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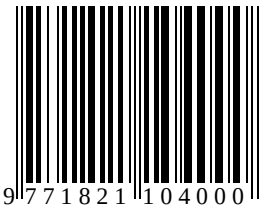

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AIR TEMPERATURE CHANGES IN SERBIA IN PERIOD 1949-2010 IN VIEW OF GLOBAL CLIMATE CHANGES

Ljiljana BRAŠANAC-BOSANAC, Tatjana ĆIRKOVIĆ-MITROVIĆ[1]

Abstract: *Global climate, biological, geological and chemical processes and natural ecosystems are interconnected, and changes in any of these components of the environment may affect humans and other living beings. According to the reports of the IPCC (2000, 2007, 2009) a single rate of global temperature growth that was observed during the twentieth century is the highest in the past millennium and it is closely connected with the greenhouse effects as a result of increased emissions of gases that cause this effect. Evaluation of changes in the average annual air temperature in Serbia in this paper was carried out on the basis of the results of climate modeling of the IPCC, by the most commonly used scenarios SRES A1B and SRES A2. It should be noted that by the global IPCC models, a problem of climate changes of specific climate parameters is observed in a planetary scale. If we want to get a fine structure of changes within particular regions for which can be crucial local effects such as complex orography, distribution and types of vegetation or soil, the results of these models are not accurate enough. Therefore, for the study of climate changes of the individual regions are used regional models in which the local characteristics of the selected region are accurately presented, so the results of these models have a more detailed structure. This paper analyzes the trend changes in the mean annual air temperature and the air temperature in the growing season, in the period from 1949 to 2010 (a series of 62 years), on the network of 32 meteorological stations in Serbia.*

Key words: air temperature, trend changes, Serbia.

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ПРОМЕНЕ ТЕМПЕРАТУРЕ ВАЗДУХА У СРБИЈИ У ПЕРИОДУ 1949-2010. ГОДИНА СА АСПЕКТА ГЛОБАЛНИХ КЛИМАТСКИХ ПРОМЕНА

Abstract: *Глобална клима, биолошки, геолошки и хемијски процеси и природни екосистеми међусобно су повезани, а промене у било којој од наведених компоненти животне средине могу утицати на човека и друга жива бића. Према извештајима IPCC-а (2000, 2007, 2009), јединствена стопа раста глобалних температура која је забележена током XX века, највећа је у протеклом миленијуму и уско је повезана са ефектом стаклене баште, као последицом повећане емисије гасова који изазивају тај ефекат. Процена промене просечне годишње температуре ваздуха у Србији у овом раду извршена је на основу резултата климатског моделирања IPCC-а, по најчешће коришћеним сценаријима сценарио SRES A1B и сценарио SRES A2. Треба нагласити да се глобалним IPCC моделима проблем климатских промена одређених климатских параметара посматра у планетарним размерама. Уколико хоћемо да добијемо фину структуру промена у оквиру појединих региона, за које могу бити пресудни локални ефекти као што су сложена орографија, расподела и врста вегетације или земљишта, резултати ових модела нису довољно прецизни. Зато се за истраживања климатских промена над појединим регионима користе регионални модели, у којима су локалне карактеристике одабраног региона прецизније представљене, па и резултати ових модела имају детаљнију структуру. У раду су анализирани трендови промена средње годишње и температуре ваздуха у вегетационом периоду, за период 1949-2010. година (низ од 62 године), на мрежи од 32 метеоролошке станице у Србији.*

Key words: температура ваздуха, тренд промена, Србија.

1. INTRODUCTION

In the analysis of climate changes including climate modeling, influence assessment, adaptation and adjustment, are used so called IPCC scenarios (IPCC 2000, 2007, 2009). They are alternative views of how specific measures or lack of their implementation may affect future emissions of greenhouse gases and how the future is uncertain in that sense. It is very uncertain that any path from the given scenario will appear in the form in which it is described. Scenario SRES A1B (IPCC) belongs to a group of moderate scenarios, and it includes a partial implementation of measures to reduce emissions of greenhouse gases, and predicts that the concentration of CO_2 at the end of the century will be about 700 ppm.

According to the results of IPCC models, the increase in mean annual temperature in Europe at the end of the twenty-first century (period 2071-2100) compared to the 1961-1990 climate normal, will be in the range of 2-3°C, if the increase in the concentration of greenhouse gases follows the scenario A1B. If the century ends up with a higher concentration that predict some "more aggressive" scenarios, the increase in temperature according to the results of other regional models can be twice as high compared to these values.

The results of these models are usually not accurate enough if we want to get the fine structure of changes within particular regions, for which can be crucial local effects such as complex orography, distribution and types of vegetation or soil. For this reason, for the study of climate changes in individual regions are used

regional models, in which the local characteristics of the selected region are accurately presented, so the results of these models have a more detailed structure.

According to Popovic, T. et al. (2009) estimates based on climate modeling, using moderate scenarios, indicate that the annual temperature in Serbia until the end of the century will increase for 2.6°C. Warming will not be equal throughout the year, summer will be warmer for 3.5°C, fall for 2.2°C, winter for 3.2°C, and the spring for 2.5°C. It is expected the increase in frequency, intensity and duration of heat waves, while the projections for the number of frosty and icy days say that they will continue to decline.

Increasing of the maximum and minimum annual temperature, the amount and distribution of rainfall during the vegetation period, the frequency of extreme phenomena and other climate parameters have a wide range of effects, both on the forest ecosystem as whole and individual trees and directly affect the phenology of plants. Due to high temperatures is reduced the moisture content in the soil, which directly affects the vegetation, as indicated by numerous studies: Kolić, B., Gajić, M. (1975), Jovanović, B., Kolić, B. (1980), Kolić, B. (1988), Andrasko, K. (1990), (1992), Botkin, D.B., et al. (1992), Krstić, M., Ćirković, T. (2005), Belij, S. et al. (2007) and others.

This paper analyzes the trends of changes in the mean annual air temperature and the air temperature in the growing season, for the period from 1949 to 2010 (a series of 62 years), on the network of 32 meteorological stations in Serbia.

2. MATERIAL AND METHOD

For the purposes of this study are used data from the Republic Hydrometeorological Service of Serbia. Due to the reduction of degree of error, it was performed the averaging by altitudes or height zones in which are the studied meteorological stations (areas up to 200 m above sea level, areas of 200-500 m above sea level, areas of 500-1,000 m above sea level and the areas of more than 1,000 m above sea level).

To check the statistical significance of the values of the linear trend of the mean annual air temperature and the air temperature in the growing season, it was used a test of independence of the two statistical features (**t test**) according to the formula:

$$t = R\sqrt{\frac{n-2}{1-R^2}}$$

Based on the coefficient of determination (R^2) and the degree of freedom was determined the actual value of the t test, and based on the degree of freedom (n-2) and an appropriate level of risk 0.05 and 0.01 are determined the critical values of t test. For degree of freedom 60 (n-2 elements), the critical values of t-test are: $\mathbf{t_{(60;\,0,05)} = 2,00;\ t_{(60;\,0,01)} = 2,66.}$

By comparing the actual and the critical value of t test it was determined the statistical significance of the linear trend of the mean annual air temperature and air temperature in the vegetation period in Serbia in the period 1949-2010.

In order to study the variability of the temperatures, the standard deviation was used.

3. RESULTS

In Table 1 is shown trend of changes of the mean annual air temperature and air temperature in the vegetation period in Serbia for the period 1949-2010.

Table 1: *The trend of the mean annual air temperature and the temperature in the growing season in Serbia in the period 1949-2010 (°C / year)*

Meteorological station	Altitude (m)	The trend of the mean annual air temperature °C/per year		The trend of temperature in the growing season °C/per year	
The area 0-200 m above sea level					
Negotin	42	0,021	**	0,021	**
Zrenjanin	80	0,016	**	0,013	
Veliko Gradište	80	0,007		0,007	
Kikinda	81	0,015	**	0,015	*
Sremska Mitrovica	82	0,011	*	0,010	
Vršac	84	0,016	**	0,012	
Novi Sad	86	0,014	**	0,011	
Sombor	87	0,015	**	0,016	*
Banatski Karlovac	89	0,012	*	0,011	
Palić	102	0,018	**	0,021	**
Loznica	121	0,023	**	0,025	**
Smederevska Palanka	121	0,011	*	0,011	
Ćuprija	123	0,003		0,002	
Belgrade	132	0,020	**	0,020	**
Zaječar	144	0,015	**	0,014	*
Kruševac	166	0,012	*	0,011	
Valjevo	176	0,016	**	0,018	**
Kragujevac	185	0,013	*	0,013	*
The area 200-500 m above sea level					
Niš	204	0,009		0,009	
Kraljevo	215	0,010	*	0,008	
Leskovac	230	-0,000		0,001	
Požega	310	0,016	**	0,021	**
Kuršumlija	383	-0,003		-0,009	
Vranje	432	0,004		0,005	
Dimitrovgrad	450	0,000		0,001	
The area 500-1000 m above sea level					
Novi Pazar	545	0,017	**	0,016	*
Trgovište	600	0,011	*	0,014	*
Rudnik	700	0,024	**	0,028	**
The area above 1000 m above sea level					
Zlatibor	1.028	0,014	**	0,013	
Crni Vrh	1.037	-0,097	**	-0,11	**
Sjenica	1.038	0,014	**	0,013	*
Kopaonik	1.711	0,014	*	0,017	*

* Statistically significant trend in the probability ***p = 95%***
** Statistically significant trend in the probability ***p = 99%***

In order to study the variability of mean monthly temperature and analysis of dispersion from the average of the mean monthly temperature, the values of standard deviation of the mean monthly temperatures were also calculated (Table 2).

Table 2: *Standard deviation of the monthly and annual air temperature in Serbia in the period 1949-2010*

Meteorological station	Altitude (m)	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Negotin	42	2,7	3,2	2,5	1,5	1,5	1,3	1,3	1,7	1,2	1,3	2,0	2,0	0,8
Zrenjanin	80	2,7	3,5	2,5	1,7	1,6	1,5	1,4	1,7	1,6	1,5	2,2	2,1	0,8
Veliko Gradište	80	2,3	2,9	2,2	1,7	1,5	1,4	1,3	1,6	1,6	1,5	2,1	2,0	0,7
Kikinda	81	2,7	3,4	2,3	1,7	1,6	1,4	1,4	1,6	1,5	1,5	2,2	2,1	0,8
Sremska Mitrovica	82	2,4	3,2	2,3	1,6	1,6	1,3	1,2	1,4	1,5	1,5	2,0	2,1	0,7
Vršac	84	2,7	3,3	2,4	1,8	1,6	1,4	1,3	1,7	1,6	1,7	2,3	2,2	0,7
Novi Sad	84	2,7	3,5	2,4	1,7	1,6	1,4	1,3	1,6	1,5	1,5	2,1	2,2	0,8
Sombor	87	2,6	3,4	2,3	1,6	1,6	1,5	1,4	1,5	1,4	1,5	2,1	2,1	0,8
Banatski Karlovac	89	2,4	3,1	2,3	1,6	1,6	1,3	1,2	1,6	1,5	1,5	2,1	2,1	0,7
Palić	102	2,6	3,2	2,2	1,6	1,6	1,4	1,4	1,6	1,4	1,5	2,0	2,1	0,8
Loznica	121	2,4	3,3	2,3	1,6	1,6	1,4	1,2	1,5	1,3	1,5	2,1	2,1	0,8
Smed. Palanka	121	2,5	3,2	2,3	1,7	1,6	1,4	1,4	1,7	1,5	1,6	2,2	2,2	0,7
Ćuprija	123	2,4	3,1	2,2	1,7	1,5	1,3	1,4	1,7	1,6	1,6	2,2	2,1	0,7
Belgrade	132	2,5	3,3	2,5	1,8	1,8	1,5	1,5	1,8	1,6	1,5	2,3	2,1	0,8
Zaječar	144	2,5	3,1	2,4	1,6	1,5	1,3	1,4	1,7	1,5	1,4	2,0	2,3	0,7
Kruševac	166	2,4	3,1	2,3	1,7	1,5	1,3	1,3	1,7	1,5	1,6	2,3	2,3	0,7
Valjevo	174	2,4	3,2	2,2	1,6	1,5	1,3	1,3	1,6	1,4	1,5	2,1	2,1	0,7
Kragujevac	185	2,4	3,2	2,3	1,7	1,6	1,4	1,4	1,7	1,5	1,6	2,2	2,2	0,7
The area 0-200 m above sea level		**2,5**	**3,2**	**2,3**	**1,7**	**1,6**	**1,4**	**1,3**	**1,6**	**1,5**	**1,5**	**2,2**	**2,1**	**0,8**
Niš	204	2,3	3,0	2,3	1,8	1,6	1,4	1,5	1,8	1,6	1,6	2,3	2,2	0,7
Kraljevo	215	2,2	3,1	2,3	1,7	1,6	1,3	1,3	1,6	1,6	1,5	2,3	2,2	0,7
Leskovac	230	2,4	2,9	2,1	1,7	1,4	1,3	1,3	1,7	1,6	1,6	2,3	2,3	0,7
Požega	310	2,2	2,9	2,3	1,7	1,5	1,2	1,1	1,3	1,3	1,4	1,9	2,2	0,6
Kuršumlija	383	2,2	3,0	2,2	1,7	1,4	1,2	1,3	1,7	1,5	1,5	2,3	2,2	0,7
Vranje	433	2,1	2,7	2,2	1,7	1,5	1,3	1,3	1,8	1,6	1,5	2,2	2,1	0,6
Dimitrovgrad	450	2,2	2,7	2,1	1,6	1,4	1,2	1,3	1,6	1,5	1,5	2,2	2,0	0,6
The area 200-500 m above sea level		**2,2**	**2,9**	**2,2**	**1,7**	**1,5**	**1,3**	**1,3**	**1,6**	**1,5**	**1,5**	**2,2**	**2,2**	**0,7**
Novi Pazar	545	2,3	2,6	2,1	1,8	1,6	2,6	2,8	1,7	1,5	1,6	2,0	2,1	0,9
Trgovište	600	2,0	2,7	2,1	1,6	3,2	1,1	1,2	1,6	1,5	1,4	2,2	2,1	0,6
Rudnik	700	2,4	3,5	2,7	2,0	2,8	1,8	1,4	2,1	2,3	2,0	2,7	2,3	0,9
The area 500-1000 m above sea level		**2,3**	**2,9**	**2,3**	**1,8**	**2,5**	**1,8**	**1,8**	**1,8**	**1,8**	**1,7**	**2,3**	**2,2**	**0,8**
Zlatibor	1.028	2,3	3,0	2,5	2,0	1,8	1,4	1,4	1,8	1,7	1,7	2,4	2,1	0,7
Crni Vrh	1.037	2,6	3,7	3,2	3,0	2,6	2,7	2,4	2,5	2,7	2,4	3,1	2,8	2,1
Sjenica	1.038	2,6	3,1	2,5	1,6	1,4	1,2	1,2	1,5	1,4	1,6	2,3	2,5	0,7
Kopaonik	1.711	2,0	2,4	2,3	1,9	1,5	1,4	1,5	1,7	1,5	1,6	2,1	2,2	0,9
The area above 1000 m above sea level		**2,4**	**3,0**	**2,6**	**2,1**	**1,9**	**1,7**	**1,6**	**1,9**	**1,8**	**1,8**	**2,5**	**2,4**	**1,1**

By analyzing Table 2 it can be concluded that the values of standard deviation range between 1.1 (Trgoviste - June; Pozega - July) to 3.7 (Crni Vrh - February) and that the temperatures in the warmer part of the year are more stable than in the colder part of the year. Understandably, the greater variability of temperature in the winter months in some years is the result of the penetration of cold and warm air masses.

When the influences of western air masses are stronger, the winters are relatively warm, and when is dominant the influence of northern and northeastern polar masses, the winters are very cold. The greatest variability of mean monthly temperature is in February, and the lowest in June and July.

4. DISCUSSION AND CONCLUSION

According to the obtained results, the trend of changes in mean annual air temperature in Serbia for the period 1949-2010 (62 years) at most meteorological

stations is positive (exceptions are Kursumlija and Crni Vrh). The greatest increases in the values of the linear trend have the meteorological stations Rudnik (0.024°C/annually), Loznica (0.023°C/annually), Negotin (0.021°C/annually) and Belgrade (0.020°C/annually), whereby the values of trend of changes are statistically significant at the 99% probability.

It is also noticeable the existence of territorial uniformity of trend of changes. For example, in Vojvodina the values of trend of changes in mean annual temperature are in the range of 0.011 ° C annually (MS Sremska Mitrovica), up to 0.018 ° C annually (MS Palic), where the values of trend are statistically significant at the probability of 95% for areas of Sremska Mitrovica and Banatski Karlovac, and for other meteorological stations in Vojvodina the values of trend of changes are statistically significant at the 99% probability.

Uniformity is also noticeable in the higher altitudes above 1,000 m (except MS Crni Vrh -0.097), and the value of the trend is 0.014°C annually, with statistical significance of 99% for all stations, except MS Kopaonik, where the value of the trend of changes of the mean annual temperature is statistically significant at the 95% probability.

Negative or minimally expressed positive trend of changes of mean air temperature is characteristic for the south-east of Serbia (Leskovac -0.00°C/ annually, Dimitrovgrad 0.000°C/annually), the areas along the valleys of the South and Great Morava (Vranje 0.003°C/annually, Nis 0.009°C/annually, Cuprija 0.003°C/annually), Veliko Gradiste (0.007°C/annually), but the values of the trend of changes at any meteorological station are not statistically significant.

When it comes to the trend of changes of air temperature during the growing season according to the obtained results, the trend of changes at the most meteorological stations is positive (exceptions are Kursumlija and Crni Vrh). The greatest increase in the values of the linear trend have meteorological stations Rudnik (0.028°C/annually), Loznica (0.025°C/annually), Negotin (0.021°C /annually), Palic (0.021°C/annually), Pozega (0.021°C/annually) and Belgrade (0.020°C/annually), whereby the values of trend of changes are statistically significant at the 99% probability.

Like in the trend of changes of the mean annual temperature, in the trend of changes in air temperature during the vegetation period is also noticeable the existence of territorial uniformity. In the area of Vojvodina (with the exception of Palic) the values of trend of changes of air temperature in the growing season ranges from 0.010°C annually (MS Sremska Mitrovica) to 0.016°C annually (MS Sombor), whereby the values of trend are statistically significant at the probability 95% for the area of Kikinda and Sombor, and for other meteorological stations values of trend of changes are not statistically significant.

Uniformity is also noticeable in height zones of 500-1,000 m above sea level and above 1,000 m (except for MS Rudnik and MS Crni Vrh), and trend values range from 0.013°C annually (MS Zlatibor and MS Sjenica) to 0.017°C annually (MS Kopaonik), with statistical significance of 95% for areas of Sjenica, Trgoviste (0.014°C/annually), Novi Pazar (0.016°C/annually) and Kopaonik, while for the area of Zlatibor the value of trend of changes in air temperature during the vegetation period is not statistically significant.

The negative trend of changes of air temperature in the growing season have Kursumlija (-0.009°C/annually) and Crni Vrh (-0.11°C/annually), while the value of the trend of changes in the area of MS Crni Vrh is statistically significant at the 99% probability, and the value of the trend of changes in the area of Kursumlija is not statistically significant.

Minimum expressed positive trend of changes of air temperature during the vegetation period is characteristic for south-east of Serbia (Leskovac 0.001°C/ annually, Dimitrovgrad 0.001°C/annually), areas along the valleys of the South and Great Morava (Vranje 0.005°C/annually, Nis 0.009°C/annually, Cuprija 0.002°C/ annually) and Veliko Gradiste (0.007°C/annually), but the values of the trend of changes at any weather station were not statistically significant.

The structure of the changes of annual air temperature in Serbia shows that the increase is caused primarily due to increase in summer temperatures and not due to the extremely higher winter temperatures as was emphasized in some reports of the IPCC which is opinion determined on the basis of paleoclimatic analogues in terms of domination of greenhouse gases effects (Ducic, V., Radovanovic, M., 2005).

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AIR TEMPERATURE CHANGES IN SERBIA IN THE PERIOD 1949-2010, IN VIEW OF GLOBAL CLIMATE CHANGES

Ljiljana BRAŠANAC-BOSANAC, Tatjana ĆIRKOVIĆ-MITROVIĆ

Summary

Prema većini prognoza, Srbiju kao i ceo region jugoistočne Evrope očekuju značajne promene klime u skorijoj budućnosti. Projekcije prema regionalnim klimatskim modelima predviđaju da će porast prosečne temperature na godišnjem nivou do kraja ovog veka iznositi od 2,4°C do 2,8°C prema optimističnom scenariju (SRES A1B), odnosno od 3,4°C do 3,8°C prema pesimističnom scenariju (SRES A2). Prema svim scenarijima očekuje se rast prosečne temperature, uz određene regionalne razlike, u svim delovima Srbije. Nesporno je da se klima menja i da će se menjati i u budućnosti, međutim, brzina, uticaji i posledice tih promena tokom XXI veka veoma su neizvesne, naročito u regionalnom smislu.

Prema dobijenim rezultatima sprovedenog istraživanja na većem delu Srbije trend promena srednje godišnje temperature i temperature vazduha tokom vegetacionog perioda, za period 1949-2010. godina je pozitivan, izuzetak su Crni Vrh i Kuršumlija. Najveći porast vrednosti linearnog trenda srednjih godišnjih temperatura i temperature vazduha tokom vegetacionog perioda imaju meteorološke stanice Rudnik, Loznica, Negotin i Beograd, pri čemu su vrednosti trenda promena statistički značajne pri verovatnoći 99%. Minimalno izražen trend promena srednje temperature vazduha i temperature vazduha tokom vegetacionog perioda odlikuje jugoistok Srbije, područja duž dolina Južne i Velike Morave, do Velikog Gradišta, ali vrednosti trenda promena ni na jednoj meteorološkoj stanici nisu statistički signifikantne.

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Original scientific paper

CERTAIN HISTOLOGICAL CHARACTERISTICS OF DOUGLAS-FIR NEEDLES IN DIFFERENT HABITATS

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Abstract. *Opencast coal mines of the Kolubara Mining Basin (Rudarski basen Kolubara), with the accompanying power plants, are constantly exposed to air pollution. Attempts have been made to mitigate the adverse impact on environment by means of biological recultivation by afforestation of opencast mines' tailing disposal sites. Pseudotsuga menziesii Mirbel. Franco belongs to a group of species frequently used for afforestation of such areas. Our studies, focused on substantiating the species' resistance to air pollution, involved an analysis of this factor's effect on changes in needles. The paper outlines the results of histological studies, which consisted of an analysis of diameter of needle cross-section, along with an analysis of share of diameter of certain tissues in cross-section.*

Key words: needle tissues, air pollution, open pit coal mine

NEKE HISTOLOŠKE KARAKTERISTIKE ČETINA DUGLAZIJE NA RAZLIČITIM STANIŠTIMA

Izvod. *Površinski kopovi uglja Rudarskog basena „Kolubara" sa pratećim energetskim postrojenjima su po stalnim uticajem aerozagađenja. Biološkom rekultivacijom odlagališta jalovine površinskih kopova čovek pokušava da ublaži negativne uticaje na životnu okolinu. Pseudotsuga menziesii Mirbel. Franco je jedna od često korišćenih vrsta u pošumljavanju ovih prostora. Naša straživanja su usmerena na*

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potvrđivanje otpornosti ove vrste na aerozagađenje i u okviru njih istraživano je delovanje ovog faktora na promene na četinama. U radu su prikazani rezultati histoloških istraživanja koja su se sastojala u analizi dijametara poprečnog preseka četina kao i udela dijametra pojedinih tkiva u poprečnom preseku.

Ključne reči: tkiva četina, aerozagađenje, površinski kop uglja

INTRODUCTION

Works related to opencast coal mining, coal combustion for power generation, transport and treatment of lignite for the purpose of converting it into a more valuable combustible material represent the main activities conducted in the area of Kolubara Mining Basin. The result of these activities is a day-to-day pollution of the environment.

In order to mitigate the adverse impact of pollution, along with other measures, recultivation has been conducted of the terrain created by the disposal of coal overburden layers. The problem of degradation of over 1,300 ha of tailing disposal sites has been addressed by means of biological recultivation – afforestation. For that purpose, a species frequently used in this process - *Pseudotsuga menziesii* Mirbel - has been introduced in Serbia for the first time (Šmit & Veselinović 1986). In addition to a land degradation caused by the opencast lignite mining, air pollution is particularly apparent in the Kolubara Basin mining-energy complex. It exerts an adverse impact on the living world in the immediate proximity of the mining-industrial complex.

A leaf zone represents a primary zone of impact of negative effects of gas pollutants on plant species. For that reason, the studies have been focused on investigation of changes in assimilation organs caused by air pollution, as an indicator of resistance to air pollutants. The investigations of species *Pseudotsuga menziesii* Mirbel. Franco are also important due to the fact that this plant is a fast-growing species widely used in afforestation, particularly in landscaping of peri-urban and industrial zones, on account of its decorative and other properties. As early as in the 1970s, Dassler et al (1972) an Mayer (1978) emphasised the importance of studies that would enable a selection of species resistant to air pollution and create an opportunity for establishing stable forest plantations in the zones exposed to a severe anthropogenic impact.

Various studies of extreme factors (stressors) proved that, contingent upon their intensity and exposure time, they could cause more or less intensive negative effects on plants (Wolff 1973, Goring 1982). Numerous authors have studied changes in assimilation organs caused by air pollutants (Hartig 1896, Sorauer 1908, Solberg et al 1955, Solberg & Adams 1956, Miller & Evans 1974, Smit & Davies 1978, Soikkeli 1981, Schoettle & Roshelle 2000, Kivimaenpaa et al. 2005, Haberer et al. 2006, Fares et al. 2010). The common conclusion was that air pollutants, by means of penetration into the inner part of leaf, effect changes in leaf structure. A leaf is a fundamental laboratory for the most important life processes of plants (assimilation, dissimilation, transpiration, etc.), therefore the morpho-anatomical and histological structure of assimilation organs is of importance for the

functioning of these processes. A disruption of their entire structure or individual segments impairs the basic life functions of a plant organism.

MATERIAL AND METHOD

The basic studies have been conducted among the *Pseudotsuga menziesii* Mirbel. Franco. cultures planted during the course of recultivation by afforestation in the Kolubara coal and energy basin. In this area, three sample plots under the influence of air pollution have been selected (Zs) in the forest cultures of the species *Pseudotsuga menziesii* Mirbel. Franco. aged over 30 years, whereas two sample plots, outside the air pollution zone, have been selected as control units– one containing cultures aged over 50 years, located in the Management Unit 'Jelova Gora' Forestry Office Užice – the control unit (K1), and the other containing cultures aged over 30 years, located in the Management Unit 'Juhor I' Forestry Office Jagodina – the control unit (K2).

For the purpose of our studies, one-year old and two-year old needles were taken in autumn (October-November) and spring (April) from each sample plot. The needle samples were taken from the central part of the crown, from the side exposed to the source of pollution. In the control areas, samples were also taken from the central part of crown. Only green needles from main branch axles were selected for the analysis. The samples from the sample plots in polluted environment were collected into a common group and analysed collectively.

For each age group, ten needles from ten trees were sampled. The needles from main branch axles, were placed into a cooled (t = +4°C) fixative (2% glutaraldehyde in 0.1M phosphate buffer pH/7) immediately after the field collection and transported to the laboratory. Rinsing (by a 0.1M phosphate buffer pH7), postfixation (by a 1% osmium tetroxide solution in a 0.1 phosphate buffer (pH 7)) (Soikkeli, 1978) and dehydration (by exposure to a series of alcohols and submersion into propylene oxide) were performed in the laboratory. Following the fixation and dehydration, the tissue was permeated by araldite resins. Thus prepared samples were placed into moulds, which were previously covered by pure resin and dried in thermostat.

The material for histological analysis was cut by an ultramicrotome, equipped with a glass knife. Cross-sections of 1μm thickness, placed onto microscope slides and dyed by toluidine blue, were used for a light (optical) microscope analysis.

Histological analyses consisted of measurement of needle diameter, thickness of epidermis with hypodermis and mesophyll, followed by a measurement of the diameter of central cylinder and vascular bundles. The measurements have also been performed on 100 semi-thin cross sections for each needle age group, on samples from the polluted area and samples from the control units. Following the performed measurement, the results were statistically analysed.

RESULTS AND DISCUSSION

Histological studies consisted of measurement of a diameter of needle cross-sections, along with measurement of a share of certain tissues' diameter in a cross-section. The data on a needle cross-section diameter (Table 1) indicate that the diameter of one-year and two-year old needles of autumn samples Zs is larger in comparison to the control unit K2 and that the effect of pollution is statistically significant. The cross-section diameter of one-year and two-year old needles in the control unit K1 in older cultures in a less polluted environment is larger than the needle diameter in the control unit V and the polluted zone Zs, while the difference is statistically significant. That indicates that the age of culture also has an impact on increase in needle diameter (Apple et al. 2000). The spring samples of one-year and two-year old needles from the polluted zone Zs, which endured winter, have a significantly smaller diameter in comparison to samples in the control units K1 and K2.

The data indicate that in the period of metabolic activity pollution effected a significant increase in needle diameter, while in the period of less intense metabolic activity caused by pollution, a statistically significant decrease in needle diameter in the polluted environment occurred.

Table 1*1. A diameter of cross-section of needles from the polluted environment Zs and the control units K1 and K2 in mm*

Experimental field	Needle age	Mean value ± standard error	
		Autumn	Spring
Zs	1	0.4553 ± 0.0093^{b}	0.3192 ± 0.0067^{a}
K 1	1	0.5840 ± 0.0080^{c}	0.3744 ± 0.0068^{b}
K 2	1	0.3759 ± 0.0041^{a}	0.4939 ± 0.1214^{c}
Zs	2	0.4681 ± 0.0155^{b}	0.3365 ± 0.0086^{a}
K 1	2	0.5840 ± 0.0086^{c}	0.4294 ± 0.0061^{b}
K 2	2	0.4173 ± 0.0027^{a}	0.5270 ± 0.0100^{c}

A multiple interval test – the values marked by the same letter in the column, does not indicate a difference on the level of significance $p<0.05$.

Mean values and standard error of the diameter of abaxial and adaxial epidermis are presented in Table 2. In one-year and two-year old needles of autumn samples, following the period of more intense metabolic activity under the influence of pollution, the diameter of abaxial and adaxial epidermis was increased in the polluted environment Zs and in the less polluted environment K1, in comparison to the control unit K2. The effect of pollution is statistically significant. The needle diameter in older cultures in the control unit K1 is approximately equal to the diameter of needles in the polluted environment (Apple et al. 2002), which indicates that needles in the polluted area exhibit signs of ageing.

Table 2. *The diameter of abaxial (A) and adaxial (B) epidermis of needles from the polluted environment Zs and the control units K1 and K2 in mm*

Experimental field	Needle age	Mean value ± standard error	
		Autumn	Spring
(A) Zs	1	0.0217 ± 0.0008^{b}	0.0144 ± 0.0003^{a}
(A) K 1	1	0.0198 ± 0.0007^{b}	0.0200 ± 0.0007^{b}
(A) K 2	1	0.0152 ± 0.0002^{a}	0.0157 ± 0.0042^{a}

Experimental field	Needle age	Mean value ± standard error	
		Autumn	Spring
(A) Zs	2	0.0211 ± 0.0005^{c}	0.0161 ± 0.0004^{a}
(A) K 1	2	0.0265 ± 0.0009^{b}	0.0201 ± 0.0001^{b}
(A) K 2	2	0.0137 ± 0.0000^{a}	0.0195 ± 0.0004^{b}
(B) Zs	1	0.0228 ± 0.0008^{b}	0.0163 ± 0.0005^{a}
(B) K 1	1	0.0235 ± 0.0004^{b}	0.0196 ± 0.0014^{b}
(B) K 2	1	0.0166 ± 0.0003^{a}	0.0188 ± 0.0044^{ab}
(B) Zs	2	0.0232 ± 0.0008^{b}	0.0173 ± 0.0007^{a}
(B) K 1	2	0.0237 ± 0.0003^{b}	0.0219 ± 0.0002^{b}
(B) K 2	2	0.0145 ± 0.0000^{a}	0.0245 ± 0.0002^{b}

A multiple interval test – the values marked by the same letter in the column, does not indicate a difference on the level of significance $p<0.05$.

In spring samples of one-year and two-year old needles, following the period of a less intense metabolic activity, the diameter of abaxial and adaxial epidermis is smaller in the polluted environment in comparison to both control units, while the difference is statistically significant. The effect of pollution had an impact on a statistically significant decrease in diameter of abaxial and adaxial epidermis of needles from the polluted environment.

Table 32. *The diameter of abaxial (A) and adaxial (B) chlorenchyma of needles from the polluted environment Zs and the control units K1 and K2 in mm*

Experimental field	Needle age	Mean value ± standard error	
		Autumn	Spring
A Zs	1	0.1483 ± 0.0068^{a}	0.1103 ± 0.0040^{a}
A K 1	1	0.2086 ± 0.0031^{c}	0.1072 ± 0.0041^{a}
A K 2	1	0.1255 ± 0.0008^{a}	0.1629 ± 0.0426^{b}
A Zs	2	0.1468 ± 0.0081^{b}	0.1105 ± 0.0054^{a}
A K 1	2	0.1913 ± 0.0038^{b}	0.1326 ± 0.0029^{b}
A K 2	2	0.1492 ± 0.0002^{a}	0.1627 ± 0.0037^{c}
B Zs	1	0.0908 ± 0.0033^{b}	0.0569 ± 0.0028^{a}
B K 1	1	0.1081 ± 0.0020^{c}	0.0655 ± 0.0015^{b}
B K 2	1	0.0706 ± 0.0013^{a}	0.0998 ± 0.0249^{c}
B Zs	2	0.1002 ± 0.0060^{b}	0.0686 ± 0.0038^{b}
B K 1	2	0.1154 ± 0.0032^{c}	0.0875 ± 0.0008^{b}
B K 2	2	0.0841 ± 0.0012^{a}	0.0947 ± 0.0028^{b}

A multiple interval test – the values marked by the same letter in the column, does not indicate a difference on the level of significance $p<0.05$.

The diameter of abaxial chlorenchyma (Table 3) in one-year old needle samples taken in autumn, following the period of a more intense metabolic activity, is equal to the diameter of needles in the control unit K2, while it is smaller in comparison to the control unit K1, where the difference is statistically significant. In two-year old needles, the diameter of needles in the polluted environment and the control unit K1 is approximately equal, while the difference in diameter in comparison to the control unit K2 is statistically significant. The diameter of abaxial chlorenchyma in one-year and two-year old needles is the largest in the control unit K1, followed by the needles from polluted environment Zs, while it is the smallest in the control unit K2. In both cases, the difference is statistically significant. That indicates that both air pollution and the age of cultures had an impact on changes in size of abaxial and adaxial chlorenchyma.

The diameter of abaxial chlorenchyma in one-year and two-year needles sampled in spring is the smallest in needles from the polluted environment, while the difference is significant in comparison to both control units. That indicates that

an independent effect of air pollution is significant. The diameter of adaxial chlorenchyma is the smallest in one-year old needles only, while in two-year old needles the diameter is of an approximately equal size in all three sample sources. That indicates that the impact of air pollution on adaxial chlorenchyma is negligible.

The diameter of central cylinder (Table 4) in samples of one-year and two-year old needles taken from the polluted environment Zs in autumn, following the period of more intense metabolic activity, is larger in comparison to the control unit K2, and smaller in comparison to the control unit K1. That indicates that both pollution and the age of culture had an impact on the size of diameter, and that both factors are statistically significant. In spring needle samples from the polluted zone Zs, taken after a less intensive metabolic activity, the central cylinder diameter is smaller in comparison to one-year and two-year old needles in both control units. The changes occurred solely as a result of pollution and are statistically significant.

Table 43. *The diameter of central cylinder of needles from the polluted environment Zs and the control units K1 and K2 in mm*

Experimental field	Needle age	Mean value ± standard error	
		Autumn	Spring
Zs	1	0.1657 ± 0.0039^{b}	0.1250 ± 0.0030^{a}
K 1	1	0.2196 ± 0.0024^{c}	0.1494 ± 0.0019^{b}
K 2	1	0.1471 ± 0.0007^{a}	0.1948 ± 0.0467^{c}
Zs	2	0.1822 ± 0.0055^{b}	0.1254 ± 0.0028^{a}
K 1	2	0.2251 ± 0.0039^{c}	0.1327 ± 0.0021^{a}
K 2	2	0.1519 ± 0.0030^{a}	0.2241 ± 0.0084^{b}

A multiple interval test – the values marked by the same letter in the column, does not indicate a difference on the level of significance $p<0.05$.

The diameter of vascular bundles (Table 5) in samples taken from the polluted environment Zs in autumn, following a more intensive metabolic activity, is larger in one-year old needles in comparison to the control unit K2, but smaller in comparison to the control unit K1. The differences in diameter size are statistically significant in both cases. In two-year old needles from the polluted environment Zs, the size of vascular bundles is approximately equal to those in the control unit K2, but in comparison to the control unit K1 the difference in size remained significant. In samples taken from the polluted environment in spring following a less intense metabolic activity, the size of vascular bundles is smaller in comparison to both control units. The changes in diameter of vascular bundles occured solely as a result of air pollution, where the differences in size are statistically significant.

Table 5. *The diameter of vascular bundles of needles from the polluted environment Zs and the control units K1 and K2 in mm*

Experimental field	Needle age	Mean value ± standard error	
		Autumn	Spring
Zs	1	0.0828 ± 0.0030^{b}	0.0630 ± 0.0022^{a}
K 1	1	0.0906 ± 0.0017^{c}	0.0825 ± 0.0027^{b}
K 2	1	0.0727 ± 0.0008^{a}	0.1010 ± 0.0246^{c}
Zs	2	0.0805 ± 0.0018^{a}	0.0650 ± 0.0013^{a}
K 1	2	0.1024 ± 0.0042^{c}	0.1084 ± 0.0026^{b}
K 2	2	0.0805 ± 0.0007^{a}	0.1221 ± 0.0055^{c}

A multiple interval test – the values marked by the same letter in the column, does not indicate a difference on the level of significance $p<0.05$.

CONCLUSIONS

Based on the analysis of the study results, it can be concluded:

- that the air pollution most frequently influenced the increase of diameter of all tissues, following a more intense metabolical activity, in samples taken in polluted environment in autumn.
- in samples taken in polluted environment in spring, following a less intense metabolic activity, the diameter of nearly all tissues was reduced in comparison to the control unit Juhor and that reduction, caused by air pollution, was statistically significant.
- the age of culture in the control unit Jelova Gora influenced an increase in size of cross-sections, when compared to the control unit Juhor.
- the diameter of needles from the polluted environment is approximately equal to the diameter of needles in the control unit Jelova Gora, which indicates that needles from the polluted environment exhibit signs of rapid ageing.

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SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
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Original scientific paper

TESTING OF CANADIAN DOUGLAS-FIR HEIGHT IN JUVENILE PHASE

Vera LAVADINOVIĆ[1], Vladan POPOVIĆ[1], Emil POPOV[2], Vukan LAVADINOVIĆ[3]

Abstract: *Introduction program of productive species were initiated in nearly all European countries but with different intensities. A common objective has been to create base material for seed procurement. Introduction objectives differ between countries, but most of them include adaptation and health, yield improvement, volume production and wood quality in some way.*

(Pseudotsuga menziessi Mirb/Franco) is one of the most important coniferous species in Europe both from an economic and ecological point of view. The provenance experiment of the North-West American conifer Douglas-fir were established in Serbia by the Institute of Forestry to test the genoecological characteristics of the species. Provenance experiment, contains the seed sources covering the central range of this species wich were collected from native area in Canada. The test included, fourteen seed provenances originating from Canada. Plants where produced in the nursery of the Institute, where they were measured. Early results from this provenances testing and growth information from the juvenile age in the nursery indicates that there are significant differences among Douglas -fir plants, what justifies the testing of introduced species by provenance experiment.

Keywords: Douglas-fir, provenance trials, mean height, introduction, seed transfer

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1. INTRODUCTION

Forest tree breeding has been ongoing for more than 70 years across Europe. It has successfully generated improved varieties for the major economical forest tree species. They are part of the present European forestry landscape and largely contribute to intensive wood production and other forest activities. Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) is native to the Pacific coast range and along the Rocky Mountains through Canada and USA. In the early 19th nineteenth century, it was introduced to Western Europe, where nowadays it covers almost 800,000 ha. Despite this considerable extent, the relatively recent introduction to Europe means this exotic species is still a minor forest species for several European countries. This status may be revised notably in the context of climate change, considering the high adaptability potential of the species. The original objective of most provenance tests was to identify the best seed sources for the test site area (Matyas, 1996).

Recent and projected changes in climate have increased interest in the potential growth responses of forest trees to climate change. Forest trees are adapted to their past environments, and their future growth and survival will depend on their ability to modify their phenotype in response to environmental change (Matyas, 1996).

The dominant height of a uniform stand, at a given age, is a good indicator of the potential productivity of that type of forest on that particular site (Cailliez, and Alder, 1980). This is based on Eichhorn's hypothesis (Eichhorn, 1904) that total production from a fully stocked stand, which is the volume currently standing plus anything removed in previous thinnings, is a function of its height (Savill et al. 1997).

The European forest almost dominated by introduced, non-native, tree species which occur on a wide range of site conditions. They have found a place in the classification in European Forest Types. The new European Forest Types are organized according to a hierarchical classification system structured into 14 Categories and 78 Types.

Introductions of forestry species were recorded for all regions, but the largest number of reports was for introductions to Africa (219 species). The dataset contained fewest records of forestry species introduced into Europe (95 species) and the Pacific (97 species) (EEA-2006).

Investigating the effect of transfer distances on the expression of genotype by environment interactions began with the innovative analyses of(Campbell, 1974), who regressed height growth of populations on geographic transfer distances. The use of transfer distances with the objective of understanding climate change effects on forest growth is more recent (Popov, 1990, Matyas, 1994, 1996, Schmidtling 1994, Carter, 1996, Rehfeldt et al. 1999, Wang et al. 2006, Thomson and Parker, 2008, Thomson et al. 2009).

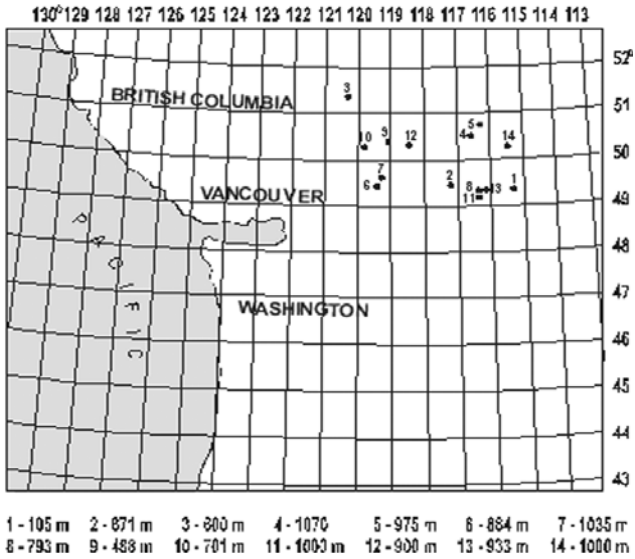
There is strong evidence that in woody plants, as in many other organisms, the transition from juvenility to sexual maturity is genetically controlled (Hackett, 1985, Greenwood and Hutchison, 1993, Greenwood, 1995). For this reason it is necessary to start with the control elements of growth in the juvenile stage of plant development.

2. MATERIAL AND WORK METHOD

As the material for this study, were used plants of fourteen Douglas-fir, which were produced in the Institute's nursery for forestry. Plant material was produced from the original seed of Douglas- fir, which comes from a part of Canada's natural range. Displaying origin provenance is given in Figure 1. Seeds were obtained through a forest seed centers 'Canadian Forest Service' from British Columbia. Table 1 presents the geographical characteristics of seed origin provenances of Douglas-fir and localities.

In the spring of 1999, the seeds were planted in containers. In April 2002, the seeds were transplanted in the nursery Sremčica, near Belgrade. The planting was conducted in rows, one provenance in one row. The distance between the rows was 2 m, while the distance between seedlings in a row was 1m.

In the end of vegetative season at 2003rd, the heights were measured of all plants in the experiment using a ruler, with an accuracy of 0.1 cm. The data were processed by a computer program STATGRAPHICS Plus. The statistical justification for the difference between the mean values of height was determined by LSD test with a probability of 95%. Influence of geographical origin provenances in height of seedlings was determined using Pearson's linear correlation coefficient



Picture 1. *Spatial layout chart of investigated provenances*

A comparative analysis of the attained mean height of Douglas-fir seedlings from fourteen Canadian provenances was published for the purpose of establishing inter-provenance variability and its dependence on geographic characteristics of the seed origin.

3. RESULTS AND DISCUSSION

Comparative analysis of medium height of fourteen Douglas-fir seedlings of different provenances from Canada, was conducted to determine the provenance variability and depending on the geographical characteristics of the seed origin.

The highest average height of 40.2 cm seedlings reached the provenances number five (30460), the provenances number three 38.9 cm (30667), and the lowest seedling the provenance number fourteen 25 cm (05092), the provenances number four 27.7 cm (05227), and the provenances number thirteen 28 cm (03 389), (Table 1).

Table 1. *Geographic characteristics of tested provenances*

Provenance		Location			Altitude (m)	Height (cm)
No.	Code		latitude	longitude		
1.	03333	Cranbrook	49°25'	115°20'	1050	28,4
2.	00848	Inonoaklin	49°50'	118°10'	671	37,8
3.	30667	Mann Creek	51°35'	120°10'	600	38,9
4.	05227	Gavia Lake	50°56'	116°35'	1070	27,7
5.	05226	Nine Bay	50°58'	115°32'	975	29,7
6.	03356	Trout Cr	49°40'	119°52'	884	30,5
7.	03360	Michell Cr	49°54'	119°37'	1035	29,1
8.	01198	Salmo	49°15'	117°30'	793	30,0
9.	30460	Mara Lk	50°48'	119°00'	488	40,2
10.	00278	Monte Crk	50°37'	119°52'	701	34,5
11.	03383	Sheep Creek	49°10'	117°15'	1000	35,3
12.	30461	Cooke Creek	50°38'	118°49'	900	32,2
13.	03389	Benton Creek	49°12'	117°25'	933	28,0
14.	05092	Sun Creek	50°08'	115°52'	1000	25,0

The statistical data indicates the existence of genetic variability in selected provenances of Douglas-fir from whose recognition depends heavily on the future success of the work on introduction.

Table 2. *Analysis of variance*

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6551,65	13	503,973	13,54	0,0000
Within Groups	11653,5	313	37,2317		
Total	18205,2	326			

Results of analysis of variance (Table 2) show a statistically significant difference at $p < 0.05$ between the mean height of seedlings, fourteen provenances of Douglas-fir.

Table 3. *LSD test*

Provenances	Mean	Homogeneous Groups
14	25,0	X
4	27,7	XX
13	28,0	XX
1	28,4	XX
7	29,1	XX
5	29,7	XX
8	30,0	XX
6	30,5	XX
12	32,2	XX
10	34,5	XX
11	35,3	XX
2	37,8	XX
3	38,9	X
9	40,2	X

LSD test were determined statistically significant differences between the mean height of seedlings of Douglas- fir provenances at confidence level $p < 0.05$. Provenances were grouped into six homogeneous groups which confirmed the high variability of the height of seedlings in fourteen provenances of Douglas-fir. In a homogenous group with the highest mean altitude of provenance are the provenances number: 9, 3 and 2, in the group with at least a high altitude provenances were the provenances number: 14, 4, 13 and 1 (table 3).

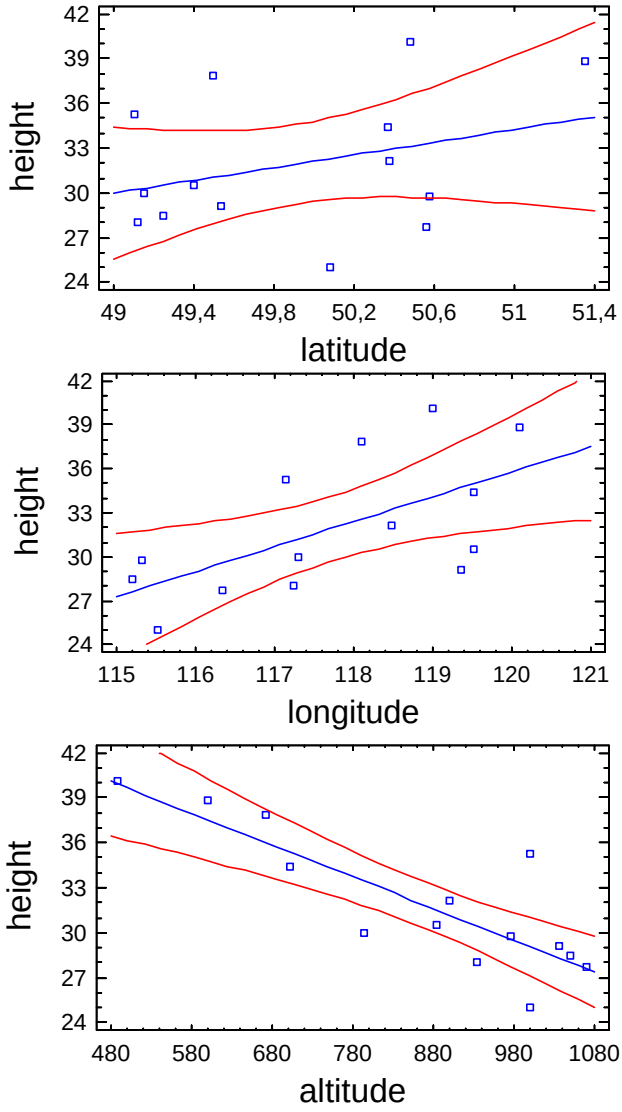
Influence of geographical origin provenance of Douglas-fir seedlings height was assessed by Pearson's linear correlation coefficient.

Table 4. *Geographic location and mean height correlation matrix of 14 Douglas-fir provenances, marked correlations are significant for $p<0.05$*

	Latitude	Longitude	Altitude	Mean Height
Latitude	1,00	0,2897	-0,3803	0,3271
Longitude		1,00	-0,6337*	0,6167*
Altitude			1,00	-0,8410**
Mean Height				1,00

On the basis of the Pierce coefficient values (table 4), it could be concluded that there is a positive correlation between latitude and mean height, but that correlation is not statistically significant.

There is a positive correlation between longitude and mean height and this correations is statistically significant. There is a negative correlation between altitude and mean height, and that correlation is statistically significant. A similar correlation was also established in the tests involving seeds of the same provenances (Lavadinović et al. 2004.), the same as in the tests with the average diameter (Popović and Lavadinović, 2011.).



Graph 1. *Latitude, longitude and altitude impact to a height of seedlings*

Based on the obtained results, it can be concluded that the height size is increasing from east provenances to the west. The height size is decreasing with the increase of altitude and that is the most pronounced impact (graph 1).

4. CONCLUSION

Maturing trees is characterized by elements of growth: height and diameter, so monitoring is in order to control genetic variation of seed transfer and environmental influences. Clearly, the potential for height growth is under strong genetic control, and the genetic potential is strongly moderated by the availability of resources in nursery conditions.

Developmental in height growth does not exhibit the environmental sensitivity or variability that is evident in absolute height growth or maximum height.

Variation in growth is associated with the geographic characteristic of the provenance.

This association suggests we can transfer seed sources a considerable distance without significant risk of maladaptation

Based on the obtained results it can be concluded that bares seedling height increased going from Eastern to Western provenances and from the southern to the northern provenances. With the rise of sea level height sizes are smaller and this effect is the most expresive.

Earlier genecological work showing Douglas-fir to be locally adapted and therefore seed transfer should be limited in new environment. For that reason the selection of best adapted provenaces is possible by testing the introduction species by provanance test.

Acknowledgement

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TESTING OF CANADIAN DOUGLAS-FIR HEIGHT IN JUVENILE PHASE

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Summary

The European forest almost dominated by introduced, non-native, tree species which occur on a wide range of site conditions. They have found a place in the classification in European Forest Types. The new European Forest Types (EFTs-2006) are organized according to a hierarchical classification system structured into 14 Categories and 78 Types.

Introductions of forestry species were recorded for all regions, but the largest number of reports was for introductions to Africa (219 species). The dataset contained fewest records of forestry species introduced into Europe (95 species) and the Pacific (97 species).

The majority of forestry species for introduction, are with the purpose to improve the economical, production and marketing value of the forestry sector.

General observation is that the introduced species Douglas-fir is the most promoted in most countries of Europe

In Serbia, the program introduction, Douglas fir was initiated by placing provenijeničnog test with the original seed originating from North America. Continued with the establishment of a test douglas fir provenijeničnog originating in Canada.

This paper presents the results of the test height of Douglas- fir seedlings of different provenances of the original native seeds from Canada. Significant differences between provenances confirmed the validity testing of introduced species through provenance test.

TESTIRANJE VISINA KANADSKE DUGLAZIJE U JUVENILNOJ FAZI

Vera LAVADINOVIĆ, Vladan POPOVIĆ, Emil POPOV, Vukan LAVADINOVIĆ

Rezime

Evropskim šumama gotovo da dominiraju introdukovane vrsta drveća koje se javljaju na širokom spektru uslova staništa. Oni su našli svoje mesto u klasifikaciji evropskih tipova šuma. Novi evropski tipovi šuma (EFTs-2006) su organizovani prema hijerarhijskom sistemu klasifikacije koja su struktuirana u 14 kategorija i 78 vrsta.

Introdukcija šumarski vrsta zabeležena za sve regione, a najveći broj je u Africi (219 vrsta) a najmanji u evidenciji šumskih vrsta: u Evropi (95 vrsta) i Pacifiku (97 vrsta).

Većina šumskih vrsta za introdukciju, su sa ciljem da se unapredi ekonomska, proizvodna i tržišna vrednost šumskog privrednog fonda.

Opšte zapažanje je da je od introdukovanih vrsta Duglazija je njazastupljenija u većini zemalja Evrope.

U Srbiji program introdukcije duglazije započet je postavljanjem provenijeničnog testa sa originalnim poreklom semena iz Severne Amerike. Nastavljeno je sa osnivanjem provenijeničnog testa duglazije poreklom iz Kanade.

U radu su prikazani rezultati testiranja visina sadnica duglazije, različitih provenijencija sa originalnim poreklom semena iz Kanade.

Značajne razlike izmedju prvenijencija su potvrdile opravdanost testiranja introdukovanih vrsta putem provenijeničnog testa.

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UDK 504.3:582.736.3 Amorpha fruticosa L.(497.11)=111
Original scientific paper

THE MOST COMMON FOREST PHYTOCOENOSES ENDANGERED BY FALSE INDIGO SPREADING IN SERBIA

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Abstract. *False indigo or indigo bush, Amorpha fruticosa L. is a deciduous shrub that belongs to the family Fabaceae. Since its introduction in the early 20th century, the plant had spread rapidly and become naturalised in the entire Balkan region. Indigo bush populations favour moist alluvial habitats; the species grows densely along the banks of lowland rivers, tributaries and streams, spreading into wet habitats, drying out meanders, blocking drainage canals. Occasional or regular flooding favours dispersal of its mature pods. The species was identified in ecological units ranging from hygrophilic wetland to communities in automorphic soils with no excessive wetting. It is common in the following types of forests: narrow-leafed ash and goat willow Salix caprea forests (Saliceto-cinereae-Fraxinetum angustifoliae), narrow-leafed ash and pedunculate oak forests with hygrophilic companion species (Fraxino-Quercetum roboris hygrophyllum), narrow-leafed ash and pedunculate oak forests on occasionally flooded terrains (Fraxino-Quercetum roboris subinundatum), pedunculate oak, hornbeam and narrow-leafed ash communities, flood-prone poplar forests and willow groves. In the south of Serbia, it grows individually along streams in mesophilic forests (Fagetalia Pawl. 1928.). The research findings on Amorpha entomofauna, which are the result of a six-year long study, opened up the opportunity for implementation of biocontrolling strategy, aimed at suppression of generative propagation of this invasive weed.*

For sure and soon this strategy should be tested, convincing that seed propagation of invasive weeds, could be inhibited after bio control agent, precisely useful weevils pods harm reduction experiments. Next step leads to serious expectations of its appliance, also blocking violent aggressors such Amorpha is, to continue making further floristic vanishing of diverse plant species, in wild nature habitats.

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Key words. Indigo bush, forest phytocoenoses, habitats, introduction, Serbia

НАЈЗАСТУПЉЕНИЈЕ ШУМСКЕ ФИТОЦЕНОЗЕ УГРОЖЕНЕ ШИРЕЊЕМ БАГРЕМЦА У СРБИЈИ

Извод. *Багремац, Amorpha fruticosa L. је листопадни жбун из породице Fabaceae. Након интродукције почетком XX века, биљка се брзо проширила и одомаћила на подручју читавог Балкана. Популацијама погодују влажна станишта алувијуми, густо расте уз обале равничарских река, рукаваца и потока, осваја ритска станишта, исушује меандре, блокира мелиоративне канале. Повремено или редовно плављење погодује разношењу његових зрелих махуна. Врста је забележена у еколошким јединицама од типова мочварних хигрофилних, до заједница на аутоморфним земљиштима без суфицитног влажења. Карактеристична је за шуме: пољског јасена са барском ивом Salix caprea (Saliceto-cinereae-Fraxinetum angustifoliae), пољског јасена и лужњака са хигрофилним пратиоцима (Fraxino-Quercetum roboris hygrophyllum), пољског јасена и лужњака на повремено плављеним теренима (Fraxino-Quercetum roboris subinundatum), у заједницама лужњака, граба и пољског јасена, поплавним топољацима и врбацима. На југу Србије, појединачно, расте уз токове речица у саставу и мезофилних шума (Fagetalia Pawl. 1928.). Налази истраживања ентомофауне аморфе, након шестогодишњих студија, отварају могућност примене стратегије биоредуковања генеративног размножавања популација овог инвазивног корова.*

Кључне речи. Багремац, шумске фитоценозе, станишта, интродукција, Србија

1. INTRODUCTION

Invasive plant species present a great problem and impediment to preservation of biodiversity (McNeel *et al*, 2001, Finnoff *et al*, 2007), causing significant and irreversible changes of the environment, primarily changes in floristic structure and the course of succession, along with social-economic damage. Invasive species first invade unstable ecosystems (degraded and devastated areas), later spreading into surrounding ecosystems, causing homogenisation of the regional flora (Jordan and assoc., 2009). The entire Pannonian Basin is populated by domestic or introduced leguminous plants of herbaceous form, perennial species, shrubs and tall stem plants, harmful to a different extent in ecological-economic terms. There is a certain number of already naturalised species, while some of them, planted in horticulture, occur only in parks and well-maintained plantations (Vukićević,1996). Some taxa are aggressively invasive and management authorities have no mechanisms for growth control of these populations in nature (Landis, W. G. 2004); as well as areal spreading (geographic) spatial adaptation (adaptation to habitat characteristics). False indigo, indigo bush or Amorpha, scientific name *Amorpha fruticosa* L., taxonomic Fabaceae: Papilionaceae: Amorpheae, is a deciduous woody shrub and the only species of this genus identified in Serbia, since these populations have been monitored (Tucović & Isajev V., 2000). The material had been collected for

six years in Croatia, Bosnia, the Montenegrin coast, along the seashore in Albania and the Skadar Lake shore; although some specimens occur individually, they only confirmed the findings related to distribution of this species of *Amorpha* genus.

A multi-disciplinary scientific approach, but also the engagement of experts from applied bio-technological disciplines (forestry, water-industry, spatial planning, agriculture) enabled perceiving Amorpha as a 'serious problem' and initiating a systematic undertaking aimed at placing the weed under control (Praseeda *et al* 2010). The plant occurred in Serbia at the beginning of the 20th century, since when it has spread rapidly and become naturalised, first in the regions of Posavina and Podunavlje. Today it is, as a rule, an omnipresent floristic element in any location where its unrestricted propagation is facilitated; however, the north part of Serbia belongs to a group of regions in which it has become an unavoidable vegetational 'pestilence'.

The recognised forest phytocoenoses endangered by indigo bush are enumerated and listed according to their system affiliation. The most detailed and comprehensive phytocoenological studies in lowland forests were conducted by Jovanović, B. and Tomić, Z. (1983-1984), with the aim of singling out ecological units (Jović, N. *et al.* 1990; Jović, N. *et al.* 1997), for the purpose of forest management based on typological principles (Jović, D. *et al.*1994.). The issue concerning cultivation of narrow-leafed ash (*Fraxinus angustifolia* Vahl.) in different types of forests in the Srem region was studied by Bobinac, M. (1988.) in his Master thesis, while the same author (1999) in his PhD thesis, studied natural regeneration of pedunculate oak (*Quercus robur* L.) contingent upon habitat and stand conditions. Pedunculate oak and narrow-leafed ash are the species young growth of which and, hence, their forests, are most directly endangered by indigo bush thickets.

The subject of this paper was presentation of the obtained results on floristic-phytocoenological characteristics of localities in which indigo bush is recognised as an important element of the existing vegetation. The main objectives of the research were also: (i) quantification of occurrence of Amorpha as a vegetation element (ii) determining the type of vegetation, (iii) determining the frequency of occurrence of *A. fruticosa* as a weed and dominant inter-species relationships with adjoining vegetation.

2. SUBJECT AND RESEARCH METHOD

The analysis of the structure and floristic composition of plants was performed according to the standard method of the Central-European Phytocoenological School (Braun-Blanquet-a 1964), where communities were not determined in the first year of the study. For all phytocoenological records, the following number and coverage scale (BraunBlanquet, 1928) was used: + (a rare species), 1, 2, 3, 4, and 5 (the largest mark indicates dominance of the species in terms of numbers and coverage). Certain small groups of edificators, which represent an indicative ground and shrub flora in weed-infested habitats, were singled out. In addition, certain species, growing synchronously with Amorpha and capable of endangering natural regeneration by their increased cover and association, were also singled out (Čokeša, *et al* 2008 ; Obratov-Petković *et al*

2009.). For the purpose of sampling, typical locations were selected, in which dense indigo bush thicket is inaccessible, while puny young growth of domestic broadleaved species on alluvium was scarcely visible in the understory, and where, for the same reason, its prospects in terms of dieback were very poor. The localities were selected as the most promising trial fields and in-depth analysed individually through phytocoenological records (Table 1). The selection of the future trial indigo bush plants – shrubs of excellent physical constitution and in perfect condition, as well as the habitus, was performed, along with the assessment and confirmation of abundant fruit bearing in crowns, some of which are in 'the most critical spots' reaching the heights of 5.5 and even 6m. Localities situated in management unit branches were identified in forest-economic management plans, where the data on the original vegetation type of the habitat were obtained. Numerous records were taken and sampling of fresh plant material was performed during several, mainly three aspects, in four vegetational seasons. By means of engagement and work of the researchers from the Institute of Forestry, Belgrade, elementary floristic material was gathered; in some cases, for the purpose of conducting skillfully reconstructed assessment of the origin of the source phytocoenological affiliation. In degraded areas or in areas under intensive succession, regardless of whether it concerned production and exploitation of the cultures, or their negligence and destruction, communities were determined conditionally, or the attempt to perform typological classification was abandoned.

3. RESULTS – OVERVIEW OF FOREST COMMUNITIES

Indigo bush was identified in the following ecological units ranging from hygrophilic wetland forests, over increasingly drier ones, to those on automorphic soils with no excessive wetting: narrow-leafed ash and goat willow forest (*Saliceto-cinereae-Fraxinetum angustifoliae*), narrow-leafed ash and pedunculate oak forest with hygrophilic companion species (*Fraxino-Quercetum roboris hygrophyllum*), narrow-leafed ash and pedunculate oak forests on occassionally flooded terrains (*Fraxino-Quercetum roboris subinundatum*), pedunculate oak, hornbeam and narrow-leafed ash forests (*Carpino-Fraxino-quercetum roboris inundatum*). An example, which concerns the type of forest most frequently invaded in terms of numbers, is presented in the content of a created phytocoenological record **(Table 1)**. In the Kolubara Basin, Amorpha thrives in alder forests *(Alnetalia glutinosae* R.Tx. 1937), as a part of riverine vegetation, occasionally in form of dense, twig-like, 'live' sheaves in Forelands; it grows remarkably successfully in shrub willow communities (*Salicetalia purpureae* Moor 1958.) and flood-prone alluvial forests (*Populetalia albae* Br.-Bl. 1931.). In the south of Serbia, it can be found on several localities, although it grows as a part of mesophilic forests along streams (*Fagetalia* Pawl. 1928.).

Table 1. *A phytocoenological record; a privately-owned forest with a distinctly incomplete canopy; indigo bush invades sunlit areas; the area is of a square shape and small in size, bounded by arable land and roads (regional and not very far - trunk roads)*

Locality	**Predejane**	Note
First summer aspect, Date	09 July 2008	Gagić R.
Area	Jablaničko	
Forest Management	Leskovac	14October 2008
Forest Administration	Predejane	
Management Unit		09 May 2009
	Privately-owned forest	
Locality	Predejane	
X	47631__	
Y	75715__	
Altitude m	252	
Exposition	NE	
Inclination º	5	
Geological Layer	Granodiorite (granite)	
Soil Type	District Regosols	
State of Preservation	Preserved	except for weed
Origin	Generative	
Age	61-80	
Surface Area m²	500	
Phytocoenosis	*Fraxino-quercetum roboris*	
Tree Layer		
Canopy	0,9	
Mean Height m	25,0	
Mean Diameter cm	35,0	
Mean Distance	4,0	
Quercus robur	3.0	
Quercus cerris	1.0	
Fraxinus angustifolia	1.0	
Robinia pseudoacacia	2,0	
Shrub Layer		
Canopy	0,2	
Mean Height m	2,0	
Cornus mas	2,0	
Rosa canina	2.1	
Salix alba	1.0	
Amorpha fruticosa	2.5	
Ligustrum vulgare	1.0	
Herb Layer		
Coverage	0,8	
Acer tataricum	1.1	
Arum maculatum	1.1	
Geum urbanum	1.1	
Helleborus odorus	1.1	
Lonicera caprifolium	1.1	
Melica uniflora	1.2	
Polygonatum officinale	1.1	
Urtica dioica	1.1	
Viola hirta	1.1	

Table 2. *Research localities in the course of 6 vegetational seasons; the locality code, the present type of vegetation/forest; the phytocoenological affiliation, the number and coverage of indigo bush in sample plots*

CODES	MARK IN SAMPLE CODING SYS.	PRESENT VEGETATION COVER LOCALITY	AUTOCHTHONOUS PHYTOCOENOLOGICAL COMMUNITY AFFILIATION	Evaluation of number and coverage (Indigo bush)
q1	GO	Grabovacko-Vitojevacko ostrvo,Klenak Pedunculate Oak - Ash Young Culture Stand	(*Fraxino-Ulmetum effusae* Slav. 1952.)	**3**
q2	SB	Senajske Bare, Klenak, EA Poplar Culture	(*Fraxino angustifoliae-Quercetum roboris* B. Jov. et Tom. 1979.)	**3**
q3	ZM	Zasavica I - Macv. Mitrovica, Swamp Bank Vegetation	(*Salicetum albae* Issl. 1936	**4**
q4	AO	Ada Ciganlija Lakeshore Greenery *Aster lanceolatus*†	(*Populetum nigrae* Knapp. 1948.	**1**
q5	CD	Cortanovacka Forest, Danube Bank, Willow-Poplar Forest	(Salicetum triandrae Male. 1929.	**3**
q6	SA	Šabac, River Sava Bank, Willow-Poplar-Ash Forest	(*Salicetum triandrae* Male. 1929.	**4**
q7	MA	Makis, Devastated Pedunculate –Ash- Elm Stand *Aster lanceolatus*†	(Alnetum glutinosae Vuk. 1956.)	**2**
q8	OM	Obedska bara A (Matijevica-Kadionica) Kupinovo, Pedunculate Oak Young Forest (20 years old)	(*Carpino- Fraxino -Quercetum roboris* Miš. et Broz 1962.)	**3**
q9	DO	Dobrec, *Juglans nigra* Mature (50 years old) Culture Stand	(*Violo-Quercetum roboris* Jov. et Tom. 1980.)	**1**
q10	SR	Sremska Raca, Visnjicevo, Mature Pedunculate Oak-Ash Forest	(*Carpino- Fraxino -Quercetum roboris* Miš. et Broz 1962.)	**3**
q11	OO	Obedska bara B (Obreške širine) Kupinovo Mixture Pedunculate Oak-Ash Forest (50 years old)	(*Genisto elatae-Ouercetum roboris* Horv. 1938.)	**2**
q12	OK	Obedska bara C (Kupinske grede 39, 40) Kupinovo, Pedunculate Mature Virgin Oak Forest (100 years old)	(*Leucoio-Fraxinetum angustifoliae* Glav. 1959.)	**3**
q13	OP	Obrenovac, Road Buffer Greenery *Ambrosia artemisiifolia* †	Completely anthropogenically modified	**4**
q14	BG	Backo Gradiste, DTD Canal Bank, Willow forest	(*Aceri tatarici-Quercetum* Zol. et Jak. 1957.	**5**
q15	OS	Ostruznica, Bridge Sava River Bank Greenery	(*Salicetum albae* Issl. 1936	**5**
q16	KO	Kovilj, Swamp Bank, Willow-Poplar Forest	(*Salici-Populetum nigrae* Parabuć. 1965.	**3**
q17	VG	Vracev Gaj, Lake Shore Greenery	(*Fraxino-Ulmetum effusae* Slav. 1952.	**2**
q18	BM	Backi Monostor,Siga Pedunculate-Ash Virgin Forest	(*Tilio-Quercetum crassiusculae* Slav. 1952.)	**5**

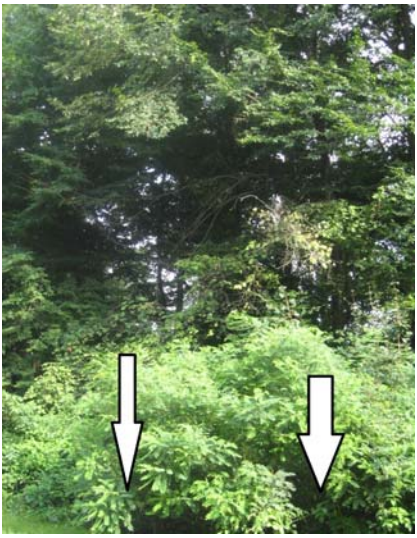
q19	CB	Carska Bara, Perlez, Swamp Bank,	(*Salicetum albo-amygdalino-purpureae* Slav. 1952	4
q20	BO	Borkovac, Lakeshore Greenery	Completely anthropogenically modified	+
q21	AM	Ada Ciganlija, Willow-Poplar Bank Forests, Sava River *Aster lanceolatus*†	Completely anthropogenically modified	4
q22	AT	Ada Ciganlija, Taloznik,Oak-Elm-Ash Forest *Ailanthus altissima*†	Completely anthropogenically modified	5
q23	FU	Futog Adica, River Danube Bank- Willow-Poplar Forests	(*Salicetum albo-amygdalinae* Slav. 1952.	2
q24	DJ	Đerdap Gorge, Dobra, Road Buffer Greenary *Robinia pseudoacacia*†	Completely anthropogenically modified	5
q25	SI	Simanovci, Ruderal Vegetation, *Ambrosia artemisiifolia* †	Completely anthropogenically modified	1
q26	VL	Vlasina River Bank, Vlasotince,Willow	(*Salicetum purpureae* Zel. 1952.)	+
q27	PL	Predejane, Leskovac, Road Buffer Greenery (*Robinia pseudoacacia*†	Completely anthropogenically modified	2+
q28	ZJ	Zoljevo, Jelasnica and Korbevacka Rivers, Bank-Willow-Elm Beech, latitude ≈≈1000m	(*Salicetum purpureae* Zel. 1952.)	1, +, +
q29	KD	Kamenjar, Danube River Bank, Oak-Elm-Ash forest, *Reynoutria japonica & Reynoutriax bohemica*†	(*Desčampsio-Quercetum roboris* B. Jov. 1979.	2
q30	BA	Barunovac, 0,5 ha Homogenous Stand of *A.fruticosa* *Ambrosia artemisiifolia* †	Completely anthropogenically modified	5
q31	TO	Topcider, Ruderal Vegetation *Ailanthus altissima*†	Completely anthropogenically modified	2

The forest vegetation groups, in terms of typology forest vegetation alliances, in which Amorpha occurs in the medium layer, are the following: pioneer shrub communities of goat willow (*Salicion cinereae* Muli. et Gors 1958), marshy Europan alder and narrow-leafed ash forests (*Alnion glutinosae* Male. 1929.), shruby almond willow and purple willow communities (*Salicion triandrae* Muli. et Gors 1958), flood prone willow and poplar forests (*Salicion albae* Soo 1940.), hygrophilic pedunculate oak and alder forests (*Alno-Quercion roboris* Horv. 1938), mesophilic hornbeam forests (*Carpinion betuli illiirico-moesiacum* Horv. 1956), thermophilic pedunculate oak and Tatar maple forests (*Aceri tatarici-Quercion* Zol. et Jak. 1957.) and thermophilic Hungarian oak and Turkey oak forests (*Quercion frainetto* Ht. 1954).

4. CONCLUSION AND DISCUSSION

The anthropogenic impact on indigo bush spreading is currently reflected in the fact that neglecting the increase of ruderal areas facilitates plant survival and provides it with a needed space. When the opinion, in the framework of field research conducted throughout Serbia, was sought from local, rural population (in

form of short uniform surveys – a set of few questions), on the issue of aggressive indigo bush spreading, the conclusion drawn was that the level of ecological awareness is currently low and that the concept of invasiveness is generally insufficiently well-known. Unfortunately, this is also the case in numerous instances when the forestry profession itself is insufficiently aware of the scope of the problem. However, it is a general belief that it is not rational to exert impact on weeds through forestry and nature protection interventions conducted by means of use of large amounts of herbicides on terrains that are protected areas or areas of exceptional features. There is a possibility that such procedure takes place in the proximity of valuable water springs; it is not harmless, and given the required active substances that prevent spreading of indigo bush by final stump coating, it is far from being ecologically justified.



Photograph 1. *Impact of the A. Fruticosa layer; The arrows indicate places where, in* ***undisturbed*** *conditions, young growth of pedunculate oak would stand a chance to grow. The Amorpha canopy in the shrub layer, on a small forest clearing. A mature pedunculate oak with hornbeam stand, Visoka šuma Lošinjci, Forest Management Kupinovo, July 2009, (Photo: Orig).*

Photograph 2. *Young plants growing around a pond that retained the flood water. A mixed pedunculate oak and hornbeam stand with forest fruit trees. Management Unit Karakuša, Forest Management Klenak, August 2008 (Photo:Orig).*

Despite all efforts, Amorpha increasingly invades neglected agricultural lands in rural areas, in rural communities in the proximity of settlements, areas neglected on account of the fact that cultivation of more valuable forest species and pursuing agricultural work on infertile soil are not cost-effective. Corridors, natural or artificial, rivers, streams, whose flood-waters distribute its seed, and road networks where man directly participates in supporting its generative and

vegetative propagation and enables its spreading, present even more serious problem when they border with forests.

Communities, however, must be preserved in their original form and natural regeneration is the only way to eliminate excessive and aggressive members from the exceptionally rare, complex existing communities. Indigo bush presents one of the largest problems in natural regeneration of the Serbian lowland flood-prone forests, since it grows densely in the understory of old pedunculate oak trees and narrow-leafed ash trees and other autochthonous trees and shrubs. With its dense canopy, it completely prevents seed development of forest tree young growth, by blocking its source of light, usurping a necessary space and absorbing nutrient matter and water from forest land (photographs 1 and 2). Unless a solution is found, which is not only a combined application of extremely expensive mechanical suppression and spraying by, in long-term, barely acceptable pesticides, expansion of indigo bush will become impossible to prevent. Without timely and effective engagement, forestry professionals could resign themselves to inevitability of facing a serious problem in near future.

Given the fact that the presence of insects – indigo bush spermophagus, identified as a significant reduction factor of indigo bush generative propagation (Gagić Serdar *et a*l, 2012), has been recorded in Serbia, it is necessary to continue the phytocoenological research and, concurrently, the research of indigo bush entomofauna, for the purpose of indigo bush suppression. By recording new instances of its occurrence in autochthonous forests, where it acts as an impediment or disturbs the balance in any other way, the scope and the characteristics of what actually indigo bush as 'conflict species' represents in phytocoenological and interspecies terms, will be understood more clearly. This deservedly obtained attribute has been confirmed in numerous forest ecosystems in Serbia

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THE MOST COMMON FOREST PHYTOCOENOSIS ENDANGERED BY FALSE INDIGO SPREADING IN SERBIA

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Summary

Gradually invaded by indigo bush, as a result of insufficiently developed legislation in the field of nature and forest protection, increasingly large spaces of commercial and protected forest areas in Serbia are facing a serious problem, of which neither expert, scientific nor broader public is aware, and which may escalate in near future, This problem may be the cause of disturbances of water regime in Serbian alluvial forest ecosystems, eutrophication of wet habitats, and prevention of succession in its normal course. The lack of adequate measures for weed control resulted in presence of Amorpha in numerous phytocoenoses and forest complexes that are either managed by or a part of protected areas throughout Serbia. This type of legume has been identified in ecological units of a hydrophilic marshy species type, but also in those where soils are without excessive wetting.

They include the following types of forests: the ash and goat willow forest (*Saliceto-cinereae-Fraxinetum angustifoliae*), the ash and pedunculate oak forest with marshy vegetation (*Fraxino-Quercetum roboris hygrophyllum*), the ash and pedunculate oak forest on flooded terrains, stands with pedunculate oak as an edificator (*Fraxino-Quercetum roboris subinundatum*), the pedunculate oak, elm and ash forest, along with

flood-prone poplar forests and willow groves. In the south of Serbia, it grows individually within mesophilic forests along streams (*Fagetalia* Pawl. 1928.). Sensitive biotopes ought to be recognised, their reconstruction or recultivation conducted; it is also necessary to monitor and analyse the success of the interventions themselves; application of biocontrol by means of use of their natural enemies would be the most desirous method, in the spirit of sustainability. By studying the agents of suppression, through scientific studies and experimental methods, weeds should be eliminated in the period when their seed is in the phase of maximum exposure. Spermophagus, as potential reducers of invasive plant population and potential means of biological combat against their adverse impact on environment, should become tools of sustainable forest ecosystem management.

NAJZASTUPLJENIJE ŠUMSKE FITOCENOZE UGROŽENE ŠIRENJEM BAGREMCA U SRBIJI

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Rezime

Полако запоседнути багремцем простори у привредним и заштићеним шумске области у Србији се због недовољно разрађеног законодавства из области заштите природе ишума суочава са великим проблемом који може ескалирати у блиској будућности, а кога још нису потпуно свесни нити, нити стручна ни научна шира јавност. Ово може бити разлог поремећаја водних режима у нашим алувиалним шумским екосистемима, еутрофикације влачних станишта, и стопирања сукцесија у њиховом нормалном току. Недостатак адекватних мера за контролу коровима, узроковао је присуство аморфе и бројним фитоценозама шумских комплекса којима се или управља, или су у заштићеним подручјима широм Србије. Ова врста махунарки је забележена у еколошким јединицама хидрофилних мочварних врста, али и у онима где су земљишта без вишка додатног влажење.

То су шуме: јасена са барском ивом (*Saliceto-cinereae-Fraxinetum angustifoliae*) јасена и лужњака са барсом вегетацијом (*Fraxino-Quercetum roboris hygrophyllum*), јасена и лужњака на поплавним стаништима, станишта салужњаком као едификатором (*Fraxino-Quercetum roboris subinundatum*), лужњака, бреста и јасена, са поплавним шумама тополе, и врбаци. На југу Србије појединачно расте дуж водотока, и речица у заједници мезофилних шума (*Fagetalia* Pawl. 1928.). Осетљиве биотопе потребно је препознати, урадити реконструкцију истих или рекултивацију, а неопходно је пратити и испитати успехе самих интервенција, од којих би примена метода биконтроле контрова њиховим природним непријатељима био најпожењнији, у духу одрживости. Проучавајући био агенсе сузбијања, путем научних студија и експерименталним путем корове би требало елиминисати, онда када им је семе у фазама максималне изложености., Семеноједи као потенцијални редуценти популација инвазивних биљака и кандидати за биолошку борбу против њиховог негативног дејства на околину требало би да постану кандидати - инструменти за одрживо управњање шумским екосистемима.

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STAND VOLUME TABLES FOR BEECH IN SERBIA

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Abstract: *The study results are a regression model and two-way stand volume tables intended for practical application. The Model and the tables resulted from a large data-set collected in beech high forests in Serbia. Eleven all-aged beech high stands were selected in six forest areas and measured using a simple systematic sample. Altogether 241 circular sample plots of 500 m^2 were distributed using the square grid network design, spacing 100 m. The models were constructed by the method of stepwise multiple regression. The model accuracy was tested on the material that was used for the construction of tables. However, the true reliability and efficacy of the models can be evaluated only after their practical implementation.*

Key words: beech stand, stand volume,model, stand tables

SASTOJINSKE ZAPREMINSKE TABLICE ZA BUKVU U SRBIJI

Apstrakt: *Rezultat ovog rada je regresioni model i dvoulazne sastojinske zapreminske tablice namenjene za primenu u praksi. Model i tablice su dobijeni na bazi obimnog materijala prikupljenog u visokim bukovim šumama na području Srbije. U šest šumskih područja odabrano je i premereno jedanaest raznodobnih sastojina bukve. Primenjen je jednostavni sistematski uzorak. Postavljena je 241 probna površina, oblika kruga i veličine 500 m^2, u kvadratnom rasporedu na rastojanju 100 m. Za konstrukciju modela i tablica primenjen je metod postepene (stepwise) višestruke regresije. Proverena je tačnost modela i tablica na materijalu koji je poslužio za izradu tablica. Međutim, ocena stvarne efikasnosti dobijenog modela i tablica biće moguća tek posle njihove primene u praksi.*

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Ključne reči: sastojina bukve, zapremina sastojine, model, sastojinske tablice

1. INTRODUCTION

In forest management planning, one of the most significant estimation elements is stand volume (growing stock) per hectare and over the entire area. The same applies to larger forest management or forest classification units (e.g. management class). The main goal of forest inventory is to estimate the size of growing stock and its distribution per diameter degrees or classes, as accurately as possible both for the principal tree species and in total. The methods used to this purpose must be accurate and economic, i.e. efficient. The most frequently implemented methods both in the world and in our country are based on the sample, i.e. on partial stand measurement. The *method of stand volume tables* is one of many stand inventory methods. These tables have been used for a long time in the forestry of the USA, Canada and some countries in Europe (Scandinavian coutries). The interest in the construction of stand volume tables for different tree species particularly increased after the invention of relascope and the development of relascopy method (Bitterlich, R. 1948, after Mirković, D., Banković, S. 1993). As it is known, the relascopy can determine the basal area of a stand (primarily even-aged) per hectare and its distribution per diameter degrees or classes relatively quickly and precisely enough.

The tables are constructed based on the dependence of the stand volume per hectare on other stand estimation elements (most often basal area per hectare and mean height). The examples for the construction of stand volume tables for pure and mixed all-aged and even-aged stands of our principal tree species, were produced only for the area of Bosnia and Herzegovina (Matić, V. *et al*., 1963, Stojanović, O. *et al*., 1987). There are no tables of this type for natural stands in Serbia. There are only tables for artificially established stands of Austrian pine up to fifty years of age (Koprivica, M. 1995). In all the above cases, stand tables were calculated by the method of multiple regression analysis.

The aim of stand volume table construction is to provide the data on stand volume per hectare and total area with relatively little stand measurement and hence with minimal forest inventory costs. This is most easily performed in pure and even-aged stands. The main disadvantage of this method is that it is not accurate enough and that it does not encompass the distribution of stand volume per diameter degrees or classes. However, rough volume distribution can be estimated based on the percent distribution of stand basal area per diameter degrees or classes (Koprivica, M., Matović, B. 2010).

The task of this paper is to define the regression model and to construct tables for volume estimation in all-aged beech high stands in Serbia. Therefore, three aspects should be analysed construction, accuracy and implementation.

2. MATERIAL AND METHOD

The data for this research were collected within the project "*Method of evaluation of quality and assortment structure of beech high stands in Serbia",* carried out by the Institute of Forestry in Belgrade in the period from 2005 to 2007. Eleven all-aged high stands of beech were selected under the predetermined criteria in six forest regions: Severno Kučajsko, Podrinjsko-Kolubarsko, Jablaničko, Golijsko, Donje Ibarsko, and Rasinsko. Altogether 241 circular sample plots of 500 m^2 were established. The simple systematic sample of sample plots i.e. the square grid network with a 100 m spacing was used in all stands. The selection intensity accounted for 5% of the stand area. The data were processed using the application programme "SORTIMENT", especially designed to this purpose (Marković, N. *et al*., 2007). More detailed information on the method of data collection and processing had been previously reported by Koprivica, M. *et al*. (2005).

The main characteristics of the sample of selected plots are presented in Table 1.

Table 1: *Statistics of the elements in beech high forests in the sample (n = 241)*

Element	Statistical indicators							
	$X_{aver.}$	$X_{min.}$	$X_{max.}$	S	CV%	m%	α_3	α_4
V	382.88	49.96	983.92	163.52	42.71	5.50	0.93	4.25
G	26.95	6.91	54.00	9.10	33.78	4.35	0.30	2.66
N	298.34	60.0	1200.0	145.55	48.78	6.28	1.72	10.04
H_l	28.42	13.73	40.33	4.77	16.78	2.16	0.07	2.62
H	23.79	11.7	39.4	5.02	21.08	2.72	0.43	2.94
D_g	35.76	17.95	61.26	8.31	23.23	2.99	0.47	3.02
D	32.66	17.50	60.20	8.35	25.58	3.30	0.64	3.16
SK	0.84	0.14	1.00	0.163	19.41	2.50	-1.54	5.40
TN	3.34	1.0	8.0	1.47	44.16	5.69	0.34	1.95
NV	846.5	406.0	1370.0	255.53	30.19	3.89	0.13	2.17

Legend:

V - stand volume per hectare
G - stand basal area per hectare
N - number of trees per hectare
H_L- Lorey's mean height
H - arithmetic mean stand height
D_g - stand quadratic mean diameter
D - arithmetic mean stand diameter
SK- stand canopy
TN - tariff series (site class)
NV- stand altitude
NT- stand slope
EK- stand aspect

Because of a small number of stands in the sample, further analyses had to start from the assumption that the sample plot characteristics (estimation elements and site) can be conditionally equated with the characteristics of hypothetical stands. From the statistical aspect, this can be justified because the variability of all elements in the plot sample is higher than the variability of the same elements in the stand sample. This attitude is confirmed by the papers dealing with theoretical analysis of the sample structure intended for modelling in forestry (Box, G.E.P. and Draper, N.R., 1987, Vancelay, J.K. *et al*., 1993, Rennolls, K. 1997). The above papers also deal with the issue of optimal data collection, assuming that the regression method will be used in modelling. It is concluded that the best results of modelling can be achieved if the variables include different values within the domain of their variation, taking into account extreme values, not only those with

minor deviations from the average. Also, the data for the modelling at the stand level should be collected on sample plots.

The method of stepwise multiple regression was applied for the definition of the statistical relations between stand volume (V) as dependent variable and the selected stand and site elements (G, N, H_L, H, D_g, D, SK, TN, NV, NT, EK) as independent variables (Hadživuković, S. 1991). The data were processed using STATGRAPHICS, ver. 5.0. From the formal – statistical aspect, the analysis includes not only eleven original independent variables, but also thirty-five independent variables obtained by the transformation of the original independent variables.

3. RESULTS AND DISCUSSION

The study result is the regression model (1) which is applied in the volume estimation of beech high stands per hectare. The model has only two original independent variables (G and H_L) and it is the best practical solution of the problem.

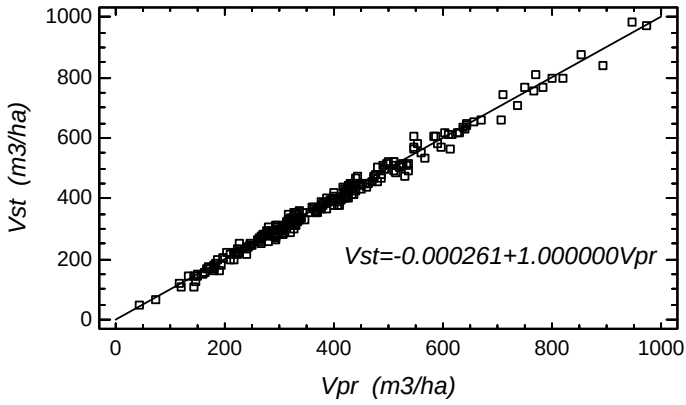
$$V = - 113.725 - 2.47698G + 8.93191H_L - 0.17812H_L^2 + 0.592762GH_L \qquad (1)$$

In equation (1), all partial regression coefficients are statistically significant at the risk level $p < 0.001$, as well as the whole regression. Standard error of regression is +/-16.74 m^3/ha, and mean absolute deviation is 12.70 m^3/ha. Coefficient of multiple determination is 98.97%. The stand volume tables (TABLE I) constructed by this Model are graphically illustrated (Graphs 2a and 2b).

The Model reliability was tested in several ways: by the analysis of residual deviations of original values of stand volume per hectare from the values estimated by this Model (analysis of residuals), by the graphic illustration of the linear correlation between the original and the estimated values of volume per hectare (method of linear correlation) and by the analysis of percent deviations of the estimated values from the original values of stand volume per hectare.

The analysis of standardised residuals shows that the residuals are distributed almost completely by the probability law of normal distribution. Of the total number of all residuals, there are 12 or 4.98% standardised residuals of absolute value above 2.0 and only 3 or 1.24% above 3.0. This practically means that it can be expected at the probability of 95% that the error of the estimated stand volume per hectare will not exceed +/- 33.50 m^3/ha.

The linear correlation between original and estimated values of stand volume per hectare is presented in Graph 1.



Graph 1: *Correlation between original and estimated values of beech stand volume per hectare*

In the ideal case, that is at the complete congruence of data, the values of straight line equation parameters are a = 0 and b = 1 (Stojanović, O., 1976). From the statistical aspect, true values of parameters of linear regression differ accidentally from the expected, so it can be concluded that the obtained regression model is reliable for the estimation of the beech stand volume per hectare. This is confirmed by a very narrow dispersion interval along the correlation line.

In our previous research study of the use of regression models to estimate the volume of beech stands (same material) a slightly better regression model was obtained, but only theoretically (Koprivica, M. *et al*., 2010).

TABLE I: *STAND VOLUME TABLES FOR BEECH IN SERBIA* (volume of wood above 3.0 cm)

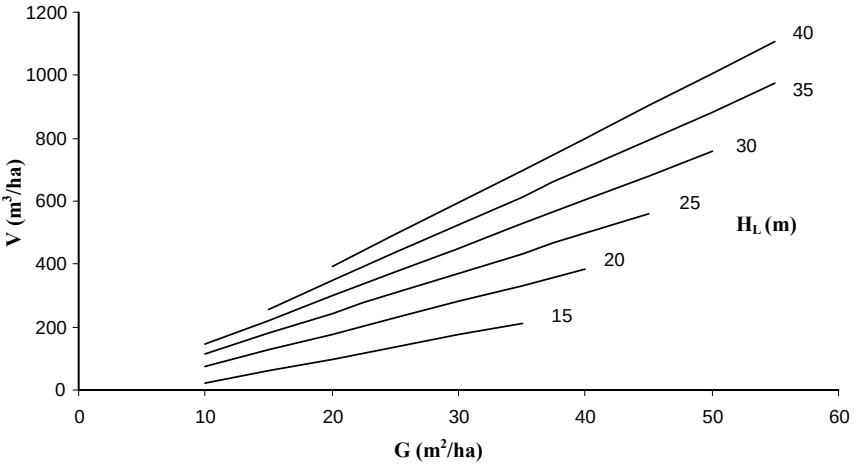
m^3/ha		Stand basal area (m^2/ha)														
		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Lorey`s mean stand height (m)	**15**	**44.32**	**50.74**	**57.15**	**63.56**	**69.98**	**76.39**	**82.81**	**89.22**	**95.64**	**102.05**	**108.47**	**114.88**	**121.29**	**127.71**	**134.12**
	16	53.66	60.67	67.67	74.68	81.69	88.70	95.70	102.71	109.72	116.72	123.73	130.74	137.75	144.75	151.76
	17	62.64	70.24	77.84	85.44	93.04	100.64	108.24	115.84	123.44	131.04	138.64	146.24	153.84	161.44	169.04
	18	71.27	79.46	87.65	95.84	104.04	112.23	120.42	128.62	136.81	145.00	153.19	161.39	169.58	177.77	185.96
	19	79.53	88.32	97.11	105.89	114.68	123.46	132.25	141.03	149.82	158.60	167.39	176.18	184.96	193.75	202.53
	20	**87.45**	**96.83**	**106.20**	**115.58**	**124.96**	**134.34**	**143.72**	**153.10**	**162.47**	**171.85**	**181.23**	**190.61**	**199.99**	**209.37**	**218.74**
	21	95.00	104.98	114.95	124.92	134.89	144.86	154.83	164.80	174.77	184.74	194.71	204.69	214.66	224.63	234.60
	22	102.20	112.77	123.33	133.90	144.46	155.02	165.59	176.15	186.72	197.28	207.84	218.41	228.97	239.53	250.10
	23	109.05	120.21	131.36	142.52	153.68	164.83	175.99	187.14	198.30	209.46	220.61	231.77	242.93	254.08	265.24
	24	115.54	127.29	139.04	150.78	162.53	174.28	186.03	197.78	209.53	221.28	233.03	244.78	256.53	268.28	280.03
	25	**121.67**	**134.01**	**146.35**	**158.69**	**171.04**	**183.38**	**195.72**	**208.06**	**220.41**	**232.75**	**245.09**	**257.43**	**269.77**	**282.12**	**294.46**
	26	127.44	140.38	153.31	166.25	179.18	192.12	205.05	217.99	230.92	243.86	256.79	269.73	282.66	295.60	308.53
	27	132.86	146.39	159.92	173.45	186.97	200.50	214.03	227.56	241.08	254.61	268.14	281.67	295.19	308.72	322.25
	28	137.93	152.05	166.17	180.29	194.41	208.53	222.65	236.77	250.89	265.01	279.13	293.25	307.37	321.49	335.61
	29	142.63	157.35	172.06	186.77	201.49	216.20	230.91	245.62	260.34	275.05	289.76	304.48	319.19	333.90	348.62
	30	**146.98**	**162.29**	**177.59**	**192.90**	**208.21**	**223.51**	**238.82**	**254.12**	**269.43**	**284.74**	**300.04**	**315.35**	**330.65**	**345.96**	**361.27**
	31	150.98	166.88	182.77	198.67	214.57	230.47	246.37	262.27	278.17	294.07	309.96	325.86	341.76	357.66	373.56
	32	154.62	171.11	187.60	204.09	220.58	237.07	253.56	270.06	286.55	303.04	319.53	336.02	352.51	369.00	385.49
	33	157.90	174.98	192.07	209.15	226.23	243.32	260.40	277.49	294.57	311.65	328.74	345.82	362.91	379.99	397.08
	34	160.82	178.50	196.18	213.85	231.53	249.21	266.88	284.56	302.24	319.91	337.59	355.27	372.95	390.62	408.30
	35		**181.66**	**199.93**	**218.20**	**236.47**	**254.74**	**273.01**	**291.28**	**309.55**	**327.82**	**346.09**	**364.36**	**382.63**	**400.90**	**419.17**
	36			203.33	222.19	241.05	259.92	278.78	297.64	316.50	335.37	354.23	373.09	391.95	410.82	429.68
	37				225.83	245.28	264.74	284.19	303.65	323.10	342.56	362.01	381.47	400.92	420.38	439.83
	38					249.15	269.20	289.25	309.30	329.35	349.39	369.44	389.49	409.54	429.59	449.63
	39						273.31	293.95	314.59	335.23	355.87	376.51	397.15	417.80	438.44	459.08
	40							**298.30**	**319.53**	**340.76**	**362.00**	**383.23**	**404.46**	**425.70**	**446.93**	**468.16**

TABLE I: *STAND VOLUME TABLES FOR BEECH IN SERBIA* (volume of wood above 3.0 cm) (continued)

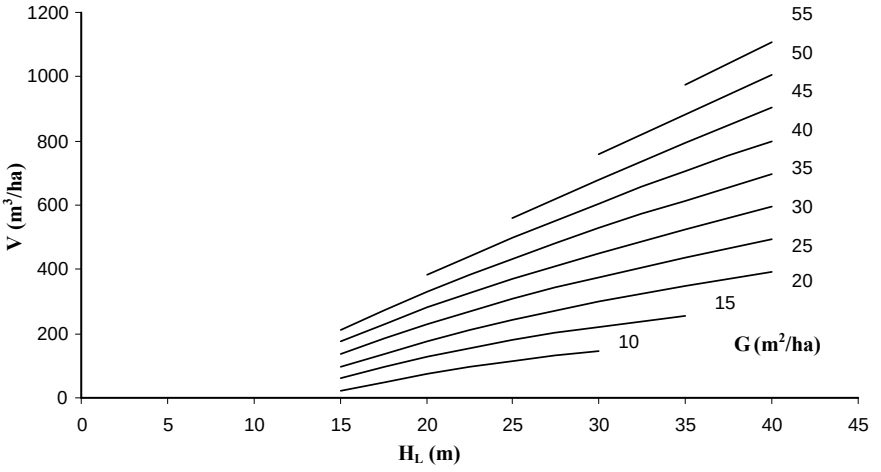
Lorey`s mean stand height (m) / m^3/ha	Stand basal area (m^2/ha)														
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
15	**140.54**	**146.95**	**153.37**	**159.78**	**166.20**	**172.61**	**179.02**	**185.44**	**191.85**	**198.27**	**204.68**	**211.10**			
16	158.77	165.77	172.78	179.79	186.80	193.80	200.81	207.82	214.82	221.83	228.84	235.85	242.85		
17	176.64	184.24	191.84	199.44	207.04	214.64	222.24	229.84	237.44	245.04	252.64	260.24	267.84	275.44	
18	194.16	202.35	210.54	218.74	226.93	235.12	243.31	251.51	259.70	267.89	276.08	284.28	292.47	300.66	308.86
19	211.32	220.10	228.89	237.67	246.46	255.24	264.03	272.82	281.60	290.39	299.17	307.96	316.74	325.53	334.31
20	**228.12**	**237.50**	**246.88**	**256.26**	**265.63**	**275.01**	**284.39**	**293.77**	**303.15**	**312.53**	**321.90**	**331.28**	**340.66**	**350.04**	**359.42**
21	244.57	254.54	264.51	274.48	284.45	294.42	304.40	314.37	324.34	334.31	344.28	354.25	364.22	374.19	384.16
22	260.66	271.23	281.79	292.35	302.92	313.48	324.04	334.61	345.17	355.74	366.30	376.86	387.43	397.99	408.55
23	276.40	287.55	298.71	309.87	321.02	332.18	343.34	354.49	365.65	376.81	387.96	399.12	410.28	421.43	432.59
24	291.78	303.53	315.28	327.02	338.77	350.52	362.27	374.02	385.77	397.52	409.27	421.02	432.77	444.52	456.27
25	**306.80**	**319.14**	**331.48**	**343.83**	**356.17**	**368.51**	**380.85**	**393.19**	**405.54**	**417.88**	**430.22**	**442.56**	**454.90**	**467.25**	**479.59**
26	321.47	334.40	347.34	360.27	373.21	386.14	399.08	412.01	424.94	437.88	450.81	463.75	476.68	489.62	502.55
27	335.78	349.30	362.83	376.36	389.89	403.41	416.94	430.47	444.00	457.53	471.05	484.58	498.11	511.64	525.16
28	349.73	363.85	377.97	392.09	406.21	420.33	434.45	448.57	462.69	476.81	490.93	505.06	519.18	533.30	547.42
29	363.33	378.04	392.76	407.47	422.18	436.90	451.61	466.32	481.03	495.75	510.46	525.17	539.89	554.60	569.31
30	**376.57**	**391.88**	**407.18**	**422.49**	**437.79**	**453.10**	**468.41**	**483.71**	**499.02**	**514.32**	**529.63**	**544.94**	**560.24**	**575.55**	**590.85**
31	389.46	405.36	421.25	437.15	453.05	468.95	484.85	500.75	516.65	532.54	548.44	564.34	580.24	596.14	612.04
32	401.99	418.48	434.97	451.46	467.95	484.44	500.93	517.43	533.92	550.41	566.90	583.39	599.88	616.37	632.87
33	414.16	431.24	448.33	465.41	482.50	499.58	516.66	533.75	550.83	567.92	585.00	602.09	619.17	636.25	653.34
34	425.98	443.65	461.33	479.01	496.68	514.36	532.04	549.71	567.39	585.07	602.75	620.42	638.10	655.78	673.45
35	**437.44**	**455.71**	**473.98**	**492.25**	**510.52**	**528.79**	**547.06**	**565.32**	**583.59**	**601.86**	**620.13**	**638.40**	**656.67**	**674.94**	**693.21**
36	448.54	467.40	486.27	505.13	523.99	542.85	561.72	580.58	599.44	618.30	637.17	656.03	674.89	693.75	712.62
37	459.29	478.74	498.20	517.66	537.11	556.57	576.02	595.48	614.93	634.39	653.84	673.30	692.75	712.21	731.66
38	469.68	489.73	509.78	529.83	549.87	569.92	589.97	610.02	630.07	650.11	670.16	690.21	710.26	730.31	750.35
39	479.72	500.36	521.00	541.64	562.28	582.92	603.56	624.20	644.84	665.48	686.12	706.77	727.41	748.05	768.69
40	**489.40**	**510.63**	**531.86**	**553.10**	**574.33**	**595.56**	**616.80**	**638.03**	**659.26**	**680.50**	**701.73**	**722.97**	**744.20**	**765.43**	**786.67**

TABLE I: *STAND VOLUME TABLES FOR BEECH IN SERBIA* (volume of wood above 3.0 cm) (continued)

m^3/ha		Stand basal area (m^2/ha)														
		40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Lorey`s mean stand height (m)	**15**															
	16															
	17															
	18															
	19															
	20	**368.80**														
	21	394.14	404.11													
	22	419.12	429.68	440.25												
	23	443.75	454.90	466.06	477.21											
	24	468.02	479.77	491.51	503.26	515.01										
	25	**491.93**	**504.27**	**516.61**	**528.96**	**541.30**	**553.64**									
	26	515.49	528.42	541.36	554.29	567.23	580.16	593.10								
	27	538.69	552.22	565.75	579.27	592.80	606.33	619.86	633.38							
	28	561.54	575.66	589.78	603.90	618.02	632.14	646.26	660.38	674.50						
	29	584.03	598.74	613.45	628.17	642.88	657.59	672.30	687.02	701.73	716.44					
	30	**606.16**	**621.47**	**636.77**	**652.08**	**667.38**	**682.69**	**697.99**	**713.30**	**728.61**	**743.91**	**759.22**				
	31	627.94	643.84	659.73	675.63	691.53	707.43	723.33	739.23	755.13	771.02	786.92	802.82			
	32	649.36	665.85	682.34	698.83	715.32	731.81	748.31	764.80	781.29	797.78	814.27	830.76	847.25		
	33	670.42	687.51	704.59	721.67	738.76	755.84	772.93	790.01	807.10	824.18	841.26	858.35	875.43	892.52	
	34	691.13	708.81	726.48	744.16	761.84	779.51	797.19	814.87	832.55	850.22	867.90	885.58	903.25	920.93	938.61
	35	**711.48**	**729.75**	**748.02**	**766.29**	**784.56**	**802.83**	**821.10**	**839.37**	**857.64**	**875.91**	**894.18**	**912.45**	**930.72**	**948.99**	**967.26**
	36	731.48	750.34	769.20	788.07	806.93	825.79	844.65	863.52	882.38	901.24	920.10	938.97	957.83	976.69	995.55
	37	751.12	770.57	790.03	809.48	828.94	848.39	867.85	887.30	906.76	926.21	945.67	965.13	984.58	1004.0	1023.5
	38	770.40	790.45	810.50	830.55	850.59	870.64	890.69	910.74	930.79	950.83	970.88	990.93	1011.0	1031.0	1051.1
	39	789.33	809.97	830.61	851.25	871.89	892.53	913.17	933.81	954.45	975.10	995.74	1016.4	1037.0	1057.7	1078.3
	40	**807.90**	**829.13**	**850.37**	**871.60**	**892.83**	**914.07**	**935.30**	**956.53**	**977.77**	**999.00**	**1020.2**	**1041.5**	**1062.7**	**1083.9**	**1105.2**



Graph 2a: *Dependence of beech stand volume on its basal area and mean height*



Graph 2b: *Dependence of beech stand volume on its mean height and basal area*

Percent deviation of the estimated values of beech stand volume from their true values is obtained by the equation (2),

$$p = 100\ (V_{pr.} - V_{st.})/V_{st.} \qquad (2)$$

The accuracy of the estimated volume was checked for all eleven beech stands analysed in this research separately and for all stands together, starting from

the assumption that the stands belong to the same management class. The results are presented in Table 2.

Table 2: *Accuracy of the beech stand volume estimated by the Model*

Stand	n	$V_{st.}$ (m^3/ha)	$V_{pr.}$ (m^3/ha)	Δ (m^3/ha)	Δ (%)
33a	23	522.52	524.03	+1.51	+0.29
42a	18	379.57	379.11	-0.46	-0.12
42b	10	333.22	323.89	-9.33	-2.80
122a	29	503.68	502.10	-1.58	-0.31
27a	20	350.38	349.76	-0.62	-0.18
31a	32	290.89	301.13	+10.24	+3.52
46a	28	316.04	318.70	+2.66	+0.84
8a	16	385.19	393.72	+8.53	+2.21
8b	10	360.83	354.52	-6.31	-1.75
44a	22	502.25	499.83	-2.42	-0.48
116a	33	289.90	294.27	+4.37	+1.51
All	241	382.88	383.50	+0.62	+0.16

Percent deviation for individual stands varies from -2.80% to +3.52%, and for all stands together it accounts for +0.16%. Absolute deviations of the estimated from the true volume range from -9.33 m^3/ha to +10.24 m^3/ha and they are much lower than the standard error of regression (+/-16.74 m^3/ha). This result confirms our original hypothesis in the Model construction - that sample plot characteristics can conditionally be equated with the characteristics of hypothetical stands.

All methods of checking the accuracy of the Model show that the Model is highly reliable, which means that the obtained stand volume tables are reliable too. However, the accuracy of the Model and the tables will in practical application depend exclusively on the accuracy of the calculated stand basal area per hectare and Lorey's mean height. In the study material, the basal area and the mean height were determined with extremely high accuracy. In each sample plot, the height and the diameter at breast height were measured for all trees. Furthermore, volume and basal area were calculated separately for each tree and then extrapolated per hectare. Of course, this level of accuracy cannot be achieved in the practical application of the Model, so the error of the estimated stand volume will be significantly higher.

4. APPLICATION OF THE STUDY RESULTS

The obtained stand volume tables are intended for practical application. The regression equation (1), or the Model can be used as well. Table or regression equation inputs can be determined most readily using the *relascopy method.*

The procedure is in short as follows. First the stand structure should be evaluated (per tree diameter and per stand area) and then the tree enumeration factor should be selected, so that the average number of trees per sample plot is 20 - 25. The number of sample plots should be 3 - 5, and their location should be determined by a competent professional so that they represent the stand volume as well as possible. Each selected tree in the sample plot (when sighting from the center of the sample plot tree diameter at breast height is wider than scope of the

measuring scale) should be enumerated and its height and diameter at breast height should be measured. Stand height curve can be constructed and Lorey's mean height (H_L) can be calculated based on the collected data. Stand basal area per diameter degrees (G_1, G_2, ... G_k) and total basal area (G) per hectare are estimated based on the classification of the measured trees per diameter degrees. Of course, the tree enumeration factor should be used if it is different from factor 1 (1 : 50 scale).

When stand basal area (G) and Lorey's mean height (H_L) are determined in the above way, stand volume (V) can be read in the tables or calculated by the Model. The distribution of stand volume per diameter degrees or diameter classes can be approximated based on the relative distribution of stand basal area, because the difference between the relative (percent) distribution of basal area and volume in the study beech stands is not great (Koprivica, M., Matović, B. 2010).

If the calculation accuracy of beech stand volume per hectare is to be increased, an additional number of sample plots can be established for the determination of basal area, without measuring the tree diameters and heights. This can be theoretically justified, because the coefficient of variation of basal area in the applied sample is twice higher than the coefficient of variation of Lorey's mean height (CV_G = 33.78%, CV_H = 16.78%). Taking into account the method of sample plot selection in the stand, this is a two-phase sample type (Kangas, A., Maltamo, M, 2006., Koprivica, M., Maunaga, Z. 2012).

Example: In stand 122a, based on the detailed measurement of 29 sample plots, it was calculated that the average volume amounted to 503.68 m^3/ha, average basal area 29.03 m^2/ha, and Lorey's mean height 34.35 m. In the same stand, 5 sample plots were randomly selected out of 29 sample plots and it was determined that G = 30 m^2/ha and H_L = 32 m. The average stand volume for these inputs in the tables was 484.44 m^3/ha. The difference in the average stand volume was -19.24 m^3/ha or -3.82%. Based on the basic sample amounting to 29 sample plots, the real average stand volume (resulting from the complete measurement) ranged between 434.62 m^3/ha and 572.73 m^3/ha, with the probability of 95%. The average stand volume calculated using the tables based on five randomly selected samples also ranges within these values.

In exceptional cases, when a fast assessment of beech stand volume per hectare is necessary, the described procedure should be maximally simplified. In other words, stand basal area (G) per hectare should be determined using the relascope based on 2-3 representative sample plots, without the measurement of tree diameters, and Lorey's mean height (H_L) should be estimated by measuring the height of a small number of dominant and codominant trees. However, this requires a high professional experience of the taxator.

5. CONCLUSION

The volume of beech high stands per hectare depends on numerous factors. However, the resulting regression model in this research study shows that stand basal area per hectare and Lorey's mean height are the most significant factors in the estimation of stand volume. The effect of basal area on stand volume is linear, and the effect of mean height is curvilinear.

When the Model (1) is applied to the concrete beech stands used in this research, it results in an exceptionally high accuracy. Percent deviation of stand volume per hectare varies from -2.80% to +3.52%, that is in absolute amounts from -9.33 m^3/ha to +10.24 m^3/ha. However, so high accuracy cannot be expected in practice, because the accuracy of the estimated stand volume will depend exclusively on the accuracy of the calculated basal area and stand mean height.

The true reliability and efficacy of the resulting regression Model and stand volume tables can be evaluated only after their practical implementation. In fact, it is difficult to foresee the magnitude of the error which can occur in volume estimation of individual stands, but a satisfactory accuracy of volume of the management class comprising the estimated beech stands can be expected with high dependability.

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STAND VOLUME TABLES FOR BEECH IN SERBIA

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Summary

This paper deals with the issue of the construction of stand volume tables for beech in Serbia. There are no tables of this type for natural stands of the principal tree species in this region. The regression model and tables resulted from a set of data collected in six forest regions. The study comprised 241 circular sample plots of 500 m^2 . They were distributed using the square grid network design, spacing 100 m. On all sample plots, a complete measurement of the stand estimation elements was carried out on all trees with diameters above 10 cm and their site characteristics were determined. The data were processed using an application programme especially designed to this purpose. For each sample plot, the estimation elements were determined as aggregate values and extrapolated to hectare (number of trees, basal area, volume, volume increment) as well as mean values (diameter, height, stand canopy), and site characteristics (tariff series, altitude, slope, aspect). The method of multiple regression or the method of stepwise multiple regression was applied on the sample plot data. We assumed that the characteristics of the sample plots can be equalised with the characteristics of hypothetical beech stands. It later proved to be justified. The obtained regression model (1) has the greatest practical significance. This model was used to construct two-way stand volume tables for beech in Serbia (TABLE I). The two variables are Lorey`s mean height (H_L) and stand basal area per hectare (G). The table contains the values for the volume of beech stands per hectare (V). The accuracy of the regression model and tables was tested. When the Model (1) is applied to the stands used in this research, the percent deviation of the model stand volume per hectare from the stand volume determined based on all sample plots distributed in the stand

varies from -2.8% to +3.5%, that is in absolute amounts from -9.3 m^3/ha to +10.2 m^3/ha. It is also concluded that the standardized residuals are distributed almost completely by the probability law of normal distribution. All regression parameters are statistically significant at the risk level $p < 0.001$. Standard error of regression is +/-16.74 m^3/ha, and coefficient of multiple determination is 98.97%. The true reliability and efficacy of the resulting regression Model and stand volume tables can be evaluated only after their practical implementation, because the accuracy of the beech stand volume determination will depend solely on the accuracy of the determined basal area and mean stand height.

SASTOJINSKE ZAPREMINSKE TABLICE ZA BUKVU U SRBIJI

Miloš KOPRIVICA, Bratislav MATOVIĆ,
Vlado ČOKEŠA, Snežana STAJIĆ

Rezime

U radu je razmatran problem izrade sastojinskih zapreminskih tablica za bukvu u Srbiji. Na ovom području za prirodno nastale sastojine glavnih vrsta drveća nisu ranije izrađivane tablice ovog tipa. Regresioni model i tablice su dobijeni na bazi podataka prikupljenih u šest šumskih područja. Istraživanjem je obuhvaćeno jedanaest visokih raznodobnih sastojina bukve, u kojima je postavljena 241 probna površina, oblika kruga i veličine 500 m^2. Probne površine su bile raspoređene u kvadrdatnom rasporedu na rastojanju 100 m. Na svim probnim površinama izvršen je potpun premer taksacionih elemenata stabala prečnika iznad 10 cm i uzeti su podaci o staništu. Obrada podata izvedena je po posebnom aplikativnom programu izrađenom za ove svrhe. Za svaku probnu površinu, polazeći od izmerenih stabala, utvrđeni su taksacioni elementi kao agregatne veličine prevedene na hektar (broj stabala, temeljnica, zapremina, zapreminski prirast) i prosečne veličine (prečnik, visina, sklop), kao i karakteristike staništa (tarifni niz, nadmorska visina, nagib terena, ekspozicija). Na podatke o probnim površinama primenjen je metod višestruke regresione analize, odnosno metod postepene (stepwise) višestruke regresije. Pretpostavljeno je da karakteristike probnih površina mogu biti istovremeno i karakteristike hipotetičkih sastojina bukve. To se kasnije pokazalo kao opravdano. Dobijen je regresioni model (1) koji ima najveći značaj za primenu u praksij. Po ovom modelu izrađene su dvoulazne sastojinske zapreminske tablice za bukvu u Srbiji (TABELA I). Ulazi u tablice su srednja visina sastojine određena po Lorajevoj formuli (H_L) i temeljnica sastojine po hektaru (G). U polju tabele nalazi se zapremina sastojine bukve po hektaru (V). Ispitana je tačnost regresionog modela i tablica. Kada je Model (1) primenjen na sastojine korišćene za ovo istraživanje procentualno odstupanje zapremine sastojine po modelu u odnosu na zapreminu sastojine koja je utvrđena na bazi svih probnih površina postavljenih u sastojini varira od -2,8% do +3,5%, odnosno u apsolutnom iznosu od -9,3 m^3/ha do +10,2 m^3/ha. Takođe, konstatovano je da su standardizovani reziduali raspoređeni skoro u potpunosti po zakonu verovatnoće normalnog rasporeda. Svi parametri u regresionom modelu statistički su značajni na nivou rizika $p < 0,001$. Standardna greška regresije je +/-16,74 m^3/ha, a koeficijent višestruke determinacije 98,97%. O stvarnoj valjanosti i efikasnosti dobijenog regresionog modela, odnosno izrađenih sastojinskih zapreminskih tablica, može se sigurnije zaključivati tek posle njihove primene u praksi, jer će tačnost utvrđene zapremine sastojine bukve zavisiti isključivo od tačnosti sa kojom će biti utvrđena temeljnica i srednja visina sastojine.

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STAND CONDITION AND SILVICULTURAL NEEDS IN ARTIFICIALLY ESTABLISHED EASTERN WHITE PINE STAND (*Pinus strobus L.*) IN THE BOGOVAĐA REGION

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Abstract: *The paper presents the condition of the artificially established eastern white pine stand (Pinus strobus L.), planted in the Hungarian oak and Turkey oak with hornbeam forest site (Carpino betuli-Quercetum farnetto-cerris (Rud.1949) Jov.1979). The stand is located within the Bogovađa forest complex, which encompasses forests and forest lands owned by the Bogovađa Monastery. Based on the study of the environmental and stand conditions, as well as the development of individual trees, the extent of use of the site production potential by this species was analysed, and whether its use for reconstruction of Hungarian oak and Turkey oak coppice forests in this area proved justified.*

Key terms: eastern white pine, Hungarian oak and Turkey oak forest, stand condition, tree development, Bogovađa.

SASTOJINSKO STANJE I UZGOJNE POTREBE U VEŠTAČKI PODIGNUTOJ SASTOJINI BOROVCA (*Pinus strobus L.*) NA PODRUČJU BOGOVAĐE

Izvod: *U radu je prikazano stanje veštački podignute sastojine borovca (Pinus strobus L.), podignute na staništu sladuna i cera sa grabom (Carpino betuli-Quercetum farnetto-cerris (Rud.1949) Jov.1979). Sastojina se nalazi u šumskom kompleksu Bogovađa, koji obuhvata šume i šumsko zemljište koje su u vlasništvu manastira Bogovađa. Na osnovu proučenih uslova sredine i sastojinskog stanja, kao i razvoja pojedinačnih stabala analizirano je u kojoj meri ova vrsta koristi proizvodni potencijal staništa, i da li se pokazalo opravdanim koristiti je prilikom rekonstrukcije izdanačkih šuma sladuna i cera na ovom području.*

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Ključne reči: Borovac, šuma sladuna i cera, sastojinsko stanje, razvoj stabala, Bogovađa.

1. INTRODUCTION

Previous criteria for introduction of various coniferous species in the oak forest belt, performed in the mid 20th century, were based on the coniferisation strategy, where paying insufficient attention to complex properties of vegetation-forest eco-systems resulted in plantation of conifer monocultures. The coniferous species most commonly introduced in beech and oak forests in Serbia, in the process of land amelioration, were pines – black and white and, to a lesser extent, spruce. Since the 1970s, other coniferous species were increasingly used in smaller areas: Eastern white pine (*Pinus strobus* L.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), European larch (*Larix decidua* Mill.), Balsam fir (*Abies concolor* Lindl. et Gord.) and other species, without previous assessment of their suitability for specific forest sites. That resulted in an occurrence of a mass dieback of introduced coniferous species and, in some instances, in a complete deterioration of these cultures. As Stilinović, S. (1988) states, the most reliable method in selection of species used for afforestation and land amelioration is prior establishing of sample plots on representative areas. Given the fact that these species are not homogenous natural entities in biological, silvicultural and production terms, they must be assessed under conditions of a concrete forest site and, in that manner, their suitability for a given forest site should be determined.

In the area of the Bogovađa forest complex, works on land amelioration of coppice forests have already been performed. Intensive works on reconstruction of coppice forests, by means of introduction of fast-growing conifers, primarily domestic pines, eastern white pine, Douglas-fir and larch, were initiated in 1964.

2. STUDY OBJECT, MATERIAL AND WORK METHOD

'Bogovađa' Management Unit is located in the upper upstream part of the Kolubara Basin, at approximately 4km point-to-point distance from the confluence of the River Ljig with the River Kolubara in the south. The studies were conducted through a series of sample plots planted in the artificially established eastern white pine stand (*Pinus strobus* L.), in the 40 years old Hungarian oak and Turkey oak with hornbeam forest site – *Carpino betuli- Quercetum farnetto-cerris,* for the purpose of establishing to what extent the introduction of the above-mentioned species into this forest site was justified.

The basic climatic characteristics of the studied locality are characterised by the following values: the mean annual temperature is 10.7º (in the vegetation period 16.9º), the annual amount of precipitation is 836.8 mm, while the relative air humidity ranges between 67 and 80%. According to the Thornthwaite climatic classification, the climate of the area is mid-humid.

According to the research by Antić, M. i Marković, D., (1971), the geological layer of the area consists of lake sediments (marl and claystone), while

the soil in the analysed stand is deeply loess-affected with elements of pseudogley (Stajić, S. et al., 2008).

Gathering of taxation data was conducted according to a standard work method. A detailed analysis of the forest site and stand condition was performed; additionally, a cut down of required number of trees among the thickest 20% was carried out in each series of sample plots for the purpose of dentrometric analysis,.

The stand quality was determined according to a standard silvicultural methodology of the Faculty of Forestry in Belgrade (estimate of biological position, stem quality and crown quality).

Data processing was conducted according to a standard work method for this type of study.

3. STUDY RESULTS AND DISCUSSION

3.1 Forest site and stand basic data

The analysed eastern white pine stand (*Pinus strobus* L.) is situated at the altitude of 210m, the exposition is northern, the inclination very mild, less than 3º. The stand is 40 years old; canopy closure is 0.8-0.9. In addition to eastern white pine, the tree layer includes lime tree, of seed origin, occurring naturally, with a large number of good-quality trees.

3.2 Stand condition and structure

The total number of trees in the studied stand ranges between 975 and 1,150 per *ha*, or 1,062 per *ha* (Table 1) on average. The percentage representation of eastern white pine in the stand accounts for 73.0%. The number of lime trees ranges between 150 and 350 per *ha*, or 287 per *ha* on average, which accounts for 27% of the total number of trees in the stand.

The total basal area in the analysed stand ranges between 42.89 m^2/ha and 51.02 m^2/ha, or, 46.01 m^2/ha on average. The eastern white pine basal area ranges between 30.96 and 40.90 m^2/ha, or 36.63 m^2/ha (79.6%) on average. The representation of lime tree in the basal area is in the range between 12.9 and 28.2%, and, on average, it amounts to 9.37 m^2/ha (6.05 do 12.62 m^2/ha), or, in percentage, 20.4% of the stand total basal area.

The total volume of the stand ranges between 365.96 and 524.25 m^3/ha, or 455.82 m^3/ha on average. The lime tree average volume amounts to 101.4 m^3/ha, and it ranges between 66.66 and 135.32 m^3/ha.

Table 1. *Basic data on analysed stand*

	Management Unit: "Bogovađa", branch: 18c						Sample plot: I						Altitude: 210 m					
	Inclination: 3º						Exposition: northern						Stand age: 40 years					
Artificially established eastern white pine stand (*Pinus strobus L.*) in the Hungarian oak and Turkey oak with hornbeam forest site (Carpino betuli - *Quercetum farnetto-cerris) on a deeply loess-affected soil with elements of pseudogley*																		
Diam. class	Eastern white pine						Lime tree						Total					
	N		G		V		N		G		V		N		G		V	
	per ha	%	per ha	%	per ha	%	per ha	%	per ha	%	per ha	%	per ha	%	per ha	%	per ha	%
	INITIAL CONDITION																	
7.5							44	15.4	0.19	2.1	2.28	2.2	44	4.1	0.19	0.4	2.28	0.5
12,5	13	1.7	0.15	0.4	1.13	0.3	37	12.9	0.46	4.9	5.16	5.1	50	4.7	0.61	1.3	6.29	1.4
17.5	75	9.7	1.80	4.9	15.48	4.4	50	17.4	1.20	12.8	13.25	13.1	125	11.8	3.01	6.6	28.73	6.3
22.5	381	49.2	15.16	41.4	141.99	40.1	112	39.0	4.47	47.7	48.53	47.9	493	46.4	19.63	42.7	190.52	41.8
27.5	250	32.2	14.85	40.5	147.87	41.7	25	8.7	1.48	15.8	15.85	15.6	275	25.9	16.33	35.5	163.72	35.9
32.5	56	7.2	4.67	12.8	47.95	13.5	19	6.6	1.56	16.7	16.33	16.1	75	7.1	6.23	13.5	64.28	14.1
total	**775**	**100.0**	**36.63**	**100.0**	**354.42**	**100.0**	**287**	**100.0**	**9.37**	**100.0**	**101.40**	**100.0**	**1062**	**100.0**	**46.01**	**100.0**	**455.82**	**100.0**
	TREES MARKED FOR THINNING																	
12.5	13	7.3	0.16	2.6	1.1	2.1	13	13	0.15	4.2	1.72	4.4	25	9.1	0.31	3.2	2.85	3.1
17.5	63	35.6	1.50	25.6	12.7	24.4	19	19	0.45	12.5	4.97	12.7	81	29.5	1.95	20.6	17.69	19.4
22.5	88	49.7	3.48	59.2	31.4	60.2	62	62	2.49	68.9	26.96	69.0	150	54.5	5.97	62.9	58.38	63.9
27.5	13	7.3	0.74	12.6	6.9	13.3							13	4.7	0.74	7.8	6.94	7.6
32.5							6	6	0.52	14.4	5.44	13.9	6	2.2	0.52	5.5	5.44	6.0
total	**177**	**100.0**	**5.88**	**100.0**	**52.2**	**100.0**	**100**	**100.0**	**3.61**	**100**	**39.09**	**100.0**	**275**	**100.0**	**9.48**	**100.0**	**91.29**	**100.0**
	Representation N=22.8% per: G=16.2% V=14.7%						Representation N=34.8% per: G=38.5% V=38.6%						Representation N=25.9% per: G=20.6% V=20.0%					

The average current volume increment amounts to 16.2 *m3/ha*, and it ranges between 12.6 and 18.5 *m3/ha*, while the increment percentage accounts for 3.53%.

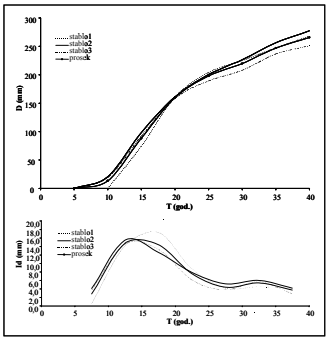
The obtained results correspond to the research results presented by Stojanović, Lj. et al. (1994) for the artificially established eastern white pine stands in the Kučevo area, as well as to the results presented by Koprivica, M., i Ratknić, M. (1996) for the area of Loznica.

3.3. Tree development

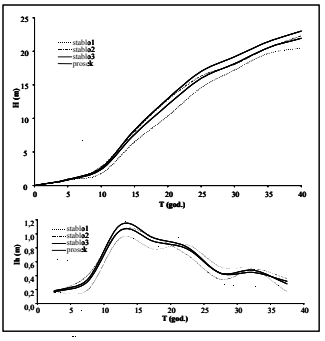
Three eastern white pine trees, whose diameter and height approximately correspond to the mean diameter and the mean height of the stand dominant class trees (the thickest 20%), were analysed. The analyses of diameter and height development, along with diameter and height increment, are presented in the Graphs 1 and 2.

The path of the diameter growth line indicates an intensive increase until the year 20, after which the growth becomes more balanced. In the most advanced analysed age, the attained diameter values were between 25.1 and 27.8 *cm*, or on average 26.6 *cm*. The culmination of the current diameter increment took place in the period between the year 10 and the year 15 (10-20 for individual trees) and it has value of 14.8 *mm*, while the average diameter increment culminates later, approximately at the age of 20, and it has an average value of 8.0 *mm*. The culmination values are slightly lower than the values recorded in the eastern white pine cultures established in the beech forest site in the Arilje area, as well as the values of cultures in Debeli Lug, established on a sessile oak forest site Vučković, M. et al., 1994). In the area of Kučevo Stojanović, Lj. et al. (1994) recorded slightly earlier culmination of the current diameter increment, with a higher value of 16.0 mm.

Following the culmination, the current increment shows a declining trend, with smaller oscillations after the year 25, which is obviously the result of thinning felling conducted on two occasions in that period, which had no significant effect on increase of increment.



Graph 1. *Diameter development of dominant trees and current diameter increment*



Graph 2. *Height development of dominant trees and current height increment*

The total and the current height increment of the analysed eastern white pine trees are presented in the Graph 2. Based on the line of the total height growth, it can be noted that the height growth rate is slightly slower until the year 10, it is followed by a sharp increase that continues until the year 25, after which a slightly slower growth ensues.

The culmination of the current height increment takes place approximately in the year 12, and it has an average value of 1.05 *m*. The culmination of the average increment took place later, approximately in the year 25 (for individual trees between the year 20 and 25) and it has an average value of 0.64 *m*. The identical values for the current height increment, as well as the culmination period, were presented by Vučković, M. et al. (1994) for eastern white pine cultures in Debeli Lug, established in the sessile oak forest site. In terms of heights attained in the year 25, there are no significant differences either, but they are considerably lower than the heights stated by the same authors for eastern white pine cultures in the Arilje area, established on a beech forest site. Rakonjac et al. (2003) recorded lower values of the current height increment of 0.8 *m* in the artificially established eastern white pine stand in the Pešter Plain region, while the culmination took place slightly later, approximately in the year 14.

As it is the case with diameter increment, the height increment after culmination sharply drops, with smaller oscillations.

3.4 Quality and health condition of analysed stands

More than half of eastern white pine trees are situated in the dominant layer – 52.8%, 36.6% in the second and 10.6% of the trees belong to the understory category. It is a similar case with lime tree, where 46.1% of trees are in the dominant layer, 38.5% in the second biological position, while 15.4% belong to understory category.

The quality of stems in this stand is mainly good; stems are moderately cleared from branches up to 1/3 of the tree height. Eastern white pine trees are mainly straight and solid, with a stem of a good quality and such trees account for 72.4% of the total eastern white pine trees in the stand. Certain individual trees possess defects, which places them into the category of trees of a medium stem quality, and they account for 19.5% of the total number of eastern white pine trees, while 8.1% of the trees have the stem of a poor quality, which largely concerns mechanical damage occurred due to snowbreak, while an occurrence of decay was also observed in individual trees. With respect to lime tree, only 28.2% of trees have the stem of a good quality, whereas the equal number of trees, 35.9% each, have medium and poor stem characteristics. The most common defects that served as the basis for this type of assessment, concerned curvature and forks, which are common for nearly every tree, while mechanical damage, occurred during felling of neighbouring trees, is also present.

Table 2. *Representation of trees according to biological position, stem and crown quality (%)*

Species	I	II	III
Biological position			
Eastern white pine	52.8	36.6	10.6
Lime tree	46.1	38.5	15.4
Stem quality			
Eastern white pine	72.4	19.5	8.1
Lime tree	28.2	35.9	35.9
Crown quality			
Eastern white pine	4.1	50.4	45.5
Lime tree	23.1	53.8	23.1

The quality of crowns in this stand is mainly poor, eastern white pine crowns are mostly too narrow, asymmetrical and of an insufficient size. The condition of lime tree is slightly better, although its crowns are also asymmetrical and mainly too wide. Only 4.1% of eastern white pine trees have crowns of good quality, 50.4% of medium quality and even 45-5% of crowns is of poor quality. Lime tree has an equal percentage of crowns of good and poor quality (23.1%), while 53.8% of trees have crowns of medium quality.

The health condition of the stand is assessed as unsatisfactory, given that occurrence of dieback is observed in a large number of trees.

3.5 Proposal of silvicultural measures

The artificially established eastern white pine stand in the Hungarian oak and Turkey oak with hornbeam forest site (*Carpino betuli-Quercetum farnetto-cerris* (Rud.1949) Jov.1979) exhibited good productivity under these conditions; however, based on the diminished vitality of trees and poor health condition of the stand, it can be concluded that site conditions do not suit this species, hence, the re-introduction of autochthonous vegetation, after planned conifer rotation, is proposed as a long-term silvicultural objective.

It is evident that thinning performed in this stand was of a low intensity and untimely, which resulted in formation of trees of great thinness, and with reduced crowns. Such condition additionally endangered biological balance in the stand, which resulted in diminished resistance of trees to damage caused by snow and wind, to which this species is highly sensitive. Untimely performance of thinning also resulted in a decline of the value of the diameter and height increment, while thinning conducted slightly later did not have a significant effect on their dynamics. Based on the time of culmination, it can be concluded that the first thinning in this stands should have been performed after the culmination, approximately in the year 15.

For the purpose of the improvement of overall condition of the artificially established eastern white pine stand, a selective mixed thinning was proposed. On average 220 future trees per ha, whose mean diameter is 27.4 cm and mean height 21.4 m, were selected in the stand. The intensity of marking for thinning was mainly moderate to high and on average accounted for 25.9% in terms of number of trees and approximately 20% in terms of volume. Given the fact that a large

number of trees with the signs of dieback are present in the stand, it was necessary to conduct thinning of a slightly higher intensity in the segments in which the dieback was more pronounced, in order to improve the current condition. Eastern white pine trees with signs of dieback were removed, cleaned from snow and wind, as well as all those of insufficient growth, currently endangering future trees. With respect to lime tree, first of all, a negative selection was performed by removing all trees with any impact on future trees, as well as those of poor quality. In the analysed stand, the eastern white pine slenderness coefficient, which indicates stability of the stand, that is, a potential endangerment by wind and snow, ranges between 80 and 85. Based on the above-mentioned, the performed thinning will not endanger stability of the stand, given the fact that the intensity of the treatment was within the range of 25%, both in terms of number of trees and the volume.

4. CONCLUSION

The artificially established eastern white pine stand was planted in the process of reconstruction of this forest complex in the 1960s.

The total number of trees in the stand ranges between 975 and 1,150 per *ha*, or 1,062 per *ha* on average. The total basal area in the studied stand ranges between 42.89 m^2/ha and 51.02 m^2/ha, or 46.01 m^2/ha on average. The total volume in the stand ranges between 365.96 and 524.25 m^3/ha, or 455.82 m^3/ha on average. The current volume increment amounts to 16.2 *m3/ha* on average, and ranges between 12.6 and18.5 *m3/ha*, while the increment percentage accounts for 3.53%.

The culmination of the current diameter increment in the studied trees took place in the period between year 10 and year 15 (10-20 for individual trees) and it has the value of 14.8 *mm,* while the average diameter increment was attained later, approximately in the year 20, and that value amounts to 8.0 *mm* on average. The culmination of the current height increment occurs approximately in the year 12, and it has an average value of 1.05 *m*. The culmination of the average increment took place later, approximately in the year 25 (in some trees between the year 20 and 25) and it has an average value of 0.64 *m*.

The quality and health condition of the stand is not satisfactory. The quality of stem is mainly good, and 72% of trees have the stem of good quality. The quality of crowns is poor, only 4.1% of eastern white pine trees have crowns of the best quality, while even 45.5% have crowns of the worst quality (of insufficient size, asymmetrical, etc.). Such a poor quality of crowns is partly caused by non-performance of adequate silvicultural measures in the stand, which resulted in a reduced space for growth and formation of small crowns.

For the purpose of improvement of the general condition in the studied stand, a selective mixed thinning should be performed. On average 220 future trees per ha, the mean diameter of which is 27.4 cm, were selected. The intensity of selection was moderate to strong, on average 275 trees per ha were marked, which is 25.9% in terms of number of trees, and 20% according to the volume.

It can be concluded that this species showed good productivity under these conditions, however, based on the general condition of cultures and diminished vitality of trees, the species cannot be recommended for further works on

substitution of coppice forests under these condition. After the planned rotation, dereconstruction, that is, re-introduction of the autochthonous vegetation, which is at any rate biologically better suited to conditions of these stands, is proposed.

Acknowledgement
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STAND CONDITION AND SILVICULTURAL NEEDS IN ARTIFICIALLY ESTABLISHED EASTERN WHITE PINE STAND (*Pinus strobus L.*) IN THE BOGOVAĐA REGION

Snežana STAJIĆ, Vlado ČOKEŠA, Zoran MILETIĆ

Summary

The artificially established eastern white pine stand in the Hungarian oak and Turkey oak with hornbeam forest site *(Carpino betuli-Quercetum farnetto-cerris (Rud.1949) Jov.1979)*, produced good results in terms of growth and increment rate, however, the vitality of eastern white pine trees in this stand is greatly diminished. A large

number of trees exhibited signs of dieback of different intensity, while the additional damage was caused by snow and windbreak. The above-mentioned indicates that eastern white pine is not the species to be recommended for further substitution works under these conditions.

For the purpose of the improvement of current situation, a silvicultural measure *mixed selective thinning,* of a moderate to strong intensity, was proposed. The slenderness coefficient (SC) of eastern white pine trees, which indicates the stability of stand, that is, a potential exposure to wind and snow, ranges between 80 and 85 in this stand. Based on the above-mentioned, it can be concluded that the performed thinning will not endanger the stability of stand, given the fact that the intensity of treatment on eastern white pine trees in trial field was within the limit of 25%.

Based on the analysis of trees, and the trend of diameter and height development, it can be noted that the timely thinning was not performed; it was supposed to be carried out approximately in the year 15 – in the period of culmination of the current height increment.

The artificially established eastern white pine stand ought to be tended until the end of the planned rotation, after which a re-introduction of autochthonous vegetation, capable of attaining the maximum use of the stand potential, is recommended.

SASTOJINSKO STANJE I UZGOJNE POTREBE U VEŠTAČKI PODIGNUTOJ SASTOJINI BOROVCA (*Pinus strobus L.*) NA PODRUČJU BOGOVAĐE

Snežana STAJIĆ, Vlado ČOKEŠA, Zoran MILETIĆ

Rezime

Veštački podignuta sastojina borovca na staništu sladuna i cera sa grabom *(Carpino betuli-Quercetum farnetto-cerris (Rud.1949) Jov.1979)*, pokazala je dobre rezultate u pogledu brzine rasta i prirašćivanja, međutim vitalnost stabala borovca u ovoj sastojini prilično je oslabljena. Dosta stabala je sa znacima sušenja različitog inteziteta, a dodatne štete nastale su od snego i vetroloma. Sve ovo ukazuje da borovac nije vrsta koja bi se mogla preporučiti pri daljim radovima supstitucije u ovim uslovima.

U cilju poboljšanja trenutne situacije kao uzgojna mera predlaže se *mešovita selektivna proreda*, umerenog do jakog zahvata. Koeficijent vitkosti stabala borovca (KV) koji ukazuje na stabilnost sastojine, odnosno na potencijalnu ugroženost prema vetru i snegu u istraživanoj sastojini kreće se u intervalu 80-85. Na osnovu ovoga izvedena proreda neće ugroziti stabilnost sastojine, obzirom da se jačina zahvata kod stabala borovca po oglednim poljima kretala u granicama do 25%.

Na osnovu analize stabala, i tokova razvoja prečnika i visina, primećuje se da je izostala blagovremena proreda u sastojini, koja je trebala biti izvedena oko 15. godine - u vreme kulminacije tekućeg debljinskog prirasta.

Veštački podignutu sastojinu borovca treba negovati do kraja predviđene ophodnje, nakon čega se preporučuje *vraćanje autohtone vegetacije*, koja će u najboljoj meri iskoristiti potencijal ovog staništa.

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VIABILITY OF TREES ON BIO-INDICATOR PLOTS LEVEL -A 1 IN REPUBLIC OF SERBIA IN 2013

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Abstract: *Frequent droughts occurring in recent years greatly affect the viability of the forests whereby as a consequence can occurs their dieback. The primary causes of forest dieback are usually not known, which is why many authors consider that the long term drought effect is the main cause of damage of the entire forest ecosystem. A large number of abiotic and biotic factors that act in forest ecosystems make it difficult to determine the primary factors. Years 2011 and 2012 as extremely hot and dry, resulted in the tree damage that significantly manifested in 2013. This paper presents the results of the condition of individual trees on bio-indicator plots Level – a 1. These researches were conducted on 121 bio-indicator plots in Republic of Serbia that were set in a grid of squares 16x16 km and in an additional grid 4x4km, in order to obtain a more accurate sample. Number of trees covered by this survey is 2,794, of which 2,456 are broadleaves and 338 conifers.*

Key words: Bio-indicator plots, tree damage, drought.

VITALNOST STABALA NA BIOINDIKACIJSKIM TAČKAMA NIVO-A 1 U REPUBLICI SRBIJI U 2013. GODINI

Abstract: *Učestale suše koje se javljaju poslednjih godina u velikoj meri utiču na vitalnost šuma, pri čemu se kao posledica može javiti i njihovo sušenje. Primarni uzroci sušenja šuma u glavnom nisu poznati, usled čega brojni autori dugotrajan uticaj suše smatraju glavnim uzročnikom oštećenja celokupnog šumskog ekosistema. Veliki broj abiotičkih i biotičkih faktora koji deluju u šumskim ekosistemima otežavaju utvrđivanje primarnih faktora. Kao ekstremno tople i sušne, 2011 i 2012 godina, uticale su na*

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oštećenja na stablima koja u se značajno ispoljila u 2013 godini. U radu su prikazani rezultati stanja pojedinačnih stabala na bioindikacijskim tačkama Nivo-a 1. Ova istraživanja su sprovedena na 121 bioindikacijskih tačaka u Republici Srbiji, postavljenih u mreži kvadrata 16x16 km i dopunskoj mreži 4x4km, radi dobijanja preciznijeg uzorka. Broj stabala koji je obuhvaćen ovim istraživanjem je 2.794, od čega je lišćara 2.456 a četinara 338.

Ključne reči: Bioindikacijske tačke, oštećenja stabala, suša.

1. INTRODUCTION

Evidences that the effects of human activities pollute the environment by changing climate in the world have become irrefutable. Due to the change caused by the concentration of gases with greenhouse effect it comes to an increase in average annual temperature, which has a number of consequences on both the forest and the individual trees. The effects of global warming could be so strong in some regions and they could even lead to changes in forest productivity and composition of plant and animal communities in them (Brasanac-Bosanac Lj. et al, 2011).

There are many programs that deal with the topic of changes in forest ecosystems caused by both biotic and abiotic stress factors, with the aim of finding causes and their solution. One of them is an international program for monitoring forests (ICP Forests)1 . Today, 41 countries Europe as well as Canada and the United States actively participate in this program. ICP Forests monitors the forest condition using two different intensities of monitoring. One is based on the grid of bio-indicator plots (level 1) which contains approximately 6,000 plots arranged in a grid of squares 16 km x 16 km in Europe, whereby the system of this level of monitoring adequately covers the most important forests in Europe. In some countries there is a denser national grid in aim of fuller assessment of the forest condition on the national and regional level (Nevenić et al . 2012). The second level (Level 2) includes about 800 plots in selected forest ecosystems. Monitoring of forest condition across the grid of bio-indicator plots in the Republic of Serbia has been carried out continuously since 2003 (Nevenić et al. 2013).

The main objectives of the ICP Forests program are to provide periodic insights into the spatial and temporal variability of forest condition in relation to anthropogenic (in particular air pollution) and natural stress factors through the systematic grid of bio-indicator plots and to contribute to a better understanding of cause-and-effect relationship between the condition of forest ecosystems and anthropogenic and natural stress factors. The obtained results can provide information on forest health, air pollution, climate change and biodiversity. In addition to the soil chemistry and nutrition of forest trees, one of the main parameters that are continuously monitored at each tree (during vegetation period) is the lack of assimilation organs, i.e. the percentage of defoliation and achromatization of leaf mass i.e. percentage of discoloration. Defoliation may be

[1] International Co-operative Programe on Assessment and Monitoring of Air Pollution Effects on Forests.

the cause of various biotic and abiotic factors. By its assessment is determined the missing leaf mass that may be the indicator of different stress factors.

Changes in defoliation can not be assigned to air pollution, for example, because they are difficult to distinguish from those caused by other causes. In addition to defoliation, the percentage of discoloration (achromatization of leaf mass i.e. of the whole crown) is also monitored, which may also be the indicator of some stress factor and point us to the health condition of the whole tree. The assessment of defoliation and discoloration is carried out in 5 classes. In defoliation assessment ranking is done based on the following scale: no defoliation (0-10 %), slight defoliation (> 10-25 %), moderate defoliation (> 25-60 %), severe defoliation (> 60 < 100 %), dead tree (100 %) , while in the discoloration assessment ranking is done in this way: no discoloration (0-10 %), slight discoloration (10-25 %), moderate discoloration (> 25-60 %), severe discoloration (> 60 %). Insects, phytopathogenic fungi and other factors which may damage trees are visible in 32.6 % of all trees, where a third of all visible damage is caused by insects (Fischer et al. 2012a).

All the previously mentioned indicators can point out the situation and the degree of endangerment of forests and individual trees of a possible dieback. Also, the symptoms caused by insects are not always recognized only as damage, because many insect species live and depend on the forest trees. However, when forests are already damaged by drought then insect population can cause serious economic consequences (Fischer et al. 2012b).

The main objective of this paper is to point out the possible consequences of temperature extremes that occurred in previous years and which have affected or will affect the vitality of the forest and individual trees in Republic of Serbia.

2. MATERIAL AND METHOD

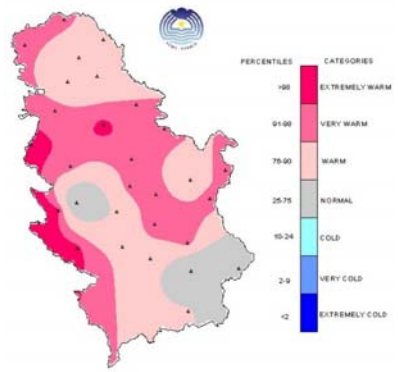
This paper analyzes the data of climatic and meteorological conditions in the Republic of Serbia based on the Republic Hydrometeorological Institute report, as indicators of large temperature extremes that occurred in 2011 and continued throughout 2012. Based on data obtained from bio-indicator plots (Level 1) during 2013, the number of almost dry and dry trees was determined. Data from previous years obtained during the field work and from bio-indicator plots were also used. The data were analyzed in the Institute of Forestry and Institute of Lowland Forestry and Environment. By this action was determined the number of trees whose vitality was unchanged in the previous research period (2011 and 2012) and mortality expressed in 2013, as well as trees whose percentage of defoliation and discoloration is higher than 60% and whose dieback could be expected in coming years. Also, from the analysis were left out trees whose high percentage of defoliation was caused by the gypsy moth (*Lymantria dispar* L.) which in 2012 and 2013 damaged large forest areas in Serbia, as well as trees that have for years showed a high percentage of defoliation or discoloration due to oppression or some disease. The study was performed on all trees within the bio-indicator plots (Level 1). Number of trees covered by this survey is 2,794, of which 2,456 are broadleaves and 338 conifers.

3. RESULTS AND DISCUSSION

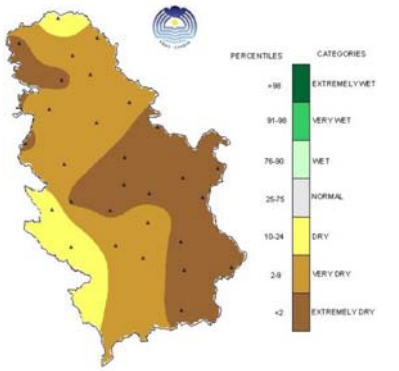
Analysis of climatic and meteorological characteristics of the Republic of Serbia began with the appearance of the first major extreme temperatures during the summer 2011 which was one of the 10 warmest in the whole territory of Serbia since the beginning of the measurements. During the summer 2011 the mean air temperatures were above normal, ranging from 1.5 to 2.5°C above normal with a lack of rainfall in most parts of the territory of Serbia. Number of tropical days and nights in the whole country was much above normal to extremely above normal. During the autumn 2011 the temperatures were above normal with extremely dry period and at the end of autumn temperatures dropped below normal. After the autumn occurred extremely cold winter with temperatures significantly below normal and powerful snow cover which has surpassed historical absolute maximum. On the Map 1 are shown categories of mean annual temperature in 2011, while the Map 2 shows categories of normality of annual amount of precipitation to the corresponding percentiles during 2011.

In the spring of 2012 the air temperature in most parts of Serbia was above normal with two heat waves recorded in March and April. After this period occurred extremely hot and dry summer, which proved to be the warmest and driest since beginning of temperature measurement in Serbia, whereby was overcome the absolute maximum number of tropical days and nights. Temperatures above average have continued during the autumn 2012 when 15 meteorological stations in Serbia measured warmest temperature since there are meteorological measurements, whereby the amount of rainfall in the autumn of the same year in most parts of Serbia was below average with categories dry to extremely dry. Map 3 shows the air temperature during the summer of 2012 that was determined by using method of percentile compared to the reference period (1981-2010), while Map 4 shows the total amount of rainfall during the summer of 2012 that was determined by using method of percentile compared to the reference period (1981-2010).

Map 1. *Categories of normality of mean annual temperature in 2011*[1].

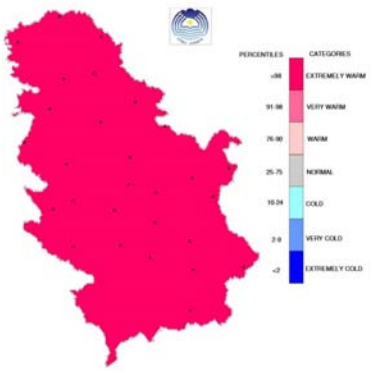


Map 2. *Categories of normality of annual amount of precipitation in 2011.*

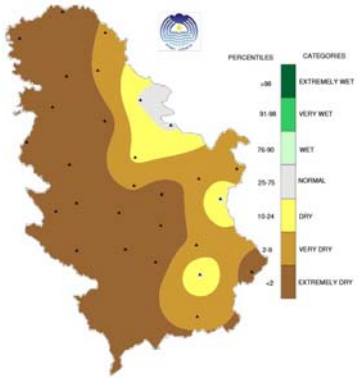


[1] Maps 1-4: Source- Republic Hydrometeorological Institute - www.hidmet.gov.rs

Map 3. *Air temperature during summer 2012.*



Map 4. *Amount of precipitation during summer 2012.*



The emergence of large-scale forest dieback in the Republic of Serbia in the 2013 was recorded at 13,885.00 hectares, individual tree dieback on the area of 12,084.00 hectares, dieback of group of trees on the area of 1,800.81 hectares, while dried timber volume was 81,631.61 m^3 (Jančić, 2013). Encompassing all the forests in the Republic of Serbia it was recorded a higher percentage of dieback in coniferous than in broadleaf species. However, on the bio-indicator plots of Level 1 was observed the reverse state and the main reason for that is much smaller number of conifers, which are continuously monitored, with respect to the broadleaf species (Table 1 and 2). The most common broadleaf species on bio-indicator plots are Balkan beech (*Fagus moesiaca*), Turkey oak (*Quercus cerris*), Hungarian oak (*Quercus frainetto*), Sessile oak (*Quercus petraea*) and Hornbeam (*Carpinus betulus*) (Table 1), while the most present conifers are Silver fir (*Abies alba*), Common spruce (*Picea abies*), Austrian pine (*Pinus nigra*) and Scots pine (*Pinus silvestris*) (Table 2). Bio-indicator plots are arranged in a zone of 75 - 1558 meters above sea level, while the majority of them is in the area of 400 meters above sea level – at 600 meters above sea level (Stefanovic et al. 2012). Map 5 shows the distribution of bio-indicator plots on the territory of the Republic of Serbia.

Table 1. *Presence of broadleaf species on bio-indicator plots*

Broadleaf species							
Species	**Hornbeam**	**Balkan beech**	**Turkey oak**	**Hungarian oak**	**Sessile oak**	**Other broadleaf species**	**Total**
Number of trees	117	833	516	368	161	461	**2456**

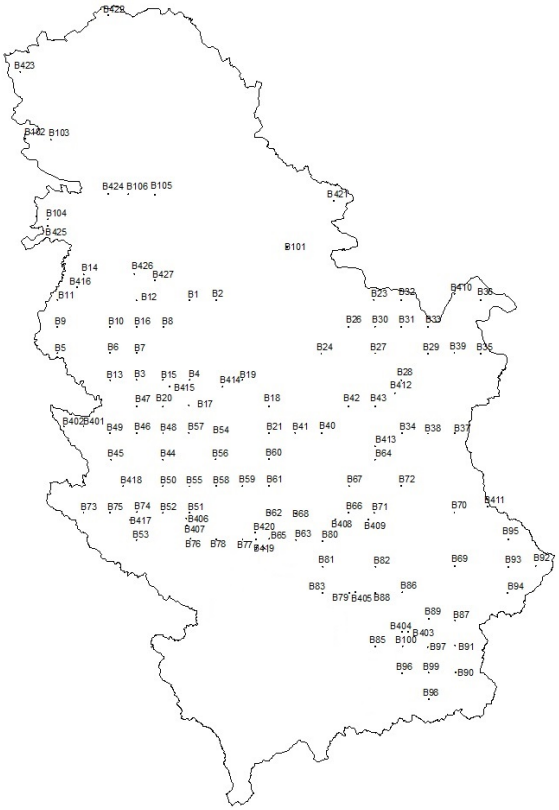
Table 2. *Presence of conifer species on bio-indicator plots*

Conifer species					
Species	**Silver fir**	**Common spruce**	**Austrian pine**	**Scots pine**	**Total**
Number of trees	69	146	67	56	**338**

Table 3 shows the results of the percentage of defoliation (lack of assimilation organs) and discoloration (achromatization of leaf mass) on trees of

bio-indicator plots in the past 3 years (2011, 2012 and 2013), which show that dieback is probably caused by the extreme cold temperature and long-lasting drought. Some trees in 2011 and 2012 have shown a normal percentage of defoliation and discoloration like it was in the previous years, while in 2013 this percentage has risen in the zone of 100% dry tree, while the other trees in the first year of analysis (2011) showed some change compared to the previous years, which increased in the next year, and in 2013 it reached maximum becoming almost dry or dry tree. Discoloration as one of indicators of stress factors, in relation to defoliation, is more expressed in conifer species in the early years of the appearance of dieback.

Map 5. *Distribution of bio-indicator plots of Level 1 in the Republic of Serbia*



Coniferous species may keep the needles on their branches long after dieback and thereafter the defoliation in this case can not be taken as an indicator of some stress. Defoliation can be much more expressed in high-density stands where tree itself discards leaves or needles on the lower branches due to lack of light. However, this phenomenon is much more expressed in dense conifer forests and in most cases it can not be taken into account when assessing the health status, so the occurrence of discoloration is much more relevant indicator of the real state. This statement can be seen in the example of bio-indicator plot No. 59 (Table 3) where the trees of Scots pine (*Pinus sylvestris*) had discoloration of > 60 % (severe

discoloration), while defoliation was in the range of 0-10 % (no defoliation). On the aforementioned bio-indicator plot No. 59 the soil is very shallow and the ability of trees to survive after extreme drought, severe soil drainage and slowing down of physiological processes depends on adoption of nutrients and water (Miletic, 2009). Also, on this bio-indicator plot was also observed a large number of Scots pine trees that are dry or nearly dry and they are not in the very grid of bio-indicator plots, so this plot can be an example of conifer dieback in the Republic of Serbia in 2013.

As already mentioned, the percentage share of dry conifers in Serbia is more expressed than in broadleaf species, and based on example of bio-indicator plot No. 415 in mixed stand of beech and fir it can be seen a sudden high percentage of discoloration i.e. dieback in 2013. On this bio-indicator plot is also much expressed the dieback of young fir trees and group of trees outside of the grid of bio-indicator plots. From broadleaf species on bio-indicator plots the most vulnerable is hornbeam that on the bio-indicator plot No. 14 showed the highest percentage of defoliation compared to the previous years, so the real state of dieback can be expected in the coming year. The hornbeam is followed by beech and Turkey oak, also with a large percentage of defoliation, which goes up to 100%.

Table 3. *Dry or almost dry trees on bio-indicator plots (Level 1) with shown percentage of defoliation and discoloration in the period 2011-2013. Source-Original*

No.	Bio-indicator plot	Species	Defoliation %			Discoloration %		
			2011	2012	2013	2011	2012	2013
1.	3	*Q. Frainetto*	20	10	95	0	0	>60
2.	13	*Fagus moesiaca*	0	0	99	0	0	0
3.	14	*Carpinus betulus*	20	20	80	0	0	0
4.	14	*Carpinus betulus*	20	20	70	0	0	0
5.	14	*Carpinus betulus*	20	10	80	0	0	0
6.	14	*Carpinus betulus*	10	10	80	0	0	0
7.	14	*Carpinus betulus*	0	10	90	10	0	0
8.	14	*Carpinus betulus*	10	10	90	0	0	0
9.	14	*Carpinus betulus*	10	10	90	10	0	0
10.	14	*Carpinus betulus*	10	0	80	0	0	0
11.	14	*Carpinus betulus*	10	0	80	0	0	0
12.	14	*Carpinus betulus*	10	10	99	0	0	0
13.	14	*Carpinus betulus*	0	10	99	10	0	0
14.	20	*Carpinus betulus*	20	20	80	0	10	0
15.	21	*Fagus moesiaca*	0	10	99	0	10	0
16.	21	*Fagus moesiaca*	0	15	90	0	0	0
17.	37	*Q. Frainetto*	0	0	70	10	0	>60
18.	50	*Fagus moesiaca*	0	0	99	0	0	0
19.	56	*Q. Frainetto*	5	0	90	0	0	>60
20.	56	*Acer campestre*	15	5	80	0	0	0
21.	56	*Fagus moesiaca*	10	25	95	0	25	0
22.	59	*Pinus sylvestris*	0	15	15	0	0	>60
23.	59	*Pinus sylvestris*	0	10	10	0	0	>60
24.	59	*Pinus sylvestris*	0	10	10	0	0	>60
25.	60	*Q. Cerris*	20	100	100	0	>60	0
26.	76	*Fagus moesiaca*	10	10	80	0	0	0

27.	81	*Q. Cerris*	10	30	80	0	0	0
28.	81	*Q. Cerris*	10	10	80	0	0	0
29.	81	*Q. Cerris*	10	20	80	0	0	0
30.	403	*Fagus moesiaca*	20	85	100	10	>60	>60
31.	409	*Fagus moesiaca*	15	10	100	0	0	0
32.	415	*Abies alba*	30	80	90	>60	>60	>60
33.	415	*Abies alba*	0	0	30	0	0	>60
34.	415	*Abies alba*	80	80	99	>60	>60	0
35.	415	*Abies alba*	0	0	20	10	10	>60
36.	415	*Fagus moesiaca*	0	0	80	0	0	0
37.	415	*Abies alba*	10	10	40	10	10	>60
38.	417	*Picea abies*	5	5	75	0	0	0

As already noted, a number of bio-indicator plots were left out from this analysis (bio-indicator plots 23, 24, 27, 28, 29, 33, 34, 35, 36, 38, 39, 40, 55, 58, 63, 66, 410 and 413) due to gradation of the gypsy moth in 2012 and 2013, so the data from these plots would not present the true state due to the high percentage of defoliation which gypsy moth have caused. Trees on which the evident reason is some disease (e.g., bio-indicator plot No. 96 – Sweet chestnut blight) or fire (e.g., bio-indicator plot No. 41) were also left out. According to P. Marinkovic, J. Popovic and Karadzic, D., (1990) mentioned stress factors along with extreme temperature and moisture deficit in the soil will greatly contribute to a faster dieback process which will certainly be developed in the coming years. These authors also noted that in the case of large-scale forest dieback a sanitary felling is required i.e. removal of dead trees and trees that are in the final stages of drying in order to eliminate sources of further infection and prevent overgrowth of bark beetles. The current visible damages of trees on bio-indicator plots have to be considered as the result of a number of factors including extreme temperatures, drought, and factors that started to act much earlier. The forestry profession continuously makes efforts to organizedly conduct the protection of forests against all harmful factors and to improve methods of combating them. These efforts are more significant when having in mind the knowledge of the multiple role of forest and that is why is required for this role to be permanently secured (Tabakovic-Tosic, et al. 2002a).

4. CONCLUSION

The vitality of a tree or of a whole forest ecosystem will largely depend on the influence of the abiotic and biotic factors which may act simultaneously or successively replace each other, and the final result of the observed changes on the tree will not always mean that the last agent of succession is the most important one. Based on the before mentioned, without a doubt, the causes of the weakening of the vitality and drying of trees are numerous and the action is complex. Since the vitality of the trees has been observed on bio-indicator plots, not even in one year so far the stress on the plants was not more clearly visible than it was during 2011 and 2012, and especially in 2013. This showed that the situation is very worrying, because yellow leaves in early summer alertly signal that the trees are draining, and deep cracks in the soil indicate the lack of much-needed moisture.

Based on monitoring of forest condition through bio-indicator plots the causes of dieback of forests and individual trees in 2013 are not entirely reliable, because of a small sample and lack of the dense grid. The results would be more complete and they would give more relevant information if in 2012 and 2013 the attack of gypsy moth was not so expressed, which is why a large number of bio-indicator plots were left out from this analysis. These data will allow the next years' researches to be compared with the existing ones and more precise results to be obtained on the cause of forest dieback in the Republic of Serbia because the observed period was too short for making general conclusion.

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TREE CROWN CONDITION AT LEVEL II SAMPLE PLOTS KOPAONIK, CRNI VRH AND MOKRA GORA IN 2013

Radovan NEVENIĆ[1], Svetlana BILIBAJKIĆ, Miroslava MARKOVIĆ, Goran ČEŠLJAR, Tomislav STEFANOVIĆ, Ilija ĐORĐEVIĆ, Zoran PODUŠKA

Abstract: *Intensive monitoring at Level II sample plots represents a multipurpose research system. Evaluation criteria for intensive monitoring are all in compliance, so that upon recording and statistical analysis, the obtained data on forest condition are easy to compare analytically and logically, providing the basis for a variety of comparative studies. Dedicated sample plots for intensive monitoring and assessment of air pollution and its impact on forest ecosystems in Serbia – Level II sample plots were established on Mt. Fruška Gora in 2009, on Mt. Kopaonik in 2010, in Odžaci in 2011 and on Crni Vrh and Mokra Gora in 2013. Level II monitoring program encompasses the following groups of parameters: tree crown condition, foliar analyses, soil chemistry, soil solution chemistry, growth and yield, ground vegetation, atmospheric deposition, meteorology, phenology and forest litterfall. This paper presents the results of monitoring crow condition at Level II sample plots on Kopaonik, Crni Vrh and Mokra Gora in 2013.*

Key words: Level II sample plot Kopaonik, Crni Vrh, Mokra Gora, crown condition, defoliation, damage

STANJE KRUNA STABALA NA OGLEDNIM POLJIMA BIT NIVO-a II KOPAONIK, CRNI VRH I MOKRA GORA U 2013.GODINI

Abstract: *Intenzivni monitoring na bioindikacijskim tačkama Nivo-a II, predstavlja višenamenski sistem istraživanja. Kriterijumi procene koje intenzivni monitoring podrazumeva, usaglašeni su i tako određeni da se dobijeni podaci o stanju šuma, nakon unosa u bazu podataka i statističke obrade analitički i logički lako porede,*

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dajući osnovu za različite komparativne studije. Ogledne parcele za praćenje i procenu uticaja vazdušnih zagađenja i njihovih efekata u šumskim ekosistemima na teritoriji Republike Srbije - bioindikacijske tačka Nivo-a II osnovane su 2009.godine na Fruškoj gori, 2010. godini na Kopaoniku, 2011. godine u Odžacima i 2013.godine na Crnom vrhu i Mokroj Gori. Programom monitoringa Nivo-a II obuhvaćene su sledeće grupe parametara: stanje kruna stabala, folijarne analize, hemizam zemljišta, hemizam zemljišnog rastvora, prirast, prizemna vegetacija, atmosferska depozicija, meteorologija, fenologija i šumska prostirka.U radu su dati rezultati praćenja stanja kruna stabala na oglednim parcelama BIT Nivo-a II na Kopaoniku, Crnom vrhu i Mokroj gori u 2013. godini.

Ključne reči: BIT Nivo II Kopaonik, Crni vrh, Mokra Gora, stanje kruna, defolijacija, oštećenja

1. INTRODUCTION

According to the uniform ICP Forests program methodology, sample plots have been installed all over the European continent for Level II intensive monitoring aiming at performing continuous measurements and collection of data on condition of forests featuring different specific ecological conditions. Evaluation criteria for intensive monitoring are all in compliance, so that upon recording and statistical analysis, the obtained data on forest condition are easy to compare analytically and logically, providing the basis for a variety of comparative studies.

By establishment of sample plots in Fruška Gora National Park, Kopaonik National Park, in Odžaci, Crni Vrh and Mokra Gora Serbia has joined the European network of more than 800 Level II sample plots.

2. MATERIAL AND METHOD

Intensive monitoring sample plot - Level II sample plot on Kopaonik was established in 2010. The plot is situated in the 74th division of the "Samokovska reka" estate unit in Kopaonik National Park, within the pure stand of Norway spruce (*Picea abies* (L.) H.Karst.).

The area of the Level II sample plot covers 0.5 hectares (100x50m). There are three subplots within the sample plot, as follows: subplot for assessment of crown condition and growth and yield, subplot for assessing soil chemistry and subplot for assessment of ground vegetation. All the trees within the sample plot are designated with permanent bark marks, i.e. ordinal numbers from 1 to 195. The as-built site plan[1] of the sample plot is shown in Figure 1.

[1] As-built site plan was prepared at the Institute of Forestry in Belgrade in digital form in accordance with the filed status and the blueprint of the basic setup of test subplots prepared by the Team of Faculty of Forestry in Belgrade in 2010.

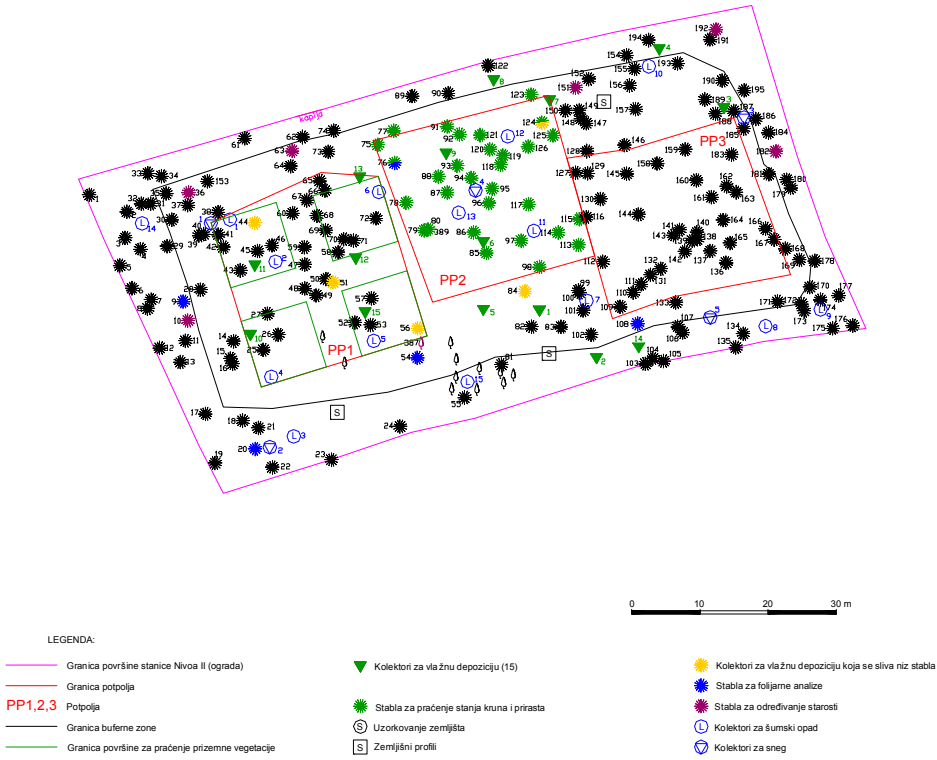


Figure 1. *As-built site plan of sample plot Kopaonik*

During 2013 another two Level II sample plots were set up, one on Crni Vrh and the other in Mokra Gora.

The Level II sample plot on Crni Vrh is situated in the 17th division of the "Crni Vrh – Kupinovo" estate unit, within the pure beech stand (*Fagus moesiaca*).

The area of the Level II sample plot covers 0.5 hectares (100 x 50 m) at the altitude between 930m to 945m. Within the entire test plot, three subplots for customized sampling and a buffer zone are delineated. All the trees within the sample plot are designated with permanent bark marks, i.e. ordinal numbers from 1 to 150. The as-built site plan[1] of the Crni Vrh sample plot is shown in Figure 2.

[1] As-built site plan was prepared at the Institute of Forestry in Belgrade in digital form in accordance with the filed status and the blueprint of the basic setup of test subplots prepared by the Team of Faculty of Forestry in Belgrade in 2010.

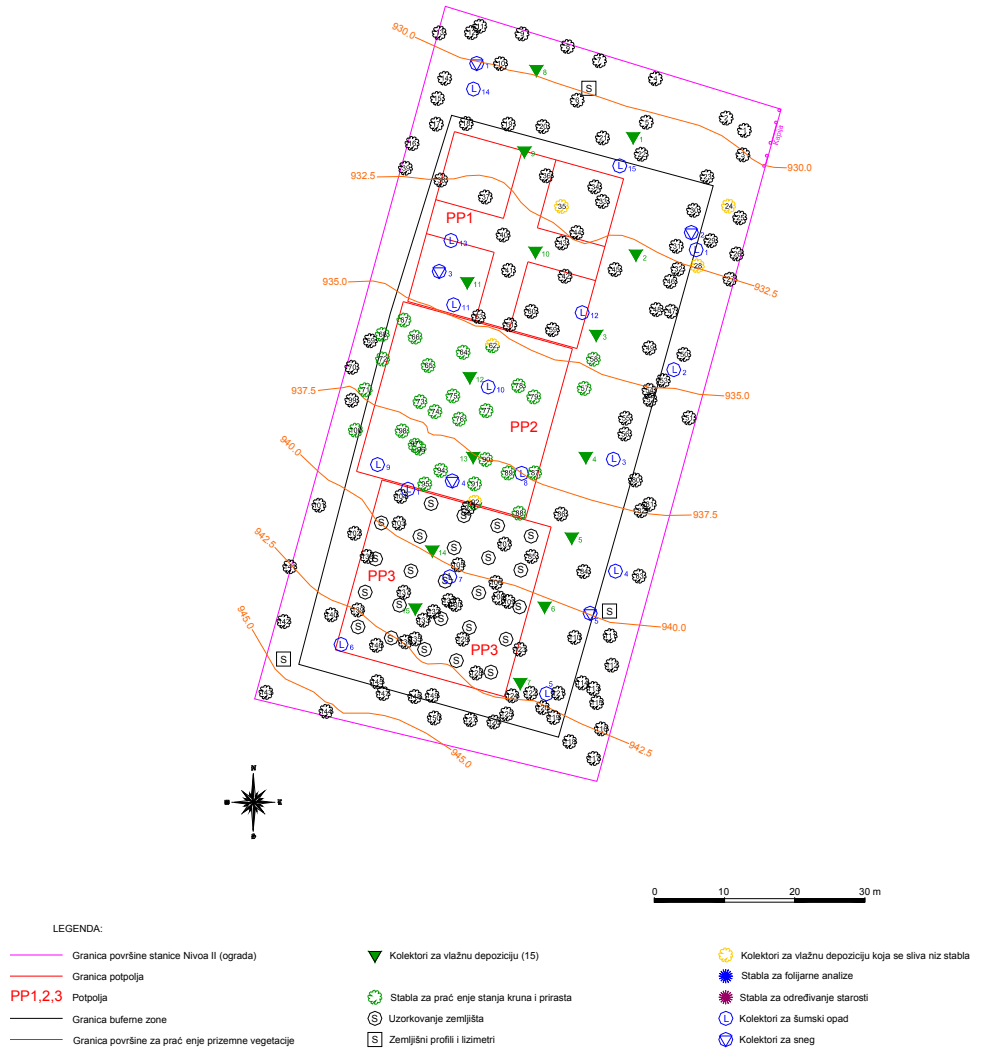


Figure 2. *Digital as-built site plan*[1] *of sample plot Crni Vrh*

The Level II sample plot in Mokra Gora is situated in the 20th division of the "Mokra Gora – Panjak" estate unit within the artificially grown stand of the Scots pine *(Pinus silvestris*).

The area of the Level II sample plot covers 0.55 hectares (110 x 50 m) within the altitude zone between 580 m and 600 m.

Within the entire test plot, three subplots (25×25 m) for customized sampling and a buffer zone are delineated.

All the trees within the sample plot are designated with permanent bark marks, i.e. ordinal numbers from 1 to 450, and the position of each tree is defined by the coordinates of the kilometer grid (Figure 3).

[1] As-built site plan was prepared at the Institute of Forestry in Belgrade in digital form in accordance with the filed status.

Figure 3. *Digital as-built site plan[1] of sample plot Mokra Gora*

The 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 (Nevenić, 2011). Frequency of monitoring individual parameters is shown in Table 1.

[1] As-built site plan was prepared at the Institute of Forestry in Belgrade in digital form in accordance with the filed status

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

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

For crown condition monitoring at the sample test plots on Kopaonik and Crni Vrh 30 trees were selected within subplot 2, and 32 trees were selected at the sample test plot on Mokra Gora.

3. RESULTS AND DISCUSSION

Parameters with annual and continuous monitoring frequency were monitored during 2013.

3.1. Assessment of crown condition – intensive monitoring in 2013 – Level II sample plot Kopaonik

Crown condition of trees at the Level II sample plot on Kopaonik was assessed on October 17, 2013. The assessment was performed on 30 spruce trees selected for annual crown condition monitoring within subplot 2.

Table 2. *(PLT) Data on the sample plot dedicated for crown condition assessment, Level II – Kopaonik*

No.	Country code	Plot no.	Assessment date	Latitude	Longitude	Altitude /code	Team ID	Other findings
1	67	2	171013	+43^{0}17'30"	+20^{0}48'50"	35		

The crown condition assessment included determining the extent of defoliation, drying up – removal, tree status, crown shadow, crown visibility, foliage transparency and other findings (Table 3).

Tables 3 and 4 present parameters of crown condition and damage at the Level II sample plot on Kopaonik in 2013.

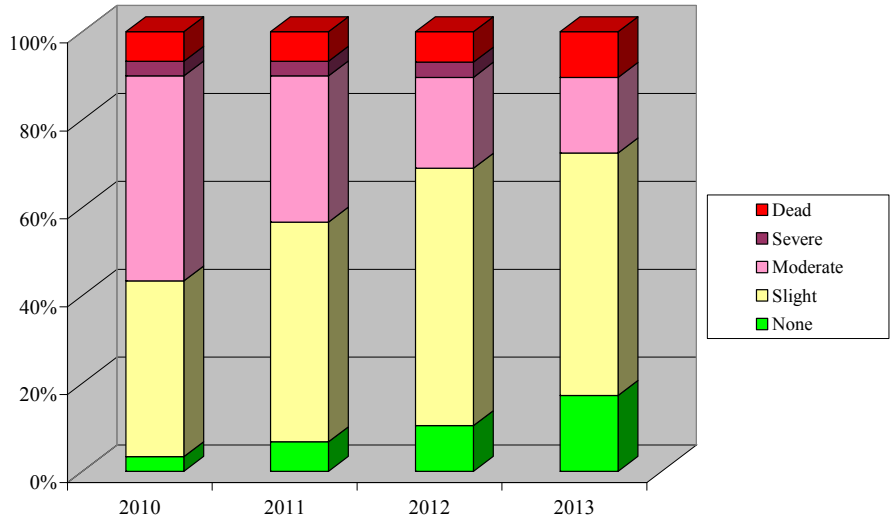
Table 3. *(TRC) Crown condition parameters, Level II - Kopaonik*

No.	Plot no.	Assessment date	Number of trees	Species	Drying – removal	Tree status	Crown shadow	Crown visibility	Defoliation	Foliage transparency	Other findings
1	2	171013	75	118	01	1	2	2	5	25	*U.b.**
2	2	171013	76	118	01	1	1	2	15	20	*U.b.**
3	2	171013	78	118	01	1	2	2	10	25	*U.b.**
4	2	171013	79	118	01	1	1	2	15	25	*U.b.**
5	2	171013	80	118	01	1	1	2	10	25	*U.b.**

No.	Plot no.	Assessment date	Number of trees	Species	Drying – removal	Tree status	Crown shadow	Crown visibility	Defoliation	Foliage transparency	Other findings
6	2	171013	85	118	01	1	2	2	10	25	*U.b.**
7	2	171013	86	118	01	1	3	3	10	30	*U.b.**
8	2	171013	87	118	01	3	3	3	35	70	*U.b.**
9	2	171013	88	118	38	5	6	2	100	99	*U.b.**
10	2	171013	91	118	41						
11	2	171013	92	118	01	2	3	3	30	60	*U.b.**
12	2	171013	93	118	01	1	3	3	30	60	*U.b.**
13	2	171013	94	118	01	3	3	3	40	80	*U.b.**
14	2	171013	95	118	01	2	3	3	20	30	*U.b.**
15	2	171013	96	118	01	1	4	4	20	30	*U.b.**
16	2	171013	97	118	01	1	3	3	15	50	*U.b.**
17	2	171013	98	118	01	1	3	3	20	80	*U.b.**
18	2	171013	113	118	01	1	2	2	20	60	*U.b.**
19	2	171013	114	118	01	1	4	3	20	80	*U.b.**
20	2	171013	115	118	01	1	3	3	25	50	*U.b.**
21	2	171013	117	118	01	1	4	3	25	50	*U.b.**
22	2	171013	118	118	01	1	3	2	20	65	*U.b.**
23	2	171013	119	118	38	3	3	3	100	90	*U.b.**
24	2	171013	120	118	01	1	1	2	30	40	*U.b.**
25	2	171013	121	118	01	1	3	3	15	20	*U.b.**
26	2	171013	124	118	01	1	2	2	20	60	*U.b.**
27	2	171013	125	118	38	5	3	3	100	99	*U.b.**
28	2	171013	126	118	01	1	2	2	15	40	*U.b.**
29	2	171013	77	118	01	1	3	2	15	30	*U.b.**
30	2	171013	123	118	01	1	1	1	15	20	*U.b.**

**Usnea barbata*

The percentage of trees not suffering from defoliation increased at the sample plot Kopaonik in 2013 as compared to the previous three years. The percentage of dead trees increased slightly, while the percentage of trees exhibiting moderate defoliation decrease in comparison to the previous year. In 2013 severe defoliation was not observed in any of the trees selected for crown condition assessment.



Graph 1. *Comparative overview of defoliation in the period from 2010 to 2013, Level II –Kopaonik*

Table 4. *(TRD) Damage parameters, Level II - Kopaonik*

No.	Plot no.	Assessment date	Number of trees	Damaged tree portion	Symptom	Symptom designat.	Crown portion	Time of damage occurrence	Cause	Cause name	Damage intensity	Other findings
1	2	171013	75									*U.b.**
2	2	171013	76									*U.b.**
3	2	171013	78	11	11	56	3	3	301	Chrysomyxa	1	*U.b.**
4	2	171013	79	11	11	56	3	3	301	Chrysomyxa	1	*U.b.**
5	2	171013	80									*U.b.**
6	2	171013	85									*U.b.**
7	2	171013	86	11	11	56	3	3	301	Chrysomyxa	1	*U.b.**
8	2	171013	87									*U.b.**
9	2	171013	88									*U.b.**
10	2	171013	91									
11	2	171013	92									*U.b.**
12	2	171013	93									*U.b.**
13	2	171013	94									*U.b.**
14	2	171013	95									*U.b.**
15	2	171013	96									*U.b.**
16	2	171013	97									*U.b.**
17	2	171013	98	33	11	60		3	390		1	*U.b.**
18	2	171013	113									*U.b.**
19	2	171013	114									*U.b.**
20	2	171013	115									*U.b.**
21	2	171013	117									*U.b.**
22	2	171013	118									*U.b.**
23	2	171013	119									*U.b.**
24	2	171013	120									*U.b.**
25	2	171013	121									*U.b.**
26	2	171013	124									*U.b.**
27	2	171013	125									*U.b.**
28	2	171013	126									*U.b.**
29	2	171013	77									*U.b.**
30	2	171013	123									*U.b.**

**Usnea barbata*

On October 17, 2013, the selected 30 spruce trees were examined and assessed for health condition. During examination, it was determined that since 2010 4 trees had completely dried up. With regard to damage, only slight conifer needle chlorosis was identified in trees no. 78, 79, 86 and rot at the root collar in tree no. 98. Presence of lichen *Usnea barbata* all over the sample plot indicates a healthy habitat.

Figure 4. *Slight chlorosis of spruce conifer needles*

3.2. Assessment of crown condition – intensive monitoring in 2013 – Level II sample plot Crni Vrh

Crown condition of trees at the Level II sample plot on Crni Vrh was assessed on July 9, 2013. The assessment was performed on 30 beech trees selected for crown condition monitoring within subplot 2.

Table 5. *(PLT) Data on the sample plot dedicated for crown condition assessment, Level II – Crni Vrh*

No.	Country code	Plot no.	Assessment date	Latitude	Longitude	Altitude /code	Team ID	Other findings
1	67	4	090713	+44^{0}07'55"	+21^{0}58'38"	19		

Table 6. *(TRC) Crown condition parameters, Level II - Crni Vrh*

No.	Plot no.	Assessment date	Number of trees	Species	Drying – removal	Tree status	Crown shadow	Crown visibility	Defoliation	Foliage transparency	Other findings
1	4	090713	57	018	01	1	4	2	25	20	
2	4	090713	58	018	01	1	4	2	20	20	
3	4	090713	62	018	01	1	1	1	0	10	
4	4	090713	64	018	01	1	4	1	10	5	
5	4	090713	65	018	01	1	4	1	5	5	
6	4	090713	66	018	01	1	4	1	10	10	
7	4	090713	67	018	01	1	4	2	5	15	
8	4	090713	68	018	01	1	4	2	100	99	
9	4	090713	69	018	01	1	4	2	20	20	
10	4	090713	71	018	01	1	4	2	5	10	
11	4	090713	72	018	01	1	4	2	10	15	
12	4	090713	73	018	01	1	4	1	0	5	
13	4	090713	74	018	01	1	4	1	0	5	
14	4	090713	75	018	01	1	4	1	5	5	
15	4	090713	76	018	01	1	3	1	5	5	
16	4	090713	77	018	01	1	5	1	10	15	
17	4	090713	78	018	01	1	3	1	20	20	
18	4	090713	79	018	01	1	5	1	0	5	
19	4	090713	87	018	01	2	1	1	0	5	
20	4	090713	88	018	01	1	4	1	0	5	
21	4	090713	89	018	01	1	3	1	10	15	
22	4	090713	90	018	01	2	3	1	10	10	
23	4	090713	91	018	01	2	4	1	20	10	
24	4	090713	92	018	01	1	3	1	10	20	
25	4	090713	94	018	01	1	4	2	10	20	
26	4	090713	95	018	01	1	4	1	0	15	
27	4	090713	96	018	01	1	4	1	5	10	
28	4	090713	97	018	01	2	4	2	10	10	
29	4	090713	98	018	01	1	4	1	0	15	
30	4	090713	100	018	01	1	4	2	60	50	

In 2013, 76.67% of the trees selected for crown condition monitoring displayed no defoliation, whereas slight defoliation was detected in 16.67% and severe in 3.33% of the trees.

Table 7. *(TRD) Damage parameters, Level II - Crni Vrh*

No.	Plot no.	Assessment date	Number of trees	Damaged tree portion	Symptom	Symptom designat.	Crown portion	Time of damage occurrence	Cause	Cause name	Damage intensity	Other findings
1	4	181013	57	14	01	33	3	3	210	*Lymantria disper*	2	
2	4	181013	58									
3	4	181013	62									
4	4	181013	64									
5	4	181013	65									
6	4	181013	66	14	01	33	3	3	210	*Lymantria disper*	2	
7	4	181013	67									
8	4	181013	68									
9	4	181013	69									
10	4	181013	71									
11	4	181013	72									
12	4	181013	73									
13	4	181013	74									
14	4	181013	75									
15	4	181013	76									
16	4	181013	77									
17	4	181013	78									
18	4	181013	79									
19	4	181013	87									
20	4	181013	88									
21	4	181013	89									
22	4	181013	90									
23	4	181013	91									
24	4	181013	92									
25	4	181013	94									
26	4	181013	95									
27	4	181013	96									
28	4	181013	97									
29	4	181013	98									
30	4	181013	100	14	01	33	3	3	210	*Lymantria disper*	2	

On October 18, 2013 the selected 30 beech trees were examined and assessed for health condition. With regard to the diseases and pests, a beech bark disease was identified – insect *Cryptococcus fagisuga* transferring fungus spores was observed in trees no. 38, 57 and 100. Pustulae of the fungus *Nectria coccinea* causing this disease were identified in trees no. 57 and 100. In addition, carpophores of the fungus *Trichaptum violaceum* and a fertilized brood of gypsy moth - *Lymantria dispar* were detected in tree no. 100. Beside the aforesaid tree, fertilized non-parasitized gypsy moth broods in the root collar or in the armpits of branches were identified in trees no. 2 (two broods), 57 and 66 (a brood each) and a non-fertilized damaged brood in tree no. 40. Bark beetle canals in a dry branch were perceived in tree no. 100. Rot in nodes and branches was observed in trees no. 57 and 72, while tree no. 14 suffered from severe central rot. Fungus *Diatrype stigma* was observed on the bark of tree no. 68. Mild bark inflammation resulting from intense insolation was recorded in trees no. 58 and 66.

On the whole, the damage to the trees within the sample plot may be regarded as not significant and not affecting a large number of trees; not many gypsy moth broods were observed although this year was the year of gypsy moth

gradation in the eastern region of Serbia. The presence of lichen is evidence of a healthy habitat. There is minor abiotic damage while out of biotic damage causes, in addition to the gypsy moth, the beech bark disease is the only harmful one as there is a possibility of its spreading although for the time being the infection is very mild.

Figure 5. *Fertilized non-parasited gypsy moth brood in the root collar of a beech tree*

3.3. Assessment of crown condition – intensive monitoring in 2013 – Level II sample plot Mokra Gora

Crown condition of trees at the Level II sample plot on Mokra Gora was assessed on August 15, 2013. The assessment was performed on 32 Scots pine trees selected for crown condition monitoring within subplot 2.

Table 8. *(PLT) Data on the sample plot dedicated for crown condition assessment, Level II –Mokra Gora*

No.	Country code	Plot no.	Assessment date	Latitude	Longitude	Altitude /code	Team ID	Other findings
1	67	5	15.08.2013	+43^{0}45'27"	+19^{0}29'00"	12		

Table 9. *(TRC) Crown condition parameters, Level II - Mokra Gora*

No.	Plot no.	Assessment date	Number of trees	Species	Drying – removal	Tree status	Crown shadow	Crown visibility	Defoliation	Foliage transparency	Other findings
1	5	150813	82	018	1	2	2	1	0	30	*C.l.**
2	5	150813	83	134	1	1	1	1	10	30	*C.l.**
3	5	150813	84	134	1	2	2	1	10	30	*C.l.**
4	5	150813	105	134	1	1	3	1	10	20	*C.l.**
5	5	150813	106	134	1	1	2	1	15	30	*C.l.**
6	5	150813	107	134	1	2	1	1	0	20	*C.l.**
7	5	150813	113	134	1	1	1	1	0	25	*C.l.**
8	5	150813	114	134	1	1	4	1	15	50	*C.l.**
9	5	150813	140	134	1	2	2	1	5	25	*C.l.**
10	5	150813	141	134	1	1	2	1	0	10	*C.l.**
11	5	150813	142	134	1	2	2	1	0	20	*C.l.**
12	5	150813	143	134	1	2	2	1	0	15	*C.l.**
13	5	150813	144	134	1	2	2	1	5	20	*C.l.**

No.	Plot no.	Assessment date	Number of trees	Species	Drying – removal	Tree status	Crown shadow	Crown visibility	Defoliation	Foliage transparency	Other findings
14	5	150813	165	134	1	2	1	1	0	15	*C.l.**
15	5	150813	166	134	1	2	2	1	0	10	*C.l.**
16	5	150813	167	134	1	2	2	1	5	15	*C.l.**
17	5	150813	168	134	1	2	3	1	5	15	*C.l.**
18	5	150813	183	134	1	1	1	1	10	15	*C.l.**
19	5	150813	184	134	1	2	2	1	0	20	*C.l.**
20	5	150813	185	134	1	3	3	2	5	25	*C.l.**
21	5	150813	193	134	1	1	1	1	0	10	*C.l.**
22	5	150813	194	134	1	1	2	1	0	10	*C.l.**
23	5	150813	213	134	1	2	2	1	0	15	*C.l.**
24	5	150813	214	134	1	3	3	1	0	10	*C.l.**
25	5	150813	215	134	1	3	2	1	0	10	*C.l.**
26	5	150813	223	134	1	1	2	1	0	10	*C.l.**
27	5	150813	224	134	1	3	2	1	0	10	*C.l.**
28	5	150813	320	134	1	2	2	1	10	20	*C.l.**
29	5	150813	359	134	1	1	2	1	0	10	*C.l.**
30	5	150813	407	134	1	1	2	1	0	5	*C.l.**
31	5	150813	408	134	1	4	3	2	0	20	*C.l.**
32	5	150813	412	134	1	1	2	1	0	5	*C.l.**

** Crust-like lichen*

In 2013 93.75% of the selected trees within the Level II sample plot in Mokra Gora exhibited no signs of defoliation, whereas slight defoliation was detected in 6.25% of the trees. No severe defoliation was identified in the selected trees.

Table 10. *(TRD) Damage parameters, Level II - Mokra Gora*

No.	Plot no.	Assessment date	Number of trees	Damaged tree portion	Symptom	Symptom designat.	Crown portion	Time of damage occurrence	Cause	Cause name	Damage intensity	Other findings
1	5	101013	82	33	11	57		2	390	*Mycena sp.*		*C.l.**
2	5	101013	83									*C.l.**
3	5	101013	84									*C.l.**
4	5	101013	105									*C.l.**
5	5	101013	106									*C.l.**
6	5	101013	107									*C.l.**
7	5	101013	113									*C.l.**
8	5	101013	114									*C.l.**
9	5	101013	140									*C.l.**
10	5	101013	141									*C.l.**
11	5	101013	142	32	550			2			1	*C.l.**
12	5	101013	143	32	550			2			1	*C.l.**
13	5	101013	144									*C.l.**
14	5	101013	165									*C.l.**
15	5	101013	166									*C.l.**
16	5	101013	167									*C.l.**
17	5	101013	168									*C.l.**
18	5	101013	183	33	11	57		2	390	*Mycena sp.*		*C.l.**
19	5	101013	184									*C.l.**
20	5	101013	185									*C.l.**
21	5	101013	193									*C.l.**
22	5	101013	194									*C.l.**
23	5	101013	213									*C.l.**
24	5	101013	214									*C.l.**
25	5	101013	215									*C.l.**

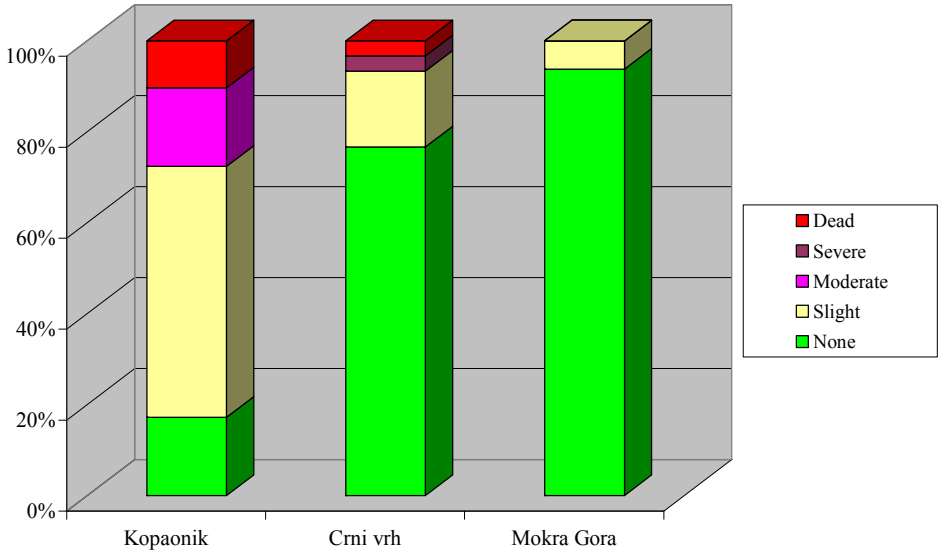
No.	Plot no.	Assessment date	Number of trees	Damaged tree portion	Symptom	Symptom designat.	Crown portion	Time of damage occurrence	Cause	Cause name	Damage intensity	Other findings
26	5	101013	223									*C.l.**
27	5	101013	224									*C.l.**
28	5	101013	320									*C.l.**
29	5	101013	359	33	11	57		2	390	*Mycena sp.*		*C.l.**
30	5	101013	407									*C.l.**
31	5	150813	408									
32	5	150813	412									

** Crust-like lichen*

On October 10, 2013, the selected 32 trees at the level II sample plot Mokra Gora were examined in detail and assessed for health condition.

There is little damage on the tree trunks located at the root collar at the height of 1.2 m, which is slight and solely mechanical, caused by the anthropogenic factors, probably upon removal of tees or other materials or performance of other works in the forest. The only biotic damage recorded was in the form of a small number of carpophores of the saprophytic rot-causing fungus from the genus *Mycena sp.,* which appeared at the foot of a few trees close to the ground. No damage caused by insects, birds, game and the like was observed.

Presence of crust-like lichen at the lower portion of tree trunks, at the height of 2 m, indicates a healthy habitat.



Graph 2. *Overview of defoliation at Level II sample plots in 2013*

Among the three sites, the largest percentage of tress not suffering from defoliation was recorded in Mokra Gora; moreover, neither moderate nor severe defoliation was observed there.

3.4. GIS applications for forest condition monitoring in the Republic of Serbia in 2013

Geographic information system (GIS) is a digital tool for graphic and alpha-numeric presentation of real spatial phenomena, for manipulation with large numbers of spatial data and spatial analyses and models. GIS approach within the entire ICP Forests work of large-scale forest condition monitoring at the country level is an invaluable and irreplaceable procedure that allows adequate presentation of all data in the real coordinate system. The usage of GIS approach commences with the starting phase of determining the network of sample plot locations, continues through the field work when sample plots are marked by means of GPS manual devices to the entry of data into the GIS system, preparation of analyses, models and data archiving (Nevenić, 2011) according to the GIS procedure.

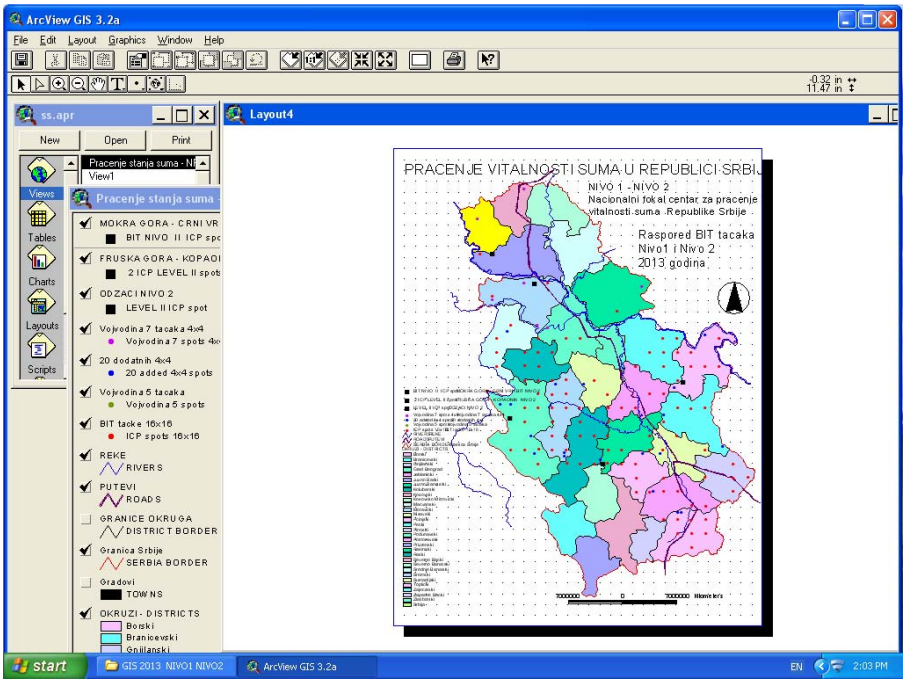


Figure 6. *Distribution of Level I and Level II sample plots in the territory of the Republic of Serbia in 2013 – GIS application*

For the purpose of practical implementation of GIS, the reference coordinate system (RCS) can be explained as the coordinate system linked to the Earth via the Geodetic Datum. The RCS may be a geodetic coordinate system where positions are defined by means of longitude and latitude. In most instances a projected coordinate system is used where the coordinates are transformed into plane using the Map Projection. This term, as well as other terms used here, is precisely defined by the international standards (ISO 19111:2003).

Trees in the Level II sample test plots in the territory of the Republic of Serbia are geodetically recorded and entered into the coordinate system. Figure 6 shows the distribution of the Level I and level II sample plots. Using the

manipulative approach within the appropriate GIS program, by selecting a certain topic or desired information, this application can provide clear presentation of all relevant alphanumeric and spatial data.

4. CONCLUSION

In 2013, in addition to the existing Level II monitoring sample plot on Kopaonik, another two sample plots were set up – one on Crni Vrh and the other in Mokra Gora, where parameters with continuous and annual monitoring frequency were monitored.

The percentage of trees unaffected by defoliation at the sample plot Kopaonik increased in 2013 as compared to the previous three years, whereas the percentage of trees with moderate defoliation decreased in comparison the previous periods.

Examination and assessment of the health condition of the selected 30 spruce trees at the sample plot Kopaonik revealed that since the setup of the sample plot 4 trees had completely dried up; as for damage, only slight chlorosis of conifer needles was recorded.

In 2013, 76.67% of the trees within subplot 2 of the sample plot Crni Vrh showed no sign of defoliation, in 16.67 % of the trees slight defoliation and in 3.33% of the trees severe defoliation were detected.

Of diseases and pests, beech bark disease - insect *Cryptococcus fagisuga,* pustulae of the fungus *Nectria coccinea,* carpophores of the fungus *Trichaptum violaceum,* broods of gypsy moth - *Lymantria dispar* and fungus *Diatrype stigma* were identified. On the whole, the damage to the trees within the sample plot may be regarded as not significant and not affecting a large number of trees.

In 2013, 93.75% of the trees at the Level II sample plot Mokra Gora selected for crown condition monitoring displayed no indication of defoliation, while slight defoliation affected only 6.25% of the trees.

Of biotic damage, at the Level II sample plot Mokra Gora only a small number of carpophores of the saprophytic rot-causing fungus from the genus *Mycena sp.* was recorded*,* at the foot of several trees close to the ground.

In 2013, defoliation was the least present in trees at the Level II sample plot Mokra Gora.

A particular significance of the GIS digital approach is that it allows manipulating data obtained during field work, preparation of reports, exchange of data via the Internet network and continuous collaboration with the headquarters of ICP Forests in Hamburg.

Entries of new data into the GIS system of Serbia's NFC are regularly made on an annual basis, which will provide valuable archive for future scientific research in a few years' time, when multiannual analyses of the vitality of the Republic of Serbia's forests commence.

GIS methodology also provides great opportunities for preparation of simulation models for forecasting future condition of the ground cover vegetation and environment, where the work of collecting sample plot data performed up to date could have a significant role.

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Original scientific paper

RESULTS OF RESEARCH OF DEFOLIATION ON BIO-INDICATOR PLOTS IN REPUBLIC OF SERBIA IN 2013

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Abstract: *The initial symptoms of stand-level dieback of forests are defoliation and change of a tree crown color. Therefore, the defoliation, along with the color change, was accepted as the main parameter for estimation of crown condition for monitoring of forest condition. In this work were analyzed the data on defoliation as a part of the results of the monitoring of forest condition on bio-indicator plots in 2013. On plots the assessment of defoliation is performed regardless of the cause of a loss of leaves, and the results are not aiming at establishing cause-effect relationships, but only represent the defoliation condition on bio-indicator plots in 2013. Linking these results with other indicators of environmental conditions will provide more specific information and conclusions about the dependence of plant vitality on environmental conditions.*

Key words: defoliation, bio-indicator plots, assessment of crown condition

REZULTATI ISTRAŽIVANJE DEFOLIJACIJE NA BIOINDIKACIJSKIM TAČKAMA U REPUBLICI SRBIJI U 2013. GODINI

Abstract: *Početni simptomi sušenja šumskih sastojina su defolijacija i promena boje krošnji stabala. Zbog toga je defolijacija, uz promenu boje, prihvaćena kao glavni parametar procene stanja krošnji za praćenje stanja šuma. U ovom radu analizirani su podaci o defolijaciji kao deo rezultata rada na praćenju stanja šuma na bioindikacijskim tačkama u 2013. godini. Na tačkama se ocena defolijacije vrši bez obzira na uzrok gubitaka lišća, pa dobijeni rezultati nemaju za cilj utvrđivanje uzročno-posledičnih odnosa, već samo reprezentuju stanje defolijacije na bioindikacijskim tačkama u 2013. godini. Povezivanje ovih rezultata sa drugim pokazateljima uslova sredine omogući će konkretnija*

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saznanja, i donošenje zaključaka o zavisnosti vitalnosti biljaka od uslova sredine.

Key words: defolijacija, bioindikacijske tačke, procena stanja krošnji

1. INTRODUCTION

Forest condition monitoring project (ICP Forests) operates as an international European project in which, on the grid of bio-indicator plots, annually has been monitored the condition of forests, the data on defoliation and discoloration have been recorded and other damages on trees have been registered. The objective of this program is to collect data on the condition of forests in Europe using unique methodology and to obtain information about the spatial and temporal variation of forest condition in the countries of Europe.

On the territory of the Republic of Serbia the first record of health status, agreed with the abovementioned program was carried out in 1988. During 2003 the grid of these plots was reconstructed, with the most of bio-indicator plots that had to be re-set. In 2004 it was found that 103 reconstructed bio-indicator plots in the 16 x 16 km grid does not fully represent the state of vegetation cover in Serbia, so 27 new plots have been set in the 4 x 4 km grid. During last years in the localities of some bio-indicator plots were performed clear deforestations, so it is impossible to carry out further observations in that locations, and from two plots for technical reasons were not continuously obtained the necessary data. On all other plots the monitoring of the condition has been performed, all field data necessary for further processing have been collected, so the aforementioned program has been implemented in the continuity on the 121 bio-indicator plots.

In this paper have been analyzed the data on defoliation, as a part of the results of the monitoring of forests condition on bio-indicator plots in 2013.

2. MATERIAL AND METHOD

Within this project the crown condition is expressed by classes of leaf losses, color changes and combined classes of damages. Assessment of the crown condition has been performed every year on permanent sample plots called bio-indicator plots.

Permanent sample plot or bio-indicator plot consists of the center determined based on coordinates and metal rod clearly marked in the field. At 25 meters from the center, in the direction of the four main corners of the world the sample plots were determined and on them were selected per 6 trees labeled with numbers from 1 to 6. The selected trees are permanently marked with numbers, and the trees removed for any reason shall be replaced with new, selected trees.

Defoliation or loss of needles or leaves on the tree crown, for each tree on the permanent sample plots, in the field is estimated at intervals of 5%, and the results are grouped into five classes of unequal range (Table 1).

Table 1. *Defoliation class*

Class	Degree of defoliation	Percentage of leaf/needle loss
0	No defoliation	0-10 %
1	Slight	10-25 %
2	Moderate	25-60 %
3	Severe	60-100 %
4	Dead tree	100 %

In this paper were also used the data from the minute-books that researchers fill in the spot during visiting the bio-indicator plots. Based on these minute-books, the mean values of defoliation for each plot have been calculated. Mean values of defoliation for each plot were calculated based on individual values of defoliation for each tree on the plot no matter of the tree species.

Determination of the mean values of defoliation for each sample plot enabled the designing of defoliation map. By interpolation of mean values of defoliation of adjacent sample plots were obtained points with the same values of defoliation. By connecting these points, with equal values of defoliation, were formed isolines. Isolines, in this case, represent the same average annual values of defoliation on the territory of Serbia.

3. RESULTS AND DISCUSSION

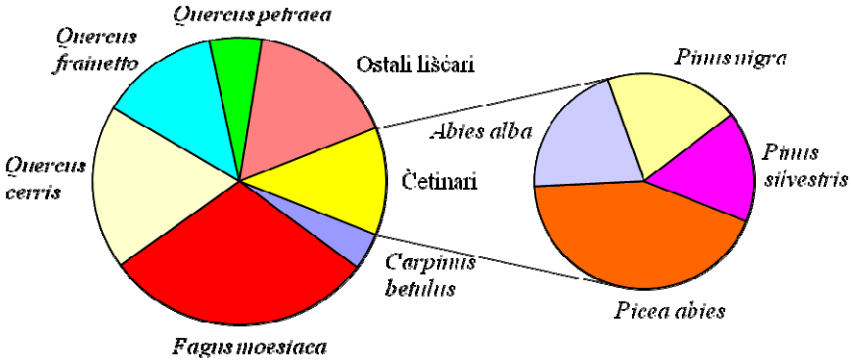
On the territory of the Republic of Serbia monitoring of the forest condition in 2013 was performed on 121 bio-indicator plots. Field work on the data collection (observations and measurements) was carried out in the period June - September.

Plots were arranged at altitudes of 75-1558 m above sea level and the largest number of plots is at altitudes of 400 - 600 m above sea level, which is a total of 27 plots (Table 2).

Table 2. - *Distribution of bio-indicator plots related to altitude*

Altitudes	0 - 200	200 -400	400 -600	600 -800	800 -1000	1000-1200	1200-1400	1400-1600	Total
Number of BIP	17	24	27	16	9	13	11	4	121

The assessment of defoliation was performed on 2,794 trees. The most represented tree species on bio-indicator plots are: *Fagus moesiaca* (833 trees), *Quercus cerris* (516), *Quercus frainetto* (368), *Quercus petraea* (161) and *Carpinus betulus* (117). Of conifers there are represented: *Abies alba* (69 trees), *Picea abies* (146), *Pinus nigra* (56) and *Pinus silvestris* (56) (Graph 1.).



Graph 1. *Represented tree species*

On all bio-indicator plots was performed the assessment of degree of defoliation and presence of defoliation processes in the most represented species of broadleaves and conifers is shown in Tables 3 and 4.

In 2013, hornbeam proved to be the most resistant species because 74.4% of the trees have no signs of defoliation, while the slight defoliation has been registered at 8.5% hornbeam trees. On beech trees defoliation does not occur in 69% of the trees, while the process of slight defoliation affected 18.9% of the trees. Species of the genus *Quercus* proved to be the most endangered and the most endangered species is Sessile oak where only 50.9% of the trees have no signs of defoliation.

Table 3. *Defoliation – broadleaves in 2013*

	Hornbeam	Balkan beech	Turkey oak	Hungarian oak	Sessile oak	Others
No defoliation	74.4	69	56	73.1	50.9	58.1
Slight	8.5	18.9	29.2	14.1	31.7	21.7
Moderate	7.7	8.6	10.5	8.4	13.1	13
Severe	8.5	2.9	3.7	4.1	3.1	4.8
Dead tree	0.9	0.6	0.6	0.3	1.2	2.4

Defoliation (falling of needles) in coniferous trees in 2013 was minimum presented in fir, with 92.8% of the trees with no signs of defoliation. A similar situation was registered in spruce trees (90.4%), while the Austrian pine trees are far the most endangered by these processes of all species registered in the bio-indicator plots. On only 35.8% of Austrian pine trees were not noticed signs of defoliation, while almost 50% of the trees are affected by the processes of moderate to severe defoliation.

Table 4. *Defoliation – conifers in 2013*

	Silver fir	Common spruce	Austrian pine	Scots pine
No defoliation	92.8	90.4	35.8	83.9
Slight	1.4	6.2	17.9	8.9
Moderate	4.4	2	34.3	0
Severe	1.4	1.4	10.5	7.2
Dead tree	0	0	1.5	0

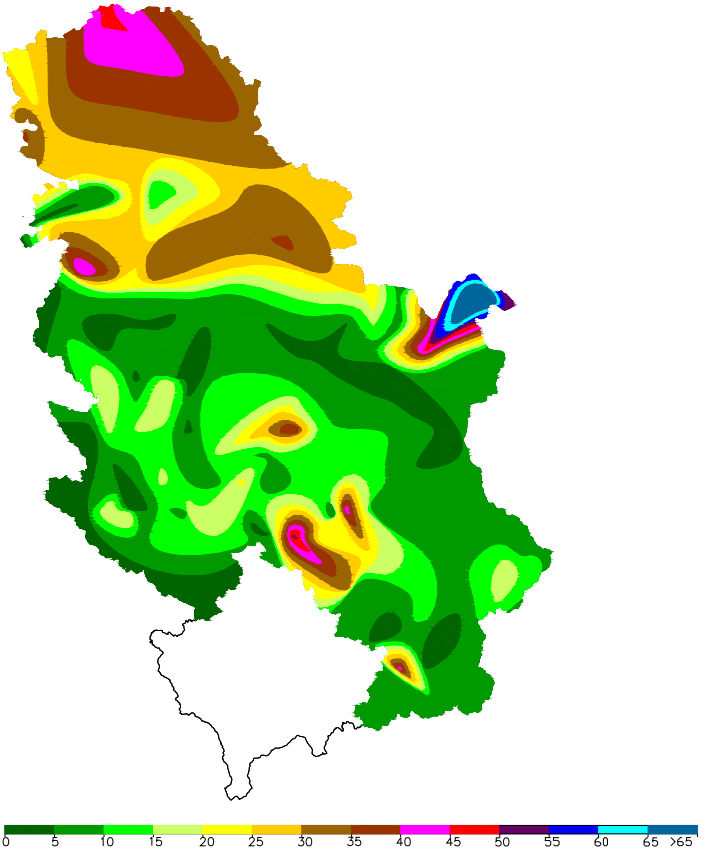
For all bio-indicator plots are calculated mean values of defoliation and the summary results per each bio-indicator plot are shown in Table 5.

Table 5. *Average annual defoliation on bio-indicator plots*

BIP	%	BIP	%	BIP	%	BIP	%	BIP	%	BIP	%
2	7.9	27	5.6	49	16.3	70	8.2	93	15.6	407	14.4
3	4.2	28	0.0	50	15.6	71	7.9	94	17.5	408	7.1
4	0.4	29	45.0	51	17.3	72	6.5	95	6.4	409	20.2
6	5.4	30	15.6	52	11.7	73	2.1	96	41.3	410	56.3
7	9.4	31	6.7	53	9.2	74	0.4	97	5.2	412	3.3
8	4.4	32	7.5	55	10.0	75	20.0	98	8.9	413	10.8
9	6.7	33	34.6	56	14.4	76	13.1	99	4.4	414	13.3
10	3.3	34	8.8	57	4.4	77	14.2	100	9.4	415	18.3
11	2.6	35	9.4	58	6.5	78	14.8	101	36.0	416	13.3
12	9.4	36	83.8	59	21.0	79	29.6	102	35.8	417	20.2
13	16.7	37	3.1	60	9.2	80	20.8	103	28.1	418	0.8
14	45.0	38	6.0	61	5.6	81	40.0	104	3.3	419	6.3
15	12.1	39	22.1	62	15.8	82	20.0	105	9.8	420	2.9
17	6.9	40	11.5	63	50.8	83	23.8	106	23.5	421	25.8
18	15.4	41	40.0	64	12.9	85	5.0	401	3.1	422	47.3
19	10.8	42	8.3	65	5.0	86	9.0	402	4.6	423	21.9
20	20.0	44	14.4	66	42.5	87	3.8	403	9.4	424	7.1
21	29.6	45	6.7	67	19.6	89	11.1	404	4.4	425	23.3
23	24.2	47	10.4	68	23.8	91	2.7	405	7.1	426	23.8
24	2.5	48	13.8	69	6.0	92	11.3	406	7.3	427	32.1
26	5.0										

From Table can bee seen that in 2013 occurred great oscillations of mean annual values of defoliation. On plot no. 28 (Potaj Čuka, *Fagus moesiaca*) in this year there was no signs of defoliation, while on plot no. 36 (Kladovo, *Quercus cerris, Quercus petraea*) has been registered the severe defoliation (83.8 %). On 16 more plots the values of mean annual defoliation are in the class of moderate defoliation.

Based on values that have been shown, it was designed the Map of defoliation for the territory of Serbia. This map enables simpler review of spatial variation of defoliation values.



Picture 1. *Map of defoliation of forest tree species in the territory of Serbia*

4. CONCLUSION

Forest condition monitoring project (ICP Forests) operates as an international European project in which, on the grid of bio-indicator plots, annually has been monitored the condition of forests, the data on defoliation and discoloration have been recorded and other damages on trees have been registered.

In this paper have been analyzed the data on defoliation, as a part of the results of the monitoring of forest conditions on bio-indicator plots in 2013 on territory of the Republic of Serbia. During this year the assessment of crown condition has been performed on 121 bio-indicator plots. Field work on the data collection (observations and measurements) was carried out in the period June - September.

In deciduous species in 2013, hornbeam and beech in processes of defoliation showed to be more resistant species than oak. On bio-indicator plots in 2013 as most endangered species in broadleaves has been proved to be Sessile oak. Among conifers, fir and spruce have been shown to be more resistant species, while the Austrian pine trees are far the most endangered by these processes comparing to all species registered on the bio-indicator plots.

Calculating of mean values of defoliation for each plot allowed the

comparison of the values of defoliation and the degree of endangerment by defoliation of the individual plots.

Also, the determination of the mean values of defoliation for each sample plot enabled the designing of Map of defoliation. This map enabled simpler review of spatial variation of defoliation values.

On plots the assessment of defoliation has been performed regardless of the cause of loss of leaves, so the obtained results are not aimed at determining of cause-effect relationships, but only represent the condition of defoliation on bio-indicator plots in the studied period. The conducted researches are a baseline for monitoring changes in forest condition and connecting these results with other indicators of environmental conditions will provide more specific information and conclusions about dependence of vitality of the plants on environmental conditions.

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BIOLOGICAL RECLAMATION OF LANDSCAPE DEGRADED BY SURFACE MINE EXPLOITATION -CASE STUDY OF COAL SURFACE MINE "TAMNAVA – ZAPADNO POLJE"

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Abstract: *Degraded landscapes, ecosystems out of the natural balance and areas with impaired aesthetic value are just some of the issues man is facing nowadays. Failure to resolve those issues is both luxury and a major threat leading to the degradation of the entire environment. Biological reclamation, phytomediation and other technologies for the recovery of the environment based on the use of plants represent appropriate ways for easy remedy of the consequences caused by surface coal mining. This paper presents a proposed solution for reclamation of a part the disposal site of the open pit coal mine Tamnava – Western field. Biological reclamation ought to enable restoration of the landscape degraded by the surface lignite mining close to its original condition from the pre-mining period. The works undertaken under obligation to incorporate the reclaimed landscape into the structure of the surrounding area in all ecosystem aspects to the maximum extent possible should result in revitalization and reclamation of the degraded landscape in such a manner that, following the lignite exploitation period, it can be reused. Selecting the appropriate dendroflora species, method of setting up the protection zone and technological procedure for soft landscaping of plateaus and slopes will result in restoration and strengthening of natural components, creation of more favorable microclimatic conditions, protection of land from erosion, protection of the open pit surrounding area from air pollution, and creation of visual barriers and habitats for the return of the old and arrival of the new plant and animal species.*

Key words: surface coal mining, degraded landscape, biological reclamation, revitalization

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BIOLOŠKA REKULTIVACIJA PREDELA DEGRADIRANIH POVRŠINSKOM EKSPLOATACIJOM UGLJA NA PRIMERU POVRŠINSKOG KOPA „TAMNAVA – ZAPADNO POLJE“

Izvod: *Dregradirani predeli, ekosistemi van prirodne ravnoteže i prostori narušenih estetskih vrednosti su samo jedni od problema sa kojima se čovek danas sreće. Nerešavanje ovih problema predstavlja luksuz i veliku pretnju, koja svakako dovodi do degradacije celokupne životne sredine. Biološka rekultivacija, fitoremedijacija i druge tehnologije za oporavak životne sredine koje se baziraju na korišćenju biljaka, predstavljaju dobar put, kojim bi lako mogle da se saniraju posledice koje za sobom ostavlja površinska eksploatacija uglja. Ovaj rad prikazuje predlog rešanja za rekultivaciju dela odlagališta površinskog kopa „Tamnava – zapadno polje“. Biološkom rekultivacijom treba da se obezbedi privođenje prostora narušenog površinskom eksploatacijom uglja lignita na kopu „Tamnava – Zapadno polje“ do približno prvobitnog stanja pre rudarske aktivnosti. Radovi treba da omoguće revitalizaciju i rekultivaciju degradiranog prostora, tako da on po završetku eksploatacionog perioda može ponovo da se koristi, uz obavezu da rekultivisani prostor bude maksimalno ukomponovan u strukturu okolnog predela po svim delovima ekosistema. Izborom odgovarajućih vrsta dendroflore, metoda osnivanja zaštitnog pojasa i tehnološkog postupka za ozelenjavanje platoa i kosina omogućiće se obnavljanje i jačanje prirodnih elemenata, stvaranje pogodnijih mikroklimatskih uslova, zaštita zemljišta od erozije, zaštita okoline kopa od aerozagađenja, stvaranje vizualnih barijera, kao i staništa za povratak starih i dolazak novih biljnih i životinjskih vrsta.*

Ključne reči: površinska eksploatacija uglja, degradirani predeli, biološka rekultivacija, revitalizacija

1. INTRODUCTION

As a result of setup of open pit mines and surface mining, landscapes suffer substantial alteration, not only to their structure, but also to their purpose, flow of matter and energy, landscape outline, etc. Local population inevitably migrates to other locations, flora and fauna change, new infrastructure facilities are introduced into the landscape, huge quantities of matter and energy are extracted from the landscape, different pollutants are generated and the landscape gradually becomes imbalanced (Dražić *et al.*, 2010).

In addition to the environmental pollution, a particular issue is that of occupation and degradation of vast areas of land. Upon disposal, geological series are usually randomly distributed over the disposal site, which leads to the creation of areas with mixed overburden materials with different physical, mechanical and chemical properties (Dražić*,* 2002). Because of the manner in which overburden is removed and disposed of, series of soil with substantially reduced biological value commonly end up on the surface of the disposal site, whereas the humus layer is found at the bottom. In addition to reducing the quantity of nutrients, which would otherwise be available to the vegetation spontaneously inhabiting the site, such a manner of overburden disposal affects the bearing capacity and stability of the disposal site/landfill itself. Disposal of stripped overburden as a mixture of different layers onto the external disposal sites can easily destroy any form of vegetation in the surrounding area (Dražić *et al.*, 2012).

Today, an environmentally aware society defines clear requirements in order to prevent and remedy various forms of pollution originating from the industry and other sources of environment contamination. In this respect, techniques using plants in order to alleviate adverse effects of and prevent further soil, water and air pollution are becoming more and more significant. In addition to the protective function, plants can assist in full recovery of the degraded areas through the biological processes of phytoremediation.

It is this understanding of the significance of environmental protection and increasing focus on the reclamation of the degraded land at open pit mines of the Kolubara-Tamnava basin that has led to investing great efforts into restoring the land for agriculture and forestry, reducing the environmental pollution with harmful substances, preventing erosion of slopes and providing water supply near open pit mines. Moreover, the efforts have been made not to disrupt the relief by landscaping but to create opportunities for establishing recreational centers and leisure zones instead.

Previous experience in area reclamation and landscaping (Schlattzer, 1973; Knabe, 1973; Jonaš, 1973; Lindley and Mansfild, 1979; Hage *et al.*, 1996; Hildmann and Wonsche, 1996; Bismarck, 2000; Dražić *et al.*, 2002) suggested the possibilities for arranging lignite basin areas and provide multifunctional facilities with modifications imposed by the newly created environmental conditions, manner of deployment, equipment and other factors. There is no need to insist on the restoration to the authentic shapes, facilities and functions that existed prior to the commencement of the mining activities; instead, taking into account the altered ecological, social and other conditions other ambience values of these landscapes can be created (Čule *et al.*, 2012). Such areas, with their relief, vegetation, actually existing and potential water bodies and by appropriate planning of further reclamation and restoration works can provide all natural and other prerequisites for various activities (Dražić, 2002). The aforedescribed transformations ought to make the post-mining landscapes attractive, rich in offer of amenities and multi useful for the inhabitants of the surrounding settlements despite drastic alterations to the landscape and ecosystems (Dražić, 2006).

The area under the open pit mine "Tamnava – Western Field" is situated in the south of the Posavina-Tamnava Lowland within the territory of the Municipality of Lazarevac. It constitutes a part of the disrupted and almost completely destroyed autochthonous anthropogenic spatial units and their original contents, both living and non-living. This open pit mine, as other surface mines, represents an area with more or less sterile substrate. Unless reclamation is performed, such areas are subject to intense eolian erosion, which causes air pollution jeopardizing the environment of a larger area.

At such man-made biologically empty and degraded areas, self-renewal – spontaneous revitalization – is ether impossible or inadmissibly slow. In order to enable formation of initial vegetation as soon as possible, which will in the long run lead to the final stages of formation of biocenoses and ecosystems, technical and technological process of reclamation is to be applied.

The area selected for reclamation is a part of the inner disposal site. The disposal site consists of a cassette for gypsum, cassette for ash, two plateaus and two slopes. The slopes and plateaus are intended for reclamation.

2. LANDSCAPE ANALYSIS

The open pit mine "Tamnava – Western Field" is located about 50 kilometers to the south-west of Belgrade and covers an area of 1,569 hectares within the region of Šumadija, with topography typical for valleys and mildly rolling terrain at the altitude between 100 and 160 meters. It is situated along the lower course of the Kladnica River, i.e. in the floodable area between this river and the Kolubara River. This is why in pre-mining period there were forests of *Querceto Fraxinetum Serbicum* in higher and poplar and willow forest communities in lower wastelands (Vučković, 1986.).

The area (a part of the inner disposal site) intended for reclamation is located at the north-east section of the Western Field. Plateau A is located at level 109, and Plateau B at level 94. Between the two plateaus there is Slope a and at the foot of Plateau B there is Slope b. The total area of land intended for reclamation covers 86.9 hectares.

Figure 1. *Position of Plateaus A and B (left) and Slopes a and b (right) within the disposal site*

Based on the analysis of climatic parameters for development of flora (temperature, precipitation and winds), it may be concluded that the climate of the Kolubara basin is rather dry, with continental and steppe climate properties (Dražić *et al.*, 2012). In winter months there is little precipitation and the soil does not provide sufficient moisture in the initial vegetation phase. In late spring precipitation is plentiful but not sufficient to prevent injury form summer heat. Moreover, even if larger quantities of rainfall occur in June, July and August, those are still insufficient due to the high air temperatures. In fall there is substantial precipitation, yet rains are untimely as they occur toward the end of the vegetation period. The analysis of the climate elements confirms that the climate of this area is under strong steppe climate influence from the Pannonia Plane.

The analysis of the soil leads to the conclusion that substrates (deposols) formed from the tailings on the surfaces intended for biological reclamation exhibit poor physical properties, which, in addition to the low contents of humus and lack of easily available nutrients, causes low effective and potential fertility of those surfaces. Therefore it is necessary to perform melioration which will lead to formation of structure aggregates, which will, in turn, improve the physical

properties of the substrates and trigger pedological processes. It is vital that the substrates be enhanced with organic matter, which will improve the structure of the substrates and give rise to the biological processes within soil as energy materials for the work of a large number of heterotrophic microorganisms in the soil. This will further induce the processes of organic matter degradation and humus synthesis, and further humification processes will lead to the inflow of plant assimilants. Pedological processes will commence and gradually, over time, convert the tailings into fertile soil.

Natural vegetation of this region comprised forests of white willow (as. *Salicetum albe* Issl., 1926), forests of English oak with broom (as. *Genisto elatea-Quercetum roboris* Horv., 1938), forests of English oak and hornbeam (as. *Carpino betuli-Quercetum roboris* Rauš., 1969), forests of English oak with and hornbeam with silver linden (as. *Carpino-quercetum roboris* subas. *Tilietosum tomentosae* Rauš., 1969), forests of sessile oak and hornbeam with butcher's broom (as. *Querco-Carpinetum* subas. *aculeatetosum* Jov., 1951), forests of sessile oak and hornbeam with Hungarian oak (as. *Querco-Carpinetum quercetosum farnetto* Gaj.), forests of Hungarian oak and Turkey oak (as. *Quercetum farnetto-cerris* Rud., 1949), stands of silver linden (*Tilia tomentosa*) and Turkey oak (*Quercus cerris*), etc. (Vučković, 1986.). Setup of surface mines and surface mining have degraded the natural vegetation to a great extent.

In previous works on land reclamation in the Kolubara-Tamnava lignite basin, a number of forest plantations of deciduous and conifer species have been grown. Depending on the micro-environmental conditions and the types of deposol, a large number of deciduous and conifer species were used for forestation (Dražić *et al.*, 2011). In numerous reclamation projects, the selected species used were the following: *Pseudotsuga menziesii* Mirbel. Franco, *Picea pungens* Engelm., *Picea abies* L. Karst., *Larix europaea* Lam. et DC, *Pinus wallichiana* A. B. Jacks., *Pinus strobus* L., *Pinus ponderosa* Dougl. et Laws., *Pinus nigra* Arn., *Pinus silvestris* L., *Chamaecyparis lawsoniana* Murr. Parl., *Liriodendron tulipifera* L., *Ulmus pumila* L., *Quercus borealis* Michx., *Quercus robur* L., *Betula pendula* Roth., *Alnus glutinosa* L. Gaertn., *Populus x euramericana* Dode. Guinier., *Tilia* sp., *Robinia pseudoacacia* L., *Acer negundo* L., *Acer platanoides* L., *Acer saccharinum* L., *Acer pseudoplatanus* L., *Fraxinus excelsior* L., *Fraxinus americana* L., etc. (Dražić., 2006). Using the above listed species, stable forest ecosystems were formed, with allochtone and autochtone species and rich in flora diversity.

3. BIOLOGICAL RECLAMATION OF THE PLATEAUS AND SLOPES OF THE DISPOSAL SITE

Biological reclamation of the open pit mine Tamnava – Western Field is to enable restoration of the area disrupted by the surface lignite mining in the open pit mine Tamnava – Western Field close to its original condition from pre-mining period. The works undertaken under obligation to incorporate the reclaimed landscape into the structure of the surrounding area in all ecosystem parts to the maximum extent possible should result in revitalization and reclamation of the

degraded landscape in such a manner that, following the lignite exploitation period, it can be reused.

Taking into account the environmental conditions (climate, substrate, types of habitats), condition of the vegetation in the industry plant impact zone and objectives set at provision of multiple positive functions by taking biological measures, dendroflora species were selected.

Woody species are used for forestation of plateaus A and B. One conifer and four deciduous tree species were proposed for reclamation: *Pinus nigra* Arnold – Austrian pine, *Tilia parvifolia* Ehrh. – small-leaved linden, *Tilia argentea* Desf. ex DC. – silver linden, *Ulmus pumila* L. – Siberian elm and *Betula verrucosa Ehrh.* – silver birch.

Herbaceous species are used for landscaping Slopes a and b. The following species: *Spiraea x vanhouttei* (Briot.) Zbl. and *Pyracantha coccinea* M. Roem. were selected as the most suitable.

The proposed woody and herbaceous species fully meet the requirements necessary for the plants in such an area. In addition, the combination of these species will achieve an even better effectiveness of the zone given the fact that weaknesses of one species are compensated by the advantages of another one. For example, the zone features a combination of trees and shrubs minimizing the boundary layer conductance. Beside the protective function, i.e. prevention of particle dissemination from the disposal site, upon selection of vegetation, other functions mandatory for such a category of green area were taken into account. The selected species are therefore very decorative, the compact form of greenery will result in the reduction of noise level in the vicinity of the disposal site and, in time, a green area will be formed which will completely blend into the surroundings.

Seedlings to be used for reclamation of the plateaus and slopes must originate from the registered nurseries, must be of even quality, with well-developed root systems and stems, without mechanical damage or injury caused by insects and diseases (Veselinović *et al.*, 2010). Only well nurtured transplanted seedlings (trees of 3+0 and shrubs of 0.3 to 0.5 m in height), balled and burlapped are planted. In this manner, unhindered starting growth will be enabled within the first year following plantation and solid growth and yield and functional development in the near term. This is particularly significant given the green area category being established at the disposal site.

3.1. Method of Protection Zone Establishment

Given the aforesaid task, formation of two large masses of trees on Plateaus A and B was proposed. For the slope separating the two plateaus (Slope a) as well as for Slope b, herbaceous species were planned as the slopes are rather steep. The entire area intended for reclamation will also be grassed.

3.1.1. Reclamation through forestation on Plateaus A and B

The total area of Plateaus A and B covers 76.8 hectares. Here triangular plantation of trees is carried out at distances of 6 x 6 m. The ratio of conifer to deciduous seedlings equals 40:60.

Plateau A is divided into two parts given the varying width of the stretch to be forested.

The first part is 180 meters long and 1,167 meters wide. Woody species will be planted there in 34 rows. Looking from the western side of Plateau A toward Plateau B, the green belt of trees will appear as follows: the Siberian elm will be planted in 8 rows in full length; small-leaved linden will be then planted in 8 rows in full length; in the next 7 rows at each 50 meters the Austrian pine seedlings will be followed by silver linden; there will be 3 rows of the Austrian pine seedlings in full length; eventually, there will be 8 rows with intermittent silver birch and Austrian pine seedlings at each 50 meters.

The second part of this Plateau is 935 meters long and 101 meters wide. The green stretch will comprise the total of 19 rows of trees. Looking onto the stretch from the same point as in the case above, the plantation scheme will be as follows: 2 rows of the Siberian elm in full length; 1 row of small-leaved linden in full length; 6 rows with intermittent Austrian pine and silver linden at each 50 meters; 3 rows with Austrian pine seedlings in full length; and finally, 7 rows with intermittent silver birch and Austrian pine seedlings at each 50 meters.

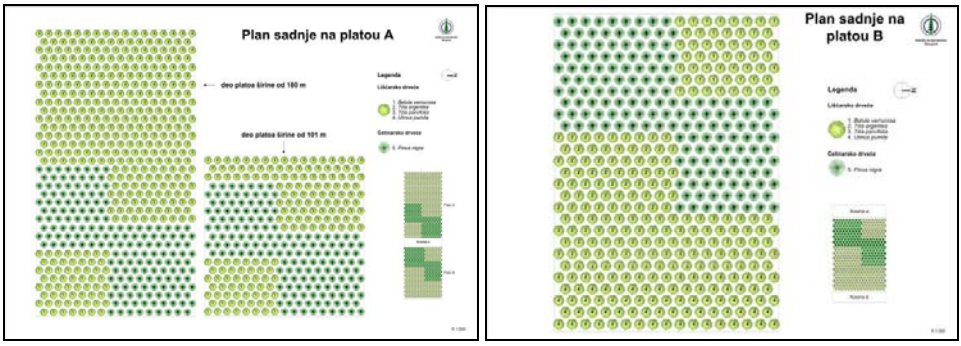

Figure2. *Plantation plan for Plateau A (left) and Plateau B (right) in a 100-meter length*

Plateau B is 3,291 meters long and 141 meters wide, allowing for the plantation in the total of 26 rows. Looking from Plateau A toward Plateau B, the rows follow each other as follows: 7 rows with intermittent silver birch and Austrian pine seedlings at each 50 meters; 3 rows of the Austrian pine in full length; 7 rows with intermittent silver linden and Austrian pine seedlings at each 50 meters; 4 rows of small-leaved linden in full length; and finally, 5 rows of elms in full length.

3.1.2. Reclamation through forestation on Slopes a and b

The total area intended for reclamation in Slopes a and b covers 10.1 hectares. The plantation on Slope a will be identical to that on Slope b. Triangular plantation of shrubs at distances of 2 x 2 m will be carried out.

Slope a is 3,284 meters long and 22 meters wide. Slope b is 3,366 m long and varying in width from 6 to 41 meters.

Plantation of shrubs in the first row of each slope will commence at 9/5 meters from the slope peak. At each 50 meters there will be intermittent seedlings of *Spiraea x vanhouttei* (Briot.) Zbl. and *Pyracantha coccinea* M. Roem. The following 3 rows will be identical. The final fourth row ends at 8.5 meters from the slope foot. In this manner, shrub grouping is positioned in the midst of both slopes so that the growth will not be affected even when the trees on the plateaus reach larger sizes.

3.1.3. Reclamation through grassing plateaus and slopes

Setup of a lawn on the entire area intended for reclamation (86.9 hectares) represents an efficient way of protection from eolian erosion. The problem that is to be resolved upon lawn setup on this substrate is bonding and stabilizing the substrate itself in order to prevent eolian erosion until the grassy cover is formed, as well as introduction of substantial quantities of organic and mineral fertilizers.

As the most suitable mix of species the following combination was selected: red clover - 20 kg per hectare, Italian ryegrass - 12 kg per hectare and orchard grass - 12 kg per hectare. The share of red clover is significant as red clover is a species best suited for the reparation of land in the short term.

3.2. Technological Procedure of the Green Zone Formation

The plan is to commence the procedure of biological reclamation with planting woody and herbaceous plants and grass the area thereafter. If the procedure were reversed, it would be possible to damage the newly-sawn lawn. However, if the investor is not in possession of sufficient funds to have these operations performed in succession, it is possible to have the grasses sawn first and, after the lawn has formed, to commence deciduous and conifer tree species. It is recommended that the works be initiated in spring, before vegetation starts.

Prior to plantation, agro-technical preparation of the terrain was completed and locations of planting holes were marked.

Plantation of trees and shrubs was performed using the standard technological procedure, with machinery digging circular planting holes (60 x 60 cm) for the trees, whereas the holes for planting shrubs were dug manually.

Given the fact that the soil is poor in respect of the available nutrients and inability to provide the seedlings with sufficient quantities of water in the initial nurturing period, upon plantation, a mix of hydro absorbing substances and nutrients, root growth activating and supporting substances will be added to the soil (*TerraCottem Univerzal* preparation), which would absorb water and gradually

release it together with the nutrients over the period most significant for the development of plants. The application of this treatment allows for reducing the need of irrigation by as much as 50%, given the extremely high water retention efficiency. All the seedlings will be abundantly watered upon completion of the plantation.

Following the agro technical preparation of the terrain for lawn formation, the preparation *TerraCottem Turf* will be introduced into the soil in order to provide the future lawn with sufficient quantities of nutrients and water. Sowing will be conducted manually in two cross-directions. The sawn area will then be rolled over using the spiked and smooth grass rollers and abundantly watered thereafter using sprinklers.

Implementation of nurturing and protective measures is uniform for both trees and shrubs. The period of initial nurturing covers the first two years upon plantation. Operations performed during the period include: watering, fertilizing, pollination, weed removal, mulching and pruning. If necessary, harmful insects and diseases are fought as well.

The period of initial lawn nurturing covers the first year upon sawing the lawn. The primary nurturing of the newly formed lawn includes watering, fertilizing, first mowing and weed removal.

Upon the expiry of the initial nurturing period of the newly planted trees and shrubs and newly sawn lawn, implementation of the aforesaid measures ought to continue. The intensity of the measures may be reduced, yet they certainly need to continue to achieve the desired objective – that the green area fulfills its functions.

4. CONCLUSION

Degraded landscapes, ecosystems out of the natural balance and areas with impaired aesthetic value are just some of the issues man is facing nowadays. Failure to resolve those issues is both luxury and a major threat leading to the degradation of the entire environment. Biological reclamation, phytomediation and other technologies for the recovery of the environment based on the use of plants represent appropriate ways for easy remedy of the consequences caused by surface coal mining.

Formation of green zones on the degraded surface, which at some point will grow into stable forest ecosystems, can certainly lead to the revitalization of the surface mine areas. The newly formed protection zones will result in restoration and strengthening of natural components, creation of more favorable microclimatic conditions, protection of land from erosion, protection of the open pit surrounding area from air pollution, and creation of visual barriers and habitats for the return of the old and arrival of the new plant and animal species. In this manner, the biological value of the newly formed landscape will increase. By applying the selected methods and technologies for the setup of protection zone, the landscape degraded by the lignite surface mining in the open pit mine Tamnava – Western Field will in time be restored close to the original pre-mining condition and blended into the structure of the surrounding landscapes in all ecosystem aspects.

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BIOLOGICAL RECLAMATION OF LANDSCAPE DEGRADED BY THE OPEN PIT COAL MINING – EXAMPLE OF THE OPEN PIT COAL MINE "TAMNAVA – ZAPADNO POLJE"

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Summary

At locations where open pit mines are set up, the structure and purpose of landscapes suffer substantial alteration, as do the flow of matter and energy and landscape outline. In addition, local population inevitably migrates to other locations, new infrastructure facilities are introduced into the landscape, plant and animal communities change, flow of matter an energy within the landscape change and the environment becomes polluted. As a result, the landscape's natural balance gradually becomes impaired.

Owing to the development of environmental awareness in modern societies, the techniques using plants to alleviate adverse effects and prevent further soil, water and air pollution are becoming increasingly significant. In addition to the protective function, plants stimulate the recovery of the degraded areas through the biological processes of phytoremediation.

The area under the open pit mine "Tamnava – Western Field" is situated in the south of the Posavina-Tamnava Lowland within the territory of the Municipality of Lazarevac. This open pit mine, as other surface mines, represents an area with more or less sterile substrate. Such areas are subject to intense eolian erosion, which causes air pollution jeopardizing the environment of a larger area. This is why it is important to perform reclamation of this area. The area intended for reclamation is located at the north-east section of the Western Field and consists of two plateaus (Plateau A and Plateau B) and two slopes (Slopes a and b).

Following the landscape analysis, this paper presents the proposed solution for the biological reclamation of the two plateaus and lopes of the disposal site. Taking into account the environmental conditions, condition of the vegetation in the industry plant impact zone and objectives set at provision of multiple positive functions by taking

biological measures, dendroflora species were selected. For the forestation of Plateaus A and B woody species were proposed, i.e. one conifer and 4 deciduous tree species, while for the slope landscaping of the slopes two herbaceous species were proposed. The proposed woody and herbaceous species fully meet the requirements necessary for the plants in such an area. Moreover, the selected species are very decorative; the compact form of greenery will result in the reduction of noise level in the vicinity of the disposal site and, in time, a green area will be formed which will completely blend into the surroundings.

This paper presents a detailed description of the method of the setup of the green zone, i.e. the procedure to be performed upon reclamation through forestation of the plateaus and slopes, as well as upon reclamation through grassing of the plateaus and slopes. There is a description of the technological procedure for the setup of protection zone, whereby it is planned for the biological reclamation to commence with agro technical preparation of the terrain and designation of the planting hole positions, whereafter plantation of the woody and herbaceous species will be carried out, followed by grassing. In addition, implementation of the measures for nurturing and protection of the newly formed green areas is proposed.

Biological reclamation of the degraded area will in time result in the formation of the stable forest ecosystems, which will fully revitalize the open pit mine area. By applying the selected methods and technologies for the setup of protection zone, the landscape degraded by the lignite surface mining in the open pit mine Tamnava – Western Field will be restored close to the original pre-mining condition and blended into the structure of the surrounding landscape.

BIOLOŠKA REKULTIVACIJA PREDELA DEGRADIRANIH POVRŠINSKOM EKSPLOATACIJOM UGLJA NA PRIMERU POVRŠINSKOG KOPA „TAMNAVA – ZAPADNO POLJE“

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Rezime

Na mestima gde se otvaraju površinski kopovi, menja se struktura i namena predela, protok materije i energije, kao i slika predela. Pored toga, stvaranje površinskih kopova dovodi do raseljavanja stanovništva na druge lokacija, unošenja novih infrastrukturnih objekata u predeo, menjanja sastava biljnih i životinjskih zajednica, zagađenja životne sredine, kao i do promene toka energije u predelu. Kao posledica ovih promena, prirodna ravnoteža predela se narušava.

Razvojem ekološke sveti u modernom društvu, tehnike koje koriste biljke kako bi ublažile negativan uticaj i sprečile dalje zagađenje zemljišta, vode i vazduha imaju sve veći značaj. Pored funkcije zaštite, biljke pospešuju oporavak degradirane sredine kroz biološke procese fitoremedijacije.

Područje zahvaćeno površinskim kopom „Tamnava – Zapadno polje“ se nalazi u južnom delu posavsko – tamnavske nizije i teritorijalno pripada opštini Lazarevac. Ovaj kop, kako i ostali površinski kopovi, predstavlja površinu sa sterilnim supstratom u manjoj ili većoj meri. Na ovakvim površinama izražena je eolska erozija, koja dovodi do aerozagađenja i ugrožavanja životne sredine šireg područja. Zbog toga je važno izvršiti rekultivaciju ovog prostora. Površina koja je predviđena za rekultivaciju nalazi se na severoistočnom delu zapadnog polja i sastoji se od dva platoa („A“ i „B“) i dve kosine („a“ i „b“).

U radu je nakon analize predela dat predlog rešenja za sprovođenje biološke rekultivacije platoa i kosina odlagališta. Polazeći od ekoloških uslova sredine, stanja vegetacije u zoni uticaja industrijskih postrojenja i postavljenih ciljeva da se biološkim merama obezbede višestruke pozitivne funkcije, izvršen je izbor vrsta dendroflore. Predloženo je korišćenje drvenastih vrsta za pošumljavanje platoa „A“ i „B“. Za rekultivaciju je predložena jedna četinarska i 4 lišćarske vrste drveća, dok su za ozelenjavanje kosina predložene dve žbunaste vrste. Izabrane vrste drveća i žbunja u potpunosti ispunjavaju sve uslove koje biljke na jednom ovakvom prostoru moraju da imaju. Pored toga, odabrane vrste su vrlo dekorativne, a sama kompaktna forma zelenila će uticati i na smanjenje buke u okolini odlagališta. Nakon određenog vremena, projektovana zelena površina će se u potpunosti uklopiti u okolni predeo. U radu je detaljno opisan metod osnivanja zaštitnog pojasa, odnosno postupak koji treba sprovesti pri rekultivaciji pošumljavanjem na platoima, rekultivaciji pošumljavanjem na kosinama „a“ i „b“, kao i pri rekultivaciji zatravljivanjem platoa i kosina. Opisan je i tehnološki postupak osnivanja zaštitnog pojasa, kojim je predviđeno da biološka rekultivacija započne agrotehničkom pripremom terena i obeležavanjem položaja sadnih jama, nakon čega će se vršiti sadnja drvenastih i žbunastih vrsta, a potom zatravljivanje. Pored toga, predloženo je i sprovođenja mera nege i zaštite novih zelenih površina.

Biološka rekultivacija degradiranih površina vremenom će dovesti do formiranja stabilnih šumskih ekosistema, što će u potpunosti revitalizovati prostor površinskih kopova. Korišćenje odabranih metoda i tehnologija za podizanje zaštitnog pojasa, predeo narušen površinskom eksploatacijom uglja lignita na kopu „Tamnava – Zapadno polje“ će dovesti do približno prvobitnog stanja predela i njegovog uklapanja u strukturu okolnog predela.

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CHANGES OF FOREST HABITATS DESTROYED BY FIRE AND THE RATE OF NATURAL REVITALISATION OF DAMAGED ECOSYSTEMS

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Abstract: *The paper examines the possibilities of natural regeneration of forest ecosystems destroyed by fire. The development of monitoring is presented in particular for black pine and beech forest sites, in which successive vegetation changes were analysed. The vegetation dynamics in presented localities was monitored immediately after the fire, a year, two years, three years, four years, five years and ten years after the fire. It has been established that the vegetation in a submontane beech forest site belongs to the Atropetum belladonnae association (Br.Bl.1930) - Tx.1931, Em, 1950. Four facies have been identified in the association. The post-fire natural regeneration of black pine depends on intensity of fire and the possibility for insemination of the area after the fire. The vegetation of fire sites on black pine forests' serpentine soil belongs to the Euphorbieto (cyparissias)-Brachypodietum pinnati association, and within it, four facies have been identified.*

Key words: fire, ecosystem, revitalisation, monitoring

ПРОМЕНЕ СТАНИШТА УНИШТЕНИХ ПОЖАРИМА И БРЗИНА ПРИРОДНЕ РЕВИТАЛИЗАЦИЈЕ ОШТЕЋЕНИХ ЕКОСИСТЕМА

Извод: *У раду су анализиране могућности природне ревитализације шумских екосистема уништених пожарима. Развој мониторинга посебно је приказан за станишта црног бора и букве, где су анализиране сукцесивне промене вегетације. Динамика вегетације на приказаним локалитетима је праћена непосредно после пожара, годину, две, три, четири, пет и десет година после пожара. Констатовано је да вегетација пожаришта на станишту брдске букове шуме припада асоцијацији Atropetum belladonnae (Br.Bl.1930)-Tx.1931, Em, 1950. У асоцијацији је издвојено*

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четири фацијеса. Природно обнављање црнога бора после пожара зависи од јачине пожара и могућности осемењавања површине после пожара. Вегетација пожаришта на серпентинској подлози шума црнога бора припада асоцијацији Euphorbieto (cyparissias)-Brachypodietum pinnati, и у оквиру ње издвојена су два фацијеса.

Кључне речи: *пожар, екосистем, ревитализација, тониторинг.*

INTRODUCTION

Global warming is followed by increasingly intensified and prolonged forest fires in the northern parts of the planet, resulting in additional emission of carbon dioxide (CO_2) and acceleration of climatic changes. Ten years of monitoring led to the conclusion that during forest fires far more carbon dioxide gets emitted into the atmosphere than the forests have absorbed in the process of photosynthesis, which is a tendency that may only get worse in the future.

Even though most people see forest fires as burning trees, these fires are in fact fuelled mainly by dry grassy plants, shrubs, moss and organic materials in the soil.

One-half of the world's carbon reserves stays in the soil. This carbon, deposited over thousands of years, now gets into the air in the form of CO_2. The intensity and duration of fires in the northern regions are also impacted by ever-shorter snowy period of the year, altered plant composition, diminishing glaciers and the zone of eternally frozen land.

Over the last decade the area of fires has increased up to ten times, which is highly significant not only for climatic changes but also for the human health, as even the smallest particles of smoke may cause respiratory diseases. Moreover, the fires lead to release of harmful matters, including mercury, into the atmosphere.

Picture 1. *Usce - natural stand of black pine on serpentinite (area engulfed by high-intensity fire)*

The problem of global warming is one of the key ecological problems of the Earth. The scientists have linked global warming to numerous changes in the animal behavior and way of life, as well as in the development of plants (*Natura Geoscience*).

Fires cause major damage to the forests of Serbia every year. The occurrence, spread and duration of fires are influenced by numerous conditions, among which the most important are the presence of dry vegetative cover, its flammability and type of growth overlay. Organization of preventative measures though swift notification and extinction are crucial for reducing the occurrence and scope of forest fires, but once a fire breaks out, the size of direct damage and possible consequences depend on the speed of reaction and recovery of the forest site. Successful afforestation of burnt areas is particularly significant. Trees in areas affected by fire burn very quickly, resulting in disappearance of the original stands. Following the cleanup and recovery, it is necessary to carry out afforestation so as to create conditions for restoration of the natural balance into the original state. The presence of symbiotic fungi on the root of the replanted seedlings helps overcome the problems of afforestation, manifested through the inability of these plants to use micro and macro elements from the soil. The health condition of seedlings and cultures on burnt areas largely depends on the presence of biotic harmful factors, primarily phytophagous organisms. Following the completion of recovery and afforestation, young plants in newly erected cultures are higly vulnerable and their vitality is jeopardized given that the conditions of the environment, the soil in particular, substantially differ from those in the facilities for production of seedling materials. These facilities provided the plants with all conditions for normal and unobstructed development. With their vitality weakened, they now become susceptible to impact of multiple harmful factors existing in and around the forest-affected area. In order to avoid or reduce to a minimum the impact of the numerous harmful factors, it is essential to apply new and standard methods of substrate preparation based on the results of the analysis of all the required indicators.

With properly selected planting types and methods, protective measures and placement of fire protection strips, the positive effects of recovery become much more strongly assured. The application of biological methods through planting of mycorrhizal seedlings reduces the application of chemical agents for recovery of burnt areas and thus contributes to protection of soils and waters, i.e. to the protection of the environment.

Changes made to the forest ecosystem degraded by a forest fire may be properly assessed and investigated on the basis of measurable indicators. The standard assessment of damages presented through a market value of the burned trees does not comprise changes that may not be adequately expressed monetarily, but the consequences and duration of the period it takes the ecosystem to return to the original state reflect the enormity of the damage inflicted by the fire to the forest system. Indicators demonstrating the effects of fire on a forest ecosystem at the same time point to the direction of recovery of forest-affected areas. Indicators to be followed on the level of consequences of a fire may be classified into those related to the flora and fauna in the part above the ground, primarily linked to the health condition of the vegetation.

According to the reference sources, the effect of a fire on active and substitutional acidity of the soil is reflected in increased alkalinity. Ashes produced by burning of the organic matter of forest trees and shrubs, as well as herbaceous plants, contain high quantities of both alkaline and earth-alkaline elements.

The effect of a fire on earth organic matter may greatly vary depending on the type and intensity of a fire (high, low, etc.), the nature of burnt materials (wood, organic layover, dry grass), and type and humidity of the soil at the moment of fire. The effects of a fire on processes in the soil and their intensity may therefore be quite variable and cannot be generalized (Jose´ A. et al., 2004). No conclusions on generialized tendencies can be made for the majority of changes in the composition of humus caused by a fire. Strong fires (Almendros et al.,1990) cause formation of pyromorphic forms of humus, showing increased stability to chemical and biological degradation.

Burning of the organic matter leads to oxidation of organic carbon and its release into the atmosphere. This is turn destroys the organic cover. A part of the carbon from the organic cover is released into the atmosphere, while the remainder stays on the surface of the soil in the form of charred remnants. Carbon dust coming off the charred remnants of trees is also piled onto the ground surface. During a fire, the humus matter existing in the organo-mineral part of the soil are lost only in part, while the remaining (bigger) part is transformed into fractions that are more difficult to dissolve and break up. That means that in the group fraction composition of the humus, the ratio of brown humic acids drops whereas the ratio of humin is drastically increased.

Depending on the type of fire, type of soil and its properties (porosity, aeration and moisture at the moment of fire), as well as the quantity of charred organic remnants, the quantity of carbon in the soil surface layer may either increase or drop. Charred organic remnants of the organic cover and the living part of a forest ecosystem also form matter that is difficult to dissolve and resistant to bio-chemical degradation.

The ratio of organic carbon and nitrogen in the soil is an important indicator of the character of earth organic matter, the conditions for the acitivity of saprophytic microorganisms and release of nutrients from the humus. In the majority of cases the impact of fire reflects on the decrease in content of organic carbon in the soil. In certain cases, percentage of carbon content in the surface layer may increase due to accumulation of particles of charred parts of the burnt matter. The content of total nitrogen in the soil always drops after a fire (Neff et al. 2005). The decrease of total nitrogen is always greater than the decrease of carbon, which in all cases leads to extension of the ratio of carbon and nitrogen in the soil compared to the state prior to the fire.

As opposed to the organic forms of nitrogen, immediately after the fire the content of mineral nitrogen forms increases. At the same time, the content of both ammonia and nitrate nitrogen also goes up. Both of these nitrogen forms easily disappear from the soil. The ammonia form is susceptible to evaporation, particularly from neutral and alkaline pedo-chemical environments, while the nitrate is susceptible to rinsing by descendant flows outside of the physiologically active part of the solum.

Picture 2. *Svojbor (Novi Pazar) - area inflicted by strong fire*

After a fire, the change of content of easily accessible forms of phosphorus and potassium in the soil is more than other properties impacted by the character of burnt matter. Phosphorus and potassium represent macroelements of nutrition, existing in the organic form both in the living part of the ecosystem and in the organic cover. Unlike nitrogen, both these elements remain in the ashes, hence after a fire their content in the soil increases.

The concentration of phosphorus and potassium in the ashes produced as a consequence of a fire depends primarily on the type of burned matter, i.e. the species of trees or grass. Different types of plants have different needs for assimilating the phosphorus and potassium from the soil, which means that concentrations of these elements vary in different plants. Oligotrophic tree species, such as black pine or spruce, assimilate small quantities of these elements from the soil for their nutritional needs. The quantities of phosphorus and potassium in the soil are thus not large. Assimilation organs and meristematic tissues in all tree species have a significantly higher content of all plant assimilators compared to the bark and the trunk. Basophilic and neutrophilic herbaceous species may be especially rich in phosphorous and potassium content.

Improved methods of recovery and protection, as well as as advanced technological practices of field preparation and seeding, will enable better reception of seedlings, their survival and resistance to pathogens. The speed of natural revitalization of burnt areas may substantially decrease the costs of erecting new forests and restoring damaged econsystems.

Indicators related to the processes in the part of the ecosystem above the ground will be determined and used to records destruction and disappearance of certain species, succession of species and health condition of the surviving vegetation.

BIOLOGICAL MONITORING AS A PART OF THE MONITORING OF THE ENVIRONMENT

Biological monitoring is defined as a system of collecting, assessing and forecasting the changes in the environment caused by anthropogenic factors. The lead role in the system of biological monitoring belongs to ecosystem monitoring.

PRINCIPLES OF ECOSYSTEM MONITORING

Principles of monitoring the changes on sites destroyed in fires and speed of the natural revitalization of damaged ecosystems represent the commitment in the national environment protection policy and especially dynamics of strengthening the development of institutions specialized in monitoring of changes, securing their financial and human resources.

In general, these include the following:

- Rationalizing the system of monitoring the experimental areas, optimizing the ecosystems destroyed or damaged in fires, frequency of testing, automation of testing, selection of indicators and testing sites.
- Developing the monitoring with similar systems in the neighboring countries, harmonized with the EU countires, formulated and implemented in a joint testing program.
- Consistent monitoring of quantitative and qualitative site properties defined through quality control of the applied practices and standards measurements and observations.
- Reducing the list of indicators and frequency of their testing.
- Establishing and supporting the regional organizations for follow-up of ecosystem monitoring. The basic unit and organizational model is a territorial unit defined through climatic zones of vegetation in Serbia.
- Implementing the program tasks of the monitoring. Once all the set conditions have been met, it is delegated on equal terms to scientific institutions and NGOs that have adequate human resources for monitoring the required indicators.
- The strategic goal is that monitoring, in addition to fundamentals for protecting the needs of inhabitants, protection and control of water sources, gets the function of permanent surveillance over ecological changes in terms of protection of the ecological status and natural wealth.
- Active public participation in the information process and consolidation of the condition, causes and assessments of ecosystem revitalization.

Monitoring the ecosystems destroyed in fires and speed of natural revitalization

The plan and functioning of a monitoring program comprises numerous aspects, such as field measurements, sampling (collecting samples, preparation, storing methods and transport of samples), chemical analyses and data collection. All of these elements merit equal attention in the monitoring process. Planning of the monitoring program, selection of indicators of the degree of ecosystem damage, sites, testing frequency, field determination and measurement and laboratory analyses.

The basic rules for a successful monitoring program and ecosystem analysis are as follows:

1. Defined required information and monitoring program adjusted to the needs, rather than the other way round. It is assumed that the necessary financial resources and equipment have been secured.
2. Types and properties of the ecosystem must be considered in a comprehensive manner (through preliminary research, spatial and time changes separately).
3. Components for testing the condition of the ecosystem (biological indicators) must be defined.
4. Indicators, types of samples, testing frequency and sites must be carefully selected in compliance with the required information, instead of vice versa.
5. Mobile field equipment and lab devices should be selected in accordance with the specific nature of the required data, accuracy and sensitivity of selection, not the other way round.
6. Complete and operative review of data processing should be established.
7. Monitoring the ecosystem changes should be followed up through the relevant microclimatic measurements and analyses.
8. Quality of data should undergo regular internal and external control.
9. Data and findings should be provided to the decision-makers not only as tables with reviews of measured proportions but also as analyses, assessments and expert findings with relevant recommendations, solutions and measures of management.
10. The monitoring program should be periodically assessed from the standpoint of needs and experience, especially if carried out in areas with drastically changed site conditions compared to the natural state.

Monitoring program

The current monitoring in Serbia is not unified and is carried out on outdated equipment by insufficiently qualified personnel. Measurement programs are not fully compliant with the international standards. It is therefore necessary to

integrate the monitoring system, staff training and relevant programs with the methods and standards of the European Union and normative acts of the expert groups within the ICPDR.

Monitoring should rely on systemic collection and assessment of data to explain what happens in ecosystems destroyed by fires and what is the speed of their natural revitalization. These indicators, as a whole, should be compared to the condition on the same undamaged ecosystems to show how quickly an ecosystem is revitalized and the direction taken during the recovery (which, given the climatic changes, need not gravitate toward the natural (currently existing) ecosystem).

One-sided approach to defining the biological responses, when analyzing distribution of organisms in view of a single factor (e.g. organic or inorganic matter, acidification, toxicants) is replaced by multivariant practices that analyse the dynamics of biocoenosis in view of several variables simultaneously.

The tendency to define a universal method of biomonitoring for large territories has been sidelined by the view that it is necessary to develop separate procedures for each area representing a natural biogeographic whole (eco-region) that will respect the individual features of each region. All procedures of biological monitoring should be based on the same principles, while the results must be comparable.

Unlike the methods that use physical or chemical parameters and mark the current conditions, biological methods of assessing the state of an ecosystem register long-term consequences. In addition to establishing the degree of damage to (destruction) of an ecosystem, the results of bio-monitoring enable determination of the capacity for natural revitalization.

Biomonitoring presented in this paper has rarely been used world-wide. It has mostly been criticized due to the length and cost of the process, lack of standardization of the techniques, complexity of data interpretation and variations in responses of organisms to the degrees of damage. Many of these criticisms have been overcome by placement of permanent sites in ecosystems that have been affected by fires of various intensities over different time periods.

Methods used in the biomonitoring are based on two fundamental principles:

- systems based on indicator organisms;
- structural and analytic principle (biological indexes and ecological methods) (Washington, H.G., 1984).

Each of these methods has its advantages and disadvantages, and therefore in different countries various approaches are used in research and practical work, depending on which method may be traditionally used or deemed the most suitable for the given environment. In the development of monitoring **"Changes of sites destroyed by fire and the rate of natural revitalization of damaged ecosystems",** given the long-term monitoring, elements of both principles were applied as this was seen as the only way to achieve the goals set in the Concept of Monitoring.

CONCEPT OF BIOMONITORING

The plan of organization of biomonitoring depends on the strategic goals. The goals are based on the following assumptions:

1. Establishing a regular biomonitoring system within the entire monitoring for following the condition of forests;
2. Defining efficient procedures, in accordance with the conditions in the field relevant for functioning of the national monitoring;
3. Relying on the existing, previously used procedures and their adjustment to the concrete conditions;
4. Ensuring the continuity of monitoring;
5. Defining an adaptable system of biological assessment.

The monitoring within **"Changes of sites destroyed by fire and the rate of natural revitalization of damaged ecosystems"** defines two phases:

Phase I

- Proposing procedures to make the biological monitoring operative.
- Define the activities for improvement, verification and application of procedures of assessing the ecological status of the area.

Phase II

- Defining the monitoring long-term.
- Defining the monitoring short-term.
- Basic framework of functioning of the monitoring, comprising:
  - Ratio between the monitoring component
  - Ratio between the national monitoring and other programs.
- Activities related to achievement of goals of previous points.
- Institution in charge of achieving the set tasks.
- Mechanisms, obligations and frameworks based on which the institution in charge would accomplish the task.
- Procedures to be improved and tested.
- Detailed time schedule of activities.

ELEMENTS OF BIOLOGICAL MONITORING

The following elements are included into the determination of the condition of ecosystems destroyed by fires and the rate of their revitalization:

- Herbaceous species, shrubs and woody species.

LOCATIONS OF TESTED BURNT AREAS AND CHARACTERISTICS OF FOREST SITES

Table 1 presents the basic data on sites from which samples were collected for monitoring of changes in ecosystems.

Table 1. *Basic data on sites*

Location	Coordinates	Exposition	Inclination (°)	Altitude (M)	Forest site
Usce 1	7464966 4814949	W	20	790	Black pine forest
Usce 2	7465019 4814882	W	7	808	Black pine forest
Usce 3	7464933 4814696	W	5	780	Black pine forest
Trstenik 1	7469367 4779350	S	2	925	Black pine forest
Trstenik 2	7469367 4779350	S	2	925	Black pine forest
Trstenik 3	7469367 4779350	S	2	925	Black pine forest
Lisa 1	7428582 4794844	S	20	1158	Black pine culture
Lisa 2	7428563 4794866	S	20	1158	Black pine culture
Lisa 3	7428821 4794783	SE	15	1158	Black pine culture
Goc 1	7475959 4836847	E	8	296	Black pine culture
Goc 2	7475959 4836847	W	10	288	Black pine culture
Goc 3	7475959 4836847	W	10	280	Black pine culture
Svojbor 1	7462254 4777581	W	24	603	Black pine culture
Svojbor 2	7462215 4777400	W	20	620	Black pine culture
Zavoj 5	7635794 4792680	SE	38	830	Beech forest
Vidlic 10	7641818 4780849	NE	8	1105	Beech forest
Vidlic 11	7641758 4780866	NE	6	1118	Beech forest
Vidlic 12	7641000 4678176	N	25	1113	Beech forest
Tupiznica 4	7586719 4838391	N	10	874	Beech forest
Radicevac 5	7613929 4826251	N	35	855	Beech forest
Markov kamen	7585910 4877380	N	25	630	Beech forest
Brezovica 1	7564855 4871958	N	35	860	Beech forest
Stol 1	7598004 4882186	N	25	303	Beech forest
Stol 2	7591621 4893660	NE	17	810	Beech forest
Stol 3	7591667 4893660	E	20	794	Beech forest
Stol 4	7591364 4894091	S	10	805	Beech forest

MONITORING OF SUCCESSIVE CHANGES IN VEGETATION

Dynamics of vegetation on the presented sites was monitored immediately after the fire, one, two, three, four, five and ten years after the fire. Within the scope of this paper data for beech forests and black pine forests will be presented.

BURNT AREA ON THE HABITAT OF BLACK PINE FOREST (*Pinus nigra* Arn.)

According to EUNIS classification, forests of black pine бора (Pinus nigra) (CODE G3.5) belong to pine forests of the Western Balkans (CODE G3.52).

Dynamics of the vegetation

Based on the analysis of the burnt area, the following were found to have the greatest degree of presence and coverage on the tested areas:

- In year one after the fire: *Moehringia trinervia, Rumex acetosella, Ajuga reptans, Vicia cracca,* etc.
- In year two after the fire: *Galium lucidum, Vicia cracca,Calamintha acinos, Alyssum murale, Potentilla opaca;*
- In year three after the fire: *Vicia cracca, Rumex acetosella, Senecio rupestris, Cirsium pannonicum, Viola tricolor, Ajuga reptans, Silene flavescens, Bromus squarosus, Sesleria rigida;*
- In year ten after the fire: *Vicia cracca, Verbascum nigrum, Euphorbia cyparissias, Brachypodium pinnatum, Erica carnea, Rubus tomentosus, Carex caryophyllea, Festuca gigantea* etc.

Regeneration of shrubs and woody species on burnt areas

Natural revitalization of the black pine after a fire depends on the strength of the fire and the possibility to inseminate the burnt area. A strong fire destroys not only the herbaceous cover but also the trunks on the site, thus making the revitalization impossible. Any seed that may have existed on the soil surface prior to the fire would also burn out. In a strong fire, the structure of the soil surface layers worsens and the soil becomes more compact, which makes natural regeneration of the burnt area even more difficult, but it creates conditions for quick propagation of species which in the absence of competing forest species "conquer" the area. This is the case with the facies *Potentilla opaca-Brachypodium pinnatum.*

In moderate ground fires the ground layer burns out and the seed directly reaches the soil, which may accelerate the natural regeneration. This situation is recognized by the facies defined as *Moehringia trinervia-Vicia cracca* and *Senecio rupestris-Vicia cracca.*

In the third year after a fire birch is well-regenerated and extensively present on the ten-year fire site. Trembling poplar and forest sallow are far less present. Among the shrubs, well-regenerated are the species *Genista* and *Cytisus*.

Vegetation of the burnt area on serpentine base of black pine forests belongs to the association *Euphorbieto (cyparissias)-Brachypodietum pinnati*.

The characteristic species of the association comprise 4 species, while the characteristic species of the class order and sub-order comprise 10. These species are among the best-developed on the burnt area and dictate its overall appearance.

The facies identified in the association are as follows:

1. Facies *Moehringia trinervia-Rumex acetosella* characterizes the first few years following a fire. It comprises therophyte plants, as well as those that have swift vegetative propagation.
2. Facies *Moehringia trinervia-Vicia cracca* is linked to two-year old burt areas. It is composed of therophyte plants of the family *Papilioniaceae*.

The above-named facies correspond to the phases of development of the association during individual years of age of a burnt area.

Picture 3. *Moehringia trinervia*

Picture 4. *Vicia cracca*

BURNT AREAS ON THE HABITAT OF BALKAN BEECH (FAGUS) FOREST

Under the EUNIS classification, Balkan beech forests (CODE G1.69) belong to beech (Fagus) forests (CODE G1.6).

Dynamics of the vegetation

- In the first year after a fire the most extensive coverage is by *Galium aparine,* then *Urtica dioica, Chrysanthemum parthenium, Galeopsis tetrahit, Rubus hirtus,* etc. Woody species have not been found.

- In the second year also *Galium aparine*, *Chrysanthemum parthenium,* then *Lathyrus pratensis, Galium mollugo* i *Rubus hirtus,* while among trees notable is the presence of vegetative shoots of hornbeam.
- In year five vegetative shoots of beech and trembling poplar are much more numerous, while among other species the most extensive coverage is by *Calamagrostis epigeios, Sambucus ebulus, Rubus hirtus, Epilobium angustifolium, Fragaria vesca,* etc.
- In year ten the presence of woody species is quite conspicuous. Beech has the largest degree of presence and coverage compared to other species. In this year *Populus tremula* is most extensively present. Other species are also numerous: *Rubus hirtus, Fragaria vesca, Calamagrostis epigeios, Circaea lutetiana, Epilobium angustifolium,* etc.
- Among woody species in year 25 afer a fire, beech is most extensively present, followed by trembling poplar. Among herbaceous species extensively present are *Rubus hirtus, Fragaria vesca, Circaea lutetiana, Epilobium montanum,* etc.

Vegetation of burt area on the habitat of mountain beech forest belongs to the association *Atropetum belladonnae (Br.Bl.1930) - Tx.1931, Em, 1950.*

There are four facies identified in the association:

1. Facies *Galium aparine*. The species *Galium aparine* develops the facies on a the burnt area of a mountain beech forest during the first years following a fire. This facies comprises fewer species than the others. The soil here has neutral reaction and is provided with potassium and phosphorus. It is rich in nitrogen, but the form of nitrogen is unsuitable for nutrition of the plants. Previous results on microbiological properties of the soil have shown that on a one-year burnt area the number of bacteria is increased, while the number of fungi and amonificators is reduced. Such a situation in the soil therefore does not favor development of many plants. During the first year after a fire there are no developed species from the family *Papilionaceae* on the burnt area, but they do appear as soon as year two.
2. Facies *Epilobium angustifolium*. Facies *Epilobium angustifolium* develops to an extensive degree on a burnt area of these forests a bit later on. It is most numerous around year five following a fire. At the same time other species develop on the burnt area, namely nitorphilous plants: *Calamagrostis epigeios, Sambucus ebulus, Rubus hirtus,* etc. Along with these plants pioneer tree species – trembling poplar and sallow – appear on the burnt area, while the edificator of the previous phytocenosis (*Fagus moesiaca)* has a rather extensive coverage. The soil is characterized by neutral reaction and particularly high quantity of nitrogen (1.08%).
3. Facies *Rubus hirtus-Fragaria vesca.* These two species virtually dominate the burnt area in the year ten after a fire. They are linked to many more types of burnt areas, even though their number is somewhat smaller compared to the

presence in the previously described facies. Pioneer tree species are well developed here. In the soil of this facies the number of bacteria and actinomycetes is somewhat reduced, while the overall number of fungi and amonificators is increased. According to its chemical and physical properties, the soil is similar to the conditions of forest unaffected by fire.

4. Facies *Populus tremula*. The coverage of trembling poplar in this facies surpasses the other species (with the exception of beech). In all likelihood its presence was even more extensive several years before, but it gradually dwindles in competition with the beech. The number of types of burnt areas is reduced, while the number of forest species is increased. In this facies the burt area is closest to the forest, according to both floristic composition and conditions of soil.

The above facies in the association at the same time represent phases in the progressive development of the association. Each phase characterizes a certain period of association development. The facies, i.e. phase *Populus tremula* is at the same time the final phase of the association and the final stadium of the development of vegetation until regeneration of the previous phytocenosis.

Association *Atropetum Belladonnae* is linked to burnt areas of *Fagion* on lower altitudes, on shadowy expositions with moist or fresh soil. The presence of *Atropa belladonna* is especially extensive in the first years after a fire. It grows in the places where the fire or another factor has opened the canopy and allowed more light to penetrate the cover and soil, thus making piling of organic matter and formation of humus impossible while enabling improvement of aearation conditions and therefore expediting the process of humification, i.e. mineralization of organic matter. That is why belladonna represents an indicator of soil conditions, primarily of wealth in plant assimilators.

CONCLUSION

Monitoring of successive changes on the habitat of black pine resulted in finding the following:

- In year one after the fire: *Moehringia trinervia, Rumex acetosella, Ajuga reptans, Vicia cracca,* etc.
- In year two after the fire: *Galium lucidum, Vicia cracca,Calamintha acinos, Alyssum murale, Potentilla opaca;*
- In year three after the fire: *Vicia cracca, Rumex acetosella, Senecio rupestris, Cirsium pannonicum, Viola tricolor, Ajuga reptans, Silene flavescens, Bromus squarosus, Sesleria rigida;*
- In year ten after the fire: *Vicia cracca, Verbascum nigrum, Euphorbia cyparissias, Brachypodium pinnatum, Erica carnea, Rubus tomentosus, Carex caryophyllea, Festuca gigantean,* etc.
- Natural revitalization of the black pine after a fire depends on the strength of the fire and the possibility to inseminate the burnt area. A strong fire destroys

not only the herbaceous cover but also the trunks on the site, thus making the revitalization impossible. Any seed that may have existed on the soil surface prior to the fire would also burn out. In a strong fire, the structure of the soil surface layers worsens and the soil becomes more compact, which makes natural regeneration of the burnt area even more difficult, but it creates conditions for quick propagation of species which in the absence of competing forest species "conquer" the area. This is the case with the facies *Potentilla opaca-Brachypodium pinnatum.*

In moderate ground fires the ground layer burns out and the seed directly reaches the soil, which may accelerate the natural regeneration. This situation is recognized by the facies defined as *Moehringia trinervia-Vicia cracca* and *Senecio rupestris-Vicia cracca.*

In the third year after a fire birch is well-regenerated and extensively present on the ten-year fire site. Trembling poplar and forest sallow are far less present. Among the shrubs, well-regenerated are the species *Genista* and *Cytisus*.

Vegetation of the burnt area on serpentine base of black pine forests belongs to the association *Euphorbieto (cyparissias)-Brachypodietum pinnati*.

The facies identified in the association are as follows:

1. Facies *Moehringia trinervia-Rumex acetosella*
2. Facies *Moehringia trinervia-Vicia cracca*

The above-named facies correspond to the phases of development of the association during individual years of age of a burnt area.

Monitoring of successive changes on the habitat of beech resulted in finding the following:

1. Facies *Galium aparine*
2. Facies *Epilobium angustifolium*
3. Facies *Rubus hirtus-Fragaria vesca*
4. Facies *Populus tremula*

The above facies in the association at the same time represent phases in the progressive development of the association. Each phase characterizes a certain period of association development. The facies, i.e. phase *Populus tremula* is at the same time the final phase of the association and the final stadium of the development of vegetation until regeneration of the previous phytocenosis.

Association *Atropetum Belladonnae* is linked to burnt areas of *Fagion* on lower altitudes, on shadowy expositions with moist or fresh soil. The presence of *Atropa belladonna* is especially extensive in the first years after a fire. It grows in the places where the fire or another factor has opened the canopy and allowed more light to penetrate the cover and soil, thus making piling of organic matter and formation of humus impossible while enabling improvement of aearation conditions and therefore expediting the process of humification, i.e. mineralization of organic matter. That is why belladonna represents an indicator of soil conditions, primarily of wealth in plant assimilators.

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ANALYSIS OF SILTATION SLOPE DEPENDENCE ON GRAIN SIZE COMPOSITION OF SEDIMENT IN TORRENT STREAMS OF TRGOVISKI TIMOK DRAINAGE BASIN

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Abstract: *The siltation slope is the slope of the upper surface of the deposited material in the storage area upstream of the constructed dam. Silting up is a complex process and the assessment, i.e. the forecast of the slope of siltation is a major issue in the practice of torrent management. This paper analyses the dependence of newly formed siltation slopes on grain size composition of sediment, from the siltations of the constructed dams in torrent streams of the Trgoviski Timok catchment basin. The analysis of the dependence of newly formed siltation slope on grain size composition of sediment was performed by the method of modeling as the basic method. Regression and correlation analyses were applied as the specific research methods. The obtained results show the high correlation between the siltation slope and grain size composition of sediment, based on which it can be concluded that the obtained model is a good base for the slope of siltation forecast in future.*

Key words: Trgoviski Timok, dam, siltation slope, grain size composition of sediment

ANALIZA ZAVISNOSTI PADA ZAPLAVA OD GRANULOMETRIJSKOG SASTAVA NANOSA U BUJIČNIM VODOTOCIMA SLIVA TRGOVIŠKOG TIMOKA

Abstract: *Pad zaplava je pad gornje površine nataloženog materijala u akumulacionom prostoru uzvodno od izgrađene pregrade. Formiranje zaplava je složen*

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proces, a određivanje veličine pada zaplava predstavlja značajan problem u praksi uređenja bujičnih vodotoka. U ovom radu analizirana je zavisnost novoformiranih padova zaplava od granulometrijskog sastava nanosa, na zaplavima izgrađenih pregrada u bujičnim vodotocima sliva Trgoviškog Timoka. Analiza zavisnosti novoformiranog pada zaplava od granulometrijskog sastava nanosa urađena je metodom modeliranja, kao osnovnom metodom, a korišćena je regresiona i korelaciona analiza kao konkretna istraživačka metoda. Dobijeni rezultati pokazuju značajnu povezanost između pada zaplava i granulometrijskog sastava nanosa, na osnovu čega se može zaključiti da dobijeni model predstavlja dobru osnovu za prognozu pada zaplava.

Ključne reči: Trgoviški Timok, pregrada, pad zaplava, granulometrijski sastav nanosa

1. INTRODUCTION

The determination of the length of the slope of siltation is a major issue in the practice of torrent stream management. The need to find the practical solution to this problem resulted in numerous formulas for the assessment of the slope of siltation of which usually are used formulas by Thiery, Pimpirev, Valentini, Jaggy, Valtyni, Chezy, Šamov, Strikler, Krey, Lane, Mirzazage-a, Schields, Egiazarov, Mayer-Peter, formulas of regional analytical dependencies by Biolčev, Kostadinov and Velojić (Kostadinov, 1996, Todosijević, 2004, Velojić, 2002, Kostadinov, 1989). By analyzing these formulas can be concluded that the formation of the siltation slope the decisive roles have stream bed slope and grain-size composition of the sediment (Bilibajkić, 2011).

This paper analyses the dependence of newly formed siltation slopes on grain size composition of sediment from the siltations of the constructed dams in torrent streams of the Trgoviski Timok catchment basin.

2. MATERIAL AND METHOD

This paper presents the researches conducted in the Trgoviški Timok drainage basin in the following torrent streams: Melo, Vidovacka River, Oreovica, Lesjanski Do and Trgoviska River.

Trgoviški Timok is the first rigth tributary of the Beli Timok River, which meets Svrljiski Timok in Knjazevac, at the altitude of 210 meters above the sea level. The spring of Trgoviški Timok is in Stara Planina mountain, in the vicinity of Midzor Summit (located at 1,630 meters above the sea level), and is composed of Crnovrska river and its component stems. Crnovrska reka meets Strmna River near Balta Berilovac settlement and forms Trgoviski Timok. The total length of Trgoviški Timok is 54.1 km and the drainage basin area is 536.9 km^2. The drainage basin is oblong-shaped, the right side of it is wide and steep, and the leftside is very narrow and steep.

The hydrographic network of this river is well-developed and it consists of a number of small and great tributaries. The most important right tributaries are: Janjska, Inovska, Grabovnicka, Papratska, Zukovacka and Trgoviska River and the most important left tributaries are: Strmna Reka, Crvencica, Izvorska Reka, Melo

and Lesjanski Do. These streams, along with their tributaries, consitute well-developed hydrographic network made of 216 torrent streams.

Trgoviska River is the first large, right tributary of Trgoviški Timok, looking upstream from the confluence with Svrljiski Timok. The hydrographic network of this river is well-developed. The main stream consists of two component rivers: right one called Lokvanjska River and the left one called Vidovacka River. The total drainage basin area of Trgoviška River is 22.77 km^2. Its length is 9.5 km and the mean slope is 6.3%. The drainage basin terrain features are mostly hilly. The average slope gradient in the drainage basin ranges from 35 to 40%. The confluence of Trgoviska River in Trgoviski Timok is near the settlement Trgovište.

Vidovačka River consists of two arms: the right one - Garnovica, and the left one - Crna River. The drainage basin is hilly with steep slope gradients ranging from 30 to 40 %, and its area is 8.41 km^2. The length is 5 km and the mean streambed slope is 8.1 %.

Oreovica is the right tributary of Aldinacka River and is located in Gornja Sokolovica settlement. The drainage basin area of this tributary is 0.82 km^2, the main watercourse is 1.4 km long, and the mean streambed slope is 14 %. The drainage basin is hilly, with the steep sides of mean slope of 30 %.

Lesjanski Do is the left tributary of Trgoviški Timok. Its spring is in the place called Goleme Livade. The catchment is hilly with the mean gradient of 30 %. The drainage basin area is 11.67 km^2, the watercourse is 6.65 km long, and the mean streambed slope is 5.5 %.

Melo is the third left tributary of Trgoviski Timok, looking upstream from the confluence. The drainage basin is 5.25 km^2. The main watercourse is 4.8 km long and the mean streambed slope is 7.5 %. The catchment is hilly, with the mean gradient 40 %.

Data on the current grade level of siltation were obtained by geodetic surveying of longitudinal profiles of formed siltation behind dams. Surveying was performed by leveling. Based on the data obtained by geodetic surveying in the field the longitudinal profiles of siltation are drawn and based on them were determined values of siltation slopes.

For the needs of the grain size analysis of bedload behind of every dam the sample of sediment has been taken. The sample has been taken from the area of 1.0 m^2 (1.0×1.0) to a depth of the largest grain according to the methodology of Leo Skatula (Kostadinov, 1979) and passed through sieves of diameter of 100 mm to 0.1 mm. Larger pieces of sediment were measured on the spot.

Analysis of dependence of newly formed siltation slope on grain size composition of sediment was performed by method of modelling, as the basic method, and regression and correlation analyses were used as the specific research methods.

3. RESULTS

Researches included twenty constructed longitudinal objects (dams) with formed siltation in Trgoviski Timok drainage basin.

In order to consider dependence of siltation slope and sediment characteristics, the granulometric analysis of sediment formed from siltation was performed. By passing through a series of sieves and measuring of bedload samples taken from siltation of dams, the granulometric curves were obtained from which were taken the following values of characteristic diameter of sediment.

d_{30} – grain size of sediment at 30% share of weight parts on the total weight of sediment,
d_{50} – grain size of sediment at 50% share of weight parts on the total weight of sediment,
d_{60} – grain size of sediment at 60% share of weight parts on the total weight of sediment,
d_{75} – grain size of sediment at 75% share of weight parts on the total weight of sediment.

In Table 1 are shown values of siltation slope and characteristic diameters of sediment.

Table1 . *Siltation slope and diameters of sediment*

No.	Origin	I_z (%)	d_{30} (mm)	d_{50} (mm)	d_{60} (mm)	d_{75} (mm)
I	**Trgoviska River**					
1	Dam No. 1	1,82	7,5	25,0	38,0	68,0
II	**Vidojevacka River**					
1	Dam No. 1	0,89	3,9	11,0	17,9	32,0
2	Dam No. 2	2,96	6,0	16,5	22,0	36,0
3	Dam No. 3	2,06	5,8	17,0	22,0	36,0
4	Dam No. 5	2,55	20,0	55,0	59,0	108,0
5	Dam No. 6	2,48	4,8	28,0	38,0	51,0
6	Dam No. 7	2,69	9,0	22,0	32,0	70,0
III	**Oreovica**					
1	Dam No. 1	2,92	19,3	60,0	92,0	136,0
2	Dam No. 2	4,09	44,0	76,0	86,0	114,0
3	Dam No. 3	3,33	7,8	21,0	32,0	46,0
IV	**Bujica Melo**					
1	Dam No. 1	6,22	21,2	52,5	117,0	171,0
2	Dam No. 2	4,83	25,0	50,0	62,0	88,0
3	Dam No. 3	5,21	32,0	61,0	95,0	132,0
4	Dam No. 4	4,99	8,5	38,0	49,0	82,0
5	Dam No. 5	6,56	28,0	70,0	80,0	97,0
6	Dam No. 6	10,70	5,8	12,0	17,1	32,0
7	Dam No. 7	5,22	25,0	55,0	72,0	101,0
8	Dam No.8	11,47	24,0	75,0	95,0	132,0
9	Dam No. 9	6,59	42,0	78,0	101,0	140,0
V	**Lesjanski do**					
1	Dam No. 1	1,04	1,15	1,2	1,3	5,2

Using the obtained data the scatter diagrams were made based on which several alternative functional forms (linear, degrees, exponential and logarithm) were defined. Of that forms was selected the one that was the best adapted to the given measured data and had the highest percentage of explained variations.

Picture 1. *Trgoviska River siltation of dam No. 1*

Picture 2. *Torrent Melo siltation of dam No. 1*

Siltation slope dependences on grain size composition of sediment at 30% share of weight parts on the total weight of sediment is presented in the exponential form that by suitable transformation is translated into a linear form due to application of the necessary statistical methods and tests. This regression is characterized by 43% explained variations (R^2 = 0.43) (Figure 1, Table 2). The correlation coefficient is significantly different from 0. The standard errors of the assessment of parameters and the respective t-statistics show that the parameter defining sediment at the apppropriate significance level (0.05) is sufficiently accurate while the free parameter is insignificant.

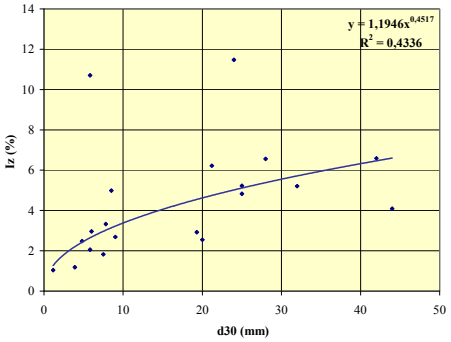

Figure 1. *Siltation slope dependence on grain size composition of sediment at 30% share of weight parts on the total weight of sediment in studied torrent steams of Trgoviski Timok drainage basin (simple correlation)*

Table 2. *Regression parameters $I_z=f(d_{30})$*

$I_z = f(d_{30})$			
$y = a\,x^b$			
a=1,194	$S_{(a)}$=0,3227	$t_{(a)}$=0,5511	$p_{(a)}$=0,5883
b=0,451	$S_{(b)}$=0,1217	$t_{(b)}$=3,7121	$p_{(b)}$=0,0016
R=0,6585	R^2=0,4336		R^2_{cor}=0,4021
F(1,18)=13,780	p<0,00159		S_c=0,5025
$I_z = 1{,}194 \times d_{30}^{0.451}$			

Analysis of the slope of siltation dependence on grain size composition of

sediment at 50% share of weight parts on the total weight of sediment gives regression model in exponential form. By this regression is explained 39% of variations (R^2 = 0.3973). The correlation coefficient 0.63 points out at significant correlation between analyzed parameters (Table 3). The standard errors of the assessment of parameters and the respective t-statistics show that the parameter defining sediment at the apppropriate significance level (0.05) is sufficiently accurate while the free parameter is insignificant.

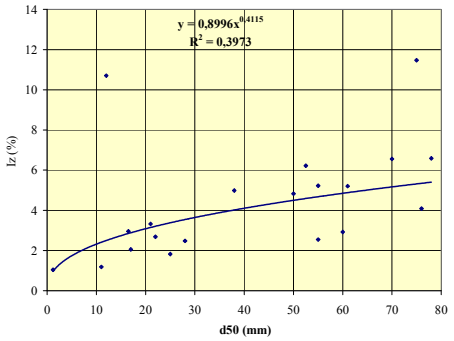

Figure 2. *Siltation slope dependence on grain size composition of sediment at 50% share of weight parts on the total weight of sediment in studied torrent steams of Trgoviski Timok drainage basin (simple correlation)*

Table 3. *Regression parameters $I_z=f(d_{50})$*

$I_z = f(d_{50})$			
$y = a\ x^b$			
a=0,899	$S_{(a)}$=0,4245	$t_{(a)}$=-0,2492	$p_{(a)}$=0,8060
b=0,411	$S_{(b)}$=0,1195	$t_{(b)}$=3,4444	$p_{(b)}$=0,0029
R=0,6303	R^2=0,3973		R^2_{cor}=0,3638
F(1,18)=11,864	p<0,00289		S_c=0,5184
$I_z = 0{,}899\ x\ d_{50}^{\ 0.411}$			

Analysis of the slope of siltation dependence on grain size composition of sediment at 60% share of weight parts on the total weight of sediment is presented by exponential form that fits the best to the given data. By this form are explained 39% of variations. The correlation coefficient R = 0.62 points out at significant correlation between slope of siltation and grain size composition of sediment at 60% share of weight parts on the total weight of sediment. The standard errors of the assessment of parameters and the respective t-statistics show that the parameter defining sediment at the apppropriate significance level (0.05) is sufficiently accurate while the free parameter is insignificant that indicates the possible deviations of its value.

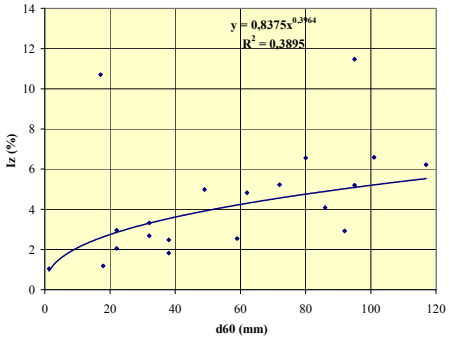

Figure 3. *Siltation slope dependence on grain size composition of sediment at 60% share of weight parts on the total weight of sediment in studied torrent steams of Trgoviski Timok drainage basin (simple correlation)*

Table 4. *Regression parameters $I_z=f(d_{60})$*

$I_z = f(d_{60})$			
$y = a\,x^b$			
a=0,837	$S_{(a)}$=0,4546	$t_{(a)}$=-0,3928	$p_{(a)}$=0,6991
b=0,396	$S_{(b)}$=0,1170	$t_{(b)}$=3,3887	$p_{(b)}$=0,0033
R=0,6241	R^2=0,3895		R^2_{cor}=0,3556
F(1,18)=11,483	p<0,0033		S_c=0,5217
$I_z = 0{,}837 \times d_{60}^{0.396}$			

Analysis of the slope of siltation dependence on grain size composition of sediment at 75% share of weight parts on the total weight of sediment gives regression model in exponential form. This regression is characterized by 37% of explained variations, the correlation coefficient that is significantly different from 0 (R = 0.61) and statistically significant assessment of parameter defining sediment at the apppropriate significance level (0.05).

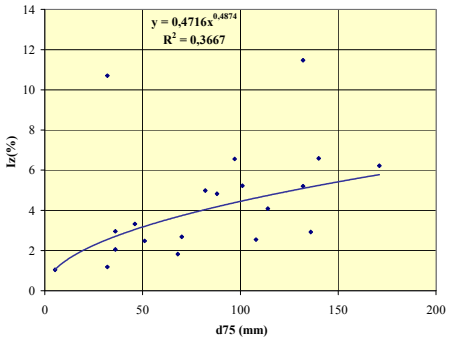

Figure 4. *Siltation slope dependence on grain size composition of sediment at 75% share of weight parts on the total weight of sediment in studied torrent steams of Trgoviski Timok drainage basin (simple correlation)*

Table 5. *Regression parameters $I_z=f(d_{75})$*

$I_z = f(d_{75})$			
$y = a\ x^b$			
a=0,471	$S_{(a)}$=0,6468	$t_{(a)}$=-1,1620	$p_{(a)}$=0,2604
b=0,487	$S_{(b)}$=0,1510	$t_{(b)}$=3,2282	$p_{(b)}$=0,0046
R=0,6055	R^2=0,3667		R^2_{cor}=0,3315
F(1,18)=10,421	p<0,0047		S_c=0,5313
$I_z = 0{,}471 \times d_{75}^{0.487}$			

4. CONCLUSION

Analysis of the slope of siltation dependence on grain size composition of sediment has shown that to the given empiric data the best are adjusted regression models in exponential form.

Grain size composition of sediment has a large influence on the siltation slope. Models of siltation slope dependence on the diameter of grain of sediment d_{30}, d_{50}, d_{60} and d_{75} i.e. on size of sediment at 30%, 50%, 60% and 75% share of weight parts on the total weight of sediment are well adjusted to empiric data and they explain well the siltation slope.

Regression analysis in simple models for Trgoviski timok draiage basin has shown that there is a significant correlation between siltation slope and grain size composition of sediment.

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Original scientific paper

GYPSY MOTH (*Lymantria dispar* L.) OUTBREAK IN THE CENTRAL PART OF REPUBLIC OF SERBIA IN THE PERIOD 2010-2013

Mara TABAKOVIĆ-TOŠIĆ[1]

Abstract: *This paper presents the results of research high levels of gypsy moth population in the forest region of Central Serbia in the period from 2010 to 2013 year. The characteristics of the individual phases of outbreak and their spatial distribution were analyzed. In addition to displaying the results of laboratory analizes of egg masses collected, the special attention was paid to the qualitative and quantitative analysis of natural enemies of the gypsy moth.*

Key words: the gypsy moth, forests, outbreak, natural enemies

GRADACIJA GUBARA (*Lymantria dispar* L.) U PODRUČJU CENTRALNE SRBIJE U PERIODU 2010-2013. GODINE

Izvod: *U radu su prikazani rezultati istraživanja visine populacionih nivoa gubara u šumskom području Centralne Srbije, u periodu od 2010-2013. godine. Analizirane su karakteristike pojedinih faza gradacije i njihov prostorni raspored. Pored prikaza rezultata laboratorijske aalize prikupljenih jajnih legala, u radu je posebna pažnja posvećena i kvalitativnoj i kvantitativnoj analizi prirodnih neprijatelja gubara.*

Ključne reči: gubar, šume, gradacija, prirodni neprijatelji

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INTRODUCTION

The gypsy moth (*Lymantria dispar* L.), insect in the order *Lepidoptera*, is one of the major 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 brought to the forests of the Balkan Peninsula, which have all the favourable environmental conditions for the gypsy moth development.

The gypsy moth is an autochthonous species and it often occurs in outbreaks. During the period of seventy years in the central part of Serbia there were five outbreaks, and the sixth outbreak started in the period 2009/2010. The outbreaks do not occur in regular time intervals. Acute and chronic outbreaks are differentiated based on the increase of the number of egg masses per unit area and the attained amplitudes in the stages of eruption and culmination. Acute outbreaks last shorter (4–5 years), the number of egg masses per hectare amounts to several tens of thousands, and the larvae cause the total defoliation in forests and orchards. In chronic outbreaks, the maximal number of egg masses per hectare does not exceed two to three thousand, which is explained by not reaching the culmination stage, so the defoliation does not occur on larger areas. The outbreak duration also depends on the altitude (it lasts for 3–5 years at up to 500 m, 2–3 years at 500 to 1200 m, and at 1200 to 1600 m, the gypsy moth is the member of the biocoenosis if there are host plants). Generally, the previous outbreaks of the gypsy moth in Serbia forests lasted averagely 4.3 years (Marović *et al.*, 1998) (minimum two to three, and maximum five to six years) (Maksimović, 1997). Also, certain phases of outbreak does not happen at the same time, since due to a variety of biotic and abiotic influences come to the gypsy moth dispersal and occupation of new territories. Regular occurrence and characteristics of all outbreaks are their spatial expansion.

The damage caused by the gypsy moth is twofold: direct - defoliation or the loss of leaf mass, and indirect, expressed as the consequences. Defoliation caused by caterpillar feeding lead to the loss of increment, absence of fructification, physiological wakening and tree dying, as well as to the creation of favourable conditions for the infestation of phytopathogenic microorganisms, fungi and xilophagous insects, disturbance of the aesthetical appearance, etc. It should be noted that the consequences of harmful effects of gypsy moth on broadleaf species are very dependent on their origin, vitality, and environmental conditions. For example, the impact of the loss of the annual increment of trees was much lower in forest stands of vegetative origin than generative, which is understandable because otherwise growth trees in these stands is much smaller.

RESULTS, DISCUSSION AND CONCLUSIONS

During the last 70 years, since the Report-diagnose-forecast service has been functioning in the region of Serbia in plant protection - forest protection, the gypsy moth had 6 outbreaks of acute type, i.e. 1945–1950, 1952–1957, 1961–1966, 1995–1999 (Mihajlović *et al.*, 1998) and 2003-2006. Due to the above facts, every year in all broadleaf forests (during the outbreaks also in coniferous forests) disregarding the ownership category (state and private), the gypsy moth density is controlled pursuant to the guidelines of the Report-diagnose-forecast service in the fields of plant protection – forest protection. The gypsy moth density in forests is controlled by the method of permanent (25x25 m) and temporary (10x10 m) sample plots, as well as by the march-route method and method of traps with sex attractant with female odour used to lure the male gypsy moths to traps (pheromone traps) (Tabaković-Tošić and Jovanović, 2007).

It is very important to determine precisely the infestation intensity and to define the infested area spatially, because they are the decisive factors for the selection of the control method and time.

Permanent sample plots are controlled every year, and temporary plots are established when it is estimated that there is an outbreak hazard. The march-route method and pheromone traps are applied as the supplement when the gypsy moth is in latency (low density), and they are obligatory methods during the outbreak.

During the assessment of the number of the gypsy moth egg masses per unit area (1 hectare), care was taken to encompass all forest complexes. This is especially important in the regions with the infestation of very severe intensity (more than 500 egg masses per hectare), because the damage rates resulting from the loss of leaf mass, which will be caused by the hatched larvae, are not the same at the infestation of 501 egg masses per hectare and e.g. 50,000 egg masses per hectare (Tabaković-Tošić, 2005).

Table 1: *Outspread of gypsy moth in the central part of Republic of Serbia in the period 2010-2013.*

FOREST ESTATE	AREA UNDER ATTACK BY THE GYPSY MOTH (ha)																			
	MAGNITUDE OF ATTACK (egg masses/ha)																TOTAL			
	WEAK (1-10)				MEDIUM (11-100)				STRONG (101-500)				VERY STRONG (more than 500)							
	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013	2010	2011	2012	2013
PUBLIC ENTERPRISE SRBIJAŠUME																				
Beograd	826	928	199	0	2024	323	162	0	865	94	0	0	21	120	0	0	3736	1466	361	0
Boljevac	25	977	7952	1671	0	756	9797	6788	0	319	4505	33399	0	76	35530	27624	25	2128	57785	69482
Vranje	0	0	0	376	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	376
Despotovac	0	0	406	5558	0	0	448	7112	0	0	0	7891	0	0	0	13420	0	0	854	33981
Ivanjica	0	0	430	168	0	0	131	52	0	0	0	685	0	0	0	288	0	0	561	1193
Kragujevac	0	283	983	272	0	0	3	618	0	0	14	153	0	0	2	475	0	283	1012	1518
Kraljevo	0	0	330	360	0	0	503	258	0	0	174	668	0	0	202	948	0	0	1210	2235
Kruševac	1094	1573	1427	1256	235	0	5154	5383	0	0	863	15450	0	0	643	14848	1329	1573	8086	36937
Kuršumlija		485	8166	2265	0	0	841	7792	0	0	89	3941	0	0	0	3774		485	9097	17772
Kučevo	1254	313	2549	552	0	81	15492	967	0	0	3056	11167	0	0	3737	70951	1254	394	24834	83638
Leskovac		100	2063	1435	0	0	1296	5686	0	0	125	1398	0	0	0	9753		100	3484	18272
Loznica	2323	12893	14706	13705	334	9160	4514	4446	20	1341	2288	673	0	0	0	40	2677	23394	21509	18864
Niš	0	47	883	1856	0	0	481	1747	0	0	33	1371	0	0	0	569	0	47	1397	5543
Pirot	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21
Raška	0	0	0	82	0	0	0	76	0	0	0	25	0	0	0	8	0	0	0	191
Užice	0	510	120	122	0	0	0	0	0	0	0	0	0	0	0	0	0	510	120	122
Total	**5522**	**18109**	**40214**	**29699**	**2593**	**10320**	**38822**	**40925**	**885**	**1754**	**11147**	**76821**	**21**	**196**	**40114**	**142698**	**9021**	**30380**	**130310**	**290145**
PUBLIC ENTERPRISE NATIONAL PARK ĐERDAP																				
Total	**+?**	**-**	**3783**	**0**	**0**	**-**	**13566**	**4688**	**0**	**-**	**9239**	**10839**	**0**	**-**	**17176**	**27947**	**+?**	**-**	**43764**	**43474**
PUBLIC ENTERPRISE BORJAK VRNJAČKA BANJA																				
Total	**0**	**-**	**6720**	**0**	**0**	**-**	**1350**	**971**	**0**	**-**	**150**	**305**	**0**	**-**	**150**	**25**	**0**	**-**	**8370**	**1300**
FACULTY OF FORESTRY, UNIVERSITY OF BELGRADE																				
Total	**0**	**-**	**-**	**300**	**0**	**-**	**-**	**400**	**0**	**-**	**-**	**900**	**0**	**-**	**-**	**400**	**0**	**-**	**2000**	**2000**
SERBIAN ORTHODOX CHURCH – MONASTERY FORESTS																				
Total	**+?**	**?**	**?**	**49**	**?**	**?**	**?**	**1065**	**?**	**?**	**?**	**1518**	**?**	**?**	**?**	**436**	**+?**	**?**	**?**	**3068**
THE CENTRAL PART OF REPUBLIC OF SERBIA																				
TOTAL	**5522**	**18109**	**50717**	**30048**	**2593**	**10320**	**53738**	**48049**	**885**	**1754**	**20536**	**90383**	**21**	**196**	**57440**	**171506**	**9021**	**30380**	**184444**	**339987**



Pictures 1-3. *Forest Administration Negotin, autumn 2012 – gypsy moth egg masses*

In August 2010 and 2011, there were a regular controls of the gypsy moth population level in all forests of central Serbia. Gypsy moth was detected on 9,021 and 30,380 ha of broadleaf forests. In 2011, the infestation intensity was weak on 59.6% of the area (up to 10 egg masses/ha), it was medium on 34.0% (11 to 100 egg masses/ha), strong on 5.8% (101 to 500 egg masses/ha) and very strong on 0.6% (more than 500 egg masses/ha) (Table 1).

Total broadleaf forest area in the central part of Republic of Serbia, in which the gypsy moth egg masses were detected in August 2012 was 184,444 ha. The largest areas were under very strong infestation intensity (57,440 ha or 31.2%), then under medium (53,738 ha or 29.1%), weak (50,717 ha or 27.5%) and finally under strong attack (20,536 ha or 11.2%) (Table 1).

In August 2013, the detailed inspection of permanent and temporary sample plots as well as the sampling points, and the march-route survey of private forests show that the gypsy moth infestation was identified on 339,987 ha, which is eleven times larger than in the first year, and two times then second year of outbreak (Table 1).

The final goal of the gypsy moth density control is forecasting, and it is not created only based of the density of egg masses. For the precise forecasting, it is necessary to perform the laboratory analysis of egg masses in the aim of getting the parameters significant to the assessment of the population viability.

Table 2. *Laboratory analysis of gypsy moth egg masses sampled from representative sample plots in the area of Central Serbia.*

Year	Number of		Average number of eggs in an egg mass						
			Fertilised				Unfertilised		Total
	Sample plots	Egg masses	Vital		Parasitised				
			N	%	N	%	N	%	N
2010	80	800	526.9	90.9	48.3	8.3	4.5	0.8	579.7
2011	120	1200	465.8	92.2	34.5	6.9	4.5	0.9	504.8
2012	297	1428	555.6	96.1	14.5	2.8	1.6	0.3	565.7
2013	690	5215	443.6	84.5	76.4	14.8	3.8	0.7	523.8

The analysis of gypsy moth egg masses, collected in the area of the Central Serbia, had been conducted at the laboratory of the Institute of Forestry every year during the outbreaks. The average number of eggs in an egg mass ranged from 504.8 (2011) to 579.7 (2010). The egg mass with the largest average number of eggs (1038.6) was submitted to the Institute in 2012 from Forest Estate Severni Kučaj Kučevo, Forest Administration Kučevo, Management Unit Brodica. The

percentage share of vital eggs in the total number of eggs ranged, averagely, from 84.5% in 2013 to 96.1 in 2012 (Table 2).

Average parasitism of eggs in egg masses at the study localities ranges from 2.8% in 2012 to 14.8% in 2013 (Table 2). The average rates of parasitism should not be taken as final ones, because under these laboratory conditions it is not possible to determine the effect of a series of parasites and predators, to which egg masses are exposed in the field. Regarding the species of egg parasites, in the period 2010-2013 *Anastatus japonicus* Ashmead, 1904 (syn. *A. disparis* Ruschka) accounted from 0 to 37%, and *Ooencyrtus kuwanae* (Howard, 1910) 63-100%.

The data on egg, larval and pupal parasitism, as well as the data on the state of the gypsy moth predators and pathogens at individual localities should also be included in the study. During the observed period, in the gypsy moth populations, the activity of 56 natural enemies of this insect - nineteen predators, twenty-eight parasites, seven parasites or saprophages and two pathogens -was reported. The gypsy moth eggs were attacked by eleven species of the predators [*Trombidium holosericeum* (Linnaeus, 1758); *Forficula auricularia* Linnaeus, 1758; *Carabus latus* Dejean, 1826; *Dermestes erichsoni* Ganglbauer, 1904; *Megatoma pici* Kalik, 1952; *Megatoma pubescens* (Zetterstedt, 1828); *M. undata* (Linnaeus, 1758); *Globicornis nigripes* (Fabricius, 1792); *Julistus floralis* (Olivier, 1790); *Malachus bipustulatus* (Linnaeus, 1758); *Formica sp.*], larvae by six [*Silpha quadripunctata* Schreber, 1759; *Carabus coriaceus* (Linnaeus, 1758); *C. cancellatus* (Linnaeus, 1758); *C. cavernosus* Frivaldsky, 1837; *C. intricatus* (Linnaeus, 1758); *C. scabriusculus bulgarus* Lapouge, 1908] and larvae and pupae by two [*Calosoma sycophanta* (Linnaeus, 1758); *C. inquisitor* (Linnaeus, 1758)] (Tabaković-Tošić, 2011, 2012a, Tabaković-Tošić *et al*., 2013).

There were three parasitic species of the gypsy moth eggs [*Anastatus japonicus* Ashmead, 1904; *Ooencyrtus kuwanae* (Howard, 1910); *Eremioscelio lymantriae* Masnil, 1958], eighteen parasitic species of the gypsy moth larvae [*Casinaria tenuiventris* (Gravenhorst, 1829); *Phobocampe disparis* (Viereck, 1911); *P. pulchella* (Thomson, 1887); *Apanteles glomeratus* (Linnaeus, 1758); *A. lacteicolor* Viereck, 1911; *Cotesia melanoscela* (Ratzeburg, 1844); *C. ocneriae* (Ivanov, 1898); *C. scabricula* (Reinhard, 1880); *Protapanteles liparidis* (Bouček, 1834); *P. porthetrie* Muesebeck, 1954; *P. fulvipes* (Haliday,1834); *Meteorus versicolor* (Wesmael, 1835); *Euplectrus liparidis* Ferrière, 1941; *Exorista larvarum* (Linnaeus, 1758); *Parasetigena silvestris* (Robineau-Desvoidy, 1863); *Compsilura concinnata* (Meigen, 1824); *Blepharipa pratensis* (Meigen, 1824); *B. schineri* (Mesnil, 1939)] , and seven parasitic species of the gypsy moth pupae [*Pimpla instigator* Fabricius, 1793; *P. inquisitor* (Scopoli, 1763); *P. turionellae* (Linnaeus, 1758); *Theronia atalantae* (Poda, 1761); *Lymantrichneumon disparis* (Poda, 1761); *Brachimeria intermedia* (Nees, 1834); *B. femorata* (Panzer, 1798)]. Parasites or saprophages of gypsy moth pupae were represented by seven species [*Agria affinis* (Fallén, 1817); *Kramerea schuetzei* (Kramer, 1909); *Parasarcophaga harpax* (Pandelle, 1896); *P. portshinskyi* Rohdendorf, 1937; *P. uliginosa* (Kramer, 1908); *Muscina pabulorum* (Fallen, 1817); *M. stabulans* (Fallen, 1817)]. Two pathogenic species (*Ld*NPV and *Entomophaga maimaiga*) have been identified (Tabaković-Tošić, 2011, 2012, Tabaković-Tošić *et al*., 2012, 2013).

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.

At the selected sites in meny regions of Central Serbia the cocoons of the parasitic species from the families Braconidae and Tachinidae were regularly found in spring. Other species were considerably less frequent and were found individually.

The activity of *Lymantrya dispar* NPV was reported at many sites, with the extremely high population sizes of the gypsy moth. For example, *Lymantrya dispar* NPV caused the death of about 20% of L_4 gypsy moth instar at one site in the Forest Administration Lipovica (Forest Estate Belgrade), 17.1% in the Forest Administration Blace (Forest Estate Kuršumlija), 13.3% in the Forest Administration Kraljevo (Forest Estate Kraljevo) (Tabaković-Tošić, 2011, 2012, 2013, Tabaković-Tošić *et al*., 2013). In addition, a large number of the larvae brought from the field and subsequently grown in the laboratory conditions were infested by this pathogenic species (Tabakovic-Tosic *et al*., 2012).

Higher mortality rate of older gypsy moth larval instars was reported in the forest complexes of Belgrade, Valjevo, Krupanj, Kučevo, Kragujevac, Kraljevo, Kruševac, Vrnjačka Banja, Brus, Blace, Donji Milanovac, Negotin and Leskovac regions, in the culmination phase of the new outbreak of the gypsy moth in Serbia. Field and laboratory studies showed the presence of conidia and resting spores of the entomopathogenic fungus *Entomophaga maimaiga* which was the cause of the mortality. This has been the first reports of occurrence of this species in Serbia, i.e. Serbia is the third European country in which this fungus has been reported. 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 (Tabaković-Tošić, 2012, 2013, Tabaković-Tošić et al, 2012, 2013).

Taking into account the significance of the biotic agents of the damage and their capacity of rapid and free spreading, i.e. transmission to huge areas in short time intervals, the regulations of plant protection – forest protection identify the measures and commitments of forest owners and users, which have to be carried out in the aim of preventing the occurrence, detection and control of plant diseases and pests (Forest Law and Law on Plant Protection against Plant Diseases and Pests). Also, taking into account the reports by the professional service, which as ordered by the Directorate of Forests, the Institute of Forestry in Belgrade, with forest protection specialists from PE Srbijašume, PE National Park Đerdap, PE Borjak Vrnjačka Banja, Faculty of Forestry, University of Belgrade and Serbian Orthodox Church – Monastery Forests (the institutions which are authorised for the activities of the Report-diagnose-forecast service in the field of plant protection – forest protection), inspected the broadleaf forests of the Central Serbia, in the aim of registering the area infested by the gypsy moth, and determining the infestation intensity. During the period autumn-winter 2010-2011, 2011-2012 and 2012-2013, the gypsy moth was suppressed in egg stage by mechanical (removal and burning)

and chemical methods (soaking in oil and petroleum) on the total area where weak and medium attack of gypsy moth were determined.

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GYPSY MOTH (*Lymantria dispar* L.) OUTBREAKIN THE CENTRAL PART OF REPUBLIC OF SERBIAIN THE PERIOD 2010-2013

Mara TABAKOVIĆ-TOŠIĆ

Summary

During the last seventy years in Serbia, the gypsy moth (*Lymantria dispar* L.) had six outbreaks of acute type, i.e. 1945-1950, 1952-1957, 1961-1966, 1995-1999, 2003-2006 and 2010-2014 (2015). During the progradation years of the current outbreak which is still in progress (2010-2011, 2011-2012) the gypsy moth infested the forests of the central part of Republic of Serbia, the area of 9,021 ha and 30380 ha. The culmination occurred in the periods 2012-2013 and 2013-2014, i.e. the infested territory covered 184,444 ha and 339,987 ha.

At some localities the number of oviposited egg masses per unit area (ha) amounted to more than 50,000. The average number of eggs in an egg mass ranged from 504.8 (2011) to 579.7 (2010). The egg mass with the largest average number of eggs (11038.6) was submitted to the Institute in 2012 from Forest Estate Severni Kučaj Kučevo, Forest Administration Kučevo, Management Unit Brodica. The percentage share of vital eggs in the total number of eggs ranged, averagely, from 84.5% in 2013 to 96.1 in 2012. Average parasitism of eggs in egg masses at the study localities ranges from 2.8% in 2012 to 14.8% in 2013 The average rates of parasitism should not be taken as final ones, because under these laboratory conditions it is not possible to determine the effect of a series of parasites and predators, to which egg masses are exposed in the field.

During the observed period, in the gypsy moth populations, the activity of 56 natural enemies of this insect - 19 predators, 28 parasites, 7 parasites or saprophages and 2 pathogens -was reported, but their activity was insufficient for a radical reduction of the gypsy moth population density. Exception to this were Belgrade and Valjevo region, where entomopathogenic fungus *Entomophaga maimaiga* caused the collapse of the outbreak in 2011 and 2012.

GRADACIJA GUBARA (*Lymantria dispar* L.) U PODRUČJU CENTRALNE SRBIJE U PERIODU 2010-2013. GODINE

Mara TABAKOVIĆ-TOŠIĆ

Rezime

U proteklih sedamdeset godina u Srbiji, gubar (*Lymantria dispar* L.) je šest puta stupio u gradacije akutnog tipa i to 1945-1950., 1952-1957., 1961-1966., 1995-1999., 2003-2006. i 2010-2014. (2015.) . U progradacionim godinama zadnje gradacije koja je u toku (2010-2011., 2011-2012.) gubar se javio u šumama centralnog dela Republike Srbije na površini od 9,021 i 30,380 ha. U periodu 2012-2013. i 2013-2014. godine došlo je do kulminacije, odnosno širenja teritorija pod napadom na 184.444 i 339,987 ha.

Na nekim lokalitetima broj položenih jajnih legala po jedinici površine (ha) iznosio je i više od 50.000. Prosečan broj jaja u jajnom leglu se kretao od 504,8 (2011.) do 579,7 (2010.). Jajna lgla sa najvećim prosečnim brojem jaja u njima (11038,6) su dostavljena Institutu u 2012. godini iz Šumskog gazdinstva Severni Kučaj Kučevo, Šumske uprave Kučevo, gazdinske jedinice Brodica. Procentualno učešće vitalnih u ukupnom broju jaja kretao se u proseku od 84,5% u 2013. do 96,1 u 2012. godini. Prosečna parazitiranost jaja u jajnim leglima je iznosila od 2,8% u 2012. do 14,8% u 2013. Prosečne stope

parazitizma ne treba shvatiti kao konačne, budući da u kalkulaciju nisu uvrštene vrednosti dobijene prilikom terenskih istraživanja.

Tokom ovih istraživanja, u populacijama gubara, uočena je pojačana aktivnost 56 vrsta njegovih prirodnih neprijatelja - 19 predatora, 28 parazita, 7 parazita ili saprofaga i 2 patogena, ali je njihova aktivnost bila nedovoljna da radikalno umanji populacionu gustinu domaćina i dovede do kolapsa gradacije. Izuzetak od ovoga se desio u šumama Beogradskog i Valjevskog regiona, gde je entomopatogena gljiva *Entomophaga maimaiga* uzrokovala kolaps gradacije u 2011. i 2012. godini.

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SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
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UDK 630*172.8 Trametes versicolor (Fr.) Pil.+630*443=111
Original scientific paper

IMPACT OF THE EDIBLE MUSHROOM ON DESTRUCTION OF OAK WOOD

Miroslava MARKOVIC[1]*, *Snezana RAJKOVIC*[1], *Radovan NEVENIC*[1], *Aleksandar LUCIC*[1]

Abstract: *The main aim of this investigations has been directed on discovering of optimal conditions for developing of medicinal mushroom Trametes versicolor [Fr.] Pil. in order to compare it with the conditions for developing of the other competitive microorganisms, to discover the possibilities of performing a spontanous infection in natural condition. The optimum for its growth T. versicolor is at temperature values close to 29*^{0} *C, and the lowest growth was reported on the base substrate (3.81). In this fungus the initial pH 2.2 was not changed after 21 days of exposure, but the metabolic processes of the fungus at the beginning of exposure caused the mild changes of pH. The results shows that the conditions of temperature and pH, which are convenient for the fungi T. versicolor, are normaly present in nature, and that from that point of view these fungi could easily perform spontanous infection. Species T. versicolor is neither favourised nor inhibited by the environmental factors in comparison with the rival rot fungus*.

Key words: Mushroom, Wood Destruction, Oak, Infection

UTICAJ JESTIVE GLJIVE NA DESTRUKCIJU HRASTOVOG DRVETA

Izvod: *Osnovni cilj ovog istraživanja je bio usmeren na otkrivanje optimalnih uslova za razvoj lekovite gljive Trametes versicolor [Fr.] Pil. u poređenju sa uslovima za razvoj ostalih konkurentnih mikroorganizama, kao i istraživanje mogućnosti spontanih infekcija ovom gljivom u prirodnim uslovima. Konstatovano je da je optimum za rast T. versicolor je na temperaturnim vrednostima bliskim 29*^{0}*C. Najslabiji porast micelije zabeležen je na baznoj podlozi (3,81). Inicijalni pH 2,2 nije se promenio posle 21 dana izlaganja dejstvu gljive, ali su metabolički procesi gljive na početku izlaganja izazvali*

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blage promene inicijalnih pH vrednosti. Rezultati pokazuju da su uslovi temperature i pH koje su pogodni za gljivu T. versicolor normalno prisutni u prirodi, pa sa te tačke gledišta ova gljiva može lako izvršiti spontanu infekciju. Vrsta T. versicolor nije ni favrizovana, niti inhibirana činiocima životne sredine u odnosu na suprotstavljene gljive truležnice.

Ključne reči: gljiva, destrukcija drveta, hrast, infekcija

1. INTRODUCTION

Mushrooms are the earliest known fungal organisms used as food for their taste and aroma. They are very good sources of protein, vitamins, lipids and mineral elements. (David *et al* 2012). More than 270 mushroom species that exhibit medicinal properties. Although mushrooms vary widely in biology, it is likely that many of the medicinal compounds are shared among different species (Brown *et al*, 2002). *Trametes versicolor* [Fr.] Pil. is famous for its medicinal properties, and is very common in forests. *Trametes versicolor* [Fr.] Pil. is the dried fruiting body or mycelia of *Trametes versicolor* [Fr.] Pil. (alternative names: *Coriolus versicolor* (L. ex Fr.) Quel., *Polyporus versicolor*, *Polysticutus versicolor* Fr.) belonging to the Basidiomycetes class and Polyporaceae family. In China, is named *Yun Zhi* (i.e., cloud-like mushroom), probably due to the fact that its wavy surface is covered with fluff. *T. versicolor* is called "turkeytail" in some European countries because it is fan shaped; is zoned with shades of brown, white, and grayin color on the upper surface; and grows in overlapping clusters on dead logs. In Japan, *T. versicolor* is known as *kawaratake*, which means "mushroom by the river bank" (David *et al* 2012).

In the aim of the better disclosure of the nature of fungus *T. versicolor* as the wood-decaying fungus, the investigations of the basic conditions which determine and enable the fungus to perform the infection were done. Under natural conditions the basic determinants of this process are temperature, pH of substrate, status of nutrients in the substrate, the level of inoculum, virulence and the competition of other microorganisms (Darrel, 1985; Chu, 2002; Markovic *et al*, 2003). In this sense, the influence of the temperature and concentration of hydrogen ions in the substrate was studied, since these are the basic parametres of the environment in which all process of the infection and the rot development are performed during the certain period of time (Karadzic and Andjelic, 2002; Lee *et al*, 2008; Markovic *et al*, 2012).

2. MATERIALS AND METHODS

2.1. Investigation of the influence of temperature on the growth of mycelium

The investigation of the speed of the growth of mycelium have been performed by the standard method, in the plastic petri dishes (D = 90 mm), on the base of malt (5 Bé) and agar (2%), at pH=6.0, and in the complete darkness. The growth of the mycelium at temperature 5, 8, 12, 16, 21, 25, 29 and 34^0C in three replications was monitored. The inoculums were set, because of the speed of the

growth of mycelium, by the wall of petri dish, and the growth of the mycelium was marked every 24 hours, in the direction of the radius of the dish and to the left and right under the angles of 22.5^0 (three directions) and expressed as the mean value in all replications in millimeters a day.

2.2. Investigation of the influence of pH substrate on the growth and production of mass mycelium

For the investigation of the different observed pH values on the development of mycelium of *T. versicolor* species, the buffered media was prepared. In order to equalize the quantity of the nutrients in the certain parts of buffer, the buffered system was prepared according to the illustrated recipe, by Wolpert method, which was used by several authors (Miric, 1993a; Jankovský *et al*, 2002). By mixing the different volumes 0.3 molar suspensions of phosphate – phosphoric acid (H_3PO_4), potassium-dihydrogen-phosphate (KH_2PO_4) and potassium-hydrogen-phosphate (K_2HPO_4) the bases with the different pH values were obtained, but with the same quantity of phosphate, so that their different quantity would not influence the results. In this way five series of phosphate of 187.5 ml which were poured into 5 erlenmayers, the volume of which was 300 ml.

A thousand milliliters of the double concentrated melt base was separated and prepared on melt (10 Bé sugar) and agar (4%), which was poured in 5 erlenmayers of 300 ml volume (of 187.5 ml). This base was autoclaved independently of 0.3 molar suspensions of phosphate and upon the check of pH they were mixed under the sterile conditions. The pH was controlled after the sterilization in order to determine the stability of buffered systems. In this way the base of the standard concentration (5Bé sugar and 2% agar) was obtained, with the physiologically equal percentage of buffer (0.15M). The buffered base which prepared in this way was poured (20 ml each) into the plastic petri dishes ((D=90 mm). For each studied pH value 3 replications were used.

The inoculation was performed in the laminar chamber, by mycelium circle-shaped fragments (D=11 mm), which were set by the rub of the petri dishes. The cultures developed in the thermostat, at 21^0 C. The growth of mycelium was marked every 24 hours, in three directions – in the direction of the radius, and at the both sides of it under the 22.5^0 angle. The average daily growth has been determined as the mean value of the growth in these three directions, and the number of days of measurement depended upon the speed of fungus growth at certain (constant) pH values of the nutritive substrate. In order to check the stability of the buffered system (check of pH substrate at the end of the investigation), the liquid base was simultaneously prepared, which was inoculated and incubated under the same conditions. At the end of the experiment pH values of substrate were measured, by digital pH meter Iskra MA 5735.

2.3. Investigation of the influence of mycelium on the change of pH nutrient substrate

For the study of the influence of fungus *T. versicolor* on the change of the pH value of the nutritive substrate, the unbuffered (liquid) media was prepared, according to Schmidt and Liese method (Schmidt, 1994). The quantity of 2,600 ml of the double concentrated melt base (10 Bé sugar) was prepared with the distilled water. Of this quantity 408 ml were poured into 6 Erlenmayer bottles, 500 ml volume (for 6 series) and according to the illustrated recipe in the defined quantity the suspension of distilled water and 1M HCl, or 1M NaOH was added. In this way the needed quantity of the liquid nutritive melt base of the standard concentration (5 Bé sugar) was obtained. Before the sterilization pH values if each series were measured. From each series 120 ml of base were poured into 3 erlenamayers 300 ml volume (for one fungus, in 3 replications), so from 6 series the base was poured into 18 erlenmayers, which were sterilized in the autovlave 20 minutes at 120 ± 1^0C temperature and 1.4 pressure. After the sterilization pH values were re-measured and they were treated as initial.

The inoculation by *T. versicolor* fungus was performed in the laminar chamber, by circle-shaped mycelium fragments (D=11 mm). For each series (initial value pH) the bases were inoculated in 3 erlenmayers.

The incubated lasted for 21 days at 21^0 C. During the incubation the alternation in pH was measured at every 7 days. For each measurement by sterile sprinkles with needles 10 ml of base was extracted under the aseptic conditions, poured into the cuvettes and pH values were measured by the digital pH meter Iskra MA 5735.

3. RESULTS AND DISCUSSION

The basic precondition for the understanding of the conditions which make it possible for the fungus to colonize the wood is the knowledge of its main physiological characteristics (Miric, 1993b). The fungi isolated from the natural habitats, and then moved and grown in the laboratory conditions, are found in the unusual conditions of existence, which causes their rather different physiological activity (Vucetic, 1998; Markovic *et al*, 2005).

It happens because it is hard to make conditions in the laboratory which adequately reflect the environmental conditions and variation in only one factor without the mutual influence (Rayner and Boddy, 1998; Markovic *et al*, 2011). Therefore, the results obtained by the most accurate laboratory methods cannot be directly applied for the natural conditions as well, and they should be accepted only as the probable indicators of the possible phenomena.

The organisms with the same temperature requirements are rarely found in nature. According to the literature data, the temperature interval of the development of epixylous fungi range between 0 and 40 degrees. Each fungus have the limit temperatures (minimal and maximal at which the development stops) and the optimal temperatures of development, which are closer to maximal than

minimal ones. The absolute maximal and minimal temperatures are lethal and do not allow the reverse process.

3.1. The influence of temperature on the growth of mycelium

Petrovic (1980) is of the opinion that the real temperature values are always two or three degrees lower than the values obtained in the laboratory conditions. The results of the laboratory study of the influence of different temperatures on the growth of mycelium *T. versicolor* are presented in the Table 1.

Table 1. *The average daily growth of mycelium at different temperatures*

Temperature °C	Average growth of mycelium (mm/day)
5	0.78
8	1.18
12	2.26
16	3.25
21	4.73
25	5.57
29	8.38
34	6.05

At 29^0 C the growth of mycelium of fungus *T. versicolor* is 8.38 mm/day, so it can be concluded that the optimum for its growth is at temperature values close to 29^0 C. *T. versicolor* developed at all investigated temperatures, but the growth of it was lower at lower temperatures (at 5^0 it is only 0.78 mm/day, while at 34^0 it is as high as 6.05 mm/day).

3.2. Influence of pH values of substrate on the growth and production of the mass of mycelium

The concentration of H ions influences the growth and metabolism of the rot fungi, as well as the development of all plant species (Jankovský *et al*, 2002). Substrate acidity can influence the stimulation or inhibition of the growth of epixylous fungi, and the change of pH value has the important influence on the velocity of consumption of nutrients and substrate decomposition (Miric, 2005).

3.2.1.Influence of pH substrate on the growth of mycelium

From the Table 2 it can be seen that the growth of the studied species *T. versicolor* was highest (3.81) on the less acid substrate.

Table 2. *The average daily growth of mycelium on the buffered (solid) bases*

Number of series	pH bases		Average growth of mycelium (mm/day)
	Initial pH (after sterilisation)	pH at the end of the experiment	
1	3.2	3.1	1.59
2	3.8	3.6	3.25
3	4.8	4.1	3.81
4	6.0	5.0	2.24
5	7.2	6.5	1.15

The lowest growth (1.15) was reported on the base substrate. According to the control series in the liquid bases, it was concluded that the studied species changed the initial pH by moving it to the optimal values, which is in the limits of tolerance, and, thus, can be considered that all buffered systems were stable during the experiment.

3.2.2. Influence of mycelium on the change of pH nutritive substrate

The results presented in Table 3 show that the greatest change of the initial pH value occurred at the initial pH and is 2.1. In this fungus the initial pH 2.2 was not changed after 21 days of exposure, but the metabolic processes of the fungus at the beginning of exposure caused the mild changes of pH.

Table 3. *Change of pH values of base under the influence of mycelium*

Number of series	Initial pH (after sterilisation)	The change of pH base after the certain number of days				Weight of the dry mass of mycelium (g)
		7 days	14 days	21 days	Total change pH	
I	2.2	2.4	2.1	2.2	0.0	0.048
II	2.8	2.9	2.9	2.5	-0.3	0.227
III	4.2	4.5	4.1	3.8	-0.4	0.447
IV	4.8	4.8	3.8	3.8	-1.0	0.359
V	5.4	5.5	4.1	3.9	-1.5	0.581
VI	6.2	5.4	4.0	4.1	-2.1	0.488

The weight of the dry mass of mycelium is the greatest in the fifth series, and smallest in the first one, in which there were no changes of pH. It means that this fungus poorly develops on extremely acid substrates and that in this case the change of pH would also happen undoubtedly, but after a longer period of action. It can be said that the less acid substrate close to the pH value 5.4 are more favourable for the development of the fungus *T. versicolor.*

4. CONCLUSION

Temperatures which are optimal for the conclusion of the investigated fungus are at the same time favourable for the growth and development of the numerous species of rot fungi. Therefore, one has to take into account that *T.versicolor* has a great number of rivals in food and environment, which also develop at temperatures which are more favourable for it.

The change of the pH value of substrate on which the cultures *T.versicolor* moved into the direction of the mildly acid reaction, which points to the fact that it, like the majority of rot fungi, prefers the weak acid base. This fact, as well as the former one – regarding the temperature, implies that *T.versicolor* in the competitive relations with other rot fungi conquer the substrate with the equal changes for success, at least regarding the temperature and H- ions concentration.

Given the results of the study of the influence of the temperature and H- ions concentration on the growth and production of mass of mycelium of fungus *T.versicolor*, as well as the change of pH substrate under the influence of this fungus, regarding the possbility for the successful colonisation of the nutritive base

in the nature conditions, it can be concluded that the studied species is neither favourised nor inhibited by the environmental factors in comparison with the rival rot fungus. The phenomenon of the competition of the microorganisms on the same substrate, of the growth inhibition or the occurance of the antagonism can be the consequence of the metabolism of the opposing fungi species, mycotoxins secretion or antibiotics in front of the increasing mycelial front and senstivity, i.e. the reaction of the competative species to it.

Not only the speed, course and consequences of the wood decomposition as substrate and food source do directly depend upon this phenomenon, but also the wood as the very important raw material for procession in the industries of all countries and which is, because of its organic origin, food for a great number of organisms and microorganisms. For this reason it is necessary to investigate the competative relations of this and other competive rot fungus in the controlled conditions, in so-called mixed cultures, in the conditions of moisture, temperature and H-ions concentration which are convenient for all species of the competative fungi.

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IMPACT OF THE EDIBLE MUSHROOM ON DESTRUCTION OF OAK WOOD

Miroslava MARKOVIC, Snezana RAJKOVIC, Radovan NEVENIC, Aleksandar LUCIC

Summary

The investigations of impact of temperature and concentration of H - ions on the growth of fungi *Trametes versicolor* (Fr.) Pil. have been performed *in vitro*. These factors, besides the status of nutrients in substrate, level of inocula and virulence, which undoubtly have to be treated as necessarry in process of colonisation and destruction of the wood, use to be of the crutial significance for performing of infection.

Temperature and pH could be the limiting factor for development of numerous competitive microorganisms colonising the same nutritive substrat.

In order to estimate the impact of these species on succession of microorganisms on the same substrate, it has been investigated the influence of *T. versicolor* on the changing of pH of substrate during it's growth by using unbuffered nutritive media. From the other side, impact of pH of substrate on the fungi has been investigated by using buffered nutritive media with stabile pH values during the test. The results shows that the conditions of temperature and pH, which are convenient for the fungi *T. versicolor*, are normaly present in nature, and that from that point of view these fungi could easily perform spontanous infection.

Therefore, at the same time, optimal conditions for the growth of these fungi are also very convenient for the development of other numerous decaying fungi, so that the question of success of infection is emphasized in the light of competitive relations of microorganisms at the same nutritive substrate.

Not only the speed, course and consequences of the wood decomposition as substrate and food source do directly depend upon this phenomenon, but also the wood as the very important raw material for procession in the industries of all countries and which is, because of its organic origin, food for a great number of organisms and microorganisms. For this reason it is necessary to investigate the competative relations of this and other competive rot fungus in the controlled conditions, in so-called mixed cultures, in the conditions of moisture, temperature and H-ions concentration which are convenient for all species of the competative fungi.

UTICAJ JESTIVE GLJIVE NA DESTRUKCIJU HRASTOVOG DRVETA

Miroslava MARKOVIĆ, Snežana RAJKOVIĆ, Radovan NEVENIC, Aleksandar LUČIĆ

Rezime

Istraživanja uticaja temperature i koncentracije H - jona na porast gljive *Trametes versicolor* (Fr.) Pil. su izvršena *in vitro*. Ovi faktori, pored statusa hranljivih materija u supstratu, nivoa inokuluma i virulentnosti, koje nesumnjivo treba da tretirati kao neophodne u procesu kolonizacije i destrukcije od drveta, su od krucijalnog značaja za uspeh infekcije.

Temperatura i pH mogu biti ograničavajući faktor za razvoj mnogih konkurentskih mikroorganizama pri kolonizaciji istog hranljivog supstrata.

Da bi se procenio uticaj ove vrste na sukcesiju mikroorganizama na istom supstratu, istraživan je uticaj *T. versicolor* na promenu pH podloge u toku njenog razvoja, korišćenjem nepuferovanih hranljivih podloga. Sa druge strane, uticaj pH supstrata na gljivu ispitan je korišćenjem puferovanih hranljivih podloga sa stabilnim vrednostima pH tokom ogleda. Rezultati pokazuju da su uslovi temperature i pH, koji su pogodni za gljivu *T. versicolor*, inače normalno prisutni u prirodi, pa ona može sa jednakim šansama za uspeh izvršiti spontane infekcije.

Dakle, u isto vreme, optimalni uslovi za rast ove gljive su takođe veoma pogodni i za razvoj drugih brojnih konkurentnih mikroorganizama, tako da pitanje uspeha infekcije zavisi od njihovih međusobnih odnosa na istom hranljivom supstratu.

Od ovog fenomena direktno će zavisiti brzina, tok i posledice razlaganja drveta kao supstrata i izvora hrane, ali i drveta kao, za ekonomiju svake zemlje, veoma važne sirovine za preradu koja zbog svog organskog porekla i predstavlja hranu za veliki broj organizama i mikroorganizama. Iz tog razloga potrebno je istražiti kompetitivne odnose ove i drugih konkurentskih vrsta truležnica u kontrolisanim uslovima u tzv. smešanim kulturama, pri uslovima vlage, temperature i koncentracije H – jona koje odgovaraju svim vrstama suprotstavljenih gljiva.

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ASSESSMENT OF THE SYSTEM OF FUNDING OF PROTECTED AREAS IN THE REPUBLIC OF SERBIA

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Abstract: *The system of funding of protected areas in Serbia represents a complex structure, composed of different actors, regulations and competences. Protected areas cover ~ 5.89% of the territory of the Republic of Serbia and funding of protected areas represents a key component of their functioning, since all activities in protected areas depend upon it. Funding was analysed through application of survey technique, aimed at obtaining an estimate of the impact of specific funding methods. The method of funding of protected areas were classified into six categories and analysed by the survey. The elements of protected area funding with the strongest impact are the primary activity (wood production) and subsidies obtained from the republic and local authorities. Although in many protected areas revenue generated from tourism represents an important funding component, its contribution is not very significant in Serbia. If this form of revenue is diversified in the following period, by means of improvement of infrastructure and protected area offerings, higher revenues from this activity may be expected.*

Key words: protected areas, funding mechanisms, importance of primary activity and subsidies

ПРОЦЕНА СИСТЕМА ФИНАНСИРАЊА ЗАШТИЋЕНИХ ПОДРУЧЈА У РЕПУБЛИЦИ СРБИЈИ

Извод: *Систем финансирање заштићених подручја у Србији представља комплексну структуру различитих актера, правила и надлежности. Заштићена подручја покривају површину од ~5,89 % територије Републике Србије и стога финансирање ЗП представља кључну компоненту, јер од њега зависе активности које се спроводе у ЗП. Финансирање је истраживано кроз примену технике анкете у*

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циљу добијања процене утицаја појединих начина финансирања. Начини финансирања ЗП су груписани у шест категорија које су кроз анкете анализирани. Елементи финансирања ЗП који имају највише утицаја је примарна делатност (производња дрвета) и дотације од стране републичких и локалних органа. Иако приходи од туризма у многим ЗП представљају битну компоненту финансирања, код нас они немају велики утицај. Уколико се у наредном периоду овај вид прихода диверзификује, кроз унапређење инфраструктуре и понуде ЗП, могу се очекивати већи приходи од ове делатности.

Кључне речи: заштићена подручја, механизми финансирања, значај примарне делатности и дотација

1. INTRODUCTION

Serbia, as a prospective EU member state, has already initiated certain processes related to introduction of legislative reforms and adoption of norms and regulations on management of protected areas. Hence, the system of protected areas (PAs) in Serbia represents a complex structure, composed of different actors, rules, competences and institutions involved in functioning of PAs. The Law on Nature Protection (2009) was one of the basic pillars of nature protection in Serbia. This law defines various forms of management in protected areas, as well as the types of protected areas. In addition, the Law on Nature Protection stipulates basic principles of protection, both from the aspect of nature protection on the one hand, and financing, improvement, control measures and implementation of its principles on the other hand. After a long period of usage of the term 'natural protected area', which encompassed several different terms and implied protection of species and heritage, this term was divided into three: protected areas, protected species and mobile protected natural documents. The protected areas are defined as areas with a distinct geological, biological, eco-system and/or landscape diversity and as such they are designated as 'protected areas of general interest', by a nature protection act. On the other hand, the International Union for Conservation of Nature (IUCN) defines protected areas as a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means[1], to achieve the long-term conservation of nature with associated 'ecosystem services' and cultural values (Emerton, L. et al. 2006).

Natural resources, along with protected areas, represent a 'treasure of mankind and attributes of economic, social, political and cultural systems of any country' (Nevenić, et al. 2009). Protection of natural property and, hence, protection of certain areas has a long history, both in the Republic of Serbia and Europe, the USA and other countries worldwide. The concept of nature protection was originally developed as a result of the need aristocracy had for privacy and their own hunting space in isolated areas. Many European forests in the last one thousand years enjoyed precisely that type of protection and were used as hunting

[1] This entails recognising protected areas by means of certain laws, international conventions or agreements. PA management, by application of legislative and other measures, must be effective but in conformity with legislation and traditional methods of use.

areas (Martinić, 2010). One of the oldest protected areas on the territory of the Republic of Serbia is 'Obedska Bara', protected in 1874, which is presently under one of the strictest forms of protection. Protection of Biogradska Gora in Montenegro dates back to 1878 and it is one of the oldest nature reserves in the world (Curovic et al 2011).

In the 20th century, the expansion of protected areas became more evident. One of the first laws on nature protection in the Republic of Serbia, designating Fruška Gora as a national park (NP), dates from 1960, while the boundaries of this National Park were precisely defined by the Law of 1977 (Đorđević, 2009). There are seven categories of protected areas and several management categories distinguished within the framework of the PA management system in Serbia (Đorđević, 2009). PA funding is directly defined by the Law on Nature Protection and the Law on Forests, while indirectly through a series of sub-legal documents and bylaws. The following three models of funding are defined in the system of PA funding (Đorđević, et al. 2013):

a) budget of the Republic of Serbia – subsidies;
b) revenues generated by an organisation managing a national park (NP);
c) donations

Direct funding through subsidies can be performed through the budget of the Republic of Serbia, funds of the autonomous provinces (AP) and funds of local self-government units. Revenues generated by an organisation managing an NP can include fees for the use of PA, revenues generated from performing economic activities and managing an NP and the funds obtained through realisation of programmes, plans and projects in the field of nature protection (Đorđević, 2009). The final category includes donations, gifts and aids, of the domestic and international character. On the other hand, from the aspect of the method of generating and use of revenue, NP funding can be classified into three categories (Sprugeon, et al. 2009).

The subject of the study of this paper is the structure of PA funding and its importance for PA management. The purpose of the study is to determine, by means of comparison, the importance of various categories of funding, both in terms of financing, and in terms of a PA size. The key objective is to determine the importance of certain elements of funding and the differences in relation to a PA size.

2. MATERIAL AND WORK METHOD

Contingent upon the study needs and objective, different general and specific scientific methods were employed. General methods, by their nature, can be employed for acquiring knowledge in all sciences and scientific disciplines. The general scientific method employed in this study is the statistical method, while the other general scientific methods include the hypothetical, deductive, analytical-deductive and comparative method (Šešić, 1984, Miljević, 2007). The specific scientific methods employed in the study are the method of analysis and synthesis, and the method of generalisation and specialisation, (Šešić, 1984). The methods and techniques of data processing represent procedures for gathering study data, as well as the instruments used in work. The method employed for gathering data is

an investigation, a technique frequently used in socio-economic studies. The investigation represents such method where gathering data is performed by means of indirect investigation. It is a method in which required information is obtained in the course of verbal communication with an examinee. An investigation can be divided into four categories according to a procedure, position, number and manner of investigation. The investigation procedure used in this study is neutral, while the position is direct, that is, an examinee was informed in advance about the investigation. The investigation was performed individually, while the investigation method, or technique, was a survey. A survey is conducted based on a sample, while an investigation is performed based on previously defined questions and forms. In addition to the questions of a closed type, the investigation also involved open type questions, where an examinee was able to provide an answer in written form. This survey was the basis for gathering data from the staff in protected areas (Nevenić, et al. 2008). The survey included six topics, covering the concept of good management, while this paper covers only one topic, related to PA funding. The total number of analysed surveys is 49.

The method employed for data processing is the SPSS programme, in which examinees' answers are entered and later processed by means of statistical methods. For the purpose of determining the impact of different sources of funding on PA management, frequency analyses, which involved a PA size, a PA source of funding and shortcomings of PA funding system, were applied. In order to analyse the impact of a PA size on funding, all PAs were divided into three categories according to surface area. By means of use of the visual binning[1] technique, PAs were divided into three categories in order to identify differences in the method of management between larger and smaller PAs (below 456ha, between 456 and 7,543ha and over 7,543ha). These PA categories based on surface area were later used for comparison with the sources of funding, for the purpose of determining a statistically significant impact. Given the fact that the analysis indicated that data were not regularly distributed, the non-parametric 'Mann-Whitney-U' test was used, which pointed out to a statistical significance between the two studied variables.

3. RESULTS AND DISCUSSION

The PA funding system in Serbia represents a set of different mechanisms, both on republic, provincial and local level, as well as on the level of the management itself. On the republic level, there are two competent ministries and several agencies providing financial support through subsidies for projects in various fields. Such form of budget funding represents the first model of funding in the system of PA management in Serbia. It represents a very important component of the management of PAs, recognised both in Serbia (Đorđević, 2009) and at the international level (Ornat et al., 2006). According to the method of allocation of funds, budget funding can be divided into direct and indirect. Direct budget funding includes PA fund allocations at the level of local self-governments, autonomous provinces and the republic level. Following the adoption of the budget

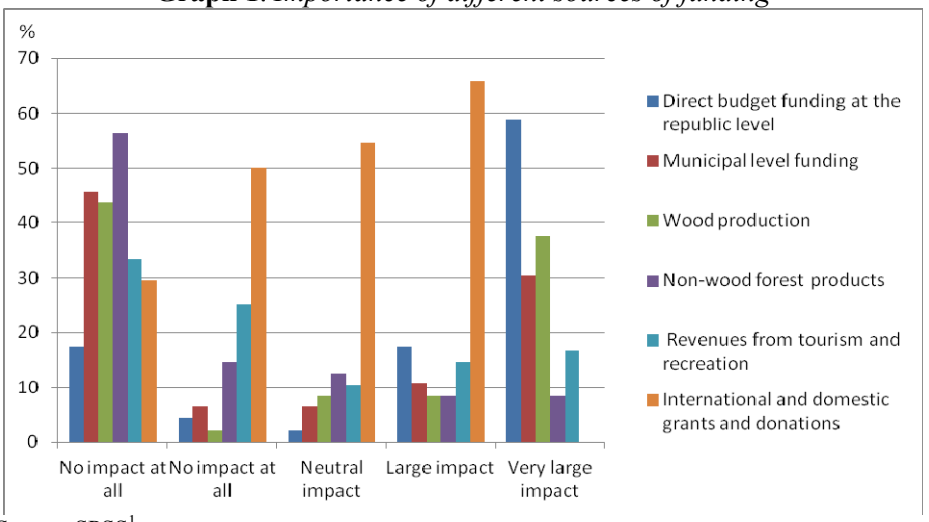
[1] This technique, in the SPSS programme, enables PA grouping according to a number of samples

at the Republic level, certain funds are transferred to local self-governments and autonomous provinces. At the level of the Autonomous Province of Vojvodina, there are two Provincial Secretariats (PS), PS for urban planning, construction and environmental protection and PS for agriculture, water management and forestry, responsible for PA management and thus representing another source of PA funding. The last form of direct funding having impact on PA management refers to funding provided by local self-governments. Indirect budget funding is performed through fees and charges collected by local self-governments on their territories; as such, those fees are not part of the Republic funding. At the level of large towns in Serbia (Belgrade, Novi Sad, Kragujevac, Niš, Obrenovac), there are Environmental Protection Secretariats, which directly finance certain activities in PAs. In addition, large industrial towns establish their own Environmental Protection Funds, which represent another funding mechanism. Another group of PA funding concerns financing performed by PA managements (Đorđević, 2009).This type of funding belongs to a group of mechanisms relying on revenues that an organisation managing a PA generates on a PA territory. These financing mechanisms are market oriented and represent an important source of PA funding (IUCN, 2003). According to the method of generating these revenues, they are divided into: a) tourism revenues b) revenues from use of PA resources and c) payments for eco-system services. Revenues generated from tourism and recreation may have a considerable importance for PAs. During a year, a large number of tourists visit PAs and some of them may represent a source of considerable revenue through entrance fees and recreational activity fees. Tourism-generated revenues include PA entrance fees and fees imposed for use of recreational services, fees collected from hotel and tourism organisations (parking, camping, bike renting, bird watching, etc) (Koteen, 2004, Đorđević, 2009). PA funding is also performed through use of a PA resource itself. A PA resource includes everything that is located within a PA territory and everything within the borders a PA territory. More precisely, a resource encompasses not only wood and non-wood products, but also the entire territory within PA boundaries. These funding elements were further analysed through surveys conducted directly in the field or by mail. In order to assess the impact of these funding elements, six groups of funding mechanisms were identified:

1. direct budget funding from the competent ministries and state funds;
2. municipality level funding;
3. wood production;
4. collection and sale of non-wood forest products;
5. revenues generated from tourism and recreational activities;
6. international donations.

The impact of the above-mentioned funding elements on all PAs, providing answers to survey questions, were presented in the graph below.

Graph 1. *Importance of different sources of funding*



Source: SPSS[1]

As can be seen from the above, direct budget funding has a considerable impact on PA management, since more than 58.7% of examinees marked this form of funding. When the answers marking both 'large impact' and 'budget funding' are singled out, the obtained results indicate that this form of funding is certainly an important component of PA management. The local level funding is not that important (45.7%), nor is the funding obtained from non-wood forest products (56.3%). A financial source, such as direct allocations at the republic level, recorded a positive exponential trend (1.4%) in the funding of all NPs in Serbia. If exponential trends of different forms of revenue in all NPs in Serbia for the period 2008-2012 are compared, NP Tara (NPT) recorded the highest values (14%), whereas NP Fruška Gora (NPFG) recorded the lowest values (-21.8%) (Đorđević et al., 2013). Subsidy allocations in comparison to gross domestic product (GDP) in Serbia in 2008 accounted for 0.0025%, whereas the Republic of Croatia allocations to NPs in the same period accounted for 0.0052% of the GDP (2008 and Spurgeon, 2009). In addition, a negative *I*s (-2.6 %) is also present. In 2004, Croatia allocated 0.028% of its GDP to all protected areas (Mansourian et al., 2008), while there are no similar data for Serbia for a long-term period. Funding generated from wood production elicited conflicting opinions among examinees. On the one hand, 43.8% examinees stated that this form of funding is not relevant at all, while 37.5% considered it very important. This may be a result of the fact that certain PAs, (such as NPs and nature parks), depend upon the primary activity, whereas other PAs are more oriented towards tourism and state subsidies. The study conducted in five national parks in the period 2008-2012 (Đerdap, Kopaonik, Tara, Fruška Gora, Šar Planina) indicated that revenues generated from sale of goods and services accounted for 64.9% of the total revenue and those revenues showed a positive exponential trend (6.4%) (Đorđević et al., 2013). Tourism, as a form of revenue,

[1] Data are processed in the SPSS programme during the work on the PAGOV Project and the Forest Management Project

has no significance at all for 33% of examinees; only 16.7% of examinees find it very important, while the international subsidies are very important for 65.9% of examinees. Specific studies for these two forms of funding have not been conducted in Serbia. There is a study carried out in Croatia, indicating that the revenues generated from tourism account for 6-80% of the total revenues (Spurgeon, 2009).

Recreation as a form of tourism in protected areas represents an additional value (Cvejić, 2008) that ought to be further developed in order to improve and enrich the content of PAs. The examples of adaptation of forest and forest land to recreational tourism are numerous, and they include eco and ethno tourism, educational and tourist paths, bird-watching, cycling paths, adventure parks, etc. (Poduška et al., 2011). Additionally, recreation in PAs, as a form of tourism, can supplement budgets of local and republic governments. The studies conducted in developed countries indicate that revenues generated from this activity experience a constant increase (Nevenić, 2006).

This segment of the study also included questions of open type related to PA funding. Within this segment, examinees specified exactly where funds were lacking and for what purposes. All questions were entered into the SPSS programme, and then, by means of qualitative technique, such is transcription, the answers were classified into six categories. The abovementioned categories are the following:

1. direct budget funding from the competent ministries and state funds;
2. funding at the municipal level;
3. wood production;
4. collection and sale of non-wood forest products;
5. revenues from tourism and recreation;
6. international donations.

As mentioned previously, a comparative analysis involving a PA size and importance of financial categories was conducted for the purpose of determining differences in funding methods. Hence, three categories of protected areas, classified according to surface area (below 456ha, between 456 and 7,543ha and over 7,543ha), were analysed. By application of the non-parametric Mann-Whitney-U test, statistical significance of the following values (surface area and funding categories) was determined.

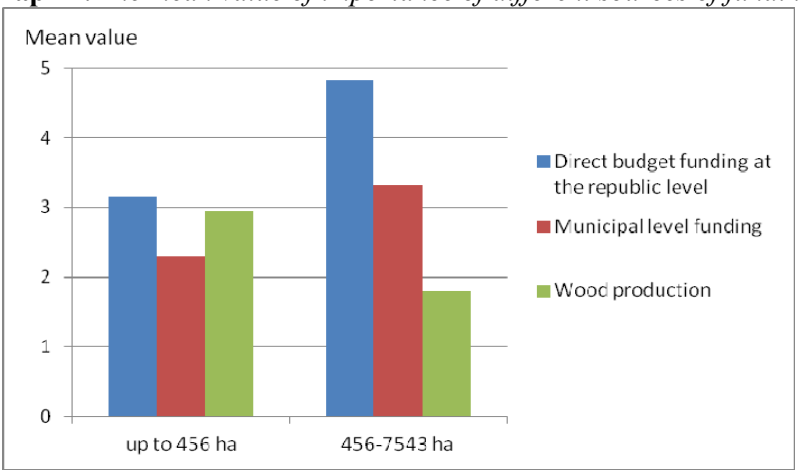
Table 1. *Impact with respect to funding method and PA surface area (below 456ha and 456 - 7,543ha)*

	Direct budget funding at the republic level	Municipal level funding	Wood production	Non-wood forest products	Revenues from tourism and recreation	International donations
Mann-Whitney U	65.500	90.000	82.500	110.000	101.000	85.000
Wilcoxon W	255.500	300.000	187.500	215.000	311.000	256.000
Z	-3.014	-2.143	-2.233	-1.266	-1.692	-1.921
Asymp. Sig. (2-tailed)	.003	.032	.026	.205	.091	.055

Source: SPSS

In the protected areas below 456ha and between 456 and 7,543ha, at $p<0.05$, the differences between direct allocations at the national, local level and wood production are statistically significant (Table 1). The impact of analysed values was determined by application of frequency analyses. These differences are presented in the graph below:

Graph 2. *The mean value of importance of different sources of funding*



Source: SPSS

Direct allocations at the republic level have a very strong impact on the PAs of surface area between 456 and 7,543ha, whereas that impact is of neutral character in the PAs below 456ha. A similar case is with allocations at the local level, where the impact on the PAs below 456ha is very low, while that impact is of neutral character in the PAs of the second category. The impact of wood production on PA management in the analysed categories slightly differs. In the PAs below 456ha, the impact of wood production is of neutral character, while in the PAs between 456 and 7,543ha, it is of very little importance.

Table 2. *Impact with respect to funding method and PA surface area (below 456ha and over 7,543ha)*

	Direct budget funding at the republic level	Municipal level funding	Wood production	Non-wood forest products	Revenues from tourism and recreation	International donations
Mann-Whitney U	78.500	99.000	85.000	125.000	117.500	89.500
Wilcoxon W	268.500	309.000	295.000	335.000	327.500	260.500
Z	-1.535	-.491	-2.089	-.558	-.487	-.443
Asymp. Sig. (2-tailed)	.125	.623	.037	.577	.626	.658

By comparison of funding importance and the two PA categories (Table 2), statistically significant differences with respect to importance of wood production (at $p<0.05$) were determined. In the PAs below 456ha, this category of funding is

of neutral character, whereas in the PAs over 7,543ha, it is of considerable importance. Although the difference is low, it could be concluded that it is statistically significant for funding of the PAs over 7,543ha, and that the primary activity is one of the main sources of basic revenue, used for financing of all other PA activities.

Table 3. *Impact with respect to funding method and PA surface area (456-7,543ha and over 7,543ha)*

	Direct budget funding at the republic level	Municipal level funding	Wood production	Non-wood forest products	Revenues from tourism and recreation	International donations
Mann-Whitney U	64.000	61.500	26.000	54.000	79.500	47.500
Wilcoxon W	142.000	127.500	131.000	159.000	170.500	113.500
Z	-1.650	-1.186	-3.610	-2.219	-.862	-1.892
Asymp. Sig. (2-tailed)	.099	.236	.000	.026	.389	.058

The final category of the analysed PAs refers to the PAs of the surface area between 456 and 7,543ha and over 7,543ha. By application of the aforementioned test, statistical significance ($p<0,05$) was determined for two financing methods (wood production and non-wood forest products). Application of frequency analysis on use of non-wood forest products determined no substantial differences in terms of importance, whereas its application on wood production identified the difference in importance for financing of PA activities. More precisely, in the PAs of surface area between 456 and 7,543ha wood production had a little impact, whereas in the PAs over 7,543ha this impact was of larger importance.

4. CONCLUSION

Based on the obtained results, it can be concluded that revenue generated from wood production, along with allocation of funds at republic and local level, represent a significant funding component for PA management. As a result of an increasing presence of international organisations in PA managing, international donations and aid represent funding components of growing importance; however, they are presently small and largely performed through international projects and support provided by republic institutions. In addition, revenue generated from tourism is of importance for certain PAs, however, statistical significance is determined only for allocations made by local and republic authorities and revenue generated form wood production. Furthermore, the impact of revenue from tourism is of importance for certain PAs; however, statistical significance is established only for allocations made by republic authorities and wood production. Financing of PA activities through wood production in the PAs of surface area between 456 and 7,543ha has only little impact, whereas in the other two analysed categories its impact is considerable. The reason for a low impact of this funding element in this PA category lies in the fact that PAs in this sample belong to the category of

special nature reserves, managed by non-governmental organisations and the church, as well as the PAs with no forest areas. If these facts and the answers specifying that funding depends entirely on primary activity, that is, wood production, are singled out, it can be concluded that most PAs finance their activities from wood-production. State funding, at the republic and local level, also proved statistically significant and that impact is of considerable importance, particularly in the PAs over 456ha. That points out to a large importance of financial allocations by state in the PAs covering large areas. Lack of importance of revenue generated from tourism is very common. Only certain managements pointed out to the importance of this element of funding, while PA surface area plays no importance in this respect. This reveals that PA management is not orientated on generating this form of revenue and that tourism in is not developed in PAs. One of the reasons for the above-mentioned could be a complicated procedure for introduction of tourism fees supposed to be collected by managements. Certain forms of tourism fees do exist in PAs, but the recipients are local communities, that is, municipalities.

For that reasons, PA funding methods should be improved and the source of their revenue diversified in the following period. One of the important funding component in the region and in the world is the revenues generated from tourism, not adequately developed in Serbia, whereas in some countries they represent the most important funding component, even more important than subsidies by local and regional state authorities. Subsidies, as a form of funding, must also be orientated on improvement of PA infrastructure, equipment and staff training in the field of protected area management. The future studies ought to determine the PA needs, with a view to enhancing PA tourism offering, and consequently, improving the sources of funding. Furthermore, for the purpose of creating the most effective funding mechanism possible, it is necessary to establish stable and long-lasting sources of funding at the level of competent ministries, thus enabling conditions for a continuous improvement of management in protected areas.

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ПРОЦЕНА СИСТЕМА ФИНАНСИРАЊА ЗАШТИЋЕНИХ ПОДРУЧЈА У РЕПУБЛИЦИ СРБИЈИ

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

Резиме

Финансирање заштићених подручја у Србији је једна од битних компоненара у систему управљања са ЗП. ЗП покривају ~5,89 % територије Републике Србије и њихова важност је веома битна зато што укључују подручја са очуваним природним екосистемима, пределе са културалним карактеристикама, која су издвојена из класичног коришћења природног ресурса. Србија као једна од будућих чланица Европске Уније (ЕУ) већ је започела одређене процесе усаглашавања свог законодавства као и усвајања одређених норми и правила у управљању са заштићеним подручјима. Систем заштићених подручја у Србији тако представља комплексну структуру различитих актера, правила, надлежности и институција укључених у рад ЗП. У систему финансирања ЗП одређена су три начина финансирања кроз буџет Републике Србије-дотације, на основу прихода остварених од стране организације која управља НП и донација. Како би се проценио утицај ових елемената финансирања издвојено је шест група механизама финансирања које су посматране у овом истраживању и упоредно приказане кроз три величине ЗП (до 456 ха, између 456-7543 и преко 7543 ха).

На основу добијених резултат може се закључити да управљачима ЗП битна компонента у финансирању представља приход добијен од стране производње дрвета као и издвајања на републичком и локалном нивоу. Због све већег присуства међународних организација у управљању са ЗП једна од компонената финансирања која све више има утицаја су међународне донације и помоћи, које су у овом моменту мале и углавном се спроводе кроз међународне пројекте и подршку која се пружа од стране републичких институција. Такође утицај прихода од туризма има значаја за поједина ЗП, али статистичка значајност је утврђена само за издвајања од стране локалних и републичких органа и производње дрвета.

ASSESSMENT OF THE SYSTEM OF FUNDING OF PROTECTED AREAS IN THE REPUBLIC OF SERBIA

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

Summary

Funding of protected areas in Serbia is one of the key components in the system of PA management. PAs cover ~5,89 % of the territory of the Republic of Serbia and are of great importance, since they include areas with preserved natural eco-systems, areas with cultural characteristics, singled out from the standard use of natural resource. Serbia, as a prospective EU member state, has already initiated certain processes related to introduction of legislative reforms and adoption of norms and regulations on management of protected areas. Hence, the system of protected areas (PA) in Serbia represents a complex structure composed of different actors, rules, competences and institutions involved in functioning of PAs. The system of PA funding involves three methods of funding – through the budget of the Republic of Serbia – subsidies, through the revenue generated by an organisation

managing an NP, and through donations. In order to assess the impact of these elements of funding, six groups of funding mechanisms were selected and comparatively presented through three different PA sizes (below 456ha, between 456 and 7,543ha and over 7,543ha).

Based on the obtained results, it can be concluded that the revenue generated from wood production, along with allocations at the republic and local level, represent important components of financing for PA management. As a result of an increasing presence of international organisations in PA management, international donations and aid represent funding components of growing importance; however, they are presently small and largely performed through international projects and support provided by republic institutions. Additionally, revenue generated from tourism is of importance for certain PAs; however, statistical significance is determined only for allocations provided from local and republic authorities and wood production.

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POSSIBILITIES FOR IMPROVEMENT OF THE MANAGEMENT OF PROTECTED NATURAL AREAS

Zoran PODUŠKA, Ilija ĐORĐEVIĆ, Radovan NEVENIĆ, Svetlana BILIBAJKIĆ, Renata GAGIĆ SERDAR, Goran ČEŠLJAR, Tomislav STEFANOVIĆ[1]

Abstract: *This paper presents the analytical review of the views of the employees in enterprises and organizations entrusted with the management of the protected natural areas (PA). The employees expressed their views on the possibilities for improvement of the management of PA. The impact of the age of the respondents and thier professional training has been analyzed by means of the survey questionnaires and using the statistical methods. The results suggest that the employees have the best insight into the possibilities for improvement through training development, visitor centers, offer of recreation in the nature, organization of tourist travel and creation of a local brand. The respondents of different ages evaluated business opportunities in different manners – the younger deem that organizational changes provide better prospects. The respondents attentding the professional training courses and seminars exhibit entreprenurial proneness to business opportunities.*

Key words: management, protected natural areas, enterprise

МОГУЋНОСТИ УНАПРЕЂЕЊА УПРАВЉАЊА ЗАШТИЋЕНИМ ПРИРОДНИМ ПОДРУЧЈИМА

Апстракт: *У раду је дат аналитички приказ ставова запослених у предузећима и организацијама којима је поверено управљање заштићеним природном подручјима (ЗП). Запослени су изразили своје ставове о могућностима унапређења управљања ЗП. Анализиран је утицај старосне доби испитаника и похађање професионалне едукације и семинара на способност препознавања пословних шанси које могу унапредити управљање ЗП. Подаци су прикупљени директним интервјуима путем анкетних упитника, а анализирани статистичким методама. Резултати*

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указују да запослени виде најбоље могућности унапређења путем развоја едукације, визиторских центара, понуде рекреације у природи, организације туристичких путовања и стварања локалног бренда. Испитаници различите старосне доби различито вреднују пословне шансе, млађи дају веће шансе организационим променама. Испитаници који похађају професионалну едукацију и семинаре показују предузетничке склоности ка пословним шансама

Кључне речи: управљање, заштићена природна подручја, предузеће

1. INTRODUCTION

In Serbia around 528,691 *ha* or approximately 6% of the territory (***2012) is under protection. The protection entails harmonization of the human activities and economic and development plans alongside sustainable deployment of natural resources with the view to preserve and manage parts of the nature and natural areas (***2010). The protection encompasses the protected natural assets, which are classified into three categories: protected areas (PA), protected species and movable protected natural assets. Protected areas include national parks (NP), nature parks, landscapes of exceptional features, nature reserves, protected habitats, nature monuments and area of cultural and historical significance (***2013).

The management of protected areas in Serbia is entrusted to enterprises and organizations. Managers are public enterprises, NGOs, limited liability companies, shareholding companies, tourist organizations, religious organizations, state owned companies, hotels, military institutions, munincipalities, health care instititutions and individuals (Grujičić *et al.* 2009).

In current practice, most PA have dual functions, that of a commercial user of the area for the purpose of creating economic benefits and that of an entity repsonsible for protection and advancement of the natural values (Puzović, 2009). Puzović (2009) further concludes that it is this *"contradictory dual function that generates contemporary governance and protection issues in PA."*

From the institutional, organizational and legislative aspects, PA governance issues can be formulated in respect of the manner of selecting companies or organiyation as well as in respect of their professional, human resourse and insfrastructual conditions (Puzović, 2009), ownership structure in PA, (Milijić et al. 2009), financing of PA (Đorđević *et al.* 2009; Aleksić, Jančić, 2009), collision of laws and regulations (Nevenić *et al.* 2009), insufficient efficacy of legislative (Nikolić, 2009), illegal construction (Aleksić, Jančić, 2009) and illegal mining and mineral exploitation (Ostojić, Petraš, 2009). In addition to the aforesaid governance issues, vast research of PA underline the condition and conservation of biodiversity and geodiversity and important role of the education and participation of the public in the protection of nature (Belij, 2009).

Review of the available literature on protected nature areas revealed a lack of research in attitudes, needs and motivation of the employees of the enterprises entrusted with the management of the protected areas. Given the fact that the enterprises for management in PA are business entities whose purpose is to realize economic benefits, it is necessary to research the possibilities for improving PA

management through development of business opportunities. Here the employees' views on business opportunities are studied and the differences in those views depending on the age of the respondents and their attendance of professional trainings and seminars. The objective of this research is to analytically present the significance of different business activities. The purpose is to suggest measures to be applied by the PA managers in order to improve management.

The research was conducted within the following projects:

- Development of Technological Procedures in Forestry with the Aim of Realizing Optimum Forestation, TR 31070, RS Ministry of Education and Science;
- Analysis of PA Management Organizations in the Republic of Serbia; the project was financed by the Forestry Directorate.
- "FOPER II" – Consolidation of the Human Capacities in Forestry Policy and Economics Education and Research in the South-Eastern Europe Region and the subproject "PAGOV – Governance Assessment of Management of Protected Areas in the South-Eastern European Region (Albania, Bosnia and Herzegovina, Croatia, Macedonia and Serbia)."[1]

2. IMPROVEMENT OF THE MANAGEMENT OF THE PROTECTED NATURAL AREAS

Management of protected areas is governed by, inter alia, the Environmental Protection Law, Forestry Law and relevant decisions enacted by the Republic of Serbia Assembly appointing managers. The results of the research in PA management conducted globally and in our country are comparable and share similar conclusions. Stolton and Dudley (1999) enumerate the weaknesses of protected forest area management, the basic of which are:

- Finance resources;
- Employee professional training;
- Inadequate institutional capacities;
- Inadequate legislation;
- Insufficient participation of local population in preparation of plans and
- Lack of coordination among organizations entrusted with management.

Hockings and Phillips advocate the generally accepted opinion that more attention is to be paid to the issues of effective PA management and that the management capacity depends on the legislation and government support to the PA design and management (Hockings, Phillips, 1999). James (1999) states that, although there is a lack of both funding and staff in PA, managers respond to arising opportunities in an entrepreneurial manner, particularly when it is possible to use new sources of income.

[1] "FOPER II, Consolidation of the Human Capacities in Forest Policy and Economics Education and Research in the South-East Europe Region;" PAGOV "Governance Assessment in the Management of Protected Areas in the South-Eastern European Region (Albania, Bosnia and Herzegovina, Croatia, Macedonia and Serbia)"

Aleksić and Jančić (2009) view PA management as an important factor of affirmation for enterprises entrusted with management as well as for the forestry profession. It is their belief that forestry engineers need to expand their knowledge, particularly in the fields of ecology and environment, information and communication, informatics, etc. In respect of the PA funding, they emphasize that immediate commencement of biomass utilization and collection of non-timber forest products, may be significant source of income for both the manager and local population (Aleksić, Jančić, 2009). From the financial viewpoint, PA managers invest substantial assets into preservation and development, whereas the economic power of the population does not provide opportunities for additional income through collection of entrance tickets and fees.

3. MATERIALS AND METHODS

Research in views of the employees at enterprises and organizations managing protected areas was conducted by means of the survey questionnaire. The survey questionnaire applied included the following:

- Social-demographic characteristics of respondents;
- Assessment of the legislative framework influence on the PA management;
- Assessment of efficiency and effectiveness of PA management;
- Assessment of the participation of various stakeholder groups in PA management;
- Assessment of transparency in PA management;
- Assessment of competences in PA management;
- Assessment of capacities in PA management;
- Factors for improvement of business operations of the enterprises managing PA.

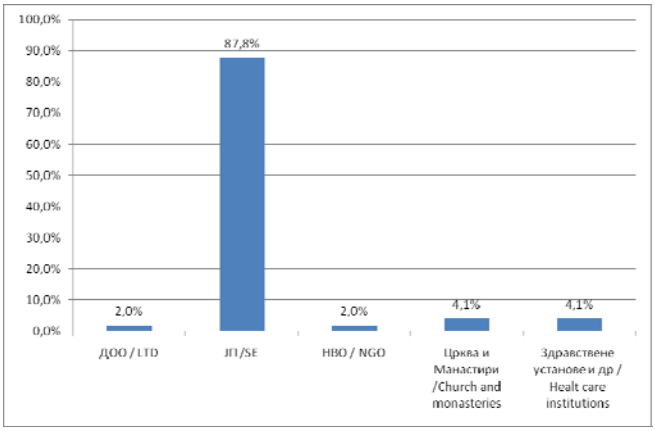
The survey was conducted on a sample of 49 employees of the enterprises and organizations entrusted with PA management. The sample comprised limited liability companies, State enterprises (SE), NGOs, Church and monasteries and health care institutions.

The survey was executed via direct interviews with the employees of the enterprises and organizations managing PA. The research units were employees, and the characteristics of the sample – managerial positions or experience in PA management. The survey questionnaire was pretested on the interviewees holding university degrees in forestry. Following the pretesting, minor changes were introduced to the questionnaire and its final version was formulated.

The obtained responses were encoded and entered into a MS Excel worksheet, where the codes entered were checked against the responses provided in the survey questionnaires. The MS Excel worksheet was then imported into the program for statistical data processing SPSS. The data were processed using descriptive statistical method and statistical testing method.

4. RESULTS AND DISCUSSION

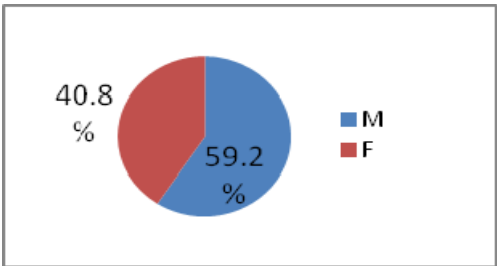
Graph 1 shows the participation of respondents in percentages per type of the enterprise managing PA.



Source: Original

Graph 1: *Managers of protected areas*

The largest number of respondents interviewed were employees of the following public enterprises: SE "Srbijašume," SE "Vojvodinašume," SE National Park "Fruška gora," SENP "Kopaponik," SENP "Đerdap," SENP "Šar planina," SENP "Tara." Social and demographic characteristics of the respondents are presented via their gender structure and age. The gender structure of the employees interviewed is presented in graph 2, whereby there are more men tha women in the sample. Men comprised 59.2% and women 40.8 % of the total sample of respondents.



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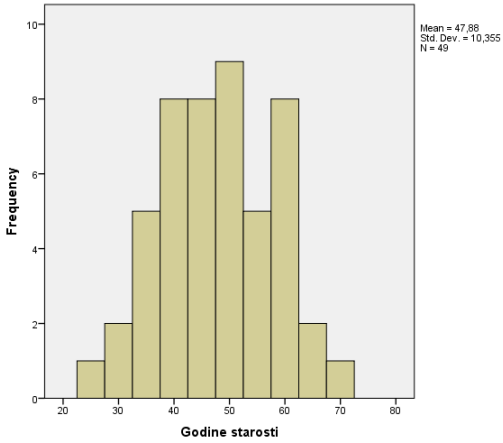
Graph 2: *Gender structure of repsondents*

Distribution of the respondents within the sample per age is shown in graph 3. The youngest repsondent was 25 years old and the oldest 71. Distribution of respondent is presneted by a histogram. The largest number of respondents within the sample were 57 to 58 years old, while the average age of respondents was 47.88 years.



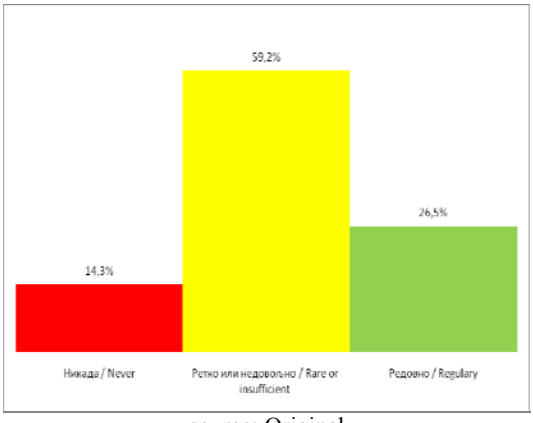
Source: Original

Graph 3: *Distribution of respondents in the sample per age*

The respondnets were able to assess the frequency of attending professional trainings and seminars. To the question: „*How often do you attend professional trainings and seminars in PA management ?"*, the respondents selected one of three offered responses: never, rarely or not often enough and regularly. The frequency of attending professional trainings and seminars is providied in graph 4.

Most respondents attend profssional trainings; however, 59.2 % of them think this is not sufficent or that they are rarely included in professional trainings. 26.5% of the respondnets had regular trainings and 14.3% had never attended porfessinal trainings or seminars in PA management.

The respondents assessed business opportunities that may have effect on PA management using 1 to 5 scale grades in their evaluation. Grade 1 means totally irrelevant, grade 2 – irrelevant, grade 3 expresses a nuetral view, grade 4 means relevant and grade 5 – a highly relevant activity for PA management.



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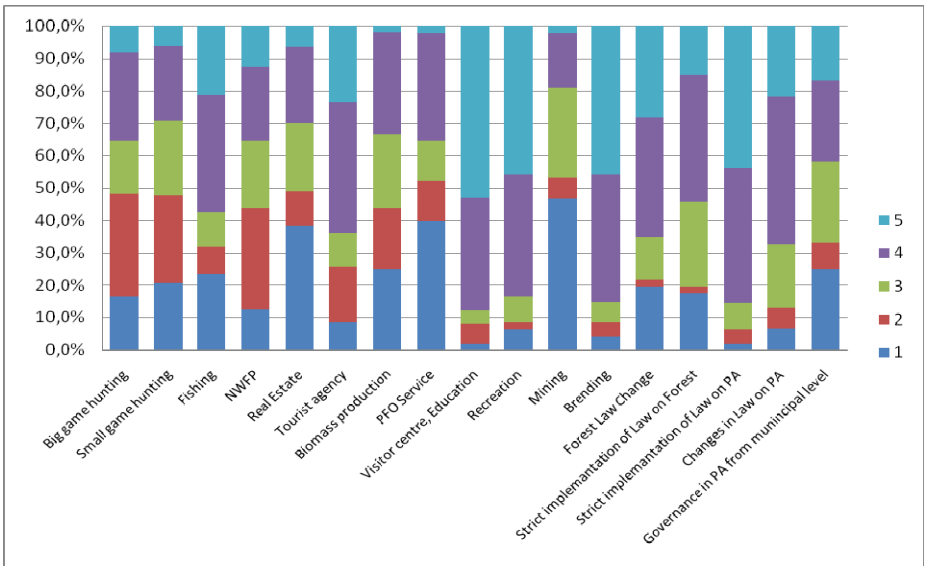
Graph 4: *Frequency of attending professional trainings*

The respondents assessed the following activities: big-game hunting, small-game hunting, issue of fishing permits and organization of fishing, gathering and processing non-timber forest prodcuts (NTFP), real estate business, organization of tourist travel, production of biomass, extention services to private forest owners (PFO), educational programs and visitor centers in the nature, offer of reacreation in the nature, ore and mineral exploitation and creation of a local brand. Graph 5 presents summary assessment of the repsondents, i.e. the percentage share of the repsondents per activity.



Source: Original

Graph 5: *Assessment of business activities*

The respondents regarded as the most relevant for improvement of PA management the business activities entailing the participation of visitors. As many as 87.8% of respondents assessed education programs in the nature and visitor centers as relevant or a highly relevant activity. Offer of recreation in the nature is assessed as a relevant or highly relevant business opportunity by 83.3% of the respondents, while 85.4% of them saw creation of a local brand as relevant or highly relevant for PA advancement. For 63.9% of the interviewed respondents organization of tourist travel is relevant or highly relevant. The lowest grades were allocated to mining and mineral exploitation. More than half of the respondents (52.4%) assessed this activity as irrelevant to the PA advancement.

The views of the respondents were analyzed using the Mann-Whitney test. The test compared the sum of rang of assessment of business opportunities for improvement of PA management. The assessments of different age respondents were compared. The first group was comprised of respondents up to 45 years old, and the second of respondents with over 45 years of age. In addition, differences in views on the possibilities for the improvement of PA management were tested between the respondents attending professional trainings and seminars and those not-attending the trainings and seminars. Table 2 provides the statistical

significance for the expressed differences in views between the groups under observation. Column 1 lists the business opportunities assessed by the respondents with grades from 1 to 5. Column 3 provides the results of the Mann-Whitney test, which was used for comparing the views of the two groups of respondents. The first group was comprised of (column 4), and the other of respondents with over 45 years of age (column 5). Column 7 shows the results of the Mann-Whitney test, which compared the views of the respondents with regard to their attendance of professional trainings and seminars. The first group comprised respondents not attending (column 8) and the second respondents attending (column 9) professional trainings and seminars.

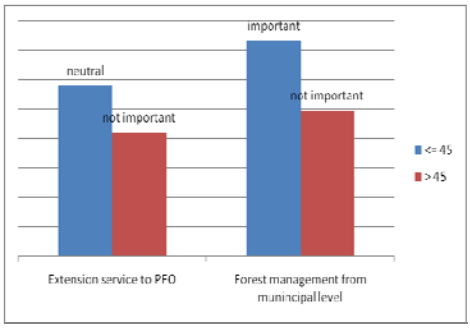
Table 1: *Differences in views of respondents: business activity assessment per age and attendance of professional trainings*

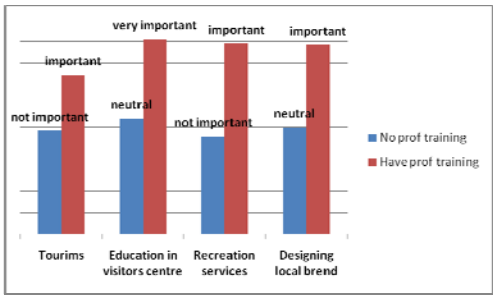
Test Statistics[a]								
1	2	3	4	5	6	7	8	9
Business opportunities	Mann-Whitney U	Asymp. Sig. (2-tailed)	Up to 45 years of age	Over 45 years of age	Mann-Whitney U	Asymp. Sig. (2-tailed)	Not attending training	Attending training
Big-game hunting	207.000	.101	3.14	2.52	124.000	.557	2.57	2.83
Small-game hunting	212.000	.127	3.00	2.41	103.500	.230	2.14	2.76
Issue of fishing permits, organization of fishing	225.500	.292	3.43	3.08	68.500	.071	2.17	3.39
Gathering, processing and sales of non-timber forest products	246.500	.429	3.10	2.78	84.500	.076	2.14	3.05
Real estate business	223.000	.265	2.71	2.31	85.500	.213	1.83	2.59
Organization of tourist travel	257.500	.729	3.62	3.46	**72.000**	**.034**	**2.43**	**3.73**
Production of bioenergy raw materials	240.500	.356	2.86	2.52	138.500	.880	2.57	2.68
Private forest owners extension services	**185.000**	**.031**	2.90	2.11	138.000	.865	2.57	2.44
Education in the nature, visitor centers	277.500	.711	4.24	4.36	**39.000**	**.001**	**2.71**	**4.57**
Nature based recreation	272.500	.804	4.14	4.15	**32.500**	**.000**	**2.29**	**4.46**
Mining and mineral exploitation	232.500	.353	2.43	2.04	93.500	.137	1.57	2.33
Creation of a local brand	275.000	.847	4.24	4.15	**16.500**	**.000**	**2.50**	**4.43**
Forest management at the local/municipality level	**153.500**	**.006**	3.67	2.48	95.500	.150	3.71	2.88

Source: Original

Comparing the views of the older respondents to those of the younger ones, statistically significant differences were identified at the risk level of p=0.05 for the opinion that extension services to the private forest owners can improve PA management. The younger respondents think that extension services to the private forest owners has a neutral impact on the improvement of PA management whereas the older ones regard it as irrelevant. The views of the respondents classified into

age groups are presented in graph 8. Comparing the views of the respondents attending to those of the respondents not attending professional trainings and seminars, statistically significant differences were identified at the risk level of p=0.01 for the views on the following activities: organization of tourist travel, offer of education programs and visitor centers in the nature, offer of recreation in the nature and creation of a local brand (graph 9).





Source: Original

Graph 6: *Views of the different age respondents*

Graph 7: *Differences in assessment of business opportunities by respondents attending and those not attending professional trainings and seminars*

Respondents not attending professional trainings and seminars consider organization of tourist travel not important, whereas those attending the trainings and seminars see this activity as important to the improvement of PA management. Respondents not attending professional trainings and seminars find offer of educational programs and visitor centers in the nature important, while those attending the trainings and seminars regard it as a very important activity for improvement of the PA management. Respondents not attending professional trainings and seminars consider offer of recreation in the nature not important, whereas those attending the trainings and seminars see this activity as important to the improvement of PA management. Respondents not attending professional trainings and seminars find creation of a local brand not important, while those attending the trainings and seminars regard it as a important activity for improvement of the PA management. Differences in average ratings between the two groups are shown in graph 9.

The attitudes of the employees interpreted in this manner confirm the previously formed conslusions on the possibilities for branding in the forestry of Serbia (Ranković, 2009).

Utilization of biomass and non-timber forest products is not yet viewed as relevant for the management and earning income, which is contrary to the suggestions of prior research (Aleksić, Jančić, 2009).

Management of protected areas is of great significance for the protection of biodivesity as well as for the fulfillments of the society's requirements toward forest and nature. There is a concern that protected natural areas both world-wide

(Hockings, Phillips, 1999) and in our country (Aleksić, Jančić, 2009) are not managed in the manner which contributes to the environmental, economic and social benefits. A number of research and condition monitoring project have been initiated in respect of efficient PA management and possibilities for improvement of PA management. Advancement of protected areas with preservation, sustainable utilization and valuation of functions and ecosystem services is becoming an unavoidable aspect of the forestry development strategy (***2006).

So far, little attention has been paid to the employees and managerial staff in PA, more focus has been placed on the institutions, laws, procedures and funds. This research enables insight into the views of the employees in enterprises and organizations managing PA, which indicate business opportunities that may improve management. In high regard are business acitivities involving visitors such as: offer of education in the nature and visitor centers, offer of recreation in the nature and organization of tourist travel. These results are comparable to the existing studies of the advancement of business operations of forestry enterprises, where recreation and tourism are viewed as the most innovative and most proposed forms of services (Poduška *et al.* 2011). Creation of a local brand received highest grades from as many as 85.4% respondents, suggesting the need to make products and services from protectred areas more recognizable among potential consumers.

The results suggest that there are views on the necessary organizational changes. Respondents regard forest management at the local level as relevant, which is contrary to the current centralized managment system, and partially contrary, at least for PA, to the results of research implying the necessity of organizing a single state forestry enterprise (Aleksić, Ivković, 2004).

Notions that professional training is a key factor in PA management (Aleksić, Jančić, 2009; Stolton, Dudley, 1999), proved justified. Respondnets attending professional trainings and seminars expressed positive opinions on and highly rated the offer of educational programs and visitor centers in the nature, offer of recreation in the nature, organization of tourist travel and creation of a local brand. In other words, all of the highly rated business opportunities were recognized by the employees attentding professional trainings and seminars. Respondents not attending professional trainings and seminars consider such activities irrelevant for the improvement of the PA management. Younger employees recognize that organizational change in terms of PA management from munincipal level provide opportunity for improvement.

5. CONCLUSION

Based on the results and siscussion presented, it is concluded that:

- Business opportunities including tourism and recreation can have great signficance for improving PA management;
- Education and visitor centers in the nature can improve PA management;
- Recreation in the nature and organization of tourist travel can improve PA management;
- With creation of a local brand products and services from PA can become recognizable while the local population and the manager can gain more economic power;

- Professional training of the employees in PA is a key factor for recognition of opportunities that can improve PA management;
- Age is significant since younger respondents recognize new business opportunities.

Managers need to organize employee professional trainings and seminars on a regular basis. It is necessary to develop ecosystem services such as recreation, education and touism in the nature. Enterprises enrusted with PA management ought to be mediatiors in creation of a local brand with features of the respective protected area.

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SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION 67-68, 2013 ZBORNIK RADOVA 67-68, 2013

UDK 595.42:630*177.117.14 Malus silvestris (L.) Mill.(497.11)=111
Original scientific paper

SPECIES COMPOSITION OF SPIDER MITES AND PREDATORY MITES (Acari: Tetranychidae, Phytoseiidae) OCCURRING ON CRAB APPLE (*Malus silvestris* Mill) IN SERBIA

Katarina MLADENOVIĆ[1], Bojan STOJNIĆ[2], Slobodan MILANOVIĆ[3], Vlado ČOKEŠA[1], Ivan MILENKOVIĆ[1]

Abstract: *New studies of crab apple, Malus silvestris, in Serbia identified the presence of five species of spider mites and nine species of Phytoseiidae. The presence of three spider mite species on this host plant has been identified for the first time in Serbia: Amphitetranychus viennensis, Schizotetranychus schizopus and Tetranychus urticae. The species S. schizopus has been identified on crab apple for the first time ever in the world. Six species of Phytoseiidae*: *Amblyseius andersoni*, *Kampimodromus aberrans*, *Neoseiulella aceri*, *Phytoseius maltshenkovae*, *Typhlodromus* (*Typhlodromus*) *pyri* and *T.* (*Anthoseius*) *rhenanus have been identified for the first time on crab apple in Serbia. Species N. aceri and P. maltshenkovae have been identified on crab apple for the first time ever in the world. Our study increased the total number of spider mite species identified on M. sylvestris to seven and Phytoseiidae to eleven.*

Key terms: Tetranychidae, Phytoseiidae, *Malus silvestris*

PREGLED VRSTA PAUČINARA I PREDATORSKIH GRINJA (Acari: Tetranychidae, Phytoseiidae) NA DIVLJOJ JABUCI (*Malus silvestris* Mill) U SRBIJI

Sažetak: *Novim istraživanjima je u Srbiji na evropskoj divljoj jabuci, Malus silvestris, utvrđeno prisustvo pet vrsta paučinara i devet vrsta fitozeida. Tri vrste paučinara su prvi put nađene na ovom biljnom domaćinu u našoj zemlji: Amphitetranychus viennensis, Schizotetranychus schizopus i Tetranychus urticae. Vrsta S. schizopus je prvi*

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put utvrđena na evropskoj divljoj jabuci u svetu. Šest vrsta fitozeida: Amblyseius andersoni, *Kampimodromus aberrans*, *Neoseiulella aceri*, *Phytoseius maltshenkovae*, *Typhlodromus* (*Typhlodromus*) *pyri i T.* (*Anthoseius*) *rhenanus su novi nalazi na divljoj jabuci u našoj zemlji. Vrste N. aceri i P. maltshenkovae su prvi put identifikovane na evropskoj divljoj jabuci u svetu. Našim istraživanjima ukupan broj vrsta paučinara je povećan na 7 a fitozeida na 11 na M. sylvestris.*

Ključne reči: Tetranychidae, Phytoseiidae, *Malus silvestris*

INTRODUCTION

Spider mites, mites of the Tetranychidae family, are considered the most important harmful group of phytophagous mites in the agriculture and forestry. In natural eco-systems spider mites live mainly in harmony with a host plant, without inflicting significant damage, as a result of the impact of a complex of mites' natural enemies.

Predatory mites of the Phytoseiidae family are natural enemies to a large number of microarthropods; however, they most frequently feed on mites from the Tetranychoidea and Eriophyoidea group; hence, they are important regulators of a population figure of species from these groups of mites in natural habitats (Edland & Evans 1998). Habitats rich in non-cultivated plant species represent a natural reservoir of phytoseiidae (Boller at al. 1988; Duso & Fontana 1996; Tixier at al. 2000 a,b). Certain species of phytoseiidae are successfully used in programmes of biological control of harmful phytophagous mites and insects in plant production (Croft & Barnes, 1971; McMurtry & van de Vrie, 1973; Walter & O'Down, 1992; etc.).

Previous studies of diversity of the spider mite and phytoseiidae fauna in Serbia were mainly focused on agro-ecosystems, while the diversity of the above-mentioned mite groups on wild fruit species in forest ecosystems remained unexplored. Data on presence of spider mites and phytoseiidae in forest plant species in Serbia are presented only fragmentary and in few scientific papers (Tomašević, 1964; Kropczynska & Petanović, 1987; Petanović i Stojnić, 1995; Stojnić i Petanović, 1994; Stojnić, 1993; Stojnić et al., 2002; Mladenović at al., 2010a, 2010b, 2011, 2012, 2013); however, the range of dominant spider mites and Phytoseiidae on most important forest broadleaved species remained virtually unknown. That holds true even more for wild fruit species, on account of the nature of their representation and uneven distribution in forest habitats. On the other hand, their botanical affinity with cultivated fruit species makes them particularly interesting, from the aspect of their role in conservation of those phytoseiidae species that may potentially represent effective agents of biological combat in commercial fruit plantations.

During previous studies of crab apple (*Malus silvestris)* in Serbia, the presence of four spider mite species and five Phytoseiidae species had been established (Stojnić & Petanović, 1994; Mladenović et al., 2013). Out of 1,275 spider mite species recorded worldwide (Migeon & Dorkeld, 2013), 11 species were identified on the European crab apple (Jeppson et al., 1975; Meyer, 1987;

Smith & Roy, 2008; Guanilo et al., 2012). Out of 2,300 recorded species of the family Phytoseiidae (Beaulieu et al. 2011; Chant & McMurtry 2007), 16 species were identified on the European crab apple (Amitai & Swirski, 1978; Jedličková, 1997, 1998; de Moraes et al., 2004; Messelink et al., 2006; Sepúlveda & Carrillo, 2008).

In accordance with the above-mentioned, the results of this study present new data on distribution of spider mites and phytoseiidae on the European crab apple in Serbia and worldwide.

MATERIAL AND WORK METHOD

The collection of crab apple specimens was performed during vegetation period, in the framework of a several-year long study of fruit species in Serbian forest ecosystems. Specimens consisting of 300 leaves each were packed into plastic bags and kept in a refrigerator at the temperature of 5-8^{o}C until mites were extracted. Prior to the mite extraction, leaf specimens were exposed to the effect of ethyl acetate for 20 minutes, which was followed by a shake-off of mites onto a white paper and their extraction under a stereomicroscope. The extracted mites were submersed into a solution of ethanol and lactic acid (Evans & Browing, 1955). After the illumination, permanent slides were made by means of use of the Hoyer's medium (Baker & Wharton, 1964).

For identification of tetranychidae, appropriate keys were used (Prichard & Baker, 1955; Mitrofanov at al., 1987; Manson, 1967; Baker & Tuttle, 1994). For identification of phytoseiidae, appropriate keys were used (Chant, 1959; Begljarov, 1981; Karg 1993), along with an additional taxonomic literature (DeMoraes et al., 1986; 2004; Demite et al., 2012). Permanent slides are kept in the depot of the Entomology and Agricultural Zoology Department of the University of Belgrade's Faculty of Agriculture.

STUDY RESULTS AND DISCUSSION

During the study on *M. silvestris,* the presence of five spider mite species and nine phytoseiidae species has been identified, which doubled the number of species recorded on this plant in Serbia (Table 1).

Table 1: *Species composition of spider mites and predatory mites (Acari: Tetranychidae, Phytoseiidae) on crab apple (Malus silvestris Mill) in Serbia*

	Spider mite species	Collecting data
Fam. Tetranychidae		
1.	***Amphitetranychus viennensis*** (Zacher, 1920)	New data **:** Goč, Cvetna Livada, 28.09.2001(leg. Mladenović); Pančevo, Starčevo, 30.09.2006 (leg. Mladenović); Mali Jastrebac, Prokuplje, 28.06.2011 (leg. Mladenović); Soko Banja, Bovansko Jezero 25.05.2011(leg. Mladenović); Goč, Jezero, 3.7.2013 (leg. Kostić); Goč, Jezero, 3.7.2013 (leg. Kostić); Goč, Brezna, 5.7.2013 (leg.Kostić);
	Bryobia sp. (unidentified)	Zlatibor, motorway, 04.09.2000 (leg. Mladenović) (Mladenović et al.,2013); Goč, 'Dobre Vode' Hotel, ski run, 28.09.2001 (leg. Mladenović) (Mladenović et al.,2013); New data **:** Soko Banja, Bovansko Jezero, 25.05.2011 (leg. Mladenović);

2.	***Bryobia angustisetis*** Jakobashvili, 1958	Veliki Jastrebac, the Lomnička River, 26.06.2001 (Mladenović et al.,2013);
3.	***Bryobia rubrioculus*** (Scheuten 1857)	Mali Jastrebac, Prokuplje, 28.06.2011 (Mladenović et al.,2013); New data : Goč, Jezero, 3.7.2013 (leg.Kostić); Goč, Brezna, 5.7.2013 (leg. Kostić)
4.	***Bryobia ulmophila*** Reck, 1947	Goč, farm and seedling nursery, 28.09.2001 (Mladenović et al.,2013);
5.	***Bryobia vasiljevi*** Reck, 1953	Three-border junction between Serbia, Bulgaria and Macedonia X 4688088 Y 7619070 Altitude 1,015 m, 11.08.2005 (Mladenović et al.,2013);
6.	***Schizotetranychus schizopus*** (Zacher 1913)	New data : Goč, Dobre Vode, 3.7.2013 (leg. Kostić);
7.	***Tetranychus urticae*** Koch 1836	New data : Divčibare, centre-Crni Vrh 02.08.2000 (leg. Mladenović); Divčibare, Pitomine, 11.08.2000 (leg.Mladenović); Zlatibor, motorway, 04.09.2000(leg. Mladenović); Goč, Brezna, 5.7.2013 (leg.Kostić)
Fam. Phytoseiidae		
1.	***Amblyseius andersoni*** (Chant, 1957)	New data : Pančevo, Starčevo, 30.09.2006 (leg. Mladenović);
2.	***Euseius finlandicus*** (Oudemans, 1915)	Goč, 'Dobre Vode' Hotel, ski run, 28.09.2001 (Mladenović et al.,2013); Goč, farm and seedling nursery 28.09.2001 (Mladenović et al.,2013); New data : Divčibare, Beogradsko Naselje 05.08.2000 (leg. Mladenović); Beograd, Vinča, 28.05.2001 (leg. Mladenović); Veliki Jastrebac, the Lomnička River, 26.06.2001 (leg. Mladenović); Goč, Jezero, 3.7.2013 (leg. Kostić); Pančevo, Starčevo, 30.09.2006 (leg. Mladenović); Mali Jastrebac, Prokuplje, 28.06.2011 (leg. Mladenović);
3.	***Kampimodromus aberrans*** (Oudemans, 1930)	New data : Šabac, Gornja Vranjska village, 08.10.2000 (leg. Mladenović); Veliki Jastrebac, the Lomnička River, 03.06.2001 and 26.06.2001 (leg. Mladenović); Goč, farm and seedling nursery, 28.09.2001 (leg. Mladenović); Zlatibor, Gostilje, 03.10.2001 (leg. Mladenović); Mali Jastrebac, Prokuplje, 28.06.2011 (leg. Mladenović); Soko Banja, Bovansko Jezero 25.05.2011(leg. Mladenović);
4.	***Neoseiulella aceri*** (Collyer, 1957)	New data **:** Goč, Jezero, 3.7.2013 (leg. Kostić)
5.	***Phytoseius corniger*** Wainstein, 1959	Zlatibor, motorway, 04.09.2000 (Mladenović et al.,2013);
6.	***Phytoseius echinus*** Wainstein & Arutunjan, 1970	Three-border junction between Serbia, Bulgaria and Macedonia X 4688088 Y 7619070 Altitude 1,015 m, 11.08.2005 (Mladenović et al.,2013);
7.	***Phytoseius juvenis*** Wainstein & Arutunjan, 1970	Kučevo, Ceremošnja, 11.6.1988 (Stojnić & Petanović, 1994); Goč, 'Dobre Vode' Hotel, ski run, 28.09.2001 (Mladenović et al.,2013); New data : Divčibare, Beogradsko Naselje 05.08.2000 (leg. Mladenović); Divčibare, Pitomine, 11.08.2000 (leg. Mladenović);
8.	***Phytoseius macropilis*** (Banks, 1909)	Zlatibor, motorway, 04.09.2000 (Mladenović et al.,2013); Goč, 'Dobre Vode' Hotel, ski run, 28.09.2001 (Mladenović et al.,2013); New data : Goč, Jezero, 3.7.2013 (leg. Kostić);
9.	***Phytoseius maltshenkovae*** Wainstein, 1973	New data : Goč, Jezero, 3.7.2013 (leg. Kostić);
10.	***Typhlodromus* (*Typhlodromus*) *pyri*** Scheuten, 1857	New data : Beograd, Vinča, 28.05.2001 (leg. Mladenović); Bukovik Mountain, 25.06.2001 (leg. Mladenović); Vranje, Koćura, X 4698494; Y 7587431, E W Altitude 1,010 m, 09.08.2005 (Mladenović);
11.	***Typhlodromus* (*Anthoseius*) *rhenanus*** (Oudemans, 1905)	New data **:** Goč, Dobre Vode, 1.7.2013 (leg. Kostić);

During previous studies of crab apple *(Malus silvestris)* in Serbia, four spider mite species had been identified: *Bryobia angustisetis* Jakobashvili, 1958, *B. rubrioculus* (Scheuten, 1857), *B. ulmophila* Reck, 1947 and *Bryobia vasiljevi* Reck, 1953, (Mladenović et al., 2013). By means of this study, another three species have been identified: *Amphitetranychus viennensis* (Zacher, 1920), *Schizotetranychus schizopus* (Zacher 1913) and *Tetranychus urticae* Koch 1836, which increased the total number of spider mite species on crab apple to seven.

During previous studies of crab apple in Serbia, five species of phytoseiidae had been identified: *Euseius finlandicus* (Oudemans, 1915), *Phytoseius corniger* Wainstein, 1959, *P. echinus* Wainstein & Arutunjan, 1970, *P. juvenis* Wainstein & Arutunjan, 1970, and *P. macropilis* (Banks, 1909) (Stojnić & Petanović, 1994; Mladenović et al., 2013). This study increased the number of phytoseiidae species by six - *Amblyseius andersoni* (Chant, 1957), *Kampimodromus aberrans* (Oudemans, 1930), *Neoseiulella aceri* (Collyer, 1957), *Phytoseius maltshenkovae* Wainstein, 1973, *Typhlodromus* (*Typhlodromus*) *pyri* Scheuten, 1857 and *Typhlodromus* (*Anthoseius*) *rhenanus* (Oudemans, 1905), thus increasing the total number of phytoseiidae species on crab apple to eleven.

The current world databases and catalogues do not provide complete records on spider mites identified on *M. silvestris.* For instance, Bolland et al. (1998), along with Migeon and Dorkeld (2013), do not include the European species of crab apple in the list of host plants, while there are individual data on only five Asian species of crab apple; Smith and Roy (2008) presented the data on a group of spider mite species on the European crab apple; however, this study lacked the precise zoogeographic data. In accordance with the above-mentioned, the authors of this study examined the available literature; added new findings made in Serbia, and created a list of 15 spider mite species identified on *M. Silvestris* worldwide (Table 2).

Table 2: *A comparative overview of species composition of spider mites (Acari: Tetranychidae) on crab apple (Malus silvestris Mill) in Serbia and worldwide:*

Species fam. Tetranychidae			
1.	***Amphitetranychus viennensis*** (Zacher, 1920)	Europe (Smith & Roy, 2008)	Serbia
2.	***Bryobia angustisetis*** Jakobashvili, 1958	/	Serbia (Mladenović et al.,2013)
3.	***Bryobia graminum*** (Schrank, 1781)	Europe (Smith & Roy, 2008)	/
4.	***Bryobia rubrioculus*** **(**Scheuten 1857)	Europe (Jeppson et al., 1975), South Africa (Meyer 1987)	Serbia (Mladenović et al.,2013)
5.	***Bryobia ulmophila*** Reck, 1947	/	Serbia (Mladenović et al.,2013)
6.	***Bryobia vasiljevi*** Reck, 1953	/	Serbia (Mladenović et al.,2013)
7.	***Eotetranychus ancora*** Baker & Pritchard, 1960	Mauritius (Meyer 1987)	/
8.	***Eotetranychus carpini*** (Oudemans, 1905)	Europe (Smith & Roy, 2008)	/
9.	***Eotetranychus pruni*** (Oudemans)	Europe (Smith & Roy, 2008)	/
10.	***Eutetranychus africanus*** (Tucker, 1926)	Egypt (Meyer 1987)	/
11.	***Meyernychus emeticae*** (Meyer, 1974)	Angola (Meyer 1987)	/
12.	***Panonychus ulmi*** (Koch, 1836)	South Africa (Meyer 1987) **Europe (Smith & Roy, 2008)**	/
13.	***Petrobia (Petrobia) latens*** (Müller, 1776)	North America (Smith & Roy, 2008)	/
14.	***Schizotetranychus schizopus*** (Zacher 1913)	/	Serbia
15.	***Tetranychus urticae*** Koch, 1836	Peru (Guanilo et al., 2012)	Serbia

Based on the tabular data, it can be concluded that nearly a half of the total number of spider mite species on *M. Silvestris* recorded worldwide have been identified in Serbia; hence, it can be inferred that the current level of research on presence of spider mites on crab apple in Serbia is proportionally higher than in other countries.

The current world databases and catalogues also include only incomplete data on presence of phytoseiidae on *M. silvestris*. De Moraes et al. (1986) listed eleven phytoseiidae species on the European crab apple; however, they were mainly found in the South American countries and Portugal. The authors of this study extended that list by including the data collected by other authors (Amitai &

Swirski, 1978; Jedličková, 1997, 1998; Messelink et al., 2006; Sepúlveda & Carrillo, 2008), as well as by adding the new data collected in Serbia, thus creating a list of 22 phytoseiidae species found on *M. Silvestris* worldwide (Table 3).

Table 3: *A comparative overview of species composition of predatory mites (Acari: Phytoseiidae) on crab apple (Malus silvestris Mill) in Serbia and worldwide*

Species fam. Phytoseiidae			
1.	***Amblyseius andersoni*** (Chant, 1957)	Portugal (de Moraes et al., 1986)	Serbia
2.	***Amblyseius chiapensis*** De Leon, 1961	Brazil – Sao Paulo (de Moraes et al., 1986)	/
3.	***Amblyseius compositus*** Denmark & Muma, 1973	Brazil-Bahia (de Moraes et al., 1986)	/
4.	*Amblyseius impressus* Denmark & Muma, 1973	Brazil – Sao Paulo (de Moraes et al., 1986)	/
5.	*Chileseius camposi* Gonzalez & Schuster, 1962	Chile (Sepúlveda & Carrillo, 2008)	/
6.	***Euseius finlandicus*** (Oudemans, 1915)	/	Serbia (Mladenović et al., 2013)
7.	***Iphiseiodes saopaulus*** (Denmark & Muma, 1973)	Brazil – Sao Paulo (de Moraes et al., 1986)	/
8.	***Kampimodromus aberrans*** (Oudemans, 1930)	Portugal (de Moraes et al., 1986)	Serbia
9.	***Neoseiulella aceri*** (Collyer, 1957)	/	Serbia
10.	***Neoseiulus fallacis*** (Garman, 1948)	Brazil – Sao Paulo (de Moraes et al., 1986)	/
11.	***Metaseiulus* (*Metaseiulus*) *flumenis*** (Chant, 1957)	USA – Arizona (de Moraes et al., 1986)	/
12.	***Phytoseiulus persimilis*** Athias-Henriot, 1957	Izrael (Amitai & Swirski, 1978)	/
13.	***Phytoseius corniger*** Wainstein, 1959	/	Serbia (Mladenović et al.,2013)
14.	***Phytoseius echinus*** Wainstein & Arutunjan, 1970	/	Serbia (Mladenović et al.,2013)
15.	***Phytoseius juvenis*** Wainstein & Arutunjan, 1970	/	Serbia (Stojnić & Petanović, 1994; Mladenović et al.,2013)
16.	***Phytoseius macropilis*** (Banks, 1909)	Portugal (de Moraes et al., 1986)	Serbia (Mladenović et al.,2013)
17.	***Phytoseius maltshenkovae*** Wainstein, 1973	/	Serbia
18.	***Typhlodromips sabaculus*** Denmark & Muma, 1973	Brazil – Sao Paulo (de Moraes et al., 1986)	/
19.	***Typhlodromus* (*Anthoseius*) *rhenanus*** (Oudemans, 1905)	Portugal (de Moraes et al., 1986)	Serbia
20.	***Typhlodromus* (*Anthoseius*) *richteri*** Karg, 1970	Slovakia (Jedličková, 1997)	/
21.	***Typhlodromus* (*Typhlodromus*) *corticis*** Herbert, 1958	Slovakia (Jedličková, 1998)	/
22.	***Typhlodromus* (*Typhlodromus*) *pyri*** Scheuten, 1857	Belgium (Messelink et al., 2006)	Serbia

Based on the tabular data, it can be concluded a half of the total number of phytoseiidae species on *M. Silvestris* recorded worldwide have been identified in Serbia; consequently, it can be inferred that the current level of research of phytoseiidae on crab apple is also more comprehensive than in other countries.

Based on the obtained study results, and given the great diversity of spider mites and phytoseiidae on a proportionally small number of examined specimens and localities, it can be expected that a considerably higher number of spider mite and phytoseiidae species than the currently established, is present on crab apple. In that regard, it is necessary to conduct a more comprehensive research on *M. Silvestris* in future.

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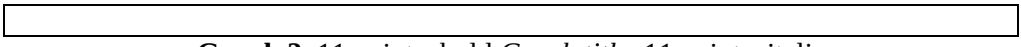

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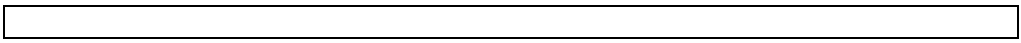

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Roberts, G., Parrotta, J. and Wreford, A. (2009): *Current Adaptation Measures and Policies.* In: Risto Seppälä, Alexander Buck and Pia Katila. (eds.). Adaptation of Forests and People to Climate Change - A Global Assessment Report. IUFRO World Series Volume 22. Helsinki. 123-13311

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