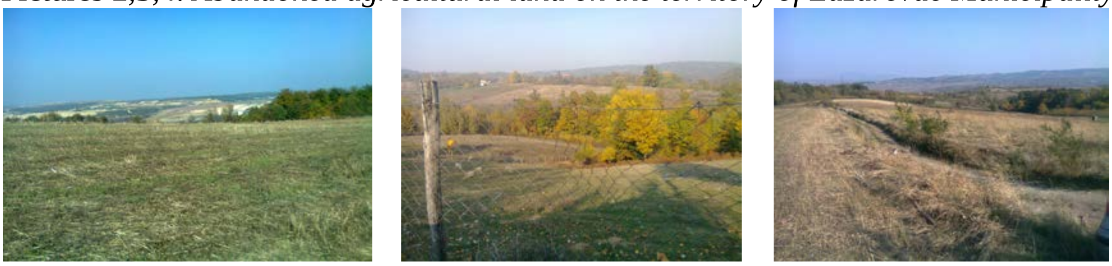


Photo: M. Cvejic 2012

3.3. Assessment of a Landscape Degradation Level

3.3.1. Evaluation of a Landscape Character

With respect to its character, this region in one of its parts comprises a flood plain of the alluvial flatland in the valley of the Kolubara River's lower and central course and the Tamnava River's lower course, while, in its other part, it creates the Kolubara Coal Basin (Cvejić et al.2008).

Two landscape features are clearly distinct: an intensive agricultural production and mining industry, which places this landscape into a class of agro-industrial areas.

The landscape character has been determined by an analysis of landscape elements that constitute a matrix and network, consisting of line and riverine corridors.

The remnants of forests remained in forms of 'blocks', fragmentary distributed in gullies and shallow valleys. The corridors occur in form of a partially preserved riverine vegetation.

In terms of preservation of landscape diversity, marshes and dead waters, occurred as a result of meandering of the Kolubara River, represent an important landscape element.

It is an open landscape, with long horizons, which end, over undulating foothills, at distant hills, on which fragments of meadows and fields, as well as few remaining woods in the river basin, can be seen.

In structural terms, the matrix consists of geometrically shaped agricultural areas, bounded by a network of hedges forming line corridors, or encircled by roads without tree lines.

Open-cast mines in the Kolubara Coal Basin represent the other type of landscape elements. They are characterised by an irregular shape of mining areas, creating a visual impression of degraded, lifeless area, a ‘moon landscape’. The areas of the above-mentioned landscape types are characterised by presence of local roads, built for the purpose of ore exploitation, and a lack of vegetation.

Woods and thickets in depressions and gullies between ploughed lands are most represented. Narrow strips of riverine vegetation remained along the water courses.

The largest settlement within this landscape type is a town of Lazarevac. It is situated on a slightly undulating terrain in the valley of river courses of the Turija, Peštan and Onjega River. Smaller settlements of variable character are located at the edges of this type of landscape: Vreoci, Veliki Crljeni and Stepojevac. The largest change in the landscape was effected by coal mining in the Kolubara Coal Basin, on account of which once forested and ploughed land has undergone drastic changes. In addition to a serious adverse ecological impact, they also resulted in a complete change of a landscape character (Cvejić et al., 2008).

3.3.2. Evaluation of Landscape Stability

The analysis of a landscape characteristic structure and functioning represents a basis for an assessment of landscape stability, through evaluation of the following aspects (Vasiljević, 2008):

- fragmentation of landscape elements,
- functioning of corridors and connection of landscape elements,
- heterogeneousness of landscape structures and edge structures.

The abandonment of once cultivated highly-valuable agricultural areas, which form a matrix of these landscapes, along with degraded areas that occur after completion of mining works, define the landscape, the elements of which are disturbed, degraded.

Corridors are degraded and, consequently, they have lost the function of connecting landscape elements.

The heterogeneousness of the landscape structure and edge structure is also disturbed, particularly in the zone of open-cast mines.

It can be concluded that stability of the Lazarevac Municipality landscape has been disturbed in all aspects that define stability of an area.

3.4. Strategy for Preservation and Improvement of a Degraded Landscape’s Function and Visual Aspect on the Territory of Lazarevac Municipality

Through collection of data related to the occurred landscape damage and modifications, caused by mining works in the analysed area, a complete picture of a landscape character and stability was obtained. The results of the analysis indicate a need for preparation of a plan for preservation and improvement of degraded landscape’s ecological functions, as well as the landscape’s visual aspect.

Given the Serbia’s needs for coal exploitation, along with an open-coal mining development course and a type and kind of occurred landscape damage, the following measures have been proposed:

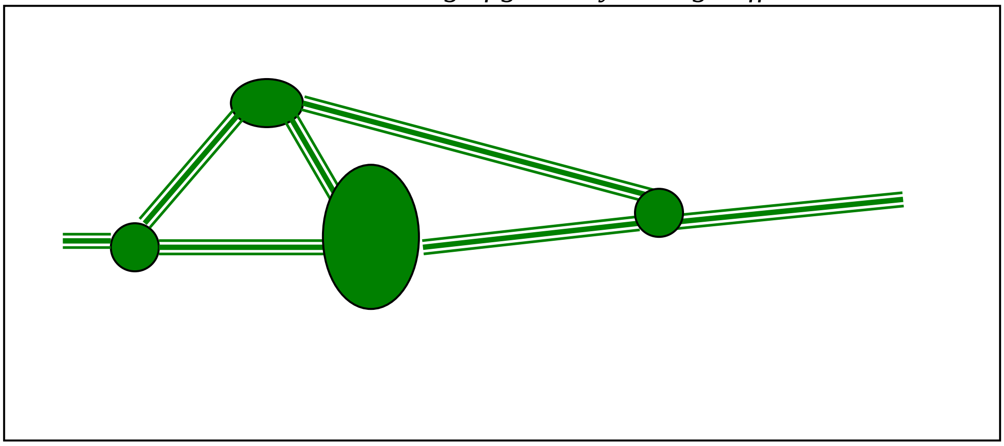
Implementation of re-cultivation by restoring, in a shortest possible period, disturbed natural processes, necessary for a recovery of disturbed landscape functions.

Afforestation based on a principle of formation of ‘hubs’ and line corridors (Picture no. 5) would improve the situation in terms of re-introduction of disappeared flora and fauna, which would lead to a proper rehabilitation of a degraded landscape's ecosystem and establishing harmonious, uninterrupted relation between biotopes in the area.

Connecting the remaining part of forests by afforestation and formation of a green belt would ensure flow of matter and energy within the landscape.

Afforestation should be conducted in relation to settlement centres (8 towns and 24 villages), with a view to integrating the entire greenery into a green area system, by formation of a green network (according to the 2021 General Urban Plan, formation of greenery systems), consisting of forests located around settlements, and connected by line corridors, (created from forest vegetation in the process of afforestation).

Picture no. 5: *Networking of greenery through afforestation*



Drawing: M. Cvejic 2012.

4. CONCLUSION

In accordance with the Republic of Serbia's Concept of Landscape Protection, Design and Development and planning conceptions, a strategy has been proposed for preservation and improvement of a degraded function and visual appearance of the landscape on the territory of Lazarevac Municipality.

Based on the analysis of secondary data collected in the field and other study and technical documentation, preservation and improvement of the landscape character has been proposed, with a view to restoring a landscape stability.

The impact of landscape degradation caused by mining works cannot be avoided, however, it can be reduced by application of landscape development planning, aimed at landscape preservation and improvement.

In conclusion, for the landscape in the mining areas to be protected, preserved and improved, it must comply with the principles that facilitate recovery of a degraded landscape's function and visual aspect, which would restore the landscape stability.

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Zakon o Prostornom Planu Srbije od 2010. do 2020.

SECTION IX

BIOMASS AND CARBON OF FOREST ECOSYSTEMS

CHAIRMEN – MODERATORS

Julius Oszlányi

Milorad Veselinović

International Scientific Conference
FORESTS IN THE FUTURE – SUSTAINABLE USE, RISKS AND CHALLENGES
4-5 October 2012, Institute of Forestry, Belgrade, Republic of Serbia

FOREST RESIDUE UTILIZATION IN BEECH STANDS THINNING

Milorad DANILOVIĆ[1], Boban MILOVANOVIĆ[2], Slavica KARIĆ

Abstract: *This article presents results of the research concerning application of the massive wood method in thinning operations. Research took place in management unit "Zeljin" on the territory of forest administration "Aleksandrovac", forest holding "Rasina", Krusevac. The objective was to research the possibilities of aplying the massive wood method as one of the harvesting methods by which the issue of greater forest residue utilization in mountainous conditions would be solved. The base of this method is utilization of the total volume of roundwood and its extraction with a tractor (skidder) equipped with a winch to a temporary landing without the use of towing horses.*

All operations were subjected to the preservation of residual trees, and the objective was to research the occurrence and sizes of damages that occurred by the application of this method. Damages were quantified by their size on residual trees during the extraction of roundwood.

Felled tree was cross cut into trunk segments of optimal lengths for skidding from the aspect of maximum qualitative utilization of wood mass by applying national quality standards for roundwood.

Partial cutting of thicker limb bases on trunk segments with branches was conducted in order to decrease the width of the load and damages on residual trees in the stand.

Quantity of damaged trees per winching cycle decreases by the increase of number of cycles.

Felling direction was especially important and the direction that causes the least damages on residual trees should be chosen. Besides that, the length of assortments should be in accordance with the direction of skidding and terrain inclination, considering that the number of damages on residual trees increases with the increase of assortment length and the angle between felling and skidding direction.

The use of towing horses is not necessary in these working conditions considering that it is possible to extract the total wood volume thicker than 3 cm at the thinner end with bark, and simultaneously keep the damages of residual trees to a minimum.

Key words: thinning, damages on residual trees, assortment skidding, adapted agricultural tractor, partial tree length segments

1. INTRODUCTION

Continuous reduction of fossil fuel reserves has encouraged activities in the field of renewable energy sources utilization. The share of energy from renewable sources in the total consumption of energy in Republic of Serbia is minor and accounts for around 6% of the total energy consumption. In the total energy produced from the renewable sources, biomass accounts for 63%. Biomass is biodegradable matter that originates from agriculture, forestry and related industries, as well as biodegradable part of industrial and municipal waste. Forest biomass is defined as plant material or wood material that is produced as the result of forest growth. It is produced in commercial forests, energy plantations and wood industry. During the technological

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[2] Srbijašume, Pablic enterprise

process of forest utilization, a part of wood mass is left behind which presents a potential raw material for energy production. This wood mass consists of branches, cut-offs during felling, irregularities, forks, stumps etc. Utilization depends on the tree species, stand and habitat conditions. In our conditions, stump utilization can be rational in poplar plantations, considering that it accounts for 15% of the roundwood volume (Danilovic, 2011). Quantity of the residues (branches) that are taken for the calculation from the relation between gross and net wood volumes is taken to be between 15 and 18%. However, it is not possible to utilize the whole quantity of this wood mass due to various reasons (biological, technological, economic). A part of wood mass such as thin branches with leaves should be left in the stand in order to preserve a part of nutrients in the soil. The other part of wood mass can be subjected to utilization from biological aspect, but there are technological constraints concerning its utilization. The problem is even more expressed in hilly and mountainous regions in relation to the lowland region where technological possibilities are significantly greater and consequently the unit costs are lower). Having this in mind, the rule of segment mass and other obstacles that arise during the utilization of forest residue, its share in energy production is low. The most part of the raw material which is used for energy production originates from wood industry or the cord wood as the raw material for pellet production. According to that a large quantity of raw material stays unused in the forest, and also there is still no grater activity on raising energy plantations where a significant quantity of dry matter per hectare can be acquired. Raising energy plantations is one of the most important tasks in forestry practice, especially if it is known that short rotation cycles between 2 and 5 years can produce a great quantity of raw material with simultaneous implementation of modern technological solutions.

In most countries as well as in Serbia there are issues with the utilization of forest residue from forests in hilly and mountainous conditions and especially the forest residue from commercial forests. The subject of utilization is small dimension wood material scattered on the whole surface area and on slopes. Utilization of this residue is not possible without technological solutions for forest utilization, or the technology which will keep the unit costs low and impact the placement of the raw material on the market. Having in mind the issues of forest residue utilization in Serbia and abroad, researches have been started which results should lead to solving the issues of forest residue utilization from forests in mountainous and hilly conditions.

The researches started out from analyzing the possibilities of forest residue utilization from ecological, technological and economic aspect or to recommend the technology which is the result of the comprehensive analysis.

Recent researches which have dealt with these issues could not have been implemented completely in the conditions which are mostly present in Serbia. They were related primarily on Scandinavian countries, Canada etc. However, forest management in Serbia significantly differs from the management in the countries that have been solving these issues.

Due to the mentioned reasons, these researches started out from the original methodology which would take into account specificity of forestry in Serbia and Central Europe.

First steps were to assess the efficiency of implementing standard harvesting methods, and until now, several have been described: cut-to-length (conventional) method, tree length method and its variation, partial tree length method, whole tree method and the whole tree method which includes above and underground parts of the trees. By analyzing advantages and disadvantages of the methods, a conclusion has been drawn that neither one of previously described methods is acceptable from every aspect.

Taking this into account, a new, original harvesting method has been developed which is in compliance with all aspects, and has also been confirmed by this research. The new method was based on harvesting the total volume of massive wood thicker than 3 cm in diameter with bark. Wood mass thinner than 3 cm with bark stays in the forest in order to preserve the nutrients. Method has been named “Massive wood method” since the massive wood is being divided into segments of various quality and dimensions. Impact of the new method on inflicting damages to the residual trees and regeneration was specially analyzed in various working conditions. According to the researches, damages inflicted during the first thinning and in the final cut when this method was applied were significantly smaller in comparison to the damages inflicted by the implementation of the CTL method which is the most common in Serbia (Danilovic et al 2011).

Partial tree length method is unacceptable since it is not possible to utilize the branches which take up a significant part of the total wood volume when this method is used. The same case is with the tree length method, where the damages are significantly greater than when its variant, the partial tree length method, is used. The whole tree method is unacceptable from ecological and technological aspects since the whole wood mass is being taken out form the forest and great damages are being developed on the residual trees and regeneration.

Skidding of the assortments is the most sensitive phase in forest utilization primarily because of the damages that can develop on trees, soil and other vegetation.

Damages on the trees are a suitable area for the development of various pathogens which eventually lead to rotting.

Many authors have been researching the damages on residual trees in various working conditions (Limbeck-Lilienau 2003, Porsinsky and Ožura 2006, Solgi and Najafi 2007, Košir, 2008, Tsorias and Liamas 2010).

The share of damages following the skidding of the assortments is highest on the roots and equals 41% from the total number of damages. The highest number of damages occurs in the zone up to 2 m from the trail (Solgi, Najafi 2007). Authors point out that it is necessary to remove thicker branches and forks prior to skidding when the skidding is conducted in mixed stands.

Specificity of the proposed method is that the complete wood mass with branches, forks etc is transported. By doing this, the quantity of the raw material that is realistically possible to utilize from the forest and place on the market is significantly greater.

Objective of the research is to determine the quantities of forest residue in beech stands following the thinning and by implementing the massive wood method. Besides that, the objective is to assess the efficiency of implementing the massive wood method from the aspect of inflicting damages to the residual trees on one side and technical and economic applicability on the other.

Basic working hypothesis is that the damages caused by the implementation of the massive wood method are not greater than the damages that occurred by the implementation of the CTL method which is taken as the most acceptable from ecological aspect.

2. MATERIAL AND METHOD

Research was done in hilly and mountainous region of Serbia, on Zeljin. MU “Zeljin” is located within FA “Aleksandrovac” FH “Rasina” Krusevac.

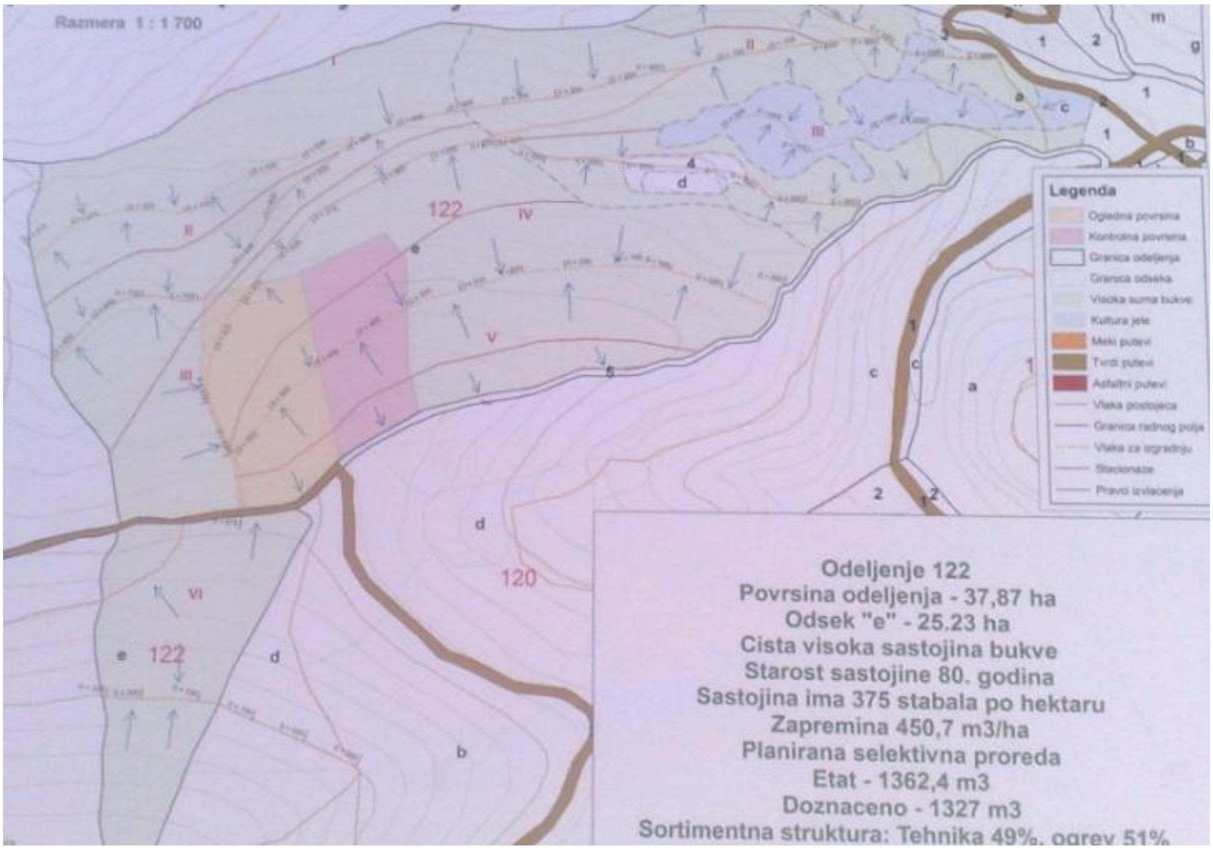

Figure 1. *Location of the experimental areas*

Experimental area is located in the beech stand which takes up 78.9% of the management unit. It is a clean, high beech stand, 80 years old. The stand has 375 trees per hectare and the standing volume of 450.7 $m^3 \cdot ha^{-1}$. A selective thinning was planned for the stand with an intensity of 12% of the volume and 59% of the increment.

A total of 955 trees have been assigned or 1327 m^3.

On EA1 harvesting was done by applying the massive wood method and on EA2 by using the CTL method (control area).


Figure 2. *Experimental area*

Harvesting was conducted by chainsaws in organizational form 1 chainsaw operator and 1 worker. A great attention was paid on the direction of felling because it impacts the occurrence of damages. General direction of felling was conditioned by the requirements of the first phase of transport (skidding), and individual direction was in the function of worker's safety and the least damages of the residual damages (Figure 3).

Figure 3. *General felling direction*

Figure 4. *Depth of the partial cutting of thicker branches*

Felled trees have been divided by previous bucking into segments whose dimensions enable the formation of an optimal load on one side with taking into account implementation of quality standards for roundwood. Subject to utilization was wood mass thicker than 3 cm with bark. Branches thinner than 3 cm with bark were left in the stand in order to conserve the soil potential.

According to the recent researches, most of the nutrients are found in this part of the tree, in the leaves and thin branches.

The essence of the massive wood method is in the following. Chainsaw operator conducts the delimbing of the branches thinner than 3 cm with bark (Figure 2). Following the completion of the previous task, the chainsaw operator conducts partial cutting of the branches at the limb base, on places where branches ramify from the stem and where the thinner branches ramify from the thicker branches (Figure 4). Partial cutting presents the essence of the massive wood method, considering that it significantly affects the decrease of occurrence of damages on the remaining trees in the stand and which is the main disadvantage of the tree length method.

Depth of the partial cutting depends on various factors: thickness of the branch, angle of insertion, length of the branch, weight of the segment etc. With the increase of the branch diameter, the depth of the partial cut also increases and it is between ½ and 2/3 of the branch diameter. For thinner branches and the branches that ramify from the stem as well as the branches that ramify outside the stem zone, the partial cutting is shallower and is up to ½ of the branch diameter. Besides that, depth of the partial cut depends on the angle of the cut and the stem axis. The angle of the cut in relation to the stem axis impacts the occurrence of friction during the transport of the segments. The angle of insertion and the length of the branch will determine if the partial cutting will be done from the inside or the outside of the branch in relation to the stem. Besides the partial cutting with a single cut, in certain situations it can be done with 2 cuts and formation of the undercut. Partial cutting significantly decreases the stiffness of the branches and increases the elasticity of the connection between the branches and the stem and branches between each other. The effects of partial cutting are manifested during the skidding of the assortments when the segment of the stem, which has been cut out from the crown, shrinks in width and by that forms the load that takes up less space when skidded.

Besides that, in places where the contact between the standing trees and the partially cut branches occur, the friction coefficient is significantly lower.

Imposed condition for the implementation of the massive wood method is that the load contains no more than one segment that has been cut out from the crown. This is especially important when the technological process is conducted in stands where there is a larger number of trees per a unit of area, as well as in cases of final cuts. Transport of the assortments on EA 1 is conducted by skidder equipped with a double drum winch on previously designed skid road network. For the implementation of this method it is necessary to choose a suitable forwarder or tractor by their characteristics. Power of tractors that are used for pulling massive wood segments should be higher in order to make the formation of optimal loads possible especially on sloped terrain where higher pulling power is necessary as well the use of double-drum winch. Formation of optimal load is conducted from several stopping points in order to cause fewer damages to the residual stand.

After the skidding of massive wood segments, there is no wood material left in the stand that can be subjected to utilization, in comparison to the tree length method where it is necessary to transport cord wood that is located in the proximity of the stump and beside that, a part of wood material is left in the stand that could be used for energy production. Massive wood segments are skidded to a temporary landing that is located beside a truck road. Dimensions of the temporary landing should be in compliance with terrain characteristics considering that the final processing of assortments and the chipping of the residue with mobile or stationary chippers is conducted on it. Power and the capacity of the chipper should be attuned with the structure and the quantity of the wood mass that is to be chipped. Partial cutting also directly impacts the size of the landing having that the segments with partial cut branches are stacked which is even more expressed with consequent moving by tractor front draw bar. It is important to group the technical round wood and the wood mass for chipping on the landing (Figure 5).

Figure 5. *Temporary landing (forest residue)*

Figure 6. *Temporary landing (technical roundwood)*

Number of trees that were needed for the analysis was determined per diameter degree. Position of those trees as well as their felling direction in relation to the trail and the slope was also recorded (Figure 3). Recording was conducted by GPS FC 200 unit and the total station.

Total volume of massive wood segments was calculated up to 2 decimals, beside the stem, branch volume was also calculated.

Damages on residual trees during skidding were measured and presented by the number and area of the damages per a transport cycle. Number of damaged young plants was also recorded. Dimensions of the damages were measured crosswise and also, the height on which the damage occurred on the tree.

Number of occurred damages is also in relation with the number of segments in the load and its volume. Damages on residual trees and plants were marked by spray paint.

Location of the processed segment in relation to the trail and the slope of the terrain was also evidenced in this research.

Data was processed in statistical software Statgraphics Plus. Standard statistical and mathematical methods were used in the process (descriptive statistics, correlation analysis, regression analysis).

3. RESULTS AND DISCUSSION

3.1. Cutting and processing of the assortments

Cutting was done in organizational form 1 chainsaw operator + 1 worker. A total of 106 trees were cut and processed. Mean diameter of felled trees on experimental area EA1 was 35.4 cm. Wood volume by certain categories per diameter degrees in total volume is presented in table 1. According to the SRPS standards, massive wood is all wood mass thicker than 7 cm with bark but in this research it was taken as all wood mass thicker than 3 cm with bark. It is a fact that for some wood species there are volume tables for wood mass thicker than 3 cm with bark.

Table 1. *Wood volume by categories on experimental area*

Number of trees	Diameter digrees (cm)	Roundwood volume (m^3)	Volume of firewood thicker than 7 cm (m^3)	Volume of firewood from 3 to 7 cm (m^3)	Total volume (m^3)
8	17.5	-	1.594	0.133	1.727
24	22.5	-	9.442	0.561	10.003
13	27.5	2.043	6.219	0.491	8.753
17	32.5	9.969	8.409	0.764	19.142
11	37.5	8.722	7.400	0.715	16.837
7	42.5	9.529	4.323	0.418	14.270
10	47.5	19.947	6.769	0.697	27.413
6	52.5	13.386	5.69	0.493	19.569
6	57.5	15.827	6,893	0.654	23.374
1	62.5	3.876	1.143	0.039	5.058
1	67.5	4.646	2.416	0.175	7.237
1	72.5	4.752	2.362	0.041	7.155
1	77.5	7.008	1.587	0.038	8.633
106	-	**99.71**	**64.25**	**5.22**	**169.17**

Figure 7 presents the share of certain categories of wood in the total volume. The share of technical roundwood is around 60% from which it can be concluded that it is a medium quality stand. Firewood thicker than 7 cm with bark takes up 38%. Firewood was processed on the temporary landing and stacked into piles due to the lack of chipper considering that it is the beginning of the research. This quantity of wood contains the total wood mass that would have been left in the stand if the CTL method was used. This wood mass is: wood irregularities, forks, limb bases etc. Quantity of this wood mass in the total volume of massive wood is significant and takes up significantly greater share than the branch wood mass from 3 to 7 cm. According to this research and on this experimental area, the share of branch wood from 3 to 7 cm equals .,1% (Figure 7)

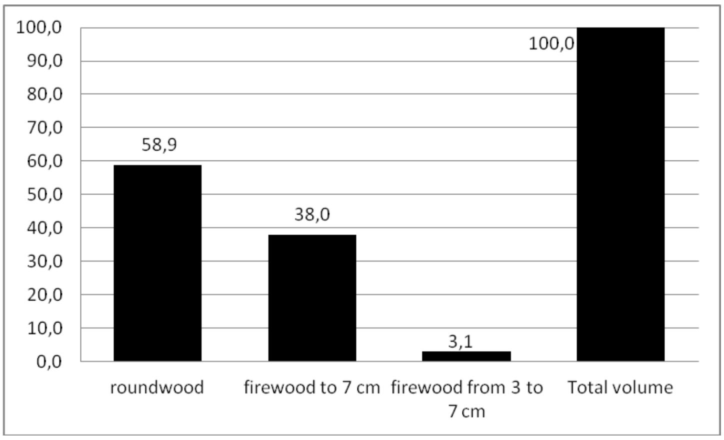

Figure 7. *Volumetric share of wood in the total volume of massive wood on experimental area*

With the increase of diameter at breast height, the volume of certain categories also increases (Figure 8). If the total volume of massive wood is observed it can be concluded that there is a very strong correlative relation and that 97.7% of variations is explained by the impact of diameter at breast height of the tree. The function that represents the nature of the relation between the variables the best is $V = (-0{,}289 + 0{,}04 \cdot x)^2$. Also, with the increase of the diameter, the volume of cord wood also increases but the branch wood between 3 and 7 cm significantly lesser.

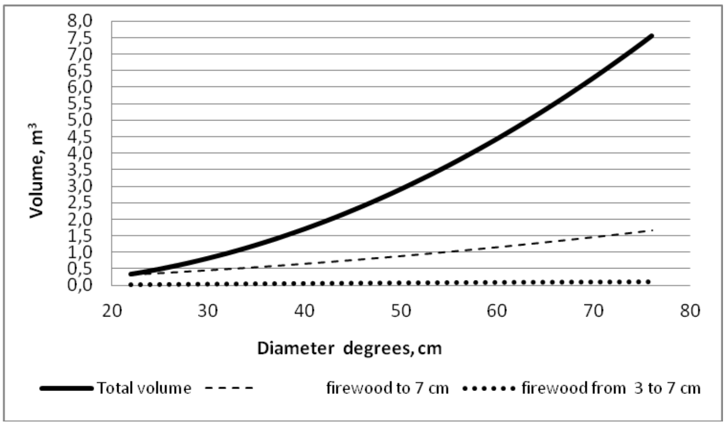

Figure 8. *Relation between the diameter of the tree and the volume of certain categories of wood*

A total of 77 trees were felled on the control area EA2. Technical roundwood and classical cordwood processing was done at the stump. Forest residue was left in the stand as it is left in the most part of Serbian forestry. Mean diameter of felled trees on the control area was 35.4 cm.

Volume of wood mass of certain categories of wood per diameter degrees in the total volume of massive wood thicker than 3 cm with bark is presented in table 2.

Table 2. *Volume of wood of different categories on the control area*

Number of trees	Diameter digrees (cm)	Roundwood volume (m^3)	Volume of firewood (m^3)	Total volume (m^3)
7	17.5	-	1.035	1.035
12	22.5	-	3.588	3.588
11	27.5	1.846	4.071	5.917
11	32.5	4.678	5.313	9.991

Number of trees	Diameter digrees (cm)	Roundwood volume (m^3)	Volume of firewood (m^3)	Total volume (m^3)
4	37.5	4.127	1.242	5.369
9	42.5	11.284	3.105	14.389
5	47.5	8.446	3.174	11.620
6	52.5	16.120	4.140	20.260
8	57.5	19.027	7.659	26.686
2	62.5	7.074	1.380	8.454
1	67.5	3.914	0.276	4.190
1	77.5	4.824	0.552	5.376
77	**-**	**81.340**	**35.535**	**116.875**

Figure 9 presents the share of certain categories of wood in the total volume of massive wood on the control area. The share of technical roundwood is around 69.6%. The quantity of firewood thicker than 7 cm with bark equals around 30.4% (Figure 9). This wood mass does not contain the wood defects, forks, limb bases etc.

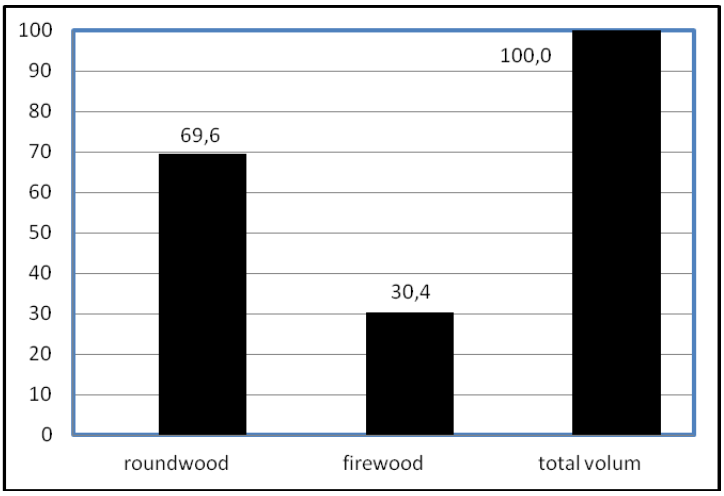

Figure 9. *Volumetric share of wood in the total volume of massive wood on the control area*

Figure 10 presents the relation between the diameter of the tree and the total quantity of wood processed by two different methods.

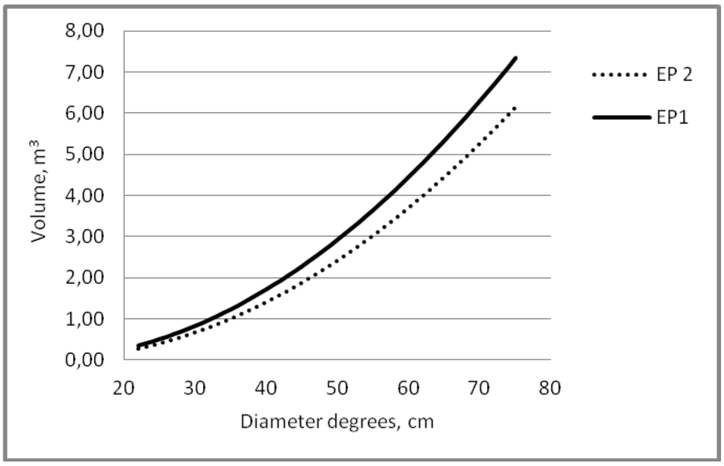

Figure 10. *Relation between the diameter of the tree and the total volume of wood processed by two different methods*

It can be seen on figure 10 that there is a difference between the quantities of wood volume that has been processed on experimental areas. The difference is the outcome of the application of two different methods.

It can be concluded that the quantity of wood, which has been acquired on the temporary landing by applying the massive wood method (Danilovic et. al. 2011), is significantly larger than the quantity acquired when the CTL method is applied.

3.2. First phase of transport

The first phase of transport was conducted by skidders equipped with a double-drum winch. Average of 5.17 segmets per tree were processed. Processed assortments were winched to the trail, and then skidded on the trail. Transport cycle was formed from several stopping points. Average number of segments per winching was 2.4. Average number of winching cycles per tree was 2.14. An imposed condition for winching was to pull no more than one segment from the crown per winching cycle and which was also provisioned by the massive wood method. Maximal number of segments per winching cycle was 9 and minimal was 1. Maximal length of the assortments which were skidded to the landing observed per winching cycle was 12 m and the minimal was 2,2 m. Average volume of the load per winching cycle was 0.75 m^3, varying from 2.72 m^3 down to 0.03 m^3. Average volume of massive wood per tree was 1.66 m^3, varying from 8.62 m^3 down to 0.12 m^3. On average, 0.76 damages occurred per winching cycle and are manifested as damaged bark (peeled off), damaged root and damaged regeneration. On average, 0.28 bark damages, 0.15 root damages and 0.33 regenration damages occurred per winching cycle. Average area of the damaged bark per winching cycle was 32.1 cm^2, with a maximum of 1836 cm^2. Average area of damaged roots per winching cycle was 29.4 cm^2, with a maximum of 2040 cm^2. Average area of damages on residual trees is 237 cm^2. According to Meng (1978) it is the cathegory IV of the damages. The greatest risk of rotting have trees with damages in the root collar zone. Damages on surface roots and above the root collar rarely get infected (Meng, 1978).

Number of damages that occur is relatively low, only 0.28 bark damages occur, which presents the significance of the applied method for the forestry practice, especially from the ecological aspct. If compared with the damages that are the result of the project "Techniques and technologies of forest residue utilization in hilly and mountainous region of Serbia", the differences are not significant. Differences that occur are the outcome of the stand and habitat conditions, as the impact of these factors could not have been isolated during the experiment and harvesting operations. If a tree is observed, 1.62 damages on average occur on residual trees and regeneration per felled tree. From the total number of felled trees, 33% caused damages on residual trees but if added the trees that have caused damages during skidding then the percentage of trees that have caused damages equals 54.2%.

Analysis of the damages that occur in the first phase of transport was conducted also on the control area. Average volume of the load per winching cycle was 0.99 m^3, and average number of segments winched was 2.29 per cycle. Maximal length of transported assortments was 6 m, and average was 4.03 m. An average of 0.66 damages occurred per winching cycle, and 0.65 damages per tree. From the total number of damages, around 65% accounts for the damages of the regeneration. Difference in the number of damages is not big and is around 15% lower when compare to the massive wood method. Average size of the damages is 72 cm^2, which is the cathegory III according to Meng (1978). However, the number of damages is generally low, and as such does not present a problem from ecological aspect. If analyzed from economic aspect, application of the massive wood method has a great advantage.

From the total number of felled trees, 56% caused damages on residual trees.

4. CONCLUSION

- Working effects of harvesting by the massive wood method in researched conditions are greater than the working effects when the CTL method is applied.
- Depth of the partial cut depends on the diameter of the branch, angle of insertion, length of the branch, segment mass etc. With the increase of the branch diameter, the depth of the partial cut also increases and is between ½ and 2/3 of the branch diameter. For thinner branches and the branches that ramify directly from the stem as well as the branches that ramify away from other branches, the partial cut is shallower and is up to ½ of the branch diameter.
- Depth of the partial cut also depends on the angle between the cut and the stem axis, or in other words, direction of the cut in relation to the stem axis impacts the resistance that occurs during the transport.
- Quantity of wood that is acquired on the temporary landing when applying the massive wood method is greater than the quantity acquired by the CTL method.
- The use of towing horses for cordwood extraction is not needed in these conditions considering that the complete wood mass thicker than 3 cm with bark is transported by skidders and tractors and that the damages are reduced to a minimum.
- Efficiency of the massive wood method depends on the accessibility of the area by roads. With the increase of the road network density, damages on the regeneration and residual trees decrease.
- Working effects of the massive wood method are also impacted by the size of the landing considering that the final processing of the assortments (technical roundwood and cordwood) and chipping is done on the landing.
- Power and the capacity of the chipper should be in compliance with the structure and the quantity of the wood mass that is subjected to chipping.
- However, number of damages during harvesting is generally low and as such does not present a problem from ecological aspect.
- Aplication of the massive wood method is more favorable from economic aspect than the CTL method.

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PRIMARY PRODUCTION OF CALORIFIC VALUE OF POPLAR CLONES IN SLOVAKIA

Rudolf PETRÁŠ[1]*, Július OSZLÁNYI[2], Gabriela JAMNICKÁ[3], Julian MECKO[1]

Abstract: *Poplar clones are characterized by very fast growth rate, a high volume of wood production and a short rotation period compared to other wood species. The greatest portion of their area is the crop land, where the forests are man-made with the poplar clones representing the stand-forming tree species. The study presents results of the calorific values on biomass of Robusta and I214 (Populus x euramericana) clones in Slovak territory. The average calorific value of all biomass fractions (wood, bark, small-wood with bark) is approximately in the range of 17.8-18.4 MJ kg^{-1} or 6.86-8.73 GJ m^{-3}. Standard deviations were in the range of only 2.4-2.8%. The calorific value production of whole stands was calculated from their volume production according to yield tables [m^{3} ha^{-1}]. The mean annual production of calorific value for site indexes 40-20 culminated at the age of 17-26 years with values of 320-80 GJ ha^{-1}. The culmination for the I-214 clone occurred 2-3 years earlier than for the Robusta clone. This age is optimal for total stands felling. Robusta and I-214 poplar clones have not only fast growth, large biomass and calorific value production, but also have the high energy use efficiency in comparison to other wood species. Most of the poplar stands accumulated more than 1% heat, which originated in the solar energy.*

Keywords: biomass, calorific values, energy use efficiency, poplar clones

INTRODUCTION

Global environmental problems of 21-st century have triggered the major interest in bioenergy and biofuel crop development. On the present is appeared that in Slovakia (and also in Europe) is abundance of agricultural land, which may be replaced by means of fast-growing tree species planting in lowlands nearby the water courses. Various poplar clones, both imported ones and also those of local origin have different qualities including growth-rate and utilisation which offer possibilities for the production of bioenergy. A most important preference for I-214 and Robusta poplar clones (*Populus* x *euramericana)* is the rapid production of quality biomass.

Petráš and Mecko (2001, 2005) published the yield tables, which simulate biomass production dependent on stand age and site index for poplar stands. I-214 clone within 10 to 15 years with a stand diameter for the best site indices was reported in the range of 40-50 cm and annual increment in above-ground biomass of 55-65 m^{3} ha^{-1}. Many studies have reported that bark has lower density than wood; moreover wood density differs not only according to wood species but also to location on the tree (Husch et al., 2003; Petráš et al., 2010). The density of the bark of Robusta and I-214 poplar clones were found at about 370-415 kg m^{-3}; for wood of Robusta at about 400-450 kg m^{-3} and for I-214 only 350-400 kg m^{-3}; for branches from the

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crowns at about 470-450 kg m^{-3}. Kord and Samdaliri (2011) found wood density at about 306-367 kg m^{-3} for *Populus* x *deltoids* clones.

The main purpose of this research was to determine the calorific value of the basic biomass components (wood, bark and branches) of Robusta and I-214 clones. Moreover, this study brings valuable findings for estimation of “energy use efficiency” as the capability of wood species to utilize global solar radiation.

MATERIAL AND METHODS

From the entire set of 41 trees for density measurements, a total of 11 trees were selected for calorific value of above-ground biomass determination. The trees grew in forest stands in a temperate climatic zone with an average annual temperature of 9.0-10.0 °C and a vegetation period of 180 days. The poplar stands are located in lowlands of Western (nearby the rivers Dunaj and Váh), Central (nearby the river Hron) and Eastern Slovakia (the Bodrog tributaries). 88 tree sample cuttings consisted of 33 for wood (W), 33 for bark (B) and 22 for small-wood with bark (SW- branches of tree crowns with diameter < 7 cm). Moreover, bark and wood samples were taken from 3 different locations (1, 2, 3) on the stem of each tree: the base (B1, W1), the middle (B2, W2) and the top (B3, W3).

All samples were dried at 105°C and evaluated at a precise oven-dried weight of 0.01 g and subsequently they were milled with a cutting mill. The calorific values of dry matter (CVDM) in [J g^{-1}] were evaluated by calorimeter C-200 according to the Slovak technical standard – STN ISO 1928 44 1352, with 4 repeats for each homogenized sample.

The calorific value production (CVP) in above-ground biomass of I-214 and Robusta clones was recalculated from its volume production (VP) using the models of yield tables (simulating the biomass dependent on age and site index), the biomass density values (D) and the CVDM values:

$$\text{CVP [GJ ha}^{-1}] = \text{VP [m}^3 \text{ ha}^{-1}] * \text{D [kg m}^{-3}] * \text{CVDM [J g}^{-1}] * 10^{-6}$$

The calorific value production CVP [GJ ha^{-1}] of poplar clone whole stands dependent on age (t) and site index (q) was determined.

The energy use efficiency (EUE) was derived as the ratio of accumulated energy in the above-ground trees biomass combined with the solar energy (Larcher, 2003; Pretzsch, 2009). Only the period between May and September of global radiation (the percentage distribution) was considered for poplar clones:

Month	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*
%	13.9	14.8	14.7	12.8	8.6

The results were subjected to a generalized analysis of variance (ANOVA) by means of QC. Expert computer programme. The 3 factors of clone, biomass fraction and the location on the tree were used for the analysis. The additional 4 components of site index, age of stand, diameter breast height (DBH) and tree height were continuous numerical variables.

When ANOVA revealed significant differences ($P<0.05$), mean values were compared using post-hoc Tukey HSD test.

RESULTS AND DISCUSSION

The average density and calorific values and their standard deviations were recorded for individual clones (Tab. 1). The ANOVA confirmed the influence of 6 predictors consisted of the

2 factors (biomass fraction and location on the tree) and 4 variables (site index, age, height and diameter of tree) on the calorific values. The statistically significant influence with a p-value less than p=0.05 was established for all predictors. There was not significant influence recorded for clone (Tab. 2).

The highest average calorific value of 18.43 MJ kg^{-1} was recorded for wood and small-wood with bark, while the bark had an average of 17.89 MJ kg^{-1} (Fig.1). The highest calorific value content in wood and small-wood most likely corresponds with a higher abundance of plant substances such as lignin, lipids and terpenes in this biomass fraction (Larcher et al., 2003).

The significant differences in calorific values of the fractions relevant to their location on the tree were confirmed among these 3 sets: i) all of the wood fractions (W1-3) and the small-wood fraction (SW), ii) the bark in the middle and the top of the stem (B2-3), iii) the bark at the stem base (B1) (Fig.2).

Although I-214 clone had higher calorific value production than Robusta clone during the first half of its lifetime, the Robusta clone produces 0.5 GJ m^{-3} more in middle and higher age and site indexes 40-20. The Robusta clone produces approximately 7.8-8.0 GJ m^{-3} in middle and higher age and site indexes 40-20 and I-214 clone just 0.5 GJ m^{-3} less. At lower site indexes, both clones have higher values of calorific value per 1 m^3 of biomass. The average annual production of calorific value for site indexes 40-20 culminated at about 17-26 years with values of 320-80 GJ ha^{-1}, with the I-214 clone culminating 2-3 years earlier than Robusta (Fig. 3). Average annual production of calorific value both before and after this age is lower. It is therefore advisable to cut down these poplar stands at the culmination age of average production.

The poplar clones stands at the highest site indexes at 8-9 years of age achieve the highest global radiation use of approximately1.6% (Fig. 4). These values markedly decrease with lower site index and higher age, and they reach only 0.2-0.6% by 35 years of age.

Although the average calorific values derived for I- 214 and Robusta clones are lower compared to values recorded for beech or spruce (Ellenberg et al., 1986; Klašnja and Kopitovič, 1999; Oszlanyi, 1986), the above-ground biomass production of poplar stands during the certain time period is bigger than non-fast-growing species. Moreover, the energy use efficiency of I-214 and Robusta clones are higher that the values (less than 1%) reported for most wood species (Larcher, 2003; Pretzsch, 2009).

CONCLUSION

Acknowledgements
This study was financially supported by the Slovak Research and Development Agency, Project No. APVV-0131-07. Poplar clones growth and production in comparison to other economically important tree species are 5-10 times greater and faster. Thanks to the very fast growth and production of high-quality biomass, poplar clones can be utilized as an effective energy source. The results of the study can be valuable especially for industrial utilization of the above-ground biomass, where the wood from the stems and small-wood fractions have the highest energy potential.

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Table 1 *Density and calorific values of above-ground biomass of poplar clones. Values are averages with their standard deviations.*

Clone	Bark	Wood	Small-Wood
	Density [kg m^{-3}]		
I-214	385.25 (33.79)	392.96 (58.49)	456.72 (22.49)
Robusta	389.39 (29.99)	427.47 (37.45)	468.98 (39.36)
	Calorific value [MJ kg^{-1}]		
I-214	17.80 (0.55)	18.49 (0.47)	18.31 (0.55)
Robusta	17.97 (0.55)	18.35 (0.47)	18.59 (0.55)
	Calorific value [GJ m^{-3}]		
I-214	6.86 (0.61)	7.27 (1.10)	8.36 (0.51)
Robusta	7.01 (0.65)	7.85 (0.76)	8.73 (0.93)

Table 2 *The analysis of variance of the predictors (factors and variables) affecting the calorific value of poplar clones.*

Predictors (factors and variables)	Parameter	Sum of Squares	F-statistic	p-value
Biomass fraction	-	24978675	58.21	1.59E-22
Location on the tree	-	11908232	11.74	5.87E-09
Clone	-	589479	2.07	0.150
Site index	-40.384266	14527328	59.75	1.17E-13
Age	0.445169	2575075	9.29	0.002
Diameter breast height	-19.729115	8850344	34.13	1.19E-8
Height	24.181520	1897568	6.80	0.010

Fig. 1 *Average calorific values with their standard deviations for individual biomass fractions of I-214 and Robusta poplar clones.*

Different letters indicate statistical significant differences at p< 0.05 (ANOVA, Tukey-test)

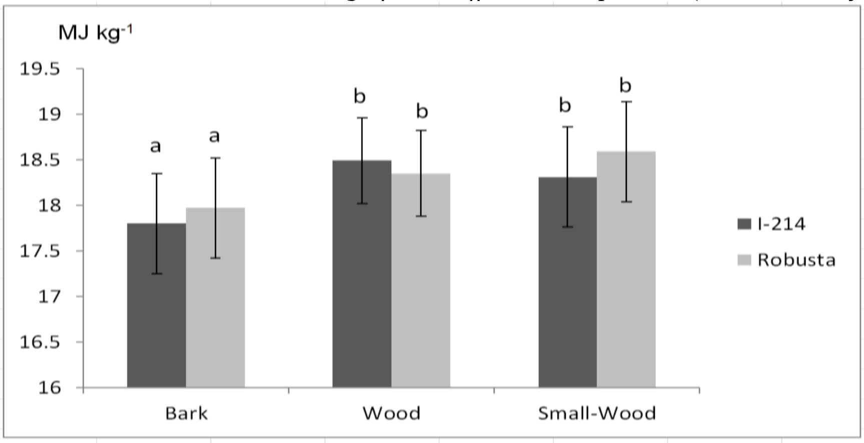


Fig. 2 *Average calorific values and their standard deviations of the fractions relevant to their location on the tree in both poplar clones.*

Different letters indicate statistical significant differences at p < 0.05 (ANOVA, Tukey-test)

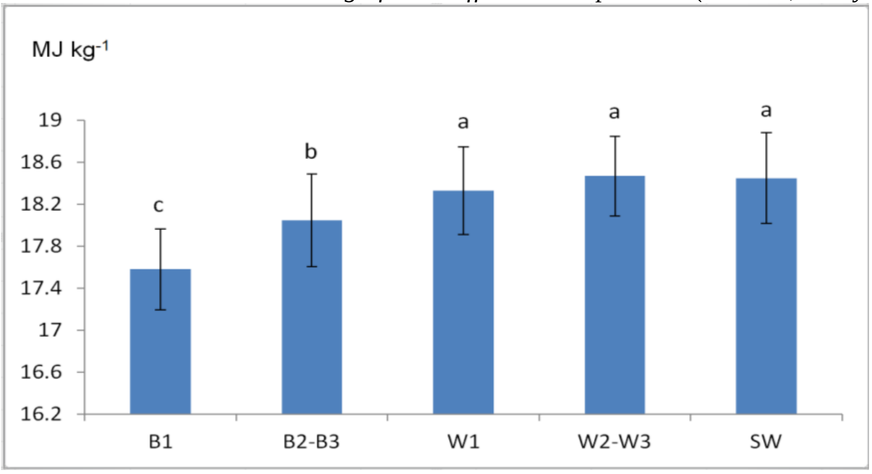
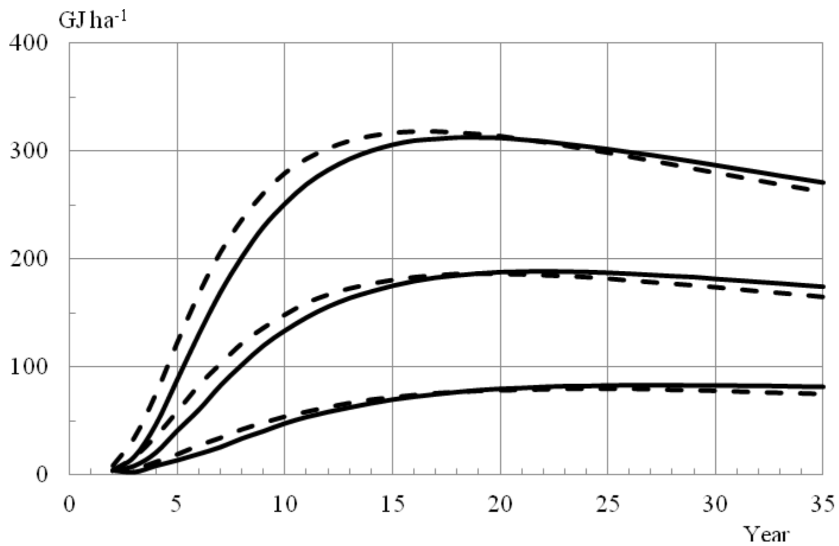


Fig.3 *Average annual calorific value production in the tree biomass of Robusta poplar clones (solid line) and I-214 (dotted line) dependent on stand age and the site index from the lowest line, denoting 20, 30 and 40*



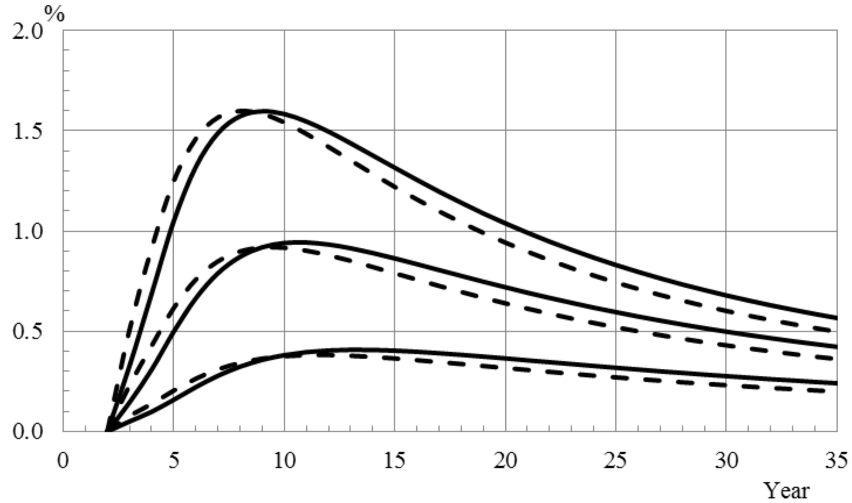


Fig. 4 *The energy use efficiency in the production of calorific value in tree biomass of poplar clones of Robusta (solid line) and I-214 (dotted line) dependent on stand age and the site index from the lowest line, denoting 20, 30 and 40.*

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APPLICATION OF CARBON CYCLE MODELING IN SUSTAINABLE MANAGEMENT OF FOREST ECOSYSTEMS

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Abstract: *Research on carbon cycle in forest ecosystems are becoming more frequent, specially related to the connection with climate change. However, this is not the case in Serbia, where there is little available data on carbon stored in forest ecosystems and its dynamics. An important tool in studying this phenomenon is environmental modeling through which we can simulate forest ecosystems and forest carbon cycle for longer periods of time. In this paper for modeling the forest carbon cycle we used CO2FIX program for management unit Semegnjevska gora. Two cases were modeled and they simulate different ways of management and realization of the CDM A/R project. Results of the first case show that different management of forest ecosystems leads to differences in amount of stored carbon, with a difference of 109,73 MgC ha^{-1} between two scenarios. Simulated afforestation in the secon case obviously leads to more carbon storage then if there was no forest, but the amount of carbon credits that could be obtained depends on the beginning of the crediting period.*

Key words: modeling, CO2FIX, carbon cycle, forest ecosystems

1. INTRODUCTION

Terrestrial part of the biosphere has an important role in the global carbon cycle, and due to the actual issues related to climate change there is an increased interest in that process, specially related to sequestration of carbon in the biosphere. During the last decade of the past century the average carbon sequestration in the biosphere was estimated at 2,3 billion tons per year, which is 36% of the total carbon emission coming from combustion of fossil fuels (Chapin et al., 2002). Forest ecosystems play an important role in the global carbon cycle since they have a large potential for carbon sequestration within forest biomass and forest soils. However they can also represent a source of carbon due to natural processes such as ageing, seasonal variations in carbon dynamics, and anthropogenic impacts related to forest management or forest degradation.

Available data on forest carbon in the forest ecosystems of Republic of Serbia are based on National forest inventory which estimates that the total amount of carbon within them is 120.237.350 t, which is 53,38 t of stored carobn per one hecatre of forest, or 0,33 t per one cubic meter of woody biomass (2009). This data gives us just an overall estimation, but more specific questions such as the specific amount of carbon within different forest ecosystems with different tree species, different age structure, different degree of degradation and/or different management

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practice, are not well known. It is also not known very well how much carbon is stored within forest litter.

In order to contribute more data on these topics this paper will analyze the carbon sequestration within the Republic of Serbia and the impact of present forest management practice on this process. To analyze this process we used modeling techniques since they provide a good way to follow the carbon dynamics within a forest ecosystem over longer periods of time. Application of modeling within areas of forestry and environmental science and protection, although a relatively new concept is already an established method in scientific community, but not yet sufficiently applied within national scientific circles.

2. MATERIALS AND METHODS

In general modeling of forest ecosystems and carbon cycle within them has to encompass all relevant factors and processes such as environmental conditions, photosynthesis, autotrophic and heterotrophic respiration, carbon allocation and differences associated with different tree species. Different models use different approaches for representing these parameters. For our analysis of forest carbon cycle we used the CO2FIX model (Schelhaas et al., 2004, Masera et al., 2003) developed within the CASFOR I and CASFOR II ("*Carbon sequestration in afforestation and sustainable forest management*") projects. This model can be used for temporal analysis of forest carbon cycle and also for carbon calculation related to projects aimed at climate change mitigation within forestry sector, such as CDM A/R – *Clean Development Mechanism Afforestation and Reforestation* or REDD – *Reducing Emissions from Deforestation and Forest Degradation* projects.

The latest version of this program CO2FIX 3.2 conducts simulations at ecosystem level in order to quantify carbon reserves and fluxes in forests by calculating the change in all relevant spheres and stocks. The model is divided in 6 modules, 4 of them are designed to follow the flow of carbon to and from forest ecosystems and include: Biomass module, Litter module, Forest products module and Bioenergy module. The remaining 2 modules are for additional options related to carbon credit calculation (Carbon credits calculation module) and finance (Financial module).

Stocks and flows of carbon within the living forest biomass (both above and below ground) are estimated by separation on specific cohorts (Reed, 1980). Cohort consists of trees of same or similar species and age which have similar characteristics so they can be treated as a same entity for the process of modeling. Carbon stored in a forest ecosystem can then be calculated as the sum of carbon stored within the biomass of each cohort. Changes in biomass that influence the carbon content during one time step (one year) are balance of the original biomass from previous time step, increases due to biomass growth and reductions due to turnover of branches, foliage and roots, tree mortality related to senescence, harvest and logging associated mortality.

CO2FIX model differentiates four types of tree biomass which include stem, foliage, branches and roots. Biomass growth is simulated from growth rate of stem volume (gross annual increment) which can be obtained from yield tables for different tree species. Based on the growth rate of tree volume and allocation coefficients other biomass compartments growth (branches, foliage and roots) is then calculated (Nabuurs and Mohren, 1995).

Tree mortality due to senescence can be modeled in two ways in CO2FIX, as a function of tree age or as a function of relative biomass (current biomass related to the maximal biomass). Besides tree mortality, in order to precisely asses the carbon cycle dynamics it is important to model the annual turnover of foliage, branches and roots. Turnover of biomass from these compartments influences the carbon content in forest litter and soil. Biomass turnover is calculated by multiplying the current biomass content in one compartment and turnover constant which has values between 0 and 1 depending on the particular compartment and tree species (Schelhaas et al., 2004).

If the modeled forest ecosystem is managed it is very likely that tree biomass will be removed from it through some form of thinning and logging. Biomass harvested in this way is always subtracted from the total biomass and is them analyzed within Forest products module and Litter module depending on its type and usage. Forest logging can lead to higher tree mortality of remaining trees due to damages that they suffer during the logging process (Pinard, 1997). The extent of this effect depends on the tree species, type of logging and type of used equipment.

Modeling of litter and soil carbon in CO2FIX is based on Yasso model (Liski et al., 2005.), which consists of 3 sub-modules for litter and 5 sub-modules for decomposition. Litter is divided in non-woody litter (foliage and fine roots), fine woody litter (branches and coarse roots) and coarse woody litter (stems and stumps). Each of these sub-modules has a specific rate of decay which determines the amount of degradation during one time step. During the decomposition process carbon within biomass in these sub-models is partially lost form the system, mostly as CO_2 to the atmosphere, and also transferred to decomposition sub-modules which include extractives, cellulose, lignin compound, humus 1 and humus 2 sub-modules. Modeling of biomass decomposition within forest litter is influenced by temperature and humidity, which is why it is important to have relevant meteorological data.

Calculation of carbon credits is based on CDM A/R methodology introduced at the CoP9 in 2003 which establishes two types of certified emissions reductions (CER), these are temporary tCER and long-term lCER (2003). One CER is equal to 1 ton of CO_2 equivalent. Difference between tCER and lCER is in their duration. tCER lasts till the end of the following commitment period, while a lCER will last till the end of the whole CDM project for which it has been issued.

Modules for forest products, finance and bioenergy were not used in our analysis since sufficient data necessary for their input parameters could not be obtained.

2.1. Modeling the carbon cycle within the management unit Segmenjevska gora

Forest carbon cycle dynamics modeling based on CO2FIX model was used in our research for case study in forest management unit Semegnjevska gora. Current, and sixth in row, management basis for this management unit was made for the period between 1.01.2011. to 31.12.2020. Most data about characteristics of this location and forest ecosystem on it which were used as input data for the CO2FIX were obtained from this document (2010). Dominant species in this management unit is European Black Pine (*Pinus nigra*). Cohorts in our model are, according to this, only composed of this species. Other necessary input data are primarily related to biomass characteristics and include yield based on yield tables, wood density, allocation coefficients, turnover rate for foliage, branches and roots, initial carbon content and carbon content in dry matter for stems, foliage, branches and roots was obtained from literature (Cannell, 1982, Matthews, 1993, Nadelhoffer and Raich, 1992, Simeunović, 1957, 2009). Some of this data are shown in tables 1 and 2.

Data on carbon content of the soil, which is also necessary as a model input, was not available. Because of that we used and option in CO2FIX to calculate it based on climate characteristics and present forest biomass.

For management unit Semegnjevska gora we analyzed two cases with CO2FIX. Case I – *management practice* shows differences in carbon dynamics related to alternative management of forest, and Case II – *CDM A/R project* – simulates the realization of this type of project at this location and calculates the possible amount of carbon credits which could be obtained from it.

Table 1. *Input data on European Black Pine biomass characteristics*

Parametar	Stem	Foilage	Branches	Roots
Carbon content in dry matter (MgC/MgDM)	0,50	0,50	0,50	0,50
Wood density (MgDM/m^3)	0,50	x	x	x
Initial carbon content (Mg/ha)	9,67	1,41	2,47	1,69
Turnover rate in one year		0,33	0,02	0,02

Table 2. *Yield table for European Black Pine*

Age	Yield (m^3)	Age	Yield (m^3)
10	0,7	80	5,3
20	3,7	90	5,1
30	5,6	100	4,8
40	6,1	110	4,5
50	6,1	120	4,3
60	5,9	130	4,1
70	5,6	140	3,9

3. RESULTS AND DISCUSSION

3.1. Case I – management practice

Based on current forest management practice in Smegnjevska gora all high and artificial stands in parcels 52 and 53 have a patrol of 160 years and besides that, thinning is conducted regularly. Thinning intensity is 14% of total volume of one management parcel for a period of 20 years. To compare the carbon cycle dynamics we created to scenarios: 1) *conventional management* and 2) *low degree of usage*. First scenario reflects the current management practice at forestry management unit Semegnjevska gora, while the second one assumes that logging would be 0,5% of total forested area of one management parcel during the period of 10 years. Only effects related to carbon dynamics with the associated changes in the management practice were analyzed. Both scenarios have same input parameters except for time and type of logging. Time period of simulation is one 160 years. Biomass growth is calculated as a function of age based on yield tables. Both scenarios also have one cohort (*pine*) which reflects the characteristics of *Pinus nigra*. Starting age was set at 0 to analyze the carbon cycle from the start of growth. Figures 1 and 2 show results of modeling in CO2FIX for these scenarios.

Comparison of the results of these scenarios shows us a difference in the amount and dynamics of carbon sequestration. Total amount of stored carbon at the end of simulation for the first scenario is 85,55 MgC ha^{-1}, and all of that is in forest litter and soil. However since this scenario has one cohort it doesn't include young trees which start growing after the first major logging event. If we include them, by using the value of carbon content for the first age class, we would get a more realistic value which is around 100 MgC ha^{-1}.

At the end of same time period simulation scenario *low degree of usage* has a total value of stored carbon at 195,28 MgC ha^{-1}. From that value 62,26 MgC $ha^{-1}$is in forest litter and soil and 133,03 MgC ha^{-1}in forest biomass. Lower content of carbon in soil then in the first scenario is due to the less intensive logging.

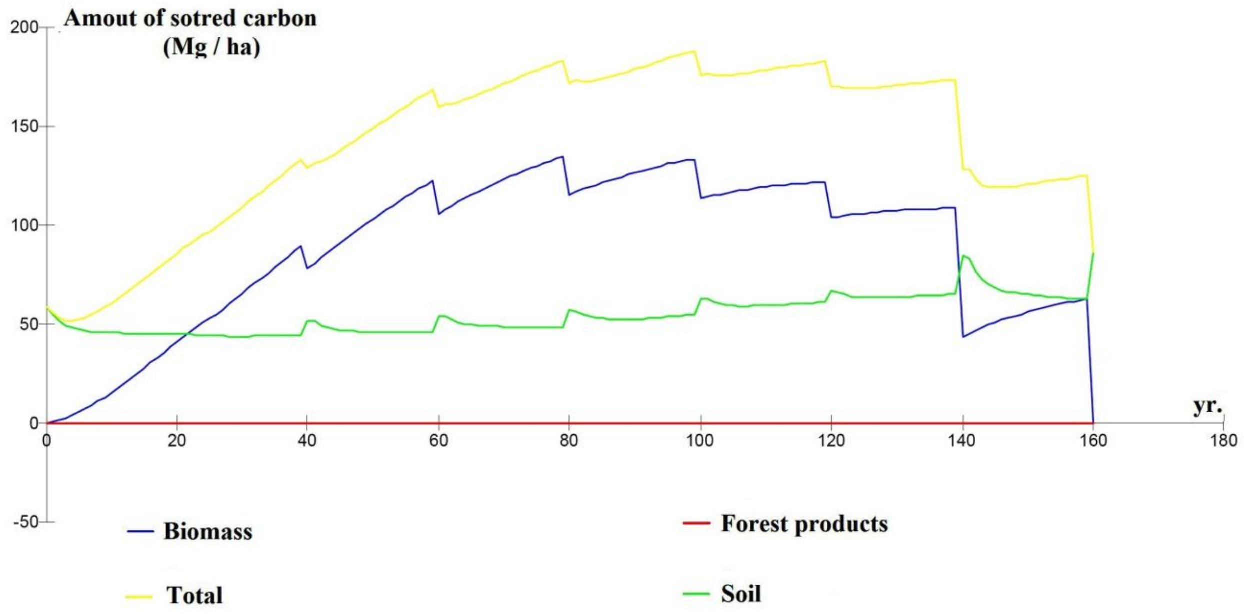

Figure 1. *Carbon storage dynamics in scenario conventional management*

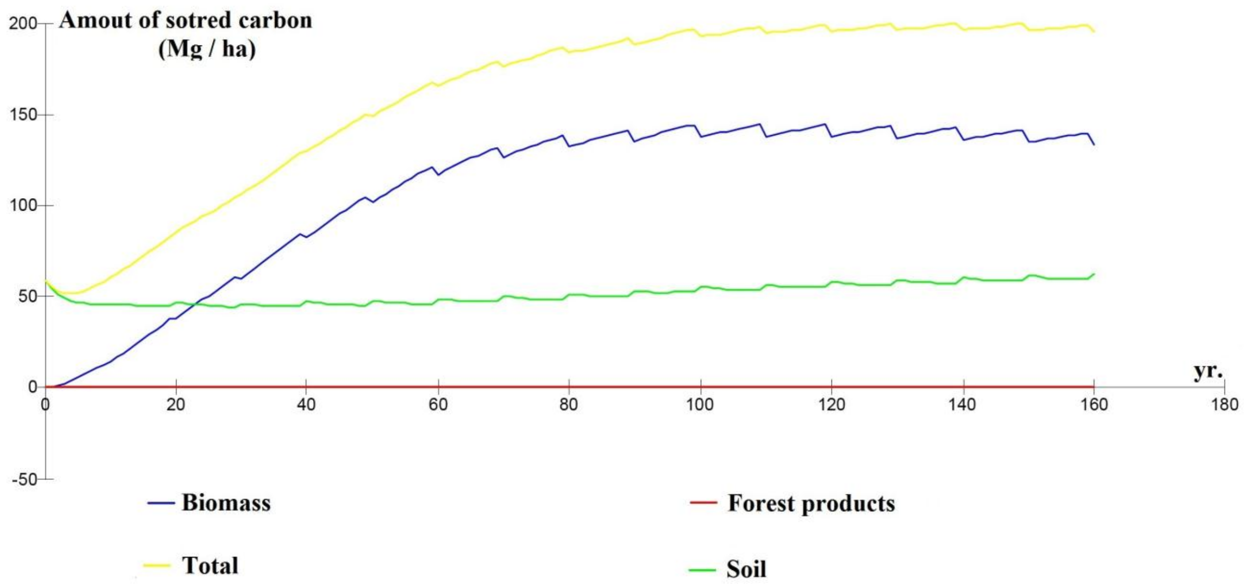

Figure 2. *Carbon storage dynamics in scenario low degree of usage*

3.2. Case II – CDM A/R project

Within the forest management unit Semegnjevska gora there is 405,24 ha of land that is not under forests. This case models the hypothetical afforestation at this area under the CDM methodology and calculates the amount of carbon credits which could be obtained in this way. To asses this it is necessary to establish a baseline scenario which calculates the amount of carbon at current land cover type if there is no afforestation. The amount of potential carbon credits is then calculated as difference between carbon sequestered through afforestation project and baseline scenario. To facilitate this we created two scenarios: 1)*grassland* which reflects the current land cover type and 2)*forest* which simulates the afforestation under CDM project. Scenario *forest* has same input data as scenario *conventional management* from Case I in order to analyze the amount of possible carbon credits which could be obtained with current management practice. Scenario *grassland* was optimized to simulate grass growth instead of forest which is a usual application of CO2FIX model. Nevertheless it can represent a grassland ecosystem for baseline comparison if input parameter modification is made. This is done by reducing the stem increment to very low values, while foliage and root compartments have high increment and also high turnover rates.

To model the amount of carbon credits which could be obtained in scenario *forest* it is necessary to set the start of crediting period, duration of crediting period and year of first verification. Possible amount of tCER carbon credits depends on the start of the crediting period. We analyzed to cases, first with the start just one year after the project implementation, and second with 20 years later start. Both cases had a crediting period of 60 years, which is maximum for CDM A/R projects. Year of first verification is 5th for first case and 25th for second.

Figure 3 shows the result of comparison for two scenarios *grassland* and *forest.* From it we can see that there is a significant difference in carbon sequestration depending on the land cover type. Total amount of sequestered carbon at the end of simulation is 54,40 MgC ha^{-1} (53,30 MgC ha^{-1}in soil) for scenario *grassland* and 82,79 MgC ha^{-1} (all in litter and soil) for scenario *forest*. The average amount of sequestered carbon per year is 158,35 MgC ha^{-1}for scenario *forest*, which is, as expected, much higher than in scenario *grassland* that has a average value of 58,10 MgC ha^{-1}. Based on the amount of sequestered carbon CO2FIX calculated that the amount of lCER credits is 342 per hectare. The amount of tCER is different depending on the start of crediting period, if the start is one year later than the project start the amount of credits is 2644 per hectare, and if it is 2o years later that amount nearly doubles to 4344 per hectare.

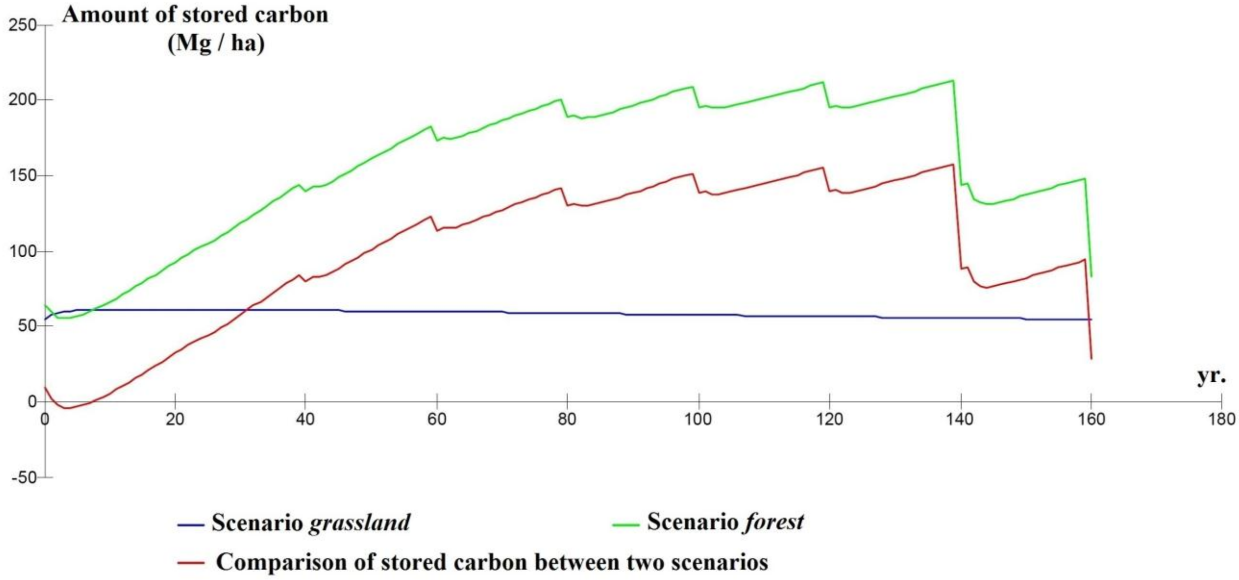

Figure 3. *Carbon sequestration dynamics in scenarios forest and grassland*

The current Strategy of Forestry Development of the Republic of Serbia assumes the increase of forested area. Since Serbia is not an Annex I country under the Kyoto protocol it can implement CDM A/R projects as one way to increase its forest cover. This would add an additional value in carbon credits besides usual benefits that forest ecosystems provide. Realization of this type of projects has several difficulties. It is not easy to translate carbon sequestration in forest biomass in certified emission reductions like CERs. Also dynamics of CDM A/R project implementation can significantly impact the amount of tCERs which could be obtained, with start of the credit period being the most crucial issue. Later start gives more credits but at a later date, and if the start of crediting period is nearer the start of project implementation there is going to be less credits but they will be available for trading sooner. Determining the amount of carbon credits and the time of their availability is very important for sustainable financing of this type of projects. Besides scientific research of forest carbon dynamics, which is not sufficiently done in the Republic of Serbia, CO2FIX can be very useful in the realization of CDM A/R projects since it deal with all mentioned issues and the end user can simulate many different scenarios in order to find the best solution.

4. CONCLUSION

It is obvious that forest management has an impact on the total amount of carbon which is sequestered in it. Conventional practice usually has a goal to focus on wood production in order to maximize profits. Lower usage of timer resources related to higher carbon content in the forest ecosystem may not be fully financially justified. Both economic and carbon dynamics analysis would have to be coupled to give such an answer as well as an optimal solution. An alternative source of profits for forest management units could be implementation of CDM A/R or REDD projects.

Modeling in CO2FIX can be used to obtain more detailed and relevant data on forest carbon dynamics in our country which are important for scientific and practical applications. The precision of these results can be improved by developing a modeling framework and conducting several preparatory analysis and measurements which include:

- Determining the biomass characteristics which are relevant for carbon content in all important species and at all relevant locations in Serbia
- GIS mapping forest areas with similar characteristics which can be modeled as one cohort in CO2FIX methodology
- Creating a database about characteristics and life cycle of forest products
- Determining the extent of logging induced mortality
- Financial analysis which is based on complete evaluation of forest ecosystems.

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ABOVEGROUND PHYTOMASS MENSURATION OF HORNBEAM TREES IN THE STANDS OF CENTRAL PART OF THE RIGHT-BANK FOREST-STEPPE ZONE

A.M. ZAIKA, P.I. LAKYDA[1]

Abstract: *Within the global climate change the research of bioproductivity of Ukrainian forests as a whole and its individual regions is a crucial scientific problem. At this time during forestry management it is limited mainly by assessment of stems part of stands. Using this approach in future work to forest management deprives foresters and researchers the opportunity to fully solve issues related to the ecological monitoring of forests and does not allow to meet information needs that arise during the solution of many environmental problems.*

Oxygen-making ability of forests and in the same time their potential for carbon sequestration and protection from carbon dioxide pollution is directly proportional to forest productivity and longevity of saving them as living natural components.

The objective of this research is to assess the aboveground phytomass of hornbeam trees in the stands of central part of the Right-Bank Forest-Steppe zone of Ukraine. A terminology and basic definitions of bioproductivity processes in forest are pointed, research trends of bioproductivity of forests are shown, methods of experimental evaluation components of phytomass of trees used by scientists in the world are described, and features of the studied tree species in the forest area are presented.

Methodological principles for collecting and processing experimental data are described. Its forest assessment characteristics, experimental evaluation and analysis of qualitative features of phytomass components' hornbeam trees are made. The dependence on mathematical equations from the main features of the assessed trees is found.

The determination of homogeneity of the collected research data, identification of the distribution patterns of the studied parameters, and insurance of the adequacy and reliability of mathematical models' connections to assess the parameters of fractions of hornbeam phytomass were done to conduct the statistical analysis of the general data set.

The theoretical and methodological approaches for modeling the change of components' phytomass depending on taxation parameters of model trees are described. The correlation of main phytomass parameters between other assessed indicators, that are easily determined in the field, was found. Based on these correlations, the adequate models were found.

Standards assessment of biotic components of phytomass productivity of trees in a completely dry state in mass units allows using the conversion factor to determine a share of carbon deposited in it. For practical use, the complex of mathematical models and tables of hornbeam phytomass components for evaluating phytomass of hornbeam trees in central part of the Right-Bank Forest-Steppe are proposed.

Keywords: Forest-steppe, hornbeam, assessment indicators, bioproductivity, phytomass components, density, modeling.

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INTRODUCTION

The value of forest is a global and vital for the whole complex of ecological systems of the Earth as forest have the highest intensity of the biological cycle. Forests are batteries and energy storage, which is involved in the course of natural processes and biosphere development.

Man's ability to greatly affect area, structure and forests productivity, make them a convenient tool for mitigation of greenhouse effect.

Right-bank of Ukraine is located in the center of the country, and its high forests have significant potential to reduce greenhouse gas concentrations in the atmosphere, which is the main goal for solving the problems of Kyoto Protocol. Existing forests under cruel anthropogenic and environmental stress serve as the object of increased attention in the scientific and practical aspects. Primarily they enforce the performance of environmental features, where the main among them is the long-term ability to accumulate the carbon by biomass of woody plants, and produce oxygen. In order to determine the deposited carbon stocks in forest ecosystems of the certain region, it is necessary to have detailed information about vegetation biomass and its dynamics.

Due to the research fragmentation about phytomass components of hornbeam stands both in terms of volume and realm of its growth (Lakyda P. et al., 1998), it was decided to continue the study in the forests of Cherkassy region. Hornbeam within stands of studied region grows in the second story of deciduous, rarely mixed forests, occasionally forms pure stands for the secondary forest and has a substantial part in the biological productivity of these stands. The forest-steppe zone is the most optimal climatic conditions for growth of hornbeam within forests.

The goal of this research is the biotic productivity study of hornbeam trees for evaluation of its aboveground phytomass in the stands of central part of Right-bank of Ukraine. The following tasks were formulated in order to achieve this goal:

- to conduct the experimental evaluation and analysis of qualitative features of phytomass components of hornbeam trees;
- to establish the mathematical dependence of these features on the main forest mensuration ones of trees;
- to develop the complex of forest mensuration norms for biotic productivity estimation of hornbeam trees, based on materials collected on temporary plots and processed with PC.

MATERIALS AND METHODS

Fieldwork and measurements

Studying the biological productivity of forests in Ukraine by components of aboveground phytomass are made by combining empirical (observation, experiment) and theoretical (analysis, synthesis, mathematical modeling) methods.

During scientific study for collecting research data base was used methodology of prof. P.I. Lakyda (Lakyda P., 2001), and modified according to the object of research.

Collecting research material for components phytomass assessment of hornbeam trees was held at the sample plots (SP) taking to account the stand’s characteristics, which were established according to conventional method of forest valuation. Within the mensurational description and plan of stands, the stratums with certain characteristics of hornbeam stands – composition, age, forest density etc. were selected.

SP were made in field in accordance with the relevant requirements for forest sample plots. They had a rectangular shape with aspect ratio not exceeding 1:2 and number of trees of the main species (hornbeam), that have to be accounted, should be at least 300 units for young stands, 250 units for middle-aged stands, and about 200 units for mature stands.

It should be also noted a list of works that were carried out on sample plots. First of all, this is a list of trees on plot, which was carried out by stories and within the story – by species and categories of technical availability. Special attention was paid to release "harvested parts" of stand, in the same time was mastered by silvicultural requirements and made a focus on the weak and medium intensity cutting. List was made by diameter class: for the average diameter of the stand up to 5.9 cm - by 1 cm, from 6 to 16.9 cm - by 2 cm, and more than 17 cm - by 4 cm.

Selection and felling sample trees (ST) are next operations after the list of trees. It was guided by the requirements of the proportional representation method by the number of stems during the selection of sample trees.

For each sample tree was determined its part of story and remain or cut down part of stand. Two mutually perpendicular diameters of crowns (N / S., W / E.) were measured and a mark at the height of 1.3 m above ground was made for the growing sample tree. Felling of STs was going to be done only for hornbeam, and therefore the heights curve was drawn on the basis of sample trees heights.

Phytomass fractions (woody foliage and green branches) of crown were separated for each felled ST. Stem length from the stump to the top, stump height, length of branchless part of trunk, the height of the first living branch on the trunk were measured, and the age of the tree was determined. In addition, the height growth over the past 5 years, the stem diameter over the bark, stem thickness and diameter growth over the past 5 years at the stump, breast height and in the middle of every 2 m sections were found for each sample tree.

The following operations were performed to determine the parameters of aboveground phytomass of hornbeam trees:

a) mass of woody foliage (small branches, less than 1 cm in diameter with leaves), and living and dead branches up to 3 m were weighed using gravimetric method for each sample tree;
b) experimental cuts of thickness 2 - 3 cm taken from the stump, breast height and the relative heights - 0,1h, 0,25h, 0,5h, 0,75h, were made for the sample trees from thin, medium and thick diameter class in order to evaluate the wood and bark density of the stem, and crown branches;
c) the small sample branches (woody foliage fraction) from the low, middle and apical parts of the crown were randomly selected for each ST to determine the proportion of leaves in woody foliage and dry matter of the leaves.

Afterwards, experimental cuts are signed and placed in plastic bags to prevent them from drying out before the laboratory studies.

The small sample branches from the low, middle and apical parts of the crown were randomly selected in amount of three or more units in order to estimate the weight parameters of leaves fraction of phytomass for each sample trees of hornbeam.

Sample branches with leaves in green condition were weighed, and afterwards the leaves were taking out and the aphyllous branches were reweighed in order to determine the percentage of leaves in the woody foliage fraction.

Analyses and statistics

Results of field and laboratory studies were processed with the PC using the Excel program, and special statistical software SPSS and STATISTIKA Report. Statistical processing of experimental data was performed by these programs, and multidimensional regression models were found. Detailed forest mensuration characteristics of the studied stands were obtained with the developed software PERTA at the forest inventory Department of National University of life and environmental sciences of Ukraine.

Such software carries out the processing of enumeration survey results of sample plots using information from felled sample trees, and diameter mensuration in the middle of 2 m sections. The parameters of generatrix equations of the trunk over the bark, under the bark, assortments volume, current and mean annual increment, tree form factor of stem over the bark and under the bark, and average forest mensuration indices of stand for 1 ha were found for each sample tree.

The results of sample plots from PC's software PERTA were used to analyze the stands of the whole region, and studied tree species.

Following operations are held for the experimental cuts made on the stump, breast height and the relative heights 0,10h, 0,25h, 0,50h and 0,75h in order to determine the natural and basic density of wood and bark of the stem and branches of the sample tree:

a) each experimental cut was conditionally devided into 18 parts, where the length of each radius over the bark and under the bark, and cut thickness in 4-point of perimeter in two perpendicular directions were measured;
b) the green mass of cuts over the bark and under the bark was determined;
c) the sample cuts were dried out in an oven until completely dry condition at 105^{o}C;
d) the mass of cuts over the bark and under the bark at absolutely dry condition was found.

RESULTS AND DISCUSSION

Silvicultural and forest mensuration characteristics, and qualitative features

The investigation of the main components of hornbeam trees phytomass in the mixed stands was carried out on 13 SP (7 SP in Cherkassy region, 6 SP in Kyiv region) (table 1). All SP were made in dominant types of forest conditions (D_2) where 59 model trees of given wood species were chosen, cut down and processed according to the methodology (Lakyda P., 2001).

Table 1. *The distribution of SP by the main forest mensuration features, ea.*

By the age classes									
I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**Разом**
0	1	1	4	1	1	1	1	3	13

By site classes					
I^b	**I^a**	**I**	**II**	**III**	**Разом**
1	3	3	3	3	13

By stand density						
1,3	**1,2**	**1,1**	**1**	**0,9**	**0,8**	**Разом**
4	2	4	2	0	1	13

The distribution of SP by the age classes, site classes and stand density, given in the table 1, shows that research data provide all age classes from II to IX. The research data were represented mainly by middle and mature stands, and by uniform distribution of productivity. It can be argued that most sites have 1,1 and 1,3 of stand density according to the data results from sample plots.

A standard sums table of the basal area and standing volume for the natural coppice growing stands of hornbeam trees was used during the determination of stand density (Tables of norms …, 1987).

The moisture, density, and contents of absolutely dry substance are the qualitative parameters of tree phytomass components. Such studies of the main phytomass components of the trees in Ukraine were carried out by P.I. Molotkov (1961), A.P. Ryabokon (1990), A.P. Ryabokon, M.P. Litash (1981), P.V. Biley, I.S. Vintoniv (1983), Y.M. Savych (1978) eat.

One tree was selected for each of the 12 SP in order to assess the quality indices of the hornbeam trees. Model trees were selected in a wide range of age, diameter and height distribution.

72 experimental cuts of wood and bark of stem and 29 experimental cuts of wood and bark of branches were chosen to study the density parameters. 28 model branches together with the low, middle and apical parts of the crown were chosen to determine the percentage of leaves in woody foliage. 16 parts of fresh leaves weighing 10 g each were chosen to determine the dry matter content in fresh leaves.

It was found that bark has the highest value of the natural density among the components of the stem phytomass, according to the results of experimental materials processing (fig. 1, a).

The natural wood density almost completely coincides with the wood density over the bark, and within the tree trunk has 1050 – 1100 kg·$(m^3)^{-1}$ values.

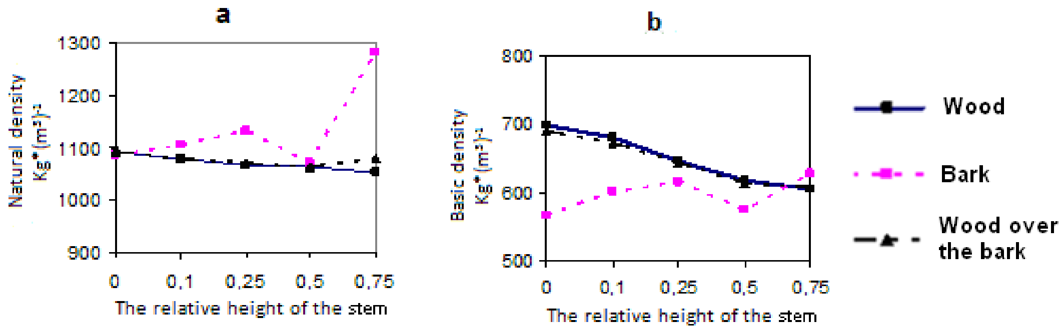


Fig. 1. *Changing of the local natural (a) and basic (b) stem density of the hornbeam trees according to the relative height*

The basic bark density has the lowest value among the components of the stem phytomass. This kind of wood density and wood density over the bark has similar decreasing changes from the root to the top of the stem (fig. 1, b).

It should be noted, that bark of stem for 0,25*h* and 0,75*h* of the tree has the highest natural and basic density of the stem.

The obtained results of the local parameters estimation of wood and bark density along the hornbeam tree trunk allow to learn a law of its changes.

Analyzing the changes in density of phytomass components of hornbeam stem with the tree age, the corresponding rates of the experimental cuts density in different trees can be compared regardless of their height. This allows better understand the process of forming the wood at different age stages of growth, to assess the quality of the assortment which is harvested from different parts of the stem, to characterize the uniformity of the stem structure, and also calculate form parameters of the stem, important for quality characteristics of the hornbeam tree, assuming that measurements of trees diameters would be taken in places of experimental cuts. The data of local density estimation of the model trees has been grouped according to age groups for such analysis (Lakyda P.I., 2012):

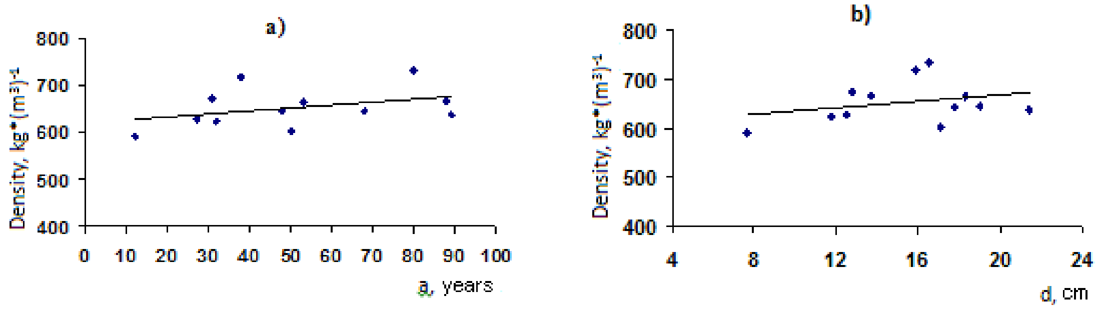
- models with age under 20 years - 1 tree;
- models with age from 21 to 40 years old - 4 trees;
- models with age more than 41 year old - 7 trees.

According to assessments of local density on the relative heights, the average stem density was calculated, and the average values for the wood of stem, stem bark and the stem over the bark were found.

The average density of the wood and bark of the hornbeam stems is regarded as one of the important parameters during the study of the biotic productivity of hornbeam stands. The total amount of dry matter accumulated within the stands can be calculated by average basic density and growing stock.

Natural wood density is close to the wood density over the bark and among the model trees is within 968-1180 kg • $(m3)^{-1}$ and 979-1193 kg • $(m^3)^{-1}$, respectively. The similarity of these values is explained by an insignificant share of the bark in the hornbeam stems (an average 8.6% according to volume).

Graphical interpretation of dependence for changes in average basic density of wood and bark of stems of the hornbeam tree on their age, diameter and height is illustrated in fig. 2 and fig. 3.



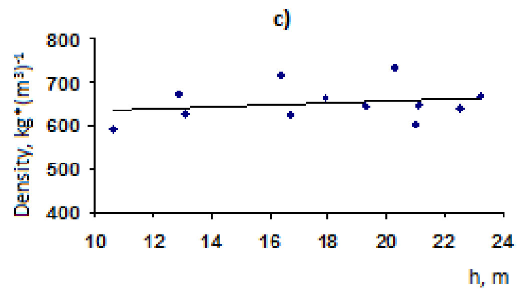
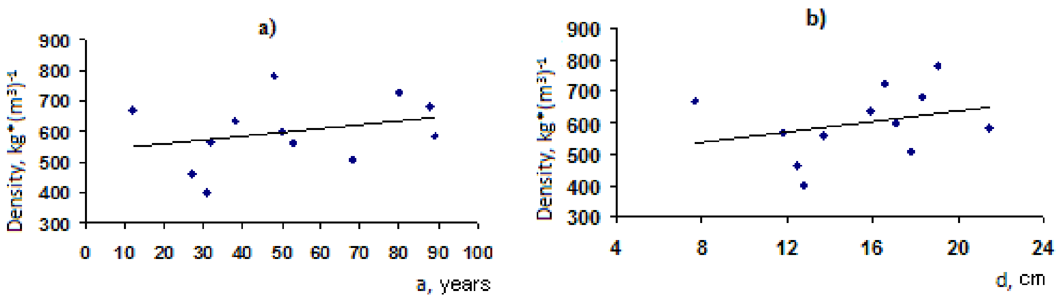


Fig. 2. *Changes of average basic density of wood of the hornbeam trees from:*
a) age;
b) diameter at breast height;
c) trees height.

According to the figures, it is possible to observe the positive trends for the average basic density values of wood and bark of stems with increasing their basic forest mensuration parameters (*a* - age, *d* - diameter at breast height and *h* - height). It should be noted (Fig. 3) sufficiently high variance of the average bark density relative to all analyzed forest mensuration indices of trees. Such data deviation is explained by the large range of model trees ages and its impact on the average wood density of the stems. As seen in figures, the average basic density of hornbeam trees is characterized by ascending type of the density variation with increasing age, diameter and stem height.



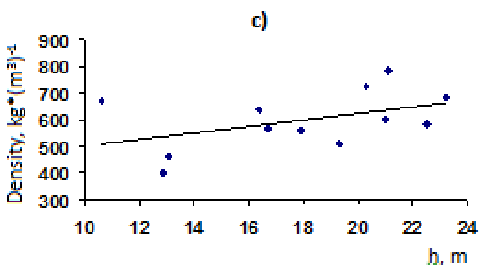


Fig. 3. *Changes of average basic density of bark of the hornbeam trees from*
a) age,
b) diameter at breast height,
c) trees height.

The research of the density of wood and bark of the crown branches is very important in study the biological productivity of the trees and forest stands with the main tree species. Wood of branches is an additional source of raw material, and very often it finds its practical usage in the wood processing industry.

With age and tree height increasing, the wood density of the branches changes by the downward line. Decrease in wood density of branches with increasing branches diameter is barely expressed. Bark density parameters of the hornbeam branches have greater variance in comparison with the same parameters of the wood of branches. It points that connection between bark density and the age, diameter and height of trees may be weak or even absent. To characterize the basic bark density dependence of hornbeam branches, trend line shows a change in the rising direction (Zaika A.M., 2011). Bark density of the branches depends more on the tree age and age of branches, their diameter and height of attachment on the stem.

In order to assess the biological productivity components of hornbeam trees should also explore the percentage of leaves in the woody foliage fraction and a share of completely dry matter in the green leaves.

The share of completely dry matter (S_L) was calculated as the ratio of the mass of sample at completely dry condition (m_0) to its mass at the green condition (m_{nat}) (Lakyda P.I., 2001):

$$S_L = m_0 / m_{nat}. \tag{1}$$

Graphical analysis shows that there is no any existed dependence of percentage of leaves in the woody foliage from the basic forest mensuration parameters of trees - age, stem diameter at breast height and tree height. Trend line indicates on reduction in the percentage of leaves in the woody foliage with age and diameter increasing. This indice grows with increasing tree height, but there is very high variation of leaves percentage, relative to the all analyzed forest mensuration indices of tree (Zaika A.M., 2011).

Increasing of leaves percentage in the woody foliage with increasing tree height is explained by connection between tree hight and forest productivity as one of the main parameters in determining site classes.

Trendline shows that the share of absolutely dry matter in green leaves increases with increasing values of analyzed characteristics, although significant oscillations of the absolute values is observed even under identical age parameters, diameter or height of sample trees (Zaika A.M., 2011).

Qualitative and quantitative assessment of woody foliage fraction showed that there is an average 51% of leaves of hornbeam as part of woody foliage. The average share of absolutely dry matter in 1 g of green leaves is 0.441.

Modeling the biological productivity components of hornbeam trees

The statistical analysis of the general data set was performed to determine the homogeneity of the collected research data, to identify the patterns of distribution of the studied parameters, ensuring the adequacy and reliability of mathematical models of relation that was built to estimate the parameters of phytomass fractions of hornbeam trees.

Baseline data that define the law of ideal distribution for actual and logarithmic values: sample average ($\overline{X}$), standard error of the mean (σ), skewness indice (A) and kurtosis (E) were used for the data analysis.

The case, when the skewness indice and kurtosis equal zero, is necessary and sufficient condition for the ideal distribution (the law works whenever, if unlimited number of factors have influence) of a random variable.

Data analysis give the reasons to believe that none of the distribution series, represented by set of values both actual and logarithmic values, of the studied parameters for hornbeam trees don't fully satisfy the conditions of the law of ideal distribution. Although, such figure as diameter is approximately corresponding to that statistical pattern, since the actual values of skewness indice and kurtosis don't exceed its extreme value (Zaika A.M., 2011).

Values parameters of branches mass, where the variability of absolute values (σ = 48,9) don't exceed their average value ($\overline{X}$ = 33.0), differs from the ideal distribution, and the significant skewness and high kurtosis can be seen. Logarithmic figures of absolute valuessignificantly reduce their variability, bringing the indices of standard error of the mean, skewness indice and kurtosis to zero. Skewness indice and kurtosis for the mass of woody foliage, mass of branches and crown diameter in logarithmic values have indices below their extreme value.

Most of the studied indices have positive skewness indice and kurtosis in actual value, except kurtosis values for the age, diameter at breast height and height of the stem. On the contrary, the logarithmic values of skewness indice and kurtosis have negative values.

In order to establish the affinity and the nature of statistical relations between the studied components of aboveground phytomass of hornbeam trees, the correlation matrix of forest mensuration indices of sample trees was found. Results of the analysis are shown in Table. 2.

Table 2: *The correlation coefficients of forest mensuration indices of hornbeam trees*

Indice	*Age,* years	*Dia-meter,* cm	*Height,* m	*Stem volume (v_s),* m^3	*Wood volume (v_w),* m^3	*Bark volume (v_b),* m^3	*Woody foliage mass (q_{wf}),* kg	*Bran-ches mass (q_{br}),* kg	*Crown dia-meter (d_{cr}),* m	*Crown length (l_{cr}),* m
Age, years	1,000	0,829	0,907	0,816	0,812	0,819	0,666	0,588	0,491	0,711
Diameter, cm	0,829	1,000	0,928	0,932	0,934	0,871	0,876	0,767	0,700	0,752
Height, m	0,907	0,928	1,000	0,904	0,903	0,872	0,773	0,721	0,560	0,790
Stem volume (v_s), m^3	0,816	0,932	0,904	1,000	1,000	0,960	0,897	0,847	0,650	0,774
Wood volume (v_w), m^3	0,812	0,934	0,903	1,000	1,000	0,952	0,899	0,842	0,654	0,775
Bark volume (v_b), m^3	0,819	0,871	0,872	0,960	0,952	1,000	0,843	0,856	0,583	0,734
Woody foliage mass (q_{wf}), kg	0,666	0,876	0,773	0,897	0,899	0,843	1,000	0,833	0,719	0,692
Branches mass (q_{br}), kg	0,588	0,767	0,721	0,847	0,842	0,856	0,833	1,000	0,467	0,624
Crown diameter (d_{cr}), m	0,491	0,700	0,560	0,650	0,654	0,583	0,719	0,467	1,000	0,541
Crown length (l_{cr}), m	0,711	0,752	0,790	0,774	0,775	0,734	0,692	0,624	0,541	1,000

The results computation mentioned at Table 2 show that all correlation coefficients of forest mensuration indices of aboveground phytomass components of hornbeam trees have positive values, and thus direct correlation. Correlation coefficients are above their extreme value at a 5% significance level for the given number of observations (n = 59) for all studied parameters (Tables of norms …, 1987), thus all relations are close, and it will provide a stable mathematical approximation models by regression analysis.

Analyzing the correlation coefficients can be argued that stem volume over the bark has the closest relation in regard to the stem diameter (r = 0,932), the wood volume of the stem – with a diameter and height (r = 0,934 and r = 0,903, respectively).

The correlations table shows that mass of woody foliage (q_{wf}) and branches (q_{br}) is most dependent on such forest mensuration parameters as diameter ($d_{1,3}$) and height (h), and has the weakest, but significant correlation, with age (a), crown diameter (d_{cr}) and crown length (c_l).

The affinity and correlation form of aboveground components of hornbeam phytomass with the main indices of trees that accurately and easily can be measured in forestry, were found using correlation analysis. After that, search and calculation of regression equations were done, using special statistical software STATISTIKA Report in order to find the main phytomass parameters. Models evaluation was carried by the coefficient of determination. The morphometric parameters of tree (age, diameter, tree height, crown diameter, and crown length) were put in the regression equation for each dependent variable (stem volume over the bark, the wood volume of the stem, mass of woody foliage, mass of branches). Then those that in joint applying lost its influence on the dependent variable or did not meet the requirements of models evaluation, were put out. The equation of logarithmic type during models developing were used to describe the paired interactions, which in theoretical biometrics called an allometric function. These equations were in such form:

$$\mathrm{y} = \mathrm{a}_1 \cdot \mathrm{x}^{\mathrm{a}_2} \qquad (2)$$

As a result of the search, multiple regression equation were obtained (Zaika A.M., 2011).

All studied components of aboveground phytomass of hornbeam trees are described by regression equations with high levels of approximation. Equation for the mass of branches and woody foliage were characterized by slightly lower, but significant at the 5% level multiple correlation ratio, because these phytomass components have high variability of absolute values, even for the same values of forest mensuration indices of trees.

Such morphometric characteristics of wood as diameter and height of the stem are the most informative, so the model, which includes the diameter (d) and height (h) of the stem can be considered as the most optimal one in order to develop the norms of components evaluation of aboveground phytomass of hornbeam trees:

$$y = a_1 \cdot d^{a_2} \cdot h^{a_3} \qquad (3)$$

The obtained results of biotic productivity of hornbeam tree in the form of mathematical models, tables, etc. that will receive a standards name in the future, alow quickly and with a certain accuracy to estimate the components values of aboveground phytomass in practice.

During the study of the biotic productivity of hornbeam trees with its role in regulation of carbon amount in the atmosphere can be argued, that there is a need to develop the standards of evaluation of phytomass components of hornbeam trees, which is a typical representative of broadleaf forest of Ukrainian step zone.

Norms, obtained from the study, are built by average basic density (wood and bark of stem) and dry matter in green leaves, and have two entrances – the diameter at height of 1.3 meters and tree height for the wood volume of stem, the stem bark, the stem with bark, branches with bark, leaves, tree crown, woody foliage and aboveground part of the tree.

Data of Table 3 shows that total crown phytomass increases with the increasing of diameter and height of trees. Considering the tables of woody foliage mass and leaves mass within one diameter class, can be argued that changes occur toward decreasing of indecis. The total aboveground phytomass of hornbeam trees increases with increasing the diameter and height of trees, apart how the mass of branches, leaves and woody foliage change with tree height; and it has logical explanation.

Table 3: *Total aboveground phytomass of hornbeam trees in completely dry condition, depending on the diameter and height of the stem, kg*

Dia-meter, cm	Height, m											
	6	8	10	12	14	16	18	20	22	24	26	28
4	3,6	4,7										
6	7,8	10,0	12,5									
8	13,4	17,1	21,2	25,6								
10		26,1	32,3	38,8	45,7							
12		37,1	45,6	54,8	64,4	74,3						
14		50,0	61,4	73,5	86,3	99,6	113,3					
16			79,6	95,2	111,6	128,7	146,3	164,5				
18			100,3	119,8	140,4	161,8	183,9	206,5	229,8			
20			123,7	147,6	172,8	199,0	226,0	253,8	282,3	311,3		
22			149,7	178,6	208,9	240,4	273,0	306,5	340,7	375,7	411,4	
24			178,6	212,8	248,8	286,3	324,9	364,7	405,4	446,9	489,2	
26				250,5	292,7	336,7	382,0	428,6	476,4	525,1	574,7	625,2
28				291,8	340,8	391,8	444,4	498,6	554,0	610,5	668,1	726,7

IMPLICATIONS AND CONCLUSIONS

Thus, the models, where diameter and height of trees serve as arguments were proposed for practical components evaluation of aboveground phytomass of hornbeam trees. The complex of norms for phytomass estimation of hornbeam trees in completely dry condition for wood volume of stem, the stem bark, the stem with bark, branches with bark, leaves, tree crown, woody foliage and aboveground part of the tree, was developed on these models basis. Table for phytomass of woody foliage was developed only for green condition.

Based on analyzing of obtained tables, we can conclude about the possibility of using odtained pattern and norms tables to estimate the phytomass components of hornbeam trees.

The developed norms of biotic productivity evaluation of phytomass components of hornbeam trees in a completely dry condition can be used in order to find a concentration of deposited carbon in its parts, using the conversion factor. The appropriate norms tables of phytomass for the stands in general and their main components separately need to be further developed in order to estimate deposited carbon within the stands.

The complex of forest mensuration norms for phytomass estimation of hornbeam trees for the central part of the right-bank forest-steppe zone, namely mathematical models and tables of amount of phytomass components of hornbeam trees were offered for practical use.

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REVITALISATION OF A BEECH STAND – ECOLOGICAL NECESSITY AND POTENTIAL OF BIOMASS UTILISATION

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Abstract: *The structure and growth of beech trees was analysed in the unmanaged beech stand with admixtures of sessile oak, lime and hornbeam on Fruška Gora, based on two periodic measurements. The first measurement was performed at the stand age of 97 years, and the second at the age of 105 years. The 97-year old stand was characterised by significant sizes of growth elements per hectare (N=208, G=32.64 $m^2 \cdot ha^{-1}$, V=467.62 $m^3 \cdot ha^{-1}$).*

In both measurements, there were 153 beech trees per hectare, which in total structure accounts for 75% per tree number, 82% per volume and 85% per current volume increment. The spontaneous stand development resulted in the increased phyto-sociological weakening of trees which was, during the study period, reflected in the following features of beech trees which were the subject of the research in present study. In both measurements, upper storey beech trees accounted for 94 % per tree number and for 98% of volume. During the first measurement, the trees with freely formed and reduced crown by less than 25% of the crown perimeter, accounted for 22% and 32% of volume, and during the second measurement, they accounted for 8.5% per tree number and 14.3% of volume. The trees with multiple-sided reduced crowns, during the first measurement accounted for 26 % and for 16% of volume, and during the second measurement they accounted for 50% and 35% of volume.

During the study period, the average annual increase in basal area, volume, above-ground oven-dry biomass and carbon quantity in beech trees with freely formed and reduced crowns by less than 25% of the crown perimeter, increased by 88-94%, and in the most prosperous trees in the silvicultural sense by 49-55%, compared to the stand average. Compared to the stand average, lower average annual increase in the above increments by 32-33% were achieved by the unprosperous trees in the silvicultural sense, which justifies their removal from the stand in the aim of the higher increment potential of the most prosperous trees in the silvicultural sense.

Key words: beech, growth elements, internal structure, revitalisation, Fruška Gora.

1. INTRODUCTION

Revitalisation of inadequately formed middle-aged and maturing stands with reduced increment potential is imposed as a necessity in ecological conditions caused by climate changes. With the biotope changes, the changes in the functioning of adverse biotic factors in forest ecosystems are also expected (Karadžić D. 2010), which is an additional indication of the significance of stand revitalisation procedures and the preventive actions.

The most expressive example of such standpoint in our region can be the decline of common oak forests at the ecologically optimal sites during the 20th century, during which the phyto-sociological weakening of forest trees was the predisponing framework for synergistic impacts of abiotic and biotic factors (Marković Lj., Manojlović 1929), whereas during the entire

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period the silvicultural strategy of their tending and formation did not really change. Monitoring of permanent sample plots in oak forests confirms that the degree of phyto-sociological weakening of the trees in the stands has an effect also on the possibility of their revitalisation (Bobinac M., Andrašev S. 2006, 2009, 2010).

In beech forests, thanks to specific biological characters of beech and the site ecological conditions, the research in the forests excluding direct human impact enables important implications for the silvicultural concept, which relies mostly on the use of self-regulating mechanisms in the realisation of management goals (Otto 1995, Schutz 1999, 2004). The most suitable are protected forests, in which management measures were not performed over longer periods, as well as virgin forests, whose adaptation mechanism to environmental conditions is the base for the definition of sustainable forest management. The retrospective and the conceptual foundation of such ideas are presented by Brang P. (2005).

The objective of this paper is to point to the relationship of stand structure or silvicultural requirements and spontaneous development, based on the example of the most represented species in unmanaged, maturing mixed beech stand in NP "Fruška Gora". The study results should be applied in the stand revitalisation, as well as for the objectivisation of ecological and production role of protected beech stands on Fruška Gora and for the advancement of the concept of protection, in harmony with the expected climate changes.

Bearing in mind that the results of research on the permanent sample plot is absolutely possible to estimate the total dry aboveground biomass and carbon stock and, to some extent, the growth of beech trees, are going to allow a comparison with the results of research on biomass and carbon in other beech forests in Serbia (Koprivica et al., 2010 Koprivica M., B. Matović 2011).

2. MATERIAL AND METHOD

The study area is Fruška Gora, which is characterised by temperate continental climate with clear alteration of seasons. According to Milosavljević *et al*., (1973) mean annual air temperature is 11.2°*C*, and during the vegetation period 17.9°*C*. Mean annual precipitation is 663 mm, of which about 55% during the vegetation period.

Because of special ecological, historical and social significance, forests on Fruška Gora are under different protection regimes within the National Park which makes possible versatile comparisons with intensively managed forests. Beech forests on Fruška Gora are an isolated and ecologically specific part of the beech forest range in Serbia. The most mesophilous forests on Fruška Gora are submontane beech forests, and the transition positions are occupied by forests of beech and sessile oak, which also have the widest spatial distribution.

The research was performed in the beech stand in NP "Fruška Gora" in management Unit "Ravne", Compartment 18 e, located in the northern, north-eastern slope, at the altitude of 360-380 m. Based on the data of the Special Management Plan (*1997), the stand belongs to forest type beech and sessile oak (*Querco-Fagetum typicum* on brown forest soil to leached brown forest soil, and eutric brown to leached brown soil). Beech forest in the study site is of mixed composition. The dominant species in the tree layer is beech, and the individually admixed species are: *Quercus petraea*, *Quercus cerris*, *Tilia platyphyllos*, *Tilia tomentosa*, *Tilia cordata* and *Carpinus betulus*. The stand is in the protection zone of the first degree (Nature Reserve) and silvicultural measures have not been performed for several decades. By the end of 2003, permanent sample plot 1 ha was established in the most homogeneous part of the stand, which is used as a seed stand, and all trees with 10 cm ($d_{1,30}$) diameter at breast height were numerated with tree marking paint. According to the date of forest management plan at the first measurement in 2003, the stand age was 97 years (*1997, Bobinac M., Dinić A. 2005).

Tree diameters and heights were measured at the ages of 97 and 105 years. The measured trees were classified per crown classes (BP): dominant (1); codominant (2); suppressed (3); stem quality (KD): good (1); medium (2); poor (3); and the degree of crown class freedom (OK): freely formed crown without touching the crowns of adjacent trees or with intermingling below 25% of crown perimeter (1); one-side reduced crown - crown intermingling of nearest neighbour trees 25-50% of crown perimeter (2); multiple-side reduced crown - crown intermingling of nearest neighbour trees above 50% of crown perimeter (3).

The trees were experimentally marked at the 97 years of stand age as prescribed by the method of selection thinning (Jovanović S. 1988), but trees were not cutted. Trees were classified into three functional categories: trees for tending, indifferent trees, and marked trees.

Stand volume was calculated at the ages of 97 and 105 years based on measurement of breast height diameter and height of all trees using volume tables for beech and the species represented in high stands in Serbia (Nikolić S., Banković S. 2009). Current volume increment was calculated from periodic volume increment between years of measurement for the same collection of trees. Total oven dry above-ground biomass of beech trees was estimated by Wutzler T. *et al*., (2008) equation, and biomass carbon was estimated by Joosten R. *et al*., (2004) equation.

3. RESULTS

3.1. Stand structure and increment

At the stand age of 97 years, altogether 208 trees were measured per hectare, and four trees of admixed species died till the age of 105 years (1.9%). In both measurements, there were 153 beech trees per hectare, which in total structure accounted for 75% of beech per tree number, 78% per basal area, and 82% per volume. Further analysis will refer exclusively to beech trees (Table 1).

Table 1. *The stand data*

Structure elements	Tree species	Year of measurement	
		2003	2011
N [$trees \cdot ha^{-1}$]	Beech	153	153
	Other	55	51
	Total	208	204
G [$m^2 \cdot ha^{-1}$]	Beech	25.47	29.26
	Other	7.17	8.09
	Total	32.64	37.35
V [$m^3 \cdot ha^{-1}$]	Beech	382.44	471.89
	Other	85.18	101.34
	Total	467.62	573.23

Growth elements of beech trees in the stand, estimated oven dry above-ground biomass, and carbon stock in the biomass at the ages of 97 and 105 are presented in Tables 2 and 3. In both measurements, in the stand structure, dominant beech trees accounted for 94 % and they were the carriers of 97 % volume; 81% trees were characterised by good and medium quality stems and they were the carriers of about 85% volume. Adequate to the volume percentage of the above crown class and stem quality categories was the percentage in oven dry biomass and carbon stock. Between two measurements, significant changes were observed in the crown class degree of freedom. At the age of 97, trees with freely formed and one-sided reduced crowns accounted for 74% and they were the carriers of 84% volume, and trees with multiple-side reduced crown accounted for 26% and they were the carriers of 16% volume (Table 1).

At the age of 105, beech tree crown structure was characterised by more unfavourable state than that at the age of 97. With equal relative percentage in the total number of trees, trees with freely formed and one-side reduced crown accounted for 65% of volume, and trees with multiple-side reduced crown accounted for 35% of volume (Table 3).

Table 2. *Growth elements, oven dry above-ground biomass, and carbon stock of beech trees at the age of 97*

Structure elements	Total	Crown class			Crown shape			Stem quality		
		1	2	3	1	2	3	1	2	3
N [trees·ha^{-1}]	153	144	7	2	33	80	40	36	88	29
G [m^2·ha^{-1}]	25.47	24.75	0.63	0.09	7.59	13.19	4.68	7.11	14.12	4.24
V [m^3·ha^{-1}]	382.44	372.88	8.45	1.12	123.31	196.33	62.80	112.14	212.66	57.64
m [kg·ha^{-1}]	247533	241258	5542	733	78324	127344	41864	71681	137211	38641
C [kg·ha^{-1}]	122261	119201	2706	354	38837	62857	20568	35466	67724	19071

N=number of trees; G=basal area; V=volume; m=oven dry biomass; C=carbon content

Table 3. *Growth elements, oven dry above-ground biomass, and carbon stock of beech trees at the age of 105*

Structure elements	Total	Crown class			Crown shape			Stem quality		
		1	2	3	1	2	3	1	2	3
N [trees·ha^{-1}]	153	144	7	2	13	63	77	36	88	29
G [m^2·ha^{-1}]	29.26	28.47	0.69	0.10	3.82	14.55	10.89	8.36	16.14	4.76
V [m^3·ha^{-1}]	471.89	460.78	9.85	1.26	67.41	240.59	163.89	141.45	260.69	69.74
m [kg·ha^{-1}]	298699	291552	6337	811	41863	151736	105100	88510	164548	45641
C [kg·ha^{-1}]	147766	144278	3097	392	20819	75233	51714	43879	81337	22551

Current increment in basal area, volume, above-ground biomass, and carbon stock of all beech trees, trees of different crown classes, crown shape and stem quality, between the ages 98 – 105 are presented in Table 4. In the total structure of increment of basal area, volume, oven dry above-ground biomass, and carbon stock, dominant trees accounted for more than 98 %, trees with freely formed crown - 16%, and trees with good quality stem - 33%. More than 50% of increment was produced by trees with one-side reduced crown and trees with medium quality stems, trees with multiple-side reduced crown (50% trees) accounted for about 29% of increment, and trees with poor stem (19% trees) accounted for about 14% of increment.

Table 4. *Current increment of basal area, volume, oven dry above-ground biomass, and carbon stock of beech trees between the ages of 98 and 105 years*

Structure elements	Total	Crown class			Crown shape			Stem quality		
		1	2	3	1	2	3	1	2	3
i_G [m^2·ha^{-1}·yr.$^{-1}$]	0.4743	0.4658	0.0077	0.0008	0.0758	0.2622	0.1363	0.1556	0.2528	0.0659
i_V [m^3·ha^{-1}·yr.$^{-1}$]	11.18	10.99	0.18	0.02	1.83	6.12	3.23	3.66	6.00	1.51
i_m [kg·ha^{-1}·yr.$^{-1}$]	6395.8	6286.7	99.4	9.7	1049.2	3521.3	1825.3	2103.7	3417.2	874.9
i_C [kg·ha^{-1}·yr.$^{-1}$]	3188.1	3134.6	48.8	4.7	526.2	1758.9	903.1	1051.6	1701.7	434.9

Compared to the stand average, higher average annual increase in basal area, volume, and above-ground oven dry biomass and carbon stock was achieved by dominant beech trees by 4%, trees with freely formed crown by 88-94%, and trees with good quality stem by 39-40%. Codominant trees, trees with multiple-side reduced crown and trees with poor quality stem increased the above elements by one-third to two-thirds of the stand annual average *(Table 5).*

Table 5. *Current increment of basal area, volume, oven dry above-ground biomass, and carbon stock of different categories of beech trees, and the coefficient of increase compared to the stand average between the ages of 97 and 105 years*

Category		Value				Coefficient			
		i_G $[m^2 \cdot ha^{-1} \cdot yr.^{-1}]$	i_V $[m^3 \cdot ha^{-1} \cdot yr.^{-1}]$	i_m $[kg \cdot ha^{-1} \cdot yr.^{-1}]$	i_C $[kg \cdot ha^{-1} \cdot yr.^{-1}]$	i_G	i_V	i_m	i_C
All trees		0.0031	0.0731	41.8026	20.8375	1.00	1.00	1.00	1.00
Crown class	1	0.0032	0.0763	43.6578	21.7681	1.04	1.04	1.04	1.04
	2	0.0011	0.0252	14.2006	6.9771	0.36	0.34	0.34	0.33
	3	0.0004	0.0087	4.8404	2.3468	0.13	0.12	0.12	0.11
Crown shape	1	0.0058	0.1410	80.7079	40.4748	1.88	1.93	1.93	1.94
	2	0.0042	0.0971	55.8939	27.9185	1.34	1.33	1.34	1.34
	3	0.0018	0.0419	23.7050	11.7285	0.57	0.57	0.57	0.56
Stem quality	1	0.0043	0.1018	58.4348	29.2103	1.39	1.39	1.40	1.40
	2	0.0029	0.0682	38.8321	19.3371	0.93	0.93	0.93	0.93
	3	0.0023	0.0522	30.1698	14.9966	0.73	0.71	0.72	0.72

3.2. Definition of measures for stand revitalisation

Of 144 (100%) dominant beech trees per hectare, there were 52 (36%) silviculturally prosperous trees in the stand. Within the above number of silviculturally successful trees, one-third were characterised with medium quality stem, more than two-thirds were characterised with one-sided reduced crown, and the condition of proper spatial distribution was satisfied to the extent that the trees were not direct competitors. To improve growth space to silviculturally successful trees, it is estimated that 63 beech trees per hectare should be removed from the stand, with the volume of 123.93 $m^3 \cdot ha^{-1}$ at the age of 97, i.e. 148.86 $m^3 \cdot ha^{-1}$ at the age of 105, which is thinning intensity of 41 % per tree number, and about 32 % per volume (Table 6).

Table 6. *Above-ground biomass and carbon stock of different silvicultural categories of beech trees at the ages 97-105*

Structure elements	97 years				105 years			
	Total	Trees for tending	Indifferent trees	Marked trees	Total	Trees for tending	Indifferent trees	Marked trees
N $[trees \cdot ha^{-1}]$	153	52	38	63	153	52	38	63
G $[m^2 \cdot ha^{-1}]$	25.47	11.30	5.55	8.62	29.26	13.22	6.36	9.68
V $[m^3 \cdot ha^{-1}]$	382.44	183.46	75.05	123.93	471.89	230.67	92.37	148.86
m $[kg \cdot ha^{-1}]$	247533	116292	50349	80891	298699	143049	60581	95069
C $[kg \cdot ha^{-1}]$	122261	57608	24830	39823	147766	70990	29920	46856

Table 7 presents current increment of basal area, volume, above-ground biomass and carbon stock on average for all beech trees and trees of different silvicultural categories, during the period from *97 to 105* years. In the total increment structure, silviculturally prosperous trees accounted for 51-53%, indifferent trees - 19-21%, and marked trees - about 28%.

Compared to the stand average, silviculturally prosperous trees produced higher average annual increase in the above increments by 49-55%, indifferent trees – lower by 14-22%, and marked trees - lower by 32-33% (Table 8).

Table 7. *Current increment of above-ground biomass and carbon stock of different silvicultural categories of beech trees in the period from 97 to 105 years*

Increment elements	Total	Trees for tending	Indifferent trees	Marked trees
i_G [$m^2 \cdot ha^{-1} \cdot yr.^{-1}$]	0.4743	0.2406	0.1010	0.1327
i_V [$m^3 \cdot ha^{-1} \cdot yr.^{-1}$]	11.18	5.90	2.16	3.12
i_m [$kg \cdot ha^{-1} \cdot yr.^{-1}$]	6395.8	3344.6	1278.9	1772.2
i_C [$kg \cdot ha^{-1} \cdot yr.^{-1}$]	3188.1	1672.7	636.2	879.2

Table 8. *Current increment of different silvicultural categories of beech trees and the coefficient of increase compared to the stand average in the period from 97 to 105* years

Categories	Quantity				Coefficient			
	i_G [$m^2 \cdot ha^{-1} \cdot yr.^{-1}$]	i_V [$m^3 \cdot ha^{-1} \cdot yr.^{-1}$]	i_m [$kg \cdot ha^{-1} \cdot yr.^{-1}$]	i_C [$kg \cdot ha^{-1} \cdot yr.^{-1}$]	i_G	i_V	i_m	i_C
All trees	0.0031	0.0731	41.8026	20.8375	1.00	1.00	1.00	1.00
Trees for tending	0.0046	0.1135	64.3199	32.1677	1.49	1.55	1.54	1.54
Indifferent trees	0.0027	0.0570	33.6561	16.7434	0.86	0.78	0.81	0.80
Marked trees	0.0021	0.0495	28.1307	13.9550	0.68	0.68	0.67	0.67

4. DISCUSSION AND CONCLUSIONS

The study stand at the age of 97 was characterised by significant values of growth elements per hectare (N=208 trees$\cdot ha^{-1}$, G=32.64 $m^2 \cdot ha^{-1}$, V=467.62 $m^3 \cdot ha^{-1}$) and the percentage of beech accounting for 75% per tree number, and 82% per volume. During the spontaneous development of the stand till the age of 105, four trees of the admixed species died (1.9%), and the volume increased altogether by 105.61 $m^3 \cdot ha^{-1}$, or on average 13.20 $m^3 \cdot ha^{-1} \cdot yr^{-1}$.

Based on the values of current increment of basal area and volume, attained by 153 beech trees per hectare (I_G=0.47 $m^2 \cdot ha^{-1} \cdot yr.^{-1}$, I_V=11.18 $m^3 \cdot ha^{-1} \cdot yr.^{-1}$), of which 94% were in dominant position and accounted for 98% in total increment, it can be concluded that the study stand had a good increment potential. However, the increment of beech trees of different biological and functional characteristics at the given age points to the impact of phyto-sociological weakening of trees in spontaneous development. During the period between the ages of 97 and 105 years, 50% of trees with multiple-side reduced crowns achieved 29% of increment, and in conformity with the presumed climate changes and the established stand protection regime, we can expect further decrease in growth of these trees.

Compared to the stand average, higher average annual increase in basal area, volume, above-ground biomass and carbon stock was attained by trees with freely formed crowns by 88-94%. The annual increase in the above elements by trees with multiple-side reduced crowns on average amounted to two-thirds of the stand average. Compared to the stand average, silviculturally prosperous trees had higher average annual increase in the above increments by 49-55%, and marked trees – lower by 32-33%, which justifies their removal from the stand from the standpoint of maintaining the increment potential of future trees in the following period.

Increment of beech trees of different biological and silvicultural categories in the maturing stand shows similar relationships as in the younger beech stands in Serbia in which phytosociological weakening of trees is more notable due to the lack of adequate tending (Bobinac M. 2003, 2006a, 2006b).

Based on the monitoring in an unmanaged beech stand, Novotni *et al.*, (2011) in a ten-year period conclude predominant removal of beech trees from the lower crown classes, and based on crown reduction, point to the process of devitalisation of beech trees also from the higher layers, whose natural removal from the stand can be expected in the further spontaneous development of the stand.

Compatible with climate changes, the focus of professional work should be directed towards the revitalisation of incorrectly formed stands from the silvicultural aspect, so that increment potential of future trees could be maximally harvested and in this way, the impact of unfavourable exogenous factors diminished. The maintenance of increment potential of silviculturally prosperous trees is proportional to carbon sequestration, which proves that their production and ecological function is satisfied by these measures. In the above procedure of the stand revitalisation in the future period, it is possible to harvest 148.86 $m^3 \cdot ha^{-1}$ or 95069 $kg \cdot ha^{-1}$ of oven-dry beech biomass.

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THE CONCEPT OF OBTAINING DRIED BIOMASS FROM COMBUSTION PROCESS AND ITS USE FOR BRIQUETTES PRODUCTION

Radivoje TOPIĆ[1], Nenad ĆUPRIĆ[2], Aleksandar DEDIĆ[2*]

Abstract: *This paper describes a high temperature drying plant for wood waste drying and briquette production and the obtained improvement in energy efficiency. A mixture of dried sawdust of wood burns in a specially designed furnace and the burning products are used as a drying agent for a high temperature drum drier. An amount of dried wood waste is used as fuel for the combustion process and the rest is used for the briquette production. Fossil fuel is used only for starting the drying process. The drying process in the high temperature pneumatic drum dryers is a complex, nonlinear thermodynamic process, with a complex energy transfer and movement of particles of the drying material. Particles change their state during movement along the drying chamber. In order to allow as much as possible intense drying, shortening the time of the drying process and using the minimum of environmentally friendly fuels, it is necessary to increase the value of initial temperature of the drying agent and to increase the agent throughput and velocity. The general layout of a plant for high-temperature drying and briquette production, which consists of: a cyclonic furnace, a pneumatic drum drier and a device for briquette production is presented. The suggested plant satisfied the strong demands of environmental protection and enabled energy savings.*

Key words: Biomasses, high temperature drying, cyclone combustion, drum dryer, briquettes.

1. INTRODUCTION

Biomass is traditionally used for years in the world of heat production. The consumption in 2008 in Serbia was only 0.3 Mtoe, which means that only 11% of available biomass is utilized. Having in mind the justification for using waste for energy purposes, should be noted that each of us makes on average 0.4 to 1.2 kg/day of waste, which calorific power is between 2.5 - 4 kW/kg. According to the Serbian Government Biomass Action Plan for the period 2010 to 2012 (Official Gazette of RS, 2010), the annual biomass energy potential in Serbia is around 2.7 Mtoe. Energy potential of biomass from forestry and wood industry (felling trees and scrap wood produced during primary and/or final wood processing) is estimated at approximately 1.0 Mtoe. The obligation of Republic of Serbia, according to EU Directive 2009/28/EC, is to introduce 20% renewable energy sources (RES) in total consumption of energy and 10% RES energy in the final consumption in transport.

The average energy consumption for heating in Serbia is 200 kWh/m^2 (Dedić, 2011) although EU directives give 30 kW/m^2 as the highest limit. Unfortunately, well-insulated house that is warmed only with the electricity, consumes up to 350 kWh of energy monthly. With the increasing use of the energy for heating, the great importance is to get cheap and

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environmentally friendly energy from renewable energy sources, and one way is by using briquettes produced from wood waste.

2. THE DRYING PROCESS IN THE BIOFUEL PRODUCTION

Increasing demands for dried materials requires the drying process has to be as short as possible. In addition, it is necessary to minimize fuel consumption and to allow the use of environmentally friendly fuels. The following ways are possible (Topić et al, 2008):

1. Increasing the initial temperature of the drying agent;
2. Increasing the flow of the drying agent;
3. Increasing the velocity of the drying agent;
4. Pre-processing and preparing the material for the drying process (dimension reduction etc).

Increasing the initial temperature of the drying agent at the entrance of the drying chamber provides several benefits: reduction of specific "consumption" of heat, reduction of the required amount of the drying agent, increases performances of the dryer and decreases the operating costs. These benefits result in a reduction of the fuel consumption and the costs for preparation and usage of the drying agent, achieving the greater utilization of the drying plant.

The main task of drying process is to provide optimal heat transfer between the drying agent and the each particle of drying material. In that way, optimal amount of moisture could be subtract from drying material by the drying agent (Dedić et al, 2003 and 2004). That task could be accomplished by selecting the proper drying process. On the constructional plan, the intensification of the drying process could be achieved by improving interior structure of the drying chamber. (Topić, 1989) and (Topić, 2008)

Wood sawdust and chips could be dried in different driers such as: drum driers, pneumatic drum driers, pneumatic pipe drum driers, belt driers, floating driers etc.

They could be direct, which use products of burning as drying agent, or indirect type.

The heat source is usually water steam, heating oil or natural gas. Thanks to the low percentage of moisture, a kilogram of wood briquettes gives about 5 kWh of heat, which is equivalent to the heat which gives a half liter of the heating oil. From the other hand, burning the wood means giving back the similar amount of the CO_2 which tree took from the air during growing, but burning the fossil fuel is additional emission of CO_2 and the other "greenhouse" gases into the atmosphere. Wood has very low sulfur content, much lower than the other fuels have. Also, the temperature during the burning process is not high enough to cause NO_x emission.

The energy balance analyzes show that the specific heat consumption in the most of the convective type driers is more than 4000 kJ/kg_w. From the other hand, the heat needed for free water evaporation on the interval from 0 to 100 ^0C is between 2500 to 2250 kJ/kg_w, which clearly shows that in this area, so far, little has been done in terms of reducing energy consumption. (Topić, 2008)

At the present level of technological development, for intensive preparation of biomass, forage crops, sugar, and inorganic materials such as stone fractions of different grain size, the most applied technology is high-temperature drying. (Topić, 1996)

All mentioned facts were taken into account during the developing the basic concept of the new plant for wood waste drying and briquette production.

3. THE BASIC CONCEPT OF THE NEW PLANT FOR HIGH-TEMPERATURE DRYING AND BRIQUETTE PRODUCTION

On the Figure 1 the basic concept of the high-temperature drying plant is shown. It consists of (Topić, 2006):

- The cyclone furnace for burning dry wood sawdust,
- The three – pass pneumatic high-temperature drum drier,
- The cyclone for separating dried material and used drying agent,
- The centrifugal ventilator for pneumatic transport of the mixture of drying material and drying agent during drying process.
- The fuel input system for supplying the cyclone furnace with dry wood sawdust from buffer,
- The input system of the wet drying material at the entrance of the drying chamber, and
- The output system of the dried material followed with the system for briquette production (not shown on the figure).

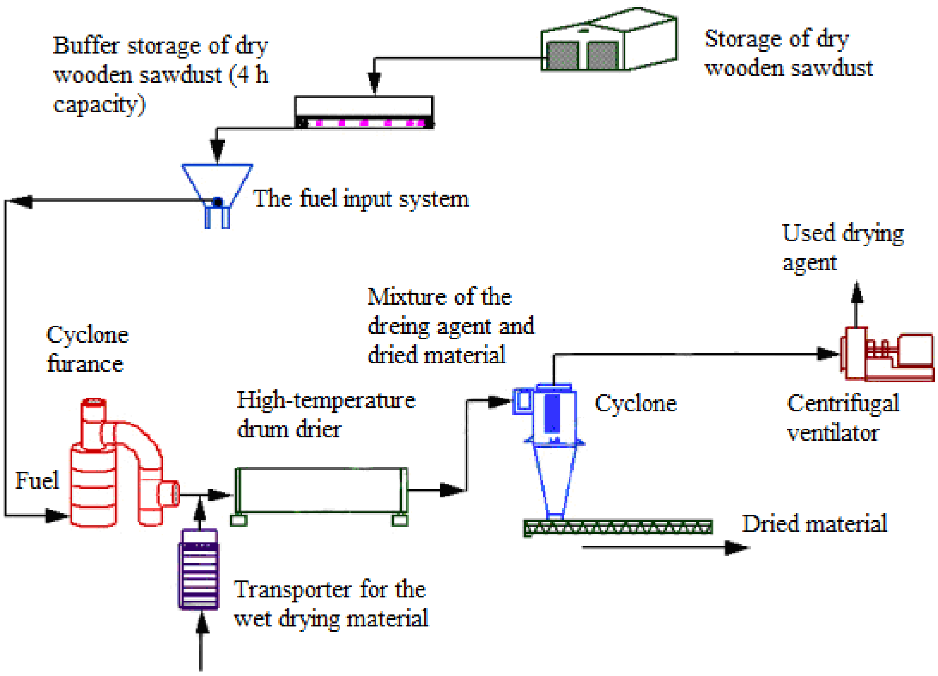

Figure 1: *The basic concept of the high-temperature drying plant for wood waste*

4. TECHNICAL CHARACTHERSTICS OF THE NEW-DEVELOPED HIGH-TEMPERATURE DRYING PLAN AND BRIQUETTE PRODUCTION

The plant is developed within the project "Development of solution and technology for high-temperature drying of wood residues", funded by Ministry of Science and Technological Development, Republic of Serbia, Program for National Energy Efficiency in the period 2006-2010 (Topić, 2010).

The plant for high-temperature drying is intended for drying the wood waste material which dimensions are less then 6 mm with the relative humidity between 50 to 80 %. As a fuel it uses the dried sawdust with the relative humidity of 15 % or less. The product is raw dry wood material with the relative humidity of 12 %, for further production of wood flour, pellets and briquettes. The drying process is the direct type, with combined heat transfer and the drying in the one-pass. The drying agent is the mixture of dry sawdust burning products and fresh air. The main technical characteristics of the drying plant are given in the Table 1.

Table 1. *The main technical characteristics of the drying plant*

Parameter	*Measuring unit*	*Value*
The drying agent temperature at the entrance of the d. chamber	^oC	542
The drying agent temperature at the exit of the d. chamber	^oC	83
The dryer capacity (wet material)	kg_{wm}/h	3143
The dryer capacity (dry material)	kg_{dm}/h	1250
Total thermal power	MW	2.932
The heat needed for evaporation 1 *kg* of material humidity	kJ/kg_w	4272
The drying time	s	300-1500(878)

The layout of the plant for high temperature drying and briquettes production from wood residues is shown in Figure 2 (Topić, 2006). Wet wood residues from hopper-type bin (1) goes by transporter (2) into shredder (3). After processing in shredder, wet material (particles less than 6 mm) goes in hopper-type bin (7) by pneumatic transportation system consists of a fan (4), a pipe (5) and a cyclone (6). After that, a screw conveyer (8) brings wet material into drying chamber entrance. Drying chamber (9) is a three pass drum structure with cylinders separated in several sections. Drying process lasts between 360 and 1500 s, the average is 878 s, depending on material dimensions.

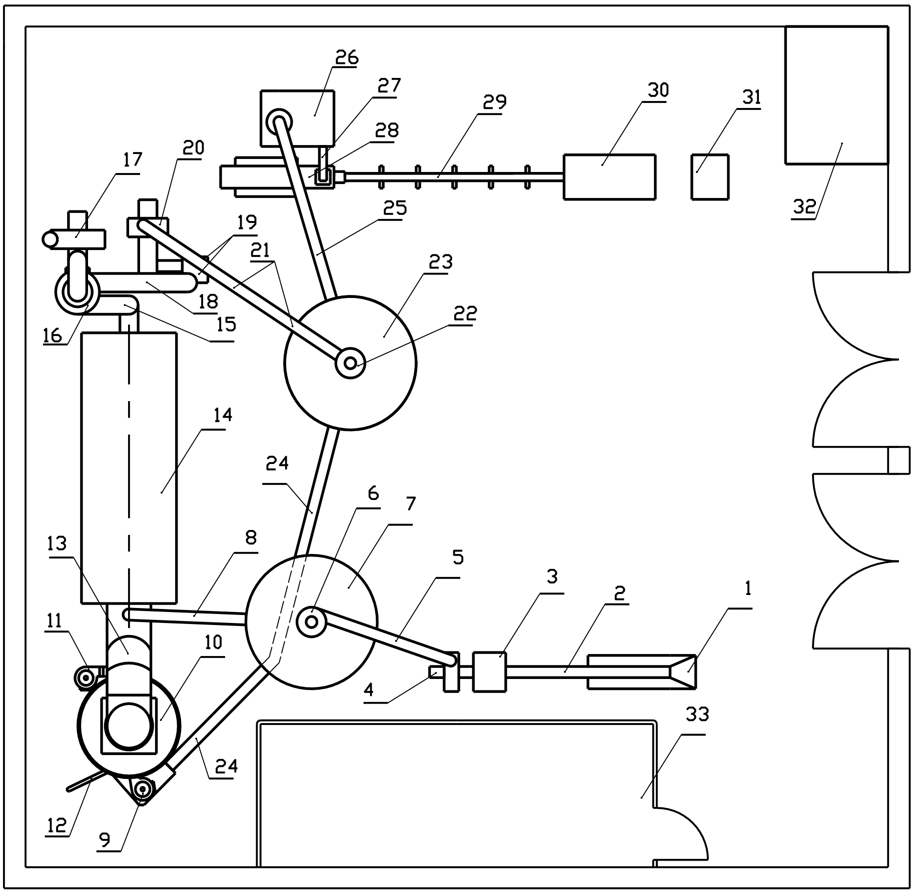

Figure 2: *The layout of high temperature drying plant for briquettes production*

Drying agent current, obtained by the main fan (17), also provides transport of dry particulate materials through drying chamber, chute (15) and into a cyclone (16) where used drying agent and dried material separates. The secondary screw conveyer (18) brings dried material into a mill (19). After milling dried material is pneumatically transported (a fan 20 and a pipe 21) to a cyclone (23). After that, dried material is stored in a silo (23). From the silo (23) a part of dried material is used for burning in the cyclone furnace (10), and the rest for briquette production.

The cyclone furnace (10) uses dried material as fuel. For the burning process initialization (12) natural gas or LP gas is used. A screw conveyer brings dried material from the silo (23) to the furnace (10), where it is mixed with current of air from a ventilator (9) and introduced into the burning chamber. A fan (11) provides necessary additional air into the burning chamber. The maximal temperature after burning is about 1093 ^{0}C, less than the temperature of NOx occurring.

The burning products, high temperature gas and ash are mixed with cold air and make drying agent which is introduced through a channel (13) into the drying chamber. In that way, the ash and the other burning products go directly to the drying chamber where they mix with the drying material and do not go directly to the atmosphere. The chimney looks like opening on the top of the furnace on Figure 3 is intake for additional air which is used for control of agent temperature. The cyclonic furnace for biomass combustion with high temperature pneumatic drum drier is presented on Figure 3.

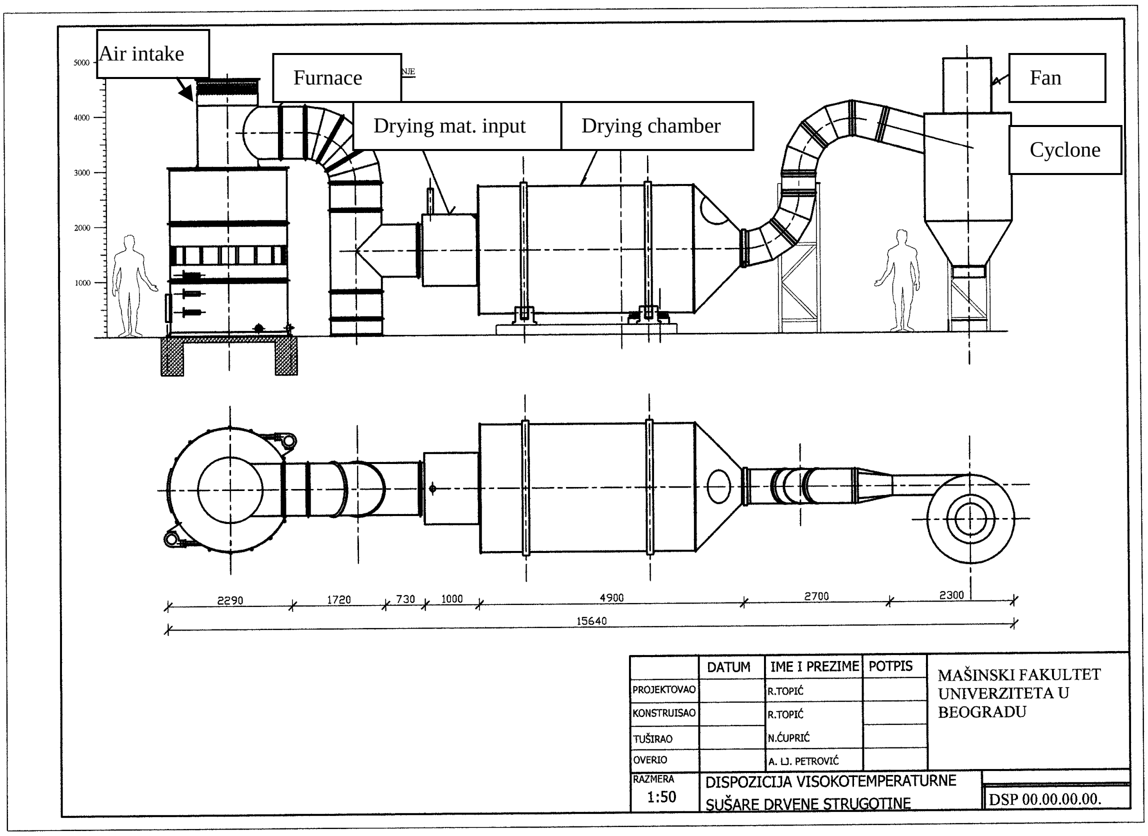

Figure 3: *The cyclonic furnace for biomass combustion and the high temperature drum drier*

5. THE DRYING PROCESS IN PNEUMATIC DRUM DRIER

Very little research of the drum dryers was done. For calculations mainly empirical models are used. (Kemp, 2004). The mathematical models for entropic and exergy analyze of the drying process in the high-temperature pneumatic drum dryers is given in Topić, 1995 and 1996. The analyzis of the parameters which have significant influence on the process control is presented in Topić, 1996, and Dedić, 2009. The research of material motion during the drying process is presented in Britton et al, 2006, and Lisboa et al, 2007.

High temperature drying process at pneumatic drum dryers is a complex, nonlinear thermodynamic process. During the drying process the drying material particles move along the drying drum and change their state in the same time (Kemp, 2004). Drying material periodically passes two phases: the phase of the ripening when the material rests at the bottom of the drum or on the flights, and the phase of moving when it is poured from the flights, and get in contact with the stream of drying agent. The shape of flights must ensure symmetrically pouring of the material relative to the vertical axis of the drum cross section, to enable the optimal use of the drying agent energy (Topić and Vasiljević, 1996) and (Lee and Sheehan, 2010). All this makes the drying process extremely difficult to be modeled and managed by conventional techniques. That is way authors suggest various approach for solving this complex task. Pirelli at al (2002) suggested Fazzy logic approach for control of these facilities, as well as the simulation of the work process and management.

During the drying process the drying material particles change their state and position. Along the drum, moisture content in the drying material decreases, as well as its volume and the mass. For that reason drying chamber – drum, is divided in sections with different flights. The sections usually have length of 500-600 mm. Each section in the drum has different inner structure which consists of flights different in: number, shape, dimensions and position. Flights are placed in "Chess schedule" position (Figure 4). The entrance to the drying chamber, the first section, has helical flights for bringing into the high moisture raw material. Flights are wider and the distance between them is greater in sections closer to the entrance to the drying chamber. For the sawdust and chips of wood the best are curved flights (Topić, 2006) and (Topić et al, 2010). On the Figure 5 the installation for the analyzing influence of different flights parameters is presented.

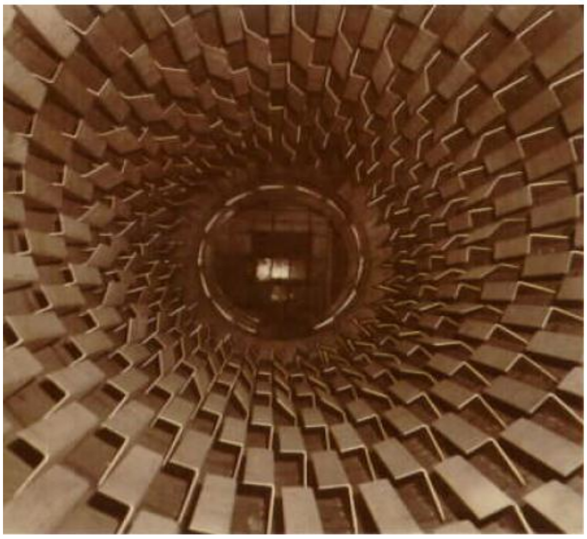

Figure 4: *Inside of the drying chamber with flights*

Figure 5: *The model of drying chamber with flights*

The heat transfers from drying agent to the drying material in three ways: convection, to the surface of the falling particles, convection together with radiation, on the boundary surface of the material which lays on the flights or on the drum surface, and conduction, during the contact with heated parts of the inside construction elements of the drum. (Topić, and Voronjec; 1984 and 1985). The research of Mihalov showed that the first way gives 70 times better heat transfer than the second one and 200 times than the third. (Valušis, 1977).

6. COMBUSTION IN A CYCLONE FURNACE

The cyclone furnace is the main alternative to the conventional furnaces. It is used for burning the biomass fuel such as sawdust, sunflower shells, chop up straw etc. The biomass fuel has to have following characteristics: particles smaller than 6 mm, the lower heating value greater than 17400 kJ/kg, the ash contain less than 6 %, the relative humidity less than 12 % and the density from 100 to 400 kg/m^3. The dried fuel is brought into the combustion chamber in exactly amount. The burning process is running in the over-pressure rather than small under-pressure. The wood sawdust is blown into the burning chamber and it burns instantly thanks to the very high turbulence which occurs in this type of furnace. The whole process has much higher intensity than the conventional ones. Also, the most of the solid parts of the burning products is taken by stream of the gases which brings them to the drying chamber. The other benefit is that there is no smoke, odor or CO emission.

7. THE BRIQUETTES MASCHINE

The last element of the plant is the device for the briquette production (Figure 6). On the layout of the plant on Figure 2, it is labeled as (28). The device consists of: a hopper-type bin for dried wood residues, a hydraulic system with a pump powered by an electromotor and a central board with electric commands. The dried wood residues from drying facility are collected in the hopper-type bin, from which flows through the feeder to the in-chamber and than through the tube, which is in front of the piston powered by a hydraulic cylinder. The role of the piston is to push and press the exactly amount of residues into the cylindrical main chamber which is in orthogonal direction. The hydraulic cylinder generates force enough to press the particles of residues and form compact cylindrical briquette. The briquette drops into the container and than goes to packing machine where briquettes is collected and packs in plastic or cotton bags for selling. It should be emphasized that the briquette is very compact and no additional glue is necessary, thanks to composition of wood residuals and high pressure of the piston. Also, it doesn’t matter if the source of residues is from hard or soft broadleaves or conifers.

Figure 6: *The device for briquettes production*

8. ASSESSMENT OF ENERGY EFFICIENCY

The main advantages of this plant are:

1. From the aspect of sustainable development, the high-temperature drying process, presented here, needs less specific energy for drying than convective driers, it is more efficient, it uses dried waste wood material as a fuel and it has less influence on the environment.
2. From the economical aspect briquette production is cheaper and with better quality.
3. From the techno-economical aspect presented here the drying chamber doesn’t need isolation because it consists of three shells, with the boundary shell temperature less than 85 ^{0}C. Also,

this concept provides better control of drying agent flow and temperature. It needs less space because the drying chamber is shorter then those with one shell.

4. It is faster thanks to the optimal inside structure of the drying chamber and more even heat transfer from the drying agent to the drying material.
5. Doesn't need fossil fuel except for ignition.
6. Compared to the other type of dryers it is much more efficient: its specific length capacity is between 0.02 to 0.04 (m h)/kg and for belt dryers it is between 0.06 to 0.07 (m h)/kg. The capacity of dried material is 5 to 15 times greater compared to low-temperature and pneumatic pipe dryers. It needs 1.55 to 1.7 times less heat per kilo of the wet drying material and it needs 10% to 40 % less electrical energy too.
7. It uses about 34 % of dried material as fuel and the rest is for briquette or similar production.

9. CONCLUSION

An original plant for drying wood waste from primary and final wood processing and briquette production was developed considering different factors. The basic characteristics of the main parts of the plant such as: cyclonic furnace, drum drier and the device for briquettes production are presented. The basic concept of automatic control of the combustion process and high temperature drying has been presented previously and the next step is automation of the whole plant that's planned in the future.

At the same time, the strong demands of environmental protection are satisfied. As it was mentioned before, the wood residues don't contain sulfur and the temperature of combustion is not high enough for the formation of NOx, that's the reason why there is no emission of SOx and NOx into the atmosphere. One of the most remarkable facts is energy savings that rise on up to 50% compared to other plants which use conventional fuels.

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MORPHO-PHYSIOLOGICAL CHARACTERISTICS OF *Miscanthus x giganteus* IN THE FIRST YEAR OF DEVELOPMENT

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Abstract: *Miscanthus giganteus (elephant grass, Chinese grass) is a rapidly growing hybrid crop that produces a high annual yield of biomass and achieves a high energy value during incineration. It is grown as an energy source for combustion in thermal power systems, 1 ha of planted miscanthus replaces 6t of coal or 75 000 kWh of electricity. Miscanthus growing season starts in the first half of April, while the maximum biological yield is established at the beginning of October. Because of the high moisture content and lower biomass quality at the time of maximum biological yield, harvest is done in February, when the moisture content decreases to 20%. Field trials with treatments that include planting density (1, 2 and 3 plants/m^2), increasing doses of mineral fertilizers (0, 50 and 100 kg/ha NPK) and irrigation (with and without irrigation), were used for the study of morpho-physiological features and determination of optimal agroecological conditions, necessary to achieve the maximum yield of biomass. In the first year of development and with the treatment of 100 kg N/ha and the density of three planted rhizomes / m ², the highest yield of 0.58 t / ha dry matter, was achieved. It has a wide ecological valence, the possibility of growing on poor quality soils with unfavorable conditions for the cultivation of annual crops and food production.*

Key words: miscanthus, morpho-physiological features, biomass yield, degraded areas.

INTRODUCTION

Man has always used biological energy sources using the products of photosynthesis of plants, not only as a food but as fuel as well. After a long use of the fossil fuels energy, global image is changing, and renewable sources are considered to be one of the key elements of the future development strategy. Using biomass for energy purposes is one sort of clean technology, i.e. green energy.

Perennial high-calorie grasses with high annual yield of biomass are energy plants, that can be used as a fuel in power plants and heating systems. Energy crops, unlike agricultural crops, are grown for the production of heating energy. They can grow on a soil (land) that is not suitable for agriculture and food production like degraded areas (abandoned open mine pits, ash disposal sites) and areas that can be flooded or dry for a long period of time. The possibility for successful growing energy crops on the soil that is characterized as not good for the needs of agricultural crops and food production mostly come from their basic characteristics.

Beside its wide ecologic valence, energy crops also posses high calorific value that ranges from 15 000 - 20 000 KJ/kg of dry biomass (average calorific value of lignite is 10 500 KJ/kg). Annual yield of biomass is 12 - 20 t/ha. They multiply mostly through rhizomes which means they are not invasive and they do not represent danger for surrounding areas and growing

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cultures. Their life span is between 10 - 20 years and maximum yield of biomass is achieved after the third year.

In the group of lignocellulose crops, which represent potential raw material for energy production, the perennial rhizomes grass Miscanthus (*Miscanthus×giganteus* Greef et Deu.) or Chinese grass stands out by its biomass quality.

As a high productive and very tall C4-grass, Miscanthus is a bioenergetic perennial crop suitable for intensive growth. Interest in Miscathus, as an energy source, started because of its numerous advantages: it produces a large amount of biomass (Heaton et al., 2008), reduction in many agronomic investments (Lewandowski et al., 2000), it has unique growing and harvesting process, good efficiency for water and nitrogen usage for bioproduction, high content of cellulose, non-invasive characteristic and low sensitivity on illness and pests (Defra, 2007; Cadoux et al., 2011). Miscanthus cultivation in European countries is usually based on one species, *Miscanthus giganteus*, a natural triploid hybrid created by crossing the two species *M. sinesis* (diploid) and *M. sacchariflorus* (tetraploid) (Greef and Deuter, 1993; Linde-laursen, 1993). It is noticed that Miscanthus yields significantly vary depending of location and climate conditions, and that the biggest yield are in the South Europe area when water wasn't the limiting factor. The large number of field experiments conducted in the last decade show significant variation in the Miscanthus dry mass yield, ranging from 4-25 t/ha in the countries of Central Europe to 30-40 t/ha for South European countries (Lewandowski et al., 1997; Lewandowski et al., 2000; Jorgensen, 1997; Christou et al., 1998; Acarogly and Aksoy., 2005). Talking about Serbia, the researches show that Miscanthus production can make profitable as much as some of agricultural crops (Dražić i sar., 2005, Dželetović, 2010).

MATERIAL AND METHODS

The experiment was set in the Nocaj village in the area of Sremska Mitrovica municipality. The soil on which the experiment was done is a type of humogley. Miscanthus rhizomes were imported from the registered Austrian manufacturer "Giganteus Miscanthusproduktion" from Boheimkirchen. Planting was done in the beginning of April 2010. 10x10m plantations were made, and each experiment was done 3 times. Rhizomes of 10-15 cm of length with 3-6 nodes were planted by hand around 10 cm in the ground.

By forming experimental fields with different experimental treatments, the research of morphological characteristics in different agroecological conditions was enabled. Morphological characteristics that were followed once a month were: germination, stem number, stem height, leaf formation, bio-covering and tillering power. From analytic methods, the total crop moisture content was measured.The influences of plantation on morphological characteristics of crops were researched in experiment treatments with 1, 2 and 3 rhizomes/m². Mineral fertilizer (NPK15:15:15) of Austrian manufacturer LINZER-AGRO TRADE was used as mineral nutrient supplements. Research was done on the influence of increasing amounts of mineral supplements on morphological characteristics of crops, used amounts varied from 50 and 100kg/ha. In the first year of the development, supplementation was done in June.

The results presented in tables show arithmetic averages of the three control groups of all experiment treatments.

RESULTS AND DISCUSSION

Germination and initial growth of the plants in the first year of the experiment started after 10-15 days from the planting. We noticed the difference in the initial development of the plants, even though the conditions in the experiment were the same. In the first year of development Miscanthus forms a small number of stems, depending on experiment treatment. In the early stages of the crop growing , the number of stems varies significantly (Danalatos et al., 2007). 8-19 stems/m² forms on average during the middle of vegetation period.

In the treatment with the plantation density of 3 rhizomes/m², 100% of biomass ground coverage was achieved, while in the treatment with 1 rhizome/m² the total plant ground coverage was 40% until the end of vegetation period (table 1).

Table 1. *Percentage of plant ground coverage and germination of crops in the first year of development*

Plantation density	1 rhizomes/m²	2 rhizomes/m²	3 rhizomes/m²	2 rhizomes/m² Without agrotechnical measures
(%) of germination	87	86	92	87
(%) of bio coverage	40	72	100	37
Total germination (%)	88			

Plantation density in the first year of the development had a different influence on the crop height. Different amounts of nitrogen did not have an influence on stem height (Christian et al., 2008; Clifton-Brown et al., 2001). Miscanthus reaches its maximum height in the first part of September, and in October it finishes its vegetation cycle and the height of the stem gradually decreases due to the climate factors. The crop reached the biggest height in the treatment with the lowest density of 1 rhizome/m² of 90-147 cm, and the lowest in the treatment with 3 rhizomes/m² 68-120 cm.

With the increase in the amount of used nitrogen, the increase of the % of leaves in the total biomass yield is noticed, which is especially noticeable in the beginning of the winter. In December, in the treatment without using nitrogen there is significant decrease in the percentage of the leaves in the total biomass. Experiment treatments with used amount of nitrogen of 50-100 kg/ha keep their leaves longer on the stems and by that they increase the percentage of the share of leaves in the total biomass of yield (table 2).

Table 2. *Percentage of leaves in the total biomass of yield - the first year*

Datum	Treatment kgN/ha	Leaves			Stems		
		upper	lower	∑	top	bottom part	∑
29 June	0	38,4	20,3	**58,7**	16,1	25,2	**41,3**
	50	41,0	19,0	**60,0**	18,7	22,3	**40,0**
	100	37,0	16,1	**53,1**	17,2	29,7	**46,9**
3 November	0	42,7	9,8	**52,5**	22,3	25,2	**47,5**
	50	44,1	12,9	**57,0**	20,9	22,1	**43,0**
	100	46,4	9,2	**55,6**	25,0	19,4	**44,4**
19 December	0	29,0	4,7	**33,7**	26,1	40,2	**66,3**
	50	33,6	7,2	**40,8**	24,4	34,8	**59,2**
	100	31,2	6,9	**38,1**	23,9	38,0	**61,9**
23 February	0	24,7	2,8	**27,5**	20,7	51,8	**72,5**
	50	29,8	5,1	**34,9**	22,8	42,3	**65,1**
	100	27,4	3,9	**31,3**	21,6	47,1	**68,7**

Tillering intensity, new stems formation from a single vital rhizome (stems/1 rhizome) increases with the increase of the amount of used nitrogen. With the increase of the plantation density, the dynamics of tillering decreases. The most intense tillering of 19 stems/1 rhizome untill the end of vegetation cycle is noticed in the fields with the plantation density of 2 rhizomes/m² and amounts of used nitrogen of 50-100 kg/ha.

Experiment treatment with the biggest plantation density without used nitrogen had the lowest average number of stems/1 rhizome. In the first year there wasn't noticeable significant influence on the tillering intensity with the amounts of 50-100 kg/ha, and the most significant variations were noticed between the treatment without nitrogen and the amount of 50 kg/ha.

Miscanthus achieves its maximum biological yield in the beginning of October, and until harvest in February the average decrease in yield varies from 31,7 to 38,5% depending of experiment treatment. Increasing amount of nitrogen increases yield in all plantation densities. In the fields with bigger amount of used nitrogen leaves stayed on the stems for a longer period of time which decreases pre-harvest losses.

According to Dželetović (2010), the influence of plantation density and used amount of nitrogen on the dry mass of Miscanthus yield in the first year of the development is in favour of the rhizomes plantation density. In the first year of the development the biggest yield was achieved in the treatment with plantation density of 3 rhizomes/m² and the amount of used nitrogen of 50 kg/ha, the field was irrigated 4 times, achieved yield was 0.64 t of dry matter/ha in February. In the same plantation density and the amount of used nitrogen of 100 kg/ha, without irrigation, achieved yield was 0.58 t of dry matter/ha. The results obtained in Italy show that the largest yields have been noted in the case of application larger amounts of fertilizers with irrigation (Foti et al., 1996). The smallest yield amount was obtained in the treatment of plantation density of 1 rhizome/m² without used nitrogen and aditional irrigation, 0.14 t of dry matter/ha, and with the application of irrigation in the same treatment the yield was 0.21 t/ha (table 3).

Table 3. *Yield of Miscanthus biomass (t/ha) in the first year of the development with and without irrigation*

The amount of N kg/ha	rhizomes plantation density/ m²	Dry matter yields without irrigation	Dry matter yields with irrigation
0	1	0,14	0,21
	2	0,19	0,27
	3	0,23	0,32
50	1	0,18	0,31
	2	0,39	0,44
	3	0,47	0,64
100	1	0,18	0,32
	2	0,41	0,46
	3	0,58	0,62

Based on obtained results from our experiment, it is noticed that the amount of used nitrogen does not significantly effect the increase of yield. It has more influence on the decrease of pre-harvest losses in the total biomass. With the application of small amounts of mineral nutrients 50 kg of N/ha with irrigation of 100 mm/m² yields can increase by 2-5 t/ha.

High amount of moisture in Miscanthus is characteristic for the period of intensive growth, from May to September. The content of moisture mostly depends on climate conditions and the amount of used nitrogen. The increase in the amount of nitrogen increases the percentage of moisture in biomass.

In June of the first year, the moisture content in stems was around 85%, and in leaves 64-75%. According to Dželetović (2010), the biggest moisture content in crops is in the beginning of June in the period of intensive growth in height. During the intensive growth of Miscanthus the moisture content in stems varies from 70-85% and from November it decreases for 20-30%. Lewandowski et al., (2000) data show that the moisture content decreases from 70% in November to 20% in March or April. During summer, leaves contain 60-70% of moisture, and in the beginning of fall it decreases to 25%. The Decrease in moisture content is the most visible in winter months, in the harvest period the most percentage of moisture is in the lower part, and the least amount in the upper part of the stem.

CONCLUSIONS

Miscanthus planting is best to perform when the temperature of soil reaches 10°C, middle of April - beginning of May.

Plantation density and the amount of used nitrogen have different effects on morphological characteristics of Miscanthus. With the increase in plantation density and the amount of nitrogen, the number of plants/m² increases, and plant height and tillering intensity decreases. Fields with the largest plantation density of 3 rhizomes/m² and the amount of 100 kg of N/ha gave the lowest yield.

Miscanthus achieves its maximum biological yield in the begging of October, and the increasing amount of nitrogen forms denser vegetation and contributes to leaves staying on the plant for a longer time in all plantation densities. The used amount of nitrogen does not have a major effect on the increase of the yield. It has more effect on the decrease in pre-harvest losses in a total biomass. Irrigation improves the application of nitrogen. In the first year of development the biggest yield of 0.64 t/ha was achieved with the plantation density of 3 rhizomes/m² and the amount of 50 kg of N/ha with irrigation. With the same treatment without irrigation the yield was 0.58 t/ha.

The quality of harvested biomass depends only on the amount of nitrogen and moisture percent. The biggest content of nitrogen and moisture in crops are in the beginning of intensive growth from May to the second half of September. Morpho-physiological characteristics and conditions necessary for achieving the maximum yield and quality of biomass with minimum economic investments were studied through different experiment treatments. The best results of our research done on humogley were achieved with the treatment with plantation density of 2 rhizomes/m² and the amount of used nitrogen of 50 kg/ha.

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THE INFLUENCE OF FERTILISING ON GROWTH OF SEEDLINGS *Paulownia* spp.

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Abstract: *Demand for wood biomass is increasing each year. This imposes the need to introduce the production of new species, characterized by rapid growth, short rotation and high energy value. The calorific value of Paulownia biomass is little over half that of coal same as is other forest biomass. But the lower content of pollutants such as sulphur, lower in Paulownia than most other biomass and the fact that Paulownia is a readily renewable resource clearly points to its environmental benefit. Relying on previous experience, the species of the genus Paulownia Sieb. et Zucc. stand out as one of the alternatives, among willows and poplars, which are mostly grown for this purpose in Serbia.*

Research conducted within these plantations are intended to contribute to determining the adaptive and productive potential of this species in Serbia. The paper presents the results of the development of annual seedlings of Paulownia elongata end Paulownia fortunei on the experimental field Veliko Polje – Obrenovac and Pambukovica – Ub, Serbia. The results obtained in the first year after planting indicate that the fertilizing affected seedling development.

Key words: planting, dendro biomass, productive potential

INTRODUCTION

Numerous studies show that genus *Paulownia* sp. is rich with species that are characterized by rapid growth, short rotation and different usage (El-Showk, S., El-Showk, N., 2003, Vilotić et.al, 2011, Mitrović, et.al, 2011.). Extremely high demand for a wood as a raw material, different researches are aimed on the introduction of species with this kind of characteristic.

The first plantations of fast-growing species *Paulownia elongata* and *Paulownia fortunei* in Serbia was established in 1993. That was an experimental plantation near Bela Crkva (Vilotić et al., 2011). Now, in Serbia, there are many experimental and production plantations of these species.

Paulownia fortunei (Seemann) Hemsley in F.B. Forbes&Hemsley (syn. *Campsis fortunei* Seemann; *Paulownia duclouxii* Dode; *P. meridionalis* Dode; *P.mikado* T.Ito) is a tree that can reaches a height of 30 m and diameter up to 2m. Rounded crown and straight trunk with gray-brown bark (Šilić, Č. 1990, Cvjetićanina, R., Popović, M. 2009).

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Paulownia elongata S.Y.Hu can reach a height over 10m, has a broadly conical crown. Wild or cultivated, this species grows in China at lower altitudes (Šilić, Č. 1990, Cvjetićanina, R., Popović, M., 2009).

Exploring the potential of fast-growing species is significant in terms of tackling global warming, which is main topic worldwide. There are many different attempts concentrate on solving this problem, but one that is common to all, is CO_2 absorption by plants, where fast-growing species have a special role.

These facts justify the increasing interest for exploring the success of fast-growing species to adapt to our conditions.

Thanks to the to the hairs on the leaf surface and a great leafs mass, species of the genus *Paulownia*, filtrate the air binding carbon dioxide and pollutants and retaining it in his crown.

Growth rate of *Paulownia* sp. depends on site conditions. Natural habitats of these species are very large scale, from tropical to Mediterranean climates. Species can grow at altitude of up to 2400m, at habitats with an average annual rainfall of 500 to 2000mm (Navroodi I. Hassanzad, Rostami, T., Vilotić, D. et al 2011).

If the tree of Paulownia sp. cultivate for the production of energy crops or production of pulp and paper, trees are ready for harvest after the third year. After cutting the wood is easily regenerated. Outgrowth totally cover the stump and a tree is ready for harvesting after tree to four years. These cycles can be repeated 10 times (Best Practice Guidlines, 2007).

Thanks to very powerful and branched root system and modest requirements in terms of soil conditions, *Paulownia* species are very suitable for stabilizing unstable soils and eroded habitats (El-Showk, S., El-Showk, N., 2003, Veselinovic et al 2010.). Thanks to the great mass of the leaf which is rich in nitrates, leaf waste of this species has a very pronounced role in improving soil quality around the tree. Plowing the fallen leaves for many years, in older cultures, can be created fertile ground, even on sandy soils (Vukovojac, S., Vilotić, D. 2007). *Paulownia* sp. can grow on all types of soil but the growth rate of plants depends on the type of soil, climate, fertilizing and care. The ideal soil pH is 5-8. Suitable soils for growing are those in which a level of groundwater does not exceed 1.5m below the surface. Different species of *Paulownia* submit differently on low temperatures, which range from -10 to -25°C.

The aim of this study was to examine the influence of fertilizing on growth of Paulownia elongata and Paulownia fortunei at different sites, in the second year after planting, in order to get the most quality plants.

MATERIAL AND METHOD

Research is focused on plants of *Paulownia elongata* and *Paulownia fortunei* age of 2 years after planting (1+2). Seedlings were planted at two sites, experimental field I in Veliko Polje near Obrenovac and experimental field II in Pambukovica near Ub.

The plot of field trial I is flat, at 74m above sea level. It is oriented in a northwest-southeast direction. It is located almost in the center of the northern warm temperate zone, where is a moderate continental climate, characterized by warm summers and cold winters.

Experimental site II is located on a parcel that is wavy; the altitude ranges from 162m to 175m. The plot in most has the southeast exposure, in one small part has northwest exposure. In the southern part the plot is surrounded by beech and oak forest. The climate is temperate continental. Transitional seasons are variable with autumn which is warmer than spring. Summers are hot with stable weather and occasional brief downpours.

In the experiments, three treatments were used:

treatment I – plants were fertilized with 120 g of Fertor,
treatment II – plants were fertilized with 240 g of Fertor,
treatment III – plants were not fertilized – control.

Photo 1. *Experimental field I located in Veliko Polje near Obrenovac, Serbia*

Photo 2. *Experimental field II located in Pambukovica near Ub, Serbia*

For fertilizing the chicken manure (Fertor) was used. Fertor is the organic fertilizer (made from 100% chicken manure, with the addition of other organic substances of plant origin) in the form of pellets. Fertor contains the basic elements (N, P, K, Ca, Mg) and trace elements (Fe, Mn, B, Zn, Cu). One part of macro and micronutrients is in a form that is easily accessible to the plant, while the other part of elements has the ability of the gradual release. This fact is of great importance, especially in acid soils. In acidic media Fertor can be available for plants immediately and over a longer period of time and dose not tied up in compounds that are inaccessible to plants. In this way is secured supply of plant nutrients throughout the growing season (http://agro-ferticrop.rs/memon).

At the end of the growing season diameter of root neck, height of the plants and number of nodes were measured.

Photo 2. *Paulownia fortunei* and *Paulownia elongata*, Veliko polje (experimental field I)

Photo 4. *Paulownia fortunei* and *Paulownia elongate*, Pambukovica (experimental field II)

In statistical data analysis, starting hypothesis was that between the average of the samples of the site, the species and the type of fertilizing has no statistically significant differences in observed characteristics (P>0.05). For statistical analysis, we used the software STATGRAPHICS (Statistical Graphics Corporation, USA).

RESULTS

Soil analysis was performed in an accredited (ISO 17024) laboratory of the Institute of Forestry, Belgrade. On experimental plots in Obrenovac soil belongs to the class of clay by the texture. The dominant fraction seems fraction of particles smaller than 0.002mm, which implies that this sample represents slightly permeable and poorly aerated soils. (Table 2). The reaction of the soil solution in water, examined soil is it between the highly and moderately acidic. According to the degree of saturation with adsorption complex soil belongs to eutric and the total content of humus is low (table 1).

Table 1. *Chemical properties of soil - Veliko Polje (experimental field I)*

label	pH		Adsorptive complex					Total		C/N	accessible	
	H_2O	KCl	T	S	T-S	V	Y1	Humus	N		P_2O_5	K_2O
			ekv.m.mol/100g			%	cm3	%	%		mg/100g	
0-20	5.60	5.03	32.20	23.32	8.88	72.43	13.66	1.08	0.23	2.78	24.19	23.27
20-40	5.81	5.23	33.51	24.63	8.88	73.51	13.66	2.17	0.37	3.38	24.89	26.72
40-60	5.81	5.16	32.64	23.76	8.88	72.80	13.66	1.68	0.35	2.81	25.62	24.00

Table 2. *Physical properties of soil - Veliko Polje (experimental field I)*

Label	Coarse sand	Fine sand	Dust	Clay	Total sand	Total clay	Texsture class
	%	%	%	%	%	%	
0-20	5.40	25.20	27.10	42.30	30.60	69.40	Clay
20-40	5.70	25.00	26.80	42.50	30.70	69.30	Clay
40-60	5.50	24.10	26.40	44.00	29.60	70.40	Clay

The soil of the area of Pambukovica belongs to clay loam by the textural class (Table 4). Total clay content is very high. The least represented fraction is the coarse sand. This means that the land is poorly permeable to water and poorly aerated. Chemical properties were characterized by strong acidity of the soil solution (Table 3). According total humus content (which is 0.68%) land belongs to the very low humic. Analysis of soil samples indicated a lack of organic matter, nitrogen and phosphorus.

Table 3. *Chemical properties of soil - Pambukovica (experimental field II)*

label	pH		Adsorptive complex					Total		accessible	
	H_2O	KCl	T	S	T-S	V	Y1	Humus	N	P_2O_5	K_2O
			ekv.m.mol/100g			%	cm3	%	%	mg/100g	
A	5.00	3.90	34.23	18.44	15.79	53.86	24.30	0.69	0.13	0.5	22.8
B	5.00	3.90	32.92	18.01	14.91	54.69	22.95	0.68	0.12	0.5	24.2
C	5.10	3.90	33.36	18.01	15.35	53.98	23.62	0.53	0.11	0.0	17.4

Table 4. *Physical properties of soil - Pambukovica (experimental field II)*

Label	Coarse sand	Fine sand	Dust	Clay	Total sand	Total clay	Texsture class
	%	%	%	%	%	%	
A	2.60	30.30	28.60	38.50	32.90	67.10	Clay loam
B	2.60	31.40	28.10	37.90	34.00	66.00	Clay loam
C	2.10	31.60	27.30	39.00	33.70	66.30	Clay loam

To improve the soil quality each plant was hoed and added 1250g of sand, 1kg inorganic soil conditioner and 25g of polymer. It was used inorganic soil conditioner Sunoco (http://www.sunoko.rs/sr/5-agroservis/), to improve the pH of the acidic soil as well as to improve the structure of the soil and polymer hydrogel Stockosorb 660 micro to improve water retention (http://corporate.evonik.com/en/products/pages/default.aspx).

Statistical analysis included the set of 540 data. The design of the experiment corresponding analysis of variance of three factors of variability. Variability factors are: site (2 levels: Site I and Site II), species (2 levels: type 1 and type 2) and fertilizing (3 levels: fertilizer 1 fertilizer 2, and control 3; total: 2 x 2 x 3 = 12). Core sample contained 15 plants which were measured on three properties (root collar diameter, height and number of nodes; total: 12 x 15 x 3 = 540).

The basic statistical parameters for the measured plant properties at the end of the vegetations season were presented at the table 5.

Table 5. *Plant properties*

location	species	fertilizing	root collar diameter n=15	Height n=15	number of nodes n=15
site 1 Veliko Polje	Species 1 *P. elongata*	fertilizer 1	11,05 ± 3,92	46,40 ± 15,05	5,60 ± 0,74
		fertilizer 2	13,47 ± 2,99	50,84 ± 11,69	6,67 ± 1,59
		control	7,14 ± 2,74	28,73 ± 5,92	3,67 ± 1,11
	species 2 *P. fortunei*	fertilizer 1	10,29 ± 1,99	37,73 ± 7,03	4,87 ± 1,25
		fertilizer 2	11,25 ± 1,71	39,17 ± 6,05	4,80 ± 0,68
		control	7,06 ± 1,64	28,33 ± 8,62	4,27 ± 0,88
site 2 Pambukovica	species 1 *P. elongata*	fertilizer 1	8,81 ± 2,67	30,67 ± 10,75	1,18 ± 0,43
		fertilizer 2	8,32 ± 2,16	30,73 ± 9,55	4,33 ± 0,72
		control	6,89 ± 2,72	23,40 ± 11,29	4,07 ± 1,22
	species 2 *P. fortunei*	fertilizer 1	9,36 ± 3,02	35,33 ± 12,32	4,93 ± 1,39
		fertilizer 2	9,20 ± 1,74	34,93 ± 7,78	4,33 ± 0,90
		control	6,43 ± 2,43	24,73 ± 10,26	4,07 ± 1,22

* mean value ± standard deviation

There were statistically significant differences in the mean values of root collar diameter between the localities (table 6 and table 7). There are also significant differences in the mean values of diameters between fertilization treatments with different amounts of added fertilizer (table 6 and table 8). Interactions between location and fertilizer was also statistically significant. However, no statistically significant differences in the mean values among species in diameter, which means that this factor does not affect the value of the diameter. Values are larger in diameter at the Veliko polje and the treatment where plants was treated with higest amount of fertilizer (table 7 and table 8).

Table 5. *ANOVA for property root collar diameter*

Source of variation	*SS*	*df*	*MS*	*F- value*
Factors				
A:locality	1,47884	1	1,47884	21,54*
B:species	0,00866893	1	0,00866893	0,13
C:fertilizing	5,40318	2	2,70159	39,35*
Source of variation				
A x B	0,0816628	1	0,0816628	1,19
A x C	0,446851	2	0,223426	3,25*
B x C	0,0108465	2	0,00542327	0,08
residual	11,6728	170	0,0686633	
total	19,1028	179		

* statistically significant difference ($P \leq 0.05$)

SS=sum of squares, df=degrees of freedom, MS=mean squeres

Table 6. *Differences in root collar diameter between sites*

location (number of plants)	mean value	standard deviation	statistical significance
Veliko polje 1 (90)	10,04	3,44	b
Pambukovica 2 (90)	8,17	2,67	a

a,b... localities marked with different letters are significantly different compared to each other ($P \leq 0.05$)

Table 7. *Differences in root collar diameter in relation to fertilizing*

Fertilizing treatments (number of plants)	mean value	standard deviation	statistical significance
fertilizer 1-120g Fertor (60)	9,88	3,03	b
fertilizer 2-240g Fertor (60)	10,56	2,94	b
control (60)	6,89	2,38	a

a,b... treatments marked with different letters are significantly different compared to each other ($P \leq 0.05$)

Site factor affects the investigated property highest and the differences in the mean values were statistically significant (table 9 and table 10). Manure as a factor also affected the status of seedling height and achieved mean difference between treatments was statistically significant (table 9 and table 11). The interaction between location and type was also statistically significant. However, no statistically significant differences in the mean values of heights between species, which means that this factor does not affect on the value of height. Values of hi ght are larger in the Veliko polje and the treatment where plants was treated with higest amount of fertilizer (table 10 and table 11).

Table 8. *ANOVA for plant hight property*

Source of variation	*SS*	*df*	*MS*	*F- value*
Factors				
A:site	3,06054	1	3,06054	35,97*
B:species	0,0166398	1	0,0166398	0,20
C:fertilizing	5,7402	2	2,8701	33,73*

Source of variation				
A x B	0,774509	1	0,774509	9,10*
A x C	0,0740328	2	0,0370164	0,44
B x C	0,0313196	2	0,0156598	0,18
residual	14,4641	170	0,085083	
total	24,1614	179		

* statistically significant difference (P≤0.05)
SS=sum of squares, df=degrees of freedom, MS=mean squeres

Table 9. *Differences in height between sites*

location (number of plants)	mean value	standard deviation	statistical significance
Veliko polje 1 (90)	38,53	12,56	b
Pambukovica 2 (90)	29,97	11,12	a

a,b... localities marked with different letters are significantly different compared to each other (P≤0.05)

Table 10. *Differences in plants hight in relation to fertilizing*

Fertilzing treatments (number of plants)	mean value	standard deviation	statistical significance
fertilizer 1-120g Fertor (60)	37,53	12,73	b
fertilizer 2-240g Fertor (60)	38,92	11,59	b
control (60)	26,30	9,30	a

a,b... treatments marked with different letters are significantly different compared to each other (P≤0.05)

There were statistically significant differences in the mean values of number of nodes between localities, that means that the factor locality affecting the studied property, number of nodes (table 12 and table 13). There are also significant differences in the mean values of the number of nodes between treatments with different amounts of added fertilizer (Table 12 and table 14). The interaction between location and amount of added fertilizer was also statistically significant. There were no statistically significant differences in the mean values of number of nodes between species, which means that this factor does not affect the value of the number of nodes.

Table 11.*ANOVA for property number of nodes*

Source of variation	*SS*	*df*	*MS*	*F- value*
Factors				
A:locality	0,489212	1	0,489212	12,05*
B:species	0,0384104	1	0,0384104	0,95
C:fertilizing	1,2813	2	0,640651	15,78*
Source of variation				
A x B	0,151073	1	0,151073	3,72
A x C	0,423645	2	0,211823	5,22*
B x C	0,307765	2	0,153883	3,79*
residual	6,90369	170	0,0406099	
total	9,5951	179		

* statistically significant difference (P≤0.05)
SS=sum of squares, df=degrees of freedom, MS=mean squeres

Table 12. *Differences in the number of nodes between sites*

locations (number of plants)	mean value	standard deviation	statistical significance
Veliko polje (90)	4,98	1,43	b
Pambukovica 2 (90)	4,35	1,13	a

a,b... localities marked with different letters are significantly different compared to each other (P≤0.05)

Table 13. *Differences in the number of nodes in relation to fertilizing*

fertilizing treatments (number of plants)	mean value	standard deviation	statistical significance
fertilizer 1-120g Fertor (60)	4,95	1,21	b
fertilizer 2-240g Fertor (60)	5,03	1,40	b
control (60)	4,02	1,11	a

a,b... treatments marked with different letters are significantly different compared to each other (P≤0.05).

CONCLUSIONS

The statistical analysis of the measured data of the indicators of quality seedlings, it can be concluded that the amount of added fertilizer affected plants in the root collar diameter and plant height. Mean values for both parameters were higher in the treatment where the plants are fertilized with plenty of fertilizer and the differences were statistically significant.

Soil analysis indicated that the soil at the site Obrenovac has better mechanical and chemical composition compared with locality Pambukovica. Results of measured properties of plant growth on the research areas show that the quality of the soil had effect on seedling growth. The differences in the mean values of the root collar diameter and height of the plants were higher at the site with more favorable pedological properties. These differences were statistically significant.

Number of nodes is higher in localities with poor characteristics of the soil and this can be explained by plants struggle to survive in poorer habitat ecological conditions. Because of the large number of nodes at a lower elevation the distance between them is shorter, so the density of leaves in the canopy of plants is larger. This has a negative impact on the growth of leaves which resulting in a lower total leaf area. Smaller total leaf area caused the reduced potential of the plant in realizing photosynthetic processes which are the basis for the development of plants and plant vitality. This phenomenon should be examined in more detail in further research.

Based on a comparison with literature data it can be concluded that the research areas regardless of the positive impact of supplemental fertilizing are not favorable for the development of the species *Paulownia elongata* and *Paulownia fortunei*. Achieved mean values of height as well as diameter of root neck are much smaller than achieved values of the fast-growing *Paulovnia* sp. species achieved at some better habitats.

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BIOMASS PRODUCTION IN CULTIVATED WETLAND ECOSYSTEMS

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Abstract: *The investigations of biomass production were conducted at wetland ecosystem near protected natural reserve of Zasavica in Srem region, near Nocaj vilage. A part of natural wetland ecosystem was used for agricultural production (crop farming), and a part stayed in natural condition. In 2010 field experiment was established with fast growing crop Miscanthus gigantheus in two variations: application of basic agrotechnical measures and application of complete agrotechnical measures. Biomass production (kg/m2) was measured in terms of maximal production, in October 2011 and recommended harvest time in February 2012 for Miscanthus I (with complete agrotechnical measures), Miscanthus II (just basic treatment), natural vegetation common reed (Phragmites communis) and natural vegetation of willow (Salix sp.). Energy values were determined after preparation of pellets. Maximal heating value was determined for Salix (18,51 MJ/Kg), for other around 17,6 MJ/Kg with low moisture and ash contents. Maximal production of dry biomass were Salix>Miscanthus I>reed>Miscanthus II, but in early spring harvest the order was Miscanthus I> Salix>Miscanthus II>reed. Yield energy was calculated per m^2 based on technologically dry biomass (with 15% of moisture) and based on dry biomass. Potential energy yield per unit of soil surface was calculated based on determined parameters with requirement of similar conditions. The results show that Miscanthus production with the application of complete agrotechnical measures is similar to willow production and that it is bigger than natural reed production. The results were discussed from the aspect of preservation and improvement by wetland production of energy crops.*

Key words: wetland ecosystems, biomass production, energy values, potential energy yield

INTRODUCTION

Wetlands are ecosystems that provide abundant services and materials that have economic value, not only to the adjacent local population but also to regional communities [1]. They provide water quality improvement, flood mitigation, erosion control and recreational enrichment. Recently, the potentials of bioenergy production from wetland biomass were getting attention. Although it was argued that displacement of natural forest and wetland by biomass crops would damage the ecosystem function [2]. It was pointed out that if biomass crop species are properly chosen and sited, the incorporation of energy crops into agricultural system or marginal agricultural lands could provide extensive wildlife habitat and address soil and water quality concerns, in addition to generating renewable energy.

The most important bioenergy feedstocks in Serbia are starch crops (such as maize or sugar beet) serving as a basis for making ethanol, oilseed crops (such as rapeseed or sunflower) for making biodiesel, residues: from agriculture (crop residues, manure), from forestry (sawdust, pellets, black liquor) and from urban areas (municipal solid waste, biogas from landfills). While the first two are agricultural crops in which only the seed or the tuber is used for energy

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generation, here it is the entire plant. Energy is obtained either through direct combustion or as a feedstock for second-generation biofuels. This biomass has very heterogenic quality and quantity, so the need for growing bioenergetic crops for providing sufficient amounts of biomass with controlled quality.

Biomass crops are usually either grasses which can produce prodigious amounts of biomass or fast-growing trees such as willow or poplar [3]. The initial question for biomass research with perennial grasses was to identify those grasses that are the best for the demands of bioenergy production, namely high biomass yields and appropriate biomass characteristics.

Several grasses and trees suitable as feedstock for bioenergy can be grown in the Serbia. Among the trees, willow is a highly suitable crop for wetlands. As for grasses, Miscanthus has been studied for this purpose. Another grass which is indigenous is the common reed (Phragmites). It is not normally cultivated, but for centuries it has been harvested in the wild as a raw material for handicrafts; today it is still used for thatching. It is a prolific producer of biomass, both above and below ground; and since it is an inhabitant of wetlands, it holds promise for the alternative use of fens [4]. Since no fertilizer is added, this deduction is much lower than with conventional biofuels; also, there is no additional emission of nitrous oxide, which greatly diminishes any positive effect that those biofuels may have. Furthermore, biomass produces more energy per hectare, so its beneficial effect on greenhouse gases is that much larger. [5]

AIM

To investigate the energy yield of *Miscanthus giganteus* grown in semi natural conditions in comparisons with natural (autochthony) vegetation.

MATERIAL AND METHODS

Site description

Experiment field is located in the area of Nocaj village, municipality of Sremska Mitrovica, near Special reservation of nature of Zasavica. Natural vegetation is characterized as swamp, but the soil is used for agricultural production of arable crops (mostly corn). Soil type is humogley and the level of the ground water is very high. The land is divided by meliorative canal on which banks wild cane (Pharagmites) grows which is being repressed by mechanical methods to clear the land for arable crops. Parts that are not cleared are under wild willow (Salix).

Plant material

Plant material, rhizomes of *Miscanthus x giganteus* (with a length of 10 cm and with 3 - 6 nodes), was purchased from commercial supplier and manually planted on agro-technically prepared land (plowing was conducted in the fall of the year before the planting and dicing just before the planting). Crop spacing was conducted with a following density of canopy: distribution of the planted rhizomes was 1 m between rows and 0.5 m between plants within one row. The experiment started in April 2010, and the experimental field divided in 2 zones: zone I – intensive mechanical and weed control, watering and fertilizer (100 kg/ha N:P:K) were applied in order to determine potential of biomass production and zone II – only land preparation and watering once after planting.

Natural reed and willow canopy at the experimental field were used without any interventions.

Aboveground biomass was harvested in the moment of maximal yield (October 2011) and recommended harvesting time (February 2012) from randomly chosen plots of 1m^2 (in 3 repetition) for Miscanthus and common reed and from 9 willow plants.

Energy values

The heating value, ash content and moisture content are determined in accordance with standards ÖNORM EN 14918, DIN 51719, ÖNORM EN 14775 and ÖNORM EN 14774 [6-9]. Energy values were determined after preparation of pellets from the total sample of Miscanthus, Common reed and Willow from the early spring harvest. Yield energy was calculated per m^2 based on dry biomass.

RESULTS AND DISCUSSION

There were no major differences between heating values of pellets which varied within the range 17,55-18,51 MJ/kg (table 1). The differences observed were caused by moisture differences of the pellets, which varied within the range 6,64-8,09%. The observed heating values are in accordance with German standard DIN 51731 which indicates that heating value for pellets should be between 17,5 and 19,5 MJ/kg. Fertilization hadn't major impact on heating value, ash content and moisture content for Miscanthus. The results presented in table 1 showed that ash content in pellets not met pellet fuel standard requirements (<1,5%) of German standard DIN 51731. In general, the leaf material has more ash content than the grass stems, so agricultural strategies like choice of soil type for producing crops, selection of mechanical harvesting techniques and reducing the leaf component by delaying the harvest may considerably improve the suitability of biomass for combustion plants [10].

Table1. *Energy values*

Sample	Upper heating value [6]	Heating value [6]	Ash content (815°C) [7]	Ash content (550°C) [8]	Upper heating value [6]	Moisture content [9]
Unit	MJ/kg	MJ/kg	% (dry)	% (dry)	MJ/m2	%
Miscanthus I	18,88	17,6	5,22	5,28	7,10	7,72
Miscanhtus II	18,83	17,55	5,30	5,29	5,10	8,09
Willow	19,79	18,51	3,50	4,02	4,86	6,64
Common reed	18,98	17,70	4,78	4,97	6,85	7,2

Yields

Yields measured in October present maximum yields for the whole research year and they ranged from 0.520 kg/m^2 (5.2 t/ha) for Miscanthus without agrotechnical measures and from 0.745 kg/m^2 for willow. Real yields were measured in the early spring and they ranged from 0.322 kg/m^2 for Miscanthus without agrotechnical measures to 0.484 kg/m^2 for Miscanthus grown with agrotechical measures. As the samples contained different amounts of moisture, values are calculated to technological moisture level of 15% and dry matter and the results were given in the chart 1. The way of results presentation did not affect the ratio of measured biomass so Miscanthus without agrotechnical measures achieved similar yields as cane which was lower compared to Miscanthus with agrotechnical measures and willow (which are closely related).

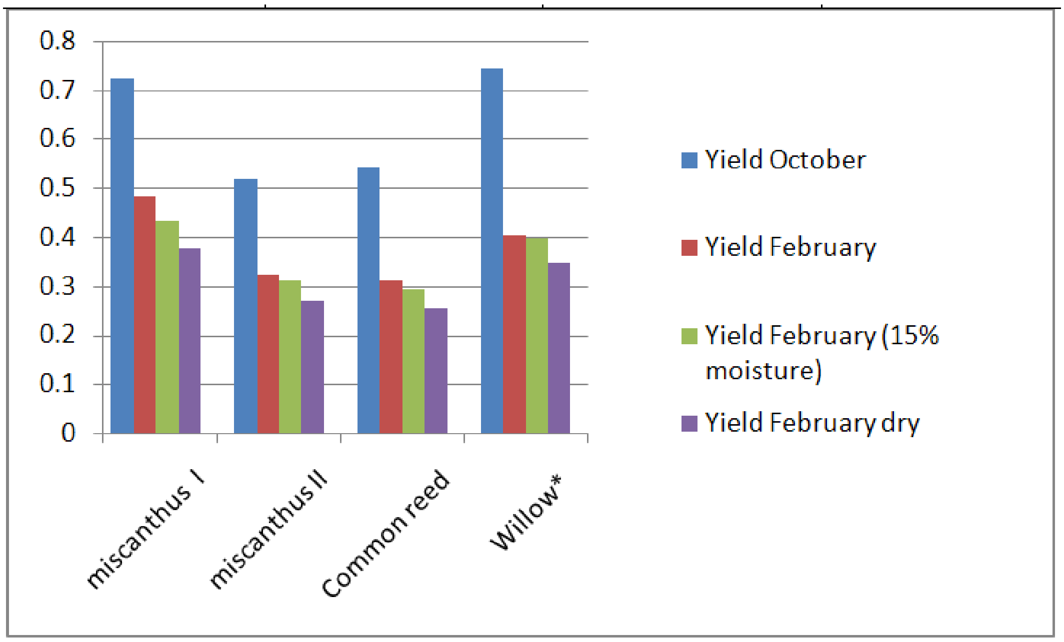

Figure 1. *Comparative review of yield*

Presents data of measured quantities related to Miscanthus yields in the first year of growth. Miscanthus achieves its maximum yields from the third year [10]. Obtained yields will be at the level of 10-14 t / ha (1 to 1.4 kg/m2) by the third year, in early spring with 15-20% humidity. Cultural practices have increased Miscanthus yields significantly.

Miscanthus yields that have been obtained in other studies ranged from 5 to 44 t / ha, (0.5 to 4.4 kg/m^2) [11]. Several studies, done in Europe, indicate that N fertilization is necessary mainly on soils with low N content. At locations with sufficient N and soil organic matter, N fertilization can be avoided or limited to 50-70 kg/ha/yr [11]. It is necessary to analyze the soil prior to plantation or use of cultural practices.

Data from the literature on biomass production in natural and manmade wetlands are very different and usually refer to total production or photosynthetic productivity and generally depend on climate parameters and water quality [12][13][14]. This is the reason that we are not going to discuss about the productivity of observed ecosystem but only compare yields of aboveground biomass. According to the obtained results we can conclude that in the conditions with humogley, high ground waters and mild continental climate, production of induced species Miscanthus giganteus achieves the same yields as common reed if minimal agrotechical measures are applied.

In case of fertilizer application yields of biomass and energy can be increased, probably as a consequence of low soil nutrients content. From the aspect of environmental protection and wetland ecosystem it is more acceptable to grow Miscanthus on this land than corn, because the use of mechanization and fertilizes is limited only to the first year of planting unlike corn where it has to be done every year. Considering willows, the results are not absolutely comparable because the experiment used one and two year sprouts from the trees that have been previously trimmed. In any case, growing of energy crops (either perennial grasses or willows) can be recommended for wetland areas if they are not already put under protection as a very sensitive ecosystems.

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POTENCIAL OF BIOMASS FROM SERBIAN FORESTS FOR COMBINE HEAT AND POWER COGENERATION

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Abstract: *In 2007, Serbia ratified the Kyoto Protocol, taking over the responsibility to increase the amount of energy produced from renewable energy sources. The annual wood biomass energy potential in Serbia is approximately 1Mtoe As the total annual consumption of primary energy in Serbia in 2011 was about 17.4Mtoe; from this it is clear that biomass derived from forestry can cover even 5.74% of primary energy in Serbia, if it is rational and adequately used. Also, wood biomass is favourable fuel as it is rich in carbon and having in mind environmental protection issues, due to closed circle of carbon-dioxide (CO_2 produced in combustion processes are used for oxygen production in photo-synthesis). In addition to that, in a system with natural air circulation in gasification process of wood biomass, there is no emission of NO_x components which is great advance in compare with classic combustion of biomass ([7]).*

The regions in Serbia, the largest producers of wood waste after forest harvesting are presented in the paper. The structure of wood waste, its characteristics, as well as machines for obtaining wood chips are analyzed. In the conclusion the estimation of amounts of wood chips is given for a demo CHP plant with 200kW of electric power which is under construction. The work is supported by The Ministry of Education and Science of the Republic of Serbia and presents the research work in frame of the the project "A new biological material to protect land and water, Project No. TR-37002.

Key words: wood waste, estimation, energy, CHP plant.

1. INTRODUCTION

According to the Biomass Action Plan from 2010 to 2012.year ([1]), the annual energy potential of biomass in the Republic of Serbia is about 2.7 Mtoe. The energy potential of biomass from forestry and wood industry (cutting of trees and the remains of trees produced in the primary and / or industrial processing of wood) is estimated to be approximately 1.0 Mtoe, while about 1.7 Mtoe derived from agricultural biomass (agricultural wastes and residues from farming, including liquid manure). As the total annual consumption of primary energy in Serbia in 2011 was 17,4Mtoe; from this it is clear that biomass derived from forestry and timber industry can cover even 5.74% of primary energy in Serbia, if it is rational and adequately used. Biomass is traditionally used for years in the world to the production of heat, but the output in 2008.year in Serbia amounted to only 0.3 Mtoe, which means that only 11% of available energy, biomass utilized. As in Serbia, doesn't exist official estimates of biomass availability to the internationally recognized methodology, this paper attempts to, based on data collected from forest logging and perform.

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2. AMOUNTS OF WOOD WASTE IN SERBIAN FOREST

Serbia belongs to the middle forested countries where the forest there is 29.1% of its total territory. In Vojvodina, the forested and only 7% of its territory, while in the central Serbian forestation percentage of 37.6% ([2]). In relation to the global aspect of this is covered close to the world that is 30% and significantly lower than Europe, which reaches to 46% ([6]).

In relation to the population of forested land in Serbia is 0.3 hectares per capita, while in neighboring countries and much higher amounts eg. in: Croatia, 1.25 hectares per capita, Bosnia and Herzegovina 1.38 hectares per capita. What joy is that in the last 20-30 years the forestation in Serbia has been increased by 3-5%. In Serbia there are 49 species of which 40 are deciduous trees, conifers and 9. The most abundant species of deciduous trees such as: beech (40%), poplar and oak, while the most common representatives of conifers: pine, spruce.

The average density of forests in Serbia is 939loggs/ha, and the average volume in the forests of Serbia is 161m^3/ha ([2]). Density values of forest regions in Serbia are quite different. A large region with municipalities that have extensive coverage of its territory is forest in eastern Serbia. The region made up of Majdanpek (80%), followed Kučevo, Žagubica, Despotovac, Pine and Baljevac (all with 41-60%). Another major forests rich region located in southwestern Serbia, comprises of Prijepolje (80%), Priboj and Kursumlija (61-80%), and several neighboring municipalities with a share of forest surfaces of between 41 and 60% of the municipality. Density values of forests are very different in parts of the region.

Figure 1 showing the ownership of forests in the municipalities in Serbia. It can be concluded that more than half the forests in state ownership and that the majority of coniferous forests in state ownership. As for Vojvodina, almost all forests are state, and very few of the coniferous stands.

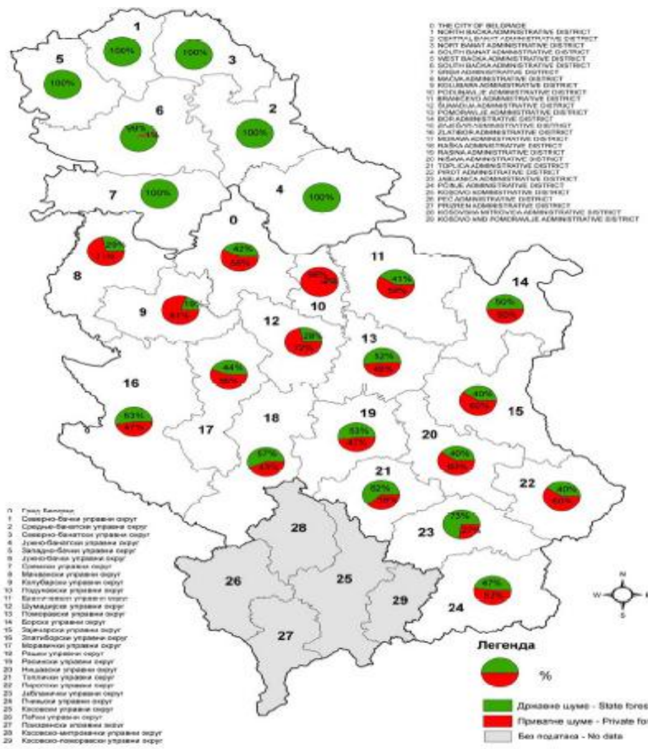

Figure 1: *Ownership of forests by the territorial districts of Serbia (state forest – green, red – private forests)*

Display felled timber by districts for 2009. Table 1 gives the broadleaves that are separated from the deciduous conifer stands. We see that the proportion of the visited timber stock in sawmills 90.1% and 9.9% of all conifers. In central Serbia was cut 75.8% of the total wood volume, whereas in Vojvodina district was cut 24.2% of total amount. Also, the dates about the visited timber stock in the regions are quite different. In central Serbia the highest volume of harvest is to: Zlatibor, Raška, Pčinj and Rasinski region, whereas in the case with: Sremski, Južnobački and Južnobanatski region in Vojvodina district. It is interesting to note that the percentage of cut hardwood stands in the regions rather uniform, while in conifers cut in the Zlatibor and Raska district reaches 70% of the total harvest. In the last column of Table 1 provides the estimated quantities of wood waste. The data on the amount of wood scrap by regions were unable to get either from JKP "Srbijašume" or from the Republic Institute for Statistics. That's why the values were calculated according to the literature [3].

Table 1: *Felled timber regions in Serbia in 2009*

Districts 1) and Regions 2)	Broadleaves		Conifers		Tecnical wood	Wood waste 5)
	m^3	% 3)	m^3	% 4)	m^3	t
Republic of Serbia	2347094	100	256369	100	935190	593589.6
Central Serbia 1)	1728861	73.66	245664	95.8	580067	450192.0
Vojvodina 1)	618233	26.33	10705	4.2	355123	143397.6
Mačvanski 2)	128714	5.48	1217	0.48	46704	29623.8
Kolubarski 2)	60169	2.56	488	0.19	13025	13830.0
Podunavski 2)	1799	0.08	-	-	471	409.8
Braničevski 2)	114580	4.88	925	0.36	20413	26335.2
Šumadijski 2)	40223	1.71	880	0.34	3717	9371.4
Pomoravski 2)	115756	4.90	2281	0.89	28998	26912.4
Borski 2)	96496	4.11	1933	0.75	24544	22441.8
Zaječarski 2)	116140	4.95	3980	1.55	16635	27387.0
Zlatiborski 2)	122078	5.20	126141	49.20	132637	56593.8
Moravički 2)	112791	4.81	19982	7.79	32325	30271.8
Raški 2)	144372	6.15	53134	20.72	89649	45031.2
Rasinski 2)	116400	4.96	8797	3.43	33869	28544.4
Nišavski 2)	83653	3.56	1783	0.69	10625	19479.6
Toplički 2)	101742	4.33	1566	0.61	24317	23716.2
Pirotski 2)	64782	2.76	7548	2.94	11589	16491.0
Jablanički 2)	127866	5.45	3010	1.17	-	29839.2
Pčinjski 2)	118483	5.05	11448	4.46	26959	29624.4
City of Belgrade 2)	62 727	2.67	551	0.21	38388	14427.0
Severnobački 2)	5569	0.23	3937	1.54	3917	2167.2
Srednjobanatski 2)	43313	1.84	-	-	29781	9875.4
Severnobanatski 2)	15322	0.65	-	-	11299	3493.2
Južnobanatski 2)	101752	4.33	6472	2.52	52103	24675.0
Zapadnobački 2)	86993	3.70	-	-	49564	19834.2
Južnobački 2)	144523	6.16	204	0.08	87967	32997.6
Sremski 2)	220761	9.41	92	0.04	120492	50354.4

1), 2) - according to the literature [11]; 3) - the total volume of felled broadleaves in the Republic of Serbia; 4) - the total volume of felled conifers in the Republic of Serbia; 5) - the estimated amount of potential scrap ([3])

In Serbia, there are four national parks. Moving from north to south these are: Fruška Gora in Vojvodina (25 390 hectares), Derdap along the Danube (63 600 ha), Tara mountain near the Drina (19 710 ha) and mountain Kopaonik (11 810 ha). In addition to these four national parks, there are several large protected areas of natural goods that are also of interest as sources of wood waste. These are: Golija, Stara Planina and the headwaters of the river Ibar. Hence, it should be noted that the National Parks of state-owned enterprises while the protected natural resource areas in general have mixed ownership, some parts are private and some state-owned. In addition to data on the visited timber stock is necessary to know the yield of wood in order to know the amount of scrap that can be counted in the coming years. Growth depends on: tree species, rainfall, soil fertility and area. Unfortunately, data on forest growth are very different. In the literature mainly contain data from 2 to 60m^3/ha. And rare species of soft wood with a higher increment than the kind of dense and hard wood such as beech, oak, poplar and others broadleaves species dominant in our forests.

3. STRUCTURE AND CHARACTERISTICS OF WOOD WASTE IN FORESTRY

In considering the structure of wood scrap it is necessary to divide into two main types: technical and stack wood. Technical wood is in possession of further sawmill and gets the final processing, furniture, doors and windows, construction of civil engineering and mining and custom products. The amounts of techical wood in Serbian regions are given in Table 1. The share of technical wood of the total cutting structure is between 15.2-60.8% and the values differ by region. The higher values are in Sremski and Južnobački region where wood industry is developed.

The stacked wood is used for fuel and industrial purposes. Industrial wood is used for: chipping board production, chemical processing and production of cellulose and paper. Fuelwood consumption in Serbia is one of the 50% of the total timber harvest. This percentage in the future should certainly be reduced to account adequately valorizided waste from forest harvesting and wood processing.

When forest is cut in the total amount of stem wood (no leaves or needles) share certain categories of wood in a climate Serbia about the following ([8]): roughly 71% of wood, small twigs 11% and 18% tree run.

Analyzing data on the amount of scrap from the aforementioned period 2007th-2009th ([9], [10]) it can be concluded that the total amount of cuts is growing, which is especially characteristic in Vojvodina Also, the total amount of recovered debris from the forest is slowly increasing. However, the volume of unused parts of the wood, which include: leaves, needles, bark, thin branches, stumps, roots and rotten wood, is as high as about 38% ([3], [4]) of the total volume of timber wood. If you think it is realistic to use about 28%, as stumps and roots no one takes out or collecting leaves and needles, this means that the current cutting trees in forests (data from 2009), about 426 thousand m^3 of wood waste, wood waste that is remains unused after cutting. These residues are different in size and shape, and are scattered in the woods. As for the quality of these biomass residues can be used as an energy source. After crushing the crushers, the scrap wood (chopping) could be used either to produce pellets and briquettes or at the plant for the production of combined heat and power (CHP plant). What part of residues from forest harvesting will be used mainly depends on the type of terrain, forest infrastructure and distance to where the use of residues. In lowland forests, where access to every part of the forest easier, it is possible to use scraps resulting from the cutting nearly 100%. However, in the mountain forests, with very steep slopes, the forest infrastructure is disrepair and where necessary to protect the soil from erosion, the percentage of forest waste that can be drawn from the forest is less. With better infrastructure and a forest with appropriate price for the forest remains much larger amount of forest residues would be used than is currently the case.

It is interesting that about 5% of the volume of cut wood still remains in the forest despite the fact that these large fragments (branches, rotten wood, wood of poor quality) that could relatively easily be collected and transported. Taking into account the current state of scale felling of trees in these large pieces of remaining forest is about 130,150 m^3 per year.

In order to understand the characteristics of wood as waste and talked about his energy evaluation is necessary to know and its chemical composition. Elemental chemical composition varies depending on the type of wood, its age, area, part of the tree, etc. Hardwood: beech, oak, elm, locust, hornbeam, Turkey oak and others, which is dominated by the Serbian forests contain approximately 50% carbon, 43% oxygen, 6% hydrogen and 1% nitrogen. Of compounds involved in the wood structure the most important are: cellulose, hemicellulose and lignin. Of these three compounds make up 80% of the composition of dried wood. Others make up water (about 17%), auxiliary materials (2%) and ash (1%). The dry wood broadleaves, pulp accounts for 43-45%, 19-26% lignin, 21-26% pento, heksozani 3-6%, and while in dry coniferous wood pulp is present 53-54%, 26-29% lignin, pento 10-12% and 13% heksozani.

4. THE PRODUCTION OF WOOD CHIPS

For the production of wood chips from forest wood residues are used mostly by mobile crushers and self-propelled or driven by some terminal equipment (usually tractor). On the market there are several manufacturers of machinery for the production of wood chips. These are mainly German companies: Heizomat (www.heizomat.de), Brooks (www.bruks.com), and Jenz (www.jenz.de). For the supply of demo-plant which provides for wood chips in the project company has to offer Heizomat machine HM 4-300, producing woodchips 300kg / h, with a screw conveyor Heizoschneck to throw wood chips after unloading from the truck (if it is an opening for filling bunkers, living on the side) or possibly Heizotransom woodchips to raise the truck pneumatic transport at a higher elevation (if the filling hole on top of the bunker daily). "Brooks" mobile machines for the production of wood chips 605PT Trailer is driven by the tractor, even though it produces wood chips transported to a height of 4238mm for filling containers (Figure 2).

Figure 2: *The Brooks mobile machine for wood chips (605PT Trailer)*

The above machines for production of wood chips exceed the annual needs for demo-plant and can be used for CHP plants, or to obtain wood chips for other purposes (briquetting, pelleting, etc). Their price is certainly high for our conditions, but the reliability high. Comparison of characteristics of machines for production of wood chips from the three mentioned manufacturers is given in Table 2.

On the world market there are individual devices from Chinese manufacturers (www.alibaba.com). They are mainly intended for shredding twigs maximum diameter 150-200mm. Grit obtained woodchips is 3-50mm, and their prices depending on the type between the 3000-10000EU. Productivity of wood chips 2-4m^3 / h. The drive is mostly electric power up to 40kW. These devices with continuous operation can be achieved annually up to 2t woodchips, which later proved to be satisfactory for continued operation of demo-plant on the project.

Certainly the quality of these devices and their reliability is much lower than the previously mentioned from Germany.

Table 2: *Comparison of characteristics the wood crushers*

Characteristic	Manufacturer and machine type		
	Brooks 605PT	Heizomat HM4-300	Jenz HEM 360Z
diameter of logg (cm)	30 - 40	to 30	27-36
chip diameter (mm)	15-40	15-30	do 40
woodchips productivity (m^3/h)	20-30	18-30	20-25
tractor power (kW)	130-220	150	120-140
price (EU)	167000 (with the manipulator)	116000	130000 (with the manipulator)

Produced chips are transported to the warehouse where naturally dry and equipment for further use. The granulation and classification of the wood chips is given in paper [5]. Transport is done by tractor trailers, and more rarely a closed container. If its moisture content below 25% is stored in closed warehouses (Figure 3a), with occasional mixing and air-conditioning, and if its moisture content above 25%, chips are stored in semi-enclosed storage (Figure 3b).

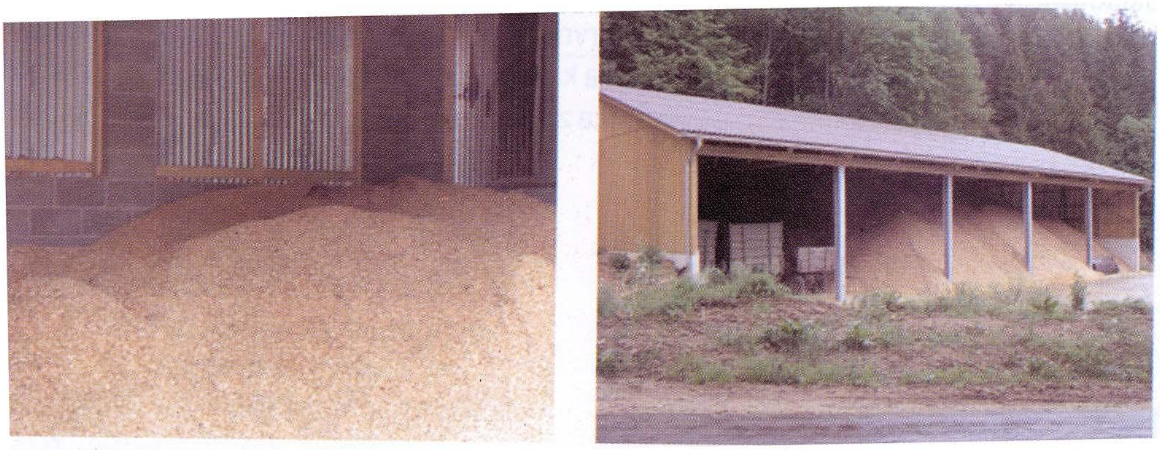

Figure 3: *a) closed and b) half closed storage for wood chips*

5. CONCLUSION

According to the demonstration facility developed on the project with a capacity of gasification 190kg/h waste which operates 24 hours, 365 working days of the year, the amount of wood waste needed for such a plant would amount to 1664t/h. Having in mind all mentioned above, it can be concluded that all the regions, except Podunavski, can produce enough wood chips for combine heat and power generation in demo CHP plant. The regions with the highest volume of harvest in central Serbia are: Zlatibor, Raška, Pčinj and Rasinski region, whereas in the case with: Sremski, Južnobački and Južnobanatski region in Vojvodina district. It should be expected that the amounts of wood chips in that regions should between 24675t and 56594t. This means that in these regions can be placed 14-34 demo plants that will produce 2.8MW-6.8MW of electric power. The main problem will be where to place the CHP plants to get the cheapest price of wood chip and on that way the cheapest kWh of electrical energy. The answer is in multicriterion analysis between appropriate technology of obtain wood chips and the way of transport it to the place of utilization. This is planned to do in the next research work.

It should be emphasized that the gasification of biomass in CHP plants is convenient and well tested technology. The CHP plant is suitable for decentralized and independent energy generation in rural or isolated areas, companies with a need for heat and electricity energy with use of cheap fuels (local biomass). Estimations of demands of heat energy for various types of wood industry are given in paper [4]. It was concluded that CHP plants are interesting for small and middle enterprises from the standpoint of cost savings and reinvestment in equipment.

At the end, it should be noted that the current incentive price of electricity generated from biomass in Serbia is 0.137EU/ kWh (under the Decree of the Ministry of Mines and Energy of the Republic of Serbia) which is very inspiring to sell it when own needs are satisfied. Having in mind environmental issues of protection of air, land and water, this is the great chance for Serbia in the future.

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WOOD BIOMASS AND DIFFERENT WAYS OF ITS UTILIZATION IN CHP PLANTS

Aleksandar DEDIĆ[1], Goran JANKES[2], Duško SALEMOVIĆ[3]

Abstract: *The substitution of conventional fossil fuels with biomass for energy production results both in a net reduction of greenhouse gases emissions and in the replacement of non-renewable energy sources. However, at present, generating energy from biomass is rather expensive due to both technological limits related to lower conversion efficiencies, and logistic constraints.*

In the introduction part of this paper the ways of conversion wood biomass to useful forms of energy were given. The stages of the biomass gasification were described as far as the final effects of CHP plant which can work with or without organic Rankine-Clausise (ORC) thermodynamic cycle. Also, one of possible utilizations of CHP plant in sawmills and producing pellets and briquettes were given. The basic principals of small-scale CHP plant based on Stirling engine were explained. At the end, it was discussed the energy efficiency of CHP using Grossmann diagram.

The paper presents the research work in frame of the project "Development of CHP Facility with Biomass Gasification", TR33049, supported by The Ministry of Education and Science of the Republic of Serbia.

Key words: gasification stages**,** ORC cycle, Stirling engine, Grossmann diagram.

1. INTRODUCTION

It is well-known fact that biomass is widely considered to be an important potential fuel and renewable energy source in the future. Moreover, the moderate sulphur and greenhouse gas emissions associated with the use of biomass for energy production respond to the growing pressure of government policies about achievement of better environmental sustainability of power generation processes in terms of air pollution control [1].

Biomass may be used to meet a wide variety of energy needs, including generating electricity, providing process heat for industrial facilities, heating homes and fuelling vehicles. The conversion of biomass to such useful forms of energy, also called bio-energy, can be achieved using a number of different technological solutions that can be separated into two basic categories, namely thermochemical processes and biochemical/biological processes. A process options classification based on the type of final energy products is presented in Table 1.

- **Combustion,** used to convert biomass energy into heat, mechanical power or electricity. Net conversion efficiencies range from 20% to 40%, even if higher values may be obtained when the biomass is co-combusted in coal-fired power plants. The most utilized combustors for biomass applications are either stoker-fired and fluid bed designs, even if

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the latter are rapidly becoming the preferred technology because of low amount of NOx emissions.

- **Gasification,** which converts biomass into a combustible gas mixture of carbon monoxide, hydrogen and methane, characterized by a low calorific value, that can be burnt to produce heat and steam, or used in gas turbines cycles to obtain electricity.

  Gasification of biomass is generally observed to follow the reaction:

$$\textbf{\textit{Biomass + }} \boldsymbol{O_2}\textbf{\textit{(or }}\boldsymbol{H_2O}\textbf{\textit{)}} \rightarrow \boldsymbol{CO, CO_2, H_2O, H_2, CH_4} \textbf{\textit{ + other CnHm + tar + char + ash}}$$

Conversion efficiencies up to 50% may be reached if biomass integrated gasification/combined gas–steam cycles are utilized. Although many biomass gasification processes have been developed commercially, only the fluid bed configurations are being considered in application ranging from 5 to 300MW.

- **Pyrolysis,** that is the conversion of biomass into a liquid fraction (bio-oil), a solid fraction (charcoal) and a gaseous fraction, by heating the biomass in absence of air.

Table 1. *The main technological solutions of obtaining energy from biomass [1–6]*.

Conversion processes	Technological solutions	Final products
Thermochemical processes	Combustion	Steam
		Process heat
		Electric energy
	Gasification	Steam
		Process heat
		Electric energy
		Generator gas (syn-gas)
	Pyrolysis	Charcoal
		Bio-coal
		Fuel gas
Biochemical processes	Fermentation	Ethanol
		Water for irrigation
	Anaerobic digestion	Compost
		Biogas

As far as biochemical processes are concerned, the main conversion options are the following [1,2,7]:

- **Fermentation,** that is used to produce ethanol from biomass containing sugar. Usually sugar is extracted through a crushing process; then it is mixed with water and yeast, and kept warm in a fermentator. The yeast breaks down the sugar, converting it to methanol. A distillation process removes the water and produces concentrated ethanol which is drawn off and condensed into a liquid form.
- **Anaerobic digestion**, that is the conversion of biomass into biogas, mainly composed of methane and carbon dioxide, by means of bacterial action in the absence of oxygen. This is a commercially proven technology widely used for treating high moisture content biomass such as MSW.

Another technology is represented by mechanical extraction processes, able to produce energy in forms of bio-diesel. However, currently the cost of bio-diesel compared with fossil fuel makes this last conversion option strongly uncompetitive, even if an increasing attention of government policies about achievement of better air-quality standards may rapidly change this situation [2].

The choice of appropriate conversion process is influenced by many key factors, such as type and quantity of biomass resource, energy carriers and the end-use applications, environmental standards, economic conditions. Apart from the amount of energy potentially available from given biomass species, other properties that dictate the most suitable form of energy conversion process are represented by moisture content, cellulose/lignin ratio and ash content. More specifically high moisture content biomass (>50%), such as herbaceous plants and sugarcane, lends itself to ‘‘wet’’ conversion process, for example fermentation and anaerobic digestion, while a ‘‘dry’’ biomass (moisture content < 50%), i.e. wood chips, is more suited to thermochemical processes such as combustion and gasification. As far as the cellulose/lignin ratio is concerned, this parameter affects only biochemical conversion processes; in particular biomass with high proportion of cellulose instead of lignin, such as hardwood characterized by 25–50% of cellulose and 20–25% of lignin, is more compatible with fermentation processes. Finally, with regards to ash content, low percentages are preferred for both thermochemical and biochemical processes because, given the available energy output of the adopted conversion technologies, the resulting end-product amount is proportionately reduced [8]. However, it is frequently the form in which the energy is required that drives the technology solution selection, followed by the type and quantity of available biomass. Despite the widely agreed potential of bioenergy utilization, key problems regarding the use of biomass remain the limited availability in terms of time, owing to biomass seasonality, and the scattered geographical distribution over the territory that make the collection, transport and storage operations complex and expensive. These critical logistic aspects strongly affect the economic and energy performances of bio-energy conversion systems, introducing limitation on their suitability. Furthermore, the large number of possible combination of various biomass sources (such as wood and wood waste, agricultural crops and their by-products, energy crops, municipal solid waste (MSW), residues from agro-industrial and food processes), the different available conversion approaches, and diverse end-use applications (power/heat generation and transport fuel) make difficult the choice of the optimal solution from either a cost and energy point of view [2].

2. STAGES OF GASIFICATION PROCESS

The wood waste is rich in carbon, oxygen and hydrogen. That’s why the valorization of wood waste obtained from wood harvesting in energy purpose is of a great interest. Combustion, pyrolysis and gasification are the three main thermochemical conversion methods. First two methods are widely used, but the interest for the last method grown up very fast in the last fifteen years. Gasification converts biomass through partial oxidation into a gaseous mixture (CO_2, water, carbon monoxide, hydrogen and gaseous, hydrocarbons), small quantities of char and condensable compounds. It is considered one of the most efficient ways of converting the energy embedded in biomass, and it is becoming one of the best alternatives for the reuse of waste solids. The gas produced can be standardised in its quality and is easier and more versatile to use than the original biomass (e.g. it can be used to power gas engines and gas turbines or as a chemical feedstock for the production of liquid fuels). Gasification adds value to low- or negative-value feedstock by converting it into marketable fuels and products. The chemistry of biomass gasification is quite complex. Broadly speaking, the gasification process consists of the following stages:

- ***Drying*****.** In this stage, the moisture content of the biomass is reduced. Typically, the moisture content of biomass ranges from 5% to 35%. Drying occurs at about 100–200^{0}C with a reduction in the moisture content of the biomass of <5%.

- ***Devolatilisation (pyrolysis)***. This is essentially the thermal decomposition of the biomass in the absence of oxygen or air. In this process, the volatile matter in the biomass is reduced. This results in the release of hydrocarbon gases from the biomass, due to which the biomass is reduced to solid charcoal. The hydrocarbon gases can condense at a sufficiently low temperature to generate liquid tars.
- ***Oxidation***. This is a reaction between solid carbonised biomass and oxygen in the air, resulting in formation of CO_2. Hydrogen present in the biomass is also oxidised to generate water. A large amount of heat is released with the oxidation of carbon and hydrogen. If oxygen is present in substoichiometric quantities, partial oxidation of carbon may occur, resulting in the generation of carbon monoxide.
- ***Reduction***. In the absence (or substoichiometric presence) of oxygen, several reduction reactions occur in the 800–1000^{0}C temperature range. These reactions are mostly endothermic.

3. DIFFERENT TYPES OF CHP PLANTS

Gasification process is widely used in CHP plants in which are obtained combine heat and electrical energy. With organic Rankine-Clausise (ORC) thermodynamic cycle the way of getting electric energy in gass turbine is possible (Figure 1).

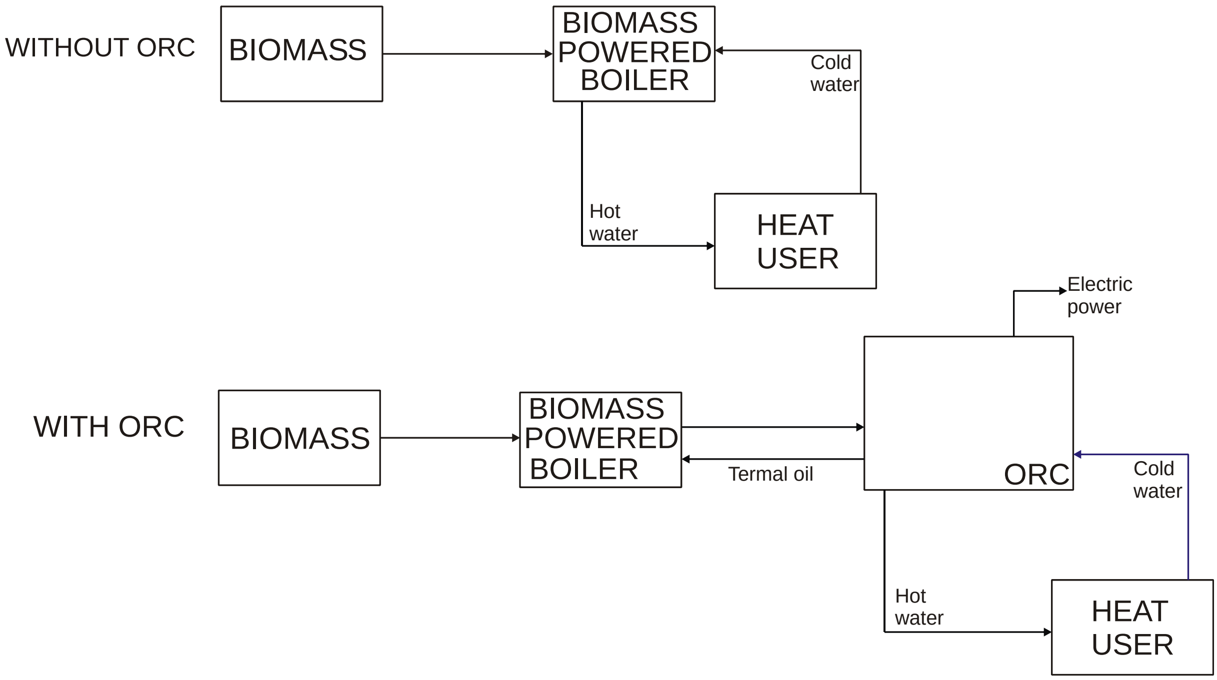

Figure 1: *Possibility with and without ORC cycle*

The wood waste generated in harvesting, shedering and wood processing such as: bark, wood chips and sawdust are used as a fuel in CHP plant. The heat energy obtained of the plant can be used for drying wood products to its final moisture content and after that in pellets and briquettes production. In this way the energy obtained from wood waste will be used on the same place where it is generated (Figure 2).

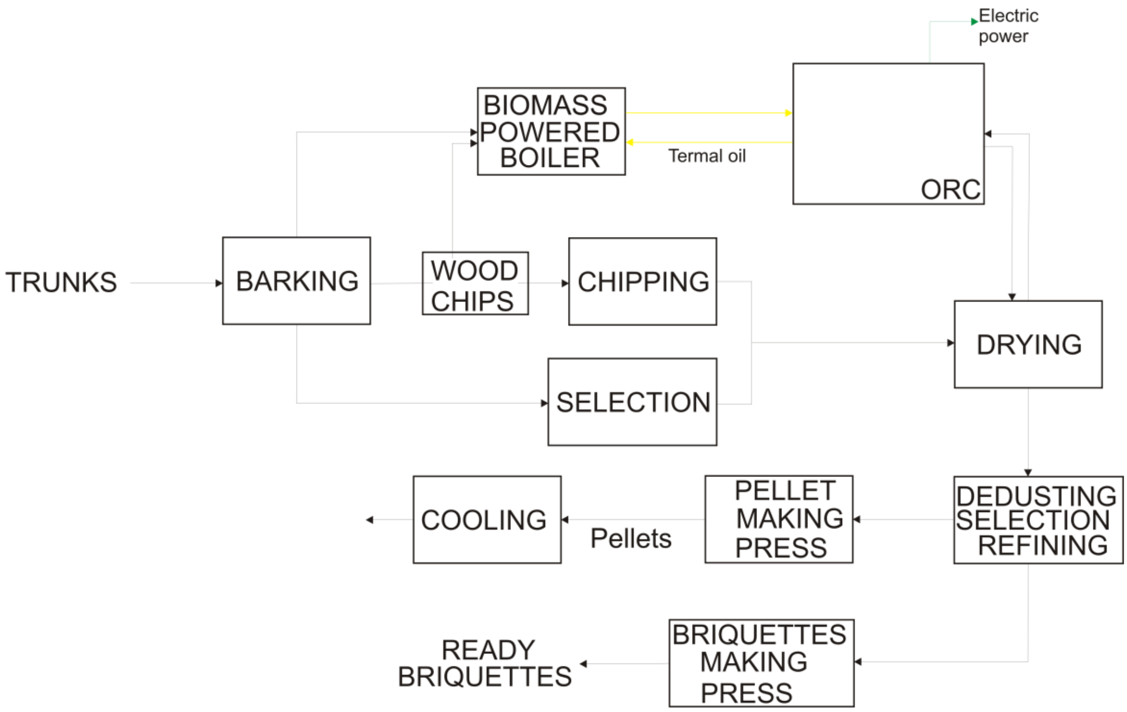

Figure 2: *CHP using for drying and pellets production*

The Figure 3 shows the schematic of small-scale CHP plant based on Stirling engine. The combustion is realized in two stage design (primary and secondary combustion chamber which are geometrically separated) in order to achieve low NOx emissions.

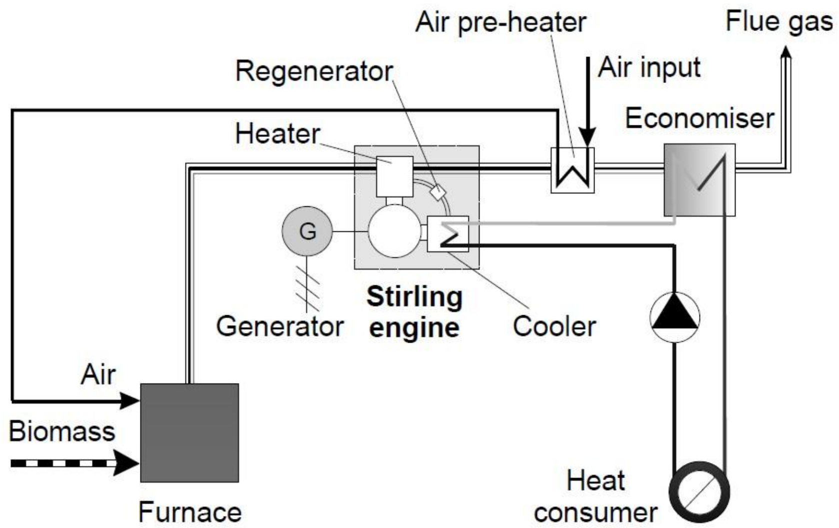

Figure 3: *Schematic of a Stirling CHP plant ([9])*

The CHP plant developed is designed for furnace temperatures of approximately 1300^{0}C. The Stirling heater designed for this high flue gas temperature and is directly connected to the surface. The surface temperature of a heater is typically between 750^{0}C and 790^{0}C. In order to obtain high temperatures in combustion chamber and high electric plant efficiency the combustion air is preheated to 450-550^{0}C in an air pre-heater situated downstream the Stirling heater. Then the flue gas is cooled in an economizer to approx. 120-150^{0}C.

Many small scale fired plants on the similar principals like Stirling engine are given in literature: [10], [11] and [12]. The paper [13] concerns numerical prediction of relationship between operating speed and shaft power output of Stirling engine and the paper [14] is aimed at development of a numerical model for a Stirling engine with rhombic-drive mechanism. Six systems comprising different technologies have been analysed in literature [10]. Also, a thermo-economic study has a great interest for CHP systems ([15], [16]). In addition to that, some countries like Portugal ([17]) and China ([18]) have they own strategy of utilization biomass in energy purpose in order to achive high efficiency.

The energy efficiency of CHP using Grossmann diagram is given on Figure 4. It is shown that mostly (about 80% of energy) goes on heating and only 20% on electrical energy. But efficiency of producing both energies is very high (usually over 75%).

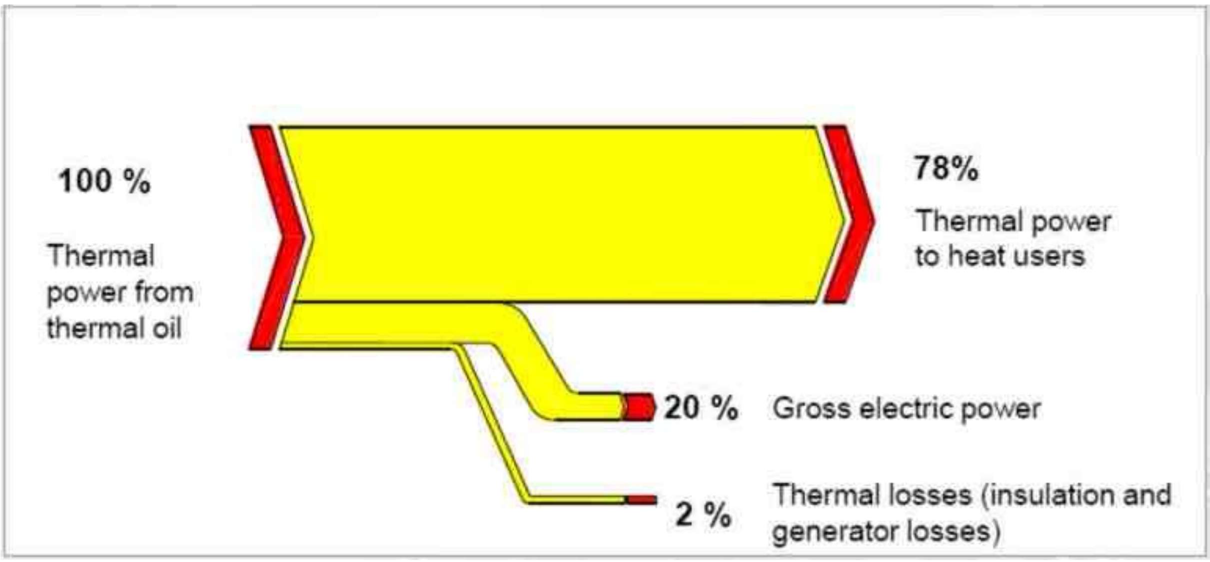

Figure 4: *The diagram of the energy efficiency of CHP plant*

4. CONCLUSION

As we could see from all mentioned above, the biomass valorization in different useful forms of energy can be achieved using a number of different technological solutions that can be separated into two basic categories: thermochemical and biochemical/biological processes. Gasification is high efficiency thermochemical process of conversion solid carbonaceous feedstock such as biomass into gaseous fuel (syn-gas), which contains carbon monoxide, hydrogen, carbon dioxide, methane, traces of higher hydrocarbons, water, nitrogen (if air is used as gasifying agent) and various amounts of tar and solid particles (ash, char) [19]. Syn-gas can be easily used for combined heat and power generation (co-generation process). Many small-scale units are widely used all over the world and one of them with electrical power of 200kW is planned to be constructed under the mentioned project.

It can be concluded that CHP plant with organic Rankine-Clausise (ORC) thermodynamic cycle is high efficiency process. The heat energy obtained of the plant can be used for drying wood products to its final moisture content or in pellets production. Using CHP plant electrical energy can be obtained with very high coefficient of efficiency in cogeneration. Also, to get better electrical efficiency the Stirling maschine should be used.

Acknowledgements

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RELATIONSHIP BETWEEN THE FOREST STAND ENERGY BALANCE AND FOREST CARBON STORAGE

Irena MARKOVÁ[1], Michal V. MAREK[2]*

Abstract: *Trees productional activity is conditioned by the input of short-wave (solar) and long-wave (thermal) radiation. Finally, the amount of radiation available for productional activity of the forest stand is the sum of incoming and outgoing short/long-wave radiation and is designated as the "net radiation" (R_N). The ratio of the sensible (H) and latent (LE) heat is known as the Bowen ratio (β) - the useful measure of the form of the stand energy dissipation. Deeper investigation of the relations between R_N, β and carbon storage in a forest stand brings description of the strength of connection between the daily course of stand energy balance and carbon fluxes and evaluation of the impact of the prevailing form of energy dissipation on the carbon flux. Some differences in spruce stand in selected clear and overcast days are presented.*

Keywords: energy balance, Bowen ratio, energy dissipation, carbon capture

The forest productivity is closely affected by the massive mass and energy exchange between the forest stand and its surrounding atmosphere. Photosynthetic assimilation, the principal process of biomass formation and maintenance, is dependent on the continuous absorption of solar energy and uptake of carbon dioxide. Moreover, the continuous transpiration conditioned by the input of long-wave (thermal) radiation is necessary for the transport of water and dissolved nutrition elements and cooling of the stand surface. It means that the final amount of radiation available for productional activity of the forest stand is the sum of incoming and outgoing short/long-wave radiation and is designated as the "net radiation" (R_N).

The ratio of the sensible (H) to latent (LE) heat, i.e. H/LE, is known as the Bowen ratio - β (Bowen 1926). Thus, the β value can be regarded as the useful measure of the actual prevailing form of the stand energy dissipation:

$\beta = \gamma\ \delta T / \delta e$, where γ – psychrometric constant, δT and δe – air temperature and water vapor pressure differences for different height levels, i.e. at and above the stand surface (Savage 2010).

It means that the value of Bowen ratio is simply calculated on the basis of measurement of the air temperature and water vapor pressure in two different levels in the atmosphere. Because of the daily course of solar and canopy microclimate is the principal microclimatological factor it is possible to expect changes of the β value, i.e. some indication of the changes in energy dissipation and particularly in its form, i.e. evaporation or convection.

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The form of energy dissipation could be related to the final physiological activity of the stand. Mainly, the production of biomass is strongly related to the solar energy input and carbon uptake. However, the LE form of energy dissipation is more related to the plants physiology, because of the importance of transpiration regulated by stomata openness. Thus, the increased participation of LE in the final value of the β indicates the intensive gas exchange of the stand canopy and strong vaporation of the soil, which are the cause of the forest stand cooling. Thus the evaporation cooling effect is responsible for the decrease of stand respiration carbon losses. Finally, the stand respiration decrease improves the assimilation/respiration ratio resulting in a bigger gain of the forest stand carbon storage.

Final amount of carbon captured in tree biomass and forest soil is the final balance between the processes of carbon assimilation and carbon evolution (autotrophic/heterotrophic respiration, decomposition and carbon efflux form the subsoil). Thus the measured carbon fluxes between atmosphere and forest stand canopy can be regarded as the "on-line" measure of the net primary production (NPP). The understanding of relationship between the daily/seasonal course of energy balance, the form of energy dissipation and final production activity measured on the basic of carbon fluxes is of great importance for the understanding of carbon storage dynamics. The principal approach used in the carbon flux study is based on the "*eddy-covariance*" technique, which makes it possible to measure exchanges of carbon and water vapor between the forest stand and the atmosphere. Eddy covariance technique is based on rapid measurement of wind speed in three-directions and CO_2 and water vapor concentration (Aubinet et al. 2000).

The forests stand final carbon storage is strongly sensitive to the impact of environmental factors, particularly the effects of microclimatic factors and external synoptic events. The principal role of a seasonal ontogeny of assimilatory apparatus and soil biota is without any doubts. As a result of these factors it is possible to expect the variations of carbon deposition dynamics of the forest ecosystem between days with different weather conditions. Moreover, the understanding of the carbon storage dynamics in forests is of great importance because the carbon storage is a principal step of mitigation of the increase in greenhouse gases. Thus it is crucial knowledge indicating the landscape capacity to carbon storage.

The forest cover in the Czech Republic is mainly formed by the Norway spruce (*Picea abies* [L.] Karst). Carbon storage is related to the seasonal carbon assimilation course which is closely related to the within stand carbon sink strength. Thus, it is possible to expect different course of Bowen ratio values (sensible/latent heat) even for different wheatear conditions.

METHOD

The investigation was realized at the ecological experimental study site of Bílý Kříž in the Moravian-Silesian Beskids Mts. (NE Moravia, the Czech Republic, 49^{o} 30´ N, 18^{o} 32´ E, 908 m a.s.l.) in Norway spruce (*Picea abies* [L.] Karst) monoculture (30 years old stand, 1400 individuals ha^{-1}, maximum LAI 10 in the 2011).

The eddy-covariance system and system for a forest stand microclimate investigation were located at the measuring tower in the 1998.

The eddy-covariance technique (Aubinet et al. 2000) was used for the carbon exchange measurement in studied spruce stand. Fluxes of carbon dioxide and water vapor and subsequently latent and sensible heat exchange between stand and atmosphere were measured using closed-path eddy-covariance system InSituFlux (InSituFlux, Sweden; IRGA: LI-7000, Li-COR, USA) and sonic anemometer (Gill R3, Gill Instruments, UK). Measured data were processed by special EcoFlux software (InSituFlux, Sweden). Application of eddy-covariance technique offers the value of the net primary production (NPP), of latent (LE) and sensible (H) heat fluxes. Thus method makes possible the calculation of the Bowen ratio values for each time of the day or season.

Values of incident global radiation (GR_I) and net radiation (R_N) were measured using net radiometer CNR1 (Kipp-Zonen, the Netherland).

Presented results were obtained from the two example days, differing in the solar radiation conditions.

RESULTS AND DISCUSSION

Selected investigated example days differed in the amount of incident solar radiation, other stand microclimate parameters were very similar (Fig.1, Tab.1.). Different solar radiation input was related to significantly different amount of carbon fluxes (Fig.2). The input of solar radiation was strongly reflected in the daily courses of sensible (Fig.3) and latent heat (Fig.4). Especially under the conditions of high input of beam radiation the relation between these types of energy dissipation was evident. The pattern of higher degree of more regulate course was evident for latent heat, because of the role of stomata regulation of transpiration.

Selected clear (03.09.) and overcast (08.09.) days differed in the net radiation (R_N) of studied spruce stand (daily sum of R_N in light part of the day was 14.6 MJ m^{-2} in clear day and 2.5 MJ m^{-2} in overcast one (Fig. 5).

The solar radiation "conditions" were strongly reflected in the solar energy dissipation form, i.e. Bowen ratio (Fig.6). Under overcast conditions, the low input of energy was dissipated mainly by the low evaporation, negligible dissipation by the heat movement was recorded. Comparable values and daily course of β were described by Iritz and Lindroth (1996) and Fischer (2012).

The crucial importance of solar radiation energy input on its dissipation was observed (Fig.7, 8). However, this relation was extremely weak under conditions of overcast day. The effect of current energetic condition within the spruce stand was very important.

The strong relationship between net carbon flux and solar radiation was confirmed for the both investigated situation (Fig.9). The "use" of solar radiation for the carbon pumping via photosynthesis was the crucial process - the relation to the solar energy input was of great importance, independently to the solar radiation type. Direct observable relation of the energy dissipation was found only under direct beam solar radiation conditions (Fig. 10).

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Tab. 1: *Meteorological characteristics of selected investigated example days at the ecological experimental study site of Bílý Kříž in 2011*

		"clearness" index	*daily sum of GR_I*	*mean daily air temperature*	*mean daily vapoure pressure*
03.09.	**clear day**	67%	21.4 MJ m^{-2}	18 ^{o}C	1.5 kPa
08.09.	**overcast day**	11%	3.2 MJ m^{-2}	12 ^{o}C	1.3 kPa

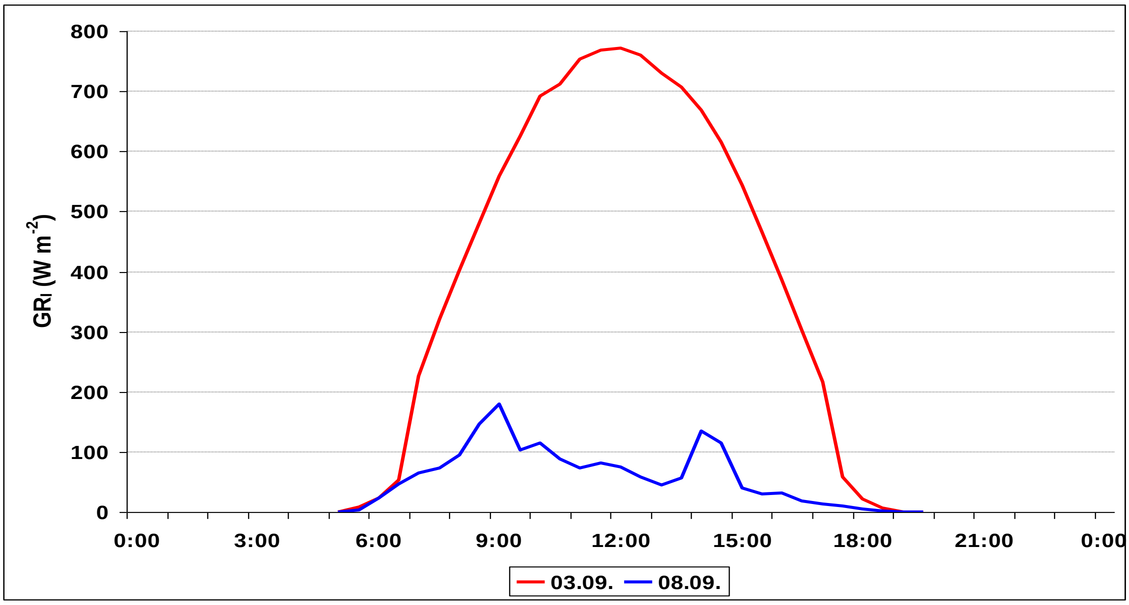

Fig. 1: *Daily course of global radiation incident on studied spruce stand (GR_I) at the ecological experimental study site of Bílý Kříž in selected clear (03.09.) and overcast (08.09.) days in 2011*

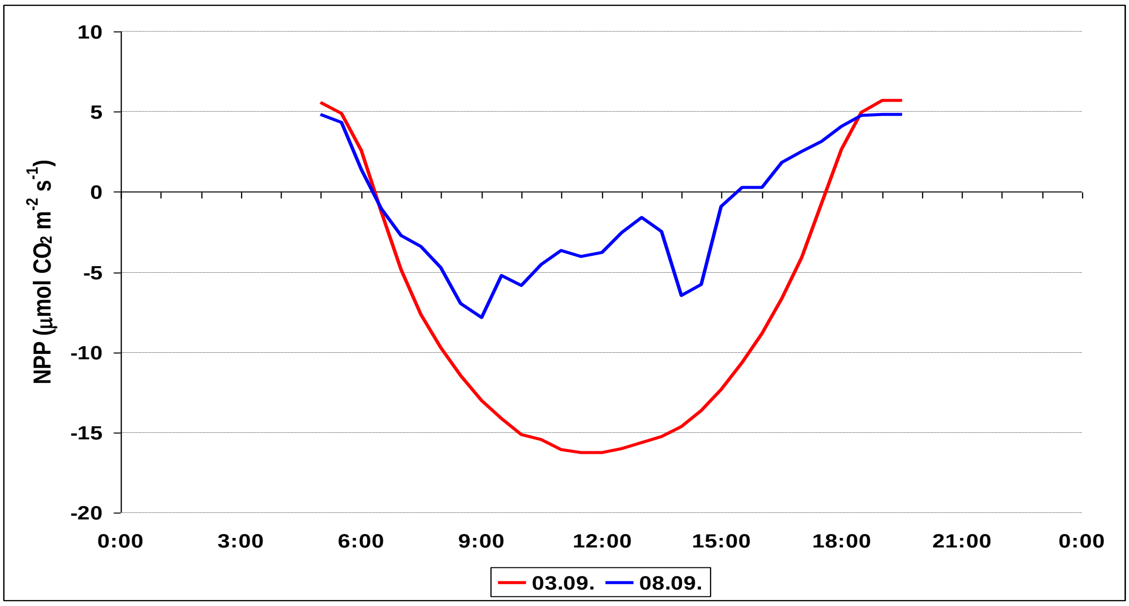

Fig. 2: *Daily course of net primary production of studied spruce stand (NPP) at the ecological experimental study site of Bílý Kříž in selected clear (03.09.) and overcast (08.09.) days in 2011*

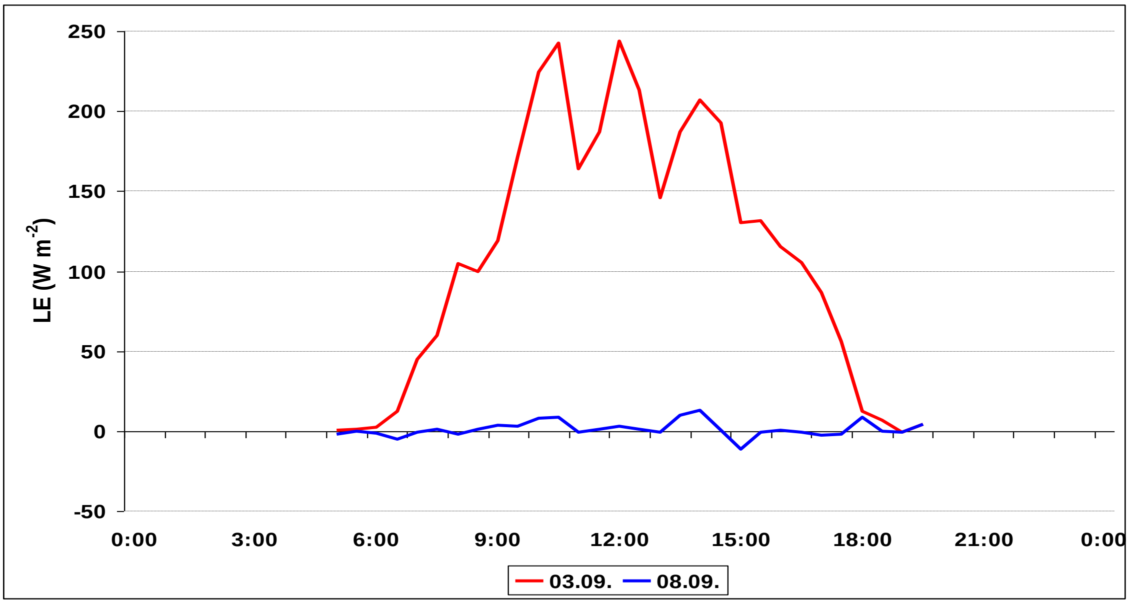

Fig. 3: *Daily course of latent heat flux in studied spruce stand (LE) at the ecological experimental study site of Bílý Kříž in selected clear (03.09.) and overcast (08.09.) days in 2011*

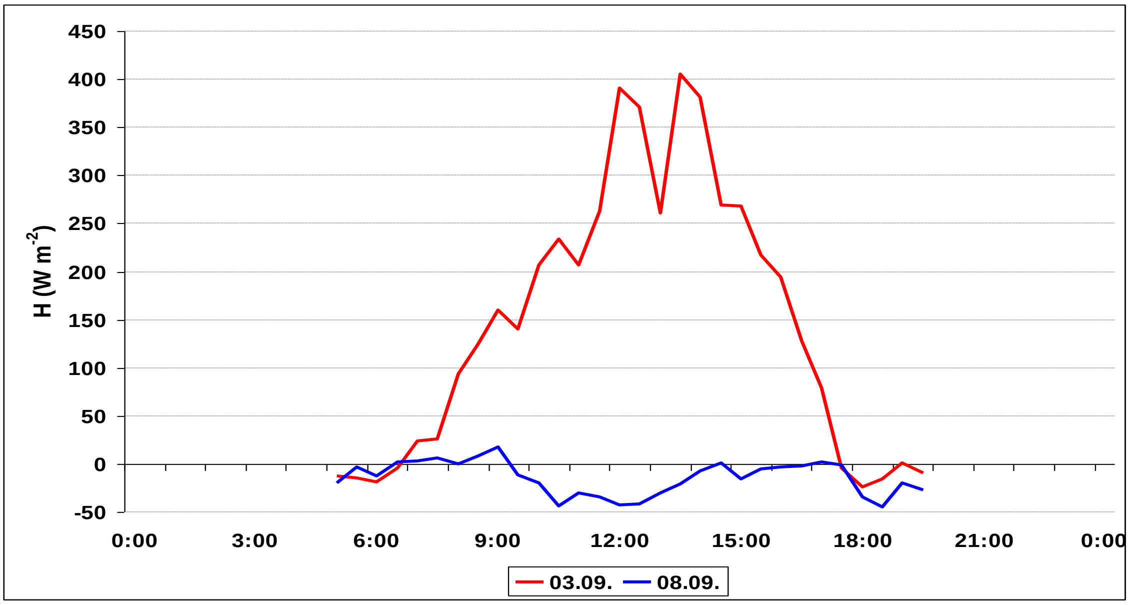

Fig. 4: *Daily course of sensible heat flux in studied spruce stand (H) at the ecological experimental study site of Bílý Kříž in selected clear (03.09.) and overcast (08.09.) days in 2011*

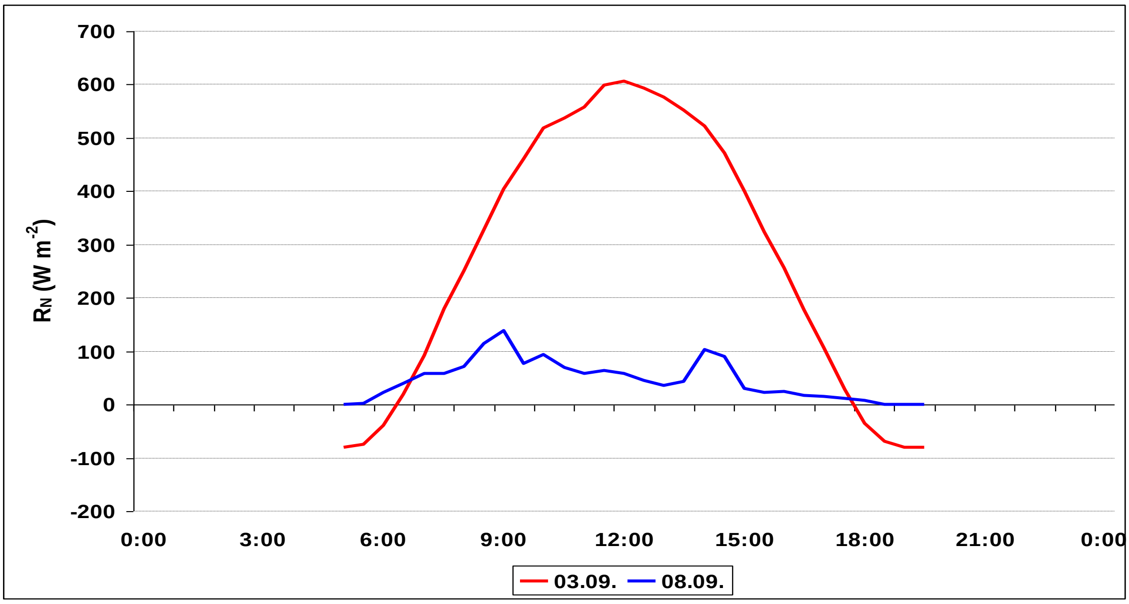

Fig. 5: *Daily course of net radiation of studied spruce stand (R_N) at the ecological experimental study site of Bílý Kříž in selected clear (03.09.) and overcast (08.09.) days in 2011*

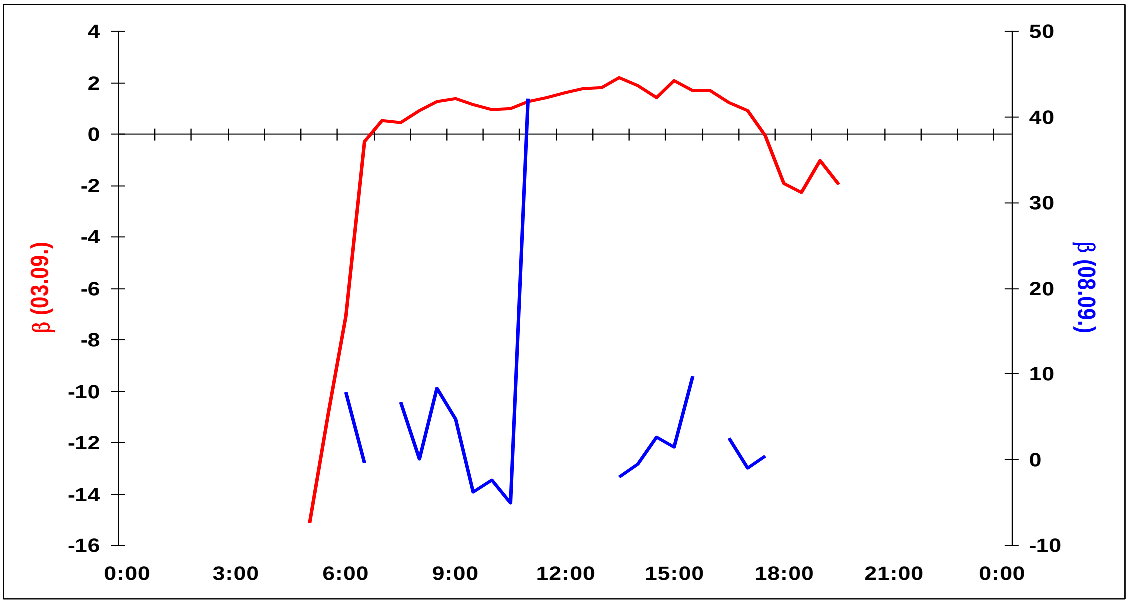

Fig. 6: *Daily course of Bowen ratio of studied spruce stand (β) at the ecological experimental study site of Bílý Kříž in selected clear (03.09.) and overcast (08.09.) days in 2011*

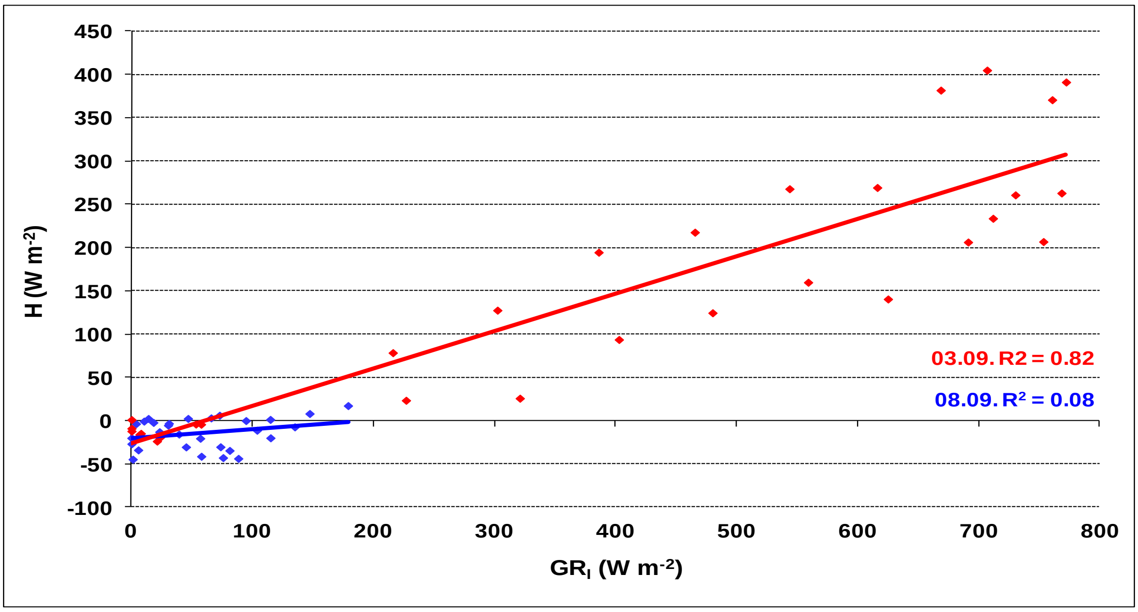

Fig. 7: *Relationship of sensible heat flux (H) on incident global radiation (GR_I) in studied spruce stand at the ecological experimental study site of Bílý Kříž in selected clear (03.09.) and overcast (08.09.) days in 2011*

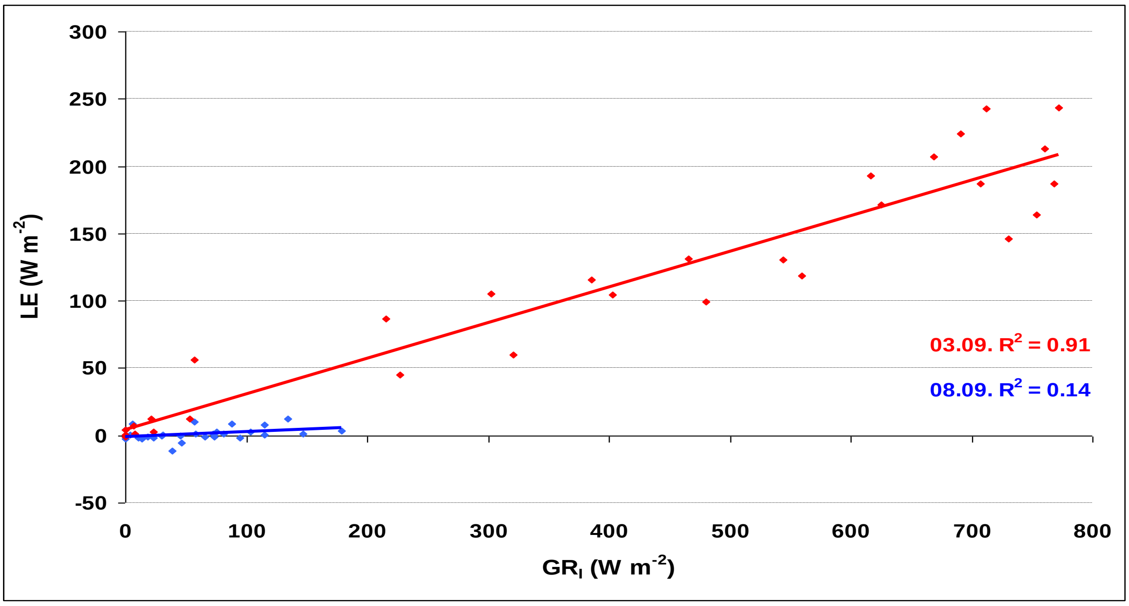

Fig. 8: *Relationship of latent heat flux (LE) on incident global radiation (GR_I) in studied spruce stand at the ecological experimental study site of Bílý Kříž in selected clear (03.09.) and overcast (08.09.) days in 2011*

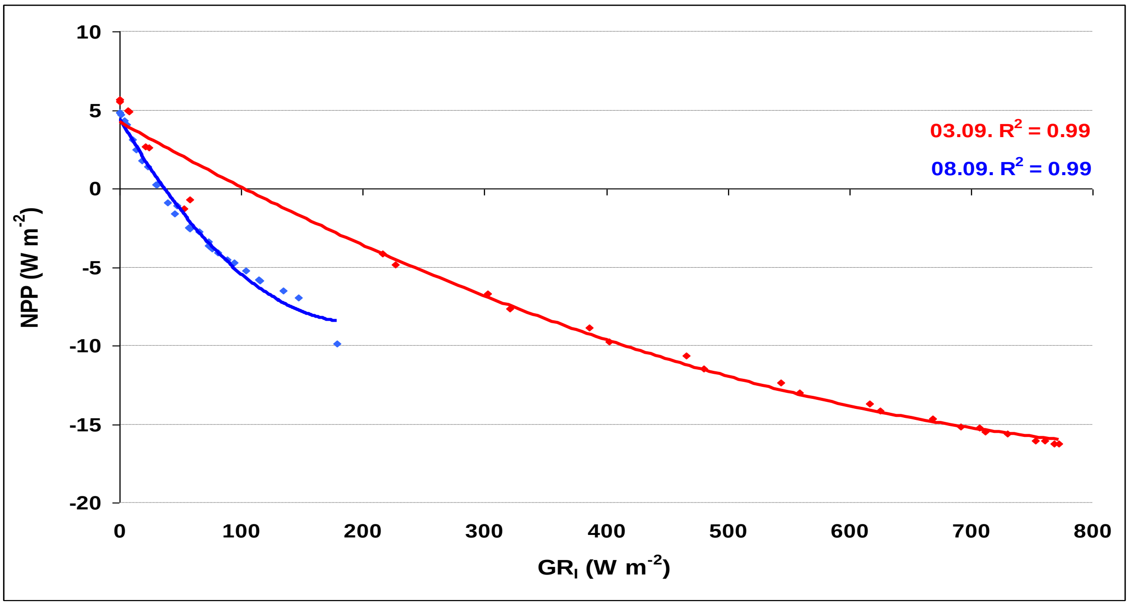

Fig. 9: *Relationship of net primary production (NPP) on incident global radiation (GR_I) in studied spruce stand at the ecological experimental study site of Bílý Kříž in selected clear (03.09.) and overcast (08.09.) days in 2011*

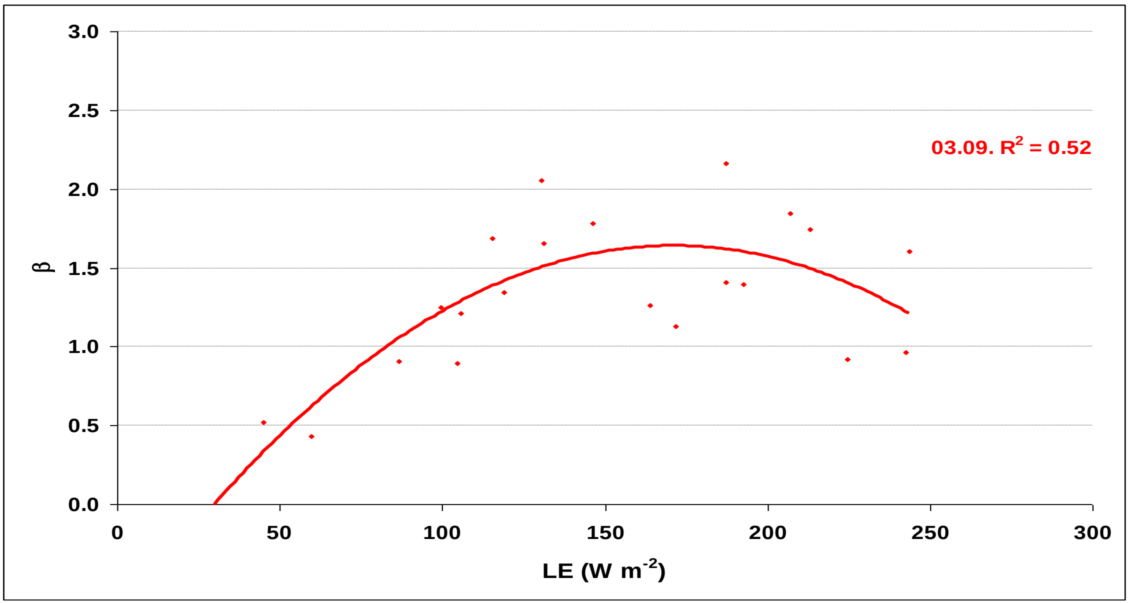

Fig. 10: *Relationship of Bowen ratio (β) on latent heat flux (LE) in studied spruce stand at the ecological experimental study site of Bílý Kříž in selected clear day (03.09.) in 2011*

SECTION X

WILDLIFE MANAGEMENT

CHAIRMEN – MODERATORS

Vedat Beşkardeş

Zoran Popović

International Scientific Conference
FORESTS IN THE FUTURE – SUSTAINABLE USE, RISKS AND CHALLENGES
4-5 October 2012, Institute of Forestry, Belgrade, Republic of Serbia

BIOLOGICAL CARRYING CAPACITY OF FOREST VEGETATION FOR THE RED DEER RE-INTRODUCTION IN THE AREA OF HUNTING GROUND HOMOLJE NEAR ŽAGUBICA

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Abstract: *Although natural conditions in Serbia are favourable for red deer (Cervus elaphus), their abundance is at an unsatisfactory level. The unfavourable red deer abundance is demonstrated by a nonuniform distribution of populations per individual regions in Serbia. The increase in red deer abundance is required not only from the ecological aspect, but also because of the economic component of sustainable hunting and rural development in Serbia. The process of red deer re-introduction to its natural habitat is complex, therefore it has to be conditioned by scientific and research activities and by the adequate preparations.*

The assessment of habitat biological carrying capacity is one of the preconditions for the correct red deer re-introduction. The purpose of the research is to enable a more objective and reliable estimation of the hunting site quality for red deer, as well as the base for etiological study of red deer migrations. This paper analysed the conditions for red deer re-introduction to natural habitats in the area of Beljanica – Crni Vrh in the hunting ground Homolje near Žagubica. Taking into account the high diversity of forest vegetation, hunting ground Homolje is a suitable area for red deer growing.

Key words: red deer, forest vegetation, biological carrying capacity, Homolje

INTRODUCTION

The territory of Serbia, thanks to its geographic position, climate, petrographic-pedological and orographic diversity, and the fact that it is a significant refugial space of the Tertiary flora, in the floristic-phytogeographical sense, is one of the most complex areas in southeastern Europe (Stevanović, 1992). The natural conditions in the Republic of Serbia are favourable for red deer (*Cervus elaphus*, L.) management, but despite the habitat general suitability, red deer abundance is at an unsatisfactory level. In addition to low abundance, Serbia is characterised by an irregular distribution of isolated red deer populations, which makes the sustainable management of this species even more difficult. The augmentation of red deer abundance in Serbia should be a priority of hunting industry in the aim of improving both the hunting sector and the environmental protection, and it is also required as an ecological and economic component of sustainable development. A higher red deer abundance is possible only through sustainable management of extant populations and by the species re-introduction. According to Jovanović (2007), when a species becomes extinct in its natural habitat in modern

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conditions (usually under anthropogenic impact), its release into the lost territory is referred to as re- patriation (Tahtadjan, 1975).

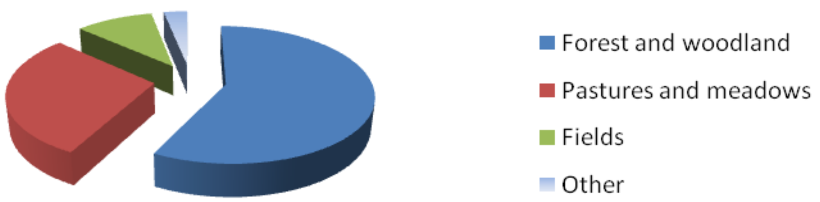
Re-introduction of game species is a complex process (IUCN, 1998), so it has to be conditioned by adequate preparations. One of primary preconditions of successful red deer release is the assessment of the hunting ground biological capacity, because food is an important factor which regulates the population abundance (Klein, 1985; Begon *et al*., 1990). The assessment of the habitat biological capacity is fundamental for sustainable management of any game species (Caughley, 1979), consequently this issue is devoted special attention to (Moen, 1973; Robbins, 1973; Bobeck, 1977; Wallmo *et al*., 1977; Mautz, 1978).

Based on the floristic classification, the study area belongs to north-eastern or Carpathian Serbia with elevations ranging from 48 to 1565 m (Stevanović, 1992). Based on natural conditions, this area is a favourable habitat for red deer management. Over the period from 1960 to 1964, red deer were introduced to three localities (Severni Kučaj, Južni Kučaj and Deli Jovan). In spite of the initial success, the release of these populations into the areas of Homoljske Planine and Kučajske Planine did not succeed, which was significantly caused also by the adverse anthropogenic impact.

This paper analyses the possibilities of red deer release into hunting ground Homolje, based on the analysis of habitat conditions, red deer nutrition, and by the determination of the hunting ground biological capacity.

THE STUDY AREA

Hunting ground Homolje is located on the territory of the Municipality Žagubica in Braničevski District and its total area is 71,791 ha. Within the hunting ground, based on its natural characteristics, the area Beljanica-Crni Vrh is singled out as a special entity, bordered in the eastern, southern and south-western sides with the mountains Crni Vrh and Južni Kučaj. The area is ellipsoid in form, total area 34,227.11 ha.



Graph 1. *Land use in Beljanica-Crni Vrh*

The study area is a hunting and production site amounting to 25,000 ha located in the area of Beljanica-Crni Vrh, on the southeastern slopes of Beljanica, Crni Vrh and Južni Kučaj. It consists of forests and woodlands, meadows and pastures, which are suitable sites for red deer release. Hunting ground altitude ranges from 380 to 1339 m, its altitudinal range is 959 metres, and the average altitude is 895.5 m, by which it is classified as a lower montane hunting ground. The hydrographic conditions in the area are favourable for game species thanks to rich water regime consisting of several rivers and streams, such as the Crna Reka and Gabrova Reka, Mala and Velika Tisnica, Dubašnica, Busovata, Stenka and Krivulja. Hunting ground is distinguished by karst relief, so parent rock, in addition to sinkholes and uvalas, consists also of underground karst forms.

The climate is characterised by mean annual temperature of 9.6^{o}C, and mean annual rainfall ranging from 682 to 783 mm/m^2 relatively uniformly distributed over 12 months. The limiting factors for game farming can be temperature extremes with the absolute minimum of -

28.6^{o}C, although the number of days with extremely low temperatures is limited and uniformly distributed over winter. It can be concluded that the climate in the area is relatively suitable for red deer existence and population survival, in view of the fact that a numerous and good-quality red deer population inhabits the deeper Južni Kučaj massif, under the same climate and habitat circumstances.

METHOD

The three research objectives dealt with in this paper are the analysis of red deer nutrition, the assessment of nutritive capacity of the area Beljanica-Crni Vrh, and the assessment of biological capacity of the habitat. The analysis of red deer nutrition is based on the comparison of domestic literature and the studies from Poland, France, the Netherlands, Spain, Great Britain, Scotland, Denmark, Slovenia and Hungary (Jensen, 1968; Dzieciolovski, 1970; Van de Veen, 1979; Gebczynska, 1980; Staines *et al*., 1982; Picard *et al*., 1985; Adamič, 1988; Matrai and Kabai, 1989; Palacios *et al*., 1989; Picard, Oleffe, and Boisaubert 1991; Picard and Gegout, 1992; Latham *et al*., 1999; Saint-Andrieux, 1999). The aim was to compare red deer nutrition in different regions of its distribution in Europe.

The nutritive capacity of the habitat is analysed based on the floristic composition of northeastern Serbia and the assessment of its suitability, by the comparison with the studies dealing with the same problems.

The biological capacity of the study area was estimated based on the study reported by Dzieciolowski (1976) and performed in Poland. As northeastern Serbia supports all the vegetation types reported in the above study, the Poland data can be applied in the study conditions. Based on the composition of the vegetation in the forest types, we estimated the biomass and the supply of dry matter of the herbaceous plant layer and the browsed woody zone, which can be consumed by red deer during winter per each category on 100 ha and with 60% feed digestibility. The quantity of food and consumption by deer was taken for 150 winter days from November to March, with the average daily consumption of 4.5 kg of dry matter. In this way, the biological carrying capacity of the habitat during the winter was calculated for each forest type represented in this study area.

RESULTS AND DISCUSSION

Red deer is a nutritionally flexible species (Popović and Đorđević, 2009) based on its feeding habits, i.e. an intermediate or mixed feeder, based on Hofmann's (1985, 1989) classification of dietary choices. Red deer nutrition depends directly on the season (Hofmann, 1985, 1989; Novaković, 1999), but according to some authors, it also depends on high sexual dimorphism, individual differences in biomass, age, and genotype (Van Soest, 1982; Bailey, 1984; Demment and Van Soest, 1985; Loison *et al*., 1999; Gebert and Verheyden-Tixier, 2001, Bugalho and Milne, 2003). Nutrition varies also depending on habitat conditions, so Gebert and Verheyden-Tixier (2001) identified three main red deer habitat groups: in mixed deciduous forests, in mixed coniferous forests, and in moorlands. Red deer eat a varied diet consisting of a great number of plant species. According to Novaković, 1999, red deer consume about 50 plant species, Adamič (1988) reported about 20 plant species consumed by red deer, and Gebert and Verheyden-Tixier, 2001, identified more than 100 species of woody and herbaceous plants in red deer diet. According to Hofmann, 1985, red deer nutrition is seasonal, but in the absence of the concentrates, they switch to leaf browsing and eat fallen fruits and seeds (Hofmann, 1973; Bugalho and Milne, 2003). Novaković (1999) reports that, during winter, the percentage of woody plants in red deer nutrition accounts for as much as 95%. The percentage of herbaceous plants accounts for 5-10% in mid-March, and up to 90-100% during summer. Adamič (1988) claims that on average during summer, volume percentage of grasses accounts for 50.7%, and the percentage of woody plants is in negative correlation with grass percentage. Gebert and Verheyden-Tixier (2001) claim that red deer diet consists of 29% of grasses constantly, with minor seasonal variations. According to the above authors, tree bark, twigs, leaves, fruits, seeds and forage plants account for 59% in red deer nutrition. From the above facts, it can be concluded that red deer nutrition is very complex and that it depends on several factors. The complexity of red deer nutrition can be explained by finding the compromise between food quantity and its nutritive quality (González-Hernández and Silva-Pando, 1999).

North-eastern Serbia is characterised by a high diversity in vegetation types, from natural forests and coniferous plantations to alpine meadows and pastures, as well as agricultural crops. Natural forests are characterised by the diversity of forest plant communities, from eastern hornbeam thickets (xerothermic forests) and oak forests, to beech forests which are the widest distributed in this area. Total area of beech forests after Krstić and Stojanović (2003) amounts to 114,812 hectares, of which high forests account for 81%, coppice 17% and other wooded land to 2%.

Based on the comparison of floristic composition of beech forests in northeastern Serbia, it was found that of 44 plant species in red deer diet identified in the studies by foreign authors (Jensen, 1968; Dzieciolovski, 1970; Van de Veen, 1979; Gebczynska, 1980; Staines *et al*., 1982; Picard *et al*., 1985; Matrai and Kabai, 1989; Palacios *et al*., 1989; Picard, Oleffe, and Boisaubert 1991; Picard and Gegout, 1992; Latham *et al*., 1999; Saint-Andrieux, 1999), 34 are represented in northeastern Serbia, which accounts for 77.27%. Additional comparison was carried out with Adamič's (1988) research in Slovenia, where out of 12 plant species which were not listed by the above authors, 7 are represented in Serbia (58.3%). Of altogether 56 plant species which are listed by foreign authors, 41 species are listed in Serbia, which accounts for 73.2%. Based on the above, it can be concluded that the areas of northeastern Serbia and Homolje provide favourable conditions for red deer nutrition and thus also for their growing. The lower number of plant species for red deer nutrition in northeastern Serbia compared to Europe (including Slovenia) is the result of the fact that Serbia does not support some plant species which are native to Europe, but it should be noted that in Serbia, and also in northeastern Serbia, there is a far greater number of plant species compared to Europe, which have not been mentioned in this paper, and which should by all means be investigated in future, considering the potentials of red deer nutrition.

Based on the results of the study performed in Poland (Dzieciolowski, 1976), the quantity of dry matter was calculated per each type of vegetation, based on which the potential biological carrying capacity for red deer in the study area was assessed. The results are presented in Table 1.

Table 1. *Biological carrying capacity of different vegetation types for red deer in the area of Beljanica-Crni Vrh*

Vegetation type	Dry matter /100 ha (t)	Number of deer /100 ha	Habitat area (ha)	Carrying capacity
Beech forests	0.5 - 1.0	0.7 - 1.5	9,300	65 - 139
Oak forests	2.2 - 6.0	3.3 - 6.8	1,800	59 - 122
Forests and other wooded land	1.5 - 1.9	2.2 - 2.8	4,100	90 - 114
Coniferous forests	1.8 - 2.9	2.7 - 4.3	1,000	27 - 43
Soft broadleaves	4.0 - 6.0	5.5 - 8.8	400	22 - 35
Montane meadows/pastures	0.5 - 0.7	0.7 - 1.0	6,500	45 - 65
Agricultural crops	0.3	0.5	800	4
Barren land	0.2	0.3	1.100	3
TOTAL	**11-19**		**25,000**	**315-525**

Based on the dry matter productivity in the above vegetation types during winter period, it was calculated that between 315 to 525 red deer can be raised in the entire area of Beljanica-Crni Vrh. The study area covers 25,000 ha, and population density could be up to 2 individuals per 100 ha. This population density is below the European average, which is 7 individuals per 100 ha (Novaković, 1999), i.e. it is similar to East German habitats reported by Neumann (1963) with the density ranging from 0.8 to 3.3 heads per 100 ha, based on natural winter nutrition potentials. In this sense, the population density in Homolje has been harmonised with the nutrition potential of the habitat during winter months.

CONCLUSION

The territory of Serbia, and thus also of north-eastern Serbia, thanks to its geographical position, climate, plant community and orographic diversity is a favourable habitat for red deer. The increase in red deer abundance is required not only from the ecological aspect, but also because of the economic component of sustainable hunting and rural development in Serbia. The assessment of the habitat biological carrying capacity is one of the preconditions for the correct red deer re-introduction.

Based on the comparative analysis with foreign studies, it can be concluded that red deer nutrition is complex and diverse. Our study shows that, compared to foreign research, 73.2% of plant species are represented in Serbia, although it should be noted that the study area supports a much higher number of plant species suitable for red deer nutrition than the number listed in foreign studies. The mosaicness of different vegetation communities and a great number of plant species points out that in Homolje area, red deer has sufficient natural nutrition potential, and consequently this area is a favourable habitat for red deer farming. By the application of the method of habitat biological carrying capacity based on the productivity of dry matter in the study area, it was found that on average 1.3-2.2 red deer can be raised per 100 ha, which for the entire complex amounts to 315 up to as much as 530 heads. The estimated red deer abundance should be the base for more in-depth research which should point to the optimal abundance, and age and sex structure of the population.

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HUNTING AND HUNTING TOURISM IN TURKEY

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Abstract: *Hunting was firstly regulated with The Law of Land Hunting No.3167 in 1937 in Turkey. This law was amended to 4915 numbered on 01.07.2003 according to requirements of current conditions. This law aims to sustain hunting and wildlife management, to protect and improve game animals with their natural habitats, to control and manage the hunting in the country. Depending on The Law of 4915 numbered, The Central Hunting Commission was established. This commission chaired by Minister of the Forest and Water Affairs, meets every year in May. In addition, The Central Hunting Commission determines game animals' bag limits, quotas and the areas which are closed or opened to hunting for the following year.*

In Turkey, hunting season begins in the middle of the August along with quails, turtledoves, wild boar and jackal's hunting. The season is closed at the end of February. Foreign hunters can hunt depending on hunting tourism. Wild goat (Ibex), chamois, red deer, roe deer, wild boar, Anatolian wild sheep, gazelle, hybrid ibex, fox and jackal are hunted according to game tourism regulations.

In Turkey, the number of game animals except wild boar is far below the carrying capacity of the country. Because of this, the quotas given for hunting between 2011 and 2013 seasons were very low. For example, the quotas for ibex 289, chamois 17, red deer 54, Anatolian wild sheep 6, gazelles 10 and roe deer 52 were given in 2011 for hunting tourism. However, the wild boar's quota given was around 3850. In 2012 hunting season, these quotas were increased a little.

Key words: Hunting in Turkey, Hunting tourism

INTRODUCTION

Hunting means that catching activity of free-living animals dead or alive has been attracted through the human history by humankind. The interest or instinct of hunting is still continuing all over the world. However, activity of hunting has changed/developed more than previous periods in terms of recreation, integration with nature, cultural and moral meanings (Geray, 1999).

Hunting influences wildlife populations and wildlife populations influence hunting. This is obviously an over-simplification of the role that hunting plays in the management and regulation of wild animal populations but nonetheless it is true to a degree (Anderson, 2012). It is the question that sustainability is possible when people use natural resources or in hunting. The answer is that natural resource use is sustainable when it does not significantly affect the wild population. It means that to be sustained hunting the use or harvest of the resources does not exceed the production (Robertson and Bennett, 1999).

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HUNTING IN TURKISH HISTORY

Hunting was very important in the history of Turks and it was considered as preparation to the war. Turks hunted many animals through the falconry (hawk, falcon, eagle and buzzard) and hounds. When they were in the Central Asia, women also used to hunt. Generally a banquet was arranged after hunting. In Seljuk Empires, there were hunting commanders and troops who were responsible for hunting. During the Ottoman Empires, there were a central hunting organization and provincial hunting organization. In both of Seljuk and Ottoman Empires, hunting was considered for preparation to the war. For hunting, the Ottomans had used leopards, hounds, falcons, hawks, eagles and buzzards. "Sekban and Samsoncu" were called who were dogs' trainers worked for the Sultans. The sultans were organized great hunting parties. For example, Yıldırım Beyazid who was the fourth Ottoman Sultan was organized a hunting party, the number of dogs' trainers was 6000 and falconers 7000. II. Murat (Hudavendigar), the second Ottoman Sultan, had over 1000 hounds and 200 falcons, eagles etc. The Sultans had hunted in Istanbul, Sariyer - Belgrad village, around the Terkos lake, Alemdag, Silivri, Edirne, Kirklareli and Bursa. In Ottoman Empire, I. Murat, Yildirim Beyazid, II. Murat, Fatih Sultan Mehmet, Yavuz Sultan Selim, Kanuni Sultan Süleyman, III. Murat, I. Ahmet, II. Osman, IV. Murat, I. Ibrahim, IV. Mehmet, II. Ahmet, II. Mustafa were enthusiastic for hunting (Mol, 2006).

HUNTING LAW IN TURKEY

In Republic of Turkey, hunting was firstly regulated with The Law of Land Hunting No.3167 in 1937. This law was amended to the Law No. 4915 on 01.07.2003 according to requirements of current conditions. This law aims to sustain hunting and wildlife management, to protect and improve game animals with their natural habitats, to control and manage the hunting in the country.

Depending on The Law of 4915 numbered, The Central Hunting Commission is established and consists of 21 members and chaired by Minister of the Forest and Water Affairs or his/her permanent secretary. Nine of them are hunters' delegate, three of them from the Ministry of Forestry and Water Affairs and General Directorate, a veterinary and a specialist of the plant protection from the Ministry of Agriculture. General Commands of Gendarmerie, General Directorate of Forestry, the Ministry of Youth and Sports, Faculties of Forestry, Non-governmental Organizations (mainly environmental organizations), and private hunting grounds companies are represented by a delegate[1]. In addition, this commission meets every year in May and determines game animal' bag limits, quotas and the areas which are closed or opened to hunting for the following year. Before the meeting of Central Hunting Commission hunting information is provided from Hunting Commission of Provinces, which is set up in 81 provinces according to The Law No. 4915.

In Turkey, hunting season begins in the middle of the August along with quails, turtledoves, wild boar and jackal hunting. The season is closed at the end of February. The commission determines the hunting season length. According to the Law, some of the hunting methods (explosives, poisons, traps, nets, motor vehicle on motion etc.) are prohibited; the law refers Bern Convention appendix IV.

According to the Turkish Law of Land Hunting, “hunting grounds are the areas which are naturally inhabited by game and wild animals or where they are subsequently introduced.” There are four types of hunting grounds in Turkey: 1) private hunting ground, 2) state owned hunting ground, 3) common hunting ground, and 4) sample hunting ground. Sample hunting grounds, which are reserved among the state, owned hunting grounds. Common hunting grounds are operated according to the criteria set by the Ministry of Forestry and Water Affairs. The

[1] The numbered 4915, Law of Land Hunting

establishment, management and control of the hunting grounds in Turkey are regulated by the principles of “Regulation concerning of the Principles and Procedures of Establishment, Management and Control of the Hunting Grounds”. According to the regulation, the management, operation of the state owned hunting grounds and common hunting grounds are carried out by the Provincial Directorates, The Ministry of Forestry and Water Affairs. Sample hunting grounds are managed by the game manager who has provided minimum adequacy conditions and technical and administrative contract which is determined by the Provincial Directorates, The Ministry of Forestry and Water Affairs. Likewise, private hunting grounds also are managed by the game manager. According to the mentioned regulation, sample hunting grounds are created at the areas bordered by the General Directorate of Nature Protection and National Parks in the state owned hunting grounds and common hunting grounds for the species with enough population density according to the pre-study and inventory studies. According to the same regulation, the sample hunting grounds must be at least 3000 ha for the game mammals and 1000 ha for the game birds (Beskardes et al., 2010). Today, there are established 55 sample hunting grounds, 10 general hunting grounds, 56 state hunting grounds and one private hunting ground which approximately cover 1 million hectares[1].

In order to get hunter certificate, a hunter course has to be completed once and made visa every year in Turkey. Foreign hunters can hunt with a temporary hunting license given by hunting tourism regulation. They may bring their bows, rifles, shotguns and bullets according to the Law of Land Hunting.

According to Bora (2009), the estimated number of hunter is around 200000 - 250000. This number is around 300000 hunters according to FACE[2] (European Federation of Associations for Hunting and Conservation). According to Kayaoz (2009) the number of hunters is around 2 million in Turkey. However, exact number of hunters is not known due to unregistered hunters and gun owners. In 2011-2012 seasons, around 115000 hunters made visa their licenses and got hunting right for that year. 45000 hunters were checked in the field during the season and 3216 illegal hunting activities were fined by Natural Protection and National Parks (Akbas, 2012). Except for hunting with poisons, the illegal hunting is always punished with pecuniary penalty. 2012-2013 compensation prices for game animals are given in Table 1. In addition, according to Safak et al. (2011) in Aegean Region, 11% of hunters hunt out of hunting period.

According to Central Hunting Commissions' Decisions, in 2012 - 2013 seasons, three hunting days (Wednesday and weekend) and public holidays are allowed for hunting except wild boar hunting which can also be hunted on Tuesday additionally. The daily limits of game animals have given in Table 2. According to Safak et al. (2011) and Bora (2009) a hunter goes hunting for 60-70 days in a season and the average of hunter's hunting day in a season is 2 - 2,5 per week respectively.

According to Safak et al. (2011), educational level of hunters are generally at primary school level. They mostly consider hunting as a sport activity and hunt quail, partridges and rabbits. Many of them (73%) have a hound at least.

[1] Genel ve devlet avlaklarının 2011 - 2012 av dönemine ait yıllık avlanma kotaları www.milliparklar.gov.tr
[2] Face Annual Report 2009-2010, http://www.face.eu/Hunting%20in%20Europe/Census/DATA%20Hunters-region,%20Sept%202010.pdf

Table 1. Protected Wild Animals by The Ministry of Forestry and Water Affairs, Central Hunting Commission and compensation prices.

Mammals and Reptiles (Additional lists I and II)	Compensation prices of illegal hunting (Euro) (1 Euro = 2,25 TL)
Anatolian wild sheep and wild sheep	26667
Leopard	22222
Fallow deer	11111
Bear	8445
Chamois	6667
Hyena	5778
Red deer, ibex	5333
Monachus monachus	3556
Gazella gazella	3333
Gazella subguttorosa	2889
Lynx lynx, Caracal caracal	2667
Lutra lutra, Felis silvestris, Felis chaus	1422
Roe deer	1333
Mustelidae and Sciuridae families	133
Herpestes ichneumon	67
The other mammals and reptiles (all of them in Additional lists I and II)	133
Birds (Additional lists I and II)	
Falconiformes, Accipitriformes	3333
Pelecanus crispus and Otitidae	2000
Bald ibis, Slender-billed curlew	2222
Tetraonidae, Gruidae,	1333
Ciconiidae, *Pelecanus onocrotalus, Phoenicopterus ruber*	889
Phalocrocorax aristotelis, Anser erythropus	356
Oxyura leucocephala, Aythya nyroca, Marmaronetta angustirostris, Branta ruficollis, Crex crex	444
Vanellus vanellus, Lymnocryptes minimus, Ardeidae and ducks under protection	200
Phasianus colchicus, Francolinus francolinus, Perdix perdix	289
Corvidae	44
The other species which are protected	178
Mammals Additional list III (exceeding hunting limit)	
Fox, Mustelidae, *Lepus europaeus, oryctolagus cuniculus*	222
Wild boar	133
Jackal	89
Birds (Additional List III)	
Anser albifrons and ducks	178
Alectoris rufa, Alectoris chukar, Turdus merula, Streptopelia turtur, Columba palumbus, Scolopax rusticola, Ammoperdix griseogularis, Gallinago gallinago	156
Corvidae (Except *Garrulus glandarius*)	22
Garrulus glandarius, Passer domesticus	67
Columba livia, Fulica atra, Coturnix coturnix	133
Using ducks, geese, pigeons and partridges as decoy	222

Table 2. *Daily hunting limits according to Central Hunting Commission' Decision.*

Birds	Hunting limits (daily)
Coturnix coturnix	10
Streptopelia turtur	8
Turdus merula	3
Columba livia	6
Scolapax rusticola	4
Pica pica	15
Columba palumbus, Fulica atra, Anser albifrons	3’er
Garrulus glandarius, Gallinago gallinago	1’er
Alectoris rufa, Alectoris graeca, Ammoperdix griseogularis	Total 2
Perdix perdix; in this hunting season it may be hunted in Erzurum, Erzincan, Yozgat, Kars, Sivas, Tunceli, Bingöl, Ağrı, Van, Iğdır, Ardahan, Elazığ, Muş, Bayburt, Gümüşhane, Tokat, Çankırı and Bitlis provinces	2
Anas platyrhynchos, Anas strepera, Anas penelope, Anas crecca, Netta rufina, Ayhtya fuligula, A. Ferina, Anas querquedula, Melanitta nigra ve Bucephala clangula (But the number of *A.fuligula, B.clangula, M.nigra* is only one duck)	Total 6
Corvus monedula, C. Corone, C. frugilegus	Total 15
Passer domesticus and *Lanius collurio (only for Falconry and after hawk catch, these birds must be released)*	Total 6 (in a year)
Mammals	
Lepus europaeus	1
Oryctolagus cuniculus, Martes martes, M. Foina, Sus scrofa	2
Sus scrofa *(during drive hunting per hunter) (drivers are not allowed to hunt)*	2
Canis aureus	1
Vulpes vulpes	2

The first activities of game tourism started in 1950s. Since Turkey became a NATO's member, Americans who were hunter, personnel of NATO, hunted in Turkey those years. In 1960s, because of Turkish people's migration to Europe, their friends and bosses had came to Turkey and hunted in Anatolia's far-flung lands. Finally, in 1967, in order to manage the hunting tourism, The Central Hunting Commission, The Ministry of Agriculture had made game tourism companies to get permission for hunting in Turkey. However, until 1970, tourists had hunted with no limit and no arrangement. After 1970s, there were made some arrangements about hunting for foreign hunters through the game tourism companies, Thus, foreign hunters had started to pay for hunting and first practice of hunting tourism had been wild boar hunting in

1977 (Serez and Baskaya, 1996). In 1981 ibex, in 1983 bear, wolf and jackal was opened for hunting in game tourism (Kayaoz, 2009). Today, 74 hunting tourism companies have A-Class License in Turkey[1] arrange hunting organizations for native or foreign tourist hunters in Turkey. In addition, Wild goat (Ibex), chamois, red deer, roe deer, wild boar, Anatolian wild sheep, gazelle, hybrid ibex, fox and jackal are hunted according to hunting tourism regulation. Hunting fees depends on game species, its weight and size of the trophy are determined by the Ministry of Forestry and Water Affairs.

In Turkey, the quotas of game animals for hunting tourism was given in Table 3 [2 and 3]. These numbers does not consist of sample hunting grounds' quotas because enough data have not been reached during this study.

Table 3. *The quotas of game animals for hunting tourism.*

Game species	2011-2012	2012-2013
Ibex	289	313
Hybrid ibex	16	17
Chamois	17	31
Red deer	54	62
Anatolian wild sheep	6	6
Gazelle	10	20
Roe deer	52	98
Selection ibex (for fault trophy)	17	17
Wild boar	3850 (with State and general hunting ground)	No data for this year

Hunting with predator birds is different from Europe. In Turkey, a hunter can use only hawk (*Accipiter nisus*) for hunting. The other species for example eagles, buzzards and falcons are not allowed to use for hunting. If a hunter wants to hunt with hawk, he must own hunting license. Moreover, falconry is made in a traditional manner.

DISCUSSION

According to Kayaöz (2009), in Turkey, wildlife habitat areas cover 74 million ha, is 95.55% of the country area. When protected areas is subtracted (around two million ha), 72 million ha area can be thought as hunting grounds and these areas have already been used for hunting areas over the years. 60% of hunting areas belongs to the government, 35% of these areas agricultural area and private lands. However, General Directorate of Nature Protection and National Parks has started to develop the hunting system. First, state-owned and common hunting grounds were determined and wildlife populations were estimated in hunting grounds. Unfortunately, this procedure has not been accomplished yet. Only 66 hunting grounds were determined for one year. This means 66 hunting grounds (1 million ha) has management plan, but the rest of the hunting areas (71 million ha) are out of the system.

The main difference in hunting between Turkey and Europe countries is ownership of the game animals. In Turkey, game animal belongs to who shot the animal, because animals belong to the government or no owners. This is the traditional thinking, which brought from the central Asia. For example, private agricultural areas have no fences generally because of their size; hunters may go into the area and hunt anything. Sometimes they can permit from landowners. In Europe, game animal belongs to landowners where animal lives. Landowners manage game animals as their livestock.

[1] http://www.milliparklar.gov.tr/DKMP/Files/atib.pdf
[2] 2011- 2012 av yılı (1 Nisan 2011- 31 Mart 2012) av turizmi uygulamalarını içerir ilkeler www.milliparklar.gov.tr
[3] 2012- 2013 av yılı (1 Nisan 2012- 31 Mart 2013) av turizmi uygulamalarını içerir ilkeler www.milliparklar.gov.tr

In Turkey, the number of game animals except wild boar is far below the carrying capacity of the country. Because of this, the quotas given for hunting between 2011-2013 seasons were very low. The reason of high population density of wild boars has two main explanations. The first reason is meat of wild boar and is not allowed to be eaten depending on Islam. The second reason is high birth rate of wild boars.

In Turkey, hunting of Red deer, roe deer, Fallow deer and the other big game animals are forbidden by both of the Law of Land Hunting 3167 numbered in 1937 and 4915 numbered in 2003 except hunting tourism. Normally it can be expected increasing in especially the number of big game animals. However, there is no increasing population of these animals. The main reason of that lower animal density except wild boar is poaching. Safak et al. (2011) has found same results in h is research.

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CORRELATION BETWEEN THE EGG SHELL COLOR AND PHEASANT EGG INCUBATION

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Abstract: *Based on research conducted in 2011 year, regarding the impact of genetic factors on the hatching and vitality of pheasant chicks and young, authors came to conclusion which indicates a strong causal relation between the egg shell color and certain production parameters such as the percentage of died embryos. A model was based on determining egg shell color for 420 eggs of the Phasianus mongolikus. Shell color of eggs obtained in aviaries is very versatile and can be expressed in almost 25 tones of colors. All these nuances are embedded in the 7 basic tones. The result shows that percent of died embryos is 85% for lime skim eggs, 50% for lime spots eggs, 50% for green eggs, 30% for blue-green eggs, 25% for dark grey eggs, 25% for brown eggs and 20% for light brown eggs. Achieved results of the research were applied to one of the biggest pheasant farm in Serbia „Šumadija"form Kragujevac. The total number of eggs was 216,188 from which 191,240 were fertilized eggs, and 24,948 were eggs with died embryos. So, the total number of hatched pheasant chicken was 155,690. When total number of eggs (216,188) is used with above mentioned parameters, almost same results are obtained (155,763) which confirm the correctness of the obtained results.*

Keywords: pheasant egg shell color, egg fertility, died embryos

INTRODUCTION

Pheasant game production on farms – rising areas – pheasant farms did not begin to develop on the territory of Serbia until the sixties of the 20th century, when in our country, but also in Central, Eastern and Southern Europe began to reduce the number of partridges. Since then, in most of the European countries pheasant became the main hunting game. This period, which is still ongoing, was recorded in the hunting and the ecological literature as the period in which occurred the largest population growth of one species of wild animals in human history. Tens of millions pheasants of different ages were released in various biotopes.

In order to start pheasant production and pre-determine capacity, it is needed to know:

1. The needs of the region for pheasant game hunting from artificial production, and
2. Limits of profitability of the Pheasant game farm and specific age structure (category) of the product.

Regarding that production of pheasants is very risky and expensive, it is necessary to make contract with as many as possible potential buyers before production starts in order to avoid production that may take pheasant farm to a situation in which most production remains

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unsold. This could lead to the losses at very beginning of farm development, and therefore the investment in such farm would be called into question.

Minimum capacity based on the experiences of Milisavljević (1989) is 40,000 pheasant chickens. Based on the research of Gajić (1975), the minimum capacity below which such production should not be started is 25,000 pheasant chickens, while by the research of Ristić et al. (2009), the production of at least 15,000 pheasant chicks is within acceptable limits.

In building the pheasant farm infrastructure facilities such as main buildings (halls of hatchery and hall for floor battery or floor upbringing), as well as construction of other buildings (houses for upbraiding with discharge, or so called,, Prato's" hall, "winter aviary", aviaries for keeping parent flock, etc..) are necessary and can be built in phases (not recommended) or at a time, before the commencement of such production. For example, some farms which were built in stages are still not finished.

LITERATURE REVIEW

During researches carried out in Turkey, the average pheasant egg weight was determined at 31.03 g (Kiricki et. al, 2003).

Based on the research of Jović (1964), was noticed that most of the observed eggs were fawn-colored paint (up to 43%), green-brown (about 24%) and brown (about 19%), followed by: a dark brown color (up to 4%), white (5%), green blue (up to 4%) and finally, a very light green (up to 1%).

The occurrence of irregular lime shell gave interesting results. It is noted that these eggs, which are not coated with a layer of wax, almost never give chicks. According to these data, such eggs are represented as an average of 2.5%, but their number is increasing by the end of the hatching period up to 5.47% (lime eggs). Eggs with stronger lime occurrence revealed as white spots are only 0.58% (Ušćebrka et al., 2011).

The role of these characteristics of the egg shell is not yet sufficiently explored during incubation process. To explore connection of the egg shell color and some of the phenomena that occurs on it, was performed an experiment which requires additional testing, because small number of eggs was taken into account. Groups of eggs were made according to the colors of the shell, and in each group were 20 eggs. All eggs were equally old, and the incubation was running normally. The eggs that were incubated simultaneously with those in experiment and were normal in terms of color composition of the shell during incubation were rejected 25% to 30%, i.e. hatching ranged from 70% to 75%. The acquired data from four groups of eggs indicate that the largest number of rejected eggs in the group with irregular lime of the shell (95%), green (50%) and lime spots on the shell (50%).

The percentage of unfertilized eggs varies during the laying period and generally is from 10% to 17%. According to research of Ristić (2005) for the period 1993-2002, from a total of 1,954.056 eggs unfertilized were 259.342 or 13.27%. The same research showed that 365.978 embryos died, so the percentage of died was 18.73% of the total eggs, and the percentage of fertilized eggs was 21.60% dead. In some pheasant farms the second eggs candling is practiced (usually after 14 days), to reject eggs in which the embryo died by a variety of reasons. In large pheasant farm this process is not usual.

Number of pheasant chickens hatched from planted eggs depends on the quality of incubation and the number of fertilized eggs. In relation to the time of planting, the number of hatched eggs is within the following range: up to 60% for the eggs hatched up to the 20th of April, followed by 60% to 70% of those hatched until 20th of June, and after this period percentage falling below 60% (Jović, 1964, Ristić et al. 2010).

According to research of Ivanović and Ristić (2006) for the period from 1993 to 2002, conducted in the pheasant farm "Ristovača", 1,330,351 pheasant chickens hatched of total of

1,954,056 eggs or 68.08%, and 1,330,351 pheasant chicks hatched of total of 1,694,714 fertilized eggs or 78.50%.

The average weight of Pheasant Mongolicus eggs was 33.79 g, with standard deviation 2.87, and coefficient of variation 8.5%. Number of taken variants was 152, and the average error 0.23. For the eggs of *mongolicus-torquatus* pheasant average weight was 32.55 g, standard deviation 2.60, and coefficient of variation 8.0%. Number of variants was 331, and a medium value of errors 0.14. From these data we can see that the weight of eggs is higher in *mongolicus* subspecies (33.79 g), slightly lower for egg of *mongolicus-torquatus* (32.55 g), while *colchicus* eggs have even less weight 29 g (Jović, 1964).

According to research of Nadezdin, pheasant egg weight ranged from minimum of 25.53 g. up to 38.17 g, so the average weight is 31.85 g (Nadazdin et al., 1996).

Based on eggs weight measurements performed in pheasant farm "Ristovača", during the experiment named "Influence of different levels of protein in diets in the parent flock of pheasants" in year 1997, was determined the average egg weight of 32.53 g, while the minimum average egg weight was 25.53 g. and a maximum of 38.17 g.

Also, the mass of one-day pheasant chickens was determined. On the basis of that study, the average minimum weight of 15.53 g was determined, with an average maximum body weight was 26.39 g. Based on these two body masses was found the average body weight of day-old pheasant chickens of 21.42 g.

MATERIALS AND METHODS

Taking in consideration the fact that, in Serbia, none of the three main subspecies of pheasants (plain - *Phasianus colchicus* Linnaeus, 1758; Mongolian - *Phasianus Mongolicus* Brandt, 1845; and Chinese - *Phasianus Torquatus* Gmelin, 1789) is preserved as a pure subspace, the last extensive research about basic biological parameters for the three subspecies of pheasants was conducted more than 50 years ago. Today, pheasant is widely produced (over 200,000 pheasant chickens annually in Serbia, and about 30 years ago about 800,000 per year). This fact raise a need for research such is - the impact of color and egg shell quality on the viability of newly hatched chicks, for so called ,,hunting" pheasant, which is produced in our country. The hunting pheasant was created by crossing the three above-mentioned ,,basic" sub-species of pheasants, and it is, in fact, the only pheasant grown and hunted in hunting pheasant farm and hunting grounds nowadays.

Research was conducted in the laboratory for Anatomy and Histology of the Agricultural Faculty in Novi Sad, with three repeats for each of 100 eggs in four different groups of egg coloration (dark brown, light brown, brown-green and blue green). Using the same methodology, in order to obtain larger sample of selected eggs, research of monitoring egg hatching were performed in Kragujevac pheasant farm.

RESEARCH RESULTS

Based on research conducted in year 2011th, regarding the impact of genetic factors on the hatching and vitality of pheasant chicks and young, researchers came to conclusion which indicates a strong causal link between the color and quality of egg shell and certain production parameters such as the ability of chicks hatching and vitality, then vitality and capacity of the parent flock, all obtained from eggs that have been selected on the basis of a different color and eggshell quality. On the basis of the preliminary results, gained from four separate groups, separated in four aviaries in which were 80 hens and 8 cocks when the parent flock was kept in aviaries during the period of hatching from 1st of March to 31st of May, the following indicators were obtained and the following can be concluded:

1. The total number of eggs:
- Based on the first control group (A) were maximum 53.4 eggs.
- Based on the fourth of the control group (D) were minimum 48.1 eggs.

2. Fertilization
- Based on the second control group (B) the best results were 92.1%.
- Based on the fourth control group (D) scores were the lowest 80.2%.

3. Hatching - sawing of pheasant chicks (from deposited eggs):
- Based on the second control group (B) the best results were 76.3%.
- Based on the first control group (A) the results were the lowest 70.2%.

4. Hatching - sawing of pheasant chicks (from fertilized eggs):
- Based on the fourth control group (D) the results best were 91.0%, indicating that the viability of embryos of this group of pheasants is extremely high.
- Based on the first control group (A) the results were the lowest 78.8%.

5. The mass of eggs:
- Based on the fourth control group (D) the results were the best 31.1 g.
- Based on the first control group (A) the results were the lowest 29.6 g.

On the basis of described parameters following can be concluded:
- Based on the criteria of color and eggshell indirect reflection on some of the production characteristics can be expected,
- Shell color may indirectly affect the quality of shell eggs, fertilization in certain measure, and consequently on the total result of hatching, but it has very low affect on the eggs weight and a number of eggs laid by pheasant hens.

We should have in mind that these are preliminary studies, which were performed on a limited number of samples.

In order to make more concrete conclusions in this regard it is necessary to continue this research. Moreover, if opportunities permit, a place in this research should have a diet, physiology and genetics.

Table 1. *Production parameters of pheasant by the color of eggshells*

Type of eggs	Number of eggs/pheasant	Fertilized eggs, %	Died embryos %	Hatching % From total number	Hatching % From fertilized	Average egg weight
A dark-picking	53.4	89.1	14.92	70.2	78.8	29.6
B brown	51.8	92.1	14.11	76.3	82.8	30.9
C green	50.8	89.8	15.45	75.4	83.9	30.3
D blue-green	48.1	80.2	16.33	73.0	91.0	31.1
Average:	51.03	87.93	15.18	72.76	82.74	30.48

Table 2. *The parameters of the incubation of pheasant eggs*

Gruops by aviaries	Total number of eggs in group	Total number of fertilized eggs	Eggs with died out embryos	Number of hatched pheasant chickens	Hatching % From total number	Hatching % From fertilized eggs
A	4,272	3,806	637	3,169	70.2	78.8
B	4,144	3,817	585	3,232	76.3	82.8
C	4,064	3,649	628	3,021	75.4	83.9
D	3,848	3,086	628	2,458	73.0	91.0
Total:	16,328	14,358	2.478	11,880	72.76	82.74

Figure 1. *Pheasants in the parent flock* Figure 2. *Pheasant chickens*

Photo: Pap J.

Aviaries for lying eggs

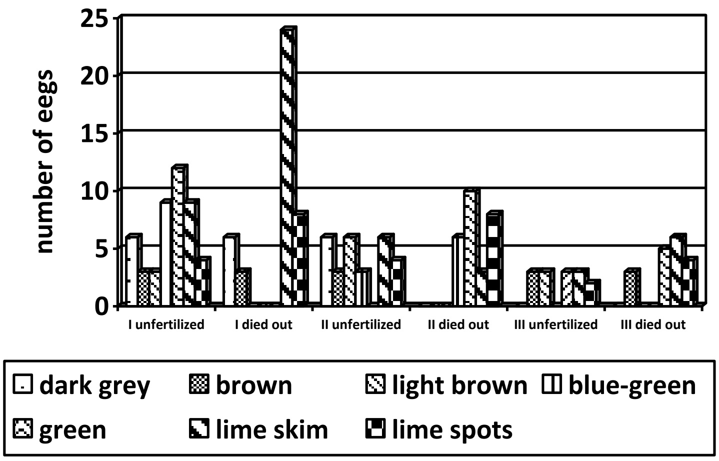
Jovetić (1957) dealt with the issue of the optimal sex ratio of the parent pheasant flock breeding in aviaries back in 1957, researching the percentage of fertilization of eggs in different gender ratio from 1:10 to 1:20 (in favor of females). Since there were no significant differences, it was recommended, in artificial breeding, to use sex ratio up to 1:16. Lukas and Jamroz in 1961 came to similar conclusions. On the basis of the present study, the percentage of fertilization at different gender ratio in artificial breeding was defined. For example, in case of sex ratio 1:5 was found that conception was 95%, in case of sex ratio 1:12 conception was 93%, in case of sex ratio 1:15 conception was 91% and in case of sex ratio 1:20 conception was 83%.

Egg shell color

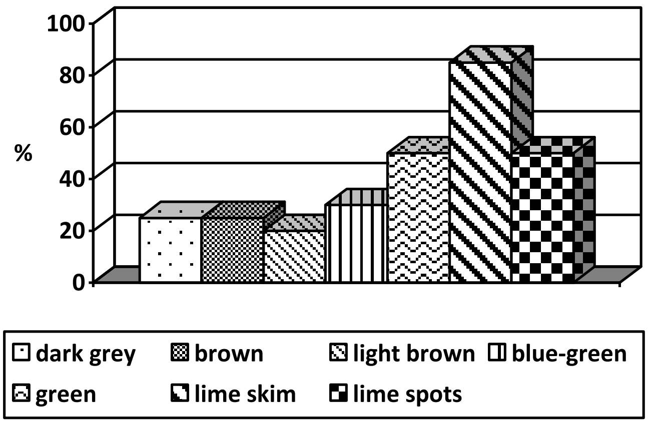
Shell color is determined for 420 eggs of the *Phasianus mongolikus*. Shell color of eggs obtained in aviaries is very versatile and can be expressed in almost 25 tones of colors. All these nuances are embedded in the 7 basic tones. In addition to color, stronger limes appear as white spots and irregular lime shell are described.

By applying the achieved results of the research, adapted to the nowadays conditions in the shades of color and applying the current terms of one of the largest pheasant farms in this area, based on the 420 eggs samples led to the following indicators (Graph 1 and Graph 2).

Graph 1. *The sample for the first, second and third monitoring of the pheasants eggs*



Graph 2. *Percentage of died embryos by egg shell color*



The result shows that percent of died embryos is 85% for lime skim eggs, 50% for lime spots eggs, 50% for green eggs, 30% for blue-green eggs, 25% for dark grey eggs, 25% for brown eggs and 20% for light brown eggs.

Aplication of obtained results – Pheasant farm in Kragujevac

In one of the biggest pheasant farm in Serbia „Šumadija“ form Kragujevac, the data for this study has been collected during 2011. year. The total number of eggs was 216,188 from which 191,240 were fertilized eggs, and 24,948 were eggs with died embryos. So, the total number of hatched pheasant chicken was **155,690**. When total number of eggs (216,188) is used with above mentioned parameters, almost same results are obtained (**155,763**) Table 3.

Table 3. *Aplication of percentage of died embryos*

egg shell color	number of eggs	% of died embryos	number of died embryos	number of hatched ckickens
dark grey	8,648	25	2,162	6,486
brown	41,076	25	10,269	30,807
light brown	92,961	20	18,592	74,369
blue-green	51,885	30	15,566	36,319
green	2,162	50	1,081	1,081
lime skim	8,648	85	7,351	1,297
lime spots	10,808	50	5,404	5,404
Total:	**216,188**		**60,425**	**155,763**

Figure 3. *Different eggs shell colors*
Photo: Ristić Z.

CONCLUSION

The goal of this research is to suggest realistic parameters that will primarily serve to establish the true indicators of the number of fertilized, or the percentage of fertilized eggs, as well as number (percentage) of died embryos. These two parameters are required as a base for accurate determination of how many eggs are necessary for a production in each particular year, and what should be the number of the parent flock at formation (late February and early March). In production facilities - pheasant farms those data are incorporated in the Production plan that should by defined at the end of previous year.

This kind of research give us an argument, for all Pheasant eggs that differ from the typical colors (brown, dark-picking, green, and blue-green), which have a smaller percentage of hatching, as compared to standard - the typical color of the egg shell, not to put at all in incubators (but also if the eggs are with lime scum and lime spots on the shell). It was found that 50% to 85% of those eggs had to be thrown away. Obtained data confirmed that most of the discarded eggs are with shell lime skim 85%, while in the egg shell of green coloration and eggs that have lime spots on shell 50% eggs are discarded.

Research showed that of four analyzed groups of pheasant hens only group D had a lower capacity than other groups in which the laying of eggs was larger than 50 eggs (Table 1). Fertilization of the Pheasant eggs was highest in group B (92.1%), and lowest in group A (70.2%). The average egg weight for all 4 groups was 30.48 g, in the way that the groups A and C had less mass than the average, while groups B and D had a bigger mass than the average.

Based on the color of the pheasant eggs shell can be concluded that, indirect reflections on production success can be expected. Also, in the production cycle, nutrition is likely to affect color and shell quality, fertilization, and thus the overall hatching, but it has a very low affect on the eggs weight and a number of eggs laid by pheasant hens for the same period of holding the parent flock (March 1 - May 31).

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COMPARATIVE ANALYSIS OF HUNTING GROUNDS IN THE AREA OF BELGRADE

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Abstract: *Sustainable utilisation and protection of natural resources are some of the leading objectives of the present and future economic development of Serbia. In the area of Belgrade, there are 15 hunting grounds with total area reaching about 316,000 ha. The largest number is managed by the Hunting Association of Serbia through its members - Hunting Associations (10 hunting grounds - total area about 300,000 ha), while the other grounds are managed by the State Enterprise "Srbijašume" and the Serbian Army. The hunting grounds support some of our autochthonous and biologically and economically most valuable species of big game (e.g. roe deer and wild boar), as well as our principal species of small game (brown hare, pheasant, and partridge). The above game species are also a significant (but not also a high) economic potential, however they are much more significant as the best bio-indicators of environmental quality. The Afforestation Strategy of Belgrade Area (Official Gazette of the City of Belgrade, No 20/2011) defines many goals and measures aiming at the rational utilisation of forest resources, biodiversity conservation and environmental protection. Also, the subject of the Afforestation Strategy is to improve the state of natural forests and artificially established stands, as well as the establishment of new forests and green spaces of all categories and their integration into one functional entity. This study presents the results obtained by the comparative analysis of the Afforestation Strategy and the state of hunting grounds in Belgrade area, with the emphasis on the main threats and protection measures of raised game species and their forest habitats.*

Key words: game, hunting ground, forest, management, Belgrade

INTRODUCTION

Belgrade is one of the oldest cities in Europe and it is the largest urban centre in the Balkans after Athens. The name of Belgrade was mentioned for the first time in 878, and during its long and stormy history the city was occupied by 40 different armies and rebuilt from its ashes 38 times. The Capital of the Republic of Serbia, having city status as a separate territorial unit, and with its own local government bodies, it comprises 3.6% of the territory of Serbia, it is the home to 15.8% of the population of the country, and 31.2% of the employed population of the Republic work there (Grozdanić, 2008, Grubačević *et al.*, 2010).

There are numerous diverse natural sites of broadleaved deciduous forests in the area of Belgrade, whereas conifers are artificially introduced by afforestation. Nevertheless, the percentage of forest cover and the total area of forests in Belgrade area are absolutely insufficient, and the actual state of the forests is highly unfavourable, mainly because of the strong impact of anthropogenic factors – uncontrolled cutting in the remote past, as well as clear cutting during both World Wars (Živadinović, Isajev, 2006). More recently, forests in Belgrade

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suburban zones have been highly threatened by urbanisation, uncontrolled dumps, forest cutting, and conversion into agricultural land. In addition, the populations of almost all game species are endangered by the establishment of traffic infrastructure (motor roads, railway lines), burning of vegetation in hunting grounds (weeds, stubbles, reeds and grasses), expansion of settlements and industrial and economic zones, as well as by the presence of an increasingly higher number of dogs and cats without owners or without owner's control (they disturb, pursuit and hurt the individuals of various game species), and also by the soil, water, and air contamination.

Environmental protection of Belgrade is one of the imperatives of future development of the area (about 322,000 ha), and a special place is devoted to the development and advancement of forestry and hunting (Strategy of Afforestation in Belgrade Area, Official Gazette of the City of Belgrade, No 20/2011). The hunting grounds in Belgrade area sustain our autochthonous and the most valuable species of big game (roe deer, wild boar, red deer), allochthonous species of big game (fallow deer, mouflon), as well as the main species of small game (brown hare, pheasant, partridge). The above game species are a significant (but not also a high) economic potential, however they are much more significant as the best bio-indicators of environmental quality. The number of hunting association members in the area of Belgrade over the period 1996-2006 ranged between 5,000 and 7,000 hunters. Despite that fact, the game species raised in the above hunting grounds are insufficiently investigated, and their populations and natural habitats are not monitored. Also, because of the vicinity of the city core, and the general unfavourable changes in environmental conditions, all hunting associations in Belgrade area are required to perform rational management also of the game species protected by closed hunting seasons, and the game species under permanent (strict) protection.

The aim of this paper is to analyse the state of the populations of game species raised in hunting grounds in Belgrade area managed by hunting associations (estimated density and registered shooting in 2000/01 compared to 2009/10), as well as the Strategy of Afforestation in Belgrade Area (Official Gazette of the City of Belgrade, No 20/2011) and its effect on hunting grounds and game populations.

MATERIAL AND METHOD

The geographical position of Belgrade is specific and unique. It is situated on the convergence of two large and diverse natural entities: the Pannonian Plain and the Balkan Peninsula, with lowland in the North, and hill and hill and mountain terrains in the South. The rivers Sava and the Danube represent in the greatest part the natural boundaries between the two entities.

According to the charter of the city of Belgrade in 2010, the city of Belgrade is composed of 17 municipalities: Stari Grad (5 km^2), Vračar (3 km^2), Savski Venac (14 km^2), New Belgrade (41 km^2), Zvezdara (31 km^2), Rakovica (30 km^2), Voždovac (148 km^2), Čukarica (156 km^2), Zemun (150 km^2), Palilula (451 km^2), Surčin (288 km^2), Barajevo (213 km^2), Obrenovac (411 km^2), Grocka (289 km^2), Sopot (270 km^2), Lazarevac (383 km^2) and Mladenovac (339 km^2). The area of Belgrade covers about 322,200 ha. Agricultural land covers about 217,000 ha, which accounts for 67% of the total territory of the city of Belgrade. The greatest percentage is occupied by cultivable lands which include arable lands, gardens, meadows, orchards and vineyards (205,000 ha or 95%). Forests occupy about 39,000 ha, which means that the percentage of forest cover is very low (12.1%), though the percentage of forest cover per municipalities is not uniform.

The comparative analysis is based on the data from Hunting Industry Development Programme in Serbia 2001-2010 (2001), official records of the Hunting Association of Serbia and State Enterprise "Srbijašume" (Belgrade), Statistical Yearbook of Belgrade (SGB-10) and Strategy of Afforestation in Belgrade Area (Official Gazette of the City of Belgrade, No

20/2011). It is obvious that the study data originate from different sources and documents, but nevertheless they can be used for the comparison of raised game species density and shooting in hunting grounds in Belgrade area.

RESULTS AND DISCUSSION

In the area of Belgrade, pursuant to the Law on Hunting (Official Gazette of the Republic of Serbia, No 39/1993), there are 15 established hunting grounds which cover the total area of 315,685 ha (Table 1). The greatest number is managed by the Hunting Association of Serbia through its members - hunting associations (10 hunting grounds with altogether 303,954 ha). The average area of the hunting grounds amounts to about 30,000 ha, which is above all the official norms, as they are predominantly hunting grounds for small game. The other subjects, with different activities and management goals (State Enterprise "Srbijašume" and the Serbian Army), are the managers of 5 hunting grounds with total area of 11,731 ha, of which 1,962 ha are located in fenced hunting grounds ("Trešnja" and "Dobanovački Zabran") and fenced parts of hunting grounds ("Crni Lug"). However, this state will soon be changed during the new process of hunting ground establishment, pursuant to the Law on Game and Hunting (Official Gazette of the Republic of Serbia, No 18/2010).

In the hunting grounds of the hunting associations in Belgrade area, the dominant shares are cultivable lands with farm crops and vegetables, perennial plantations and grasses. They are cultivated, mowed and treated by other agricultural operations, and the crops are harvested regularly every year. Over the period 2005-2010, cereal crops were sawn on more than 90,000 ha (mainly wheat and maize, and less barley, rye, and oats), forage plants on over 30,000 ha (clover, alfalfa), vegetables on more than 20,000 ha (potato, tomato, cabbage, kale, green peas), industrial plants on more than 6,000 ha (soy, sugar beet, sunflower, oil-seed rape), and the share of uncultivated arable land ranged between 10,000 and 14,000 ha (SGB-10, p. 224-225).

Table 1. *Total area of hunting grounds in the area of Belgrade*

Hunting ground	Area (ha)	Forests and other woodland	Meadows and pastures	Fields and arable lands	Orchards and vineyards	Other land uses
Hunting Association of Serbia						
Pančevački Rit	39,390	1,016	3,821	23,700	812	10,041
Avala	14,849	2,598	1,260	8,165	1,117	1,709
Topčiderska Reka	18,380	2,282	1,091	11,022	1,067	2,918
Barajevska Reka	21,312	4,266	1,752	12,919	1,336	1,039
Gavranski Potok	28,674	2,761	1,451	17,620	5,004	1,838
Varovnice	33,844	2,969	4,132	21,220	3,514	2,009
Posavina	40,995	3,234	2,321	28,968	1,846	4,626
Kosmaj	26,962	4,634	2,392	16,520	2,122	1,294
Donji Srem	45,902	1,631	2,099	33,013	836	8,323
Kolubara	33,646	7,024	4,454	19,949	2,179	40
State Enterprise "Srbijašume"						
Rit	8,263	1,438	-	5,620	-	1,205
Lipovačka Šuma	1,253	1,133	18	45	-	57
Trešnja	117	111	6	-	-	-
Crni Lug	973	737	59	13	-	164
Serbian Army						
Dobanovački Zabran	1,125	494	8	412	2	209
Total	**315,685**	**36,328**	**24,864**	**199,186**	**19,835**	**35,472**

Source: Hunting industry development programme in Serbia 2001-2010, Belgrade, 2001

The largest forest area is on the territory of the municipality Lazarevac (hunting ground "Kolubara"), and the smallest is on the territories of the municipalities Zvezdara and New

Belgrade. State-owned forests account for 43.9% of the total area, and private forests account for 56.1%. State-owned forests managed by State Enterprise “Srbijašume“ in Belgrade area (about 14,000 ha) are grouped in 10 functional entities: production of technical wood (42.6%), water and flood control (19.2%), recreation-tourist centres of the first degree (16.8%), soil erosion control (13.4%), hunting and rearing centres for big game (5.0%), climate-protection forests (1.5%), water (water supply) protection of the first degree (1.2%), seed stands (0.2%), permanent protection forests (without management treatment), and strict nature reserves. This points clearly to the complexity of Belgrade area and different social requirements from these forests. Of the total forested area of state forests, high stands occupy 1,501 ha, coppice forests 6,152 ha, artificially established stands 6,313 ha (mainly poplar plantations), and other wooded land about 9 ha. As for forest mixture, pure stands are dominant (62.1%) compared to mixed stands (37.9%), although more than 35 tree species are identified in Belgrade area.

The hunting grounds in Belgrade area support some of our autochthonous and biologically and economically most valuable species of big game (roe deer and wild boar), as well as our principal species of small game (brown hare, pheasant, and partridge). Also, red deer is reared in the fenced part of the hunting ground “Crni Lug“ (about 100 individuals), and two allochthonous big game species are raised in the fenced hunting ground “Dobanovački Zabran“ (fallow deer and mouflon). The above game species are a significant (but not also a high) economic potential, however they are much more significant as the best bio-indicators of environmental quality. There are also many small game species protected by closed hunting season (e.g. fox, jackal, European badger, turtle dove, common quail), and many strictly protected species (e.g. European otter, wild goose).

Summary data on the estimated spring density and registered shooting of reared game species in Belgrade area hunting grounds managed by hunting associations are presented in Tables 2 and 3.

Table 2. *Density of reared game species in hunting grounds of the hunting associations in Belgrade area*

Hunting grounds	**Year**	**Game species**				
		Roe deer	**Wild boar**	**Brown hare**	**Pheasant**	**Partridge**
Pančevački Rit	2001	300	20	1,200	1,480	950
	2010	250	132	1,900	1,800	1,000
Avala	2001	162	0	790	1,950	1,200
	2010	330	0	1,500	2,350	300
Topčiderska Reka	2001	183	0	1,120	940	600
	2010	285	0	1,460	2,350	788
Barajevska Reka	2001	600	0	2,580	2,400	2,600
	2010	688	0	2,300	3,650	2,480
Gavranski Potok	2001	56	0	2,100	2,000	1,480
	2010	142	0	2,320	3,200	400
Varovnice	2001	1,145	30	6,100	6,000	1,850
	2010	1,100	30	3,000	6,000	30
Posavina	2001	700	0	3,000	5,000	3,000
	2010	1,325	0	5,000	7,500	4,476
Kosmaj	2001	900	30	1,500	3,500	1,200
	2010	944	60	2,180	3,770	358
Donji Srem	2001	171	0	2,300	3,560	1,600
	2010	301	48	3,978	2,924	990
Kolubara	2001	700	0	2,200	4,700	0
	2010	780	0	3,222	3,640	0
Total (n)	**2001**	**4,917**	**80**	**22,890**	**31,530**	**14,480**
	2010	**6,145**	**270**	**26,860**	**37,184**	**10,822**

The density of reared big game species (roe deer and wild boar) in the spring 2010 was considerably higher than that ten years before, while among raised small game species, a great decrease in density occurred only in partridge (except in hunting ground "Posavina"). The numerical and territorial expansion of wild boar (80 individuals in 2001 i.e. 270 individuals in 2010) is obvious, especially of its registered shooting (as much as 116 individuals in hunting ground "Pančevački Rit" in 2009), which is similar to many hunting grounds in Vojvodina and central Serbia (Hunting industry development programme in Serbia 2001-2010).

The data on registered shooting of roe deer in hunting grounds in Belgrade area are symbolic compared to the hunting ground area and natural conditions (Table 3). This can be best illustrated by the percentage of utilisation of the population compared to spring density (2.2% in 2000 i.e. 6.7% in 2009), as some authors point out that it is real that annual shooting accounts for 10-12% of the spring density, of course in managed and professionally operated hunting grounds (Hunting industry development programme in Serbia 2001-2010). In contrast to the above, the percentage of utilisation of brown hare populations was 25.5% in 2000 i.e. 20.6% in 2009. However, it is well known that a part of shooting is not registered (Šelmić *et al.*, 2001), not only that carried out by illegal hunting and poaching, but also a good deal of shooting from legally organised hunting. The highest percentage of utilisation of is characteristic of pheasants (46.8% in 2000 i.e. 66.0% in 2009), which can be explained by an elevated introduction of pheasants in Belgrade area hunting grounds, mainly of pheasant chicken.

Table 3. *Shooting of reared game species in hunting grounds of the hunting associations in Belgrade area*

Hunting grounds	**Year**	**Game species**				
		Roe deer	**Wild boar**	**Brown hare**	**Pheasant**	**Partridge**
Pančevački Rit	2000	7	7	184	995	85
	2009	10	116	239	932	11
Avala	2000	4	0	115	300	0
	2009	4	0	154	1,265	0
Topčiderska Reka	2000	4	0	183	471	0
	2009	17	0	399	2,043	0
Barajevska Reka	2000	10	0	590	640	0
	2009	110	0	303	1,597	0
Gavranski Potok	2000	0	0	450	1,200	160
	2009	0	0	690	3,120	0
Varovnice	2000	25	1	880	1,700	0
	2009	74	10	436	2,477	0
Posavina	2000	0	0	1,215	3,165	0
	2009	37	0	1,591	4,491	0
Kosmaj	2000	40	2	440	1,300	0
	2009	70	30	348	1,752	0
Donji Srem	2000	0	14	582	1,500	0
	2009	0	32	511	2,896	0
Kolubara	2000	18	0	1,200	3,500	0
	2009	90	0	868	3,985	0
Total (n)	**2000**	**108**	**24**	**5,839**	**14,771**	**245**
	2009	**412**	**188**	**5,539**	**24,558**	**11**

Sustainable utilisation and protection of natural resources are some of the leading objectives of the present and future economic development of Serbia (The Law on the Spatial Plan of the Republic of Serbia from 2010 until 2020, Official Gazette of the Republic of Serbia, No 88/2010). The conservation of natural habitats and biological diversity in conformity with the World and European Conventions and Protocols is the priority of the Spatial Plan of the Republic of Serbia (Biodiversity Strategy of The Republic of Serbia: for the period 2011-2018).

Also, the Law on Game and Hunting (Official Gazette of the Republic of Serbia, No 18/2010) defines clearly that the utilisation, protection and development of game populations and their habitats is the activity of public interest, which is ensured *inter alia* by: permanent monitoring of the game populations and their habitats; passing the Hunting Development Strategy of the Republic of Serbia; providing the financials for the establishment and maintenance of the information system on game populations and their habitats; research and development in hunting; and hunting promotion.

The Strategy of Afforestation in Belgrade Area (Official Gazette of the City of Belgrade, No 20/2011), should ensure the noise and air pollution control, protection of agricultural and forest lands, rational utilisation of natural resources and building sites, and avoidance of environmental conflicts between different land users. This also includes the conservation of forest ecosystems in the city surroundings, establishment of new forest stands, protection of habitats of some species (especially steppe) from uncontrolled forest cutting, application of chemicals and seasonal burning of vegetation, as well as planned organisation of hunting and fishing.

The objective of the Strategy of Afforestation is: (1) to improve the state of natural forests and artificially established stands, and (2) the establishment of new forests and green spaces of all categories and their integration into one functional entity. Natural forests in Belgrade area are grouped into three main types: *urban forests* (their primary function is recreation, but their positive effect on the improvement of urban environmental conditions is also significant); *suburban forests* (important areas for recreation and protection, as well as the "barrier" for further expansion of urbanisation); *protection forests* (e.g. forests on the Danube and the Sava left banks, headwater forests). The establishment of new forests includes: (1) afforestation of agricultural areas of poorer site classes (in addition to economic effect, care will be taken about the habitats, mosaic distribution of vegetation, biodiversity and landscape values); (2) establishment of forest complexes for biological reinstatement (spoil banks, slag dumps and waste tips); (3) establishment of shelterbelts with forest vegetation along the roads; (4) establishment of windbreaks; and (5) establishment of green and environmental corridors. The continued and middle-term goals of the Strategy include the improvement of management in the field of hunting and fishing and the reduction in their impact on biodiversity and protected areas.

Before the Strategy of Afforestation in Belgrade Area (Official Gazette of the City of Belgrade, No 20/2011), for example, during 2009, altogether 11.9 ha were afforested in the area of 6 municipalities: Palilula (7.0 ha), Čukarica (3.2 ha), Surčin (1.0 ha), Voždovac (0.4 ha), Savski Venac (0.2 ha) and Zvezdara (0.1 ha) (SGB-10, p. 238). The study results on the plantations established within the programme of reclamation of open cut mines and mine spoils of REIK "Kolubara" at Lazarevac (Радосављевић, 1991) show that roe deer can damage the seedlings of different tree species (e.g. ash, oak, maple). The afforestation of Belgrade area predicts the planting of more than 60 tree and shrub species, depending on the site characteristics, excluding the allochthonous, invasive and allergenic species, or cultivars and clones on natural or partly modified natural habitats. The Strategy of Afforestation foresees a significant increase in the total area under forest cover. Potential area for afforestation is planned on about 99,900 ha, mainly in the fringe municipalities (Surčin, Sopot, Obrenovac, Mladenovac, Barajevo, Grocka and Lazarevac).

CONCLUSIONS

Hunting grounds in Belgrade area support some of our autochthonous and biologically and economically most valuable species of big and small game (e.g. roe deer, brown hare), as well as many game species which are also strictly (permanently) protected by closed hunting seasons. They are a significant (but not also a high) economic potential, however they are much more significant as the integral part of the environment and the best indicators of environmental conditions. The present population density of the principal game species in many hunting grounds in Belgrade area is considerable lower than the site potential. Generally, the populations of almost all game species are threatened by forest cutting and conversion into agricultural land, illegal hunting, construction of traffic infrastructure, burning of vegetation in hunting grounds, expansion of urban and industrial zones, presence of an increasingly higher number of dogs and cats without owners or without owner's control, and also by the soil, water, and air contamination.

The main goals of game rearing in Belgrade area are similar to the goals of hunting development in Serbia, such as: increase the population of reared small game (brown hare, partridge, pheasant); increase in the number and improvement of the structure (by sex and age) of roe deer, as well as higher value of their trophies; rational (tenable) use of other game protected on the basis of closed season; and preservation and improvement of the population of the fauna species (game) enjoying permanent protection. Also, they are similar to the main goals of the Strategy of Afforestation in Belgrade Area (Official Gazette of the City of Belgrade, No 20/2011) which include the improvement of environmental quality, biodiversity protection, and the development of other activities related to planned utilisation of natural resources.

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WILDLIFE RESERVES, MANAGEMENT PLANS AND PLANNING EFFORTS IN TURKEY

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Abstract: *Protected areas are least affected by humans and provide protection to the wildlife the most. Allocation of some areas for preservation of natural values is a common practice, which dates back almost to the beginning of the history of humanity. Wildlife reserves are one of the efficient instruments of protecting natural areas. According to the Turkish 4915 numbered Law of Land Hunting "Wildlife reserves are the areas in which game, wild animals and wildlife are protected and improved and also are introduced to there and habitat improvements practices are taken and when it is necessary hunting is released with the framework of special hunting plan." In Turkey, there are 80 wildlife reserves, covered 1.201.212 ha. 56 of these wildlife reserves were declared on 07.09 2005 and 23 of these were declared as wildlife reserves on 16.08.2006 with Cabinet Degree. The last one is Birecik - Firat Wildlife reserve established on 04.06.2011 for bald ibis. The general purpose of declaring as these wildlife reserves are for protecting of Red deer, Fallow deer, Roe deer, Gazelle, Chamois, Wild goat, Wild sheep, Grouse, Pheasant, Great bustard, Hyena, Bear, Waterfowls and Bald ibis in Turkey. Although it is seemed to protect one species in wildlife reserves, wildlife management and improvement plans are prepared to manage considering whole ecosystems, resource values of protected area such as biodiversity and the beauty of landscape etc, which take into account administration, social, economic and technical dimensions.*

Despite 80 wildlife reserves were declared to establish in 2005 and 2006 and 2011, 50 of their management plans have not finished yet. Wildlife management and improvement plans are tried to complete for future in six years in Turkey.

Key words: Wildlife reserves, Wildlife management plan

INTRODUCTION

Protected areas are least affected by humans and provide protection to the wildlife the most. Allocation of some areas for preservation of natural values is a common practice, which dates back almost to the beginning of the history of humanity (Margules and Pressey, 2000). According to Shaw (1985) National parks, biological and wildlife reserves are the areas that ensure survival of many wild species and provide the habitat varieties for wildlife. In addition, the other areas are for producing timber woods and raw materials for people.

The protected area covers 13.9 % of all over the world. In Turkey, this rate is 5% (Anonymous, 2011). According to National Parks the Law No. 2873 and the Law of Land Hunting No. 4915, there are five instruments for protecting wildlife and biological richness; National park, Nature Protecting Area, Nature park, Nature monument and Wildlife reserve.

In this study, we aimed to explain how to reserve plans are made in Turkey. What are the studies that were carried out in the reserves? In addition, we tried to explain wildlife reserves, their management plans and planning efforts.

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WILDLIFE RESERVES IN TURKEY

In Turkey when wildlife reserves were established, the main reason was to protect and raise game animals in their natural areas. The first wildlife reserve was established for Fallow deer (*Dama dama*) in 1966 in Duzlercami, Antalya. Then Demirkoy, Kırklareli wildlife reserve for roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*) and Bozdag, Konya wildlife reserve for Anatolian wild sheep (*Ovis orientalis*) were established (Huş, 1967). They are still being managed as wildlife reserves.

Today, the main aim for establishing wildlife reserve was to protect wildlife that was decreasing animal population in Turkey. Wildlife reserves have two conservation statuses. The first one is where animals and natural habitats are protected with strict regulations and hunting was completely forbidden. It is more like as sanctuary. The second reserve type is aimed to protecting wildlife and improving their habitats but the rules are flexible, when it is necessary hunting is released with the framework of special hunting plan. It is more like as reserve.

In Turkey, there are 80 wildlife reserves, which cover 1.201.212 ha. 56 of these wildlife reserves were declared on 07.09 2005[1] and 23 of these were declared as wildlife reserves on 16.08.2006[2] with Cabinet Degree (Figure 1). The last one is Birecik - Firat Wildlife Reserve established on 04.06.2011 for bald ibis[3]. The general purpose of declaring as these wildlife reserves are for protecting of Red deer, Fallow deer, Roe deer, Gazelle, Chamois, Wild goat, Wild sheep, Grouse, Pheasant, Great bustard, Hyena, Bear, Waterfowls and Bald ibis in Turkey (Table 1).

Figure 1. *Wildlife reserves in Turkey (Tatar, 2012)*

Since 16 of wildlife reserves were established for waterfowls. Wetland Division, Sensitive Areas Department prepares the wildlife reserves management plans of wetlands. In addition, the management plan of wetlands wildlife reserve should consider the RAMSAR. The land wildlife reserve management plans are prepared by Wildlife Improvement Division, Wildlife Department.

[1] Official gazette, 2005, number 9453
[2] Official gazette, 2006, number 26310
[3] Official gazette, 2011, number 27984

Table 1. *Wildlife reserves by species (Tatar, 2012)*

Protected Species	Area (ha)	Reserve's numbers
Ibex/wild goat	350.797	22
Wild sheep	77.581	2
Great bustard	13.679	1
Pheasant	28.611	1
Waterfowls	92.086	17
Hyeana	35.811	1
Roe deer	15.585	7
Red deer	186.582	15
Ibex and Roe deer	26.077	1
Red deer and Roe deer	82.443	4
Fallow deer	24.658	1
Gazelle	20.504	1
Chamois and Bear	4.320	1
Chamois and Ibex	182.709	4
Grouse	59.589	1
Bald ibis	180	1
Total	1.201.212	80

The criterions of allocation for wildlife reserves[1]

- The area that was allocated as a wildlife reserve should have endemic, endangered species and high biological diversity.
- The area where is protected game and wildlife or biodiversity, ensured the route of migratory animals or birds, improved wildlife habitats or the habitats where introduced endangered species can be chosen as wildlife reserve.
- The area should provide food, shelter, water and enough space for wildlife, and also must have a natural landscape.

There are several principals to be cared in wildlife reserves [3]

- Wildlife cannot be destroyed
- Ecosystems cannot be damaged
- It is not allowed to build any structure (buildings, roads and watering canal etc.) that affects the wildlife negatively.
- If there is a building or structure in the wildlife reserve, its wastes must be refined or cleaned.
- Some precautions or additional prohibitions can be taken by The Ministry of Forestry and Water Affairs.

[1] Official gazette, 2004, number 25637

Wildlife reserves management plans and planning efforts

In Turkey, wildlife reserve plans are made to protect natural resources, ecological and biological abundance and diversities, in addition to transfer all these resources to the next generations (Tatar, 2012).

Wildlife reserve management plans consist of three parts. The first part contains general information about wildlife reserve, physical characteristics of the area (Geology, geomorphology, hydrology, soil features, climatology, biogeography, ecosystem and habitat's types in the reserve, flora, vegetation and fauna lists of the reserve) and socio-economic, socio-cultural aspects of stakeholders. Second part is assessment part in which are researched the values of wildlife reserve (Biodiversity, history and cultural, geologic and geomorphologic richness and recreational values), also protection targets/objectives are determined and SWOT analysis are tried to make in that part. The last part is planning of the wildlife reserve. In that part, the management strategy and vision of the wildlife reserve is constituted, conservation programs and targets are defined then zoning of wildlife reserve areas and strategic action plan are completed and the monitoring program is prepared.

Preparation of wildlife reserve management plans consists of four processes and those processes have shown in figure 2. Without participation of stakeholders, the management plans will fail. Thus, in the wildlife management plans, the participation of stakeholders is very important and stakeholders' opinions are taken consideration for all planning process (Figure 2).

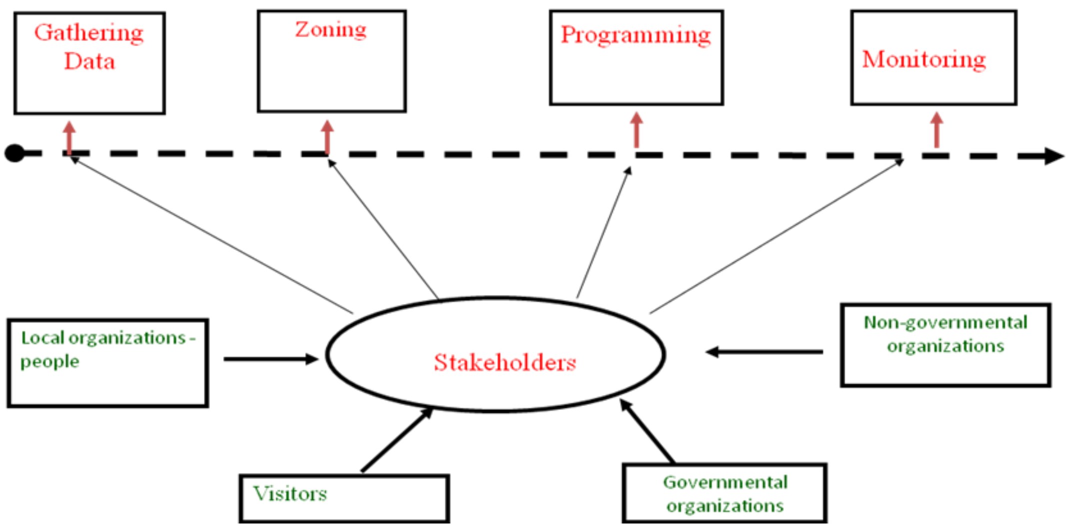


Figure 2. *Planning process (Tatar, 2012).*

Gathering data

All kind of data about reserve should be collected. For example; maps (1/25000 or 1/10000 scaled), habitat types of the reserve area, animal and plant species lists, target species (endemic, endangered, game or introduced species etc) and their habitat preferences. In the wildlife reserves, counting wild animals especially targets are conducted yearly. Many techniques (drive counts, point counts etc.) are used in the counting procedure. Also the master or doctorate thesis and scientific studies about wildlife reserve are researched in the libraries (electronically or classically).

For SWOT analysis, meetings with stakeholders are arranged in many times during preparing plans. In addition, it is made formal correspondences with governmental organizations, if they conduct any projects in wildlife reserve area.

Zoning

There are five types in zoning; core zone, conservation zone, sustainable utilization zone and sustainable utilization buffer zone, outer buffer zone (only for wetlands) (Yılmaz, 2012) (figure 3).

a) Core zone (Absolute protection zone) is chosen from target species habitats, which is natural and without human intervention. This zone must be natural, unique and non-manipulative.
b) Conservation zone (Sensitive protection zone); if a natural resource with traditional utilization is reached to the future, so we can protect that unit as conservation zone. This zone should be natural or semi-natural, is able to be restored and it should be unique.
c) Sustainable utilization zone is the area to protect the nature with together human economic activities (for example forestry and transhumance activities). Therefore, that unit is open to utilization for human.
d) Sustainable utilization buffer zone (Controlled utilization zone), if there are villages, settlements, recreational usages and tourism potentials, those areas in wildlife reserve before establishing, their surroundings is allocated as a sustainable utilization buffer zone.
e) Outer buffer zone is used only wetlands not for land wildlife reserves. This zone is allocated for eliminating negative impacts of human utilization and providing to use the resource in sustainable way.

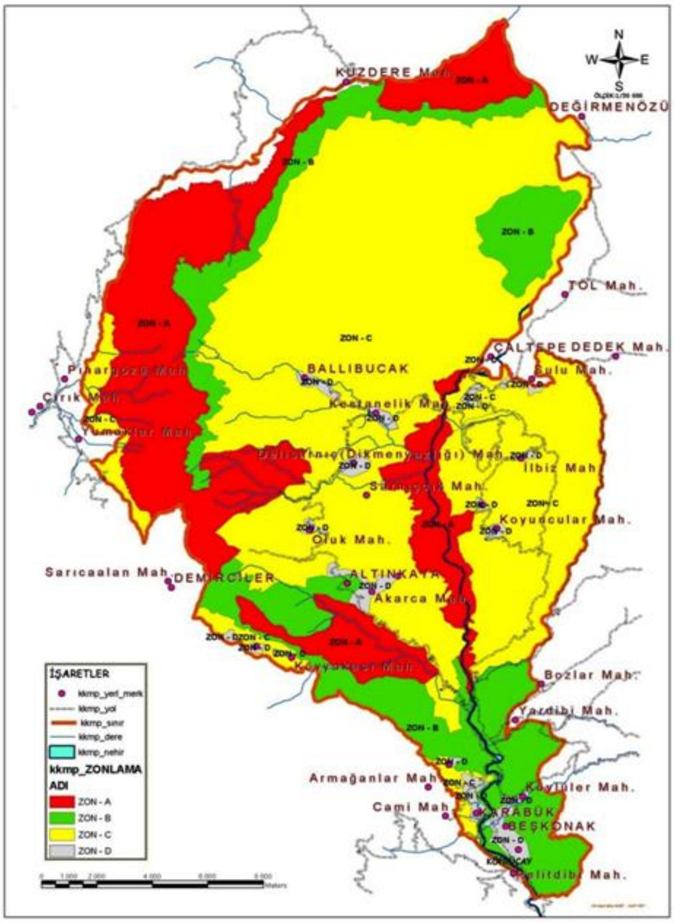


Figure 3. *Koprulu Canyon National Park (Yılmaz, 2012)*

Programming (Planning)

In this part of wildlife management plans, all data (field data, SWOT analysis data, maps, vision of the reserve, core or buffer zones are evaluated and programs and action plans were determined (Table 2). Principals and rules of the reserve are determined during planning stage. In Yedigoller-Yesiloz Wildlife Reserves Management Plans, it was determined four programs, those are 1) Continuing to determine biodiversity, 2) Conservation, Education and Consciousness-raising, 3) Management program, 4) Monitoring program (Anonymous, 2010). After determining these four programs, we have to find out our subprograms (the objective, strategy, target and action). For example; the first program "In order to determine biodiversity".

Program 1: Continuing to determine biodiversity

The objective 1: in order to complete flora and fauna lists.

Strategy 1: Bringing out the biodiversity values of the area completely in order to make decisions to revise the plan.

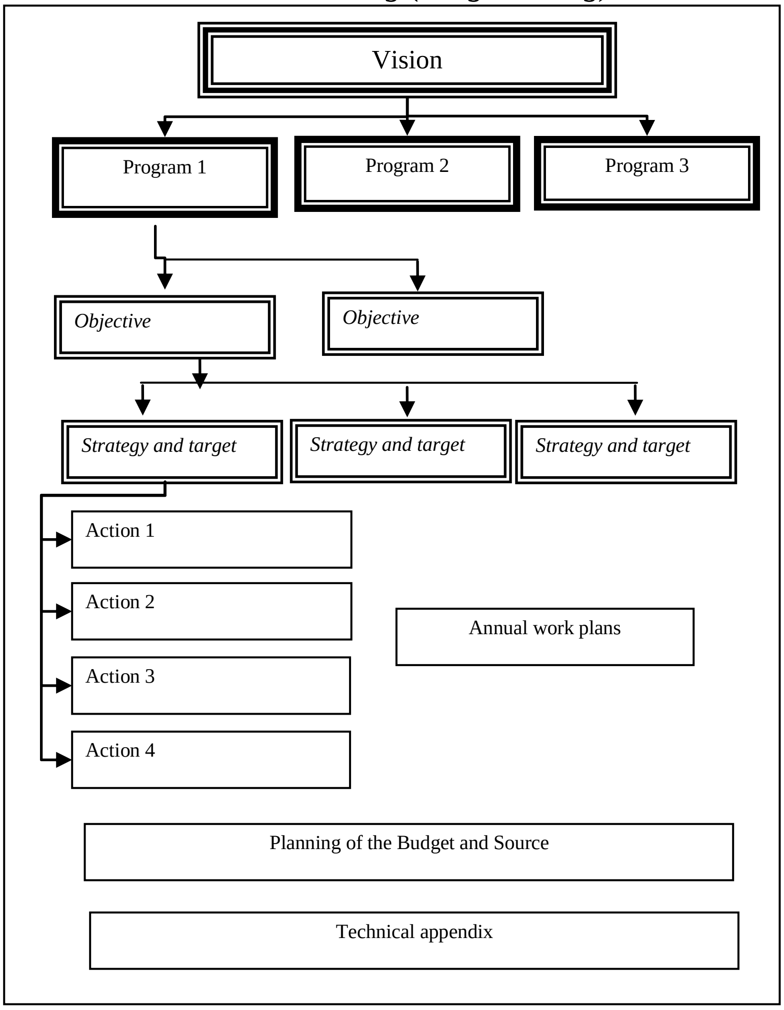
Target 1: Determining fauna and flora species.

Action 1: Supporting by financially, providing worker, tools, maps etc. for master degree/PhD thesis (researchers) relation with the area in order to determine fauna/flora species

Monitoring

Monitoring plan is prepared to achieve for conservation objectives, to monitor practices and any change in the reserves, to solve the problems in time and revision of the action plan.

Table 2. *Planning (Programming)*



DISCUSSION

In Turkey, one of the main problems is land use right for protecting wildlife. Because of this, the management of the area cannot be clearly defined. For example, today, in the current situation, forestry has been managed by General Directorate of Forestry and Wildlife has been managed by General Directorate of Nature Protection and National Parks in wildlife reserves. Thus, many problems and conflict were come out because of the differences of management objectives. Today these conflicts are still going on.

Protected areas do not belong to only Turkey or any other country. They are our world heritages because they contain many life forms and biodiversity. In addition, these diversities is formed through the millions years by evolution. When we compared to the protected area in Turkey (5%) and the world (13,9%), we have to allocate another protected areas in Turkey.

Preparing management plan of wildlife reserve is very new for Turkey. At first, the wildlife reserves were established for game animals and cared just one species. However, that comprehension has changed today because of the global awareness and the necessity of protecting nature and wildlife. Therefore, wildlife management and improvement plans are prepared to manage considering whole ecosystems and resource values of protected area such as biodiversity and the beauty of landscape etc, which take into account administration, social, economic and technical dimensions.

Despite 80 wildlife reserves were declared to establish in 2005, 2006 and 2011 50 of their management plans have not finished yet. Wildlife management and improvement plans are tried to complete for future in six years in Turkey.

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MORPHOLOGICAL CHARACTERISTICS OF PHEASANT EGGS AND THEIR INFLUENCE ON THE EMBRYONIC AND NEONATAL DEVELOPMENT OF PHEASANT CHICKENS

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Abstract: *According to the biological constraints (short period of reproduction and exceptional variability of hatching in relation to the quality and color of the eggshell), scientific knowledge about biological mechanisms and the biological potential of pheasant embryos is essential, in order to define the optimal conditions of incubation and increased hatching of pheasants, their viability and meat quality, and therefore the economic validity of farm production of pheasant game. Role of morphological characteristics of pheasant eggs (egg weight, color of eggshells, calcification of eggshell) on incubation, and particularly on the postnatal development and production characteristics has not been sufficiently determinated. In order to obtain answers to questions and current biological limitations, this paper presents the examinations of distribution, weight, conception, hatching and vitality of pheasants hatched from eggs which were visually classified into 4 groups (A/dark brown; B/light brown; C/brown-green and D/blue-green) and incubated under standard production conditions. Based on the monitoring and analysis of these parameters, it can be concluded that based on the criteria of the color of eggshells it can be expected indirect reflections on some of the production characteristics: the quality of the eggshell, conception of eggs and hatching.*

Keywords: embryonic development, pheasant, egg, color

INTRODUCTION

Pheasant as allochthonous game is ever present in our hunting grounds, and as such is the most important game bird in the hunting tourism, representing a source of high quality food and an essential factor in the maintenance of biodiversity in the hunting grounds and environments. Considering the biological constraints (short period of reproduction and exceptional variability of hatching in relation to the quality and color of the eggshell), scientific knowledge about biological mechanisms and the biological potential of pheasant embryos is essential, in order to define the optimal conditions of incubation, increased hatching and viability of pheasants, improved hunting characteristics and meat quality, and therefore the economic validity of farm production of pheasant game.

Role of morphological characteristics of pheasant eggs (egg weight, color of eggshells, calcification of eggshell) on incubation, and particularly on the postnatal development and production characteristics has not been sufficiently determinated. In order to obtain answers to questions and current biological limitations, the aim of this paper was to define morphological characteristics of eggshell, percentage of eggs with certain morphological characteristics in

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controled breed conditions and their influence on embryonic development (conception of eggs and hatching).

MATERIALS AND METHODS

The examinations were conducted in 2012. on the pheasant farm of the Hunters association of Kikinda, on the parent flock of hunting pheasant (*Phasianus spp.*), for the period from the beginning of April to the end of May. During the whole period of rearing, pheasants feeding was *ad libitum* using complex mixture of concentrate, properly adjusted to their age. In laying period, eggs were regularly collected three to four times a day and kept in the premises at 12-18 º C. Eggs taken for incubation were kept for no longer than seven days.

Eggs were measured and on the basis of color, visually sorted into 4 groups: A / dark brown, B / light brown, C / brown-green and D / blue-green). It was incubated 13808 pheasant eggs through five loading. The first loading was 09.04.2012., and in intervals of one week, the following loading was carried out. Incubation was carried out following the technological standards. On the eighth day the lightning of eggs and fertility monitoring were done. Data obtained during examinations were summarized and presented in tables.

RESULTS AND DISCUSSION

Based on the results presented in Table 1, it can be concluded that the egg laying capacity was the highest during the third and fourth collection period, while the most of eggs were from group B (light brown), and the least from the group D (blue-green). The average egg weight was equal. The highest average weight of the eggs had a dark brown color eggs (group A, 31.82g), and the smallest eggs of blue-green color (group D, 30.70g).

Kozuszek et al. (2009a, 2009b) examinated some of the quality characteristics of pheasant eggs, depending on the color of the eggshell. In the very structure of the eggs, there were no significant differences. The highest weight had the eggs with olive-green shell, and the lowest weight had the eggs with light brown shell eggs. Kirikci et al. (2005) had carried out similar research. They were working on shell eggs with different colors (white, blue, olive-green and brown) and found that the average egg mass was 30.6 grams. Based on the shape index, they found that blue eggs had a similar index with the green and brown, while the shape index of white eggs was lower. White eggs had the lowest, and the dark brown eggs the highest yolk weight. They also found that for the same features blue and white eggs have lower values than the brown and olive eggs. Ozbey et al. (2011) found a significant correlation between pheasant's egg weight at the beginning of incubation and quality of hatched pheasants.

Table 1. *Egg laying capacity of parent flock and egg weight, according to eggshell color (A, B, C, D) and collection periods*

Collection periods	A		B		C		D		Total
	Number of eggs /%	Weight (g)	Number of eggs / %	Weight (g)	Number of eggs / %	Weight (g)	Number of eggs / %	Weight (g)	Number of eggs
I	242	31.32	888	30.22	225	30.91	103	30.81	1458
	16.60		60.91		15.43		7.064		
II	772	31.56	1782	30.94	365	30.97	73	30	2992
	25.80		59.56		12.20		2.44		
III	861	32.58	2003	30.57	440	30.86	114	30.57	3418
	25.19		58.60		12.87		3.33		
IV	800	31.63	2071	31.17	298	31.03	95	30.65	3264
	24.51		63.45		9.13		2.91		
V	727	31.99	1703	30.84	158	30.7	88	31.48	2676
	27.17		63.64		5.90		3.29		
TOTAL	3402	31.82	8447	31.24	1486	30.89	473	30.70	13808

Incubation parameters (hatched pheasants, unfertilized eggs, dead-in-shell embryos) and the influence of eggshell color on them is showed in Table 2.

Table 2. *Incubation parameters*

	GROUPS OF EGGS				
Number of loaded eggs	A	B	C	D	Total number of eggs in a loading period
I	350	985	308	94	1737
II	769	1795	359	74	2997
III	862	1995	440	112	3409
IV	800	2004	299	91	3194
V	722	1704	154	84	2664
Total	3503	8483	1560	455	14001
Hatched pheasants (%)	A	B	C	D	Average in a loading period
I	86	86.29	80.84	54.26	83.53
II	87.91	86.96	84.96	79.73	86.79
III	74.18	85.96	83.86	79.46	81.11
IV	89	89.97	87.96	84.62	89.39
V	85.87	84.98	81.82	75	84.72
Average	84.59	86.96	84.10	74.51	85.11
Unfertilized eggs (%)	A	B	C	D	Average in a loading period
I	6.29	3.25	9.09	48.94	7.37
II	5.85	7.3	5.85	8.11	6.77
III	4.87	6.62	7.73	8.04	6.37
IV	4.5	4.64	5.69	6.59	4.76
V	8.73	8.74	12.34	15.48	9.16
Average	5.94	6.33	7.63	17.58	6.74
Dead-in-shell embryos (%)	A	B	C	D	Average in a loading period
I	7.71	7.41	10.06	5.32	7.83
II	6.24	5.74	8.91	12.16	6.41
III	6.15	7.42	8.41	12.5	7.39
IV	6.5	5.39	6.35	8.79	5.85
V	5.4	6.28	5.84	9.52	6.12
Average	6.25	6.35	8.21	9.67	6.64

Based on the obtained data it can be concluded that the average hatching was high (82.54%). As for the average hatching by periods, the highest percentage of hatching was in fourth loading. The lowest percentage of hatching was in blue-green colored eggs, which for the entire loading period was 74.51%. The highest percentage of hatching was in eggs of group B, but the deviation from the groups A and C were not significant. The highest percentage of unfertilized eggs was evident in the fifth loading in all groups, but significantly higher than the average was the percentage of unfertilized eggs from the blue-green group of eggs, particularly in the first loading, suggesting that the period of laying eggs affects the level of eggs fertility. The lowest average percentage of unfertilized eggs was in a group of dark-brown eggs (5.94%), while the same parameter for the group of blue-green eggs was 17.58%.

In experiments of the other authors, it was found that the fertility of dark brown and olive-green eggs was increased by 10.3% from the blue eggs. Dark brown and olive-green eggs kept 7 days or more had a higher percentage of hatched pheasants, from the fertilized eggs, in relation to blue eggs. The lowest percentage of hatched pheasants, from the fertilized eggs, was in blue eggs. Hatching percentage was increased by about 22% in dark brown eggs, compared to the blue (Kozuszek et al., 2009a; Kozuszek et al., 2009b).

In our experiment, the highest percentage of dead-in-shell embryos was also in group D, i.e. in the group of eggs with blue-green eggshell color (average for the whole period was 9.67%); while for the whole period average of dead-in-shell embryos in all groups was 6.64 % (Table 2).

CONCLUSION

On the basis of the parameters of the experiment and collected data, we can conclude:

- There is a clear differentiation of the different types of eggs by eggshell color within a parent flock
- The highest number of laid eggs was with brown eggshell color (61.17%), and the lowest with blue-green eggshell color (3.42%)
- Egg weight was the highest (31.82g) in group A (dark brown eggshell color), and the lowest (30.70g) in group D (blue-green eggshell color)
- The highest percentage of hatched pheasants (86.96%) was in group B (light brown eggshell color), but there were no significant deviations comparing to groups A and C; while the significant lower percentage of hatched pheasants (74.51%) was in group D (blue-green eggshell color)
- The highest percentage of unfertilized eggs (17.58%) and dead-in-shell embryos (9.67%) was in group D (blue-green eggshell color).

The main conclusion arising from these studies is that the eggs with blue-green eggshell color are least favorable from the aspect of their influence on the embryonic and neonatal period of development and for these reasons it should be taken into account that these eggs should not be load in incubators but consumed as the eggs of high quality.

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IMPROVEMENT OF VETERINARY LEGISLATION IN HUNTING IN ACCORDANCE WITH EU STANDARDS

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Jelena PETROVIĆ[4], Igor JAJIĆ[5], Ana MRKSIC[6]

Abstract: *In hunting are used scientific knowledge from life sciences, forestry, veterinary medicine, agriculture, law and others. Within the hunting economy in European Union, a significant place take legislation of veterinary medicine. Considering that Serbia has become a candidate country for EU membership, is obligated to harmonize regulations in the veterinary profession in hunting with legislation in the EU. This is also an important step when applying with co-financing projects to the funds of European Union.*

This paper analyzes the regulations concerning the health status of wildlife populations and game meat hygiene in Republic Serbia: Law on Game and Hunting ("Off. Gazette of RS" No. 18/2010) Veterinary medicine law ("Off. Gazette of RS" No. 91/2005) and the Law on Food Safety ("Off. Gazette of RS", No. . 41/2009) and other subsidiary legal acts. Are discussed in particular EU regulations on the inspection of game meat: Laying down specific rules on official controls for Trichinella in meat, EC-Commission Regulation No 2075/2005 in accordance to Regulation (EC) No 854/2004 of the European parliament and of the council: „Laying down specific rules for the organization of official controls on products of animal origin intended for human consumption". Are described also examples of projects about education on these regulations in previous years granted for co-financing by the European Commission in Brussels.

Having in mind differences in subsidiary legal acts which are applicable in Serbia in relation to the European Union, we believe that their adaptation is necessary in order for protection the health of game animals, and prevent the appearance of zoonotic diseases in humans. With compliance to EU legislation we can increase the level of food safety and condition for export of game meat to the European Union, as well as, encourage the arrival of larger number of foreign hunters in our country.

Key words: hunting, veterinary, regulations, European Union, Serbia

INTRODUCTION

In Serbia and all West Balkan region, wild game meat has great economic (hunting), and nutritional significance -in cooking because of the high content of valuable protein and less fat

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content. Certainly, ensuring the safety of game meat has an important role in the entire system of food safety, particularly in terms of zoonoses (Urosevic et al, 2011). Within the hunting economy in European Union, a significant place take legislation of veterinary medicine. In Austria, meat from free-range, wild game, is a highly valued product. Consumers appreciate the idea of sustainable meat production and rank meat from free-range game similar to food from organic farming. To ensure food safety "from forest/field to fork", hunters supplying meat to consumers or retailers have to undergo specific training. (Winkelmayer, 2009).

Serbia adopted a many Veterinary medicine and hunting regulations including by-law relating documents (Urosevic et al, 2011). But, considering that Serbia has become a candidate country for EU membership, in terms of hunting tourism and the export of game meat we need to harmonize our veterinary and sanitary regulations with European Union member countries. Currently, it is a big obstacle standing in the way the arrival of a number of foreign tourists in our hunting grounds, the greater shooting of small game, and then legal game meat transportation to their country of origin (Urosevic et al, 2011).

One of the prerequisites for the drafting regulations about Suppression and eradication of the disease is also the knowledge their epidemiology. Unfortunately, no recent literature data (i.e. from the last 10 years) could be found on the following diseases or agents in wild animals in Serbia: Listeriosis, Q-fever, Aujeszky's disease, Salmonellosis, Cysticercosis. Compared to data on Trichinella spp., reports on other parasitical, or bacterial and viral zoonoses are rather scarce. (Urosevic et al, 2012-A). One example of compliance with EU legislation are regulations on trichinelosis. In many European countries, trichinellosis has been declared a disease that must be monitored, and for European Union Member States this is obligatory according to the European Union directive on zoonoses, 2003/99/EC. According to regulation (EC) no. 2075/2005, meat inspections are required for wild boars, and other wild animal species that are susceptible to Trichinella infection and that are slaughtered for consumption. Until now, our regulations consistent only in part on the maximum allowable pieces of meat samples a day, which can inspect veterinarian - trichinoscopic examiner. (Urosevic et al, 2012-B).

In relation to Serbia and other countries in the region, Austria is an example of countries with similar hunting tradition and highly developed economic impact of hunting with regulations (Regulation on the inspection of meat in 2006 „FlUVO") that comply with the European Union (Regulation no. 854/2004). (Urošević et al, 2011).

This was the reason that we make an analysis of regulations in the field of veterinary medicine in relation to diseases of wildlife, game meat hygiene and game management in general.

MATERIAL AND METHODS

This paper analyzes the regulations concerning the health status of wildlife populations and game meat hygiene in Republic Serbia: Law on Game and Hunting ("Off. Gazette of RS" No. 18/2010), Veterinary medicine law ("Off. Gazette of RS" No. 91/2005), the Law on Food Safety ("Off. Gazette of RS", No. . 41/2009), "Regulation on veterinary-sanitary conditions, and general and specific requirements for food hygiene to be met by facilities for handling with shot wild game, and how to carry out official controls shot wild game ("Off. Gazette of the Republic of Serbia" 68/10 by 2010.) and other subsidiary legal acts.

Are discussed in particular EU regulations on the inspection of game meat: Laying down specific rules on official controls for Trichinella in meat, EC-Commission Regulation No 2075/2005 in accordance to Regulation (EC) No 854/2004 of the European parliament and of the council: „Laying down specific rules for the organization of official controls on products of animal origin intended for human consumption". Are described also examples of projects about education on these regulations in previous years granted for co-financing by the European Commission in Brussels.

RESULTS

Overview of legislation in Serbia relating to wildlife management

Law on Food Safety (Official Gazette RS, No. 41/2009)

In it there is a provision about hunting and supporting activities relating to the storage, handling and transport of game carcasses from the production place to the facility. It was highlighted that in relation to the distribution of responsibilities, duties of state administration in food safety, veterinary inspections carried out as follows: in the phase of export products of animal origin, as well as the retail trade of game meat in specialized stores.

Law on Veterinary Medicine („ Official Gazette of RS, No 91/05)

In this Law provided the obligations to be fulfilled a hunting grounds user in the handling of game meat. This law regulates and issues of veterinary - sanitary control of game animals meatmeat. Legal persons engaged in hunting and Hunting associations shall be obliged to temporary store carcasses and parts of the of game for the implementation of veterinary - sanitary controls, in the case the game is safe for human consumption. Here's is described in details official control of game.

Export facilities

If the game meat and trophies exported from our country it shall be subject of veterinary sanitary control at border crossings. Facilities which fulfill the veterinary-sanitary conditions, general and specific requirements for food hygiene and food for animals assigned the export control number and are entered in the Register of export facilities. It is forbidden the export from facilities that are not approved for export. In general, the export consignments of animals and animal products shall be issued by the original international veterinary certificate which confirms that the shipment fulfills the conditions of the importing country, and for food of animal origin, that these foods are safe for human consumption.

Trophies of wild animals can be set out without the export facility, but with adequate preparation and provision of required documentation according to EU regulations. Supporting documents issue the competent veterinary inspector at loading shipments in the place of origin and border veterinary inspector verifies the certificate at the border.

Furthermore, the trade of hunted game and and trophies was defined in this law as a set of actions from movement of hunted game that is properly marked from the shooting places up to delivering to end user. In the transport of hunted game and and its parts, the main responsibility has a hunting ground user, which is in accordance with the Law on Hunting and Game (and "Off. Gazette of RSand " No. 18/2010). Hunting grounds user belongs dead or caught animals and their parts (trophies, etc..). He shall determine by its act the price of: hunting wild game, meat of shot game, hunting services of the wildlife, etc.

Hunting grounds user shall issue an accompanying document for the hunted wild game and trophy certificate in the prescribed form, he is obliged to keep evidence of shot game, trophies, anf about issued trophy sheets. Hunting grounds user can export game shot animals or its parts, only if it registered for such activities. However, according to Law on Hunting and Game (and "Off. Gazette of RS" No. 18/2010) in hunting tourism export of of game meat formally organized travel agency.

In the 2010th the Ministry of Agriculture of Serbia passed a subsidiary act concerning to the safety of meat from game animals: „Regulation on veterinary-sanitary conditions, and general and specific requirements for food hygiene to be met by facilities for handling with shot wild game, and how to carry out official controls shot wild game ("Off. Gazette of the Republic of Serbia" 68/10 by 2010.).

In these regulations more closely prescribed the veterinary-sanitary conditions, general and specific requirements for food hygiene, which in terms of construction and reconstruction of facilities must fulfill the the temporary storage of shot game animals, and the manner of carrying out official control shot game animals. It is an building in which carried out the official control of meat and organs of game immediately after the shooting in order for their own use or referral to a facility for cutting and processing of game meat (if it is for public consumption). Facilities for temporary storage of shot game animals must be located within the hunting grounds. However, there is an exception, these buildings may be located outside the hunting grounds, if within two hunting grounds is not possible to fulfill the requirements regarding the construction and equipment of facilities, in compliance from special regulations and these rules. Are described in detail also construction - technical requirements that these buildings must satisfy. It is important to note that these facilities must be of such capacity to enable to completion of the official control. Which means, carcasses and organs carried out separately by wildlife species from receiving to storage in cooling chambers and for temporary storage to avoid their accumulation.

Official control of wildlife game immediately after killing may be performed also in facilities for processing and cutting of game meat wildlife if they are in the hunting area in which the game the shot, or nearby.

Anyway, hunting grounds users have at least 48 hours before the hunt to submit hunt to a competent veterinary inspector or authorized veterinary practice, which conducting official control of game immediately after killing. Meat and organs shot game animals, that are after the official control in the facilities for temporary storage of shot game animals, if can be assessed as safe for their own use or to be given to the facility for cutting and processing of game meat. When carrying out official control, authorized person in the hunting ground shall veterinary inspector or authorized veterinary practice to give a statement on executed kill all game animals with all the details: notice about unusual behavior or suspicion of change in health status of game carcasses, any changes to the trunk and organs that would indicate any abnormality in the health status of wild animals.

It is prescribed that pull the skin of game and cutting is not allowed on killing location. After removal of internal organs, on carcass of shot game animals, and packed organs, which are submitted for examination, shall be placed special registration mark for marking shot game animals, that is in the compliance with regulations governing hunting. Meat should be as soon as possible and no later than 10 hours after killing placed in the appropriate device for cooling. After completing the examination the meat must be cooled fast enough so that in the depth of the muscular tissue of large game reach a maximum temperature of + 7 C, and up to + 4 C in the meat of small game.

The buildings in which are examined shot game animals, a veterinary inspector make detailed evidence of completed the official control of shot game animals: date of examination of shot game animals, name of hunting grounds nad their user, species of game, the number of shot game animals which are examined, the number of registration marks, etc.

Overview of legislation in European Union – example from Austria

Austrian legislation of 1994 (Wildfleischverordnung 1994; BGBl. Nr. 400/1994) introduced a three-step inspection system. The hunter was responsible for *ante-mortem* inspection and examination of the carcass and intestines upon evisceration. Trained persons were responsible for the examination of the carcass and (edible) inner organs. The official veterinarian was responsible for the inspection of carcasses entering game handling establishments and was also always responsible when serious abnormities were detected during inspection by hunters or trained persons. For small game, a simplified version was established. Under the "new" EU hygiene package from year 2006 (EC Regulation 853/2004), the responsibility of trained persons increased. This means, that in all situations of direct marketing, the (documented) inspection by both hunters and trained persons is mandatory, and in case of serious abnormities, also the inspection of the official veterinarian.

The Austrian act on direct marketing requires that game meat is from "own production", which means that game originates only from these hunting grounds, for which the hunter is licensed. In case of marketing of meat from other hunting areas, other legislation (for food retailers) applies. For direct marketing of meat from game which can be infected by *Trichinella*, inspection can be done by trained persons. For these trained persons, specific evaluation and proficiency testing schemes have been implemented.

Since 1994, ca. 20.000 hunters have been trained as „trained persons", which includes theoretical lessons on hygiene, and the training books have been updated regularly to address changes in legislation (Winkelmayer et al., 2004; 2008). These experiences allowed to develop a training concept for "direct marketing", which consists of theoretical lessons (based on a textbook on „Wildbret-Direktvermarktung" (Winkelmayer et al., 2007) and a practical, which is done in cooperation with agricultural schools. Currently, e.g. in Lower Austria, four schools cooperate in these courses, and provide one-day seminars on fresh meat handling; meat products and processing of small game.

In January 2007, a training book on direct marketing of game meat was issued in Austria by the „Zentralstelle Österreichischer Landesjagdverbände". This book serves as a „Guide to Good Practice" and addresses not only hunters, but also official veterinarians.

The direct supply of small quantities of game meat from the hunter to the consumer or to local retailers supplying to the consumer, is in Austria an important pathway in marketing of game meat. To ensure that legal and hygiene requirements are fulfilled, hunters have to undergo specific training and develop consciousness relating to food hygiene issues. Such training systems have been implemented in Austria since 1994, and experience shows that a combination of basic courses, advanced training courses, and evaluation schemes can be effective in enabling hunters to fulfill the needs for a hygienic and safe direct supply of game meat in the sense of a longitudinal integrated "from forest/field to fork" approach.

Responsibilities in the food chain:

The hunter has to report abnormities of the game before shooting, and abnormities of the organs detected during evisceration to the official veterinarian. In case of no abnormities, this is certified on a tag. Hunters supplying directly the consumers or the local market: They are responsible that the game meat and the products like ham and sausages are „safe food". They have to document „one step forward" and „one step back" in the food chain and also to implement a hygiene system based on HACCP principles. Especially for direct-supplying the local market and the consumers it is important to avoid any risk of zoonoses, as i.e. Tularemia.

For supplying the local market or the consumers, the examination, done by the trained person, is the end-examination of game meat. They are responsible that this meat is „safe"! The trained person checks the certificate done by the hunter and records his findings on the same tag. Trained persons passing an advanced course for examination of wild boars for supplying the local market or the consumers (trichinelloscopy method). The performance of the examinator is periodically tested by a performance assessment (ring-trial, all 5 years).

Official Veterinarian after examination, which takes into account the findings documented by the hunter and the trained person, game meat may enter the EC/EU market (Winkelmayer, 2009).

Interestingly that the rules which regulate this material is under the authority of the Government of certain Austrian provinces, and are not uniform at the federal level. The competent authorities of provincial check out whether the the hunter fulfills the conditions for it.

Experiences from Croatia

Harmonization of the Croatian legislation to the one in the European Union in the field of veterinary medicine has been one of the more complex packages that Republic of Croatia is should to fulfill as a candidate country. The process was extremely demanding and comprehensive, and it was attended by officials of the Veterinary Directorate of the Ministry of Agriculture, enhanced with numerous scientists and experts, some of them were members of negotiating teams. It was held a series of consultations, meetings and workshops in order to create best possible quality of the legal framework. After that should have to access the implementation of new regulations in practice, so they maintained many meetings in order to presented those to professional public. Greater part of laws and regulations which have adapted to European legislation relating directly or indirectly to wild animals or hunting, where we should emphasize treatment of after shooting wild animals or wild animals meat hygiene. In particular, they highlighted the Veterinary Law (Anonim., 2007), Law on Food (Anonim., 2007a), the Law on Hunting (Anonim., 2005) and others, that provide a framework whereby they have made many subordinate legislation which specifically elaborates action in certain cases. So, Mikus (2010) notes that vagrants wild game meat is subject veterinary inspection (Anonim., 2007b, 2007c) and certain procedures prior to marketing. Vagrants game must be inspected as soon as possible after admission to the facility for the processing of carcasses wild game. The official veterinarian takes into consideration the statement or information in accordance with the provisions of the Regulations on the hygiene of food of animal origin (Anonim., 2007b) delivered by a trained person who took part in the killing. In this sense, in Zagreb in the middleApril 2011. was held a two day workshop entitled "Improvement in the implementation of EU hygiene package in wild game meat," which was organized by the European Commission and its Office of Technical Assistance and Information Exchange (TAIEX European Commission - Technical Assistance Information Exchange Instrument) in cooperation with the Ministry of Agriculture R. Croatia. The lecturers were experts by TAIEX from Slovenia, and the workshop was attended twenty veterinary inspectors and representatives of the Croatian Hunting Association. During the first day of lectures presented by EU hygiene package of facilities for the inspection of game meat, which are dealt with EU regulations 852/2004, 853/2004 and 854/2004 and conveyed experiences of Slovenia about their application in practice and official control of game meat (basic requirements for approval , equipment, veterinary inspection official controls).). He then described the Slovenian and education program for "trained person" who undertake an initial examination of wild game on the spot or in the house for receiving the shot wild game, where they talked about legislation with administrative provisions on animal and public health and hygiene conditions governing the placing on the market of wild game, wildlife diseases (parasitic, and organic) and pathological changes in the meat of wild game etc.

The second day of workshop was held on practical training and use of appropriate techniques during evisceration, handling, transportation and initial examination of the shooting wildlife. The same organizers, this time in cooperation with the Croatian Food Agency, in November 2011. years held a workshop entitled "Inspection, monitoring and diagnosis of trichinellosis and other parasitic foodborne diseases." The lecturers were experts by TAIEX from European Union countries Italy and the Netherlands. At the workshop was attended about a hundred people mostly experts, primarily veterinary, and other professionals (agricultural engineers, food technologists, biologists, etc.).

There is a pointed out that Croatia is on the issue of prevention of trichinosis is an example on the world level, but is still in a specific situation and must strictly comply with the prescribed measures. Today, Croatia is a relatively stabile epidemiological and epizootic situation regarding this dangerous disease, but it still occurs almost every year in isolated cases in animals and humans. It is important that in Croatia trichinellosis regularly occurs in wild animals. Out of a hundred species of mammals and ten species of birds are important natural reservoirs of Trichinella spp. and its indicators in the nature of are fox, wolf, jackal, and other rodents., a particular threat are those animals whose meat is used for human consumption (wild boar, bear and badger).

It is therefore very important that after the killing of these species must do the examination of meat in an authorized veterinary institution. They already in the transitional period (1 January 2010. to 31 December 2013.) can examine the meat using the method of artificial digestion . After that an examination of the meat that is intended for public consumption, can be performed only by laboratories accredited to ISO / IEC 17025. It is further emphasized that the trichinellosis is disease which must be reported to the veterinary services in Croatia, because the disease is on the list of the world organization for animal health (OIE in Paris). Regulation on methods of conducting examination for the presence of Trichinella spp. in meat (Anonim., 2008) provides that the carcasses of wild boars and other wild animals susceptible to Trichinella spp. must be systematically sampled in facilities for processing and cutting of the game in the post mortem examination.

The sample is taken from each carcass and inspection in the laboratory identified by the competent institution. Samples of weight at least 10 g are taken from the foreleg, tongue or diaphragm of wild boar and the diaphragm, chewing muscles (m. masseter) and tongue in the bear. Some EU countries have requested to be declared free of trichinosis, but he prescribed by strict conditions. Thereby, the problem is not so in the breeding of domestic animals, as much wild animals in free natureso that the monitoring is necessary in in species important for public health whose meat is consumed (wild boar, bear, badger), and in so-called. indicator species (fox, wolf, jackal, etc..). On its own, cycle of development and maintenance of Trichinella spp. in wildlife or in silvatic cycle is very complicated and is influenced by many factors (biological, ecological, economic, social and cultural). An additional problem makes the fact that animals which are hosts of this parasite usually have no symptoms, nor parasites are visible "with the naked" eye. On the other hand, the smallest carelessness in the consumption of infected meat and wildlife, which was not examined can in humans lead to serious health problems that leave lasting consequences in the organism, and in more severe cases to come to death.

These are some concrete examples about how to work in decision and in particular the implementation of certain legislation in the field of veterinary medicine related to hunting. Considering the legislative framework, if observe hunting from the perspective of sustainable development, particularly where aspire following modern European heritage, we can say that the framework of legislative measures and regulations of Republic of Croatia is really respectable (Florijančić et al., 2010). In Anyway, the Croatian experience in adapting of legislation can be very useful for future candidate countries for accession to the European Union.

DISCUSSION

As shown, the legal framework in Serbia related to game meat is divided between the jurisdictions of rules that regulate hunting, veterinary, food safety and others. Therefore dealt also responsibilities in the food chain. In relation to legal regulations in the EU (for example in Austria) evident are major differences compared to the relatively large competencies there have hunter and trained person, practically as a veterinary inspector in Serbia. It is important to note that the examination of meat for trichinellosis do trained person there, that atended the appropriate courses, and not exclusively a veterinary inspector (as is the case in Serbia). Unfortunately, in many hunting grounds in Serbia, workers in hunting areas pulled open the carcasses on the ground (in the forest) and the offal leaving there to eat other animals, as a significant risk of transmitting disease. Although in Serbia there are detailed regulations regarding the facilities for temporary storage of shot game animals, there are numerous exceptions in relation to their number and territorial distribution. This can be interpreted that they are not obligated in each area, although this is a minimum requirement for the use of game meat for its own purposes.

But, if the game meat is intended for public consumption or sale raises the question of further handling and control of this in facilities for meat processing and cutting. Thus, the export of game meat from Serbia in an EU country would be complicated process. It should be emphasized also sharing of veterinary competence in control of game meat. In Serbia it is centralized at the federal level exclusively, and in Austria the jurisdiction transferred to Government of nine federal provinces. Least but not last, if we look the hunting legislation in Croatia, there are significantly used resources from the EU pre-accession funds for education and general harmonization of these regulations. This was not the case with Serbia, because according to available information there was nothing from EU projects directly related to hunting, including game meat hygiene. An exception is the action of oral vaccination of foxes and suppression of classical swine fever as a project funded from IPA funds, which is more or less implemented in all countries / EU candidates the our region.

CONCLUSIONS AND RECOMMENDATIONS

According to the strategy of Serbia's accession to the European Union, and the commitment to harmonization of regulations related to human and animal health and health safety of food of animal origin, there is space for correction and supplement of legislation relating wildlife management including game meat hygiene.

Anyway, it should be determine the transitional period before the entry into force of provisions the Regulation - EC No. 852/2004; 853/2004 and 854/2004 to amend in the current Serbian regulations. Thereby it should take good (and bad) experiences of countries in the region, which have this passed for example as Croatia. It is also necessary previously do extensive scientific researches on the situation concerning the hygiene of meat of game animals in Serbia, due to lack of information about it. Concrete, how many facilities we have for temporary storage of game meat in accordance with the regulations of Serbia and /or from EU, how is comply valid national regulations, and how many hunters themselves or trained person know about this. This means conduct a survey how many they are aware about the importance of compliance with regulations related that human and animal health and food safety of animal origin. After receiving of detailed data in Serbia, that means state estimation in our wildlife management, it would be possible to do a feasibility study on implementation of EU legislation, which gives more authority to hunters and trained person. And naturally, what are needs to be done to enable the easier procedures for the export of game meat that foreign hunters hunt in Serbia. After all mentioned, we could recommend Good experience according game meat inspection system is from Austria, and apply this model for future use in Serbia. There is implemented an inspection system in compliance with current EU directive, which involves three categories (hunter, trained person and official veterinarian), and provides continuous training and evaluation ofe these people in a consistent and logical way. This system relies on motivated trained presons and recognises the self-responsibility of the primary producers (i.e. the hunters), which currently is not the case in Serbia.

Effective control of zooonotic diseases will require more efforts in studying the role of wildlife as a reservoir for zoonoses. This includes epidemiological studies as well as ensuring effective meat inspection of game, implementation of safe game handling and evisceration techniques and safe disposal of offal. The latter requires consciousness and compliance of hunters, which has to be based on training and motivation. It should not be ignored the continuing education of all stakeholders in hunting, which would be solve by the drafting guide for collection and testing with the instructions on the type of biological agents to be monitored in the meat of wild game, to determine the presence and frequency of hazards in wild game meat, which are important for human health. Hunters need to be educated to avoid leaving animal carcasses and/or entrails in the field because this increase probability of infectious and parasitic diseases spread to new hosts. Anaway, the hunters and the consumers could be educated and advised to freeze the meat from wild boars before its futher home-processing into products, or to cooc the products before consumption, or both, aimed at the Trichinella larvae inactivation.

However, it should be considered that for effective implementation of regulations in regard to game meat hygiene, and the future implementation of EU regulations, it is not enough just to intensify control and penalty provisions for particular violations or crimes. Contrary, raising awareness about the importance of these measures for human and animal health should be a prerequisite, and education of all participants (hunters, trained preson, veterinarian) is practically an obligatory part of its. All these measures requires time, persistence and of course the unity of all stakeholders, which currently is not the case in Serbia (Federal and Local authorities, Hunting Association, Hunting Chamber, consumers and others.)

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FOREST CERTIFICATION AND PROTECTION OF THE BIRDS FAUNA IN SERBIA

Slobodan PUZOVIĆ[1]

Abstract: *Certification introduction in forestry sector in Serbia has significantly improved the environmental approach in forest practice and management. Process is successfully implemented in Public Enterprise "Vojvodinašume" and "Srbijašume". Main goal is reduction of conflict between economic forestry and need to preserve biodiversity in forests. Improvement is evident in monitoring development of certain bird fauna representatives and public informing, nests mapping of rare raptors and black storks, including disturbances reduction in reproduction period. Regenerated areas are left by individual autochthonous trees and shrubs, as assistance in biodiversity preservation and landscape area structure. Neverthels, there are several problems included excessive use of chemicals in forestry which are harmful for biodiversity, in intensified use of machinery in forest activities, in unified classification of natural forests and in planting monocultures of allochthonous clones. Paper analyses advantages of introducing forest certification and existing problems, including some proposals of adequate measures for reaching compromise, particularly with regards on improvement of forest bird fauna.*

Key words: Birds, forest certification, protection, improvement

INTRODUCTION

The richness of species diversity of the bird fauna is closely connected with the preservation of habitat and landscape diversity. Forest ecosystems are the most significant habitats for many animal species in most European countries due to their great distribution, environmental conditions they create and their influence on the composition and number of the bird fauna. In bio-geographical sense, Serbia is very heterogeneous and ecologically diverse so the bird diversity and the diversity of their habitats is one of the highest in Europe, having in mind the size of a country (Vasić, 1995; Puzović et all, 2003; Puzović et al, 2009). The forest ecosystems themselves greatly contribute to this fact. There are 59 vegetation classes with more than 1,000 associations and about 3,660 taxa of vascular flora in Serbia (Lakušić, 2005; Mijović et al, 2012). In the forests of Serbia, 49 types of trees have been registered, 40 of which being broadleaf and 9 being coniferous. Among broadleaf trees, the predominant types are beech and oak and among coniferous trees, spruce and pine (Banković et al, 2009).

With 29.1% of its territory covered with forests, Serbia represents a country with relatively modest forest coverage in comparison to the European average (46%). A distinct imbalance in the forest coverage of certain regions is evident. In Central Serbia, the forest coverage reaches as much as 37.6% while in Vojvodina, it is only 7.1% and is the lowest in Europe (Orlović i Tomović, 2011). In Kosovo and Metohija, the forest coverage in the last decade of the 20th century was 40%. The total forest area in Serbia is 2,252,400 ha (excluding

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Kosovo and Metohija), out of which 53% was regarded as the state property and 47% as private property ending with 2007. In Serbia, due to a great significance of forests for preservation of biodiversity, about 522,790 ha (5,92%) have been put under special protection so far, 2/3 of which being occupied by forests and forest land in national parks, special and strict nature reserves, areas of exceptional natural values and nature parks (462 protected areas)(Mijović et al, 2012). The largest portion of state forests and national parks is managed by "Srbijašume", "Vojvodinašume" public companies.

Up to now, 360 bird species have been registered in Serbia (Simić and Puzović, 2008; Puzović et al, 2009). According to the research results for the period of 1990-2002, Puzović et al (2003) concluded that 237 species of birds nested in Serbia, 114 of which were songbirds (Passeriformes) and 123 non-songbirds (Nonpasseriformes). Many of these species are forest species or at least a significant part of their life cycle depends on the preserved forest habitats. 14.25% of the territory of Serbia or 1,259,624 ha, is occupied by 42 international bird areas (IBA). Within 13 IBAs, different types of natural forest ecosystems dominate, mostly located in the hilly and mountainous areas. An analysis of the most important threatening factors for the bird fauna in IBAs in Serbia provided data confirming that intensive forestry causes a high threat level in 8 IBAs, medium threat level in 15 and low threat level in 8 IBAs. Afforestation of open spaces significant for the bird fauna, especially afforestation with poplar clones carried out in the vicinity of fragile habitats on wet meadows, shallow ponds and pastures, is a threatening factor that resulted from forestry activities and which was detected in 28 IBAs in Serbia (Puzović et al, 2009).

Along with the struggle to improve the system for the protection of nature, especially for the protection of the bird fauna and birds` main habitats, the process of forest certification was adopted by two forest management public companies - „Srbijašume“ and „Vojvodinašume in the first decade of the 21st century”. In the course of this process, they obtained FSC certificate, which was a confirmation of proper and sustainable forest management with regard to the environment and biodiversity. **FCS** is an independent**,** non-profit and non-governmental organization which was established in 1993, with the aim to promote the responsible “ecological” forest management (source: http://info.fsc.org). Certification based on the FSC programme is performed according to 10 principles and a number of criteria. They are the basis for development of local standards, taking into consideration all the specificities of the area where they are applied (Vasić et al, 2011). At the end of 2011, there were 57 registered FSC certificates, 3 of which issued for the forest management and 54 for the chain of custody (Tintor, 2012). In 2013, new legislation shall come into force in the EU which will significantly tighten the terms of placing wood and products from other countries on this market and that will require providing the proof of origin. Since the EU is the most important market for wood products exported from Serbia, fulfilling the abovementioned and other conditions is of great significance for forest companies from Serbia (Vasiljević i Glavonjić, 2011). "Vojvodinašume" obtained the FSC certificate for 4 forest holdings (Sombor, Novi Sad, Pančevo, Sremska Mitrovica) in August 2008 and it is valid until August 2013. Within "Srbijašume" public company, forest holdings based in Loznica, Belgrade, Kraljevo, Kruševac, Despotovac and Užice have a certificate valid until the end of 2014 while forest holdings in Vranje, Kuršumlija, Leskovac, Niš, Pirot, Boljevac, Kučevo, Kragujevac, Raška, Ivanjica and Prijepolje have a certificate valid from February 2012 until February 2017.

This paper particularly considers the potential effects of forest certification application on bird habitats in certain parts of Serbia, with a special focus on the insufficiently wooded territory of Vojvodina, but it also considers specific impacts of certification in certain protected forest areas in the period of 2008 to 2011. The quality of conducted monitoring for certain representatives of the bird fauna was especially analysed and some suggestions were made so that it could be improved. Starting from the idea proposed by Vasić (1995) that geographical areas which have typical vital bird habitats and set of conditions preserved to a greater or lesser extent are important for the preservation of the bird fauna diversity and focusing on the fact that past adverse effects of the (unsustainable) forest management on biodiversity and the bird fauna in particular (Stevanović and Vasić, 1995; Vasić, 1995), partially negative attitude of the public and some citizens` associations towards the contemporary impact of intensive forestry on nature, this paper gives guidelines aiming to achieve further approximation of interests in forestry and nature protection.

MATERIAL AND METHODS

Published professional and scientific material and documentation regarding forest certification in the territory of Serbia were analysed, with a special focus on the territory of Vojvodina and the part which refers to the protection and improvement of the state of environmental biodiversity, the bird fauna and the protection of nature. The data available on the Internet sites of certification bodies and public companies operating in the field of forestry in Serbia were used. The results that followed implementation of some projects by certain forest holdings, especially in the protected areas, were analysed as well as the results that were the product of drafting and implementation of plans in the area of forestry based on the application of forest certification. The effects of the paper on the bird fauna in forest habitats were evaluated, bearing in mind state of affairs and the attitudes prior to the forest certification implementation.

RESULTS AND DISCUSSION

In the last three decades, Serbia has been characterized by two processes which influenced the structure and abundance of birds living in the forest ecosystems. On the one hand, the undeniable fact is that the wooded area in the period of 1980-2007 increased at the national level by more than 50,000 ha (Banković et al, 2009; Mijović et al, 2012), but on the other hand, it is evident that in the course of this rather long time period, the structure of forests simplified and the average age of forests decreased as well as their potential for providing ecosystem services. This undoubtedly affected the abundance of particular bird species in forests. One of the rare analyses covering this topic estimates that the majority of forest bird species in Serbia have had stable population in the last three decades due to the increase in the amount of wooded areas (Živković, 2007) despite the violation of numerous forest complexes in terms of their naturalness, age, heterogeneousness, density, coverage and the increased intensity of forest activities and use of machinery.

Having in mind the constant and ever increasing pressure on forest and other ecosystems in Serbia, Stevanović and Vasić (1995) pointed out more than two decades ago that in the future, only protected areas were most likely to have original nature and biodiversity protected and more or less preserved. What they were not aware of back then was the fact that the change in the legislation at the end of the first decade of the 21st century would allow performance of almost the same activities within the protected areas as well as outside them, thus practically making no difference between them. Apart from cataloguing significant areas and species, it is necessary to make inventory and to establish a network of protected valuable and threatened ecosystems, that is, representative habitat types where forest ecosystems have a special role (Matvejev and Puncer, 1989) significant for dispersing birds which are impossible to protect only by means of insufficiently expanded network of protected areas (Vasić, 1995).

Having in mind these grim trends and assumptions regarding the bird fauna diversity preservation in the forests of Serbia, the introduction of forest certification in the period of 2007-8 represented an exceptionally positive novelty which made way to finding a compromise and mechanisms for active field work. The importance of involving public companies for forest management in the process of certification (which contributes to the preservation and enlargement of forest bird population) becomes most evident when we take into account the fact that „Srbijašume“ public company manages 92 protected areas in the territory of more than 244,600 ha (Aleksić and Jančić, 2008; Jančić, 2008), and that „Vojvodinašume“ public company manages 22 protected areas in the territory of more than 73,740 ha (Grujičić et al, 2008). The positive influence on new trends was enabled by the enactment of the Strategy on Biodiversity at the level of Serbia for the period of 2011-2018. (Radović and Kozomora, 2011).

By means of a specific web site and appropriate procedures, SGS QUALIFOR makes sure that the forest management certification provisions are complied with in order to meet the key principle of making the management ecologically responsible, socially useful and economically sustainable (SGS, 2012). All stakeholders must be included in the process of obtaining FSC standard at local, national and international level, which therefore provides transparency in the work and balance of certain interests through planning documents.

„Srbijašume“ public company has commenced the forest certification process through a project supported by the competent Ministry (Zelić, 2008). A similar approach was applied by „Vojvodinašume“ public company. The effort these two companies have made in the past few years in order to improve the activities of coordinating interests in forest management with the necessity to preserve nature and biodiversity are evident mostly because of the introduction of certification. The forest practice in the function of preserving the area diversity and biodiversity has been improved, so it is of utmost importance to emphasise the significance of implementing particular measures, such as allowing up to five indigenous trees in the areas which are in the process of forest regeneration, promoting indigenous trees, replacing plantations and crops with natural stands of mixed composition, looking after ecological forest (green) and water (blue) corridors, reducing the use of harmful chemical substances in forestry as well as strengthening professional capacities for managing the protected areas. There is a visible effort to build partnerships with the general public, especially with local communities and citizens` associations in whose territory the certified forests are located. A whole set of guidelines and recommendations (available for the general public on the Internet) has been developed, as a basis for the sustainable and transparent forest and forest biodiversity management.

There are numerous guidelines that need to be developed and applied in order to meet certain certification requirements. Those include guidelines for establishing protection zones and for promoting indigenous species with the aim to positively affect ecosystems, fragile habitats, biodiversity and geodiversity. There are also some guidelines regarding the use of chemicals in forestry, particularly regarding their selectivity and efficiency. Inadequate use of chemicals in forestry and agriculture but also illegal placement of contaminated baits caused many cases of poisoning of white-tailed eagles (*Haliaeetus albicilla*).

As a part of its activities related to the forest certification implementation, „Vojvodinašume“ public company has developed guidelines for regeneration, care and the protection of forests, which is very important for the harmonisation of interests between the bird protection and forest management. Adequate brochures, leaflets and posters for employees and other stakeholders have been printed, mainly focusing on forest birds (Vujasinović et al, 2011). The activities regarding the regeneration of forests are mostly elaborated here since this regeneration is implemented in many forests through the preparatory, establishment and removal cut. In order to provide support for the preservation of biodiversity, up to five trees of main and supporting tree species per hectare are permanently left in the removal cut (one of which needs to be dried if possible or at least at the advanced stage of drying) as well as the certain number of fallen trees. Such measures implemented in the lowland and hilly forest habitats encouraged numerous bird species to use these locations also during the period of reproduction. Amongst them, there are certain species of woodpecker (*Dendrocopos major, D.syriacus*, *D.medius*), tit (*Parus major*, *P.coeruleus*, *P.palustris*), Eurasian nuthatch (*Sitta europaea*), Eurasian golden oriole (*Oriolus oriolus*). Having in mind the primary needs of woodpeckers and green woodpeckers but also of stock doves (*Columba oenas*), collared flycatchers (*Ficedula albicollis*), common redstarts (*Phoenicurus phoenicurus*), wood warblers (*Phylloscopus sibilatrix*), it is necessary to leave aside certain old mixed forest complexes with natural habitat conditions in order to preserve the population stability. This was especially proved by detailed research conducted on Fruška Gora (Stojnić, 2009; Janković, 2009). Even greater is the significance of leaving individual and grouped trees in the places of forest`s regeneration for the purpose of resting and watching large birds of prey (*Haliaeetus albicilla, Accipiter gentillis, Milvus migrans, Buteo buteo*) as well as the black stork (*Ciconia nigra*) whose life is closely tied to forest habitats. In the future, it is necessary to be persistent in leaving five trees per hectare during the regeneration of forest stands (especially with common oak and ash), along with the favouring of indigenous tree species of different age and their grouping in order to obtain greater resistance to climate impacts.

One of the best examples of the effects of forest certification and positive change in forests companies with regard to the rare species of birds of prey is the monitoring and active protection measures for the white-tailed eagle (*Haliaeetus labicilla*) in the territory of Vojvodina. Earlier in the past, it was not uncommon to have trees with nests felled during forest works or not to have them registered. In the last few years, a modern programme of mapping the active nests, monitoring the successfulness of reproduction and reduction of disturbance of adult birds at their nesting places has been developed with the assistance of forest holdings. Along with the dominant global processes, this caused the significant increase in the number of these species in Serbia- from several dozens of nesting territories in the past to over 100 (Ham et al, 2009). Western capercaillie (*Tetrao urogallus*) could be a good example of positive effects on the rare bird species, which came as a result of introducing the forest certification. This especially refers to the area of Tara, Kamena gora, particularly Stara planina in the vicinity of Arbinje, Jarišor and Kopren, where it is necessary to provide favourable habitat conditions, peace and quiet during the reproduction period and resettlement measure (where necessary) by applying certification principles (Gačić et al, 2009).

One of the best examples of the successful application of forest certification in the protected areas of Serbia managed by „Vojvodinašume" public company is the „Obedska bara" Special Nature Reserve where the regeneration of natural forests with common oak and ash in the flooded area poses the greatest challenge along with the reduction of the poplar plantations, prevention of spread of invasive species in open habitats of wet meadows and pastures and the revitalization of vulnerable ecosystems, regulation of water system and maintenance of favourable relations between spatial distribution and the proportion of forest, meadow and marsh habitats (Puzović i sar., 2010). Application of the forest certification principles enabled the revitalization of numerous endangered habitats and the improvement of the conditions for the survival of birds, which resulted in stabilization and slight recovery of some species of forest birds.

Implementation of the appropriate monitoring is one of the most important segments of the forest certification procedure because we can perceive the effects of the applied measures in a measurable way and make necessary corrections. In 2010, within the framework of forest certification programme, „Vojvodinašume" public company established monitoring of rare, vulnerable and endangered species in the territory of its forest holdings, especially in the protected areas it manages. Services that take care of forests, the game and protected areas are engaged in the field collection, processing and presentation of the monitoring results. Animal and plant species are monitored at the level of forest holdings, management units, areas, departments and sections. The data is entered in the neatly presented tables and it is available on the Internet. The database also includes observations about human activities significant for the protection of biodiversity.

„Banat“ forest holding is implementing the mapping of nests of white-tailed eagle *(Haliaeetus albicilla)* and black stork *(Ciconia nigra)*, and the key monitoring species include Eastern imperial eagle *(Aquila heliaca)* and Ural owl *(Strix uralensis)*. „Sombor“ forest holding is registering nests of the white-tailed eagle *(Haliaeetus albicilla)* and black stork *(Ciconia nigra)*, while the selected species for monitoring include greylag goose *(Anser anser)* and European roller *(Coracias garrulus)*. „Novi Sad“ forest holding is implementing the mapping of nests of white-tailed eagle *(Haliaeetus albicilla)* and black stork *(Ciconia nigra)* and it is monitoring the mute swan *(Cygnus olor)* and European green woodpecker *(Picus viridis)*. „Sremska Mitrovica“ forest holding is registering nests of the white-tailed eagle *(Haliaeetus albicilla)* and black stork *(Ciconia nigra*), while the key bird species for monitoring include common spoonbill *(Platalea leucorodia)* and black woodpecker *(Dryocopus martius)*. There is a difference in the quality of the collected data between some holdings, which means that the training of employees should be improved as well as their readiness to record their observations from the fieldwork and forward them to the appropriate services.

Despite the undeniable progress in the treatment of the bird fauna in certified forests, it is possible to improve activities in various areas even more. It is necessary to increase the proportion of old forests and trees in forest complexes and improve their composition, structure and stratification. It is also necessary to further limit the use of chemicals and ferilisers in forestry, primarily within the boundaries of protected areas. We need to improve active protection of the bird fauna in forests at the national and international level, especially of those rare and endangered species.

CONCLUSION

Application of forest certification standards in Serbia significantly improved the attitude of forest companies towards the environment and protection of biodiversity, primarily by means of the ecological approach to forest management. There was a reduction in conflicts of interest between the economic management and the necessity of preserving biodiversity in forests. The significant progress was made in environmental education of employees. Monitoring of certain important representatives of the bird fauna was established and the general public is informed on this on regular basis. Nests of rare species of daytime birds of prey and black storks are being mapped, along with monitoring the success of nesting and the reduction of disturbance in the reproductive period. However, it is necessary to expand the area of old forest coverage and improve its composition, structure and stratification, limit the use of chemicals and fertilisers in forestry and improve the active protection of rare and endangered bird species in forests.

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