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SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
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UDK 630*232.12:582.475 Pseudotsuga menziesii (Mirb.) Franco (497.11)=111
Original scientific paper

THE DIFFERENCES OF NEEDLE LENGTH OF DOUGLAS-FIR PROVENANCES AT TWO SITES IN TEST PLANTATIONS

Vera LAVADINOVIĆ[1], Nenad MARKOVIĆ[2]

Abstract: *Douglas-fir (Pseudotsuga menziesii/Mirb.Franco) is the most successful introduced and ecologically adapted species in Europe since 1827. Its natural range extends from British Columbia in the north, as far as New Mexico in the south. Douglas-fir has the most extensive latitudinal range of any North American commercial conifer, from 19° to 55° North latitude (New Mexico – British Columbia). Genetic and ecological diversity of Douglas-fir results from its wide natural range of species distribution. Such a wide distribution of a species requires the testing of its characteristics.*

One of the models for testing the genetic diversity, variability and adaptability of introduced species is the provenance test.

This study was conducted to evaluate the effects of site environmental factors upon morphological characteristics of Douglas-fir needles.

Key words: Douglas-fir, provenances, needle length, sites, Serbia

RAZLIČITOST DUŽINE ČETINA PROVENIJECIJA DUGLAZIJE NA DVA STANIŠTA U OGLEDIMA

Izvod: *Duglazija (Pinus menziesii / Mirb.Franco) je najuspešnija introdukovana vsrta i ekološki prilagođena vrsta četinara u Evropi od 1827. Prirodni areal proteže se od Britanske Kolumbije na severu, pa do Novog Meksika na jugu. Daglazija ima najširi raspon geografske širine od bilo kog severnoameričkog komercijalnog četinara, od 19 ° do 55 ° severne geografske širine (Novi Meksiko – Britanska Kolumbija). Genetička i ekološka raznovrsnost Duglazije je rezultat njenog širokog spektra distribucije vrsta. Takva široka distribucija vrsta zahteva testiranje karakteristika. Jedan od modela za ispitivanje genetske*

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različitosti, varijabilnost i prilagodljivost introdukovanih vrsta je provenijenični test. Ova istraživanja su sprovedena da se procene efekti staništa ekoloških faktora na morfološke karakteristike četina duglazije u test kulturama na dva lokaliteta u Srbiji.

Ključne reči: Duglazija, provenijencija, dužina četina, staništer, Srbija

1. INTRODUCTION

Climate conditions and environment may have an impact on the productivity of conifer trees by influencing the morphology (size and surface characteristics) and function (capacity for gas exchange) of conifer needles. Needle characteristics, including length, width, stomatal density, needle function are important for water vapour and transpiration. Needle length increases significantly with increased temperature (Martha E. Apple *et al*., 2000).

More specifically, the objective was to determine whether site environment conditions affect the morphology and function of Douglas-fir needles of different provenances at two sites in Serbia.

In order to be able to forecast and estimate the state and dynamics of forest ecosystems, it is necessary to understand the mechanisms and character of response reactions of trees to the different complexes of environmental factors. Balanced metabolism, in which an optimum supply of nutrients is of prime importance, is indispensable to preserve functional and structural integrity of a tree (Malle Mandre and Aljona Lukjanova, 2011).

Institute of Forestry Belgrade established two experimental plots, in Central (Juhor) and east Serbia (Tanda) of Douglas-fir provenances, with original seeds from North America.

Douglas- fir, as exotic species need to be provenance tested before introduction.

Genetics and ecological adaptability can be confirmed, by morphological and anatomical variable characteristics which is the aim of this research. For that reason, two experimental plots with twenty Douglas fir provenances were established in Serbia .

A considerable number of quantitative and qualitative properties were analyzed in Douglas-fir test plantations in Serbia (Lavadinović. V., Isajev,V., Koprivica, M. 1998, Lavadinović, V., Isajev,V., Koprivica, M.2001, Lavadinović, V., Isajev,V., (2003)., Lavadinović,V. (2008)

2. MATERIAL AND METHOD

Two experimental fields of Douglas fir provenances in Serbia were the basis for the sampling and analysis.

The samples were taken from the selected provenances for the analysis of the existence and effects of the impact of site conditions on the variability of morphometric characters of Douglas-fir needles at both locations. The selection criteria in choosing the provenances for sampling in this study were the results of the studies of variability of inventory variables. Two provenances with the smallest, two with the average and two with the largest mean values of inventory variables were taken for this study.

Fresh needles were fixed in 50% ethyl alcohol and transported to the laboratory, where they made a permanent anatomical sections with 30 needles, randomly chosen. Permanent anatomic preparations thickness 17 µm were made in the middle of the needle microtome, stained with safranin red and toluidine blue and rinsed with water, followed by dehydration was carried out by increasing the ethyl alcohol concentration of alcohol of 50% to 96%. Fully fixing section was performed in xylene for several hours, after which the needles were glued on glass slides Canada balm, covered with the covering glass and dried in an oven at 60 º C. After three weeks, the morph metric traits were measured: width, length, thickness of the needle.

Geographical characteristics of the original seeds of Douglas-fir, which were collected from a part of the natural range of species is shown in Table 1.

Table 1. *Geographical co-ordinates of the tested Douglas-fir provenances*

Provenance Number	Our mark	Latitude (º N)	Longitude (ºE)	Altitude (m)
Oregon 205–15	1	43,7	123,0	750
Oregon 205–14	2	43,8	122,5	1200
Oregon 202–27	3	45,0	122,4	450
Oregon 205–38	4	45,0	121,0	600
Washington 204–07	9	49,0	119,0	1200
Oregon 205–13	10	43,8	122,5	1050
Oregon 205–18	11	44,2	122,2	600
Oregon 202–22	12	42,5	122,5	1200
Washington 202–17	15	47,6	121,7	600
Oregon 201–10	16	44,5	119,0	1350
Washington 201–06	17	49,0	120,0	750
Oregon 202–19	18	45,3	123,8	300
Washington 204–09	19	49,0	119,3	900
Oregon 205–11	20	45,0	123,0	150
New Mexico 202–04	22	32,9	105,7	2682
New Mexico 202–10	23	36,0	106,0	2667
Oregon 202–31	24	44,3	118,8	1500
Oregon 205–29	26	42,6	122,8	900
Oregon 204–04	30	45,0	121,5	900
Washington 205–17	31	47,7	123,0	300

3. RESULTS

According to Table 2, it can be concluded that:

a) There are statistically significant differences between the mean values of needle length at the localities Juhor and Tanda;
b) There are statistically significant differences between the mean values of needle length of individual provenances;
c) There is an interaction between the factors "locality" and "provenance". Mean value of needle length in individual provenances is affected by the changes in locality, and the opposite.

Table 2. *A two-way analysis of variance (locality x provenances) for needle length*

Source of variation	Sum of squares	Degree of freedom	Variance	F	p-value
A: Locality	306.178	1	306.178	87.93	0.000
B: Provenance	6221.76	5	1244.35	357.37	0.000
Interaction AB	538.989	5	107.798	30.96	0.000
Error	1211.73	348	3.48199		
Total	8278.66	359			

Difference of needle lengths on sites

The least significant difference (LSD) test examined the difference in mean values of needle lengths for two factors (Locality and Provenance)

Table 3. *LSD test for localities*

Locality	Sample size	Mean value	Difference	Homogeneous groups
Juhor	180	31.7389	0.139084	X
Tanda	180	33.5833	0.139084	X
			Difference	+/– Limits
Juhor–Tanda			*–1.84444	0.386861

- indicates a statistically significant difference
-

Table 3 shows that there is a statistically significant difference in the lengths of Douglas fir needles for the sites Juhor and Tanda. The average value of needle length at Tanda (33.58 mm) was significantly higher than at Juhor (31.74 mm), and the test shows that there is an influence of environmental factors on these two sites on needle lengths (Figures 1 and 2).

Difference of needle lengths in provenances

LSD test checked the difference in needle lengths mean values in different provenances (geographical origin)

Table 4. *LSD test for provenances*

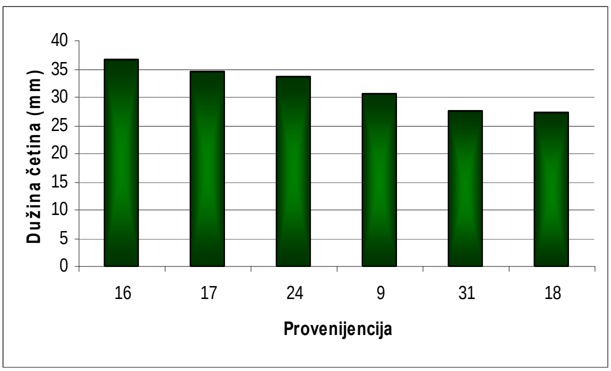
Provenance	Sample size	Mean value	Difference	Homogeneous groups
31	60	27.9333	0.240901	X
18	60	28.3667	0.240901	X
9	60	29.85	0.240901	X
24	60	34.25	0.240901	X
16	60	37.7667	0.240901	X
17	60	37.8	0.240901	X

Comparison	Difference	+/–Limit
9–16	*–7.91667	0.670062
9–17	*–7.95	0.670062
9–18	* 1.48333	0.670062
9–24	*–4.4	0.670062
9–31	* 1.91667	0.670062
16–17	–0.0333333	0.670062
16–18	* 9.4	0.670062
16–24	* 3.51667	0.670062
16–31	* 9.83333	0.670062
17–18	* 9.43333	0.670062
17–24	* 3.55	0.670062
17–31	* 9.86667	0.670062
18–24	*–5.88333	0.670062
18–31	0.433333	0.670062
24–31	* 6.31667	0.670062

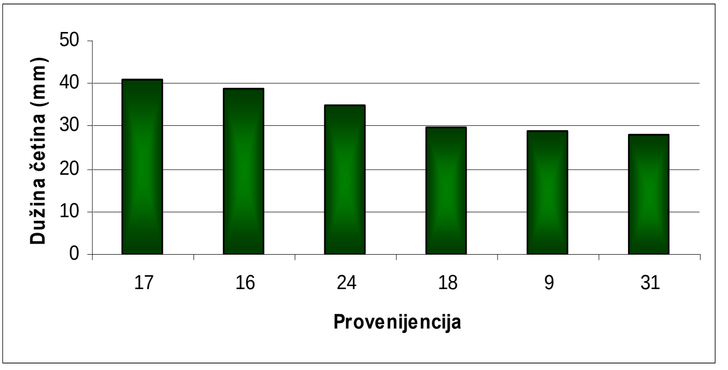
* indicates the statistically significant difference

According to the results of analysis of variance (Table 4), it can be concluded that there are statistically significant differences between the mean values of needle length in some provenances. LSD test demonstrates that provenances 31 and 18 make one homogenous group, and provenances 16 and 17 the other. Smaller range of variation of needle length of these provenances in relation to the other can be tentatively considered as a consequence of their genetic closeness which caused similar phenotypic expression of the properties of the interaction with the external factors of the location where the tests were established.

The differences are shown on Diagram 1 for locality Juhor, and on Diagram 2 for locality Tanda.



Graph 1. *Variability in needle length among the provenances on the locality of Juhor*



Graph 2. *Variability in needle length among the provenances on the locality of Tanda*

4. CONCLUSION

The investigation of the influence of two factors (site and provenance), the two-way ANOVA was carried out on the Douglas-fir provenance trail at two sites in Serbia.

The major conclusion is that care must be exercised in describing the trait variability, so the particular environmental gradient must be specified.

The LSD test shows that the provenances 31 (Washington 205–17) and 18 (Oregon 202–19) make one homogenous group, and provenances 16 (Oregon 201–10) and 17 (Washington 201–06**)** the other, so the differences in their mean values are not statistically significant. The lower range of character variation in these provenances, compared to others, can be conditionally considered as a consequence of their genetic similarity which conditioned the similar phenotype expressions in the interaction with the external factors of the sites where the tests were established.

Acknowledgment

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UDK 630*165+630*232.311.2:582.476 Taxodium distichum (L.) Rich=111
Original scientific paper

VARIABILITY IN CONE MORPHOMETRIC CHARACTERS AMONG TEST TREES OF BALD CYPRESS (*Taxodium distichum* L. Rich.) IN SEED STAND NEAR BAČKA PALANKA

Vladan POPOVIĆ[1], Mirjana ŠIJAČIĆ-NIKOLIĆ[2],
Ljubinko RAKONJAC[1], Dušan JOKANOVIĆ[2]

Abstract: *Bald cypress is monoecious, long-lived, deciduous conifer. It belongs to the family Taxodiaceae and genus Taxodium. In Serbia, there is only Taxodium distichum (L.) Rich. that mostly can be found in the green areas of major cities. The possibility of wider application of Bald cypress as a forest species should be based on an assessment of its genetic and adaptive potential, quantity and quality of yield, primarily at the level of the existing Bald cypress seed stand. In this paper are presented research results of the variability in cone morphometric characters among 20 test trees. The determined values of cone dimensions indicate good genetic and adaptive potential of this species that can be considered as starting point for the mass production of quality seed and planting material in Serbia.*

Key words: Bald cypress, cone, seed, variability.

VARIJABILNOST MORFOMETRIJSKIH SVOJSTAVA ŠIŠARICA TEST STABALA TAKSODIJUMA (*Taxodium distichum* L. Rich.) U SEMENSKOJ SASTOJINI KOD BAČKE PALANKE

Izvod: *Taksodijum je jednodomi, dugovečni listopadni četinar. Pripada familiji Taxodiaceae i rodu Taxodium. U Srbiji je zabeležen samo Taxodium distichum (L.) Rich. koji se uglavnom javlja pojedinačno na zelenim površina većih gradova. Mogućnost šire primene taksodijuma kao šumske vrste treba bazirati na proceni njegovog genetskog i*

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adaptivnog potencijala kao i kvantiteta i kvaliteta uroda, pre svega, na nivou postojeće semenske sastojine taksodijuma. U radu su prikazani rezultati ispitivanja varijabilnosti morfometrijskih svojstava šišarica na nivou 20 test stabala. Utvrđene vrednosti dimenzija šišarica ukazuju na dobar genetski i adaptivni potencijal ove vrste, što se može smatrati polaznom osnovom za masovnu proizvodnju kvalitetnog semenskog i sadnog materijala u Srbiji.

Ključne reči: taksodijum, šišarice, seme, varijabilnost.

1. INTRODUCTION

Bald cypress is monoecious, long-lived, deciduous conifer. It belongs to the family *Taxodiaceae* and genus *Taxodium* that includes three species (Vukićević, 1987). In Serbia, there is only *Taxodium distichum* (L.) Rich. Bald cypress capability for establishment of forest cultures on lowland and floodplains of our country was recorded in the 1950s (Petrović, 1951; Špiranec, 1959, 1966). At the beginning of the 1980s, Stilinović and Tucović (1970) concluded that in our environmental conditions Bald cypress can be considered as a species of rapid growth, one of the few conifer species that may be suitable for introduction of conifers on lowland and floodplain sites where it can achieve high productivity.

Nevertheless, on the territory of the Republic of Serbia this species has practically never got out from the range of horticultural activities. Researches on the variability and adaptive potential of Bald cypress in our conditions which have been published until now refer to trees that grow individually and in smaller or larger groups mainly in the city green areas (Dražić, Batos, 2002; Ninić-Todorović, Ocokoljić, 2001, 2002; Tucović, Ocokoljić, 2005). The possibility of wider application of Bald cypress as a forest species should be based on an assessment of its genetic and adaptive potential as well as quantity and quality of yield, primarily at the level of the existing Bald cypress seed stand.

2. MATERIAL AND METHOD

Researches were conducted in Bald cypress seed stand in Bačka Palanka, registration number S 01.10.01.01, which is managed by FE Novi Sad, FA Bačka Palanka. Seed stand is within MU "Palanačke Ade- Čipski poloj", Department 11, Section a, with area of 0.22 ha and with 111 trees. Its origin is artificial, aged about 70 years, with the measured taxation values of mean diameter ds = 51.7 cm and mean height, hs = 26.5 m. It is located on flat ground with an average altitude of 80 m, with a uniform slope and without clear exposure. Flooding is not present, but it is heavily influenced by underground wetting. The site on which the seed stand is located belongs to coeno-ecological group of White willow and Populus (*Salicion albae*) forests on undeveloped semi-gley soils.

On the basis of phenotypic characteristics and abundance of yield in 2010, 20 test trees were selected and per 200 cones were collected from each of them. Cones were put into separate bags. Then by random sampling method 50 cones per tree were taken for processing at the laboratory of Institute of Forestry. Cone opening was done in the dryer at the temperature of 40 °C, and seed cleaning was done manually. The basic morphometric parameters of each cone (length and width) were measured by caliper with an accuracy of 1 mm. Also, after cone opening the number of grains was determined for each cone. The obtained data were processed in a computer program Statgraph 5.0.

3. RESULTS AND DISCUSSION

Variability in cone morphometric characters of 20 test trees of Bald cypress is presented in Table 1.

Table 1. *Variability in cone morphometric characters of 20 test trees of Bald cypress*

Trees	Parameter	Average (mm)	Min	Max	Standard deviation	Coefficient of variation
1	Cone length (mm)	31.56	22.5	38.7	4.25	18.08
	Cone width (mm)	28.67	20.9	36.5	4.14	17.14
	Number of seeds (pcs.)	28,50	22,0	32,0	2,30	5,28
2	Cone length (mm)	30.70	22.6	37.2	4.07	16.56
	Cone width (mm)	28.44	22.1	36.0	3.98	15.85
	Number of seeds (pcs.)	27,22	20,0	33,0	3,38	11,40
3	Cone length (mm)	29.67	22.4	38.4	4.21	17.76
	Cone width (mm)	27.77	21.3	34.5	3.40	15.97
	Number of seeds (pcs.)	27,50	21,0	34,0	3,01	9,03
4	Cone length (mm)	30.55	22.3	38.4	3.58	12.78
	Cone width (mm)	27.97	21.0	36.2	3.47	12.06
	Number of seeds (pcs.)	27,84	21,0	32,0	2,72	7,40
5	Cone length (mm)	30.67	22.6	37.6	4.01	16.07
	Cone width (mm)	27.96	19.1	34.6	3.89	15.10
	Number of seeds (pcs.)	27,06	20,0	33,0	3,35	11,24
6	Cone length (mm)	29.54	21.4	38.4	4.31	18.56
	Cone width (mm)	26.48	19.4	35.6	4.05	16.39
	Number of seeds (pcs.)	26,08	20,0	32,0	3,30	10,89
7	Cone length (mm)	30.25	21.5	38.4	4.47	20.00
	Cone width (mm)	26.97	18.6	35.1	4.26	18.15
	Number of seeds (pcs.)	26,66	20,0	33,0	3,59	12,88
8	Cone length (mm)	29.05	21.3	37.5	4.47	19.95
	Cone width (mm)	25.85	19.4	34.6	4.30	18.45
	Number of seeds (pcs.)	25,40	20,0	33,0	3,58	14,82
9	Cone length (mm)	29.84	20.6	37.1	4.15	17.20
	Cone width (mm)	26.01	8.0	33.8	4.89	23.95
	Number of seeds (pcs.)	25,90	21,0	32,0	3,60	12,95
10	Cone length (mm)	29.08	21.3	38.4	4.26	18.11
	Cone width (mm)	25.73	19.5	34.1	4.23	17.93
	Number of seeds (pcs.)	25,44	20,0	32,0	3,60	12,99
11	Cone length (mm)	28.41	22.3	36.5	3.37	11.35
	Cone width (mm)	25.27	20.1	33.2	3.38	11.45
	Number of seeds	25,76	20,0	33,0	3,28	10,76

Trees	Parameter	Average (mm)	Min	Max	Standard deviation	Coefficient of variation
	(pcs.)					
12	Cone length (mm)	28.84	22.3	36.5	3.29	10.84
	Cone width (mm)	25.96	19.9	33.6	3.40	11.59
	Number of seeds (pcs.)	26,30	21,0	33,0	2,99	8,95
13	Cone length (mm)	28.73	21.8	34.3	3,00	9,00
	Cone width (mm)	25.82	19.9	31.8	2.98	8.89
	Number of seeds (pcs.)	26,08	20,0	33,0	3,15	9,95
14	Cone length (mm)	28.99	21.3	36.1	3.44	11.81
	Cone width (mm)	25.96	19.9	33.2	3.26	10.65
	Number of seeds (pcs.)	25,86	20,0	33,0	3,34	11,14
15	Cone length (mm)	28.64	23.6	35.2	3.27	10.71
	Cone width (mm)	25.58	20.9	31.5	3.19	10.20
	Number of seeds (pcs.)	25,20	20,0	33,0	3,73	13,88
16	Cone length (mm)	28.90	23.6	34.5	2.79	7.76
	Cone width (mm)	25.53	19.6	30.8	2.96	8.75
	Number of seeds (pcs.)	25,56	20,0	31,0	3,03	9,19
17	Cone length (mm)	28.99	22.8	36.2	3.49	12.17
	Cone width (mm)	25.78	19.5	31.2	2.98	8.86
	Number of seeds (pcs.)	26,46	21,0	32,0	2,68	7,19
18	Cone length (mm)	29.13	23.6	35.2	2.96	8.74
	Cone width (mm)	26.35	21.2	32.3	2.81	7.90
	Number of seeds (pcs.)	26,74	22,0	32,0	2,48	6,16
19	Cone length (mm)	29.34	24.3	35.6	2.92	8.51
	Cone width (mm)	26.59	21.3	32.6	3.06	9.34
	Number of seeds (pcs.)	27,08	21,0	33,0	3,04	9,22
20	Cone length (mm)	29.07	23.0	35.9	2.80	7.85
	Cone width (mm)	26.05	21.0	32.1	2.50	6.25
	Number of seeds (pcs.)	26,40	21,0	32,0	2,47	6,12

Based on the statistical indicators, it can be concluded that the highest mean value of cone length shows a test tree marked with number 1 (31.56 mm), while the smallest mean value of cone length has the test tree marked with number 11 (28.41 mm). The highest mean value of cone width has the test tree marked with number 1 (28.67 mm) and the smallest mean value of cone width has the test tree marked with number 11 (25.27 mm). The highest mean value of number of grains has the test tree marked with number 1 (28.5 pieces), and the smallest mean value of number of grains has the test tree marked with number 15 (25.2 pieces.). Test tree marked with number 1 stands out like the best for all three characters, while the test tree number 11 has the smallest mean value of cone length and width, but not the number of grains. The values of the analyzed characters coincide with the values that in their researches obtained other authors. In Motovun forest, Croatia, Bald cypress cone diameter ranges from 20 to 25 mm and one cone contains from 18 to 30 grains (Špiranec, M. 1959.). Under Belgrade's environmental conditions cone diameter ranges from 20 to 30 mm (Dražić, D., Batos, B. 2002.). Under the environmental conditions of Bulgaria cone diameter ranges up to 30 mm, cone length from 20 to 40 mm, and cones contain approximately 20 to 25 grains (M i l e v , M . , et al. 1999.). In Bald cypress population at Veliko Ratno ostrvo, cone diameter ranges from 22 to 39 mm, and cones contain from 10 to 32 grains, on average about 20 grains (Š i j a č i ć - N i k o l i ć , M . , et al. 2011.).

The coefficient of variation can be used as an indicator of statistical set homogeneity. By analyzing the values of this coefficient, we can conclude that for the cone length character the most homogeneous is the test tree marked with number 16 (7.76), and the most heterogeneous is the test tree marked with number 7 (20). For the cone width character, the most homogeneous is the test tree marked with number 20 (6.25), and the most heterogeneous is the tree test marked with number 9 (23.95). For the character number of grains, the most homogeneous is the test tree marked with number 1 (5.28), and the most heterogeneous is the test tree marked with number 8 (14.82).

ANALYSIS OF VARIANCE

1. Cone width

Table 2. *Analysis of variance for cone width*

	Sum of Squares	Df	Mean Square	F- Ratio	P- Value
Between groups	1045.11	19	55.0058	4.15	0.0000
Within groups	12977.8	980	13.2427		
Total	14022.9	999			

Results of analysis of variance (Table 2) show statistically significant differences at level p <0.05 between cone width of 20 Bald cypress test trees.

Table 3. *LSD test*

Trees	Mean	Homogeneous groups
11	25.2700	X
16	25.5300	X
15	25.5806	XX
10	25.7298	XX
17	25.7780	XX
13	25.8180	XX
8	25.8500	XX
12	25.9580	XX
14	25.9620	XX
9	26.0112	XX
20	26.0460	XX
18	26.3500	XXX
6	26.4800	XXX
19	26.5880	XXXX
7	26.9740	XXX
3	27.7660	XXX
5	27.9600	XX
4	27.9680	XX
2	28.4380	X
1	28.6676	X

Analysis of variance shows that the differences between the mean values of cone width of 20 Bald cypress test trees are statistically significant at the confidence level p <0.05. Test trees are grouped into 5 homogenous groups and with that is confirmed variability of cone width of 20 Bald cypress test trees. In the homogeneous group with the greatest cone width are test trees 1, 2, 4, 5 and 3, and in the group with the smallest cone width are test trees 11, 16, 15 and 10 (Table 3).

2. Cone length

Table 4. *Analysis of variance for cone length*

	Sum of Squares	Df	Mean Square	F- Ratio	P- Value
Between groups	671.144	19	35.3233	2.58	0.0002
Within groups	13416.2	980	13.69		
Total	14087.4	999			

Results of analysis of variance (Table 4) show statistically significant differences at level p <0.05 between cone length of 20 Bald cypress test trees.

Table 5. *LSD test*

Trees	Mean	Homogeneous groups
11	28.410	X
15	28.636	X
13	28.730	X
12	28.836	XX
16	28.898	XX
17	28.988	XX
14	28.994	XX
8	29.054	XX
20	29.074	XX
10	29.080	XX
18	29.130	XXX
19	29.340	XXXX
6	29.544	XXXX
3	29.666	XXXX
9	29.844	XXXX
7	30.246	XXXX
4	30.554	XXX
5	30.670	XX
2	30.698	XX
1	31.558	X

Analysis of variance shows that the differences between the mean values of cone length of 20 Bald cypress test trees are statistically significant at the confidence level p <0.05. Test trees are grouped into 5 homogenous groups and with that is confirmed variability of cone length of 20 Bald cypress test trees. In the homogeneous group with the greatest cone length are test trees 1, 2, 5, 4 and 7, and in the group with the smallest cone length are test trees 11, 15 and 13 (Table 5).

3. Number of grains

Table 6. *Analysis of variance for number of grains*

	Sum of Squares	Df	Mean Square	F- Ratio	P- Value
Between groups	731,496	19	38,4998	3.82	0.0000
Within groups	9870,2	980	10,0716		
Total	10601,7	999			

Results of analysis of variance (Table 6) show statistically significant differences at level $p < 0.05$ between number of grains of 20 Bald cypress test trees.

Table 7. *LSD test*

Trees	Mean	Homogeneous groups
15	25,2	X
8	25,4	XX
10	25,44	XXX
16	25,56	XXXX
11	25,76	XXXX
14	25,86	XXXXX
9	25,9	XXXXX
6	26,08	XXXXXX
13	26,08	XXXXXX
12	26,3	XXXXXXX
20	26,4	XXXXXXX
17	26,46	XXXXXX
7	26,66	XXXXXX
18	26,74	XXXXX
5	27,06	XXXX
19	27,08	XXXX
2	27,22	XXX
3	27,5	XXX
4	27,84	XX
1	28,5	X

Analysis of variance shows that the differences between the mean values of number of grains of 20 Bald cypress test trees are statistically significant at the confidence level $p < 0.05$. Test trees are grouped into 9 homogenous groups and with that is confirmed variability of number of grains of 20 Bald cypress test trees. In the homogeneous group with the greatest number of grains are test trees 1, 4 and 3, and in the group with the smallest number of grains are test trees 15, 8 and 10 (Table 7).

Table 8. *Regression analysis*

Trees	Parameter	r	r^2	p	N
1	Cone length x Number of seeds	0,548611	0,300974	0,0000	50
	Cone width x Number of seeds	0,528498	0,27931	0,0001	50
2	Cone length x Number of seeds	0,890308	0,792648	0,0000	50
	Cone width x Number of seeds	0,889399	0,791031	0,0000	50
3	Cone length x Number of seeds	0,825719	0,681812	0,0000	50
	Cone width x Number of seeds	0,81389	0,662417	0,0000	50
4	Cone length x Number of seeds	0,888308	0,789091	0,0000	50
	Cone width x Number of seeds	0,903113	0,815613	0,0000	50
5	Cone length x Number of seeds	0,940068	0,883728	0,0000	50
	Cone width x Number of seeds	0,923862	0,853521	0,0000	50
6	Cone length x Number of seeds	0,908907	0,826112	0,0000	50
	Cone width x Number of seeds	0,928016	0,861214	0,0000	50
7	Cone length x Number of seeds	0,913761	0,834959	0,0000	50
	Cone width x Number of seeds	0,913203	0,83394	0,0000	50
8	Cone length x Number of seeds	0,914862	0,836972	0,0000	50
	Cone width x Number of seeds	0,933206	0,870873	0,0000	50
9	Cone length x Number of seeds	0,912043	0,831822	0,0000	50
	Cone width x Number of seeds	0,954006	0,910127	0,0000	50
10	Cone length x Number of seeds	0,886714	0,786262	0,0000	50
	Cone width x Number of seeds	0,890744	0,793425	0,0000	50
11	Cone length x Number of seeds	0,844746	0,713596	0,0000	50

Trees	Parameter	r	r^2	p	N
	Cone width x Number of seeds	0,830205	0,68924	0,0000	50
12	Cone length x Number of seeds	0,840029	0,705649	0,0000	50
	Cone width x Number of seeds	0,85299	0,727592	0,0000	50
13	Cone length x Number of seeds	0,752248	0,565877	0,0000	50
	Cone width x Number of seeds	0,793055	0,628936	0,0000	50
14	Cone length x Number of seeds	0,858214	0,736531	0,0000	50
	Cone width x Number of seeds	0,8997	0,80946	0,0000	50
15	Cone length x Number of seeds	0,885102	0,783406	0,0000	50
	Cone width x Number of seeds	0,910709	0,829391	0,0000	50
16	Cone length x Number of seeds	0,892438	0,796446	0,0000	50
	Cone width x Number of seeds	0,913385	0,834272	0,0000	50
17	Cone length x Number of seeds	0,840042	0,705671	0,0000	50
	Cone width x Number of seeds	0,825407	0,681297	0,0000	50
18	Cone length x Number of seeds	0,793743	0,630028	0,0000	50
	Cone width x Number of seeds	0,833713	0,695077	0,0000	50
19	Cone length x Number of seeds	0,864266	0,746956	0,0000	50
	Cone width x Number of seeds	0,886702	0,78624	0,0000	50
20	Cone length x Number of seeds	0,653156	0,426613	0,0000	50
	Cone width x Number of seeds	0,711399	0,506089	0,0000	50

Table 8 shows the coefficients of the linear correlation, the correlation coefficient (r), and the coefficient of determination (r^2). By regression analysis was tried to link cone length and number of grains, as well as cone width and number of grains whereby is being determined only correlation. Coefficients of the linear correlation are statistically significant for the confidence level 5%.

The correlation coefficient shows linear correlation of observed characters. A positive value of the correlation coefficient shows the positive correlation of observed characters. Increasing the value of one character leads to increasing the value of another. The coefficient of determination, as relative indicator, is used to determine the relationship of the observed characters. The relationship between the cone length and number of grains is the strongest in the test tree marked with number 5 (r^2=0,883728), and the weakest in the test tree marked with number 1 (r^2=0,300974). Relationship between the cone width and number of grains is the strongest in the test tree marked with number 9 (r^2=0,910127), and the weakest in the test tree marked with number 1 (r^2=0,27931).

4. CONCLUSIONS

The variability of the quantity and quality of yield of more important tree species is for a long time the subject of research of forest science and profession. However, the degree of exploration of the genetic variability of quantity and quality of forest trees' seed yield and the possibility of its adequate use in our country is still below the actual needs and it is not in accordance with the economic importance. Thanks to the research results of Tucović, A. (1975), Mrva, F. (1976, 1984), Popnikola, N. (1978), Tucović, A., Stilinović, S. (1982), Tucović, A., Isajev, V. (1985), Isajev, V. (1987), Tošić, M. (1991), Mataruga, M. (2003), Lučić, A. (2007), Lučić, A. (2012) etc., the knowledge has been gradually completed and relationship between genetic constitution of populations and environmental conditions has been explained closer, as well as the morphological and physiological characters of seed.

To the learning about the variability in size of cones depending on the population, genotype and collection year, contributed following papers: in Scots pine T o š i ć , M . (1991); L u č i ć , A . (2012), in Austrian pine L u č i ć , A . (2007), in Serbian spruce I s a j e v , V . (1987); T u c o v i ć , A . et al. (1982); Š i j a č i ć - N i k o l i ć , M . (2000, 2003) and in Spruce Š i j a č i ć - N i k o l i ć , M . et al. (2010).

The results obtained from the analysis of variability of morphometric characteristics of cones of 20 Bald cypress test trees originated from seed stand near Bačka Palanka contribute to better understanding of relationships of analyzed characters, as well as the influence of analyzed characters on differentiation of test trees. Based on these results differences were noticed in the values of the observed characters for the each test tree individually. The test tree marked with number 1 stands out with the highest value for all three observed characters, the test tree number 11 has the smallest value for characters cone length and cone width, while the smallest value for the number of grains has test tree number 15. By regression analysis was tried to link cone length and number of grains, as well as cone width and number of grains whereby was being determined only correlation. The relationship between the cone length and number of grains is the strongest in the test tree marked with number 5 and between cone width and number of grains in the test tree number 9. The test tree number 1 has the weakest relationship in both, the cone length and number of grains as well as the cone width and number of grains.

Conducted researches have to be continued in the direction of continuous monitoring of yield quality and quantity in Bald cypress seed stand near Bačka Palanka as the basis for the mass production of genetic quality seed and planting material of this species in Serbia.

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NATURAL REGENERATION OF BEECH FORESTS IN SERBIA

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Abstract: *Natural regeneration of beech forests has been studied in eleven high beech stands in Serbia. The stands are very heterogeneous and predominantly uneven-aged in terms of structure, owing to which group-shelterwood felling was recommended as a means of regeneration. The regeneration process is unmethodical, while the number and quality of young growth are unsatisfactory. The optimum canopy closure for a successful beech regeneration is from 0.6 to 0.7. If canopy closure is higher, a spontaneously occurred young growth will die out, while in case it is lower than the optimum value, weed infestation occurs.*

Key terms: Beech, uneven-aged stands, regeneration

PRIRODNA REGENERACIJA BUKOVIH ŠUMA U SRBIJI

Izvod: *Prirodna regeneracija bukovih šuma je istraživana u jedanaest visokih sastojina bukve na području Srbije. Sastojine su vrlo heterogene i po strukturi pretežno raznodobne, te se u njima preporučuje grupimično-oplodna seča, kao način obnavljanja. Proces podmlađivanja je neplanski, a brojnost i kvalitet podmlatka nezadovoljavajući. Optimalan sklop za uspešno podmlađivanje bukve je od 0,6-0,7. Ukoliko je sklop veći, spontavno pojavljen podmladak izumire, a ukoliko je ispod optimalnih vrednosti dolazi do zakorovljavanja.*

Ključne reči: Bukva, raznodobne sastojine, podmlađivanje.

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1. INTRODUCTION

According to the National Forest Inventory of the Republic of Serbia (Banković et al 2009), beech forests are the most represented and cover 660,400 ha, or 29.3% of the total forest area, 67.4% out of which is state owned. Moreover, beech dominates in terms of volume, and accounts for 40.5% of the total wood volume, and 30.6% of the volume increment.

High beech forests, which are the subject of this study, account for 53.1% of the total beech forest area. The average number of trees is 530 per hectare, the average volume is 269 m^3/ha, while the volume increment amounts to 5.0 m^3/ha. Pure stands account for 86.3% of the total beech forest area, with the average volume of 239 m^3/ha and volume increment of 4.5 m^3/ha.

As a result of the previous method of high beech forest management, the studied stands are predominantly heterogeneous and uneven-aged. Based on previous studies of beech, it has been observed that a process of natural regeneration of stands does not take place continuously and in a planned manner.

According to common practice, the term *young growth* refers to plants below the taxation threshold (5cm), when it concerns uneven-aged, that is, selection stands. The same principle is applied in even-aged stands, although the data cannot have the same character in young and middle-aged stands. The term *seedling* refers to plants of the up to 0.1m height.

The task and aim of this study of number and quality of *young growth* in high beech forests are of exceptional importance, as the obtained results provide insight into a natural regeneration of stands development process, which represents an important indicator of sustainable management.

2. OBJECT OF STUDY

The object of study consists of eleven high pure uneven-aged beech stands, selected in six forest areas: Severni Kučaj, Jablanica, Podrinje-Kolubara, Donji Ibar, Golija and Rasina.

In the Severni Kučaj forest area, three beech stands were selected. In the 'Majdan Kučajna' Management Unit, the stand 33a was selected, while in the 'Crni Vrh' Management Unit, stands 42a and 42b were selected.

In the Jablanica forest area, two beech stands were selected. In the 'Kačer-Zeleničje' Management Unit, the stand 31a was selected, while in the 'Kukavica 1' Management Unit the stand 46a was selected.

In the Rasina forest area, one beech stand was selected. In the 'Lomnička reka' Management Unit, the stand 116a was selected.

In the Donji Ibar forest area, one beech stand was selected. In the 'Željin' Management Unit, the stand 44a was selected.

In the Golija forest area, two beech stands were selected. In the ‘Javor-Koravčina' Management Unit, stands 8a and 8b were selected.

In the Podrinje-Kolubara forest area, two beech stands were selected. In the ‘Istočna Boranja' Management Unit, the stand 122a was selected, while in the 'Zapadna Boranja' Management Unit, the stand 27a was selected.

3. WORK METHOD

Data on *seedling* and *young growth* were collected concurrently with other extensive data on site and stand, on trial plots in form of circle and of different radii (Koprivica, M. et.al. 2005). A network of trial plots, at the distance of 100 x 100 m, was distributed in stands. In every trial circle, following the marking of its centre, the data on *seedling* and *young growth* numbers were collected first, which was followed by an evaluation of *young growth* quality and manner of occurrence. Three concentric circles, of radii 1.0, 1.5 and 12.62m, were placed.

In the 1.0 m radius circle, the number of *young growth* plants, of the up to 1.3 m height, was recorded according to tree species and the total number. Two categories of *young growth* were selected:

- *young growth* of the up to 0.5 m height (early *young growth*) and
- *young growth* of the height between 0.5 and 1.3 m (late *young growth*).

In the 1.5 m radius circle, the number of *young growth* plants, of the breast diameter from 0 to 5 cm (*young forest*), was recorded according to tree species and the total number. The occurrence of *seedling* was also recorded in this circle, but only in terms: '*seedling* exists' and '*seedling* does not exist'. If *seedling* occurred, it was recorded only according to tree species, while the number of plants was not determined. For the existence of *seedling* to be confirmed, it was sufficient to record at least one plant.

In the 12.62m radius circle, the *young growth* quality and manner of occurrence were recorded. The quality of *young growth* was defined by evaluation of *young growth* suppression and damage. The evaluation of *young growth* suppression and damage includes all previously mentioned categories (with respect to height and diameter) considered together, but according to tree species. Three categories of *young growth* suppression and damage were distinguished:

- *young growth* suppressed
- *young growth* slightly suppressed
- *young growth* severely suppressed

- *young growth* undamaged
- *young growth* slightly damaged
- *young growth* severely damaged

The *young growth* suppression was established based on a plant general appearance.

Damage to *young growth* (caused by livestock, wild game and all other causes) was established according to tree species. The *young growth* was slightly damaged in case when less than 1/5 of plants were damaged, and severely damaged when the number of damaged plants was higher than 1/5 of the total number of *young growth* plants.

In the 12.62 m radius circle, a manner of occurrence of *young growth* was also recorded. In that respect, it was recorded whether *young growth* occurred in form of uniformly distributed individual plants, or in groups, or in both forms together. These data were gathered collectively for all categories of young growth. The data were recorded in both uneven-aged and even-aged stands.

When counting *young growth* plants, that is, young trees, the same procedure was applied as when recording adult trees.

In the 12.62 m radius circle, orographic factors were also recorded: altitude, terrain inclination and exposure, along with all collected data on trees above the taxation threshold, necessary for determining stand factors (canopy closure, quality, number of trees, basal area, volume, volume increment, etc.)

For classification of *young growth* according to development phases, the East European nomenclature was used (Tkačenko, M.K. 1952; Bunuševac, T. 1950; Dakov, M., Vlasev, V. 1972). For the purpose of gaining insight into stand conditions, data on geological substratum, soil type and ground vegetation were collected.

4. STUDY RESULTS AND DISCUSSION

4.1 Pedological conditions

Beech is a species of broad ecological amplitude, which, in Serbia, creates a large number of plant communities, spreading from a sub-montane to a sub-alpine belt. In addition to a broad climatic amplitude, this species occurs in different geological substrata and in different soil development stages. In Serbia, beech forests occur on ten soil types (Knežević, M. 2003).

In nine localities, in which the study was conducted, seven soil types were identified.

<u>In the Severni Kučaj forest area</u>, in the stand 33a, the geological substratum consists of limestone (with clearly distinct elements of karst relief), along with red and quartz sandstone. On the limestone with steep inclinations, shallow typical black soils were formed next to colluvial soils, in areas with mild inclinations. In flat limestone terrains, luvisols were formed. In the part of stand in which red and quartz sandstones are represented, acid brown soils are present. In the stands 42a and 42b pedological conditions are uniform. The soil type is district ranker, which in the lower part of the profile attained brown colour. In all three studied stands, pedological conditions for occurrence of *young growth* are favourable.

<u>In the Jablanica forest area</u>, in the stand 31a, pedological conditions are different, which is a result of a distinctly corrugated character of the terrain, various micro-exposures and inclinations. The geological substratum consists of decomposing gneiss, while the most represented type of soil is acid brown – typical. On milder inclinations, in lower parts of stand, acid brown soil is affected by a loess process. In the under ridge part of the stand, below a dense blueberry canopy, brown podzolic soil was recorded. A high acidity indicates an increased presence of distinctly acidophilus species, which characterise a strong to extreme acidity of soil solution, such as: *Luzula luzuloides, Leucobrium glaucum, Pteridium aquilinum, Vaccinium myrtillus* and *Hieracium pilosella.* The limiting factors for occurrence and survival of *young growth* in this stand are: high inclination, erosion processes, and soil wash off. In the stand 46a, brown acid soil, (district cambisol), was recorded on gneiss of shaley structure. Owing to a high content of sand, soils are water-permeable and well-aerated, which are good preconditions for occurrence and survival of young growth.

In the Rasina forest area, in the stand 116a, brown acid soil was recorded. Physical and chemical properties of this soil are favourable for a natural regeneration process.

In the Donji Ibar forest area, in the stand 44a, acid brown soil, of relatively uniform physical and chemical properties, was recorded. Soil physical and chemical properties in this stand are also favourable for a natural regeneration process.

In the Golija forest area, in the stands 8a and 8b, acid brown soil alone was recorded in all trial plots. In most part of the studied stand, the soil is well water-permeable and aerated. A high acidity of stand is characterised by an increased presence of the following acidophilus species: *Oxalis acetosella, Veronica officinalis, Vaccinium murtillus, Luzula nemorosa, Pteridium aquilinum* and moss of genus *Hepaticae*. These stands are generally of poor quality, which results in a less successful natural regeneration. An additional limiting factor is presence of blueberry in form of large facies, which physically hamper natural regeneration.

In the Podrinje-Kolubara forest area, in the stand 122a, acid brown soil - typical was recorded. In the stand 27a, acid brown soil dominates. In addition to this type of soil, pseudogley frequently occurs, and, less frequently, luvisol. In both studied stands, in pedological terms, conditions for natural regeneration are favourable.

4.2 The impact of stand characteristics on occurrence and quality of *young growth*

Natural regeneration of even-aged beech stands is most commonly performed by means of shelterwood felling. A standard shelterwood felling on large areas has been applied in case when stand conditions are homogenous. The analysis of *young growth* occurrence and quality is contingent upon a structural and silvicultural form of stand. Generally, *young growth* is not analysed in young even-aged stands, owing to the fact that, even when it exists, it most commonly represents a result of unskilled forest management. In these stands, regeneration is not a priority silvicultural goal.

This study is concerned with uneven-aged beech stands. Stand conditions are largely heterogeneous, owing to which combined methods, employed on smaller areas and graded according to time, space and intensity, represent more suitable means of regeneration. Under the above-mentioned stand conditions, such methods are proposed by Dobrev, D. et. al. (1974), Dakov, M., Vlasev, V. (1979), Krstić, M. (1982), Stojanović, Lj., Krstić, M. (2000. 2003). Group-shelterwood felling in different variants, along with a free technique of silviculture (Mlinšek, D. 1968), were most frequently proposed as combined regeneration methods.

4.2.1 The analysis of taxation elements

According to structure, nearly all stands are group uneven-aged. The exceptions are stands 42a and 8a, which are, as a result of a solely low thinning, currently even-aged in terms of structure. In all stands natural regeneration occurs spontaneously. *Young growth* predominantly occurs in small groups, in areas where conditions for its occurrence were fulfilled as a result of applied silvicultural measures. In areas where canopy closure is more open, that is, creates a gap, weed infestation and absence of *young growth* occurred. The summary of basic taxation elements for studied stands is presented in Table 1.

Table 1. *Basic taxation elements of studied beech stands*

Management Unit	Stand	Quality	Dg	H_L	Type of tree	N (pcs)	G (m^2/ha)	V (m^3/ha)	Iv (m^3/ha)
Majdan-Kučajna	33a	II	39,4	31,0	beech	258.3	32.01	504.54	8.14
					other	15.7	1.41	17.95	0.46
					total	273.9	33.42	522.49	8.60
Crni vrh	42a	III	35,4	24,5	beech	321.1	31.68	379.61	6.61
Crni vrh	42б	III/IV	36,1	21,7	beech	304.0	31.39	332.41	4.93
					other	4.0	0.14	0.81	0.03
					total	308.0	31.53	333.22	4.96
Kačer-Zeleničje	31a	II	30,2	28,0	beech	294.4	21.41	289.86	6.28
					other	6.9	0.12	0.98	0.08
					total	301.3	21.53	290.84	6.36
Kukavica I	46a	II/III	31.5	27,5	beech	281.4	22.89	314.04	9.94
					other	17.1	0.32	1.96	0.13
					total	298.6	23.21	316.00	10.07
Lomnička reka	116a	II/III	30,0	26,7	beech	248.5	20.34	273.02	7.16
					other	65.5	1.86	16.83	0.87
					total	313.9	22.20	289.85	8.03
Željin	44a	I/II	36,7	32,1	beech	292.2	31.01	501.81	9.22
					other	1.7	0.03	0.22	0.01
					total	293.9	31.04	502.03	9.23
Javor-Koravčina	8a	II/III	33,3	25,9	beech	352.5	30.78	385.15	8.92
Javor-Koravčina	8б	II/III	27,9	24,6	beech	482.0	29.45	360.90	6.70
Istočna Boranja	122a	I/II	41,6	33,7	beech	213.8	29.03	503.58	10.49
Zapadna Boranja	27a	II	33,7	30,2	beech	259.0	23.10	353.76	8.03

Number of trees per hectare is uniform in all stands. As a result of recently performed felling, there is a slightly lower number of trees in Istočna and Zapadna Boranja, while there is a slightly higher number of trees in the stand 8b on account of non-performed shelterwood felling. In addition to the above-mentioned stand characteristics, number of trees is contingent upon a stand quality and, in consequence, the best quality stands have the lowest number of trees.

Basal area and volume, as direct indicators of productivity, are also contingent upon the stand quality. The highest values of these taxation elements are attained in the best quality stands, while they decrease as the quality deteriorates. However, the average volume values in studied stands are higher than the average and optimum values for Serbia, amounting to 207.2 m^3/ha (Tomanić, L. 1993) and 250.0 m^3/ha (Milin, Ž. et al 1994) respectively in high beech forests in Serbia.

Furthermore, a current volume increment, as an indicator of stand productivity, is directly contingent upon the stand quality. The stand of best quality (122a) has a current volume increment of over 10 m^3/ha, whereas a stand of worst quality (42b) has a current volume increment of 4.96 m^3/ha. The average value of current volume increment in high beech forests in Serbia amounts to 4.6 m^3/ha

(Tomanić, L. 1993), whereas the optimum volume increment amounts to 6.0 m³/ha (Milin, Ž. et.al. 1994).

4.2.2 The impact of canopy closure on natural regeneration

In the studied beech stands, regeneration largely occurred spontaneously, in form of groups in areas where canopy closure was more open. For initiation of the process of natural regeneration in beech stands, canopy closure should be reduced to 0.6 – 0.7 (Stojanović, Lj., Krstić M. 2000). As can be seen in Table 2, there are very few such areas, which indicates that a planned regeneration has not been initiated. In all studied stands, there are most trial plots with the largest canopy closure, and the fewest trial plots with the smallest canopy closure. The exceptions are stands 31a and 8a, where the average canopy closure is optimum, although a high representation of areas with the canopy closure over 0.7 has also been recorded in these stands. In areas where canopy closure is more open, the presence of *Rubus sp., Vaccinium myrtillus* and *Pteridium aquilinum,* which hamper natural regeneration of beech, is increased.

By bringing canopy closure to the optimum level (0.6-0.7), a more rapid transformation of organic matter and improvement of general soil characteristics take place, while reducing the canopy closure below this threshold can lead to increased presence of species *Vaccinium myrtillus* and *Pteridium aquilinum*, which hamper natural regeneration.

In the areas in which canopy closure is 0.6-0.7, *young growth* occurred in most cases and its tending will depend on stand characteristics. In the stands 33a, 44a and 8b, there were no exemplary areas with canopy closure optimum for regeneration, while the average canopy closure in these stands is over 0.9. A large canopy closure and lack of canopy closure areas optimum for regeneration in stands 33a and 8b can account for a large decrease in number of plants, from *seedling* and early *young growth* phases to a late *young growth* phase. More specifically, a large number of plants die out within a short period in a negative selection phase, due to a lack of light. In the stand 33a, favourable pedological conditions, primarily in terms of receiving and retaining accessible water, cannot enable survival of plants in long-term, due to a closed canopy closure and lack of lights.

Table 2. *Distribution of beech stand areas according to a canopy closure degree*

Management Unit	Stand	Land coverage degree (%)									
		1-20	21-30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	Average
Majdan-Kučajna	33a	-	-	4.35	-	-	-	8.70	21.73	65.22	90.43
Crni vrh	42a	-	-	-	-	5.55	11.11	11.11	22.23	50.0	86.78
Crni vrh	42б	-	-	-	-	10.0	10.0	20.0	10.0	50.0	83.9
Kačer-Zeleničje	31a	3.12	-	3.12	21.88	3.12	12.50	15.63	25.00	15.63	69.38
Kukavica I	46a		3.57	-	3.57	-	3.57	10.71	10.71	87.86	87.14
Lomnička reka	116a	-	-	-	6.06	-	9.09	18.18	36.36	30.30	83.1
Željin	44a	-	-	-	-	-	-	8.70	17.39	73.91	93.7
Javor-Koravčina	8a	-	6.25	-	6.25	6.25	12.50	25.0	37.5	6.25	74.38

Javor-Koravčina	8б	-	-	-	-	-	-	10.0	40.0	40.0	91.2
Istočna Boranja	122a	-	-	-	-	6.90	10.34	6.90	31.03	44.83	85.55
Zapadna Boranja	27a	-	-	-	-	-	15.0	10.0	30.0	45.0	85.35

In the stand 44a, canopy closure is large, while regeneration and weed infestation are low. A favourable capacity for receiving and retaining accessible water in this stand enabled germination of *seedling* and its preservation until the early *young growth* phase; however, lack of light was a limiting factor causing a drastic drop in its number in the late *young growth* phase. Although the average canopy closure in the stand 8a is optimum, the total canopy closure area below 0.6 accounts for 20% of the stand, which increased a share of areas strongly infested by weed, which could not be regenerated. A large number of plants in the *seedling* and early *young growth* phase were recorded. In such cases, the increased weed infestation affected the reduction of *seedling*. More specifically, a previously uneven-aged stand was transformed, by means of a radically low thinning, into a structurally even-aged stand, which led to a higher opening of land and its weed-infestation.

The stand 31a has an average canopy closure optimum for regeneration, but approximately 30% of the area has canopy closure below 60%, which led to occurrence of more than 20% of area with an increased weed-infestation and low number of *seedling*. Unfavourable pedological conditions probably also had an impact on number of *seedling* in this stand.

All other stands have had a large share of areas with canopy closure over 0.7 for a long period, which resulted in a low number of *seedling* during all *seedling* development phases. In the stands of poorer production capacity and quality, in certain groups it was necessary to perform shelterwood felling, that is, tending of spontaneously occurred *young growth*. In some groups with a sufficient number of trees of good productivity and quality, tending of quality trees ought to be continued, regardless of occurrence of *young growth*. In groups where canopy closure is interrupted, it is necessary to start natural regeneration by means of group-shelterwood felling. In stands in which *young growth* reached the 0.5-0.6m height, and canopy closure is interrupted, *young growth* ought to be released from a large shade and canopy closure reduced to 0.2-0.4 by a subsequent felling (Stojanović, Lj., Krstić, M. 2000).

A large presence of areas with terraced canopy closure indicates uneven-aged stands. The exceptions are two structurally even-aged stands (8a and 42a), in which areas with horizontal canopy closure prevail.

4.2.3 Weed infestation impact

Weed infestation of stands is directly related to their canopy closure. It has been already observed that natural regeneration of stands cannot take place unless the canopy cover is reduced to 0.6-0.7. Further reduction of a canopy closure degree usually leads to soil weed infestation. Depending on forest site conditions, weed infestation can occur if natural regeneration was not successful, due to a lack of seed yield or other reasons. With deterioration of a site quality, stand productivity and quality, weed infestations increases, which hampers natural regeneration. In most stands, weed infestation is moderate (Table 3), while its increase is influenced by a felling performed in the previous period (8a).

Table 3. *Distribution of beech stand areas according to a weed infestation degree*

Management Unit	Stand	A weed infestation degree (%)					
		1-20	21-40	41–60	61–80	81–1000	Favourable
Majdan-Kučajna	33a	17.39	8.70	8.70	8.70	8.70	47.83
Crni vrh	42a	-	27.78	22.22	16.67	33.33	-
Crni vrh	42б	-	-	10.00	10.00	80.00	-
Kačer-Zeleničje	31a	12.50	21.88	21.88	12.50	6.25	25.00
Kukavica I	46a	75.00	10.71	-	7.14	7.14	-
Lomnička reka	116a	30.30	15.15	15.15	15.15	21.21	3.03
Željin	44a	56.52	17.39	13.04	8.70	4.35	-
Javor-Koravčina	8a	12.50	12.50	6.25	25.00	31.25	12.50
Javor-Koravčina	8б	40.00	40.00	-	-	20.00	-
Istočna Boranja	122a	17.24	20.69	10.34	27.59	24.14	-
Zapadna Boranja	27a	65.00	15.00	-	-	-	20,00

The stand most affected by weed infestation is 4b. If a set silviculture goal is regeneration, that is, rejuvenation, in some cases auxiliary measures ought to be taken for removal of weed.

Among woody species hampering regeneration, the most represented is *Sambucus nigra*. Other woody species such as *Fraxinus ornus*, *Corylus avellana*, *Cornus mas*, *Sambucus racemosa*, *Lonicera sp*. and *Rosa sp.* are far less represented. The most important among semi-shrubs is *Vaccinium myrtillus*, which crates whole facies on strongly acid soils, which completely prevent natural regeneration of beech. Among herbaceous species, the most important are species of genus Rubus. *Pteridium aquilinum,* which can threaten natural regeneration on acid soils, occurs slightly less frequently. Other species from the shrub storey and ground flora do not have a significant impact on natural regeneration of studied beech stands.

4.2.4 Young growth number and manner of occurrence

According to studies by Dobrev, D. et al (1974), for a stand natural regeneration to be successful, a number of *young growth* plants in the earliest phase should amount to 10-15 pieces per m^2, that is, 100-150 thousand per hectare. This refers to *young growth* of the 11-50 cm height. When *young growth* is over 50 cm high, a final or subsequent felling is performed. As can be seen in Table 4, in studied stands there are no sufficient numbers of *young growth* of any category. In some stands (32a, 42a, 8a and 8b), a slightly higher number of plants in the early *young growth* phase (11-50 cm) was recorded. However, a significant reduction of late *young growth* (51-130cm) and early *young forest* plants (of a 0-5 cm breast height diameter) was recorded in all stands. The analysis of canopy closure impact on a *young growth* number indicates that canopy closure in these stands is far larger than the optimum for a successful regeneration process. It is clear that canopy closure performed the key role in a die out of large number of plants in negative selection, from the early *young growth* phase to the late *young growth* and early *young forest* phase. Furthermore, a regression analysis confirmed that a number of *young growth* in the early *young forest* phase is most affected by canopy closure of parent stand. Soils in these stands are of good water-air properties, which particularly refers to stand 33a, which has the largest number of plants in the early *young growth* phase (11-50 cm).

In other stands (42б, 31a, 46a, 116a, 44a, 122a and 27a), number of *young growth* in all development phases is far below the minimum necessary for the process of regular natural regeneration. However, since the *young growth* in stands is most frequently distributed in groups, in some groups there is a sufficient number of *young growth* for stand regeneration by shelterwood felling. In stands 33a and 8b, due to uneven-aged character of trees in the entire area, *young growth* most frequently occurs individually. The priority silvicultural goal in such cases is removal of predominant and overage trees. Following the removal of these trees, it is probable that a new *young growth* core will be created with a group occurrence of *young growth*.

Table 4. *Number of young growth in beech stands according to given categories*

Management Unit	Stand	Tree type	Number of *young growth* plants (per hectare)			
			Height 11–50 cm	Height 51–130 cm	Diameter 0–5 cm	Total
Majdan-Kučajna	33a	Beech	28.524	831	62	29.417
		Other	1.107	-	-	1.107
		Total	29.631	831	62	30.524
Crni vrh	42a	Beech	18.754	14.685	4.797	38.236
		Other	-	10	31	41
		Total	18.754	14.695	4.828	38.277
Crni vrh	42б	Beech	2.866	2.548	-	5.414
Kačer-Zeleničje	31a	Beech	6.170	896	4.777	11.843
Kukavica I	46a	Beech	682	341	758	1.781
		Other	683	341	202	1.226
		Total	1.365	682	960	3.007
Lomnička reka	116a	Beech	2.316	483	2.574	5.373
		Other	1.448	-	472	1.920
		Total	3.764	483	3.046	7.293
Željin	44a	Beech	4.154	415	738	5.307
Javor-Koravčina	8a	Beech	26.473	398	885	27.756
Javor-Koravčina	8б	Beech	9.236	-	425	9.661
Istočna Boranja	122a	Beech	3.075	110	1.367	4.552
Zapadna Boranja	27a	Beech	2.548	2.229	1.274	6.051

It should be noted that the data on numbers of *young growth* given in Table 4 represent the average value for the entire stand area. However, stand conditions are heterogeneous and suitable for group-shelterwood regeneration methods, therefore, the number of *young growth* is more important in certain groups in which regeneration is set as a silvicultural goal. The occurrence of *seedling* and development of *young growth* also depends on site conditions. Among others, climatic factors, which are largely determined by the altitude, are of significant importance. With the increase of altitude, a climate humidity increases, duration of vegetation period decreases, winters are colder and longer, which affects seed germination and *seedling* development. Additionally, less favourable climatic conditions affect the frequency of fruit bearing, quantity of seed and its germination ability. For that reason, in addition to stand condition, high altitude can be one of the reasons that number of *young growth* per hectare is among the lowest in stand 42b. General macro-climatic conditions can be modified by a form, size and direction of initial regeneration core felling, by which more favourable micro-climatic conditions for occurrence and survival of *young growth* are created (Krstić, M., Stojanović, Lj. 2003).

4.2.5 Young growth quality

Young growth was evaluated based on a level of plant suppression and damage. The best quality *young growth* was recorded in stands 33a, 31a, 42a. The next in terms of quality are the stands 27a, 122a, 46a and 42b, while the *young growth* of poorest quality is found in stands 44a, 116a, 8a, 8b. It has been observed that suppression of *young growth* is most frequently represented in stands with overlarge canopy closure, as well as in stands that had such a canopy closure prior to last felling. Physical and chemical properties of soil did not have a significant impact on quality of *young growth*. Similarly to *young growth* suppression, the largest representation of trial plots with damaged *young growth* is in stands 116a, 8b, 8a, 44a and 27a.

All other stands have a relatively low percentage of damaged *youth growth*. The damage to *youth growth* is largely caused by felling and extracting of trees, and, to a less extent, by wild game, livestock and antibiotic factors.

4.2.6 Presence of seedling

Seedling is most represented in stands 33a, 8b and 8a. Owing to a large area crown spreading, the highest number of *seedling* occurs in stands with the largest canopy closure. However, when the opening of canopy closure and its reducing to the optimum size did not take place, this *young growth* most frequently deteriorates, which can be seen from the analysis of *young growth* numbers. *Young growth* in these stands remains until the end of early *young growth* development phase, after which a die out of plants occurs, due to lack of light. Physical and chemical properties of soil did not have a significant impact on occurrence of *young growth*.

5. CONCLUSION

By studying natural regeneration of high beech stands in Central Serbia, the following conclusions can be drawn:

- All studied stands are heterogeneous and uneven-aged, for which reason in most cases it is necessary to perform regeneration by means of group-shelterwood felling.
- Natural regeneration of stands depends mostly on site and stand factors. A site produces an impact as a complex of correlated factors, while micro-climatic conditions are changed following the performance of various shelterwood

felling measures. Among stand conditions, canopy closure, which regulates the amount of light influx, has the strongest impact on occurrence and preservation of *young growth*. In stands with the largest canopy closure, owing to a large area crown spreading, a relatively high quantity of seed and, consequently, a high quantity of *seedling* is obtained, which survives until the end of early *young growth* phase, after which it abruptly dies out through negative selection, as a result of lack of light.

- A regeneration level of all studied stands is low in the entire area, but in certain groups, as a result of heterogeneous structure, it is sufficient for performance of group-shelterwood felling, if, based on site and stand conditions, regeneration is set as a silvicultural goal in these groups.
- In certain parts of stands in which canopy closure is more open, a strong weed infestation occurred. In order to transform these areas into *young growth* cores, it is also necessary to apply auxiliary measures to aid natural regeneration, primarily removal of weed and, in extreme climatic conditions, to introduce 1-2 subsequent felling.
- The previous method of high beech forest management in Serbia led to their strong heterogeneousness and uneven-aged character. A system of selection and, after that, group management, has been applied for a long period. Since 1990's, a system of moderate stand management has been introduced, which has not produced significant results. In practice, quality trees were frequently cut off, which led to a decrease of capacity of stands for production and regular natural regeneration. The process of their natural regeneration does not take place in a planned manner and continuity. A number of plants per hectare of all categories of *young growth* is insufficient, while its quality is unsatisfactory. That is in collision with the principles of sustainable forest management. Therefore, this aspect of the analysis of condition of high beech forests also points out to a need for re-examination of current systems of beech forest management in Serbia.

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BEECH AND FIR FOREST RESOURCES IN THE PEŠTER PLAIN AREA

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Abstract: *According to EUNIS classification, the analysed stands belong to a mixed beech-fir forest type (G4.61). The soils are eutric cambisol, eutric rankers, distric cambisol and luvisol. 65 plants were identified, out of which 6 tree species, 9 shrub species and 50 ground flora species. The ecological indices have the following averages values: humidity from 2.90 to 3.00, soil chemical reaction from 2.71 to 3.15, nutrient matter from 2.55 to 2.83, light from 2.28 to 2.60 and temperature from 2.56 to 3.07. Out of the total number of recorded plants, 29, that is, 46.0% are medicinal, namely; 4 species come under healing class one, 2 come under healing class two, 11 come under healing class three, 6 come under healing class four and 6 come under healing class five. The following fruit tree species were identified: Vaccinium myrtillis, Crataegus monogyna, Fragaria vesca, Sorbus aucuparia, Lonicera nigra, Rubus hirtus, Sorbus austriacus. 24 melliferous plants were recorded in beech and fir forests, out of which 6 woody, 6 shrub and 10 herbaceous plants. The highest number of melliferous plants blossom in May. The beech and fir forest was recorded on 464.09 hectares. The total volume is 161,015 m^3. The trees with a diameter lower than 30 cm account for 51.5%.*

Key terms: beech and fir forests, G4.61, sustainable use, natural resources

RESURSI ŠUME BUKVE I JELE NA PODRUČJU PEŠTERSKE VISORAVNI

Извод: *Po EUNIS klasifikaciji analizirane sastojine pripadaju mešovitim bukovo-jelovim šumama (G4.61). Zemljišta su eutrični kambisoli, eutrični rankeri, distrični*

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kambisoli i luvisoli. Konstatovano je 65 biljaka, od čega 6 vrsta drveća, 9 vrsta žbunova i 50 vrsta prizemne flore. Ekološki indesi za vlažnost imaju prosečnu vrednost od 2.90 do 3.00, za hemijsku reakciju zemljišta od 2.71 do 3.15, za hranljive materije od 2.55 do 2.83, za svetlost od 2.28 do 2.60 i za temperaturu od 2.56 do 3.07. Od ukupno registrovanih biljaka 29 je lekovito, odnosno 46.0% i to: 4 pripadaju prvoj, 2 drugoj, 11 trećoj, 6 četvrtoj i 6 vrsta petoj kategoriji lekovitosti. Konstatovane su sledeće vrste voćkarica: Vaccinium myrtillis, Crataegus monogyna, Fragaria vesca, Sorbus aucuparia, Lonicera nigra, Rubus hirtus, Sorbus austriacus. U šumama bukve i jele konstatovano je 24 medonosnih vrsta, od čega 8 drvenastih, 6 žbunastih i 10 zeljastih. Broj medonosnih biljaka u cvetu je najveći tokom maja. Šuma bukve i jele konstatovana je na 464.09 hektara. Ukupna zapremina je 161015 m^3. Stabla sa tanjim prečnikom od 30 cm učestvuju sa 51.5%.

Ključne reči: šume bukve i jele, G4.61, održivo korišćenje, prirodni resursi

1. INTRODUCTION

Disappearance of forests by 10 million hectares per year points out to the gravity of the problem and necessitates urgent measures aimed at preventing degradation and devastation of existing forest ecosystems. In the concept of ecocentric (or biocentric) use of resources, the ecosystem represents a complexity of living organisms and has its value per se, as it considers human needs and relation to nature in a different way. A manner in which nature creates and maintains ecosystems is respected. The ecocentric concept protects, maintains and restores functioning of natural resources, at the same time exploiting, on lasting and permanent basis, all goods and services necessary for fulfilment of human needs. The preference is given to ecological processes in ecosystems, providing for the economic needs of the society, but not in a manner of industrial use. An integral part is consideration for soil, water, bio-diversity and biomass. Attainment of these goals is based on ecological, socio-demographic and economic criteria. The paper is based on the Concept of sustainable use and it is focused on smaller territorial units (areas)

2. MATERIAL AND METHOD

Habitat classification is based on EUNIS system of habitat classification. Habitat classification constitutes an integral part of EUNIS (European Nature Information System) system. This classification is created with a view to providing a universal, integral classification for European habitats (Lakušćić, D. et all., 2005; Ratknić, M., 2008). Species diversity of beech stands (floristic composition) was determined based on phytocenological records. The floristic composition was used for the analysis of life forms, spectra of floristic elements, preparation of ecological indices of communities, representation of medicinal herbs, fruit trees and melliferous species. Life forms, as indicators of stand conditions, were determined based on the representation of *Phanerophyta, Chamephyta*, *Hemycryptophyta, Cryptophyta* and *Therophyta.* Classification on basic types of life forms was conducted according to Raunkiaer (Diklić, N. 1984), based on characteristics for each species, given in *Flora of Serbia* I-X. Spectra of floristic elements were processed in conformity with the systematisation of plant-geographical elements by Gajić (Gajić, M. 1984), while the characteristics of each species were given in *Flora of Serbia* I -X. Ecological indices of communities were determined based on a biological spectrum of plants (Kojić, N. et al, 1997). Ecological indices for soil humidity, acidity, amount of nitrogen in soil (richness of mineral matter), according to light and temperature, were analysed. Medicinal plants were defined based on the data from the Strategy of medicinal plant protection in Serbia (Amidžić et al, 1999). Fruit tree types were defined based on the data from the book 'Wild fruit species of Serbia' (Mratinić, E, et Kojić, M., 1998). Melliferous species in beech stands were determined by drawing up a flora inventory. A number of melliferous species, the melliferousness degree and the average melliferousness of community were determined. Beech forest wood resources were determined based on the Specific forest-economic basis of the area.

3, RESEARCH RESULTS

According to EUNIS classification, analysed Pešter Plain forests belong to a mixed beech-fir forest type (G4.61). Beech-fir forests in the Pešter Plain occur only at three locations: at Gutavica- above the village of Ugla in Fakuf Zabran, in the Bare area and at Ogorijevac. Their low representation is a result of the sensitivity to browse and stamping. Fir is less preserved than spruce, and in small groups. It has not been preserved at positions exposed to wind, either. It survived only in inaccessible canyons and river cliffs in the Bare area. This forest does not exist as a complex, but it occurs alternately with other communities, in form of a mosaic. In degraded stands, a mass occurrence of aspen, and in some places aspen and birch tree, took place. The beech fir community at the Ogorijevac, Markovića Potok and Jasikovac locality is situated at the altitude between 1,100 and 1,350m. It occupies northern exposures at lower altitudes, while in western, south-western and north-western exposures, it is located at higher altitudes. In the area of Dubočica, the stands are located at inclinations of 20 to 45^0 (in the Markovića Potok canyon). The soil in beech and fir forest at Ogorijevac is luvisol. At Jasikovac, distric cambisol is represented. The soil is acid, with pH value in water from 3.8 to 4.8, while in KCl it is from 3.0 to 4.0.

65 plant species were identified in the community. There are 6 species in the tree storey, 9 shrub species in the second storey and only 50 species in the ground flora layer.

Community floristic composition in beech and fir forests: *Abies alba* Mill., *Lapsanacommunis* L., *Acer pseudoplatanus* L., *Loniceranigra* L., *Aegopodium podagraria* L., *Luzula luzuloides* (Lam.) Dan., *Ajuga reptans* L., *Luzula pilosa* (L.), Willd., *Anemone nemorosa* L., *Melampyrum pratense* L., *Anemone ranunculoides* L., *Moehringia trinervia* (L.) Clairv., *Angelica sylvestris* L., *Mycelis muralis* (L.) Rchb., *Aremonia agrimonoides* (L.) DC., *Orchis pallens* L., *Asperula odorata* L., *Oxalis acetosella* L., *Athyrium filix-foemina* (L.) Roth., *Paris quadrifolia* L., *Betula pendula* Roth., *Pinus silvestris* L., *Brachypodium silvaticum* (Huds.) P.B., *Platanthera bifolia* (L.) Rchb., *Calamagrostis arundinacea* (L.) Roth., *Polygonatum verticillatum* (L.) All., *Campanula persicifolia* L., *Polypodium vulgare* L., *Carex hirta* L., *Polystichum aculeatum* (L.)

Roth., *Carex silvatica* Huds., *Populus tremula* L., *Cephalanthera rubra* (L.) Schr., *Potentila erecta* (L.) Raucsh., *Corylus avelanna* L., *Prenanthes purpurea* L., *Crataegus monogyna* Jacq., *Ranunculus nemorosus* DC., *Dactylorhiza maculata* (L.) Soo., *Rosa pendulina* L., *Danaa cornubiensis* (Torn.) Burn., *Rosa vosagiaca* Desp., *Daphne laureola* L., *Rubus hirtus* W.et K., *Evonymus europaeus* L., *Solidago virga-aurea* L., *Fagus silvatica* L., *Sorbus aucuparia* L., *Festuca valesiaca* Schl., *Sorbus austriacus* (Beck.) Hedl., *Fragaria vesca* L., *Stachys silvatica* L., *Galium silvaticum* L., *Vaccinium myrtillis* L., *Gentiana asclepiadea* L., *Valeriana dentate*, *Glechoma hirsuta* W.etK., *Veratrum nigrum* L, *Hypericum maculatum* Cr., *Veronica officinalis* L., *Hypericum montanum* L., *Viola alba* Bess., *Knautia drymeia* Hauff.

In the spectrum of life forms, lower presence of hemicryptophytes (44.44%) can be observed in comparison to other communities in the area, which is a result of more favourable climatic conditions in the river Dubočica valley, where beech and fir community is mostly represented (Table 1). A high share of geophytes (22.22%) points out to more favourable soil conditions (depth, humidity and structure), but also to a favourable relative air humidity, which is a result of rivers and streams flowing through stands. Phanerophytes and nano-phanerophytes account for 25.39%. Chamaephytes account for 3.18% (1.59% of woody and herbaceous, respectively), therophytes account for 1.59%, while therophytes/chamaephytes account for 3.17%.

Table 1. *Life forms spectrum in beech and fir forests*

life forms (%)							
Phanerophytes	Nano-phanerophytes	Woody chamaephytes	Herbaceous chamaephytes	Hemicryptophytes	Geophytes	Therophytes	Therophytes/ chamaephytes
p	np	wc	hc	h	g	t	tc
15.87	9.52	1.59	1.59	44.44	22.22	1.59	3.17
25.39		3.18					

In the floristic elements spectrum, the Central-European floristic elements constitute the largest group in the community (38.10%). Euro-Asian floristic elements account for 26.98%, circumpolar-cosmopolitan account for 11.11%, while sub-Mediterranean account for 7.94%. Arctic-Boreal floristic elements account for 9.52%, while Pontic-Central Asian constitute 4.76%. Beech and fir forest belongs to a Central-European type of community, which is manifested through a dominant role of Central-European floristic elements (Table 2).

Table 2. *Floristic elements spectrum in beech and fir forest*

Description of a floristic elements group	Floristic element	Share in %	
1. FLORISTIC ELEMENTS OF NORTHERN REGIONS			
Arctic floristic elements			
Boreal floristic elements	sub-Boreal	1.59	
	sub-Boreal-European-west Siberian	1.59	
	Sub-Boreal-Circumpolar	6.35	9.52
2. CENTRAL-EUROPEAN FLORISTIC ELEMENTS			
Central-European	Central-European	17.46	
European	sub-Central-European	19.05	
	Alpine-Carpathian	1.59	38.10
3. SUB-ATLANTIC FLORISTIC ELEMENTS			

Description of a floristic elements group	Floristic element	Share in %	
sub-Atlantic and Atlantic	sub-Atlantic/ sub-Mediterranean	1.59	1.59
4. SUB-MEDITERRANEAN FLORISTIC ELEMENTS			
sub-Mediterranean	sub-Mediterranean	4.76	
eastern-sub-Mediterranean	eastern-sub-Mediterranean	1.59	
Balkan Balkan-Apennine	sub-Illyrian	1.59	7.94
5. PONTIC-CENTRAL ASIAN FLORISTIC ELEMENTS			
Pontic	sub-Pontic	1.59	
	Pontic-eastern-sub-Mediterranean	1.59	
	sub-Pontic-sub-Mediterranean	1.59	4.76
6. EURO-ASIAN FLORISTIC ELEMENTS			
	sub-south-Siberian	6.35	
	Euro-Asian	14.29	
	sub-Euro-Asian	6.35	26.98
7. CIRCUMPOLAR AND COSMOPOLITAN FLORISTIC ELEMENTS			
	circumpolar	4.76	
	sub-circumpolar	3.17	
	cosmopolitan	3.17	11.11

The community has a large canopy closure on the first story, ranging from 0.6 to 0.9. The mean tree height is between 19 and 30m, while the mean diameter is from 30 to 35 cm. In addition to fir (*Abies alba*) and beech (*Fagusmoesiaca*), there is a significant presence of birch tree (*Betula pendula*), aspen (*Populustremula*), maple (*Acer pseudoplatanus*) and white pine (*Pinus silvestris*). In the shrub storey, *Abies alba, Fagus moesiaca* and *Corylus avellana* dominate. There is a significant presence of *Sorbus aucuparia* and *Evonymus europaeus*, while *Betula pendula, Crataegus monogyna, Daphne laureola, Lonicera nigra, Populus tremula, Rosa pendulina* and other are less represented. In the third storey, a significant presence of *Vaccinium myrtilus* can be observed, which points out to frigoriphilic conditions for development of ground vegetation. There is also a significant presence of *Anemone nemorosa, Aremonia agrimonioides, Glechoma hirsuta, Polygonatum verticillatum, Prenanthes purpurea, Athyrium filix-femina, Brachypodium silvaticum, Carex silvatica, Galium silvaticum, Gentiana asclepiadea, Platantera bifolia, Polysticum aculeatum and Solidago virga aurea.*

3.1 Beech and fir forest ecological indices

Beech and fir forest ecological indices have the following average values: humidity (V) 2.96 (2.90 to 3.00): soil chemical reaction (K) 2.97 (2.71 to 3.15); nutrient matter (N) 2.69 (2.55 to 2.65); light (S) 2.39 (2.28 to 2.60) and temperature (T) 2.84 (2.59 to 3.07).

Table 3. *Characteristics of beech and fir forest stands*

Record number	Geological substratum	Soil	Altitude (m)	Exposure	Inclination^0
1	Diabase - hornstone	Eutric cambisol	1300	W	35
2	Gabbro-amphibolite	Eutric ranker	1300	W-SW	20
3	Gabbro-amphibolite	Distric cambisol	1280	W	45
4	Quartz conglomerates and sandstone	Luvisol	1140	N	20

Table 4. *Beech and fir forest ecological indices*

Record number	Heat coordinate	Stand	V	K	N	S	T
1	6	0.9	2.97	3.15	2.76	2.41	2.96
2	7	0.6	2.90	3.07	2.65	2.60	3.07
3	6	0.8	3.00	2.71	2.55	2.28	2.59
4	5	0.9	2.97	2.95	2.83	2.25	2.73

Medicinal plants in beech and fir forests. The presence of 63 plant species was identified in beech and fir forests, out of which 29, that is, 46% are medicinal. Within the healing class one 4 species were identified, within the healing class two 2 species, within the healing class three 11 species, within the healing class four 6 species and within the healing class five 6 species. The following species come under the healing class one: *Vaccinium myrtillis* L., *Platanthera bifolia* (L.) Rchb., *Betula pendula* Roth. and *Crataegus monogyna* Jacq.; under the healing class two: *Solidago virga-aurea* L. and *Veronica officinalis* L.; under the healing class three: *Potentila erecta* (L.) Raucsh., *Veratrum nigrum* L., *Glechoma hirsuta* W.etK., *Gentiana asclepiadea* L., *Abies alba* Mill., *Fagus silvatica* L., *Polypodium vulgare* L., *Asperula odorata* L., *Populus tremula* L., *Evonymus europaeus* L. and *Ajuga reptans* L. The species that came under the healing class four are the following: *Oxalis acetosella* L., *Angelica sylvestris* L., *Fragaria vesca* L., *Acer pseudoplatanus* L., *Corylus avelanna* L. and *Sorbus aucuparia* L., while the species under the healing class five are: *Anemone nemorosa* L., *Aegopodium podagraria* L., *Daphne laureola* L., *Paris quadrifolia* L., *Pinus silvestris* L. and *Lapsana communis* L.

Fruit trees in beech and fir forests. The following fruit tree species were identified: V*accinium myrtillis, Crataegus monogyna, Fragaria vesca, Sorbus aucuparia, Lonicera nigra, Rubus hirtus, Sorbus austriacus*.

Melliferous species in beech and fir forests. Based on the conducted analysis, 24 melliferous species were identified in the beech and fir forest, out of which 8 woody, 6 shrub and 10 herbaceous. The mean melliferousness of the community amounts to 2.66. The following woody species are represented: *Populus tremula* L., *Sorbus aucuparia* L., *Sorbus austriacus* (Beck.) Hedl., *Betula pendula* Roth., *Abies alba* Mill., *Fagus silvatica* L., *Acer pseudoplatanus* L. i *Pinus silvestris* L. The following woody species are identified: *Corylus avelanna* L., *Rosa pendulina* L., *Crataegus monogyna* Jacq., *Evonymus europaeus* L., *Vaccinium myrtillis* L. i *Daphne laureola* L.; the following herbaceous species are identified: *Anemone nemorosa* L., *Campanula persicifolia* L., *Stachys silvatica* L., *Solidago virga-aurea* L., *Gentiana asclepiadea* L., *Ajuga reptans* L., *Fragaria vesca* L., *Angelica sylvestris* L., *Aegopodium podagraria* L. and *Anemone ranunculoides* L.

The highest number of melliferous plants blossom in May.

3.2 Beech and fir forest wood resources

The beech and fir forest was recorded on 464.09 hectares (Table 5). The total volume is 161,015 m^3. Trees with diameters lower than 30cm account for 51.5%.

Table 5. *Beech and fir forest wood resources*

Surface area (ha)	Total volume (m^3)	Volume according to diameter classes								Volume increment (m^3)
		< 10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	
464.09	161015	245	35049	47595	43054	24054	7625	2639	344	3947

3.3 Ecological characteristics of pyramidal fir at Ogorijevac

Common fir (*Abies alba* Mill.) shows less variety in comparison to other conifers. According to habitus, three groups of variety can be distinguished: (1) pyramidal, pillar-shaped, conical (2) hanging or weeping (3) dwarfish. Until present, the pyramidal variety has been found only in three areas in Europe, in form of individual trees. A finding site of pyramidal fir is at the Ogorijevac locality, near the village of Kladnica in the vicinity of Sjenica. The key characteristic is a pyramidal habitus, created in a morphogenesis process during the course of development and growth. The pyramidal habitus, which occurs within many species of different systematic tree groups, is created in different ways. In pyramidal fir, that habitus property originates from twig characteristics. A comparative analysis of common and pyramidal fir twig and needle characteristics points out to common and differential properties. On these grounds, the basis for further studies of genetic, ontogenetic and physiological-ecological processes, which lead to occurrence of different habitus, can be established.

A variety of pyramidal fir forms a mixed uneven-aged stand jointly with a common fir and beech. Unlike other finding sites in Europe, in which individual trees have been recorded, a total of 7 older specimen of this variety, of various age, have been identified in this locality. Among numerous specimen of young growth, there are those which will form a pyramidal habitus. Pyramidal firs crossbreed with common fir. The majority of pyramidal and common fir offspring possess characteristics of common fir. In one part of the offspring, a sharper angle of branches in relation to stem growth, can be observed.

Pyramidal fir is a tree of first class and attains the same heights as common fir. It is difficult to visually determine its age, due to numerous branches, positioned under a very sharp angle in relation to a stem spindle, particularly near the top, where branches almost cling to a stem. The habitus is narrow-pyramidal or conical, with a very sharp top, similar to that of cypress. Branches are very thick and, since the earliest youth, positioned under a very sharp angle in relation to stem spindle (about $20\text{-}30^o$). Apart from whorls, they also occur in internodes. In pyramidal fir, a disposal of lower branches also occurs in a dense forest canopy, although dry branches remain on the stem for a long time.

The pyramidal fir's top is without a distinct terminal shoot. In adult trees, it is elongated and cylinder-shaped, with numerous lateral twigs stretched upwards and nearly clinging to the central shoot. In youth, the top is particularly sharp, due to a higher height increment.

Pyramidal fir has a very distinct vertical tendency. Its habitus bears similarities to cypress and juniper, but also have common characteristics with closer relatives, fir and spruce.

Table 6. *Morphological characteristics of common and pyramidal fir*

Common fir	Pyramidal fir
Habitus broad conical	Habitus narrow pyramidal
Oval top	Sharp top
Branching always horizontal	Branching always upward, with a vertical tendency
Needles horizontally spread in two rows	Needles pointed radially and upward, along the whole twig
Needle at cross-section flattened with a receding central nerve	Needle at cross-section elliptical with a convex central nerve
Seed wings are wide and fan-shaped	Seed wings are narrow and elongated

4. DISCUSSION

The adverse impact of climate changes on forest eco-systems will be particularly apparent through occurrence of extreme atmospheric phenomena, such as drought, storms, extremely high temperatures, intense erosion processes and occurrence of plant diseases and pests. Serbia is territorially situated in a region with the highest frequency of drought occurrence. An increase of vegetation period is expected. The increase of mean air temperature will cause a shift of climatic and, consequently, vegetation zones toward poles and in terms of altitude. A climate change of 1^0C will cause a vegetation shift toward north for 200-300 km, along with a shift toward higher altitudes of 150-200 m. Global warming will cause vegetation shift toward poles and higher altitudes, along with a change of vegetation structure. A tree (forest) dieback will increase due to inadequate ecological conditions of habitats and an increase of entomological and phytopathological diseases. Climate change will cause changes in the growth rate of certain species, hamper natural regeneration, owing to change of habitat humidity. An increased occurrence of forest fires and atmospheric disasters is also expected.

Climate changes will cause changes in natural eco-systems, not only in terms of their dislocation, but in terms of their structure. A biological potential for adaptation will be reduced and diversity limited. The most endangered are the communities and species with limited adaptation potentials. The most serious problem in adaptation of forest and shrub communities to climate changes is the rate of the change. Changes in natural eco-systems can threaten preservation of rural values. It is considered that application of adequate measures in forest eco-system management can reduce ecological and social-economic effects of deterioration of forests.

The expected effects of climate changes with respect to forest eco-systems, forest communities and tree, shrub and ground flora species, are the following;

- shifting of boundaries of certain forest types with respect to geographic latitude and altitude;
- different natural redistribution of forest type areas with respect to geographic latitude and altitude;
- probably, considered in long term, 'losing the battle' on part of certain communities and their 'giving up' the race and being driven out (extinction);
- different composition of certain plant communities, followed by disappearance of one and occurrence of other species in relation to their

storey and social position;

- change of relation of certain tree species toward light;
- forest communities will be more exposed to various adverse impacts, which are direct or indirect result of climate changes; It should be noted that relict, rare and endangered forest communities and their basic, distinctive tree types, bear a higher degree of risk from the expected negative effects.
- The above mentioned effects, considered cumulatively, will be directly reflected in the potential for preservation of biological diversity and possibility for rational management of these resources.

The above-mentioned effects directly influence the possibility and intensity of planning of sustainable forest management.

5. CONCLUSION

Given that a centuries-long destruction of plant resources in the area of Pešter Plain has endangered their condition, that also directly concerns a socio-demographic status of population. The aim of these studies is to define the condition of natural resources, determine priority activities aimed at prevention of adverse impact and to determine measures for improvement of condition. By attaining the aims of the study of sustainable use of Pešter Plain plant resources, the basis are created for: implementation of European standards and models and preparation of methodology for recording of renewable plant resources; creation of strategic framework for sustainable management of renewable resources, based on principles of sustainable development and previous level of exploration of existing natural resources; maintenance and increase of ecological, biological, climatic, social-cultural and economic benefits derived from the use of plant resources; protection of environmental, social and spiritual function and values of natural eco-systems, attained by establishment, increase and adequate management of protected areas and communities; preservation of forests in representative ecological systems and areas; preservation and management of wild game; preservation of genofund; measures aimed at providing support and ensuring sustainable use of biological resources and preservation of bio-diversity; support and improvement of national programmes for afforestation and re-cultivation of degraded habitats, establishment and improvement of existing forests of various uses, in order to reduce the pressure on existing forest eco-systems; basing the concept of planning of permanent management of renewable plant resources on a criterion – preservation of environment quality, which means that economic use of renewable plant resources must not reduce numerous ecological functions, while maintaining and enriching biodiversity of habitats; creation of conditions for establishment of elements of sustainable agricultural production; preservation and improvement of bio-diversity.

The collected data enable performance of a multi-layered comparative analysis of space by GIS technology, along with determining the degree of endangerment of natural resources. Foreseeing direct and indirect effects of excessive use of resources has been facilitated.

A number of interactively related sub-programme activities can be formulated in several general programme tasks: environment protection, optimum use of natural resources, strengthening of secondary activities, marketing analyses and analyses of commercial offering of this area, strictly in line with preservation of natural resources and environment protection (by application of principles of sustainable development of renewable plant resources).

Acknowledgement

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INTENSIVE MONITORING AT LEVEL II TEST PLOT KOPAONIK IN 2012

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Abstract: *Level II intensive monitoring of forest vitality represents a multi-purpose research system. Forest ecosystems are highly complex entities characterized by numerous different parameters subject to continuous variation due to constant and mutually inseparable effects of both biotic and abiotic factors. Evaluation criteria applied in intensive monitoring are compatible and defined in such a manner that, subsequent to their recording and statistical processing, data obtained on the condition of forests are easy to compare both analytically and logically, thus providing the basis for a variety of comparative studies. Dedicated test plot for intensive monitoring of trans-boundary air pollution impact on forest ecosystems in Serbia, a Level II test plot, was established in Kopaonik in 2010, with ten panels – from 10 separate forestry research areas, grouped according to the research subjects, which methodology is prescribed by ICP Forests Manual. This paper presents the results of intensive monitoring of parameters under review at Level II test plot Kopaonik in 2012.*

Key words: Level II test plot Kopaonik, intensive monitoring, crown condition, defoliation, deposition, litterfall.

INTENZIVNI MONITORING NA OGLEDNOM POLJU NIVO-a II „KOPAONIK“ U 2012.GODINI

Abstract: *Intenzivni monitoring vitalnosti šuma Nivo-a II, predstavlja višenamenski sistem predmetnih istraživanja. Šumski ekosistem, kao izuzetno složen entitet, odlikuju različiti parametri podložni konstatnim varijacijama usled neprestanog i*

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neodvojivog delovanja abiotičkih i biotičkih činilaca. Kriterijumi procene koje intenzivni monitoring podrazumeva, usaglašeni su i tako određeni da se dobijeni podaci o stanju šuma, nakon unosa i statističke obrade analitički i logički lako porede, dajući osnovu za različite komparativne studije. Namenska ogledna površina za intenzivni monitoring uticaja prekograničnog vazdušnog zagađenja na šumske ekosisteme u Srbiji - bioindikacijska tačka Nivo-a II osnovana je u 2010. godini na Kopaoniku, sa deset radnih panela – iz 10 zasebnih stručnih oblasti šumarstva, grupisanih prema predmetu istraživanja, a metodološki propisanim Manual-om ICP-a za šume. U radu su dati rezultati intenzivnog monotoringa praćenih parametara u 2012.godini na BIT Nivo-a II na Kopaoniku

Ključne reči: BIT Nivo II Kopaonik, intenzivni monitoring, stanje krošnji, defolijacija, depozicija, lisni opad.

1. INTRODUCTION

Level II monitoring of forest vitality is a versatile system of comparative research of many different forestry disciplines. Scientific research in forest condition monitoring is characterized by a multi-disciplinary and studious approach. Level II monitoring test stations have been installed all over the European continent according to the uniform ICP Forests methodology in order to enable continuous measurement and collection of data on condition of forests with various specific environmental circumstances. Such forest biocenoses belong to different taxonomic groups with a wide range of differences in species diversity and extent of man's impact in terms of intensifying their productive function; there are also forests where explicit management mechanisms of habitat maintenance are applied with strict protection and conservation regimes in effect. The objective of such research approach is to enable analyses performed over several years to allow observing patterns and drawing conclusions on the phenomenon of forest drying in Europe as well as clearer defining the cause–effect system for all changes monitored. Evaluation criteria applied in intensive monitoring are compatible and defined in such a manner that, subsequent to their recording and statistical processing, data obtained on the condition of forests are easy to compare both analytically and logically, thus providing the basis for a variety of comparative studies. By perceiving similarities and dissimilarities, assumptions on the primary causes of the disturbed natural equilibrium in the forest biocenoses are rejected or accepted, further progress of the changes is anticipated and further degradation of forests as invaluable natural entities is prevented strategically, from the aspects of multiple applied forestry disciplines.

By setting up test stations in Kopaonik National Park (2010), Fruška Gora (2009) and Odžaci (2011), Serbia joined the European network of over 800 Level II test plots.

2. MATERIALS AND METHODS

A Level II test plot, a dedicated test plot for intensive monitoring of trans-boundary air pollution impact on forest ecosystems in Serbia, was established in Kopaonik in 2010. The test plot is situated in the 74th division of the estate

"Samokovska reka" in Kopaonik National Park, within pure spruce stand, *Picea abies* (L.) H.Karst., which forms thick forest complexes in such altitude (1,720 m).

Level II sample plot covers an area of 0.5 ha (100 x50 m). Within its area there are three subplots for customized sampling and a buffer zone. The trees are marked with permanent bark markings, i.e. numbers from 1 to 195. Current status situation plan[1] of the test plot is provided in Figure 1.

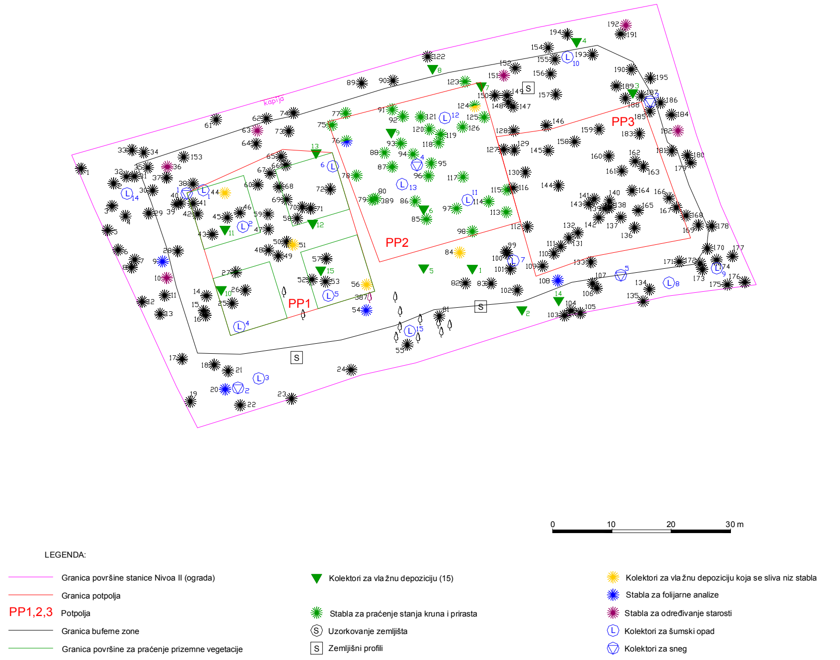


Figure 1. *Current status situation plan of the test plot area*

Level II monitoring program comprised the following parameter groups: crown condition, foliar analyses, soil chemistry, soil solution chemistry, growth and yield, ground vegetation, atmospheric deposition, air quality, meteorology, phenology and forest litterfall. Frequency of monitoring individual parameters is shown in Table 1.

Table 1. *Parameters, frequency and intensity of Level II monitoring*

Parameter type	Frequency of monitoring
Crown condition	At least annually
Foliar analyses	Every two years
Soil chemistry	Every ten years
Soil solution chemistry	Continuously
Growth and yield	Every five years
Ground vegetation	Every five years
Atmospheric deposition	Continuously
Air quality	Continuously

[1] Current status situation plan was prepared at the Forestry Institute in Belgrade, in a digital form, according to the field status and the blueprint of the basic layout of the test subplots drawn by the team of the Faculty of Forestry in Belgrade in 2010.

Parameter type	Frequency of monitoring
Ozone injuries	Annually
Meteorology	Continuously
Phenology	Several times a year
Forest litterfall	Continuously

Assessment of the crown condition in Level II intensive monitoring encompasses assessment of defoliation, injury detection, tree condition, crown shade (damage), crown visibility, fructiferousness of the visible crown parts and presence of the secondary sprouts. Out of the total number of spruce trees marked, 30 trees were selected within subplot 2 for the purpose of crown condition monitoring.

Phenological observations included 15 selected spruce trees (*Picea abies* L.). Phenophases were observed continuously, in succession, and the following parameters were detected and monitored: budding, change in color of conifer needles, significant indications of needle or crown damage, other injuries (broken branches and trees and uprooted trees), secondary budding and blooming. The aforesaid parameters were monitored in the trees located within the test plot, starting from the first field visit.

For litterfall sampling 15 collector pads for collection of dead organic remnants of forest trees (litterfall). The average collection surface area was 500 cm^2 per pad and the total collection surface area amounted to 0.75 m^2.

For wet deposition collection within the test plot, 15 collectors of precipitation falling through the tree crowns (“throughfall”), 5 collectors of deposition sliding down the tree trunks (“steamflow”) and 5 snow collectors (“bulk”) were placed in appropriate positions.

Soil solution is sampled by means of gravitational lysimeters placed into the front vertical wall of the existing pedological profiles at defined depths below the organic layer horizon.

For meteorological monitoring performed in order to obtain information on microclimatic conditions, data provided by Kopaonik automatic weather station of the Hydrometeorological Service of Serbia, which is situated near the Level II test plot on Mt. Kopaonik, were used. The location of the weather station ensured representative meteorological data according to the ICP Forests Manual. The following mandatory parameters were monitored: precipitation (PR), air temperature (AT), relative air humidity (RH), wind speed (WS), wind direction (WD) and solar radiation (SR).

At the end o 2011, the measuring instruments were checked and prepared for the climatic conditions typical of long and severe winters at such altitudes.

In April 2012, the equipment was washed and sterilized and minimum required repairs were performed. Phenological observations were conducted continuously. Wet deposition collection and soil solution sampling were carried out on a monthly basis. Upon each field visit, litterfall collectors were emptied.

3. RESULTS AND DISCUSSION

During 2012 parameters with continuous and an annual-basis frequency of monitoring were monitored.

3.1 Assessment of the Crown Condition – 2012 Intensive Monitoring

Crown condition assessment of the trees at the Level II test plot Kopaonik was performed as at August 23, 2012. As in prior years, the assessment included 30 spruce trees selected for annual crown condition monitoring in subplot 2.

Table 2. *XX2012. (PLT) Data on the subplot dedicated for crown condition assessment, Level II, Kopaonik*

No.	State code	Subplot no.	Assessment date	Latitude	Longitude	Altitude code	Team identification	Other findings
1	67	2	230812	+43^{0}17'30"	+20^{0}48'50"	35	REIGO	

Crown condition assessment focused on determining the degree of defoliation, tree drying and removal, tree status, crown shade, crown visibility, foliage transparency and other findings.

Injuries were also detected in selected trees. For each tree where injury/damage was identified, location, symptom, cause and intensity of injury/damage are stated.

Table 3. *XX2012. (TRC) Crown condition parameters, Level II Kopaonik*

No.	Sub-plot no.	Assessment date	Tree no.	Species	Drying - removal	Tree status	Crown shade	Crown visibility	Defoliation	Foliage transparency	Other findings
1	2	230812	75	118	01	1	2	2	10	25	*U.b.**
2	2	230812	76	118	01	1	1	2	10	20	*U.b.**
3	2	230812	78	118	01	1	2	2	10	25	*U.b.**
4	2	230812	79	118	01	1	1	2	15	25	*U.b.**
5	2	230812	80	118	01	1	1	2	20	25	*U.b.**
6	2	230812	85	118	01	1	2	2	15	25	*U.b.**
7	2	230812	86	118	01	1	3	3	15	30	*U.b.**
8	2	230812	87	118	01	3	3	3	30	70	*U.b.**
9	2	230812	88	118	38	5	6	2	100	99	*U.b.**
10	2	230812	91	118	41						Felled
11	2	230812	92	118	01	2	3	3	30	60	*U.b.**
12	2	230812	93	118	01	1	3	3	30	60	*U.b.**
13	2	230812	94	118	01	3	3	3	50	80	*U.b.**
14	2	230812	95	118	01	2	3	3	20	30	*U.b.**
15	2	230812	96	118	01	1	4	4	20	30	*U.b.**
16	2	230812	97	118	01	1	3	3	20	50	*U.b.**
17	2	230812	98	118	01	1	3	3	20	80	*U.b.**
18	2	230812	113	118	01	1	2	2	25	60	*U.b.**
19	2	230812	114	118	01	1	4	3	25	80	*U.b.**
20	2	230812	115	118	01	1	3	3	30	50	*U.b.**
21	2	230812	117	118	01	1	4	3	25	50	*U.b.**
22	2	230812	118	118	01	1	3	2	20	65	*U.b.**
23	2	230812	119	118	01	3	3	3	95	90	*U.b.**
24	2	230812	120	118	01	1	1	2	30	40	*U.b.**
25	2	230812	121	118	01	1	3	3	15	20	*U.b.**
26	2	230812	124	118	01	1	2	2	25	60	*U.b.**

No.	Sub-plot no.	Assessment date	Tree no.	Species	Drying - removal	Tree status	Crown shade	Crown visibility	Defoliation	Foliage transparency	Other findings
27	2	230812	125	118	38	5	3	3	100	99	*U.b.**
28	2	230812	126	118	01	1	2	2	15	40	*U.b.**
29	2	230812	77	118	01	1	3	2	15	30	*U.b.**
30	2	230812	123	118	01	1	1	1	15	20	*U.b.**

**Usnea barbata*

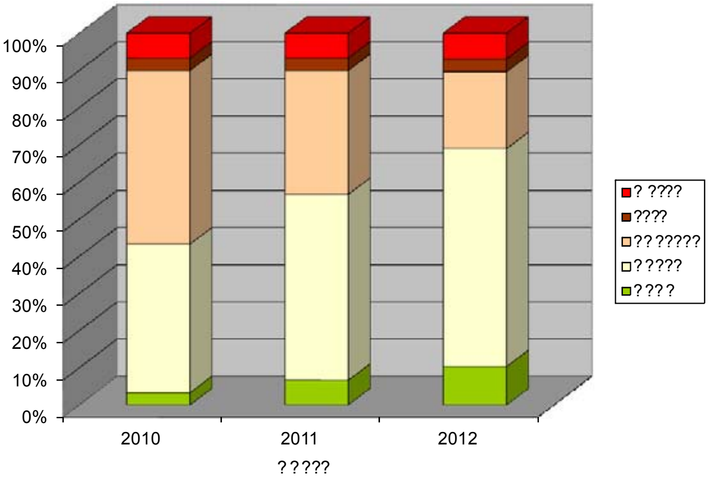
Tables 3 and 4 present crown condition parameters and injury/damage parameters at the Level II test plot Kopaonik.

Table 4. *XX2012. (TRD) Injury/Damage parameters, Level II Kopaonik*

No.	Sub-plot no.	Assessment date	Tree no.	Injured tree part	Symptom	Symptom designation	Crown part	Time of injury/damage inception	Cause	Cause description	Injury/ Damage intensity	Other findings
1	2	230812	75	00								*U.b.**
2	2	230812	76	00								*U.b.**
3	2	230812	78	11	02	38	3	3	301	CHRYABI	1	*U.b.**
4	2	230812	79	11	02	38	3	2	301	CHRYABI	2	*U.b.**
5	2	230812	80	11	02	38	3	3	301	CHRYABI	2	*U.b.**
6	2	230812	85	11	02	38	3	2	301	CHRYABI	2	*U.b.**
7	2	230812	86	13	02	38		3	999		1	*U.b.**
8	2	230812	87	31	10	65		3	220	IPSTYPO	3	*U.b.**
9	2	230812	88	04	10	65		3	220	IPSTYPO	7	*U.b.**
10	2	230812	91	04	22			1	400		7	
11	2	230812	92	33	17	58		2	500		2	*U.b.**
12	2	230812	93	33	17	58		3	500		1	*U.b.**
13	2	230812	94	33	17	58		3	500		3	*U.b.**
14	2	230812	95	11	02	38	3	2	301	CHRYABI	1	*U.b.**
15	2	230812	96	00								*U.b.**
16	2	230812	97	00								*U.b.**
17	2	230812	98	32	17	60		3	999		1	*U.b.**
18	2	230812	113	00								*U.b.**
19	2	230812	114	11	02	38	3	3	301	CHRYABI	1	*U.b.**
20	2	230812	115	00								*U.b.**
21	2	230812	117	00								*U.b.**
22	2	230812	118	00								*U.b.**
23	2	230812	119	34	11	57		3	304	TRAMSPP	6	*U.b.**
24	2	230812	120	11	02	38	3	3	301	CHRYABI	1	*U.b.**
25	2	230812	121	11	02	38	3	3	301	CHRYABI	1	*U.b.**
26	2	230812	124	24	13		2	2	999		2	*U.b.**
27	2	230812	125	04	10	65		3	220	IPSTYPO	7	*U.b.**
28	2	230812	126	00								*U.b.**
29	2	230812	77	00								*U.b.**
30	2	230812	123	00								*U.b.**

**Usnea barbata*

As compared to the previous two years, the number of trees not subject to defoliation has increased, as well as the percentage of trees with weak defoliation, whereas the percentage of trees with moderate defoliation has declined. The percentage of trees with strong defoliation has remained almost the same as in the previous years.



Graph 1. *Comparative presentation of defoliation in the period from 10/10-10/12 – Level II, Kopaonik*

3.2 Phenological Observations in 2012

At Level II test plot 15 spruce trees (*Picea abies* L.) were selected for phenological observations (Table 5).

The vegetation of the dominant species commenced rather late. Observed from different expositions of the evaluated trees, budding started in the third week of June 2012, whereafter slightly opened male and female reproductive organs were identified, which in conifer trees are called "blossoms." Pollination lasted until mid-July, which is easily perceived in mature spruce trees in the form of pollen clouds carried by the wind.

Table 5. *XX 2012. (PLP) Registration of trees selected for intensive phonological monitoring*

No.	Sub-plot no.	Species code	Placement date	Tree no.	Visible crown part	Surveillance direction	Surveillance position	Other findings
1	2	118	210612	75	3	4	1	*U.b.**
2	2	118	210612	76	3	4	1	*U.b.**
3	2	118	210612	78	3	4	1	*U.b.**
4	2	118	210612	79	3	4	1	*U.b.**
5	2	118	210612	80	3	4	1	*U.b.**
6	2	118	210612	85	3	4	1	*U.b.**
7	2	118	210612	86	3	4	1	*U.b.**
8	2	118	210612	87	3	5	1	*U.b.**
9	2	118	210612	88	2	6	1	*U.b.**
10	2	118	210612	98	3	4	1	*U.b.**
11	2	118	210612	114	2	6	1	*U.b.**
12	2	118	210612	118	2	4	1	*U.b.**
13	2	118	210612	120	1	7	1	*U.b.**
14	2	118	210612	121	1	5	1	*U.b.**
15	2	118	210612	124	2	8	1	*U.b.**

**Usnea barbata*

Table 6. *XX 2012. (PHE) Phenological phenomena monitoring (spring aspect)*

No.	Sub-plot no.	Species code	Event	Observation date	Event registered	Other findings
1	2	118	3	210612	1	*Usnea barbata*
2	2	118	3	210612	1	*Usnea barbata*
3	2	118	3	210612	7	*Usnea barbata*
4	2	118	2	210612	7	*Usnea barbata*
5	2	118	2	210612	7	*Usnea barbata*
6	2	118	2	210612	7	*Usnea barbata*
7	2	118	2	210612	7	*Usnea barbata*
8	2	118	5	210612	7	*Usnea barbata*
9	2	118	5	210612	7	*Usnea barbata*
10	2	118	5	210612	7	*Usnea barbata*
11	2	118	2	210612	7	*Usnea barbata*
12	2	118	3	210612	7	*Usnea barbata*
13	2	118	2	210612	7	*Usnea barbata*
14	2	118	4	210612	1	*Usnea barbata*
15	2	118	4	210612	1	*Usnea barbata*

Table 7. *XX 2012. (PHE) Phenological phenomena monitoring (autmn aspect)*

No.	Sub-plot no.	Species code	Event	Observation date	Event registered	Other findings
1	2	118	3	101012	1	*Usnea barbata*
2	2	118	3	101012	1	*Usnea barbata*
3	2	118	3	101012	7	*Usnea barbata*
4	2	118	2	101012	7	*Usnea barbata*
5	2	118	2	101012	7	*Usnea barbata*
6	2	118	2	101012	7	*Usnea barbata*
7	2	118	2	101012	7	*Usnea barbata*
8	2	118	5	101012	7	*Usnea barbata*
9	2	118	5	101012	7	*Usnea barbata*
10	2	118	5	101012	7	*Usnea barbata*
11	2	118	2	101012	7	*Usnea barbata*
12	2	118	3	101012	7	*Usnea barbata*
13	2	118	2	101012	7	*Usnea barbata*
14	2	118	4	101012	1	*Usnea barbata*
15	2	118	4	101012	1	*Usnea barbata*

Table 8. *XX 2012 (PHI) Phenological phenomena recording*

No.	Sub-plot no.	Tree no.	Event	Observation date	Event registered	Surveillance method applied	Other findings
1	2	75	3	210612	6	3	*Usnea barbata*
2	2	76	3	210612	6	3	*Usnea barbata*
3	2	78	3	210612	6	3	*Usnea barbata*
4	2	79	2	210612	6	3	*Usnea barbata*
5	2	80	2	210612	7	3	*Usnea barbata*
6	2	85	2	210612	6	3	*Usnea barbata*
7	2	86	2	210612	6	3	*Usnea barbata*
8	2	87	5	210612	7	3	*Usnea barbata*
9	2	88	5	210612	7	3	*Usnea barbata*
10	2	98	5	210612	6	3	*Usnea barbata*
11	2	114	2	210612	7	3	*Usnea barbata*
12	2	118	3	210612	6	3	*Usnea barbata*
13	2	120	2	210612	6	3	*Usnea barbata*
14	2	121	4	210612	6	3	*Usnea barbata*
15	2	124	4	210612	6	3	*Usnea barbata*

3.3 Litterfall Sampling and Analysis in 2012

In 2012, 1545.33 kg/ha of litterfall ended up on the land surface of the forest ecosystem represented by the test plot. The litterfall was in the form of absolutely dry dead organic remnants produced by forest trees (assimilation organs of spruce and rowan trees, twigs, bark, blossoms, fruits etc.). The examined forest ecosystem deposited via litterfall to the land surface 77.48 kg of ashes and 1467.85 kg of combustible organic matter.

The most present of all nutrition macroelements in the litterfall collected was carbon, which comprised 47.23% of the litterfall. The total carbon inflow to the land via litterfall in the examined ecosystem amounted to 729.91 kg/ha.

Second most present nutrition element in the litterfall was nitrogen. A gram of litterfall contains 11.13 mg of the total nitrogen. This means that 17.19 kg of the total amount of nitrogen reaches the land vial litterfall.

Table 9. *XX2012 (LFP) Basic data on litterfall sampling*

No.	State code	Sub-plot no.	Latitude	Longitude	Altitude	No. of collectors	Total collection area	Sample collection period		Other findings
								from	to	
1	67	02	+43^0 17' 30"	+20^0 48' 50"	1712/35	15	0.75	21.05.12	19.10.12	

Table 10. *XX2012 (LFM) Results of litterfall analysis*

No.	Sub-plot no.	Collection period		Collector no.	Species code	Sample code	Dry mass per m2 [kg/m^2]	Mass of dry 1000 Conifer needles (g)	**C** (g/100g)	**N** (mg/g)	**P** (mg/g)	**Ca** (mg/g)	**Mg** (mg/g)	**K** (mg/g)	Other findings
		from	to												
1	2	21.05.12	19.10.12	-9	118	11	0.1545	3.782	47.233	11.127	0.582	8.857	2.526	3.009	

3.4. Deposition Collection and Analysis

At Level II test plots special attention is paid to wet deposition, whereby the most relevant is examination of the chemistry of the deposit in the immediate contact with plant organs where pollutants from the air remain (ICP Forests, 2010c).

In 2012 there were eight periods of collecting samples from collectors. 5 joint samples were collected from the "throughfall" collectors, 6 joint samples from "steamflow" collectors and 4 joint samples from "bulk" collectors. The results of the chemistry analyses of the samples are provided in Tables XX2012.PLD and XX2012.DEM.

Figure 2. *"Throughfall" collector*

Figure 3. *"Steamflow" collector*

Table 11. XX2012(PLD) *General data on the test plot for atmospheric deposition*

No.	State	Test subplot no.	Collector code	Latitude	Longitude	Altitude (code)	Active collection period		No. of collection periods	Collector model	Collector height (m)	Collector area (m^2)	Number of collectors	Other findings
							from	to						
01	67	02	1	+43°17'30"	+20°48'50"	35	290212	230812	05	1	1.00	0.002	15	
02	67	02	2	+43°17'30"	+20°48'50"	35	231211	190412	04	1	1.00	0.002	5	
03	67	02	4	+43°17'30"	+20°48'50"	35	290212	230812	06	1	1.10	0.002	5	

Table 12. *XX2012(DEM) Laboratory analysis data for atmospheric deposition*

No.	Test subplot	Collection periods		Period no.	Sample code	Sampling	pH	Conductivity (µS/cm)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	N-NH4 (mg/l)	Cl (mg/l)	N-NO3 (mg/l)	S-SO_4 (mg/l)	Alcality	Other findings
		from	to															
01	02	231211	180112	01	02	1	4.92	16.8	0.176	5.143	0.320	0.246	1.2	4.004	4.422	14.547	4.64	
02	02	180112	290212	02	02	1	5.51	32.3	0.340	2.455	0.585	9.980	1.906	1.502	2.260	21.715	3.48	
03	02	290212	150312	03	02	1	5.39	21.5	0.548	3.452	0.694	4.896	1.44	3.254	4.261	12.228	3.48	
04	02	290212	150312	03	01	1	6.31	34.2	1.459	2.365	0.743	0.764	1.454	5.756	2.421	16.866	4.64	
05	02	290212	150312	03	04	1	3.98	198.5	2.478	4.784	1.785	1.387	11.112	8.009	2.311	28.462	3.48	
06	02	150312	190412	04	01	1	5.02	55.6	1.065	3.086	0.655	0.962	1.948	5.756	3.489	18.131	4.06	
07	02	150312	190412	04	02	1	4.81	27.8	0.298	4.763	0.629	0.954	0.367	5.006	4.142	21.715	2.90	
08	02	150312	190412	04	04	1	3.71	351	2.126	4.235	2.478	1.784	9.531	33.036	5.151	43.009	1.74	
09	02	190412	210512	05	01	1	5.78	21.7	1.147	1.220	0.383	0.670	0.191	4.004	7.761	30.781	4.64	
10	02	190412	210512	05	04	1	4.17	123.6	2.315	3.438	1.233	16.19	3.692	8.009	11.134	29.938	1.74	
11	02	210512	210612	06	01	1	6.3	31.1	3.876	8.953	0.974	1.268	0.777	4.505	6.040	25.089	4.06	
12	02	210512	210612	06	04	1	4.8	48.3	4.037	6.935	2.365	3.872	1.793	5.256	4.684	22.137	4.64	
13	02	210612	190712	07	04	1	5.9	100.4	4.764	7.092	1.342	2.242	2.873	7.008	3.413	32.257	5.81	
14	02	190712	230812	08	01	1	5.31	41.1	2.897	3.289	1.975	2.188	0.777	7.008	2.727	50.388	4.06	
15	02	190712	230812	08	04	1	4.54	109.4	4.984	2.785	2.102	3.025	7.427	9.010	4.922	42.587	6.97	

3.5. Soil Solution Sampling and Analysis

Tables 13. XX2012 (PSS) and 12. XX2014 (SSM) present the basic data on the soil solution measurements and chemical analyses of the collected samples of the soil solution.

Table 13. *XX2012(PSS) basic data on the soil solution measurement*

No.	State code	Test subplot no.	Latitude	Longitude	Altitude	Collector	Collector type	Earth layer	Collection depth	Commencement date	Completion date	No. of monitoring	Other findings
01	67	2	+43^{0}17'30"	+20^{0}48'50"	1712/35	1	2	H	-0.30	271011	230812	03	

Table 14. *XX2012 (SSM) Data on the soil solution*

No.	Test subplot no.	Collection period		Period no.	Collector	pH	Conductivity (µS/cm)	K (mg/l)	Ca (mg/l)	Mg (mg/l)	$N\text{-}NO_3$ (mg/l)	$S\text{-}SO_4$ (mg/l)	Alcality (µeq/l)	Na (mg/l)	$N\text{-}NH_4$ (mg/l)	Cl (mg/l)	Other findings
		from	to														
01	02	271011	210512	01	00	4.8	341	5.984	10.654	3.243	30.032	30.781	2.32	5.438	10.392	14.015	
02	02	210512	190712	02	00	6.92	122.5	6.953	12.558	2.428	24.404	24.245	2.90	11.190	2.231	5.006	
03	02	190712	230812	03	00	6.21	88.0	9.876	9.475	3.254	15.618	28.673	4.06	5.945	2.019	10.011	

3.6. Meteorological Monitoring

According to the data obtained from the weather station Kopaonik of the Hydrometeorological Service of Serbia, mean monthly air temperatures exhibit regular annual patterns, with values on the rise from January to July and on decline toward the year-end. The coldest month in the period under review was February, with the mean monthly air temperature of -6.9^{0}C, while the warmest month was July, when the mean monthly air temperature was 17.0^{0}C.

Mean monthly precipitation quantities ranged from 0.2 mm in August to 138.9 mm in January.

Mean monthly relative air humidity was the lowest in August and the highest in January.

Mean monthly wind speed in the analyzed period ranged from 2.6 to 4.3 ms^{-1}.

Table 15. *Meteorological data for 2012 from weather station Kopaonik*

Month	PR	AT	AT min	AT max	RH	RH min	RH max	WS	SR
	mm	°C	°C	°C	%	%	%	m/s	W.h/sq.m
I	138.9	-6.5	-9.5	-3.5	95	90	99	3.6	468
II	86.9	-6.9	-10.0	-3.4	93	85	98	4.3	604
III	47.6	-0.4	-4.4	4.5	76	54	91	3.0	1452
IV	111.3	3.6	-0.4	8.0	85	67	96	4.2	1592
V	113.5	7.5	3.4	11.9	88	71	99	2.9	1436
VI	47.8	14.6	8.9	19.7	72	49	93	3.0	2600
VII	16.5	17.0	11.2	22.6	69	48	91	2.8	2397
VIII	0.2	16.3	10.5	22.2	55	37	78	2.6	2305
IX	22.5	13.2	8.2	18.4	66	48	85	3.2	1750

Data obtained through research at Level II test plot Kopaonik were entered into the ICP on-line database in Hamburg.

4. CONCLUSION

As in the previous two years, parameters with continuous and an annual-basis frequency of monitoring were reviewed.

Crown assessment of the trees within Level II test plot Kopaonik was performed as at August 23, 2012.

As compared to the previous two years, the number of trees not subject to defoliation has increased, as well as the percentage of trees with weak defoliation, whereas the percentage of trees with moderate defoliation has declined. The percentage of trees with strong defoliation has remained almost the same as in the previous years.

The vegetation of the dominant species commenced rather late. Observed from different expositions of the evaluated trees, budding started in the third week of June 2012. Pollination lasted until mid-July.

In 2012, 1545.33 kg/ha of litterfall ended up on the land surface of the forest ecosystem represented by the test plot. The litterfall was in the form of absolutely dry dead organic remnants produced by forest trees. The examined forest ecosystem deposited via litterfall to the land surface 77.48 kg of ashes and 1467.85 kg of combustible organic matter. The most present of all nutrition macroelements in the litterfall collected was carbon, which comprised 47.23% of the litterfall. Second most present nutrition element in the litterfall was nitrogen. A gram of litterfall contains 11.13 mg of the total nitrogen. This means that 17.19 kg of the total amount of nitrogen reaches the land vial litterfall.

In 2012 there were eight periods of collecting wet deposition samples from collectors and three periods of soil solution sampling.

The coldest month in the period under review was February with the mean monthly air temperature of -6.9^{0}C, while the warmest month was July, when the mean monthly air temperature was 17.0^{0}C. Mean monthly precipitation quantities ranged from 0.2 mm in August to 138.9 mm in January.

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IMPACT OF THE PARENT ROCK ON EROSION PROCESS DEVELOPMENT IN GRDELICA GORGE AND VRANJE VALLEY

Sonja BRAUNOVIĆ, Mihailo RATKNIĆ, Ljubinko RAKONJAC[1]

Abstract: *In the 1950s Grdelica Gorge and Vranje Valley were subject to erosion processes of all destruction categories, from weak surface erosion on mild slopes to excessive surface erosion and deep erosion in developed configuration terrains. Excessive erosion covered 28% of the total area under review and it made itself manifest in the form of numerous ravines, gullies, landslides and patches of barren parent rock.*

This paper presents analysis of parent rock as one of the natural predispositions for development of intensive erosion processes in this area.

Key words: parent rock, erosion processes, crystalline shales, excessive erosion

UTICAJ GEOLOŠKE PODLOGE NA RAZVOJ EROZIONIH PROCESA U GRDELIČKOJ KLISURI I VRANJSKOJ KOTLINI

Izvod: *Pedesetih godina prošlog veka u Grdeličkoj klisuri i Vranjskoj kotlini bili su zastupljeni erozioni procesi svih kategorija razornosti, počev od slabe površinske erozije na blagim padinama, do ekscesivne površinske i dubinske erozije na terenima razvijene konfiguracije. Ekscesivna erozija zauzimala je 28% ukupne površine područja, a manifestovala se mnogobrojnim jarugama, vododerinama, klizištima, kao i površinama sa ogoljenom geološkom podlogom.*

U radu je prikazana analiza geološke podloge, kao jedne od prirodnih predispozicija za razvoj intenzivnih procesa erozije na ovom području.

Ključne reči: geološka podloga, erozioni procesi, kristalasti škriljci, ekscesivna erozija

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1. INTRODUCTION

"Terrain parent rock has certain impact on the development of erosion processes. Although it is known that under different climatic conditions on the same parent rock different types of pedological soil layer may be formed, it has been established that velocity and form of erosion processes on soil are predetermined by the parent rock properties to a significant extent. Parent rock affects soil formation and thus its resistance to erosion as well" (Kostadinov, S., 1996).

2. AREA UNDER RESEARCH AND METHODS

The area of Gredelica Gorge and Vranje Valley received its name based on the 1954 Law on Protection from Erosion and Torrent Control and it has been studied as a whole ever since.

The area boundaries defined by the aforesaid Law substantively deviate from the natural gorge and valley borders. They encompass portion of the Južna Morava River drainage basin of the area of 173,260.6 hectares, from Grdelica in the north to above the confluence of the Binačka Morava, not far from Bujanovac in the south. The region is situated between 42°22' and 42°55' of north latitude and between 19°21' and 20°0" of east longitude. It is elongated, stretching in the direction from south-wet to north-east. The area under research is situated in the altitude zone between from 252 to 1,923 meters and features a highly developed hydrographic network.

A digital geologic map was prepared with a 1:100 000 scale ratio and parts of sheets Leskovac, Vlasotince, Trgovište sa Radomirom and Vranje, which belong to the area. The present parent rock types were grouped into igneous, sedimentary and metamorphic rocks.

Parent rock types present were further classified based on the extent of erodibility and percentage shares of very hard, relatively hard, relatively erodible and very erodible rocks (Petrković, S., 1995).

3. RESULTS

Metamorphic rocks. Present crystalline shales, micashists, gniesses, orthogneisses, chloritoshists, quartz shales, amphibolites and amphibolte shales, serpentinites and graphite shales cover 718.85 km^2 or 41.06 % of the total area of the region (Table 1).

Crystalline shales are predominant in this area. The north portion of the terrain, up to the Ravnorečka River and Vrla is mostly formed of crystalline shales. Farther to the south, crystalline shales form terrains on the left bank of the Morava River from Plačkovica, and penetrate the granite massif of Vršnika. On the right bank of the Morava, crystalline shales stretch from Masuričko Polje to the sedimentary basins of Buštranja and Marganaca in the south and further on toward Pčinja. Crystalline shales of the lower crystallinity, the so-called "green shales," which are found downstream from Vladičin Han on the right bank of the Južna Morava River caused remarkable erodibility of this portion of the region. Similar are philites and sericite shales, stretching along the western rim of the area.

Table 1. *Metamorphic rocks*

Bedrock	Map designation	F km^2	%
Feldsparized and granitized shales genetically related to granitoids	Sf	4.42	0.26
Chlorite-sericite shales	Scose	2.82	0.16
Chlorite-muscovite shales	Scom	35.94	2.07
Amphibolic shales	A	3.40	0.19
Quartzites	Q	1.53	0.09
Small-grain biotite and biotite-muscovite gneisses	Gb	180.81	10.44
Chlorite-epidote shales	Scoep	15.16	0.88
Leptinolites and micashists	Sm	151.38	8.74
Muscovite-chlorite shales	Smco	65.93	3.81
Albite-chlorite-muscovite shales	Sabco	178.86	10.32
Migmatites: diffusely migmatized shales	Mi	8.18	0.47
Muscovite-chlorite shales	Sco	24.40	1.41
Albite gneiss with chlorite	Gab	35.03	2.02
Leucogneisses	Gf	1.90	0.11
Sericite-graphite and sericite-chlorite shales	Osse	1.61	0.09
	Total	711.40	41.06

Igneous rocks are also present in the region under research and cover 26.4% of the area. They are represented by granitoid dacite-andesite rocks and their tuffs. Granitoid rocks comprise granites, granodiorites, quartz monconites, etc. (Table 2). The areas of granitoid rock prevalence is to the south and south-east of Surdulica. This igneous massif stretches from Čemernik in the north to Bajčina Čuka and Gizdavac in the south.

Table 2. *Igneous rocks*

Bedrock	Map designation	F km^2	%
Granitoids of Surdulica	γδ	204.45	11.80
Leucogranites, granitoids (Bujanovac pluton)	G"	87.45	5.05
Tuffs	θ	2.10	0.12
Granitoids of Kukavica and Slatinska River	γ	0.94	0.05
Small-grain granitoids of Kukavica	G	3.17	0.18
Small-grain granitoids of Kukavica with quantitatively inferior granitoids of Vlajna	G/G	3.96	0.23
Small-grain granitoids of Kukavica with quantitatively superior granitoids of Vlajna	G/G	13.01	0.75
Tuffs, breccias and rarely tuffs of quartz-latite-dacite composition	ωαq	18.44	1.06
Hybrid rocks of gabbroid and amphibolite composition	Miv	4.09	0.24
Granitoids of Božica	G	23.26	1.34
Quartz latites	αq	17.63	1.02
Biotite dacite	αqb	3.00	0.17
Pyroclasts: agglomerates, breccias and tuffs	$^1E_3$	5.57	0.32
Dacites	χα	70.28	4.06
	Total	457.34	26.40

Sedimentary rocks of different ages cover 32.5% of the area (Table 3). They are comprised of conglomerates, sandstones, claystones, marlstones, bituminous shales, connected or disconnected lake sediments, gravel, sand, clay, alluvial and delluvial deposits, etc.

In studies and analyses of the terrain geologic composition and water flow deposits, physical and mechanical properties of rocks as sources of deposits are of great importance. Relevant factor of rock erodibility is also the extent of rock fracture; hence even very hard rocks may have low rigidity if tectonically damaged. In the instances of physical rock degradation superiority over chemical degradation, large-grain gravel and sand deposits are formed; if vice-versa, small-grain clay deposits and lesion rocks are created.

Table 3. *Sedimentary rocks*

Bedrock	Map designation	F km^2	%
Classic base of the series: conglomerates, colored and red sandstones	^{1}Ol, M	23.62	1.36
Conglomerates and sandstones with coal lenses in the upper part	${}_2^1K_2^3$	6.52	0.38
Mid-part of the series: limestone's with charts, sandstones and marlstones	^{2}Ol, M	5.71	0.33
Small-grain sandstones, claystones and marlstones	${}_2^2K_2^3$	7.89	0.46
Volcanogenic-sedimentary horizon: conglomerates, sandstones and tuffs	$^2E_3$	3.62	0.21
Sandy claystones and marlstones	$^2M_2$	8.98	0.52
Uppermost part of the series: bituminous claystones, sandstones and marlstones	^{3}Ol, M	3.98	0.23
Shallow-water chastises: conglomerates, sandstones and claystones	$^3E_3$	19.26	1.11
Marlstones	$^4E_3$	14.95	0.86
Sub water sliding horizon: marlstones, claystones and sandstones	$^5E_3$	93.46	5.39
Turbidity horizon: marlstones, aerolite's and sandstones	$^6E_3$	0.92	0.05
Alluvium	al	102.62	5.92
Diluvium	d	5.37	0.31
Prolluvium – face of the delta	pr	0.72	0.04
Fluvial terrace	t	12.03	0.69
Lowest terrace	t_1	9.74	0.56
Mid-terrace	t_2	8.99	0.52
Highest terrace	t_3	2.17	0.13
Prolluvium – face of the subaerial delta sediment	prQ_1	55.80	3.22
Marginal face: conglomerates and breccias	E_3	3.62	0.21
Sedimentary-volcanogenic unit: conglomerates, sandstones, greywacke, marlstones and tuffs	$^3M_2$	13.55	0.78
Loose sandstones and conglomerates	M,pl	70.94	4.09
Pellet marlstone limestones	${}_3K_2^3$	7.13	0.41
Conglomerates, gravels, sandstones, sands, clays	$^1M_2$	0.73	0.04
Sands, clays, marlstones, bentonite clays, lignite	pl	40.38	2.33
Colored sandstones, conglomerates and sandy marlstones	M_2	12.29	0.71
Grus horizon: conglomerates, sandstones and claystones	$^{3\text{-}5}E_3$	22.06	1.27
Mixed horizon of shallow-water clastites and limestones	$^{3\text{-}4}E_3$	3.64	0.21
Marlstones and marlstone limestones (santonite)	${}_2^3K_2^3$	0.89	0.05
Neogene of Vranje Valley	N	2.29	0.12
	Total	563.87	32.54

3.1 Rock erodibility in the area under research

Due to complex geologic composition and varying conditions for deposit production, the rocks were classified according to the degree of erodibility, which was determined based on the geologic morphology, structure and physical and chemical parameters of the rocks. According to their resistance to erosion devastation of the geologic formations within the drainage basin area, 4 categories were identified (Figure 2):

Very hard rocks. Granites; Granitoids (Bujanovac – Vranje); Andesites (to the left of the Južna Morava River); Dacites (to the left of the Južna Morava

River) cover 24.81% of the total area of the region.

Deposit: rock blocks, gavel, grus of igneous and limestone origin.

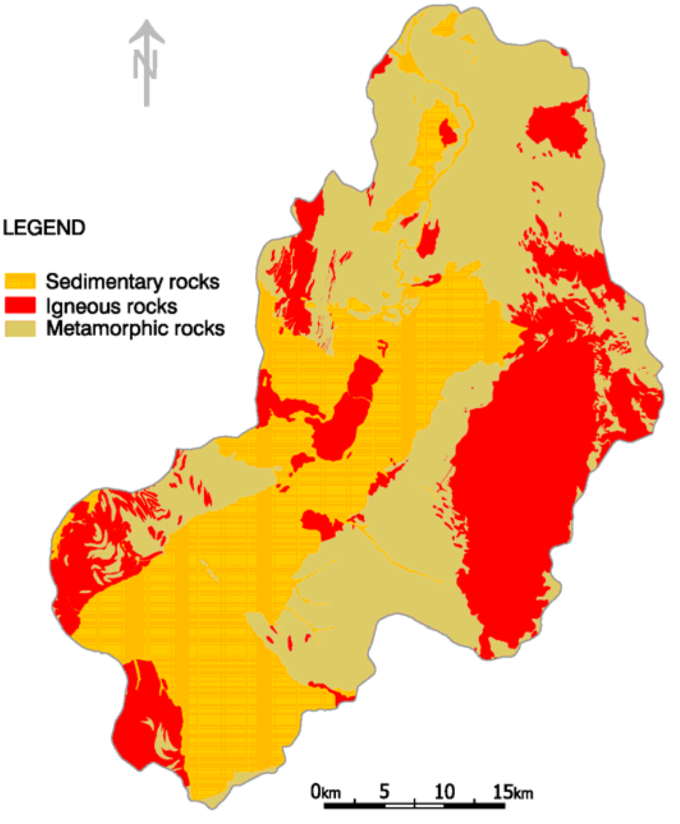

Figure 1. *Presence of sedimentary, igneous and metamorphic rocks*

Relatively hard rocks. Gneiss (crystalline shales of higher crystallinity present to the left of the Južna Morava River; sources); Granites metamorphed; Diabase philites in the Vlasina basin; Limestones with sandstones and shales.

Deposit: large-grain gravel, medium-grain deposits, grus, sands, small quantities of small-grain deposits.

Relatively erodible rocks. Sericite-chlorite shales (crystalline shales of lower crystallinity present at Vlasina Complex, to the east of the Južna Morava River); perm red sandstones; Micashists (to the right of the Južna Morava River); Volcanic tuffs accompanying andesites and dacites.

Deposit: leafy large and medium-grain gravel, cobbles, sand, some clay.

Very erodible rocks. Lake sediment of neogene age – in Leskovac and Vranje-Bujanovac basins; conglomerates, sandstones, marlstones; Fluvial terrace deposits: gravels, sands, clays along the lower course of the Južna Morava River and its widened valleys; Contemporary deposits: elluvium, delluvium, alluvium and prolluvium in the drainage basin of the Južna Morava and its tributaries, comprised of gravel-sand and clay sediments, with larger gravel contained in both elluvium and delluvium.

Deposit: gravel, sand, clay, with sand-clay deposit prevailing.

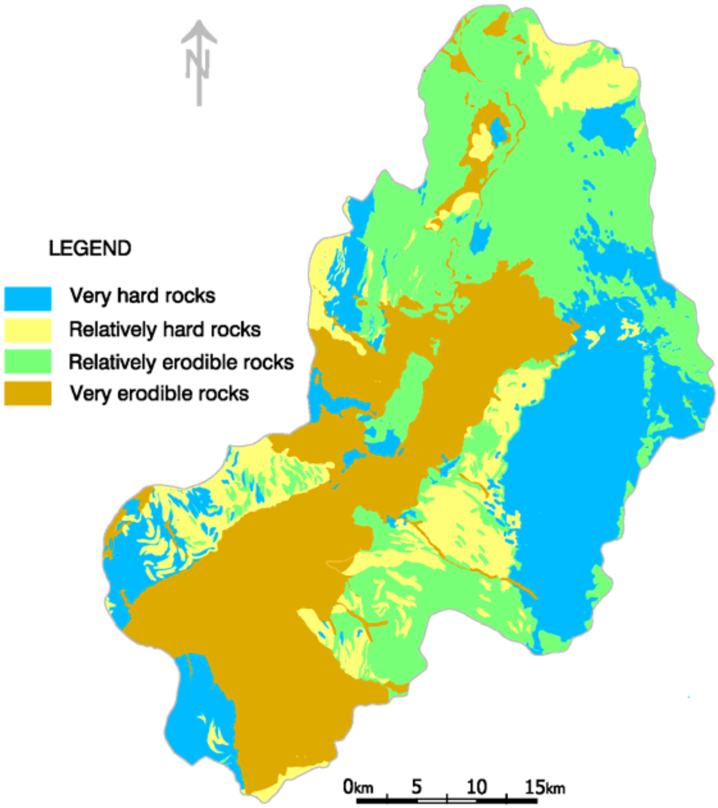

Figure 2. *Map of rock erodibility in the area under research*

For deposit formation within the investigated region, tectonic versatility of the terrain is significant as well, which is a distinctive property of the entire region and results in a number of fractures, which, in turn, intensify rock degradation process even when very hard rocks such as igneous rocks are at issue.

4. DISCUSSION AND CONCLUSION

Very hard rocks cover 24.81%, relatively hard rocks account for 13.78 %, relatively erodible rocks 29.18% and very erodible rocks 32.23% of the total area.

In the territory of Grdelica Gorge and Vranje Valley, areas potentially threatened by erosion cover over 60%, i.e. they are superior to the stable areas.

According to the values of the average erosion index Z_{sr} = 0.78, in the period reviewed (1953), the area subject to research was jeopardized by the strong surface erosion processes (Braunović et al, 2010). Excessive erosion affected 28 % of the region (drainage basins of the Jastrebačka, Letoviška, Sejanička, Radovska, Palojska, Ličindolska, Predejanska, Džepska, Jovačka, Korbevačka and Banjska rivers and numerous torrential streams: Krpejski Stream, Mlakačka Valley, Zla Valley, Repinska and Kalimanska rivers, Lještarska Valley etc.). In respect of the parent rock, the aforestated drainage basins mostly lie on the crystalline shales (Braunović, Ratknić. 2010/a, 2012), which is, together with the other factors (relief, climate, vegetation, deforestation, etc.) contributing to the intensive development of erosion processes.

Acknowledgement

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IMPACT OF THE PARENT ROCK ON EROSION PROCESS DEVELOPMENT IN GRDELICA GORGE AND VRANJE VALLEY

Sonja BRAUNOVIĆ, Mihailo RATKNIĆ, Ljubinko RAKONJAC

Summary

The paper presents and determines the geologic composition of the parent rock of the region of Grdelica gorge and Vranje Valley. Sedimentary rocks of different ages (conglomerates, sandstones, claystones, marlstones, bituminous shales, connected or disconnected lake sediments, gravel, sand, clay, alluvial and delluvial deposits, etc. . .) cover 32.5% of the area.

Igneous rocks (granitoid rocks - granites, granodiorites, quartz monconites and dacite-andesite rocks and their tuffs, etc.) cover 26.4% of the area.

Metamorphic rocks (crystalline shales, micashists, gniesses, orthogneisses, chloritoshists, quartz shales, amphibolites and amphibolte shales, serpentinites and graphite

shales) cover 718.85 km^2 or 41.06 % of the total area of the region.

Crystalline shales of the lower crystallinity, the so-called "green shales," which are found downstream from Vladičin Han on the right bank of the Južna Morava River caused remarkable erodibility of this portion of the region (Krpejski Stream, Mlakačka Valley, Predejanska River, Palojska River, Džepska River, the so-called Džepske torrents, etc.).

Very hard rocks cover 24.81%, relatively hard rocks account for 13.78 %, relatively erodible rocks 29.18% and very erodible rocks 32.23% of the total area, which means that over 60% of the region is potentially, i.e. depending on other factors, is susceptible to erosion.

Given the fact that the areas which in the 1950s were endangered by the processes of excessive and strong erosion mostly correspond to the areas formed from erodible rocks, parent rock is one of the significant causes of intensive erosion process development.

UTICAJ GEOLOŠKE PODLOGE NA RAZVOJ EROZIONIH PROCESA U GRDELIČKOJ KLISURI I VRANJSKOJ KOTLINI

Sonja BRAUNOVIĆ, Mihailo RATKNIĆ, Ljubinko RAKONJAC

Rezime

U radu je definisan sastav geološke podloge područja Grdeličke klisure i Vranjske kotline.

Sedimentne stene različite starosti (konglomerati, peščari, glinci, laporci, bitumenozni škriljci, vezani ili nevezani jezerski sedimenti, šljunkovi, peskovi, gline, aluvijalni i deluvijalni nanosi itd.) zauzimaju 32,5% površine.

Magmatske stene (granitoidne stene: graniti, granodioriti, kvarcmonconiti i dacitsko-andezitske stene i njihovi tufovi, itd.) zauzimaju 26,4% površine.

Metamorfne stene (kristalasti škriljci, mikašisti, gnajsevi, ortognajsevi, hloritošisti, kvarcni škriljci, amfiboliti i amfibolitski škriljci, serpentiniti i grafitski škriljci) pokrivaju 718,85 km^2 ili 41,06 % ukupne površine područja.

Kristalasti škriljci nižeg stepena kristaliniteta "zeleni škriljci", koji se pružaju nizvodno od Vladičinog Hana (desna strana toka Južne Morave), doprineli su veoma izraženoj erodibilnosti područja (Krpejski potok, Mlakačka dolina, Predejanska reka, Palojska reka, Džepska reka, tzv. Džepske bujice itd).

Veoma čvrste stene zauzimaju 24,81%, uslovno čvrste 13,78 %, uslovno erodibilne 29,18%, dok veoma erodibilne stene zauzimaju 32,23% ukupne površine, što znači da je preko 60% područja potencijalno tj. u zavisnosti od drugih faktora, podložno eroziji.

Obzirom da se područja koja su pedesetih godina bila ugrožene procesima ekscesivne i jake erozije uglavnom poklapaju sa površinama koje su izgrađene od erodibilnih stena, geološka podloga je jedan od značajnih uzroka razvoja intenzivnih procesa erozije.

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Original scientific paper

THE EFFECT OF APPLICATION OF DIFFERENT NUTRITION PREPARATIONS ON HEIGHT INCREMENT OF WALNUT (*Juglans regia* L.) SEEDLINGS

Tatjana ĆIRKOVIĆ-MITROVIĆ, Vladan POPOVIĆ,
Ljiljana BRAŠANAC-BOSANAC, Ljubinko RAKONJAC, Aleksandar LUČIĆ[1]

Abstract: *Providing of quality planting material which takes root well after planting, resistant to diseases, pests, stress (drought, extreme temperature, etc.) and grows well in cultures is one of the strategic and preferential tasks of modern forestry. Walnut is a fruit tree important as a founder of various varieties and hybrids, and as a rootstock for high-yielding varieties. It is also of great importance because of high nutritional value of fruit and high quality of stem. For that reason this species has to be introduced into the existing ecosystem and used for afforestation of different habitats.*

The paper presents results of research on the effect of the controlled decomposing fertilizer Osmocote Exact®, mineral NPK fertilizer Florin 2 and microbiological preparation Bactofil® B 10 on height increment of walnut seedlings. Data analysis was performed by relevant procedures using statistical software packages (SPSS Statistics 17.0). Comparative analysis of height increment of seedlings treated with these preparations and height increment of untreated seedlings, as well as a simple way of application of these preparations by adding them to the substrate, will show the justification of direct application of these types of fertilizers and microbiological preparation in mass production of high quality planting material.

Key words: walnut, mineral fertilizers, microbiological preparation, height increment.

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UTICAJ PRIMENE RAZLIČITIH PREPARATA ISHRANE NA VISINSKI PRIRAST SADNICA ORAHA (*Juglans regia* L.)

Abstract: *Obezbeđivanje sadnog materijala koji se dobro prima nakon sadnje, otpornog na bolesti, štetočine, stres (suša, ekstremne temperature, i dr.) i dobro raste u kulturama, jedan je od strateških i prioritetnih zadataka savremenog šumarstva. Orah je voćkarica značajna kao rodonačelnik različitih sorti i hibrida i kao podloga za kalemljenje visokorodnih sorti. Takođe je od velikog značaja zbog visoke hranljive vrednosti plodova i visoko kvalitetnog debla. Zato ovu vrstu treba unositi u postojeće ekosisteme i njome pošumljavati različita staništa.*

U radu će biti prikazani rezultati istraživanja uticaja kontrolisano razlagajućeg đubriva Osmocote Exact®, mineralnog NPK đubriva Florin 2 i mikrobiološkog preparata Bactofil® B 10 na visinski prirast sadnica oraha. Obrada podataka izvršena je odgovarajućim procedurama korišćenjem programskih statističkih paketa (SPSS Statistics 17.0). Komparativna analiza visinskog prirasta sadnica tretiranih ovim preparatima i visinskog prirasta netretiranih sadnica, kao i jednostavan način primene navedenih preparata dodavanjem u supstrat, ukazuje na opravdanost direktne primene ovih tipova đubriva i mikrobiološkog preparata u masovnoj proizvodnji visokokvalitetnog sadnog materijala.

Key words: orah, mineralna đubriva, mikrobiološki preparat, visinski prirast.

1. INTRODUCTION

In Serbia within natural, forest ecosystems, is noted the presence of 122 fruit trees, grouped into 23 families and 38 genera. Range of many fruit trees has declined alarmingly in the past 50 years and production of seedlings and their introduction into existing forests as well as afforestation of bare land contributes to the improvement of natural biological wealth of Serbia.

Initial planting material is of major importance for the success of afforestation. Using of poor quality planting material increases the costs of establishment and maintenance of cultures, while the success of afforestation is diminished (Oliet, J. A. et al., 2009). Previous experience in afforestation proved that a good selection of species and planting material characteristics (development of root system, resistance to temperature extremes, etc.) are very important for afforestation and must be taken into consideration.

Certain scientific researches have proved that application of nutrition preparations in contemporary seedling production represents not only an additional source of nutrients, but also a powerful mean and important factor in production of high-yielding planting material for various purposes. A nutrition system of woody plants in juvenile development phase should be planned on the basis of contemporary developments in the field of production of various types of fertilizers and experimental data obtained as a result of established experiments. The selection of type, quantity and time of use of a fertilizer depends primarily on the biological characteristics of plants, soil condition, plant development stadium as well as the characteristics of the fertilizer itself (Tucović, A., Simić, Z., 2002).

Taking into account the fact that the mineral nutrition is the most effective method to improve quality and increase biomass production in forest trees and the forest fruit trees, too, the scientific objective of this research was to select, on the basis of height increment of walnut seedlings treated with three different types of nutrition preparations, the preparation that has the biggest influence on height increment of seedlings and thus contributes to the proper development and optimal quality of seedlings. An easy way to apply the nutrition preparation by adding it to the substrate certainly would justify its use in the mass production of high quality planting material.

2. MATERIAL AND METHOD

For the purpose of research and analysis of heights and height increment during vegetation period of walnut seedlings and monitoring the effects of various types of fertilizers, a sample plot was established in the seedling nursery of the Institute of Forestry in Belgrade. The nursery is located at 20° 27' 44" east longitude and 44° 49' 14" north latitude, and the altitude of 95 meters.

By processing of data of Meteorological Service of Serbia for Weather station in Belgrade for the period from 1980 to 2009, we have obtained the average monthly air temperature and average monthly and annual precipitation for the site where the experiment was set up. Based on the obtained data we got and the average monthly amount of precipitation and average monthly temperature in the vegetative period.

The walnut seed collected in 2010 was used for establishment of sample plot. Due to dormancy of embryo, the walnut seed was held in a wet stratification from November 2010 to the end of March 2011 (at the temperature 3-5 °C). The sowing was performed in April 2011, in rows, 6 pieces per linear meter, at the depth of 8 cm.

The seed was planted in *Tref TPS fine brown* substrate, produced by *TREF Group*, *Jiffy product international AS* from Norway. For its production is used peat moss from Estonia which does not contain weeds, dirt and pathogens, of fraction <8 mm and pH 5.8 (±0,3), and represents a mixture of peat moss and perlite in a 9:1 ratio, while peat moss is a mixture containing 70% of white peat moss and 30% of black peat moss.

The analysis of height growth was performed on seedlings that were not treated with nutrition preparations, so-called 'control seedlings' (in experiment labeled with number 1), as well as on seedlings that were treated with three types of fertilizers: a controlled release fertilizer *Osmocote® Exact Standard 5-6 M* (treatment labeled in experiment with number 2), a microbiological preparation *Bactofil® B 10* (treatment labeled in experiment with number 3) and a complex NPK mineral fertilizer *Florin 2* (treatment labeled in experiment with number 4).

Osmocote® Exact consists of fine NPK granules and contains micro-elements in traces and additional magnesium. Each granule of size 2-4 mm is covered with an organic semi-permeable coating, a membrane of bio-decomposable resin produced from plant oils. A granule enables longer retention of nutrients and a more even plant nourishment, without the possibility of rinsing. The nutrients are extracted from granules by osmosis, i.e., the plant pumps them with the aid of water. *Osmocote® Exact Standard 5-6 M* has a mark 15+9+12+2MgO+micro-elements, that denotes a percentage content of nitrogen, phosphorus, potassium, magnesium and micro-elements necessary for plant growth and development. Nitrogen accounts for 15%, P_2O_5 accounts for 9%, while K_2O accounts for 12%. MgO accounts for 2%, the total Iron accounts for 0.45%, Mn accounts for 0.06%, Zn, B and Mo account for 0.020% each, while Cu accounts for 0.055%. Life span of this fertilizer is 5-6 months at the temperature of 21 °C. At higher temperatures dissolution of nutrients is more rapid and slower at lower temperatures, which suits the plant needs for nutrients. Salt level, Ph, activities of micro-organisms and quality of water or rain do not influence dissolution of nutrients, the only relevant factor is the temperature, which makes *Osmocote*® *Exact* very reliable in use.

Bactofil is a micro-biological fertilizer that contains ten most important sorts of soil bacteria, which enable optimum soil conditions for plant growth and development. Bacteria perform an irreplaceable role in sustainment of soil fertility by binding nitrogen from air and transforming it into a form that is easily accessible to plants. Furthermore, they increase phosphorus and potassium reserves in soil and help with decomposition of organic matter. Bacteria in *Bactofil* preparation are: *Azotobacter vinelandii, Azospirilium brasilense, Azospirilium lipoferum, Bacillus, Pseudomonas, Bacillus subtilis, Bacillus polymyxa, Bacillus cirkulans, Streptomyces albus, Micrococcus roseus.* By its addition to the substrate, *Bactofil* directly influences the intensity of humification and mineralisation process.

Florin 2 NPK 15:15:15, a complex NPK mineral fertilizer, contains 15% of nitrogen (6.5% nitrate and 8.5% ammonium), 15% of phosphorus oxide P_2O_5 (soluble in 2% citric acid and 9% soluble in water) and 15% of potassium oxide K_2O (soluble in water). NPK fertilizer has the widest application in Serbia, primarily due to favorable price.

The analysis of walnut seedlings involved the study of the above-ground part heights and comparison of similarities and differences depending on treatment with the above-mentioned nutrition preparations, with the comparison of obtained results with the results of the control, non-treated seedlings.

Data processing was performed by relevant procedures using statistical software packages (*SPSS Statistics 17.0*). The estimate of statistical significance of different variation factors of the monitored characteristics of walnut seedlings was performed by application of variance analysis. By models of estimation of significance of various factors' contribution to the total variation of characters, a statistical significance of the variation sources was described depending on the type of applied fertilizer (variation contingent upon the type of fertilizer used in the experiment).

The statistical justification of the differences between mean values of the analysed morphometric characteristic was determined by the LSD test with a probability of 95%.

3. RESULTS AND DISCUSSION

Climatic characteristics

The average air temperature is 12.5 °C, while the average temperature in vegetation period is 19.2 °C. The temperature reaches the lowest values in January (the average value for this month is 1.3 °C), while the hottest month is July with 22.9 °C.

The total annual precipitation sum is 692 mm, while in the vegetation period it amounts to 393 mm, which is 57% of the total annual amount.

High amount of precipitation in the vegetation period is of particular importance for development, growth and increment of all plant species. The rainiest month is June, while the lowest amount of precipitation is recorded in February. A secondary precipitation maximum, with lower values, is reached in December, while a secondary minimum occurs in October (Ćirković-Mitrović, T. et al. 2012, 2012a).

Variation of height increment of one-year-old walnut seedlings contingent upon treatment by various nutrition preparations

The statistical analysis of length of the walnut seedling above-ground part contingent upon the treatment by different preparations indicates that after a more or less uniform increase in height at the beginning of the vegetation period comes to an increasing of differentiation of this morphometric marker in plants treated with *Osmocote*. (Table 1).

After intense height increment at the beginning of the vegetative period (until May-June) in all treatments, this morphometric parameter in seedlings treated with *Osmocote* and *Bactofil* began to show a declining trend. In seedlings treated with *Bactofil* the height increment decreases abruptly, while in the seedlings treated with *Osmocote* the height increment by the end of the vegetative period retains high values and statistically differs significantly from height increment of seedlings from other two treatments and control seedlings. In control seedlings and those treated with *Florin* the current height increment culminates in period of June-July and then abruptly decreases. At the end of the vegetation period, before the start of vegetative rest, the height increment of all seedlings is uniform, with no significant differences. The curves of height development also indicate these trends (Table 1, Graph 1). In August starts the differentiation of heights of seedlings treated with *Osmocote* and control seedlings, and by the end of the vegetation period this parameter is significantly different compared to the heights of seedlings treated with *Bactofil* and *Florin*. (Table 1, Graph 1).

Table 1. *Method: 95.0 percent LSD*

Height

Measurement in June

Treatment	Count	Mean	Homogeneous Groups	
4	74	10.1027	X	
1	74	11.6311		X
3	74	12.0892		X
2	74	12.6824		X

Measurement in July

Treatment	Count	Mean	Homogeneous Groups	
4	74	16.6176	X	
2	74	17.2365	X	
3	74	17.6473	X	
1	74	18.0703	X	

Measurement in August

Treatment	Count	Mean	Homogeneous Groups	
4	74	19.3108	X	
3	74	19.5041	X	
2	74	21.477	X	X
1	74	22.4811		X

Measurement in September

Treatment	Count	Mean	Homogeneous Groups	
4	74	20.2149	X	
3	74	20.3176	X	
1	74	23.0892		X
2	74	24.2595		X

Measurement in October

Treatment	Count	Mean	Homogeneous Groups	
4	74	21.6122	X	
3	74	21.6622	X	
1	74	24.5919		X
2	74	25.9649		X

Height increment

April-June

Treatment	Count	Mean	Homogeneous Groups	
4	74	5.06757	X	
1	74	5.84054		X
3	74	6.06757		X
2	74	6.36486		X

June-July

Treatment	Count	Mean	Homogeneous Groups	
2	74	4.55405	X	
3	74	5.55811	X	X
1	74	6.43919		X
4	74	6.51486		X

July-August

Treatment	Count	Mean	Homogeneous Groups	
3	74	1.85676	X	
4	74	2.69324	X	
2	74	4.24054		X
1	74	4.41081		X

August-September

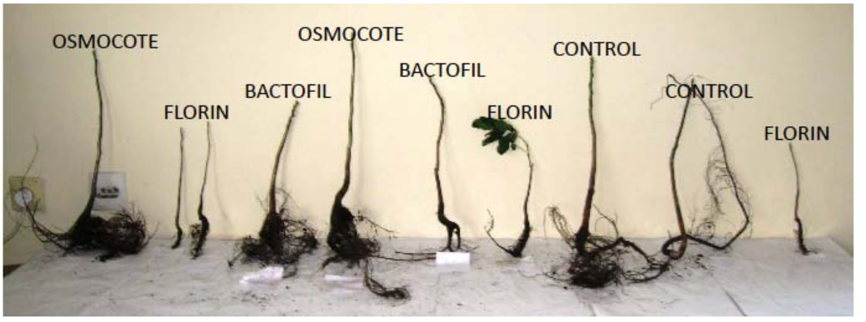
Treatment	Count	Mean	Homogeneous Groups	
1	74	0.608108	X	
3	74	0.813514	X	
4	74	0.904054	X	
2	74	2.78243		X

September-October

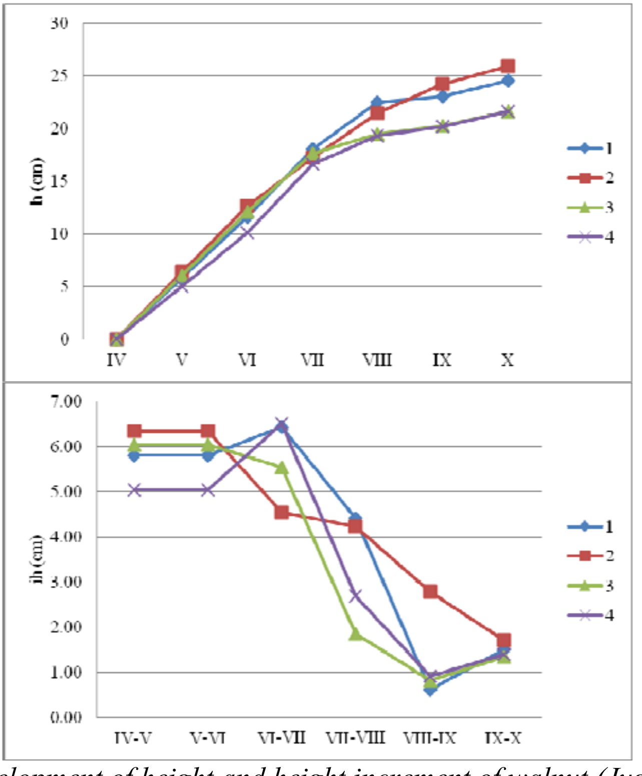
Treatment	Count	Mean	Homogeneous Groups
3	74	1.34459	X
4	74	1.3973	X
1	74	1.5027	X
2	74	1.70541	X

Table 2. *Summary statistics for the height growth of walnut (Juglans regia L.) seedlings at the end of the vegetation period*

Treatment	Count	Average	Variance	St. deviation	Minimum	Maximum	Range
1	74	24.5919	39.4687	6.28241	13.4	40.0	26.6
2	74	25.9649	94.1166	9.70137	12.5	55.0	42.5
3	74	21.6622	39.3079	6.2696	14.0	46.0	32.0
4	74	21.6122	71.8835	6.2696	9.0	45.3	36.3
	296	*23.4578*	*64.1344*	*8.0084*	*9.0*	*55.0*	*46.0*



Picture 1. *Walnut seedlings treated with Osmocote, Florin, Bactofil and control seedlings*



Graph 1. *Development of height and height increment of walnut (Juglans regia L.) seedlings during the vegetation period*

At the end of the vegetation period, the seedling with the absolute smallest height was measured in seedlings treated with *Florin* and the seedling with the absolute largest height was measured in seedlings treated with *Osmocote*. The smallest seedling has height of 9.0 cm, and the highest seedling has height of 55.0 cm (amplitude is 46.0 cm). Also, the largest average height of 25.96 cm have seedlings treated with *Osmocote*. The smallest average height of 21.61 cm have seedlings treated with *Florin* (Table 3).

Based on the obtained results it can be concluded that the nutrition preparation *Osmocote* is suitable for the production of walnut seedlings. That nutrition with nitrogen, phosphorus and potassium can influence increase of some growth parameters such as height, have shown researches in Serbia: Đukić, M. et al. (2004) with Spruce seedlings and different types of substrates, Šijačić-Nikolić, M. (2006) with Beech seedlings treated with *Osmocote*. Komlenović, N. (1997) also finds a positive impact of fertilizer *Osmocote* on the production of coastal pines in Croatia. In Turkey, the Ash (Fraxinus) seedlings in the first year respond positively to treatment with NPK fertilizers (Cicek, E. et al., 2010).

4. CONCLUSION

Based on the obtained results it can be concluded that used nutrition preparations differently affect the height of walnut seedlings. Control seedlings and seedlings treated with the slowly decomposing mineral fertilizer *Osmocote* show better results than those treated with microbiological preparation *Bactofil* and NPK mineral fertilizer *Florin*.

Controlled decomposing fertilizer *Osmocote Exact*® positively affects the development of seedlings stimulating the development of seedlings height which is of particular importance if one takes into account that height, along with root collar diameter, is one of the most important morphological criteria of quality of deciduous seedlings (Stilinović, S. 1987). Being the slowly decomposing fertilizer, *Osmocote* exerts a positive impact on seedling development, as the effect it produces coincides with the duration of the vegetation period.

An easy way of application by adding fertilizer directly to the substrate during its preparation, controlled decomposition that follows the needs of the plant and a relatively long period of activity speak in favor of justification of application of this fertilizer in mass production of high quality planting material for different purposes.

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UTICAJ PRIMENE RAZLIČITIH PREPARATA ISHRANE NA VISINSKI PRIRAST SADNICA ORAHA (*Juglans regia* L.)

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Rezime

Uzimajući u obzir činjenicu da je mineralna ishrana najefikasniji metod za poboljšanje kvaliteta i povećanje produkcije biomase kod šumskog drveća, samim tim i šumskih voćkarica, naučni cilj ovih istraživanja bio je da se na osnovu porasta visina sadnica oraha tretiranih sa tri različita tipa preparata ishrane odabere onaj preparat, čiji je uticaj na visinski razvoj sadnog materijala bio najveći i time doprineo pravilnom razvoju i optimalnom kvalitetu sadnica.

Na osnovu dobijenih rezultata konstatovano je da korišćeni preparati ishrane različito utiču na visinu sadnica oraha. Kontrolne sadnice i sadnice tretirane spororazlagajućim mineralnim đubrivom *Osmocote* pokazale su bolje rezultate u odnosu na one tretirane mikrobiološkim preparatom *Bactofil* i NPK mineralnim đubrivom *Florin*.

Kontrolisano razlagajuće đubrivo *Osmocote Exact*® pozitivno utiče na razvoj sadnica stimulišući razvoj visina sadnica, što je od posebnog značaja ako se ima u vidu da je visina, uz prečnik u korenovom vratu, jedan od najvažnijih morfoloških kriterijuma kvaliteta lišćarskih sadnica (Stilinović, S. 1987). Kao spororazlagajuće đubrivo, *Osmocote* takođe ima značaj, jer se dužina njegovog delovanja na biljke poklapa sa dužinom trajanja vegetacionog perioda.

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MICROBIOLOGICAL ACTIVITY OF THE FOREST SOIL IN THE AREAS WITHIN THE TERRITORY OF BELGRADE

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Abstract: *Within the process of matter circulation, soil microorganisms play a decisive role in the biological circulation of nutrition elements, i.e. plant assimilatives, through the process of organic matter (detritus) degradation via biosynthesis (humification) and mineralization (dehumification), releasing plant assimilatives and thus enabling forests to survive as natural ecosystems. Development of appropriate physiological groups of microorganisms participating in such processes and their biological activity are prerequisites of forest ecosystem stability. The results of the research in microbiological activity of the forest soil conducted in the areas within the territory of Belgrade include 19 locations of forested areas in both state and private ownership. Preliminary research suggested that the process of ammonification is by far the most significant in both synthesis and degradation of humus for plant assimilative formation (nitrogen, phosphorus, sulphur etc.); therefore the measures undertaken must be focused on ensuring normal and regular course of such processes.*

Key words: forest soil, ammonifying microorganisms, oligonitrofilic microorganisms, actinomycetes.

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MIKROBIOLOŠKA AKTIVNOST ŠUMSKIH ZEMLJIŠTA NA PODRUČJU BEOGRADA

Abstrakt: *U procesu kruženja materije zemljišni mikroorganiozmi imaju odlučujuću ulogu u biološkom kruženju elemenata ishrane – biljnih asimilativa kroz proces degradacije organske materije (stelje) biosintezom (humifikacijom) i mineralizacijom (dehumifikacijom) oslobađajući biljne asimilative i time omogućavajući šumi da opstane kao prirodni ekosistem. Razvoj odgovarajućih fizioloških grupa mikroorganizama koji učestvuju u ovim procesima i njihova biološka aktivnost je predpostavka stabilnosti šumskih ekosistema. Rezultati istraživanja mikrobiološke aktivnosti šumskih zemljišta koja su vršena na području Beograda obuhvataju 19 lokaliteta pod šumom u državnom i privatnom vlasništvu. Preliminarna istraživanja ukazuju da je proces amonifikacije, najznačajniji kako u sintezi tako i u razlaganju humusa za stvaranje biljnih asimilativa (azota, fosfora, sumpora i dr.), pa i mere koje se primenjuju moraju biti usmerene da se ovakvi procesi odvijaju normalno.*

Ključne reči: šumsko zemljište, amonifikaconi mikroorganizmi, oligonitrofilni mikroorganizmi, aktinomicete.

1. INTRODUCTION

Through their activity microorganisms enable today's living communities – biocenoses – to live as they are indispensable members of such communities (Varman, A.H., Evans, M.G., 2000).

Green plants create organic matter from inorganic compounds and they are producers. Animals consume the created organic matter and they are consumers. Microorganisms slowly degrade the created organic matter and create mineral compounds – plant assimilatives – necessary for the nutrition of plants and they are destroyers – reducers. This type of activity of microorganisms is called organic matter mineralization. It is the principal role of microorganisms in nature and it provides closure to the process of matter and energy circulation. Circulation itself is the material basis of all life in nature as thereby insignificant quantities of certain elements and compounds (carbon, nitrogen, phosphorus and others) are made infinite once they are introduced in the matter circulation process in nature (Sylvia, D.M.et. al., 2005, Tešić, Ž., 1968).

As natural plant ecosystems, forests rely on the natural processes of matter and energy circulation for their survival and development. Within such processes, soil microorganisms play a decisive role in the biological circulation of nutrition elements, i.e. plant assimilatives, through the process of organic matter (detritus) degradation via biosynthesis (humification) and mineralization (dehumification), releasing plant assimilatives and thus enabling forests to survive as natural ecosystems (Raičević, V. et al. 2010, Tešić, Ž., 1968). Humification refers to the biochemical and microbiological processes wherein fresh organic matter within the soil (forest litterfall) is converted into new humus matter of a colloidal nature. The course of humification and the nature of humus depend on the chemical composition. Such processes take place in a very dynamic soil environment and environmental conditions have a significant impact on the qualitative and quantitative composition of the microflora, the type of humification products and the course of humification (Atlas, R.M. et al., 1991, Mišustin, E.N., 1956). Development of appropriate physiological groups of microorganisms participating in such processes and their biological activity are prerequisites of the forest ecosystem stability. Their function in certain forest soil types with varying anthropogenic influence is a significant stability factor for such soils.

2. MATERIALS AND METHODS

Most forests in the territory of Belgrade belong to the Posavsko-Podunavski forest region, which is managed by Forest Estate Belgrade, whereof 16,686.70 hectares are state-owned and 15,636 hectares are privately owned. A portion of forests in the territory of Lazarevac Municipality belong to the Podrinjsko-Kolubarski forest region, which is managed by the Forest Estate Boranja-Loznica, whereof 379.37 hectares are state-owned and 6,172 hectares are privately owned. From May 2010 to April 2011, research in microbiological activity of forest soil was conducted at 19 locations of forested areas in both state and private ownership in the territory of Belgrade (Figure 1).

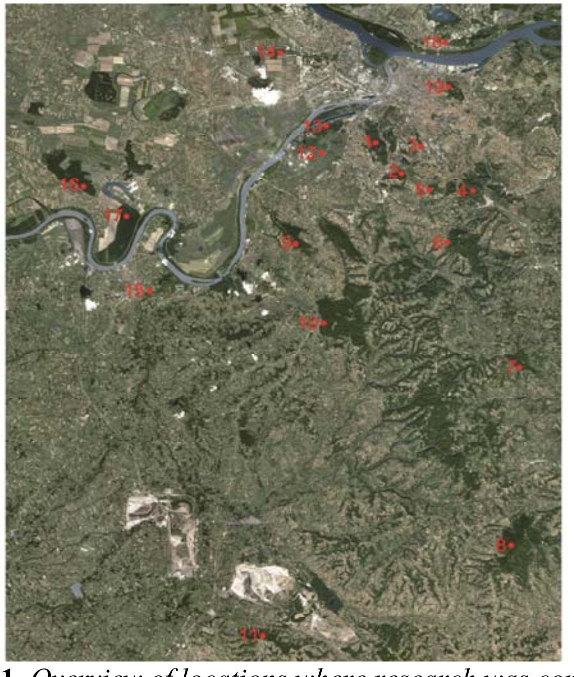

Figure 1. *Overview of locations where research was conducted*

1. **Košutnjak** – of deciduous species Turkey oak has a predominant share accompanied by large-leaved lime and silver lime, hornbeam and English oak, whereas the share of coniferous species is only 5%.
2. **Miljakovačka šuma** – poorly cultivated stands with lush and bushy stand understorey without internal open spaces.

3. **Banjička šuma** – belongs to the habitat of a potential ceno-ecological type of forest of English oak, hornbeam, Turkey oak and lime.
4. **Stepin lug-Jajinci** – dominant pure and mixed stands of black locust.
5. **Baba Velka** – mixed stands of deciduous trees (32%), mixed stands of coniferous trees (30%), pure stands of deciduous trees (23%), pure stands of coniferous trees (6%) and stands of mixed deciduous and conifers (only 1%).
6. **Avala** – most present tree species is sessile oak, which covers about 20% of the area of all forests.
7. **Trešnja** – the largest share is that of mixed stands of sprout origin (48%).
8. **Kosmaj** –79.32% of the forest area is covered by forests of sprout origin, whereas the share of tall deciduous tree forests is only 1.96% of the area.
9. **Sremački rt sa Goricom** – Turkey oak and Hungarian oak stands of sprout origin prevail here, followed by sprout origin stands of black locust and anthropogenic-originated stands of conifers (black pine and spruce) and deciduous trees (English oak and O.T.L.).
10. **Lipovica** – mixed deciduous stands of sprout origin prevail and there are, to a less extent, pure black locust stands of sprout origin.
11. **Lazarevačke šume** – most present of deciduous trees in this municipality are beech and Turkey oak and of conifers – black pine.
12. **Makiš** – both natural and anthropogenic deciduous forests.
13. **Ada Ciganlija** – these are mostly second generation stands of sprout origin, with only a very small share of Euro-American poplar.
14. **Šume uz autoput (Forests alongside the highway)** – are of anthropogenic origin with a wide range of autochthonous and allochthonous deciduous and coniferous species.
15. **Obrenovački zabran** – predominant sprout mixed stands of narrow-leafed ash and English oak, sprout mixed stands of willows and poplars and anthropogenic stands of I-214 and red oak.
16. **Bojčinska šuma** – predominant are anthropogenic tall English oak stands, both pure and mixed.
17. **Crni lug** – mostly comprised of stands of narrow-leafed ash and English oak as well as of poplar and black locust.
18. **Ritske šume** – predominant are anthropogenic stands – plantations of Euro-American poplar, which cover about 90% of the area according to data from the special records.
19. **Zvezdarska šuma** – deciduous and coniferous forests of anthropogenic origin.

During the months of analyses, sampling was conducted two times from three sites at each location and the averages thereof were analyzed in terms of presence of microorganisms as significantly indicative of soil activity in the forest ecosystems. The objective of the research was to determine the dynamics of the processes within the soil at the selected locations within forest ecosystems in the territory of Belgrade.

Field substrate sampling – at the selected locations the substrate for microbiological analysis was sampled two times in certain months whereby three samples were collected each time from the depth within the detritus zone (up to 10 cm) in the stands with formed detritus; at other sites, samples were collected from the depth of 10-20cm. The samples collected were packed in bags, labeled and placed in refrigerators in order to be prepared for laboratory analyses within 24 hours.

Substrate preparation under laboratory conditions – each month soil samples were collected from the 19 locations for determination of the total number of microorganisms present. This was achieved by cultivating soil suspension of 0.1 ccm in 10^{-3} dilution on nutritive base media. Cultivation was performed in three repetitions, and the number of microorganisms was calculated per 1gr of absolutely dry soil.

Nutritive base preparation for cultivation of soil suspension – in laboratory investigation four different nutritive bases were used: Czapek's agar, MPA (meat peptonic agar), Ashby's agar and synthetic agar. The base media used are of the following compositions:

Czapek's agar		**Synthetic agar with saccharose**		**MPA agar**		**Ashby's agar**	
$N_a NO_3$	3.0 gr	KH_2PO_4	0.5 gr	nutritive agar (Torlak, Belgrade)	41.3 gr	KH_2PO_4	0.2 gr
KH_2PO_4	1.0 gr	MgCO3	0.50 gr	distilled water	up to 1000ml	$MgSO_4$	0.2 gr
KCl	0.50 gr	NaCl	0.5 gr			NaCl	0.2 gr
$MgSO_4$	0.50 gr	KNO_3	1.0 gr			K_2SO_4	0.1 gr
$FeSO_4$	0.01 gr	$FeSO_4$	0.01gr			$CaCO_3$	5.0 gr
Agar	20.0 gr	$CaCO_3$	in excess	(1 liter of the base contains: peptone 15.0 gr, bovril 3.0 gr, NaCl 5.0 gr, potassium hydrogen phosphate 0.3gr, agar 18gr)		Agar	20.0 gr
Saccharose	3.0 gr	Agar	20.0 gr			Maltose (Glucose)	20.0 gr
Distilled water	up to 1000ml	Saccharose	25.0 gr			Distilled water	up to 1000ml
		Distilled water	up to 1000ml				

Nutritive bases were autoclaved at the temperature of 120^0C and pressure of 1.5 atm for 20 minutes. Subsequent to sterilization, the nutritive bases were poured into Petri dishes. In each Petri dish, soil suspension of 0.1 cm in 10^{-3} dilution was added to 25 ml of the nutritive base. All Petri dishes were placed in a thermostat at the temperature of 22 ± 1^0C. 5 and 10 days later, total respective numbers of fungi, bacteria and actinomycetes developed on the nutritive media were determined. Data on the numbers of microorganisms were then calculated per 1 gr of air dried soil, so that the numbers of the principal physiological groups of soil microorganisms were expressed in the units of 1,000 pcs/1gr of dry soil. Measurement data obtained per month were calculated into average values for each month analyzed and presented in tables as such.

3. RESULTS AND DISCUSSION

3.1. Total number of ammonifying microorganisms

Ammonifying microorganisms are among most significant physiological groups present in the soil. They participate in degradation of proteins thus releasing nitrogen (one of the essential elements for plant nutrition) from organic matter, converting it into more accessible forms. Degradation of organic matter through the activity of these microorganisms releases ammonia but only in the instances of sufficiently low C/N ratio within the organic matter. Otherwise almost all ammonia is used by the microorganisms for their own cell protoplasm synthesis; they partially comprise humus. At a number of locations the maximum numbers of these microorganisms were reached in September, whereas the minimum numbers were recorded in May. Large numbers were identified in autumn and winter months, from September to January. This was due to mild winter with daily temperatures above 0°C, ranging from +10 to +20°C, and precipitation which allowed sufficient moisture. The largest numbers of ammonifying microorganisms were recorded in the soil of deciduous forests in Banjica, Baba Velka, Jajinci, on Avala and in Lipovica. In the soil of anthropogenic forest parks such as Košutnjak, Miljakovac, Makiš, Ada Ciganlija, Avala and alongside the highway, the numbers of these microorganisms were significantly lower, as was the case in Obrenovački zabran, with predominant poplar trees. In Banjičke šume, Crni Lug (oak forests), Ritske šume, Trešnja and on Kosmaj (coniferous forests), the numbers of these microorganisms were significantly lower. This means that ammonification processes in organic matter degradation are depressed and inflow of plant assimilatives reduced. At such locations, these processes were influenced by vegetation (Table 1).

Table 1. *Total number of bacteria on MPA agar (1000 pcs / 1 g of dry soil)*

Locations	July	September	October	November	January	May
Kosutnjak	15.01	10.51	34.01	33.67	28.32	37.79
Miljakovac	15.62	68.19	26.26	39.87	40.67	34.86
Banjica	43.88	74.90	30.29	35.66	42.62	59.00
Baba Velka	30.26	60.14	26.58	44.98	59.29	38.81
Jajinci	38.64	30.76	29.77	32.45	23.12	61.43
Avala	21.88	33.02	39.40	53.14	37.09	44.01
Tresnja	19.27	20.59	17.18	36.93	20.83	36.40
Kosmaj	16.39	30.50	41.06	25.59	16.56	29.40
Gorica	15.48	44.16	13.86	31.22	52.55	19.98
Lipovica	39.05	87.55	41.56	45.88	38.44	17.40
Laz.sume	36.43	41.20	19.48	22.37	30.33	66.88
Makis	14.83	4.38	37.29	61.60	41.43	20.75
Ada Ciganlija	16.00	26.74	20.46	58.62	114.80	73.92
Auto put	17.28	29.81	23.19	51.53	35.21	43.78
Obrenovacki zabran	14.09	41.57	30.29	71.04	26.73	65.95
Bojcin	17.85	35.65	19.91	80.19	34.15	70.97
Crni lug	18.86	53.48	63.44	57.47	44.17	64.16
Ritske sume	17.17	39.63	49.24	75.95	56.44	81.81
Zvezdara	15.64	42.49	54.84	34.71	35.86	44.98

3.2. Total number of oligonitrofilic microorganisms

Microorganisms of this physiological group are satisfied with small quantities of nitrogen from the degraded organic matter as they have the ability to partially compensate for the lack of accessible nitrogen from the atmosphere through nitrogen fixation. This means that this physiological group, via the synthesis of its microbiological substance, introduces atmospheric nitrogen into the biological circulation. The number of bacteria (Table 2) from the group of oligonitrofililic microorganisms is rather subject to variation; however, it was observed that numbers rise at those locations where the numbers of ammonifying microorganisms are lower. In September and May these bacteria were not identified at the following locations: Banjica, Baba Velka, Jajinci, Trešnja, Kosmaj, Lipovica and Lazarevačke šume.

Table 2. *Total number of bacteria on Ashby's agar (1000 pcs / 1 g of dry soil)*

Locations	July	September	October	November	January	May
Kosutnjak	36.82	42.05	11.73	38.18	9.01	6.99
Miljakovac	21.60	20.32	12.60	15.93	5.11	6.45
Banjica	42.63	0.00	21.31	17.24	0.00	3.93
Baba Velka	39.89	35.43	35.82	1.08	0.00	4.31
Jajinci	17.56	0.00	0.00	18.07	0.00	8.38
Avala	21.88	0.00	8.75	1.36	9.27	8.56
Tresnja	25.58	0.00	13.74	23.63	0.00	8.49
Kosmaj	24.58	0.00	17.96	16.56	6.01	10.23
Gorica	26.19	0.00	9.24	22.29	0.00	0.00
Lipovica	10.12	0.00	56.22	0.00	0.00	13.38
Laz.sume	28.15	0.00	52.71	5.97	17.14	0.00
Makis	51.92	41.6	24.86	48.77	58.31	34.57
Ada Ciganlija	0.00	20.32	59.11	16.91	19.52	40.32
Auto put	11.52	6.39	40.85	21.47	50.99	3.75
Obrenovacki zabran	7.04	20.78	15.15	22.05	52.06	10.41
Bojčin	24.72	7.95	44.50	43.49	13.01	48.71
Crni lug	15.09	51.79	58.15	25.86	69.02	45.38
Ritske sume	4.29	26.42	17.30	13.32	22.88	56.14
Zvezdara	24.06	4.26	35.76	20.57	29.61	44.98

Numbers of fungi (Table 3) and bacteria (Table 2) varied immensely according to the weather and locations. Fungi were present in significant numbers and, together with bacteria from this group, suggested the lack of nitrogen in accessible form within the organic matter in the soil; on the other hand, such lack of nitrogen was compensated in certain amount with the nitrogen from the atmosphere through nitrogen fixation, which increased the inflow of plant assimilatives.

Table 3. *Total number of fungi on Ashby's agar (1000 pcs / 1g of dry soil)*

Locations	July	September	October	November	January	May
Kosutnjak	36.82	12.85	23.45	25.45	20.59	48.93
Miljakovac	44.26	22.34	7.35	14.79	21.73	27.11
Banjica	22.57	22.06	10.09	12.31	50.37	23.60
Baba Velka	18.16	38.91	16.18	2.16	51.56	18.69
Jajinci	19.90	18.23	0.0	3.87	15.03	48.86
Avala	14.16	11.79	24.07	8.17	18.77	41.56
Tresnja	45.94	28.59	20.61	23.63	7.81	26.69
Kosmaj	15.02	32.95	23.09	12.04	13.55	34.52
Gorica	45.25	33.12	16.88	8.92	37.34	19.98
Lipovica	33.27	53.16	15.89	18.16	28.83	53.54
Laz.sume	62.93	29.26	16.04	5.97	22.41	36.01
Makis	9.89	20.80	28.25	15.40	16.88	42.64
Ada Ciganlija	56.01	0.00	21.59	24.80	28.31	52.76
Auto put	58.75	28.75	4.42	9.66	10.93	56.29
Obrenovacki zabran	50.49	19.74	15.15	7.35	22.51	5.78
Bojcin	31.59	2.26	18.74	9.51	42.28	52.88
Crni lug	54.28	21.48	26.43	27.29	9.66	35.99
Ritske sume	61.54	1.10	31.94	10.66	13.73	73.79
Zvezdara	26.47	4.25	45.30	11.57	10.63	29.11

3.3. Total number of actinomycetes

Actionmycetes comprise a physiological group of microorganisms that vigorously degrade organic matter and humus up to the end-products of mineralization, thus releasing plant assimilatives. Actionmycetes were not identified on Czapek's agar. They were identified in small numbers only on the synthetic agar (Table 4), at the locations of Košutnjak, Miljakovac, Jajinci, Trešnja, on Kosmaj, in Makiš, Banjička šuma, Ritske šume and Zvezdara.

Table 4. *Total number of actinomycetes on Czapek's agar (1000 pcs/1g of dry soil)*

Locations	July	September	October	November	January	May
Kosutnjak	1.36	0.00	0.00	0.00	1.28	0.00
Miljakovac	0.00	0.00	0.00	0.00	0.00	0.00
Banjica	0.00	0.00	0.00	0.00	0.00	0.00
Baba Velka	0.00	0.00	0.00	0.00	0.00	0.00
Jajinci	0.00	0.00	0.00	0.00	0.00	0.00

Locations	July	September	October	November	January	May
Avala	0.00	0.00	0.00	0.00	19.80	0.00
Tresnja	7.41	0.00	0.00	0.00	0.00	0.00
Kosmaj	0.00	0.00	0.00	0.00	0.00	0.00
Gorica	5.95	0.00	0.00	0.00	0.00	0.00
Lipovica	0.00	0.00	0.00	0.00	0.00	0.00
Laz.sume	6.62	0.00	0.00	0.00	0.00	0.00
Makis	0.00	0.00	0.00	0.00	10.70	2.30
Ada Ciganlija	0.00	0.00	0.00	0.00	0.00	1.34
Auto put	0.00	0.00	0.00	0.00	0.00	0.00
Obrenovacki zabran	0.00	0.00	0.00	0.00	0.00	2.31
Bojcin	0.00	0.00	0.00	0.00	0.00	5.56
Crni lug	2.75	0.00	0.00	0.00	0.00	4.69
Ritske sume	0.00	0.00	0.00	0.00	0.00	11.22
Zvezdara	0.00	1.06	0.00	0.00	0.00	3.96

Table 5. *Total number of actinomycetes on synthetic agar (1000 pcs/1g of dry soil)*

Locations	July	September	October	November	January	May
Kosutnjak	1.36	1.17	2.34	15.27	0.00	4.19
Miljakovac	0.00	0.00	0.00	0.00	0.00	3.87
Banjica	6.26	0.00	3.36	0.00	0.00	0.00
Baba Velka	0.00	0.00	0.00	0.00	0.00	0.00
Jajinci	0.00	2.28	0.00	0.00	0.00	1.39
Avala	0.00	0.00	0.00	0.00	0.00	0.00
Tresnja	0.00	0.00	0.00	0.00	0.00	2.42
Kosmaj	0.00	0.00	0.00	0.00	0.00	5.11
Gorica	0.00	0.00	0.00	0.00	0.00	0.00
Lipovica	0.00	0.00	0.00	0.00	0.00	0.00
Laz.sume	0.00	0.00	0.00	0.00	0.00	0.00
Makis	0.00	0.00	0.00	0.00	0.00	2.30
Ada Ciganlija	0.00	0.00	0.00	0.00	0.00	0.00
Auto put	0.00	0.00	0.00	0.00	0.00	0.00
Obrenovacki zabran	0.00	0.00	0.00	0.00	0.00	0.00
Bojcin	0.00	0.00	0.00	0.00	0.00	5.56
Crni lug	0.00	0.00	0.00	0.00	0.00	0.00
Ritske sume	0.00	2.2	2.66	0.00	0.00	3.21
Zvezdara	0.00	0.00	1.19	0.00	0.00	6.61

3.4. Total number of fungi

In forest soil this physiological group of microorganisms mostly engages in cellulose, hemicelluloses and lignin matter degradation. Under aerobic conditions, cellulose and hemicelluloses transformations are conducted turbulently, but not up to the end-products, so they comprise humus indirectly, through synthesized microbiological substance (mucilage). Microorganisms of this physiological group were not present in large numbers on synthetic (Table 6) and on Czapek's agar (Table 7). The exceptions were coniferous forests at locations in Trešnja and on Kosmaj, as well as Bojčinska šuma and Crni lug, where their number was considerably greater. This suggests a significant role of fungi in humus biosynthesis at these locations.

Table 6. *Total number of fungi on synthetic agar (1000 pcs / 1 g of dry soil)*

Locations	July	September	October	November	January	May
Kosutnjak	13.64	26.86	17.59	16.55	38.61	23.79
Miljakovac	14.32	24.69	9.45	22.75	12.71	21.95
Banjica	12.54	4.61	14.58	23.39	27.03	24.91
Baba Velka	8.46	29.48	10.40	5.41	63.16	25.87
Jajinci	16.39	26.20	13.09	16.78	15.03	58.64
Avala	11.58	9.43	18.60	6.81	7.95	6.11
Tresnja	32.61	43.46	18.32	23.58	28.64	19.41
Kosmaj	13.66	40.27	17.96	21.78	6.02	33.24
Gorica	20.24	45.26	9.24	10.54	30.42	7.49
Lipovica	95.46	65.67	41.56	34.21	16.47	9.37
Laz.sume	27.51	27.31	14.52	10.90	7.91	33.44
Makis	28.43	16.42	11.29	8.98	12.27	31.12
Ada Ciganlija	10.29	13.90	0.00	9.02	14.15	15.11
Auto put	13.82	3.19	12.15	17.18	3.64	17.51
Obrenovacki zabran	2.35	1.04	10.82	4.89	21.11	11.57
Bojcin	40.04	17.83	23.42	36.69	27.61	57.05
Crni lug	11.31	13.89	46.26	18.68	12.42	55.12
Ritske sume	17.17	0.00	19.96	11.99	9.15	19.83
Zvezdara	16.42	6.37	10.73	3.86	11.95	15.72

Table 7. *Total number of fungi on Czapek's agar (1000 pcs / 1 g of dry soil)*

Locations	July	September	October	November	January	May
Kosutnjak	28.60	9.34	7.03	21.64	38.61	2.79
Miljakovac	13.02	18.19	13.65	13.65	11.51	5.16
Banjica	13.79	28.81	8.96	24.63	14.21	0.00
Baba Velka	19.37	11.79	4.62	0.00	6.57	2.87

Locations	July	September	October	November	January	May
Jajinci	2.34	25.06	2.38	24.52	3.76	5.58
Avala	11.58	0.00	10.94	5.45	9.27	24.45
Tresnja	42.98	34.31	4.58	7.39	9.11	0.00
Kosmaj	35.51	48.81	10.26	15.05	13.55	6.39
Gorica	28.58	18.77	16.17	17.84	22.13	3.75
Lipovica	62.19	12.51	23.22	26.83	23.34	2.68
Laz.sume	41.39	52.67	16.94	4.47	26.36	7.72
Makis	33.38	0.00	25.99	28.23	1.53	9.22
Ada Ciganlija	18.59	10.69	18.19	2.26	17.29	17.47
Auto put	5.76	10.47	7.73	9.66	3.64	18.31
Obrenovacki zabran	16.44	13.51	12.98	2.45	2.81	37.02
Bojcin	42.57	4.48	17.57	43.49	11.38	30.61
Crni lug	45.26	3.79	70.05	22.99	6.90	58.86
Ritske sume	11.45	2.20	29.28	2.66	3.05	33.69
Zvezdara	22.86	3.18	24.38	15.42	1.33	26.46

4. CONCLUSION

In the soil of deciduous forests at all locations investigated ammonification processes continue unhindered, which is suggested by the large numbers of ammonifying microorganisms. Due to smaller numbers of ammonifying organisms, weaker inflow of organic matter and its elemental composition (coniferous species, oaks and poplars) as well as due to the C/N ratio, in forest parks which are anthropogenically impaired, ammonification processes are slow. Humification processes are predominant in the soil of all locations investigated. Small numbers of actinomycetes at all locations imply that dehumification processes are performed with difficulties and the formation of easily accessible plant assimilatives is reduced. Preliminary research suggests that the ammonification process is most significant in both humus synthesis and degradation for creation of plant assimilatives (nitrogen, phosphorus, sulphur, etc.); therefore the measures undertaken must be focused on ensuring normal and regular course of such processes.

Selective logging in mixed stands should stimulate the selection of species that will provide detritus of favorable humus composition. By opening canopies, conditions are created for inflow of sunlight and soil warming. Adequate temperatures of the soil and its water and air patterns have favorable effects on the microbiological processes which will stimulate the inflow of plant assimilatives and thus growth and yield.

Soil microorganisms and processes they participate in are causally related to the environmental conditions. Soil microorganisms are very susceptible to any anthropogenic influence, which results in their degradation.

Monitoring of the numbers and activities of forest soil microorganisms ought to enable our timely identification of disorders in the relevant ecosystem and allow us to implement certain forestry and cultivation measures for the purpose of indirect prevention of further degradation. In order to infer a conclusion on the tendency, direction and extent of the soil degradation, and thus plant ecosystem degradation, monitoring ought to be continued. Based on the results of years long monitoring of the microbiological activity of forest soil, practical solution will be proposed in the future as to what systems at relevant locations can be improved by applying forestry cultivation measures. In this way, activities of soil microbe communities will contribute to the stability and sustainability of the forest ecosystems in the long term.

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MICROBIOLOGICAL ACTIVITY OF THE FOREST SOIL IN THE AREAS WITHIN THE TERRITORY OF BELGRADE

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Summary

Forest ecosystems rely on the process of natural matter ad energy circulation for their survival. Within the process of matter circulation, soil microorganisms play a decisive role in the biological circulation of nutrition elements, i.e. plant assimilatives, through the process of organic matter (detritus) degradation via biosynthesis (humification) and mineralization (dehumification), releasing plant assimilatives. In this way, nutritive matter is returned to the forests, allowing the plants to survive and develop.

Development of appropriate physiological groups of microorganisms participating in such processes and their biological activity are prerequisites of the forest ecosystem stability. Their function in certain forest soil types with varying anthropogenic influence is a significant stability factor for such soils.

From May 2010 to April 2011, research in microbiological activity of forest soil was conducted at 19 locations of forested areas in both state and private ownership in the territory of Belgrade.

Preliminary research suggests that the ammonification process is most significant in both humus synthesis and degradation for creation of plant assimilatives (nitrogen, phosphorus, sulphur, etc.); therefore the measures undertaken must be focused on ensuring normal and regular course of such processes.

Monitoring of the numbers and activities of forest soil microorganisms ought to enable our timely identification of disorders in the relevant ecosystem and allow us to implement certain forestry and cultivation measures for the purpose of indirect prevention of further degradation. In order to infer a conclusion on the tendency, direction and extent of the soil degradation, and thus plant ecosystem degradation, monitoring ought to be continued.

MIKROBIOLOŠKA AKTIVNOST ŠUMSKIH ZEMLJIŠTA NA PODRUČJU BEOGRADA

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Rezime

Na procesima kruženja materije i energije u prirodi šumski ekosistemi zasnivaju svoj opstanak. U tom procesu zemljišni mikroorganiozmi imaju odlučujuću ulogu u biološkom kruženju elemenata ishrane – biljnih asimilativa. Oni se odvijaju kroz proces degradacije organske materije (stelje) biosintezom (humifikacijom) i mineralizacijom (dehumifikacijom) oslobađajući biljne assimilative. Na taj način se šumi vražaju hranljive materije koje omogućavajući biljkama u šumi da opstanu i da se razvijaju.

Razvoj odgovarajućih fizioloških grupa mikroorganizama koji učestvuju u ovim procesima i njihova biološka aktivnost je predpostavka stabilnosti šumskih ekosistema. Njihovo funkcionisanje u određenim tipovima šumskog zemljišta različitog antropogenog uticaja, značajno je za stabilnost takvih zemljišta.

U periodu maj 2010. godine i april 2011. godine na području Beograda vršena su istraživanja mikrobiološke aktivnosti šumskih zemljišta na 19 lokaliteta pod šumom u državnom i u privatnom vlasništvu

Preliminarna istraživanja ukazuju da je proces amonifikacije, najznačajniji kako u sintezi tako i u razlaganju humusa za stvaranje biljnih asimilativa (azota, fosfora, sumpora i dr.), pa i mera koje primenjujemo moraju biti usmerene da se ovakvi procesi odvijaju normalno. Monitoring broja mikroorganizama i njihove aktivnosti u šumskim zemljištima treba da nam omogući da na vreme uočimo poremećaje u tom sistemu i da određenim šumsko uzgojnim merama posrednim putem sprečimo dalju degradaciju. Da bi se doneo zaključak o tendenciji, pravcu i stepenu degradacije zemljišta, a samim tim i ispitivanih šumskih ekosistema, istraživanja treba nastaviti.

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MANALYSIS OF THE IMPACT OF INJURIES CAUSED BY THE INFLUENCE OF MECHANICAL AND ABIOTIC FACTORS ON THE OCCURRENCE OF HARMFUL FUNGAL ORGANISMS

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***Abstract**: The research described in this paper is focused on the occurrence of pathogenic microorganisms on beech trees relative to the presence of tree injuries, with the aim to ensure protection and preservation of this species in Serbia. The research was conducted in eastern Serbia, in a hillside beech forest Fagetum moesiacae submontanum of generative origin. The testing was carried out on two sites over 51 testing plots, with a total of 829 trees and 21 species of identified fungi. On the first site 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%). On the second site there was a strong correlation link between the occurrence of fungi and presence of mechanical damage - 51.88%, as well as between the fungi and abiotic damage – 47.96%. The health condition of high beech stands was found to be heavily dependent on careful and proper manipulation during harvesting, while each injury inflicted on a beech live tree during logging opens the door to infection with pathogenic microorganisms.*

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Key words: injuries, environmental factors, fungi, beech forests

АНАЛИЗА УТИЦАЈА ОЗЛЕДА ПРОУЗРОКОВАНИХ ДЕЈСТВОМ МЕХАНИЧКИХ И АБИОТИЧКИХ ФАКТОРА НА ПОЈАВУШТЕТНИХ ГЉИВИЧНИХ ОРГАНИЗАМА

Извод: *У раду је истраживан аспект појаве патогених микроорганизама на буковом дрвету у односу на присуство озледа на стаблима, у циљу заштите и очувања ове врсте у Србији. Истраживања су вршена у источној Србији, у брдској шуми букве Fagetum moesiacae subtontanum, генеративног порекла. Испитивањем је обухваћено два локалитета на 51 огледној парцели, са укупно 829 стабала и констатовано је присуство 21 врста гљива. На првом локалитету констатовано је да појава гљива првенствено зависи од присуства механичких оштећења на стаблима (чак 73.46%), а готово уопште није у вези са присуством абиотичких оштећења (свега 3.21%). На другом локалитету постоји јака корелациона веза између појаве гљива и присуства механичких оштећења – 51.88%, као и између гљива и абиотичких оштећења – 47.96%. Констатовано је да за здравствено стање високих букових састојина изузетан значај има пажљиво и правилно манипулисање приликом сече, а свака озледа на буковим дубећим стаблима почињена при сечи је отворен пут за заразу патогеним микроорганизмима.*

Кључне речи: оштећења, спољна средина, гљиве, букове шуме

1. INTRODUCTION

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 (Milovanovic *et al* 2004). 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 Medarevic *et al* 2008).

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 (Bankovic *et al* 2009). 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% (Bankovic *et al* 2000).

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 (Stojanovic & Krstic 2003, Koprivica *et al* 2009).

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 (Vuckovic *et al* 2005), 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 (Karadzic & Milijasevic 2005).

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 (Tabakovic-Tosic & Markovic 2003, Miletic *et al* 2006, Markovic *et al* 2011a, Markovic *et al* 2011b).

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. The first tested site was located in the administration unit Majdan Kucajna, division 33. The second site was in administration unit Crni Vrh, division 42, sections *a* and *b*. The research included the total of 829 beech trees on 51 test plots.

The 500 m^2 trial experimental plots were circular, placed in the stands at 100 x 100 m distances (according to the method described by Koprivica *et al* 2008). Each experimental plot included between 4 and 24 trees on site I, and between 8 and 27 trees on site II. 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 & Matovic, 2005, Markovic *et al* 2007. 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 site 1 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 and table 2 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.

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* sp.**	**	100.0	24.6
3	***Hypoxylon* sp.**	**	100.0	8.9
4	***Stereum* sp.**	**	100.0	12.6
5	***Diatrype stigma***	*	65.2	11.1
6	***Fomes fomentarius***	***	57.0	6.5
7	***Trametes* sp.**	**	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 coraloides***	*	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

Under the classification proposed by Karadzic 2003, 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* sp. and *Trametes* sp.

* 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* sp. and *Diatrype stigma.*

- fungi with no significance (representatives of this group identified on the tested sites include *Auricullaria auricula judae*, *Auricullaria mesenterica* and *Bulgaria polymorpha*).

Table 2. *Fungi identified on site II – Administration unit Crni Vrh, division 42, sections a, b*

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	***Coriolus* sp.**	**	100.0	18.3
2	***Apiognomonia errabunda***	***	82.0	15.0
3	***Hypoxylon* sp.**	**	78.6	6.5
4	***Nectria coccinea***	***	64.3	7.1
5	***Nectria galligena***	***	53.6	6.5
6	***Diatrype stigma***	*	35.7	5.7

7	***Fomes fomentarius***	***	21.0	2.2
8	***Hydnum coraloides***	*	14.3	0.8
9	***Stereum* sp.**	**	10.7	1.2
10	***Diatrype disciformis***	**	7.1	1.4
11	***Armillaria mellea***	***	7.0	0.6
12	***Dedalea quercina***	**	3.6	0.2

Table 3 presents the testing results for the total number of the present fungi and the total number of mechanical and abiotic damage on site II.

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". On site I, this fungus was found on 1.2% of trees or on 3 experimental plots (1,3 and 9), whereas on site II its spread was much greater and covered 7.1% of trees or almost two-thirds of experimental plots. 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.

Table 3. *Overview of attack by fungi and injuries on beech trees on site I – Administration unit Majdan Kucajna, division 33*

(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				
12	1	3	4	2	3	5	0.42
24	1	4	5	3	4	7	0.29
9	1	3	4	2	3	5	0.56
11	1	3	4	1	3	4	0.36
16	1	5	6	8	1	9	0.56
9	1	4	5	6	2	8	0.89
16	4	6	10	15	6	21	0.06
12	4	6	10	20	9	29	2.42
23	6	9	15	27	4	31	1.35
15	1	6	7	3	1	4	0.27
21	2	6	8	17	9	26	1.24
18	3	6	9	21	3	24	1.33
8	1	5	6	14	2	16	2.00
11	2	6	8	15	3	18	1.64
19	2	6	8	11	10	21	1.11
4	1	5	6	4	1	5	1.25
15	3	5	8	16	42	20	1.33
9	1	4	5	9	6	11	1.22
23	4	8	12	19	7	25	1.09

8	2	4	6	7	3	14	1.75
8	1	5	6	14	3	17	2.12
17	4	6	10	12	8	20	1.18
16	3	7	10	23	4	27	1.69

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 (Karadzic 2003, Ivkovic et al 2007).

The data presented in Table 3 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, on site I, 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 from site I 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.

Condition on site II is presented in Table 4, which was the 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'.

Statistical analysis of the obtained data demonstrated that on this site there was a significant statistical link between all presented columns, as well as between the number of abiotic injuries and occurrence of fungi. While this was not the case on the previous site, it appeared here as a consequence of a large number of injuries. The strongest correlation link was the one between the total number of fungi and mechanical injuries (columns y_3 and x_1), amounting to 51.88%. Another strong link existed between the total number of fungi and abiotic injuries (columns y_3 and x_2), only slightly weaker than the previous one at 47.96%. The links between the number of dangerous and other fungi (y_1, y_2) and mechanical and abiotic injuries (x_1, x_2) were significant, ranging from 26.70% and 36.47%, where the links between the fungi and mechanical injuries were stronger by roughly 2 to 5% than the links between the occurrence of fungi and abiotic injuries.

Table 4. *Overview of attack by fungi and injuries on beech trees on site II – Administration unit Crni Vrh, division 42, sections a, b*

($x^{'}$) 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	5	6	11	16	42	58	2.90
27	3	3	6	12	7	19	0.70
22	5	3	8	16	34	50	2.27
20	4	2	6	4	34	38	1.90
21	3	3	6	10	17	27	1.29
9	1	2	3	4	8	12	1.33
11	0	3	3	7	7	14	1.27
14	0	2	2	2	7	9	0.64
22	3	2	5	5	7	12	0.54
17	4	2	6	8	37	86	5.06
10	1	2	3	2	19	19	1.90
12	2	2	4	8	14	22	1.83
16	2	2	4	10	7	17	1.06
23	3	2	5	10	3	13	0.56
21	3	2	5	14	2	16	0.76
25	2	5	7	16	27	43	1.72
19	1	3	4	11	9	20	1.05
14	1	2	3	3	11	14	1.00
23	4	2	6	14	10	24	1.04
19	3	2	5	5	17	22	1.16
11	0	2	2	6	8	14	1.27
23	3	2	5	1	18	19	0.83
20	1	2	3	3	9	12	0.60
20	0	2	2	1	3	4	0.20
8	0	2	2	1	15	16	2.00
26	3	2	5	12	20	32	1.23
18	3	2	5	15	15	30	1.67
13	3	2	5	7	8	15	1.15

This means that the occurrence of fungi (both dangerous and other fungi) on the second site – column y_3 – was directly linked to the presence of mechanical and abiotic injuries - x_1 and x_2. In other words, the results obtained through comparative analysis of sites I and II lead to conclusion that the number of injuries is in fact the determining factor linking the occurrence of fungi and damage to trees. On sites with fewer injuries the correlation links between the occurrence of fungi and the injuries on trees are less strong, and vice versa.

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 on the first site showed that the occurrence of fungi had almost no connection to the presence of abiotic damage (the correlation link was only 3.21%).

On the second site, there was a statistically significant difference between all columns, as well as between the number of abiotic injuries and the occurrence of fungi. This was not the case on the previous site, but appeared here as a result of a large of number of injuries. The strongest correlation link was the one between the total number of fungi and the mechanical injuries, amounting to 51.88%. The link between the total number of fungi and abiotic injuries was also strong at 47.96%, whereas the links between the number of dangerous and other fungi on one hand and mechanical and abiotic injuries on the other, ranging 26.70% to

36.47%, may be considered significant. This effectively means that the occurrence of fungi on the second site was directly linked to the presence of both mechanical and abiotic injuries.

Based on the results of the comparative analysis of the two sites, 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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ANALYSIS OF THE IMPACT OF INJURIES CAUSED BY THE INFLUENCE OF MECHANICAL AND ABIOTIC FACTORS ON THE OCCURRENCE OF HARMFUL FUNGAL ORGANISMS

Miroslava MARKOVIC, Snezana RAJKOVIC, Radoslav RAJKOVIC

Summary

The research was conducted in eastern Serbia, in a hillside beech forest *Fagetum moesiacae submontanum* of generative origin. The testing was carried out on two sites over 51 testing plots, with a total of 829 trees and 21 species of identified fungi. On the first site 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%). On the second site there was a strong correlation link between the occurrence of fungi and presence of mechanical damage - 51.88%, as well as between the fungi and abiotic damage – 47.96%.

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 on the first site showed that the occurrence of fungi had almost no connection to the presence of abiotic damage (the correlation link was only 3.21%).

On the second site, there was a statistically significant difference between all columns, as well as between the number of abiotic injuries and the occurrence of fungi. This was not the case on the previous site, but appeared here as a result of a large of number of injuries. The strongest correlation link was the one between the total number of fungi and the mechanical injuries, amounting to 51.88%. The link between the total number of fungi and abiotic injuries was also strong at 47.96%. This effectively means that the occurrence of fungi on the second site was directly linked to the presence of both mechanical and abiotic injuries.

Based on the results of the comparative analysis of the two sites, 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. The health condition of high beech stands was found to be heavily dependent on careful and proper manipulation during harvesting, while each injury inflicted on a beech live tree during logging opens the door to infection with pathogenic microorganisms.

АНАЛИЗА УТИЦАЈА ОЗЛЕДА ПРОУЗРОКОВАНИХ ДЕЈСТВОМ МЕХАНИЧКИХ И АБИОТИЧКИХ ФАКТОРА НА ПОЈАВУ ШТЕТНИХ ГЉИВИЧНИХ ОРГАНИЗАМА

Мирослава МАРКОВИЋ, Снежана РАЈКОВИЋ, Радослав РАЈКОВИЋ

Резиме

Истраживања су вршена у источној Србији, у брдској шуми букве *Fagetum moesiacae submontanum*, генеративног порекла. Испитивањем је обухваћено два локалитета на 51 огледној парцели, са укупно 829 стабала и констатовано је присуство 21 врста гљива. На првом локалитету констатовано је да појава гљива првенствено зависи од присуства механичких оштећења на стаблима (чак 73,46%), а готово уопште није у вези са присуством абиотичких оштећења (свега 3,21%). На другом локалитету постоји јака корелациона веза између појаве гљива и присуства механичких оштећења – 51,88%, као и између гљива и абиотичких оштећења - 47,96%.

На првом испитиваном локалитету, појава гљива првенствено зависи од присуства механичких оштећења – веза је јака, износи чак 73,46%, а осталих 26,54% зависи од других фактора. Насупрот томе, статистичка анализа добијених података на првом локалитету показује да појава гљива готово да уопште није у вези са присуством абиотичких оштећења (корелациона веза износи свега 3,21%).

На другом локалитету постоји значајна статистичка веза између свих колона, па и између броја абиотичких оштећења и појаве гљива, што није био случај са претходно приказаним локалитетом, а што је у овом случају последица великог броја оштећења. Најјача корелациона веза постоји између укупног броја гљива и механичких оштећења и износи 51,88%. Веза између укупног броја гљива и абиотичких оштећења је такође јака и износи 47,96%. То практично значи да је појава гљива на другом локалитету, у директној вези са присуством и механичких и абиотичких оштећења.

Ако се посматрају резултати добијени упоредном анализом првог и другог локалитета, може се рећи да је опредељујући фактор који доводи у везу појаву гљива

и оштећења на стаблима управо број оштећења. На локалитетима са мањим бројем оштећења корелационе везе између појаве гљива и озледа на стаблима су слабије и обрнуто. Констатовано је да за здравствено стање високих букових састојина изузетан значај има пажљиво и правилно манипулисање приликом сече, а свака озледа на буковим дубећим стаблима почињена при сечи је отворен пут за заразу патогеним микроорганизмима.

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UDK 630*416.2+630*443.2]:630*228.7 Pinus wallichiana =111
Original scientific paper

DISEASES AND INJURIES OF HIMALAYAN PINE SEED FROM CULTURE GROWN ON DEPOSOL

Vesna GOLUBOVIĆ ĆURGUZ[1], Katarina MLADENOVIĆ[2], Biljana NIKOLIĆ[2], Snežana RAJKOVIĆ[2]

Abstract: *Approximately 100 semi-ripe cones were harvested from a young forest culture of Pinus wallichiana grown on loamy deposol. Opening of cone scales and dropping of seed grains were induced under laboratory conditions. The number of damaged seeds and the type of damage, as well as the total and average number of seeds per cone, were determined on the population and individual levels. The intensity of damage was expressed in percentages. The analyses for determination of the present fungi and the intensity of their attack were conducted by placing the seeds onto a nutritious MEA bed and moist filter paper in Petri dishes. In order to establish the presence of insects, cones with visible damage were collected in the field. These cones were then examined in the laboratory and placed into photoeclectore for further growing.*

Key words: *Pinus excelsa*, Himalayan pine, *Penicillium*, *Alternaria*, *Dioryctria abietella*

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BOLESTI I OŠTEĆENJA SEMENA U KULTURI HIMALAJSKOG BORA GAJENOG NA DEPOSOLU

Izvod: *Iz mlade šumske kulture Pinus wallichiana osnovane na ilovastom deposolu, sakupljeno je oko 100 poluzrelih šišarica. U laboratorijskim uslovima indukovano je otvaranje njihovih plodnih ljuspi i ispadanje semena. Broj oštećenih semenki i vrsta oštećenja kao i ukupan i prosečan broj semenki po šišarici utvrđeni su na populacionom i individualnom nivou. Intenzitet oštećenja iskazan je u %. Analize za determinaciju prisutnih gljiva kao i intenziteta njihovog napada uradjene su postavljanjem semena na hranljivu MEA podlogu i vlažan filter papir u petri posudama. Radi utvrđivanja prisustva insekata sakupljane su šišarice, sa vidljivim oštećenjima, na terenu. Šišarice su zatim pregledane u laboratoriji i stavljane u fotoeklektori radi daljeg gajenja.*

Ključne reči: *Pinus excelsa*, Himalayan pine, *Penicillium*, *Alternaria*, *Dioryctria abietella*

1. INTRODUCTION

Himalayan pine (*Pinus wallichiana* A. B. Jacks.) is a conifer whose areal spreads over southern and western Himalayas, eastern Afghanistan, north-east Belugistan, northern Burma and Yunnan province in China. In the Himalayas it appears in pure and mixed stands, on the elevation between 2,000 and 2,000 meters. It is the second most important tree species in the Himalayas, following the Himalayan cedar. It has wide ecological amplitude, with the elevation border of 1,800 – 3,500 meters above the sea level. The Himalayan pine grows up to 50 m in height. The bark on the trunk of fully grown trees has scale-like cracks while the crown is in the shape of a pyramid, in particular in solitary trees, whose branches drop to the ground. The needles and cones of this five-needle pine are exceptionally long (Vidakovic 1982), which further contributes to its decorative value, and it is therefore frequently encountered in parks in this region.

Himalayan pine is characterized by fast growth, early flowering and seed production, high resistance to frost in urban conditions (Bunusevac 1959) and high resistance to fungal disease *Cronartium ribicola* and entomological damage from *Pissodes strobi,* both far more frequent causes of disease of its North American kin, Eastern white pine, *Pinus strobus* L. (Vidakovic1982 and the quoted references).

In Serbia, the Himalayan pine may be encountered in parks in major cities or around homes as solitary trees or in smaller groups. Although it grows best on deep, fresh soils, the stands of this species also grow well and have a solid increment on more barren soils, damaged by exploitation of coal (Drazic, 1997). Several authors have already studied the group and individual variability of this species in park plantations in our conditions, related to speed of growth and increment, flowering, seed production and adaptability (Milojevic-Nikolic 1991, 1992; Milojevic 1989; Nikolic 1996, 1997), as well as on the success of establishing and developing artificial cultures on deposits of strip mines (Nikolic et al, 1998, 2004). Moreover, there are preliminary results regarding individual resistance of grown trees of Himalayan pine to some phytopathological diseases of seeds and sprouts (Golubovic – Curguz and Nikolic, 1999). In order to undertake appropriate measures, knowledge on pest bionomics is vital because of trophic links of certain species of insects, cultures and pine stands. Economically significant types of moths are lately appearing in masses, which may lead to total destruction of seed harvest and consequently make it impossible for forests to regenerate naturally.

2. MATERIAL AND METHODS

In a 25-year-old forest culture of Himalayan pine, spreading over an area on 0.9 ha and grown on loamy deposol, deposit of lignite strip mine in Kolubara Mining Basin, Barosevac locality, in the second half of September approximately 10 semi-ripe cones were collected from 10 trees each. Under laboratory conditions (in a dry chamber at 35° C), opening of cone scales and dropping of seed grains were induced over the following month. In this process, substantial damages from insects and fungi were found on cones and seeds. The number of damaged seeds and the types of damage, as well as the total number of seeds per cone, were tested on the individual level (for each tree separately) and population level (the average of all trees). The intensity of damage was expressed in percentages (the number of damaged cones versus the total number of cones). Seed production was expressed in the number of seeds per cone.

Laboratory analyses of the health condition of seeds brought from the field were conducted in the Institute of Forestry. The seeds were first sterilized in Na hypochlorite with 1.5% content of active chlorine, and then rinsed out three times in sterile water and placed in Petri dishes. The bottom of the Petri dishes was lined with double layers of filter paper soaked in 20 ml of sterile water. The second portion of the seeds was placed into Petri dishes with nutritious MEA bed, five seeds per dish. All Petri dishes with seeds were placed in the thermostat at the temperature of 22 ± 1^0 C. After that the control of present microflora was conducted, where their morphological appearance was determined along with the ability for seed production on artificial beds and the size of seed-bearing bodies and reproductive organs.

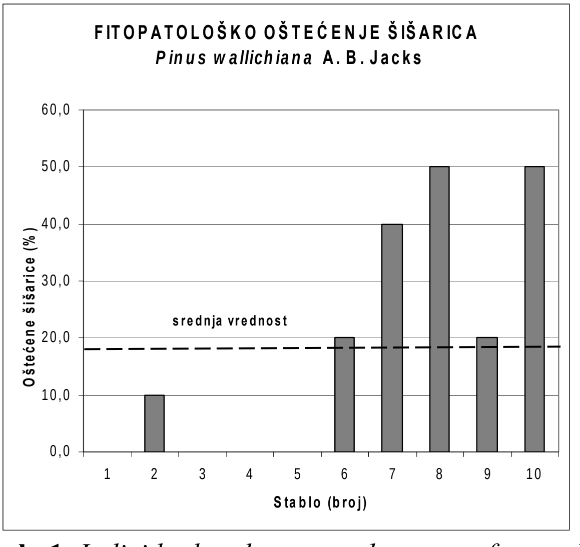
The keys used for determination of fungi keys were by B.C. Sutton (The Coleomycetes, 1980), J.V. Carmichael et al (Genera of Hyphomycetes, 1980) and R.W.G. Dennis (British Ascomycetes, 1978).

The collected cone samples were examined in the laboratory of the Division for Plant Protection of the Institute of Forestry. The samples containing moth caterpillars were cultivated for imagos. Upon eclosion the imagos were destroyed, preserved and identified. The preserved units and photographic documentation is kept in the archive of the Institute of Forestry in Belgrade.

3. RESULTS

3.1. Seed damages caused by the presence of fungi

Seed damages caused by the presence of fungal organisms were recorded in 18.28% of cones (on the average) with very high individual variability (in 0-50% of cones per tree) (Graph 1). Even though the microscopic examination revealed no symptoms of disease in seeds of trees number 1, 3, 4 and 5, samples from all trees were placed onto nutritious beds. Laboratory analysis confirmed that only the seed from tree no. 1 is free from the presence of fungi. Seeds from other analyzed trees showed presence of fungi from genera *Alternaria, Fusarium, Penicillium, Trichothecium (tab. 1).* The most frequently found were fungi from the genus *Penicillium* (in 50.4% of the analyzed seeds), while the least frequent were fungi from the genus *Fusarium* (3.5% of the analyzed seeds).



Graph. 1. *Individual and average damages of cones by fungi*

Table 1. *The intensity of the presence of fungi on seeds of the analyzed trees*

Ordinal number of trees	The intensity of the presence of fungi (%)			
	Alternaria	*Penicillium*	*Trichothecium*	*Fusarium*
2	2.7	9.9	3.5	-
3	-	8.6	3.7	-
5	-	7.4	-	1.5
6	2.4	-	-	-
7	-	6.8	-	0.7
8	2.3	7.1	1.0	1.3
9	-	6.5	-	-
10	2.9	4.1	-	-

3.2. Entomological contamination of seeds

Visible entomological damages on seeds were recorded in almost one-third of the harvested cones (31.31%, on the average), with even higher individual variability (in 0 – 80% of cones per tree) (Graph 2) than the phytopathological damages.

The presence of moth *Dioryctria abietella* (Denis & Schiffermuller 1775), or Fir Coneworm, was determined in the tested material.

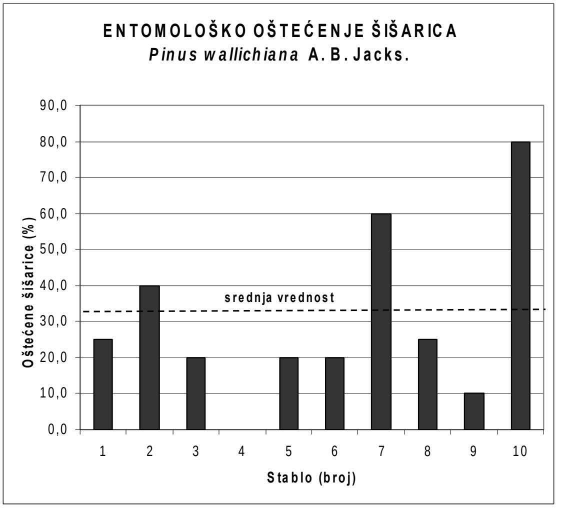
D. abietella of the order Lepidoptera, family Pyralidae, sub-family Phycitine, tribe Pictini (Karsholt et al. 2009). In the European fauna this family counts about one hundred species, whereas in our country approximately thirty have been recorded (Mihajlovic, 1978). This species belongs to the group of primary pests that feed on the cones and seeds of conifers. *D. abietella* is primarily the pest of the genus *Picea* but also frequent on species of the genus *Pinus*, *Abies, Larix* and *Pseudotsuga*.

D. abietella is among the 14 insect species that are the greatest pine pests, out of the total of 71 phytophagous species whose presence was found on species of the genus *Pinus* in Serbia (Mihajlovic, 2008).

This moth has a wingspan of 25-30 mm. The front wings are ash-colored with white wavy cross black-lined stripes, while the back wings are whitish-grey. *D. abietella* does not express sexual dimorphism. This species of injurious moths has one generation per year. The moths swarm during the summer months of June and July. Females lay one or more eggs onto the cone base. Caterpillars are reddish-brown with a dark head and shield and dark stripes, up to 25mm long. Upon hatching the caterpillars dig their way into cones, which is followed by abundant discharge of resin that may be connected to cobwebs and excrement (picture 1).

Picture 1. *Dioryctria abietella-damaged cone of Pinus wallichiana*
(photo: K. Mladenović)

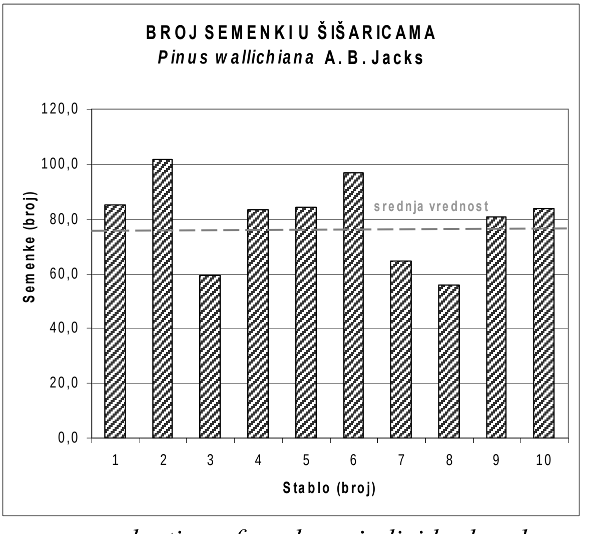
In certain years, in the absence of yield of a host plant, caterpillars may also develop in chermes galls and in newly grown increments. Due to its nutritive content, feeding on cones provides fir coneworm caterpillars the best conditions for development (Trudel et al, 1999). The cones get bitten into by one or more caterpillars. Caterpillars feed from the end of June until September on fertile scales and parts of seed. As a result of the damage, cones change their color to brown and remain on branches until autumn. In October caterpillars exit the cones by biting out round openings and move into the surface layer of the soil to spend the winter. In spring they undergo the pupae stadium.



Graph. 2. *Individual and average damages of cones by insects*

3.3. Seed Production

A single cone contained between 14 and 142 seeds (on the average 78 seeds, Graph 3). The average number of seeds in cones of individual trees varied from 56 to 102.



Graph. 3. *Average production of seeds on individual and population levels*

The comparison of results obtained from individual trees of the degree of damage (Graph 1, Graph 2) and seed production (Graph 3) was inconclusive and did not support the assumption of a significant link between phytopathological and entomological damages or their impact on seed production.

4. DISCUSSION

The results obtained through testing the contamination of Himalayan pine seeds have confirmed a significant presence of phytopathological and entomological damages. However, only in a few cases may it be assumed (but not concluded) that such damages had a substantial impact on seed production. The reasons lie in the fact that the abundant flowering and seed production by forest trees are under strong genetic control and consequently subject to extreme individual variations (Anderson 1965; Ehrenberg 1963; Krstinić 1976; Milojević 1989; Nikolić et al, 2004). It has already been found that in mother trees, from which this forest culture was established, the number of seeds is in significant positive correlation with the cone length (Milojević, 1989). It is also known that the conifers have different individual responses to influences of the environment in the period of flowering and seeding (Lindgren et al, 1977). Climatic conditions in the period of seed development may also intensify the development of diseases and damage-causing insects. (Golubović Ćurguz et al, 2010).

The appearance and spreading of diseases on forest seeds and fruits depend primarily on external factors, place and manner of harvesting, the quality, way of processing, and finally methods and conditions of storing. Seeds get infected easily if the seed capsule is damaged. Fungi inhabit seeds and fruits in trees as well as later on, during the processing and storing phases. The results of laboratory analysis of the presence microflora on seeds have confirmed the presence of various parasitic fungi of genus *Penicillium,* which are often found on the surface of the seed and under certain conditions may penetrate not only cotyledons and endosperm of the seeds and cause a disease that spreads over to saplings and leads to damping-off. Seeds of conifers are particularly vulnerable, and the most dangerous fungi are those from the genus *Fusarium*. Similar results were obtained by Peno and Popović (1969) in their research on the presence of microflora in seeds of various types of pine and its impact on seed germination. The species they isolated most frequently were from genera *Alternaria*, *Mucor*, *Rhizopus*, *Aspergillus, Penicillium*, *Trichotecium*, *Stemphylium*, *Paecilomyces*, *Thamnidium*, *Arthrobotrys* and *Fusarium.* According to Timonin (1964), fungi from genera *Alternaria, Aspergillus, Penicillium, Cladosporium, Cephalosporium, Chaetomium, Gliocladium, Aureobasidium* and *Trichoderma* were isolated from seeds of various species. Based on the analysis of seed health condition, Lazarev et al (2003) determined that the fungi that predominate on the seeds harvested in registered seed facilities in Serbia are those from the genera *Aspergillus* and *Penicillium.*

According to Medngen et al (1996) and Vukojević i Duletić-Lašević (2004), pathogenic agents of disease of seeds and fruits may spread the infection through undamaged surfaces, through undamaged surfaces from the nearby affected seeds through other parts of the plants, or through injuries. Physiological injuries caused by the external factors may also create conditions for the development of pathogens.

In practice it is extremely difficult to prevent infections of seeds and fruits (cones) during their development on trees. Only in the phases of harvesting, processing and storing the seeds does it become possible to prevent the development and spreading of pathogenic fungi. Nonetheless, harvesting and sorting of cones from non-infected trees are considered to be the main measures of protection against agents of numerous diseases. In case of registered presence of diseases on cones and seeds, the recommended course of action is to separate and destroy the infected units, harvest the healthy ones, avoid mechanical damages during harvesting, transportation, sorting, cleaning and removal of moldy parts as centers of infection (Lazarev et al, 2003).

5. CONCLUSIONS

Measures of protection against agents of diseases in seeds include the following: keeping (storing) sufficient quantities of dried and healthy seeds in dry, well-aired premises at adequate air temperatures; removal of dirt and damaged seeds; storing of seeds in hermetically closed containers at the temperature of 0 to 5^0C; avoiding mechanical damages to seeds during harvesting and processing; frequent control of stored seeds, disinfection of seeds, tools, packaging, hermetical containers for keeping and storing of seeds.

In order to obtain healthy seeding material of high quality, seeds need to be disinfected prior to harvesting by applying preparations in dry or wet form. Over the last decade chemical and biological measures are being combined. The biological measures artificially introduce relevant antagonists that prevent the development of parasitic fungi into the soil (Ozbay and Newman, 2004).

D. abietella is an economically significant pest in cultures and stands of spruce, pine and fir. *D. abietella* is considered to be the most dangerous species for pine seed stands (Mihajlović, 2008). Cones attacked by this species have irregular development. Mechanical damages to seeds occur due to moths feeding on the cones. Caterpillar bites cause abundant discharge of resin, and as a consequence the cones under attack do not open. In certain years this pest develops massively. *D. abietella* causes major damage while drilling its way into sprouts, which results in irregular growth of the attacked tree.

Pest control can be done mechanically, before the attacked cones fall off or immediately thereafter, but still before the caterpillars going into the soil for the winter exit the cones. Chemical treatments may be administered during the flight of imago, in June and July.

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DISEASES AND INJURIES OF HIMALAYAN PINE SEED FROM CULTURE GROWN ON DEPOSOL

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Biljana NIKOLIĆ, Snežana RAJKOVIĆ

Summary

From young forest culture of *Pinus wallichiana*, which was established on loamy deposol, about one hundred of nearly ripe cones were harvested. Opening of cone scales and dropping of seed grains in laboratory conditions were induced. Damages caused by the presence of fungi organisms in 18.28% of cones (in average) were recorded, with expressed individual variability (0-50%). The most often present were fungi prom genus *Penicillium* (50.4%), *Alternaria* and *Trichothecium*, while the rarest ones originated from genus *Fusarium* (3.5%).

On the cone entomological damage caused by feeding moth *Dioryctria abietella* are determined which belongs to the most important pine pests of 71 phytophagous species whose presence is found in species on genus Pinus, for the area of Serbia. Changes caused by this species of moth were recorded in almost every third cones (31.31%) were recorded, with much more expressed variability between genotypes (0-80%).

Although phytopathological and entomological damages on the cones of Himalayan pine were significant, the degree to which they affected the seed production cannot be determined with certainty, because the abundance of flowering and seed bearing in forest trees are under strong genetic control.

In practice it is very difficult to prevent infection of seeds and fruits (cones) as well as the attacks of insects during their development on the trees. Collecting cones with non-infected trees and their selection, as well as the destruction of the infected ones are the main protective measures in the seed processing. Measures to protect seeds from diseases include several measures: keeping of seeds (and cones) dry and healthy, ventilation of rooms specified for keeping cones and seeds and avoiding mechanical damages of cones and seeds during their collection and processing. In order to obtain better quality and healthier plant material it is necessary to disinfect seeds before planting by applying chemical or biological products.

D. abietella can be controlled by mechanical and chemical means. For mechanical control attacked cones must be collected from trees or the land immediately after the decline and before larva leave the track. Gathered cones must be cremated. Chemical treatment must be made by contact insecticides during the flight of imago, in June and July.

BOLESTI I OŠTEĆENJA SEMENA U KULTURI HIMALAJSKOG BORA GAJENOG NA DEPOSOLU

Vesna GOLUBOVIĆ ĆURGUZ, Katarina MLADENOVIĆ,
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Rezime

Iz mlade šumske kulture *Pinus wallichiana* osnovane na ilovastom deposolu, sakupljeno je oko 100 poluzrelih šišarica. U laboratorijskim uslovima indukovano je otvaranje njihovih plodnih ljuspi i ispadanje semena. Oštećenja semena usled prisustva gljivičnih organizama evidentirana su kod 18.28% šišarica (u proseku), sa jako izraženom individualnom varijabilnošću (0-50%). Na semenu sa analiziranih stabala konstatovane su gljive iz sledećih rodova *Alternaria, Fusarium, Penicillium, Trichothecium. N*ajčešće su konstatovane vrste gljiva iz roda *Penicillium* (na 50.4% analiziranog semena), a najmanje su bile prisutne gljive iz roda *Fusarium* (3.5% analiziranog semena).

Na šišaricama su utvrđena entomološka oštećenja izazvana ishranom leptira plamenca *Dioryctria abietella* koji pripada grupi najznačajnijih štetočina bora od ukupno 71 fitofagne vrste čije je prisustvo utvrđeno na vrstama roda *Pinus* kod nas. Promene koje izaziva ova vrsta leptira evidentirana su kod gotovo svake treće šišarice (31.31%) sa još jače izraženom varijabilnošću između genotipova (0 – 80%).

Mada su fitopatološka i entomološka oštećenja na semenu himalajskog bora značajna, ne može se sa sigurnošću utvrditi u kom su stepenu uticala na produkciju semena, jer su obilnost cvetanja i radjanja semena kod šumskog drveća pod jakom genetskom kontrolom.

U praksi je vrlo teško sprečiti infekcije semena i plodova (šišarki) kao i napade insekata za vreme njihovog razvoja na drveću. Sakupljanje šišarki sa nezaraženih stabala i njihovo prebiranje, kao i uništavanje zaraženih u postupku dorade su glavne zaštitne mere.

Mere zaštite od uzročnika bolesti semena obuhvataju više mera: čuvanje dovoljno prosušenog i zdravog semena (šišarki) u suvim, ventilisanim prostorijama, izbegavanje mehaničkog oštećivanja semena pri sakupljanju i doradi.

Da bi se dobio što kvalitetniji i zdraviji sadni materijal potrebno je uraditi dezinfekciju semena pre setve primenom hemijskih (odabir preparata za zaštitu vrši se u skladu sa postojećom nacionalnom zakonskom regulativom) ili bioloških preparata .

Suzbijanje *D. abietella* se vrši mehanički i hemijski. Za mehaničko suzbijanje potrebno je napadnute šišarke, koje su promenile boju, sakupiti sa stabla ili ili zemljišta neposredno po opadanju a pre no što ih gusenice napuste. Sakupljenje šišarke spaliti.. Hemijsko tretiranje izvršiti kontaktnim insekticidima tokom leta imaga, u junu i julu.

INSTITUTE OF FORESTRY • BELGRADE
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SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION 65-66, 2012 ZBORNIK RADOVA 65-66, 2012

UDK 630*453 Lymantria dispar L+630*443.2 Pollacia elegans (Vuill.) Fabr.]:228.7 Poplar spp.=111
Original scientific paper

SENSITIVITY OF SEVEN CLONES OF POPLAR TO THE ATTACK BY CATERPILLARS OF GYPSY MOTH (*Lymantria dispar* L.) AND FUNGUS *Pollacia elegans* (Vuill.) Fabr.

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Abstract: *Presence of herbivorous insects, Lymantria dipar (L.) caterpillars and pathogen Pollacia elegans (Vuill.) Fabr. on seven poplar clones was estimated on a short rotation plantation which was established near Junkovac (MB Kolubara).*
The highest percentage of trees with Gypsy moth caterpillars present was found in clones "Panonija" and "I214", although the percent is twice lower in the latter clone. In clones produced by hybridization of Populus nigra and P. maximowicziii and "Koltay", the number of trees with Gypsy moth caterpillars varied between 1% and 2.5%, and the lowest value was recorded in clone "Muhle Larsen". The fungus Pollacia elegans was mostly present in clones produced by hybridization of Populus nigra and P. maximowicziii "Max 1", "Max 2", "Max 3", while its presence was significantly lower in clones "Koltay"and "Panonia". The presence of this pathogen was recorded in less than 5% of plants in clones "I214" and "Muhle Larsen".

Key words: Poplar clones, Short rotation plantation, *Lymantria dispar*, *Pollacia elegans*, preference

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OSTELJIVOST SEDAM KLONOVA TOPOLE NA NAPAD GUBARA (*Lymantria dispar* L.) I GLJIVE *Pollacia elegans* (Vuill.) Fabr.

Izvod: *U plantaži sa kratkom ophodnjom koja je osnovana u blizini Junkovca (RB Kolubara) istraživano je prisutvo gusenica gubara Lymantria dipar (L.) i patogena Pollacia elegans (Vuill.) Fabr. na sadnicama sedam klonova topole. Najviši procenat stabala sa prisutnim gusenicama gubara nalazimo kod klona „Panonija“ i „I 214“, mada je taj procenat kod drugog klona duplo niži. Kod klonova nastalih hibridizacijom Populus nigra i P. maximowicziii i „Koltay“, broj stabala sa gusenicama gubara je varirao od 1 do 2,5% a njanižu vrednost beležimo kod klona „Muhle Larsen“. Gljiva Pollacia elegans je najprisutnija kod kolonova nastalih hibridizacijom Populus nigra i P. maximowicziii, „Max 1“, „Max 2“, „Max 4“, dok je značajno manje prisutna kod klona „Koltay“ i „Panonia“. Prisustvo ovog patogena beležimo na manje od 5% biljaka kod klonova „I214“ i „Muhle Larsen“.*

Ključne reči: Klonovi topole, plantaže kratke ophodnje, *Lymantria dipar*, *Pollacia elegans*, preferenca

1. INTRODUCTION

Under the Kyoto protocol, Serbia same as European countries has to reach the target of a 20% share of the energy mix by renewable energy sources by the year 2020. In order to meet that obligation, at the tailings ponds of Kolubara open pit mine, where recultivation by afforestation has been carried out for more than 40 years (Veselinović, 2006), intensive research is conducted on opportunities for the production of biomass for energy purposes (Drazic et al. 2005, 2006, 2007, 2011, Mitrović et al., 2011). Short rotation coppices (SRC) will be one of the solutions. SCR is established with the primary goal of producing biomass for energy. The technology of the SRC is more like agriculture than forestry. Harvesting of wood stands would be every 2-10 years (rotation cycle), and depending of tree species, trees can be cultivated over a period of 30 years or more. Biomass product is wood chips which can be utilized for energy production. Raw material can be utilized for briquette or pellet production. Poplar is one of the species with high rate of biomass production, are appealing as short-rotation woody crops (Coyle et al., 2006).

The production of biomass in poplar plantations may be compromised by numerous abiotic and biotic factors. Among the abiotic factors, the greatest damage may be caused by low or high air temperatures as well as lack of humidity in the soil. Among the biotic factors, great damages to poplar plantations may be caused by numerous species of insects (Mihajlović, 2008) and plant diseases (Karadžić, 2010) specific for this genus of trees, but also certain polyphagous species such as Gypsy moth. The negative effect of abiotic factors may be avoided by proper selection of the habitat on which a plantation is to be established. In the establishment of plantations the selection of species should depend on their production characteristics as well as their sensitivity to the most significant diseases and pests. *Populus* species are among the types of trees on which Gypsy moth likes to feed (which may cause major damage and even jeopardize their survival if defoliation should recur for several years in a row). However, different species of the same genus of host may differ significantly in preferences and performances of Gypsy moth caterpillars (Milanović, 2010). We therefore took the opportunity to determine the feeding preference of Gypsy moth caterpillars on seven various poplar clones in a spontaneously infected experimental plantation so that in the future we could recommend the ones least preferred by the Gypsy moth.

In the experimental plantation symptoms of disease caused by the fungus *Pollaccia elegans* Servazzi were noted. The perfect stadium of this fungus is known as *Venturia populina* (Vuill.) L. Fabricius. This species occurs on black poplars (sections *Aigeiros, Tacamahaca*) and causes spring loss of leaves in poplars. It is most damaging in nurseries and young cultures. It attacks leaves and young branches of poplars, where in the early stages of the disease the edges of leaves turn first yellow and then black. Necrosis usually spreads over one-third of the area of the leaf, which warps and eventually falls offs. The falling off commences in early spring, which is why the disease was named "spring loss of leaves". The fungus simultaneously attacks the branches and the buds, whose tissue darkens, the branch wilts, breaks and falls off. Spreading of the disease is facilitated by rainy spring and temperatures between 15 and 25^0 C. In spring, the infected leaves and branches become hosts for development of pseudothecia, and in them of asci with ascospores that carry out the primary infection. Following the primary infection through ascospores, a conidian form develops on the leaves and conidia continue spreading the disease. Since the sensitivity to pathogens of different species of the genus *Populus* may vary (Hsiang and van der Kamp, 1985; Pinon, 1992), we wanted to determine the frequency of symptoms of *P. elegans* on different clones in this experimental plantation.

2. MATERIAL AND METHODS

In the experiment for researching the opportunities for production of biomass on degraded areas of REIK Kolubara, in March 2012 an experimental plantation of willow, alder, birch and various poplar clones was established on locality Junkovac. The experimental plantation was set up between two windbreak belts dominated by coniferous tree species. The subject of our research was the presence of caterpillars of Gypsy moth (*Lymantria dispar* L.) and spring loss of leaves caused by the fungus *Pollacia elegans* on seedlings of various poplar clones. There was a total of 7 poplar clones on the plantation, as follows: "Max 1", "Max 2" and "Max 4" (*Populus nigra* × *P. maximowiczii*), "I 214", "Panonija" and "Koltay" (*Populus nigra* × *P . deltoides*) and then clone "Muhle Larsen" (*Populus trichocarpa*).

The inspection conducted in late May determined the number of trees with present Gypsy moth caterpillars, the number of trees with the symptoms of the fungus *Pollacia elegans,* and the total number of trees in a single row. As the take of the plants was incomplete, the number of seedlings with the Gypsy moth or with symptoms of *Pollacia elegans* was expressed in percentages. The number of inspected rows varied from 12 to 24 per a researched poplar clone, and the number of seedlings per row was 23, with four rows per one plot.

Statistical data processing included the analysis of covariance (ANCOVA) with the type of clone as the variable and the distance of the plot from the edge of the forest as the covariance. The intention of the analysis was to take into consideration the effect of the distance of the experimental plot from the edge of the forest as a potential source of infection on the number of trees with Gypsy moth caterpillars and with the fungus *Pollacia elagans*. The significance of differences between the observed poplar clones in the number of trees with Gypsy moth or fungus *Pollacia elegans* was determined by means of Tukey HSD test (α=0,05).

3. RESULTS OF THE RESEARCH

Table 1 presents the results of the analysis of covariance (ANCOVA) for the number of trees with Gypsy moths and symptoms of fungus *P. elegans* in a plantation of different poplar clones. The distance of the experimental plots from the windbreak belt did not have any statistically significant impact on differences in the number of trees with the presence of Gypsy moths and symptoms of *P. elegans.* The results of ANCOVA have shown that the type of clone had significantly impacted the observed parameters.

Table 1. *Analysis of covariance ANCOVA for observed parameters*

Effect		*Lymantria dispar*				*Pollacia elegans*			
	d.f.	SS	MS	F	p	SS	MS	F	p
Intercept	1	360,83	360,83	4,45	0,0369	5644,87	5644,87	55,25	0,0000
Clon	6	**5622,02**	**937,00**	**11,55**	**0,0000**	**13925,86**	**2320,98**	**22,72**	**0,0000**
Distance	1	61,14	61,14	0,75	0,3869	315,53	315,53	3,09	0,0813
Error	123	9974,73	81,10			12565,83	102,16		
Total	130	15598,81				27394,25			

Table 2 presents the mean values and standard errors for the observed parameters. The highest percentage of trees with present Gypsy moth caterpillars was found in the clones “Panonija” and “I214”, although that percent is twice lower in the latter clone. In clones produced by hybridization of *Populus nigra* and *P. maximowicziii* “Max 1”, “Max 2”, “Max 4” and “Koltay”, the number of trees with Gypsy moth caterpillars varied between 1% and 2.5%, with the lowest value noted in the clone “Muhle Larsen”.

Table 2. *Number of repetitions, Mean value and Standard errors (Mean ± SE) for observed parameters*

Clone		*Lymantria dispar*	*Pollacia elegans*
	N	Mean±SE	Mean±SE
Panonia	24	18,00±2,877**c**	9,59±1,439**ab**
I 214	23	9,65±3,094**b**	3,05±1,382**a**
Max I	12	2,54±1,130**ab**	23,50±3,542**cd**
Max II	12	1,09±0,568**ab**	35,02±4,682**d**
Max IV	12	1,09±0,780**ab**	28,80±2,194**d**
Koltay	24	1,63±0,574**a**	17,57±2,800**bc**
Muhle Larsen	24	0,91±0,522**a**	4,89±1,511**a**

Mean values within column with same letter are not significantly different (Tukey HSD test, α=0,05)

The fungus Pollacia elegans is most present in clones produced by hybridization of *Populus nigra* and *P. maximowicziii* "Max 1", "Max 2", "Max 4", while its presence is significantly lower in clones "Koltay" and "Panonia". The presence of this pathogen is noted in less than 5% of plants in the clones "I214" and "Muhle Larsen".

4. DISCUSSION

In Gypsy moths, newly hatched caterpillars are responsible for the dispersion and selection of the host, when they may travel great distances carried by the wind, depending on the wind speed and the height from which they were moved, where this passive movement may be repeated multiple times until the larva lands on a suitable host and commences feeding (Mason & McManus, 1981). Second-stage larvae easily cross the filaments with which they get attached to the branches of the host plant and can also move to a new host with the help of wind (Leonard, 1967), so those may also be used for testing the suitability of the host. Acceptance of a plant as the primary host is a complex process that depends on physiological features (Lazarević, 1994; Lazarević et al, 1994; Milanović et al, 2008) and the genotype (Lazarević, 2000; Lazarević *et al*., 2002) of the herbivore itself, as well as on physical and chemical properties of the potential host (Foss & Rieske, 2003).

Caterpillars use various physical and chemical characteristics of their host plant in order to locate them (Schoonhoven, 1973). Their sense of sight differentiates colors, and in the search for food they prefer green to brown color (Smitley *et al*., 1993). Among different nuances of green they choose lighter shades. This may be linked to aging of the leaves, where the content of tannin increases during vegetation (Feeny, 1970) and the leaves turn darker. Gypsy moth caterpillars are more attracted to a darker than a lighter trunk, and to trunks that are wider in diameter, which was determined by using plastic modules for trunk simulation (Roden *et al*.,1992). Although the sense of sight helps caterpillars locate the trees or herbaceous plants, it is still not developed enough to have a crucial role in recognition of plants, which is supported by the fact that the process is carried out in complete darkness (Schoonhoven, 1973). Chemical senses, which are well-developed in insects, not only lead the monophagous organisms to their specific feed but also help the polyphagous species, such as Gypsy moth, differentiate between various types of plants. Chemoreceptors included in the process of finding a host plant are located on the antennae and parts of the mouth apparatus of the herbivore, so that they test the suitability of food by tasting it. Since the analysis of covariance showed that the position of the plot on which a certain clone was planted had no effect on the number of trees with Gypsy moth, it may be concluded that stay on a host and commencement of feeding was conditioned by the chemical content of leaves and their physical characteristics. This claim is supported by the findings by Gruppe *et al*. (1999) who mention the increased content of defense matter in the leaf of the clone "Muhle Larsen", whose leaves was, according to our results, least frequently chosen as feed by the Gypsy moth caterpillars. The increased content of defense matter certainly impacts the resistance of plants to diseases, and thus this clone also demonstrated high resistance to infections by the fungus *P. elegnas*.

In British Columbia, *P. trichocarpa, P. balsamifera* and many of the T x D hybrids are susceptible. Other hybrids in section *Tacamahaca* are less susceptible. Some commercially utilized T x D clones such as 49–177 and T x M hybrids are known to be resistant; in the latter case the resistance is conferred by the *P. maximowiczii* parent. Elsewhere in North America, disease incidence records are from poplars in section *Tacamahaca*, while in Europe and India, poplars in *Aigeiros* are also reported as hosts (Newcombe & van Oosten, 1997).

Heavy levels of disease in hybrid T x D plantations on Vancouver Island and the lower Columbia River have necessitated the replacement of susceptible clones by more resistant ones (Newcombe &van Oosten, 1997).

In Europe, according to Karadžić (2010), clone I214 demonstrates high resistance to this fungus.

5. CONCLUSIONS

Based on the obtained results, it may be concluded that among the tested clones there are difference in susceptibility to the pathogen *P.elegans* and preferences of Gypsy moth caterpillars.

The found differences are not random and do not depend on the potential source of infection.

Clones "Max 1", "Max 2", "Max 4" are least frequently selected for feeding by Gypsy moth caterpillars, besides the clones "Muhle Larsen" and "Koltay". On the other hand, all these clones, with the exception of "Muhle Larsen", register a much higher presence of the pathogen *Pollacia elegans* compared to the clones u odnosu na klonove "I214" and "Panonija".

In our research, resistance to attack by the pathogen *Pollacia elegans* is expressed in the following order: "Muhle Larsen" > "I214" > "Panonija" > "Koltay" > "Max 1" > "Max 4" > "Max 2".

The general conclusion is that the clone "Muhle Larsen" is the least susceptible to browsing by Gypsy moth caterpillars and to the attack by the pathogen *Pollacia elegans,* and as such may be recommended for establishment of energy plantations.

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SENSITIVITY OF SEVEN CLONES OF POPLAR TO THE ATTACK BY CATERPILLARS OF GYPSY MOTH (*Lymantria dispar* L.) AND FUNGUS *Pollacia elegans* (Vuill.) Fabr.

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Summary

Presence of herbivorous insects, Lymantria dipar (L.) caterpillars and pathogen Pollacia elegans (Vuill.) Fabr. on seven poplar clones was estimated on a short rotation plantation which was established near Junkovac (MB Kolubara).

The present study was carried out in the first year of the first rotation period after establishing of plantation. The highest percentage of trees with Gypsy moth caterpillars present was found in clones “Panonija” and “I214”, although the percent is twice lower in the latter clone. In clones produced by hybridization of Populus nigra and P. maximowicziii “Max 1”, “Max 2”, “Max 4” and “Koltay”, the number of trees with Gypsy moth caterpillars varied between 1 and 2.5%, and the lowest value was recorded in clone “Muhle Larsen”. The fungus Pollacia elegans was mostly present in clones produced by hybridization of Populus nigra and P. maximowicziii “Max 1”, “Max 2”, “Max 3”, while its presence was significantly lower in clones “Koltay”and “Panonia”. The presence of this pathogen was recorded in less than 5% of plants in clones “I214” and “Muhle Larsen”.

The obtained results lead to the conclusion that there are differences between the tested clones related to the sensitivity to the pathogen Pollacia elegans and the preference of Gypsy moth caterpillars. The found differences were not random and did not depend on the distance from the potential source of infection. The general conclusion is that the clone

"Muhle Larsen" is least sensitive to browsing by Gypsy moth caterpillars and to attack of the pathogen Pollacia elegans and that as such it can be recommended for establishment of energy plantations.

OSTELJIVOST SEDAM KLONOVA TOPOLE NA NAPAD GUBARA (*Lymantria dispar* L.) I GLJIVE *Pollacia elegans* (Vuill.) Fabr

Slobodan MILANOVIĆ, Zlatan RADULOVIĆ, Milorad VESELINOVIĆ, Suzana MITROVIĆ, Katarina MLADENOVIĆ

Rezime

U plantaži sa kratkom ophodnjom određeno je prisutvo gubara *Lymantria dipar* (L.) i patogena *Pollacia elegans* (Vuill.) Fabr. Na sedam klonova topole. Istraživanje je vršeno tokom prve godine, prve ophodnje nakon podizanja plantaže. Najviši procenat stabala sa prisutnim gusenicama gubara nalazimo kod klona „Panonija" i „I 214", mada je taj procenat kod drugog klona duplo niži. Kod klonova nastalih hibridizacijom *Populus nigra* i *P. maximowicziii* „Max 1", „Max 2", „Max 4" i „Koltay", broj stabala sa gusenicama gubara je varirao od 1 do 2,5% a njanižu vrednost beležimo kod klona „Muhle Larsen". Gljiva Pollacia elegans je najprisutnija kod kolonova nastalih hibridizacijom *Populus nigra* i *P. maximowicziii*, „Max 1", „Max 2", „Max 4", dok je značajno manje prisutna kod klona „Koltay" i „Panonia". Prisustvo ovog patogena beležimo na manje od 5% biljaka kod klonova „I214" i „Muhle Larsen".

Na osnovu dobijenih rezultata može se zaključiti da među testiranim klonovima postoje razlike u osetljivosti prema patogenu *Pollacia elegans* i prefernci gusenica gubara.

Ustanovljne razlike nisu slucajne i ne zavise od distance potencijalnog izvora zaraze.

Na osnovu dobijenih rezultata se može zaključiti da postoje razlike među testiranim klonovima u odnosu na njihovu osetljivost prema patogenu Pollacia elegans i prefreniji gusenica gubara. Ustanovljene razlike nisu slučajne i ne zavise od udaljenosti potencijalnog izvora zaraze. Generalni zaključak je da klon „ Muhle Larsen" najmanje podložan brstu gusenica gubara i napadu patogena *Pollacia elegans* i kao takav se može preporučiti za podizanje energentskih plantaža

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Original scientific paper

GYPSY MOTH, *Lymantria dispar* (L.), AND ITS NATURAL ENEMIES IN THE FORESTS OF CENTRAL SERBIA

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Abstract: *In central Serbia, a total of 88 species which are natural enemies of the gypsy moth, i.e. 23 predators, 49 parasitoid insects and 10 saprophagous insects, and 6 pathogens*, *has been reported. The most abundant of them are the insects which attack the gypsy moth in the larval instar (41 species). Regarding the number of the species, the representatives of the Hymenoptera (14 species from Ichneumonidae family and 11 species from Braconidae family) and Diptera orders (12 species from Tachinidae family and 8 species from Sarcophagidae family) are most frequent. Regarding the predators of the gypsy moth, Carabidae family, from Coleoptera order, is most frequent. In addition, at some sites Lymantria dispar nucleopolyhedrosis virus and Entomophaga maimaiga had the dominant role in the reduction of the gypsy moth density.*

Key words: the gypsy moth, predators, parasitoids, pathogens

GUBAR, *Lymantria dispar* (L.), I NJEGOVI PRIRODNI NEPRIJATELJI U ŠUMAMA CENTRALNE SRBIJE

Izvod: *U centralnoj Srbiji do danas je utvrđeno ukupno 88 vrste prirodnih neprijatelja gubara, i to 23 predatora, 49 parazitoida, 10 vrsta koje se ponašaju kao saprofagi i parazitoidi, te 6 patogena. U navedenom broju najzastupljeniji su insekti koji parazitiraju larveni stadijum gubara (41 vrsta). Po broju zastupljenih vrsta, najviše je pripadnika redova Hymenoptera (12 vrsta iz familije Ichneumonidae i 11iz familije Braconidae) i Diptera (12 vrsta iz familije Tachinidae i 8 iz Familije Sarcophagidae). Od predatora gubara, najzastupljenija ja familija Carabidae iz reda Coleoptera. Takođe, u pojedinim područjima Lymantria dispar nucleopolyhedrosis virus i entomopatogena gljiva*

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Entomophaga maimaiga imali su dominantnu ulogu u smanjenju brojnosti gubara u stadijumu larve.

Ključne riječi: gubar, predatori, parazitoidi, patogeni

1. INTRODUCTION

The gypsy moth (*Lymantria dispar* L.), insect in the order *Lepidoptera*, is one of the most dangerous pests of broadleaf forests and orchards. It is characterised by a high reproductive capacity, considerable ecological plasticity and polyphagia. It occurs periodically in high numbers (outbreak). Although it is found on four continents (North Africa, Asia, Europe, North America), the greatest damage is caused to the forests of the Balkan Peninsula, which have all favourable environmental conditions for the gypsy moth development, and it often occurs in outbreaks.

Biological control, as the part of the forest integrated protection, is defined as the use of natural enemies (parasitoids, predators, and pathogens) to regulate or control pests. Various strategies have been used for the enhancement of biological control agents. Classical biological control is simply a special case of a general pattern in which populations are regulated by density-dependent processes, a major class of which involves predator-prey or parasitoid-host interactions.

Recent emphasis on the development of an integrated control program for the gypsy moth has necessitated an understanding of its mortality-causing biological agents. Throughout the holarctic region there is a wide range of natural enemies of this insect. The diseases caused by viruses, bacteria or fungi contribute to the decline of gypsy moth populations. For example, baculovirus – *Lymantria dispar* nucleopolyhedrosis virus (*Ld*NPV) is specific to the gypsy moth, the most devastating natural disease, and it causes a dramatic collapse of outbreak populations by killing both the larvae and pupae. Infection by *Ld*NPV is the most common source of mortality in high density populations and *Ld*NPV epizootics, since it usually causes the collapse of host populations (Evans, 1986; McCoy et al., 1988).

Second example is the entomopathogenic fungus *Entomophaga maimaiga* Humber, Shimazu & Soper (Entomophtorales: Entomophtoraceae) which was isolated and described as the natural enemy of the gypsy moth in Japan, where it causes the periodical epizootias. It is also spread in some parts of China and the Russian Far East (Hajek et al., 2005). In spite of the fact that it was introduced in North America in 1910-1911 (Speare and Colley, 1912), its presence in the natural populations of gypsy moth was determined only in 1989 (Hajek et al., 1996), when the pathogen caused pandemic in several countries (Andreadis and Weseloh, 1990; Hajek et al., 1990; Reardon and Hajek, 1998; Smitley et al., 1996). Today *Entomophaga maimaiga* is a very significant pathogen of gypsy moth in North America and Canada (Balser and Baumgard, 2001; Hajek, 1997; Hajek et al., 2005; Hoover, 2000; Howse and Scarr, 2002).

Bulgaria has been the third country in the world and the first one in Europe in which *Entomophaga maimaiga* was introduced successfully (Pilarska et al.,

2000). The first epizootics of it occurred in 2005 (Georgiev et al., 2007, 2010; Pilarska et al., 2006). This species is also present in oak forests in some Serbian regions (Tabaković-Tošić et al., 2012a, 2013- in press).
This paper presents the author's published and unpublished results of survey of the natural enemies (predators, parasitoids and pathogens) of the gypsy moth in Central Serbian forests, supplemented by available published results of other authors.

2. MATERIALS AND METHODS

Central Serbia, the area where the occurrence, population size and intensity of the adverse effects of the natural hosts of the gypsy moth were studied, is located in the centre and southeastern part of Republic of Serbia. It covers an area of about 55,000 square kilometers. It is located between 42 and 45 degrees northern latitude and between 19 and 23 degrees eastern longitude.

In Central Serbia, forests cover an area of 2.1 million hectares (37,6% of the total area), of which 51% is the state property and 49% is the private property, timber volume amounts to 333 million m^3 (59.2% in state forests and 40.8% in private forests), and volume increment is 3.9 m^3/ ha^{-1} (56.6% in state and 43.4% in private forests); broadleaves account for 86.9% of the total timber volume (beech 43.9%, oaks 26.3%, other broadleaves 29.8%) (Banković et al., 2009).

Every year over the last twenty years period, in all broadleaf forests, a survey of main predators, parasitoids and pathogens was conducted from April to late November during studies of the population dynamics and outbreaks of the gypsy moth (Tabaković-Tošić et al., 2002; Tabaković-Tošić, 2004, 2006, 2011).

The studies of the presence and density of the main predator species of the gypsy moth were conducted by using the methods, typical for some families to which the insects belong.

The detailed quantitative and qualitative studies of the parasitisation rate of the sampled egg masses were conducted in the laboratory of the Institute of Forestry, and, depending on the observed parameter, either ocular method or method of the survey by using binocular magnifier was applied. From each egg mass, 100 randomly sampled, previously cleaned eggs, were placed in the specially prepared test tubes. The emergence of the imago parasitoids was reported every day until the end of the process.

The field-collected larvae and pupae were grown under the laboratory conditions in the climate chamber. During the all laboratory experiments, temperature and light conditions were constant (temperature 21°C, light regime - 8 hours night, 16 hours a day).

The studies of the presence of entomopathogenic viruses, bacteria and fungi in the dead gypsy moth larvae were conducted in the field and laboratory conditions. In the field conditions the characteristic symptoms of some diseases were identified by using ocular method, while in the laboratory conditions, they were identified by dissection of the dead larvae and the microscope survey (Tabaković-Tošić et al., 2012).

3. RESULTS AND DISCUSSION

Natural enemy populations have the unique ability to interact with their prey or host populations and to regulate them at lower levels than would occur otherwise. Some are effective at extremely low prey levels, other only at higher levels.

In biological control parlance, natural enemies are referred to as parasitoids, predators or pathogens. Parasitoids may have one (univolutine), two or more generations to one of the host (multivolutine), and they tend to attack only one host stage, although there is also some overlapping in certain cases – adult insects do not serve as hosts very often (Debach, 1974). Predatory insects differ from parasitic ones since the larvae or nymphs, as the case may be, require several or many prey individuals to attain maturity.

Pathogenic microorganisms attack insects and have life cycles more or less characteristic of similar micro-organisms developing in other groups of animals. Insects are probably subject to as wide a variety of diseases. A number of pathogenic microorganisms – viruses, bacteria, fungi, and microsporidia (for example: *Lymantria dispar* nucleopolyhedrosis virus, *Bacillus thuringiensis* Berliner, *Entomophaga maimaiga* Humber, Shimazu & Soper, *Nosema lymantriae* (Weiser), *Nosema serbica* Weiser*)* – infect the gypsy moth (Pilarska and Vávra, 1991; Sidor, 1979; Stiles et al., 1983; Tabaković-Tošić, 2008; Tabaković-Tošić et al., 2011a,b; Weiser, 1998). The epizootics of them are often spectacular, and mortality is most prevalent during gypsy moth outbreaks.

Based on the literature data, a total of 81 species which are natural enemies of the gypsy moth, i.e. 17 predators, 49 parasitoids, 10 saprophagous insects, and 5 pathogens, have been reported in Central Serbia (Table 1). The parasitoids which attack the larval instar of the gypsy moth are most frequent (31 species), followed by the predators of the gypsy moth eggs (12 species), the parasitoids of the pupae of the host (13 species), saprophages and parasitoids of the same instar (10 species), predators of the larvae 5 species), parasitoids of the gypsy moth eggs (5 species), pathogens of the larvae (5 species) (Table 1).

During the observed period, in the gypsy moth populations, the activity of 59 natural enemies of this insect - twenty-one predators, twenty-nine parasitoids, seven parasitoids or saprophagy and two pathogens -was reported. The gypsy moth eggs were attacked by thirteen species of the predators, larvae by six species, and larvae and pupae by two species.

There were three parasitoids species of the gypsy moth eggs, nineteen parasitoids species of the gypsy moth larvae, and seven parasitoids species of the gypsy moth pupae. Parasitoids or saprophages of gypsy moth pupae were represented by seven species. Two pathogenic species (*Ld*NPV and *Entomophaga maimaiga*) has been identified. (Table 1).

Table 1. *Natural enemies of the gypsy moth in the forests of Central Serbia*

Gypsy moth		Significance	
Natural enemies	**Instar**	**Literature sources**	**Personal research**
PREDATORS			
Trombidium holosericeum (Linnaeus, 1758)	egg	+++	+++

Gypsy moth		Significance	
Natural enemies	Instar	Literature sources	Personal research
[Acari: Trombiculidae]		[9, 11]*	[6]**
Forficula auricularia Linnaeus, 1758 [Dermaptera: Forficulidae]	egg	+++ [9, 11]	+++ [6]
Dermestes lardarius Linnaeus, 1758 [Coleoptera: Dermestidae]	egg	-	++ [3]
Dermestes erichsoni Ganglbauer, 1904 [Coleoptera: Dermestidae]	egg	+++ [11, 12]	++ [1, 2, 3, 6]
Megatoma pici Kalik, 1952 [Coleoptera: Dermestidae]	egg	+++ [11, 12]	++ [1, 2, 3, 6]
Megatoma pubescens (Zetterstedt, 1828) [Coleoptera: Dermestidae]	egg	++ [11, 12]	+ [6]
Megatoma undata (Linnaeus, 1758) [Coleoptera: Dermestidae]	egg	++ [9, 11]	+ [6]
Ctesias serra (Fabricius, 1792) [Coleoptera: Dermestidae]	egg	++ [11, 12]	-
Globicornis nigripes (Fabricius, 1792) [Coleoptera: Dermestidae]	egg	++ [11, 12]	+ [6]
Julistus floralis (Olivier, 1790) [Coleoptera: Cantharidae]	egg	+++ [9, 11, 12]	+ [1, 2, 3, 6]
Malachus bipustulatus (Linnaeus, 1758) [Coleoptera: Cantharidae]	egg	+++ [11, 12]	+ [6]
Podisus maculiventris (Say, 1832) [Heteroptera: Pentatomidae]	egg	+ [11, 12]	+
Formica rufa Linnaeus, 1758 [Hymenoptera: Formicidae]	egg	++ [4, 9]	+ [6]
Carabus latus Dejean, 1826 [Coleoptera: Carabidae]	egg	-	+ [3, 6]
Silpha quadripunctata Schreber, 1759 [Coleoptera: Silphidae]	larvae	++ [11, 12]	+++ [6]
Xylodrepa quadripunctata (Linnaeus, 1758) [Coleoptera: Silphidae]	larvae	+ [9]	-
Carabus coriaceus (Linnaeus, 1758) [Coleoptera: Carabidae]	larvae	-	+ [1, 2, 3, 6]
Carabus cancellatus (Linnaeus, 1758) [Coleoptera: Carabidae]	larvae	++ [9, 12]	+ [1, 2, 3, 6]
Carabus cavernosus Frivaldsky, 1837 [Coleoptera: Carabidae]	larvae	-	+ [1, 2, 3, 6]
Carabus intricatus (Linnaeus, 1758) [Coleoptera: Carabidae]	larvae	-	++ [1, 2, 3, 6]
Carabus scabriusculus bulgarus Lapouge, 1908 [Coleoptera: Carabidae]	larvae	-	+ [1, 2, 3, 6]
Calosoma sycophanta (Linnaeus, 1758) [Coleoptera: Carabidae]	larvae/pupae	+++ [5, 9, 12, 19]	+++ [1, 2, 3, 6]
Calosoma inquisitor (Linnaeus, 1758) [Coleoptera: Carabidae]	larvae/pupae	++ [9, 12]	++ [1, 2, 6]
PARASITOIDS			
Anastatus japonicus Ashmead, 1904 [Hymenoptera: Eupelmidae]	egg	+++ [9, 12, 20, 21]	++ [1, 2, 3, 4, 6]
Ooencyrtus kuwanae (Howard, 1910) [Hymenoptera: Encyrtidae]	egg	+++ [9, 12]	+++ [1, 2, 3, 4, 6]
Ooencyrtus tardus (Ratzeburg, 1844) [Hymenoptera: Encyrtidae]	egg	+ [9]	-
Ooencyrtus masii (Mercet, 1921) [Hymenoptera: Encyrtidae]	egg	+ [9]	-
Eremioscelio lymantriae Masnil, 1958 [Hymenoptera: Scelionidae]	egg	++ [9, 12]	+ [6]
Casinaria tenuiventris (Gravenhorst, 1829) [Hymenoptera: Ichneumonidae]	larvae	+ [9, 12, 20]	+ [6]

Gypsy moth		Significance	
Natural enemies	**Instar**	**Literature sources**	**Personal research**
Phobocampe disparis (Viereck, 1911) [Hymenoptera: Ichneumonidae]	larvae	++ [8, 9, 10, 12, 13, 20]	+ [6]
Phobocampe pulchella (Thomson, 1887) [Hymenoptera: Ichneumonidae]	larvae	+++ [9, 12]	++ [6]
Apanteles glomeratus (Linnaeus, 1758) [Hymenoptera: Braconidae]	larvae	+ [9]	+ [3, 6]
Apanteles lacteicolor Viereck, 1911 [Hymenoptera: Braconidae]	larvae	++ [9, 10, 12, 23]	+ [3, 6]
Cotesia melanoscela (Ratzeburg, 1844) [Hymenoptera: Braconidae]	larvae	+++ [1, 3, 6, 7, 8, 9, 10, 12, 13, 20, 21, 23]	++ [1, 2, 3, 6]
Cotesia ocneriae (Ivanov, 1898) [Hymenoptera: Braconidae]	larvae	+ [7, 9, 10, 12, 23]	+ [6]
Cotesia scabricula (Reinhard, 1880) [Hymenoptera: Braconidae]	larvae	+ [9, 12]	+ [6]
Cotesia spuria (Wesmael, 1837) [Hymenoptera: Braconidae]	larvae	+ [9, 12]	-
Protapanteles liparidis (Bouček, 1834) [Hymenoptera: Braconidae]	larvae	++ [1, 8, 9, 12, 20, 23]	++ [1, 2, 3, 6]
Protapanteles porthetrie Muesebeck, 1954 [Hymenoptera: Braconidae]	larvae	+++ [6, 9, 10, 12, 17, 20, 21, 23]	++ [6]
Protapanteles fulvipes (Haliday,1834) [Hymenoptera: Braconidae]	larvae	+ [9, 12]	+ [6]
Meteorus versicolor (Wesmael, 1835) [Hymenoptera: Braconidae]	larvae	+ [8, 9, 10, 12]	+ [6]
Meteorus gyrator (Thunberg, 1822) [Hymenoptera: Braconidae]	larvae	+ [9]	-
Eulophus slovacus Bouček, 1959 [Hymenoptera: Eulophidae]	larvae	+ [9]	-
Cirrospilus pictus (Nees, 1834) [Hymenoptera: Eulophidae]	larvae	+ [9]	-
Elachertus charondas (Walker, 1839) [Hymenoptera: Eulophidae]	larvae	+ [9]	-
Euplectrus liparidis Ferrière, 1941 [Hymenoptera: Eulophidae]	larvae	+ [9]	+ [6]
Sympiesis sericeicornis (Nees, 1834) [Hymenoptera: Eulophidae]	larvae	+ [9]	-
Exorista larvarum (Linnaeus, 1758) [Diptera: Tachinidae]	larvae	+++ [4, 12, 14, 22]	+ [3, 6]
Parasetigena silvestris (Robineau-Desvoidy, 1863) [Diptera: Tachinidae]	larvae	+++ [4, 12, 13, 14, 15, 17]	++ [6]
Phorocera agilis (Robineau-Desvoidy, 1830) [Diptera: Tachinidae]	larvae	+ [9]	-
Blondelia nigripes (Fallen, 1810) [Diptera: Tachinidae]	larvae	+ [1, 9, 12, 16]	-
Compsilura concinnata (Meigen, 1824) [Diptera: Tachinidae]	larvae	+++ [1, 9, 12, 14, 15, 16, 17, 22]	+ [3, 6]
Drino inconspicua (Meigen, 1830) [Diptera: Tachinidae]	larvae	+ [9, 12, 14, 16, 22]	-
Carcelia lucorum (Meigen, 1824) [Diptera: Tachinidae]	larvae	+ [9]	-
Carcelia gnava (Meigen, 1824) Syn. *Senometopia separata* (Rondani, 1859) [Diptera: Tachinidae]	larvae	+ [9, 12, 16, 22, 24]	++
Senometopia susurrans (Rondani, 1859) [Diptera: Tachinidae]	larvae	+ [9, 12, 14]	-
Zenillia libatrix (Panzer, 1798) [Diptera: Tachinidae]	larvae	+ [9, 16]	-

Gypsy moth		**Significance**	
Natural enemies	**Instar**	**Literature sources**	**Personal research**
Blepharipa pratensis (Meigen, 1824) [Diptera: Tachinidae]	larvae	+++ [1, 4, 9, 12, 14, 16, 17, 22]	++ [1, 2, 3, 6]
Blepharipa schineri (Mesnil, 1939) [Diptera: Tachinidae]	larvae	++ [9, 12, 14, 16, 22]	+ [6]
Gregopimpla inquisitor (Scopoli, 1763) [Hymenoptera: Ichneumonidae]	pupae	+ [12, 20]	-
Acropimpla didyma (Gravenhorst,1829) [Hymenoptera: Ichneumonidae]	pupae	+ [9]	-
Apechtis compunctor (Linnaeus, 1758) [Hymenoptera: Ichneumonidae]	pupae	+ [9, 12, 20]	-
Apechtis capulifera (Krichbaumer, 1887) [Hymenoptera: Ichneumonidae]	pupae	+ [9]	-
Apechtis rufata (Gmelin, 1790) [Hymenoptera: Ichneumonidae]	pupae	+ [9, 12, 20, 22]	-
Pimpla instigator Fabricius, 1793 [Hymenoptera: Ichneumonidae]	pupae	++ [4, 9, 12, 20, 22]	+ [6]
Pimpla inquisitor (Scopoli, 1763) [Hymenoptera: Ichneumonidae]	pupae	+ [9, 12, 20]	+ [6]
Pimpla turionellae (Linnaeus, 1758) [Hymenoptera: Ichneumonidae]	pupae	+++ [1, 9, 20, 22]	++ [6]
Theronia atalantae (Poda, 1761) [Hymenoptera: Ichneumonidae]	pupae	+++ [8, 9, 12, 20, 22]	+ [1, 2, 3, 6]
Polytribax perspicillator (Gravenhorst,1807) [Hymenoptera: Ichneumonidae]	pupae	+ [9, 12]	-
Lymantrichneumon disparis (Poda, 1761) [Hymenoptera: Ichneumonidae]	pupae	+++ [4, 12, 20, 22]	+ [1, 2, 3, 6]
Brachimeria intermedia (Nees, 1834) [Hymenoptera: Chalcididae]	pupae	+++ [12, 20, 22]	+ [1, 2, 3, 6]
Brachimeria femorata (Panzer, 1798) [Hymenoptera: Chalcididae]	pupae	++ [9, 12]	+ [6]
PARASITOIDS OR SAPROPHAGY?			
Agria affinis (Fallén, 1817) [Diptera: Sarcophagidae]	pupae	+++ [9, 12, 14]	++ [6]
Agria monachae Kramer, 1908 [Diptera: Sarcophagidae]	pupae	+ [9, 12]	-
Kramerea schuetzei (Kramer, 1909) [Diptera: Sarcophagidae]	pupae	++ [9, 12, 14, 18]	+ [6]
Parasarcophaga harpax (Pandelle, 1896) [Diptera: Sarcophagidae]	pupae	++ [9, 12, 14]	+ [6]
Parasarcophaga portshinskyi Rohdendorf, 1937 [Diptera: Sarcophagidae]	pupae	++ [9, 12, 18]	+ [6]
Parasarcophaga tuberose (Pandelle, 1896) [Diptera: Sarcophagidae]	pupae	+ [9, 12, 14, 18]	-
Parasarcophaga uliginosa (Kramer, 1908) [Diptera: Sarcophagidae]	pupae	+ [9, 12, 14, 18]	+ [6]
Robineauella pseudoscoparia (Kramer, 1911) [Diptera: Sarcophagidae]	pupae	+ [9, 12, 14, 18]	-
Muscina pabulorum (Fallen, 1817) [Diptera: Muscidae]	pupae	+ [9, 12]	+ [6]
Muscina stabulans (Fallen, 1817) [Diptera: Muscidae]	pupae	+ [9, 12]	+ [6]
PATHOGENS			
Lymantria dispar nucleopolyhedrosis virus [baculovirus]	larvae	+++ [9]	+++ [3, 5, 6]
Thelohania spp. [Microsporidia: Thelohaniidae]	larvae/pupae	? [9]	-
Vairimorpha sp.	larvae	? [2]	-

Gypsy moth		Significance	
Natural enemies	Instar	Literature sources	Personal research
Endoreticulatus sp.	larvae	? [2]	-
Streptococcus spp. [Lactobacillales: Streptococcaceae]	larvae	? [9]	-
Entomophaga maimaiga **Humber, Shimazu& Soper** [Entomophtorales: Entomophtoraceae]	larvae	-	+ [5, 6]

Legend:
+ poorly represented species ++ represented species +++ highly represented species

* [1] Đorović, [2] Glavendekić et al., 2006; [3] Maksimović, 1953; [4] Maksimović, 1973; [5] Maksimović & Sivčev, 1980; [6] Maksimović & Sivčev, 1984; [7] Maksimović & Sivčev, 1987; [8] Marović & Minić, 1987; [9] Mihajlović, 2008; [10] Minić, 1988; [11] Nonveiller, 1980; [12] Ristić et al.,1998; [13] Sisojević, 1953; [14] Sisojević, 1955; [15] Sisojević, 1959; [16] Sisojević, 1975; [17] Sisojević & Vasić, 1980; [18] Sisojević et al., 1989; [19] Tomić & Janković, 1973; [20] Vasić, 1958; [21] Vasić & Salatić, 1959; [22] Vasić & Sisojević, 1958; [23] Vasić & Minić, 1980; [24] Drea, J.J., 1981)

** Unpublished and published data: [1] Tabaković-Tošić, 2006; [2] Tabaković-Tošić and Jovanović, 2007; [3] Tabaković-Tošić, 2011; [4] Tabaković-Tošić et al., 2011a; [5] Tabaković-Tošić et al, 2012; [6] Tabakovic-Tosic et al., in press)

Regarding the density of some predator species, *Trombidium holosericeum, Forficula auricularia*, *Silpha quadripunctata*, *Calosoma sycophanta* and *Carabus sp.* were most abundant ones. *Calosoma sycophanta*, which regularly occurs during the outbreak of the gypsy moth, was found more frequently than other predator species, and it reduced the population size of the gypsy moth both in the larval and imago instars.

Table 2. *The laboratory analysis of the gypsy moth egg masses and Quantitative ratio of two species of parasitoids*

Year	Number of		Average number of fertilized eggs in egg mass				Parasitoids	
	localities	egg mass	Vital		Parasited		*Ooencyrtus kuwanae (%)*	*Anastatus japonicus (%)*
			N	%	N	%		
1993	27	270	298.9	86.4	44.6	12.9	100*	0
1994	35	350	555.9	95.0	20.5	3.5	100*	0
1995	69	690	543.8	98.7	2.8	0.5	100*	0
1996	427	4270	348.4	85.9	43.8	10.8	-	-
1997	725	7250	277.7	80.7	41.6	12.1	-	-
2002	70	700	477.6	95.5	17.3	3.5	78	22
2003	431	4310	570.7	88.3	79.9	11.2	69	31
2004	1023	10230	386.1	79.2	97.4	20.0	73	27
2005	266	2660	162.5	82.4	32.0	16.2	71	29
2009	58	580	502.5	91.6	42.3	7.7	91	9
2010	80	800	526.9	90.9	48.3	8.3	87	13
2011	120	1200	465.8	92.2	34.5	6.9	90	10

*from annual reports of Serbian report-diagnose-forecast service in the domain of forest protection

The dynamics of the emergence of the imago parasitoids were studied in the special laboratory experiment. Regarding the species of egg parasitoids, in the investigated period *Anastatus japonicus* accounted from 0 to 31%, *Ooencyrtus kuwanae* 69-100% (Table 2). The average parasitism rate should not be taken as the final one, because under these laboratory conditions it is impossible to study all the effects of a range of parasitoids and predators to which the the egg masses are exposed in the field.

At the selected sites the cocoons of the parasitoids species from the families Braconidae and Tachinidae (Table 1) were regularly found in spring. Some species from Braconidae family (Apanteles genus) were most active in the parts of the forests with the highest insolation and whence the outbreak of the gypsy moth usually begins. Other species were considerably less frequent and were found individually (Tabakovic-Tosic et al., in press).

The activity of *Ld*NPV was reported at many sites, characterized by the extremely high population size of the gypsy moth (Tabaković-Tošić et al., 2012, Tabakovic-Tosic et al., in press).

The higher mortality rate of the older gypsy moth larval instars in 2011 and 2012 was reported in the forest complexes of Belgrade and Valjevo (Tabaković-Tošić et al., 2012, Tabakovic-Tosic et al., in press), Donji Milanovac and Negotin (new localities – unpublished results) region, in the culmination phase of the new outbreak of the gypsy moth in Serbia. By field and laboratory studies of the causes of their death, the presence of azygospores and conidiospores of the entomopathogenic fungus *Entomophaga maimaiga* was reported in the dead caterpillars. It showed to be a powerful reducer of the population size of the gypsy moth, and in both regions it caused the collapse of the outbreak in 2011 and 2012.

4. CONCLUSIONS

A total of 88 species which are natural enemies of the gypsy moth, i.e. 23 predators, 49 parasitoids insects, 10 ***saprophagous insects, and 6 pathogens***, has been reported in Central Serbia. The insects which attack the larval instar of the gypsy moth are most frequent followed by the predators of the gypsy moth eggs and the parasitoids of the pupae of the host. Regarding the number of the species, the representatives of the Hymenoptera (14 species from Ichneumonidae family and 11 species from Braconidae family) and Diptera orders (12 species from Tachinidae family and 8 species from Sarcophagidae family) are most frequent. Regarding the predators of the gypsy moth, Carabidae family, from Coleoptera order is most frequent.

In spite of such a great number of the natural hosts, outbreaks of the gypsy moth are still the regular and frequent phenomenon in the forests of central Serbia, which points to the fact that nature is not so powerful regarding this economically most harmful species of the broadleaf forests in central Serbia. For the time being, the only exception to this rule is entomopathogenic fungus *Entomophaga maimaiga*.

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GYPSY MOTH, *Lymantria dispar* (L.), AND ITS NATURAL ENEMIES IN THE FORESTS OF CENTRAL SERBIA

Mara TABAKOVIĆ-TOŠIĆ

Summary

Based on the literature data, a total of 81 species which are natural enemies of the gypsy moth, i.e. 17 predators, 49 parasitoids insects, 10 saprophagous insects, and 5 pathogens, have been reported in Central Serbia. The parasitoids which attack the larval instar of the gypsy moth are most frequent, followed by the predators of the gypsy moth eggs and the parasitoids of the pupae of the host. Regarding the number of the species, the representatives of the Hymenoptera (14 species from Ichneumonidae family and 11 species from Braconidae family) and Diptera orders (13 species from Tachinidae family and 8 species from Sarcophagidae family) are most frequent. Regarding the predators of the gypsy moth, Carabidae family, from Coleoptera order, is most frequent.

During the twenty-year observed period, in the gypsy moth populations, the activity of 59 natural enemies of this insect - twenty-one predators, twenty-nine parasitoids, seven parasitoids or saprophages and two pathogens was reported. Regarding the density of some species, the most abundant predators were *Trombidium holosericeum, Forficula auricularia*, *Silpha quadripunctata*, *Calosoma sycophanta and some species from genus Carabus*, while the most abundant parasitoids were *Ooencyrtus kuwanae* (Howard) and *Anastatus japonicus* Ashmead, and pathogens *Lymantria dispar* nucleopolyhedrosis virus and *Entomophaga maimaiga* .

In the observed period, average parasitism rate of eggs in egg masses ranged from 0,5 to 20%. The greatest positive change in the activity of the parasitoids occurred during the second outbreak, from 3,5% in 2002 to 20% in 2004. Regardiong the species of egg parasites, in laboratory conditions *Oencyrtus kuwanae* was absolutely dominant (69-100%). In addition, at some sites *Lymantria dispar* nucleopolyhedrosis virus and *Entomophaga maimaiga* had the dominant role in the reduction of the gypsy moth density.

The activity of *Lymantrya dispar* NPV was reported at many sites, characterized by the extremely high population size of the gypsy moth. During the growing season in 2011 and 2012, in some forest areas of central Serbia, where the increased mortality rate of the gypsy moth larvae was reported and where there was no significant damage of the foliage caused by the feeding of them, the intensive research of the possible causes of this condition was done.

By field and laboratory studies of the causes of their death, the presence of azygospores and conidiospores of the entomopathogenic fungus *Entomophaga maimaiga* was reported in the dead caterpillars. It have been the first records of this kind is Serbia, i.e. Serbia is the third European country in which this fungus has been reported. In the investigated area, it showed to be a powerful reducer of the population size of the gypsy moth.

GUBAR, *Lymantria dispar* (L.), I NJEGOVI PRIRODNI NEPRIJATELJI U ŠUMAMA CENTRALNE SRBIJE

Mara TABAKOVIĆ-TOŠIĆ

Rezime

Prema literaturnim podacima, u centralnoj Srbiji do danas je utvrđeno ukupno 81 vrsta prirodnih neprijatelja gubara, i to 17 predatora, 49 parazitoia, 10 vrsta koje se ponašaju kao saprofagi i parazitoidi, te 5 patogena. U navedenom broju najzastupljeniji su insekti koji parazitiraju larveni stadijum gubara, a na drugom mestu su predatori jaja i parazitoidi lutki domaćina. Po broju zastupljenih vrsta, najviše je pripadnika redova Hymenoptera (14 vrsta iz familije Ichneumonidae i 11 iz familije Braconidae) i Diptera (13 vrsta iz familije Tachinidae i 8 iz Familije Sarcophagidae). Od predatora gubara, najzastupljenija ja familija Carabidae iz reda Coleoptera.

Tokom dvadesetogodišnjeg istraživačkog perioda u populacijama gubara, uočena je pojačana aktivnost 59 vrsta njegovih prirodnih neprijatelja i to dvadeset jednog predatora, dvadest devet parazitoida*,* 7 parazitoida ili saprofaga i 2 patogena. Od svih nađenih vrsta, najveću brojnost i najjaču aktivnost su imali predatori *Trombidium holosericeum, Forficula auricularia*, *Silpha quadripunctata*, *Calosoma sycophanta* i pojedine vrste roda *Carabus,* parazitoidi *Oencyrtus kuwanae* i *Anastatus japonicus,* te patogeni *Ld*NPV i *Entomophaga maimaiga*.

U posmatranom periodu, prosečna stopa parazitiranosti jaja u jajnim leglima kretala se od 0,5 do 20%. Najveća pozitivna promena u aktivnosti parazitoida dogodila se tokom druge gradacije, od 3,5% u 2002. do 20% u 2004. godini. Kada je reč o vrstama janih parazitoida dobijenih u laboratorijskim uslovima gajenja jaja gubara, apsolutno dominantan bio je *Oencyrtus kuwanae* (69-100%).

Aktivnost *Lymantrya dispar* NPV je registrovana na većem broju lokaliteta gde je brojnost gubara beležila enormne vrednosti. Tokom vegetacione sezone 2011. I 2012. godine, u pojedinim šumskim područjima centralne Srbije, gde je uočena veća smrtnost larvi gubara i gde nije došlo do značajnijeg oštećivanja lisne mase prouzrokovanog njihovom ishranom, obavljena su intenzivna istraživanja mogućih uzroka ovakvog stanja. Terenskim i laboratorijskim ispitivanjima uzroka smrtnosti starijih larvenih stupnjeva gubara, dokazano je prisustvo azigospora i konidiospora entomopatogene gljive *Entomophaga maimaiga* u uginulim gusenicama. Ovo su bili prvi nalazi ove vrste u Srbiji, odnosno, Srbija je treća zemlja u Evropi u kojoj je ova gljiva registrovana. Na istraživanim lokalitetima se pokazala kao moćan reduktor nivoa populacije gubara.

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THE MOSTINVASIVEFIVE WOODY PLANTS CONTROL RISKS ASSASMENT – STRATEGIC PRECONDITION FOR SUSTAINABLE GOVERNANCE OF NATURAL RESOURCES IN SERBIA

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Abstract: *Risks assessmentand management can play a key role in the reduction of damage caused by different types of forest pests, diseases and weeds in sustainable forestry practice development. Significant diversity of serious threats to forest ecosystems condition demands special governance instruments in a goal of increasing productivity while an environmental contamination and health hazard needs to be reduced to a minimum. Sustainable forest management can be better achieved through the preferment of appropriate assessment tools (with proper risk evaluation model developing and adapting it). During testing the increasing desire to apply the "precautionary principle" in the face of scientific uncertainty had been recognized. There's luck of scientific knowledge; studies are ongoing intensive but with decade or less delay of our country/ forest practice/ introduced plant influence research object existing results or their control usage background. Potentially serious consequences prejudgment leads to the driving force of a multidisciplinary approach in research process, with objective and invaluable field experience at the first place and guidance of it.*

Key words: Nature protection, governance, Biotechnologies, invasive species control, Serbia

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ПРОЦЕНА РИЗИКА ПРИ КОНТРОЛИ ПЕТ НАЈИВАЗИВНИЈИХ ДРВЕНАСТИХ БИЉАКАУСРБИЈИ – СТРАТЕШКИ ПРЕДУСЛОВ УСПЕХА ЗА ОДРЖИВО УПРАВЉАЊЕ ПРИРОДНИМ РЕСУРСИМА

Извод: *Процена ризика и риск- менаџмент могу имати кључну улогу у смањењу штете изазване различитим врстама шумских штеточина, болести и корова у пракси развојаодрживог шумарства. Значајна разноликост озбиљних претњи по шумске екосистеме захтева примену посебних управљачких инструмената у циљу повећања продуктивности, док би контаминација животне средине и опасност по људско здравље требало да буду сведене на минимум. Одрживо газдовање шумама лакше је остварити кроз фаворизовање одговарајућих механизама (прилагођавањемоделаза процену ризика је један од њих). Током истраживања тежило се примени "принципа предострожности" у смислу тестирања чињеница које су још увек предмет научних исртраживања, у европским земњама а и код нас. На теми истраживања генерално мало је рађено до сада у Србији ; интензивне студије или су у току, или барем деценију каснимо за земљама у региону. Пракса процене утицаја инвазивних биљака и примене корисних организама за стављање истих под контролу или у циљу њиховог сузбијања, још увек не постоји у Србији. Потенцијално озбиљно опасне последице примене мера биоконтроле упућују на мултидисциплинарни приступ у процесу истраживања. Полазне хипотезе које су стављене на проверу управо су оне добијене из шумарске праксе и теренског искуства. Валидно управљање ризиком диктира опрези неопходност при примени управљачких механизама у ситуацијама где постоји недостатак проверено доказаних научних чињеница.*

Кључне речи:_Заштита природе, управљање, биотехнологије, контрола инвазивних врста, Србија

1. INTRODUCTION

Regarding the use of new biotechnologies in forestry the most common innovative procedures in silviculture and raising healthy forests in protected areas are substitution of inorganic pesticides with biopesticides and direct “tool use” of scientifically approved useful plants and animals through biological control measures in detrimental biotic agent’s suppressing. Success stories presented both with performed case studies and forest biotic agent’s research results are showed in this paper. Studies conclusions are not limited or approximated to all protected areas (PA) where plant material had been collected and members of various interest groups had been interviewed, either they are directly or indirectly involved in the decisions making as management authorities. In this regard, the investment and use of any biotechnology needs to be risk assessed on a case-by-case basis, considering the specific technology in the specific ecological, political and economic environment. Research had been performed in forest ecosystems which are managed by state PE, NP, NR… All five the most harmful IP populations occur where their existence is: barely noticed, not recognized as threats, neither need for risk assessment of their further influence... Field real problems are conflicts caused by social opposing views on the primary purpose of forest land and protection of natural resources as units covered with forest vegetation, inappropriate agricultural and forest policies, and poor rural infrastructures. Until now Serbia has not adopted IPM (integral pest management) neither as the scientifically synchronized project studies results trial testing. This article present some proposals of proven joint activities resulted with risk assessment of five common test subjects based on facts obtained from the collected data analysis.

The aim of the present guidelines is to provide guidance to forest economy to help make monitoring a practical tool for environmental policy, especially in the development of plans and strategies on biodiversity conservation and sustainable use, the mainstreaming of biodiversity conservation objectives across policy sectors and in assessing progress in achieving policy targets and the effectiveness of conservation measures. Minimization of health, environmental and socioeconomic risks resulting from biodiversity loss and ecosystem degradation, as well as the maximization of benefits from biodiversity and ecosystems, are the main objectives.

1.1. Evolution of invasiveness

Some seemingly benign species increase invasive potential after arrival on a recipient site. Genetic drift, high genetic diversity in the founder population, or a change in selection pressures can interact to produce invader populations that have greater invasive potential than populations in the home range (Blossey and Notzold 1995, Lambrinos 2004; Bossdorf et al. 2005; Schierenbeck and Ellstrand 2009). An introduced species also has the capability to increase its invasive potential through hybridization with native species (Bossdorf et al. 2005). This evolution of invasiveness is occasionally linked to the concept of “enemy release”: when introduced into a new site, a species experiences little pressure from enemies (i.e., herbivores or pathogens), and thus less energy needs to be allocated to defense, that in turn gives an evolutionary advantage to individual plants that invest more energy in growth and reproduction (Blossey and Notzold 1995). Like many other hypotheses, support for evolution of invasiveness is contradictory, with this process occurring in some invasions but not others, possibly due to the many factors interacting in invasion.

1.2. The Characteristics of Invasive Species Critical for Ecological Risk Assessment

There are four features of invasive species ecological risk assessment that are in contrast to risk assessment for chemicals and other abiotic stressors (Landis, 2004).

First, the exposure to the stressor becomes the probability of a biological invasion event even if a permanent introduction throughout the landscape does not occur.

Second, the population size of the invasive species can increase, fluctuate, or even become extinct. Third, there is a broad range of mechanisms by which invasive species can directly and indirectly impact the valued characteristics of the receiving environment. Landscape-level impacts may also occur by a change in the ecological matrix through which migration occurs, altering the spatial relationships of important habitat patches (Shea and Chesson 2002).

Fourth, the processes that govern impacts are fundamentally ecological and evolutionary. Five invasive woody plants recognized as all criteria covered were described in paper results.

2. THE RISK MODEL

This Risk Model relies heavily on reasonable judgement by the SDM (Designated Environment Officials or Statutory Decision-Makers. SDM, could use available information from staff and others (experts for plant and forest protection- employed of Next relevant Ministries : Ministry of Agriculture, Forestry and Water Management: Ministry of Natural Resources, Mining and Spatial Planning, Institute for Nature Protection, Plant Protection Society of Serbia. The Risk Model uses numbers to represent the relative magnitudes of frequency, probability, and consequences, but the model cannot be considered “quantitative” in the sense of scientific accuracy. Using numbers simply allows various risk factors to be weighed systematically during the risk evaluation process.

Description- the following description highlights the model for evaluating the risks associated with approving an operational plan for suppressing IS in sustainable and biodiversity preserving precondition. When an SDM receives an operational plan for approval the acceptability of the controlling- suppressing plan, must considered, all things reviewed, including following:

The risks to a wide range of environmental, social and economic values of ISHE; The proposed mitigation of identified risks; The potential benefits of the proposed control or plan component; The Risk Model that follows offers guidance on the key steps in assessing risk. The approach leads decision-makers to draw risk conclusions by considering:

Values of Concern; *Potential Detrimental Invasive species hindering effect (Invasive species adverse effect; Frequency of Loss Event*; *Probability of Consequences Given a Invasive species adverse effect*; *Consequences of Loss Invasive species hindering effect*.

Instructions -to ensure consistent application of this model, users should not assign numerical values other than those suggested in any of the categories. When in doubt choose the higher risk value.

The initial entry in the Risk Assessment Matrix identifies the project or component under consideration.

Frequency of Invasive species occurrence at randomly fields – PA terrains

An important factor to consider in a risk assessment deals with the frequency of invasive species presence that could cause adverse consequences. Frequency is often expressed as the number of incidents in a given time frame, also called a “return period” for some types of invasive species which was suppressed someway. Consider the frequency of invasive species occurrence if the proposed project were approved, Select from the following four categories:
Frequent 10 points; Occasional 7 points; Seldom 4 points; Rare 1 point.

Probability of Consequences -in this step, contemplate the likelihood of consequences given a loss event. For example, what is the chance of water quality degradation if a landslide occurs as a result of the proposed plan? In the study of probability, invasive species hindering effect that will definitely happen are assigned a probability of 100 percent. Incidents that are impossible are given a 0 percent chance of occurrence, and everything else lies somewhere between these two extremes.

Consider the following three levels of probability:
Probable (*7 points)*. The likelihood or probability of the consequence occurring is greater than 50 percent. *Possible* (*4 points*) The probability of the consequence falls between 20 and 50 percent. *Unlikely* (*1 point*) .There is less than 20 percent chance that the consequences will occur. The probability factors considered in selecting among the three broad categories of probability should be recorded in the comment space.

Most Likely Consequences - The next set of factors deal with the potential consequences of the plan or component, given a loss event, such as a landslide. In large part, this step requires decision-makers to consider the resources and other values that may be affected by the plan or component.
Four categories of potential consequence are available: *Catastrophic 10 points*; *Major 7 points*; *Serious 4 points*; *Minor 1 point*. Briefly record the factors and features considered in making a determination of potential consequences.

Total Risk Level- In the evaluation of risk, consider all three factors: Frequency of invasive species hindering effect presence, probability that consequences will occur, and the extent of consequences to things of value. Combining these related risk elements is a mental process that defies a strictly scientific or structured approach. However, the model suggests a simple method that has been adopted in other types of risk decision-making: Add the values for frequency and probability, then multiply the sum by the consequence value to determine a total risk score.

If users apply this model consistently for two or more components of a plan, the scores will provide a rough indication of the relative risks of the components.

Risk Assessment Results- the foregoing analysis may be enough for some SDMs to make a determination on the operational plan under consideration. Plans that present either very high or very low risk often become quickly evident. However, recall that the assessment of risks associated with the plan is only one element to the overall decision on the plan.

If the plan promotes risks that are higher than acceptable to you, and the plan lacks reasonable means to manage these risks, you should avoid considering additional mitigation possibilities in your assessment. In doing so, you are drawing a conclusion on what is, rather than what could be in the plan and may then conclude that you should not approve the plan.

Decisions on plans or specific components may be clear where the model indicates risk levels of "very high" or conversely, "low" or "very low." Decisions that fall into the "high' or "moderate" risk levels may cause additional review depending on the situation.

In all respects, decision-makers should record their reasoning for approving or not approving an operational plan. SDMs should refer to the frequency, probability, and consequence elements addressed in this Risk Model, with specific comments on the factors that contribute to the greatest risks.

3. RESULTS

Results suggest that a species that is very competitive, resistant to contaminants or new control procedures, and one that can delay its dispersal until it has established a "beachhead" in the PA landscape. The beachhead patch ensures that there is a source for further migration into the landscape. The implication is that a fragmented or patchy environment will be more likely to contain an invasive because of the increasing number of areas that can be colonized and used as beachheads for further colonization. If the invasive can remain cryptic so that eradication efforts are limited until established in several refugee patches (PA habitats), the probability of a successful invasion should increase.

The models confirm work by many other researchers (see Anderson *et al.*, 2004; Marvier *et al.*, 2004) that there is a clear interaction between the landscape, competing species, and the invasive species. Spatial structure must be incorporated if an understanding of the possible outcomes is to be factored into the risk analysis. The interaction between control measures and the native species demonstrated that only in extreme – high risk events influence had badly the outcome of the invasion (Watrud *et al.* 2004; Landis *et al.*2000).

Five alien plant species were identified through this process/ risk model as having positive responses to the posed questions. These are listed in Table 1.

Table 1. *Exotic invasive plants in prioritized as potential biocontrol targets arranged by lines into groups of decreasing priority, but of similar priority within each group*

Species Life form* Area of origin EU climate distribution Genus native to Europe

Species	Life form*	Area of origin	EU climate distribution	Genus native to Europe	Conflict of interest†	Past or current biological control programs/ publications
Fallopia japonica	Ge	Japan	Temperate	Yes	No	Yes
Fallopiabohemica	Ge	Hybrid	Temp/Med	No‡	No	Yes
Amorpha fruticosa	Ph	N. America	Mediterranean	No‡	No	Yes
Ailanthus altissima	Ph	China	Temp/Med	No‡	No	Yes
Robinia pseudoacacia	Ph	N. America	Temperate	No	F	No

*Ph = Phanerophyte, Ge = geophyte, Hy = hydrophyte, He = hemicryptophyte, Th = therophyte, Ch = chamaephyte.

Conflict of interest: †Past or current biological control programs/ publications

†O = current ornamental interest, F = value as forestry tree – simple aesthetic value of certain aliens weeds is not considered a conflict of interest as biocontrol will only reduce their density not eradicate them.

‡Family or subfamily also not native to Europe. 1. ***Fallopia japonica*** **(Houtt.).** 2. ***F.* × *bohemica*** **Chrtek & Chrtkova**

Fallopia (Polygonaceae) contains 24 species worldwide of which seven are considered weeds. *Fallopia japonica* var. *japonica* (Houtt.) Ronse Decr., the most invasive clone (Bailey, 1994), is referred to as *Reynoutria japonica* (Houtt.) in some parts of Europe and *Polygonum cuspidatum* Sieb.& Zucc. are also invasive, although their relative importance in Europe and Serbia is still being studied *Fallopia japonica and fact that mantioned*hybrid appears to spread faster than either parent (Mandák et al., 2004), makes these two species among top five Serbia's aggressive aliens.

3. *Amorpha fruticosa* L.

Origin, life history and ecology - According to some sources it was introduced in the Balkan Peninsula at the beginning of the twentieth century, precisely in 1900 (Petračić, 1938). False indigo bush *Amorfa fruticosa* L. (Fabaceae= Papilionaceae: Astragalae) reproduce generative, with pods, dispersed by water, and vegetative with a strong power of sprouting. Pods yield natural insect toxic chemical, and if demanding systematically control measures by combination of chemical and mechanical measures trailed this forest weed as woody plant are practically invincible (Gagić *et al.* 2008).

Existing and potential biological control

Without finding solution that would exclude combined application of too expensive mechanical suppressing measures and environmentally eligible suspected pesticides it is possible to predict unstoppable expansion of this plant and facing with serious major problem in the near future.

Table 2. *Natural enemies of A. fruticosa*

Insect	***Biology and host preference of A. fruticosa pod pests***
Acanthoscelides pallidipennis*Motschulsky. *Coleoptera: Bruchidae: Bruchinae	*indigo bush weevil,bruchid beetle found feeding in pods*
***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**	

4. *Ailanthus altissima* (Miller) Swingle

Ailanthus (Simaroubaceae) contains 10 species confined to Asia and Australia of which *A. altissima* (from temperate and subtropical China), the only member of the family in Europe, is considered an invasive species in most temperate regions of the world.

5. Robinia pseudoacacia **L.**

Robinia(Fabaceae) contains four species from North and Central America, all of which are considered as weeds worldwide. Now is extremely widespread in many habitats in Serbia.

Existing and potential biological control- more recently, classical biological control of weeds has also undergone significant criticism from within the ecological and evolutionary scientific community (Louda *et al*., 1997), despite there being only a few predictable non-target impacts and the release decisions for the causal agents being made at a time when society was more risk accepting.

4. CONCLUSIONS

Classical biological control is often unjustly perceived as costly in its initial stages, with no guarantee of success and will therefore only really be possible with direct or indirect government support. For environmental and urban weeds this is even more apparent, so funding of biological control can only proceed with sympathetic, informed and 'joined up' government. Such issues are not unique to biological control, however, as many forms of natural resource management have long-term benefit timeframes and require political incentives for their adoption.

Fortunately, there is also now a groundswell of interest in European Governments over the invasive species issue, partly due to their CBD commitments and a growing recognition that many species and their associated costs are getting out of control. In order to secure funding, the responsible government department(s) [often both the agricultural and environmental ministries], need to be convinced of the high benefit–cost ratios of biocontrol, and it is here where stakeholders need to work with economists, as the analyses usually fall out heavily in favor of undertaking a biological control programme.(Sheppard et al., 2005).

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ACRONYMS

PA- Protected area
PE- Public Enterprise
NP- National park
NR-Nature Reserve
ESIAS - Environment and Social Impact Assessment Study
CBD- Biodiversity Convention
ISPM No. 3 -Guidelines for the export, shipment, import and release of biological control agents and other beneficial organisms

EPPO–European (Regional) Plant Protection Organization
IPREM - Invasive Plant Risk Evaluation Management
SDM - Designated Environment Officials or Statutory Decision-Makers
ISHE-Invasive Species Hindering Effect

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THE MOSTINVASIVE FIVE WOODY INVASIVE PLANTS CONTROL RISKS ASSASMENT - STRATEGIC PRECONDITION FOR SUSTAINABLE GOVERNANCE OF NATURAL RESOURCES IN SERBIA

Renata GAGIĆ SERDAR,Radovan NEVENIĆ, Svetlana BILIBAJKIĆ, Tomislav STEFANOVIĆ, Zoran PODUŠKA, Ilija ĐORĐEVIĆ, Goran ČEŠLJAR

Summary

Many European countries are waking up to the scale and impact of invasive alien species, as highlighted by the recent publication of the ESIAS which aims to stem the flow. This document was developed under the Bern Convention and recommends the requirement of a ‘grey list’ of species posing unknown threats that need to be screened for risks before introduction, including classical biological control agents under ISPM 3.

Classical biological control offers environmentally sound and public good solutions to some important Serbia’s worst alien invasive plants. It would assist EU commitments to reducing chemicals in the environment and controlling alien invasive species, while applying the precautionary approach to intentional introductions of such beneficial exotic organisms. This review highlights 5 of these and suggests, with the full support and in the context of the CBD and the ESIAS (Environment and Social Impact Assessment Study), that the time is ripe for classical biological control of weeds to break into the mainstream, alongside public demand for action and national commitments to reduce chemical use and protect biodiversity. However, this will continue to be delayed if suitable government-assisted funding streams are not established alongside processes for assessing conflicts of interest and raising public awareness on the issue of the costs of invasive species and the available solutions to them.

ПРОЦЕНА РИЗИКА ПРИ КОНТРОЛИ ПЕТ НАЈИВАЗИВНИЈИХ ДРВЕНАСТИХ БИЉАКАУСРБИЈИ-СТРАТЕШКИ ПРЕДУСЛОВ УСПЕХА ЗА ОДРЖИВО УПРАВЉАЊЕ ПРИРОДНИМ РЕСУРСИМА

Рената ГАГИЋСЕРДАР,Радован НЕВЕНИЋ, Светлана БИЛИБАЈКИЋ, Томислав СТЕФАНОВИЋ, Зоран ПОДУШКА, ИлијаЂОРЂЕВИЋ, Горан ЧЕШЉАР

Сажетак

У многим европским земљама све се више буди и развија свест о обиму и стетном утицају инвазивних врста. Тема је детаљно елаборирана и најбитнији цињенице истакнуте су у познатој публикацији ЕСИАС која има за циљ да заустави даљи ток њиховог сирења као негативног тренда. Овај документ је усвојен у оквиру Бернске конвенције, практично кроз увођење "сиве листе" условно корисних организама-врста које ипак представљају непознату претњу иза које је неопходно урадити процену ризика пре њихове примене и њиховог увођења као биолошких агенаса при успотављању контроле над инвазивним коровима у природи.

Класична биолошка борба нуди еколошки прихватљива иисплатива решења за сузбијање И контролу пет најопаснијих и агресивнијих инвазивних биљака Србије, за које је у овом раду дат и модел процене ризика од употребе њихових стетоцина. Предлози су складу са постојањем Конвенције о биодиверзитету и ЕСИАС (Студија процене ризика и утицаја на животну средину). Рад указује на вазност и потребне услове за примену класичне биолошке борбе против корова. Билошке мере борбе требало би да постану средство у застити шума од јавног и националног интереса, чиме би се смањила прекомерна и еколоски неоправдана употреба хемијских средстава и испостовали основни постулати заштите биолошке разноврсности. Међутим, ово неће постати уобичајена пракса док год политика ресорних министарстава и владе не развије механизме финансирања оваквих подухвата, и док у саму праксу заштите не уђе процена ризика од потенцијално корисних организама у самој примени и њиховог утицаја на околину. Подизање свести стручне и научне јавности о овом питању, као и научна потврда и докази о биолшкој борби као најрентабилније од могућих расположивих решења биће први корак у савладавању све евидентнијег негативног утицаја од ширења инвазивних врста и великих губитака по привреду али и заштиту природних добара у Србији .

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1. Review paper (paper that contains original, detailed and critical review of the research issue or field in which the author made a contribution, visible on the basis of auto-citations);
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3. Preliminary communication (Original scientific paper of full format, but small-scale or preliminary character).
4. Other known forms: scientific review, case study and others, if Editorial board finds that such paper contributes to the improvement of scientific thought.

Professional articles

1. Professional paper (annex in which are offered the experiences for improving professional practice, but which are not necessarily based on scientific method).

This guide, as well as an example of correctly printed paper in the journal Sustainable Forestry, can be found on the web-site of Institute of Forestry **(*http://www.forest.org.rs*).**

Papers should be sent to:
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