ISSN 1821-1046
UDK 630

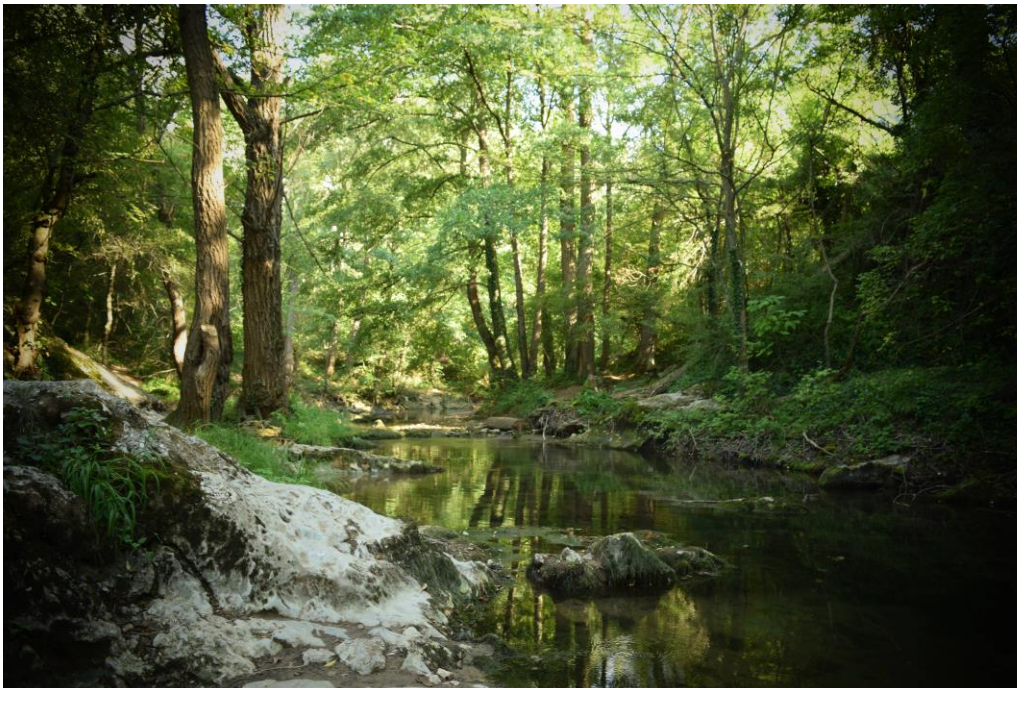
INSTITUTE OF FORESTRY
BELGRADE

INSTITUT ZA ŠUMARSTVO
BEOGRAD

SUSTAINABLE FORESTRY ODRŽIVO ŠUMARSTVO

COLLECTION
Vol. 77-78

ZBORNIK RADOVA
Vol. 77-78



BELGRADE BEOGRAD
2018.

ISSN 1821-1046

ISSN 1821-1046
UDK 630

INSTITUTE OF FORESTRY
BELGRADE

INSTITUT ZA ŠUMARSTVO
BEOGRAD

SUSTAINABLE FORESTRY ODRŽIVO ŠUMARSTVO

COLLECTION
Vol. 77-78

ZBORNIK RADOVA
Vol. 77-78

BELGRADE BEOGRAD
2018.

INSTITUTE OF FORESTRY BELGRADE	**INSTITUT ZA ŠUMARSTVO BEOGRAD**
COLLECTION OF PAPERS	**ZBORNIK RADOVA**
Publisher	**Izdavač**
Institute of Forestry Belgrade, Serbia	Institut za šumarstvo Beograd, Srbija
For Publisher	**Za izdavača**
Ljubinko Rakonjac, Ph.D.	Dr Ljubinko Rakonjac

Editor-in-Chief	**Glavni i odgovorni urednik**
Snežana Rajković, Ph.D.	Dr Snežana Rajković
Technical Editor and Layout	**Tehnički urednik i prelom teksta**
Tatjana Ćirković-Mitrović, Ph.D.	Dr Tatjana Ćirković-Mitrović
Secretary	**Sekretar Zbornika**
Tatjana Ćirković-Mitrović, Ph.D.	Dr Tatjana Ćirković-Mitrović
Printed in	**Tiraž**
100 copies	100 primeraka
Printed by	**Štampa**
Black and White Beograd	Black and White Beograd

Cover Page: Author of the Photos M.Sc. Marija Milosavljević
Naslovna strana: Autor fotografije M.Sc. Marija Milosavljević

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

630

SUSTAINABLE Forestry : collection = Održivo šumarstvo = zbornik radova / chief
editor = glavni i odgovorni urednik Snežana
Rajković. - 2008, T. 57/58- . - Belgrade (Kneza Višeslava 3) : Institute of forestry, 2008- (Beograd : Black and White). - 24 cm

Godišnje. - Je nastavak: Zbornik radova - Institut za šumarstvo = ISSN 0354-1894
ISSN 1821-1046 = Sustainable Forestry
COBISS.SR-ID 157148172

CONTENT SADRŽAJ

Vol. 77-78

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY COLLECTION 77-78, 2018

ODRŽIVO ŠUMARSTVO ZBORNIK RADOVA 77-78, 2018

UDK 630*232.31
Original scientific paper

DIFFERENT METHODS FOR BEECH SEED QUALITY TESTING

Ivona KERKEZ[1]*, Slavko PAVLOVIĆ*[1]*, Aleksandar LUČIĆ*[2]*,*
Jovana DEVETAKOVIĆ[1]*, Mirjana ŠIJAČIĆ-NIKOLIĆ*[1]*, Vladan POPOVIĆ*[2]

Abstract: *This paper presents three different methods for beech seed quality testing. The aim of this study is to determine the correlation between the electrical conductivity test, tetrazolium test and hydrogen peroxide treatment. The seed was collected in 12 different seed stands in Serbia that are commonly used for nursery production. The seed sample used for testing was randomly taken from the total amount of the collected seed. The analysis of the obtained results included the calculation of the Pearson correlation coefficient in the statistical software package "Statistica 7". The correlation was determined between the recorded results of the seed weight and the electrical conductivity; the seed weight and the tetrazolium test; the seed weight and the hydrogen peroxide treatment; the electrical conductivity and the tetrazolium test; the electrical conductivity and the hydrogen peroxide treatment; the tetrazolium test and the hydrogen peroxide treatment. Based on the conducted researches it can be concluded that the standardization of the electrical conductivity test using the tetrazolium test and hydrogen peroxide treatment could contribute to a more quality and more comprehensive determination of the beech seed quality for commercial purposes.*

Key words: Seed quality, seed stands, beech.

RAZLIČITE METODE ZA ISPITIVANJE KVALITETA SEMENA BUKVE

Abstrakt:*U radu su prikazane tri različite metode za testiranje kvaliteta semena bukve. Cilj ovog istraživanja je utvrđivanje korelacijskih odnosa između testa električne provodljivosti, tetrazolijum testa i tretmana semena vodonik peroksidom. Seme je sakupjeno iz 12 različitih semenskih sastojina na području Srbije, koje se uobičajeno koriste za sakupljanje semena za rasadničku proizvodnju. Testirani uzorak je nasumično*

[1] University of Belgrade – Faculty of Forestry, Belgrade, Serbia
[2] Institute of Forestry, Belgrade, Serbia

odabran iz ukupne količine sakupljenog semena. Analiza dobijenih rezultata obuhvatila je izračunavanje Pirsonovog koeficijenta korelacije u statističkom programu "Statistica 7". Utvrđena je korelacija između zabeleženih rezultata mase semena i električne provodljivosti, tetrazolium testa i tretmana vodonik peroksidom; električne provodljivosti i tetrazolijum testa i vodonik peroksid tretmana, kao i između tetrazolijum testa i vodonik peroksid tretmana. Na osnovu sprovedenih istraživanja može se zaključiti da standardizacijom testa električne provodljivosti uz primenu tetrazolijum testa i vodonik peroksid tretmana doprinelo bi se kvalitetnijem i bržem utvrđivanju kvaliteta semena bukve u komercijalne svrhe.

Ključne reči: kvalitet semena, semenske sastojine, bukva.

1. INTRODUCTION

As it is well known, the seed quality is very important in the nursery production from the economic point of view and optimizing storage conditions is one of the major tasks for producers. The seed of the European beech possess a deep embryo dormancy resulting in an enormous seed loss and poor seedling production in nurseries (Muller & Bonnet-Masimbert, 1982). This embryo dormancy inhibits germination of viable, mature embryos even when there are conditions suitable for germination. The dormancy is controlled by environmental, physiological and genetic factors (Milošević et al. 1996). The most common way of storage of beech seeds is in a fridge (at the temperature of about 5^{o} C) in the paper/plastic bags for about six mounts. Sometimes the storage can last longer, which may or may not necessarily reduce the quality of the seeds (Suszka, 1974; Suszka and Zieta 1977; Muller & Bonnet-Masimbert 1982; Muller, 1993; Gosling, 1991; Soltani, 2003). The seed aging processes are controlled by the temperature and the moisture conditions, and may be associated with various chemical reactions and metabolic alterations (Vertucci and Ross, 1990; Walters, 1998). The accumulation of reactive oxygen species (ROS) is often indicated as the prime cause of the seed deterioration, as it initiates reactions with polyunsaturated fatty acids, leading to lipid peroxidation and destruction of cellular membranes (Poter et al., 1947; Senaratna et al., 1988; Pukacka, 1991; Copeland and McDonald, 2001; Pukacka and Ratajzcak, 2004; Ivetic, Milovanovic 2005), but this membrane structure can be repaired after soaking seeds in the water (Ivetic and Milovanovic 2005).

The seed quality is mostly assessed by the seed germination rate but carrying out this method requires a long period of time, namely, in extreme case up to 24 weeks (Edwards and Wang, 1995). Also some viable seeds won't germinate due to dormancy which can be removed. Therefore, an effort was made to find a faster, nondestructive and easily preformed method for the seed quality testing. One of the solutions is to assess the seed viability, which is an indicator of the seed ability to germinate and produce normal seedlings under suitable conditions (Copeland and McDonald, 2001; Ivetić, 2013).

Three different methods for the seed quality determination were presented in this paper. The aim of this research is to determine a correlation between electrical conductivity test, tetrazolium test and hydrogen peroxide treatment.

2. MATERIALS AND METHODS

The seeds were collected from 12 beech seed stands in Serbia which are usually used for the nursery production (Table 1). The seeds were stored in a fridge (at the temperature of about 5^{o} C) in the paper bags for two years. The absolute seed weight was measured for each population, with a hundredth of gram accuracy, on a sample of 100 seeds in four repetitions. The seed moisture content was determined according to the SRPS and ISTA rules by drying the seeds in the oven at 130^{o} C for an hour. The seed testing with the electrical conductivity test, tetrazolium test and hydrogen peroxide treatment was performed on seeds randomly selected from the total amount of collected seeds.

The electrical conductivity test was first performed using a method described by Ivetić (2013). It was performed on 10 seeds in 3 repetitions, in the total of 30 seeds per population. The seeds were soaked in 20 ml of deionized water whose electrical conductivity was previously measured. The closed plastic containers were left for 24 hours at the temperature of 20-25^{o} C. After that period the electrical conductivity was measured by Mettler Toledo FiveEasy Plus™ pH benchtop meter with a measuring range -1999-1999 mV and an accuracy ±1 mV. The specific electrical conductivity per gram of dry seeds was calculated according to the formula 1 where the SEC is the specific electrical conductivity [μS/cm/g/mL] and SWDC – seed weight in dry condition [g].

$$SEC = \frac{\text{measured conductivity } [\mu S]}{\text{SWDC } [g] \text{x quantity of water } [mL]} [\mu S/cm/g/mL] \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Table 1. *General characteristics of studied beech seed stands*

Seed stands	Altitude	Region of provenance	The registration number
MU ”Deli Jovan”	567-720 m	34- northeastern Serbia	RS-1-1-fsy-34-796
MU ”Južni Kučaj”	890-960 m	34- northeastern Serbia	RS-2-2-fsy-34-378
MU ”Kamenička reka”	400-490 m	34- northeastern Serbia	RS-1-1-fsy-34-794
MU ”Bukovik”	740-910 m	34- northeastern Serbia	RS-1-1-fsy-34-791
MU ”Venac-Blagaja”	790-940 m	32- western Serbia	RS-1-1-fsy-32-802
MU ”Srndaljska reka”	780-1180 m	33- south Serbia	RS-1-1-fsy-33-679
MU ”Miroč”	289-500 m	34- northeastern Serbia	RS-1-1-fsy-34-795
MU ”Dubašnica I”	390-460 m	34- northeastern Serbia	RS-1-1-fsy-34-793
MU ”Medveđa”	720-950 m	35- southeastern Serbia	RS-1-2-fsy-35-816
MU ”Kukavica”	920-1210 m	35- southeastern Serbia	RS-1-2-fsy-35-817
MU ”Dubašnica”	860-890 m	34- northeastern Serbia	RS-2-2-fsy-34-373
MU ”Mali Jastrebac”	790 m	33- south Serbia	RS-2-2-fsy-33-633

The tetrazolium test was performed on the same seed samples using a method recommended in Draper et al., 1985; Ivetić, 2013; Verma and Majee, 2013. The seeds were soaked in the plastic containers filled with 25 ml of deionized water for 24 hours. After that period, the seed coat was removed. The staining was done at the temperature of 20-25^{o} C in 25 ml of 1% solution of 2.3-5 triphyltetrazolium chloride solution and left for 24 hours in a dark. The seeds were taken from the plastic containers with tweezers and cut longitudinally trough cotyledons to expose the inner side of the cotyledons. In dependence of the seed staining, the seeds were rated from 1 (totally dead seeds) to 5 (vital seeds) (Picture

1). As Verma and Majee (2013) states, among stained seeds, the seeds with bright red staining are completely viable and they give normal seedlings, while partially stained seeds may produce either normal or abnormal seedlings. Pink or greyish stained seeds indicate the presence of a dead tissue in the seed, while completely unstained seeds are non-viable. The average seed assessment category was used as an input for the correlation analysis for each population.

Picture 1. *Seed assessment categories*

The sample for the hydrogen peroxide treatment was the same as for the previous tests (10 seeds in 3 repetitions, the total of 30 seeds per population). The test was performed in two repetitions, as described by Ivetić (2002, 2013). The samples were soaked in 100 ml of 1% hydrogen peroxide solution at the temperature of 20-25^{o} C. Next day the seed coat was cut in radicular direction, and again soaked in 150 ml of 1% hydrogen peroxide solution for three days. After third day the solution was refreshed. The germinated seeds were counted after three and seven days (Picture 2). The percentage of the germinated seeds was determined for each population.

Picture 2. *Germinated seeds: third day (a); seventh day (b); mildew seed (c)*

3. RESULTS AND DISCUSSION

The analysis of the obtained results (Table 2) included the calculation of the Pearson correlation coefficient in the statistical software package *"Statistica 7"*. The correlation (Graph 1) was determined between the recorded results of the seed weight and the electrical conductivity (A); the seed weight and the tetrazolium test (B); the seed weight and the hydrogen peroxide treatment (C); the electrical conductivity and the tetrazolium test (D); the electrical conductivity and the hydrogen peroxide treatment (E); the tetrazolium test and the hydrogen peroxide treatment (F).

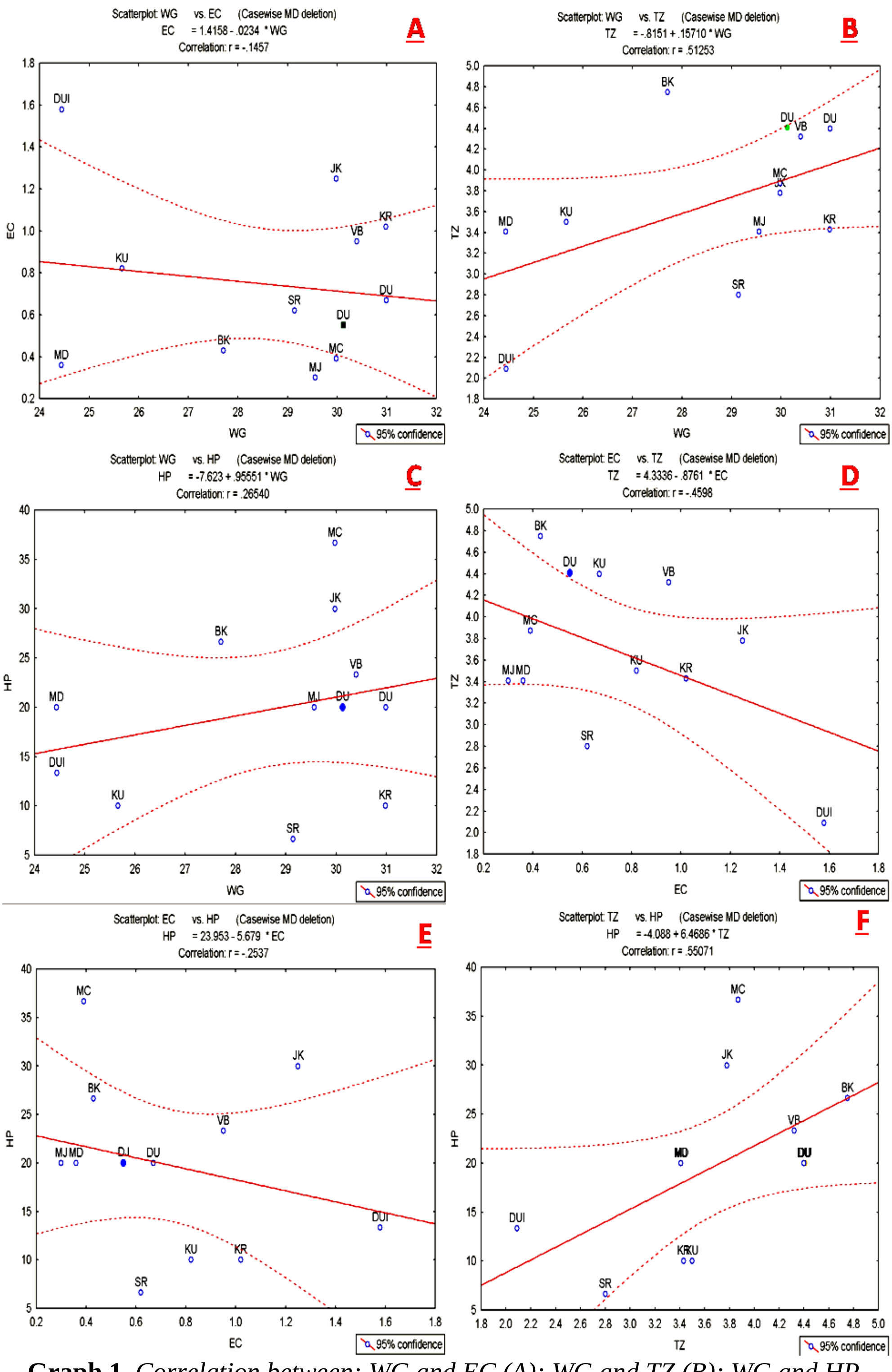
It is well known that heavy seeds germinate faster and have higher germination ability, so the positive correlation between the seed weight and the germination ability is present in almost all seeds and it is associated with high content of nutrients that causes stronger and faster emergence of the radicle (Soltani, 2003). In the beech seed, this correlation is explained by the increased genetic diversity of this species (Comps et al., 1998). According to the shown results (Graph 1), the seed weight is in the positive correlation with the results of the tetrazolium test (r = 0.51) and the hydrogen peroxide treatment (r = 0.27), and in the negative correlation with the results of the electrical conductivity test (r = -0.15). The negative correlation was also obtained in the ratio of the results of the electrical conductivity and the tetrazolium test (r = -0.46), as well as in the hydrogen peroxide treatment (r= -0.26). A small value of the correlation coefficient can also be the consequence of a small number of variables.

Table 2. *Mean values per population*

Label	**Population**	**WG** [g]	**HU** [%]	**SEC** [µS/cm/g/mL]	**TZ** [assessment category]	**HP** [%]
DJ	Deli Jovan	30.13	6.14	0.55	4.41	20.00
JK	Južni Kučaj	29.98	5.91	1.25	3.78	30.00
KR	Kamenička reka	30.98	6.92	1.02	3.43	10.00
BK	Bukovik	27.71	6.01	0.43	4.75	26.67
CV	Venac-Blagaja	30.40	5.37	0.95	4.32	23.33
SR	Srndaljska reka	29.14	8.94	0.62	2.80	6.67
MC	Miroč	29.98	5.87	0.39	3.87	36.67
VU	Vučje	24.45	7.00	1.58	2.09	13.33
MD	Medveđa	24.44	7.34	0.36	3.41	20.00
KU	Kukavica	25.66	6.68	0.82	3.50	10.00
DU	Dubašnica	30.99	5.73	0.67	4.40	20.00
MJ	Mali Jastrebac	29.56	6.03	0.30	3.41	20.00

WG – weight of 100 seed; HU – humidity; SEC – specific electrical conductivity; TZ – tetrazolium test; HP – hydrogen peroxide treatment.

The occurrence of the negative correlation coefficient was confirmed in the previous studies (Ivetić and Milovanović, 2005). This phenomenon occurs because water itself is not a good conductor of electricity, however, when dissolving ions in the water there is an increase in the electrical conductivity and it increases as the concentration of ions in the solution increases. The substances released from the seeds in the water behave as electrolytes, and having in mind that the vital seeds easily restore membranes and thus more effectively release organic matter, the electrical conductivity of water in which were vital seeds will be less than the one in which were less vital seeds. The electrical conductivity test is very fast, easy to use and nondestructive, and thus it certainly has an advantage over the classical methods for determining seed quality.



Graph 1. *Correlation between: WG and EC (A); WG and TZ (B); WG and HP (C); EC and TZ (D); EC and HP (E); TZ and HP (F).*

Although the tetrazolium test is based on the subjective seed assessment that indicates the possibility of getting unreliable results, the assessment itself largely depends on the skills of technicians who perform it (Ivetić, 2013); when the test is performed appropriately, the percentage of viable seeds is very close to the percentage of seed germinated under most favorable conditions (Verma and Majee, 2013). The hydrogen peroxide treatment can give results that are slightly higher than the results obtained by the germination test, due to the increased oxygen concentration in the solution which accelerates the breathing process, as well as the fungicidal effect of the hydrogen peroxide (Ivetić 2002, 2013).

4. CONCLUSION

The electrical conductivity test could be commercially applied in the seed quality assessment, as a quick, simple, materially undesirable and nondestructive, if the relationships between the studied tests and the classical germination test would be determined on a sample which would cover a large number of individuals or populations that are genetically and spatially distant. The standardization of the electrical conductivity test using the tetrazolium test and hydrogen peroxide treatment could contribute to a more quality and more comprehensive determination of the seed quality for commercial purposes.

Acknowledgments

This paper was realized as a part of the project "*Forest plantations in the function of increasing the forestation of Serbia*'' (TR31041) financed by the Ministry of Education and Science of the Republic of Serbia within the framework of integrated and interdisciplinary research for the period 2011-2018.

REFERENCES

Comps B., Mátyás C., Letouzey J., Geburek T. (1998): Genetic variation in beech populations (Fagus sylvatica L.) along the Alpine Chain and in the Hungarian Basin. Forest Genetics. 5: 1-9.

Copeland L. O. & McDonald, M. B. 2001. Principles of seed science and technology Kluwer Academic Publishers, USA

Draper S.R., Bass L.N., Bould A., Gouling P., Hutin M.C., Rennie W.J., Steiner A.M., Tonkin J.H. (1985): Seed science and technology 13 (2). International Seed Testing Association. Zurich, Switzerland.

Edwards D.G.W., Wang B.S.P. (1995): A training guide for laboratory analysis of forcst tree seeds. Infonnation Report BC-X-356. Pacific Forestry Centre, Canadian Forest Service, Nalural Resources Canada. Victoria. British Columbia.

Gosling P.G. (1991): Beechnut storage: a review and practical interpretation of the scientific literature. Forestry 64: 51-59.

Ivetić V. (2002): Possibility of application of hydrogen peroxide methods for determining the vitality of seeds of forest tree species. Forestry 4-6: 1-7. (Mogućnost primene metoda vodonik-peroksida za određivanje vitalnosti semena šumskih vrsta dvreća. Šumarstvo 4-6: 1 – 7.

Ivetić V. (2013): Practicum for seed and nursery production and afforestation. In: Šijačić-Nikolić M., Mataruga M., Orlović S. (ed.). University of Belgrade - Faculty of Forestry. Seed quality - parameters and methods of their determination: 37-63. (Praktikum semenarstva, rasadničarstva i pošumljavanja. In: Šijačić-Nikolić M., Mataruga M., Orlović S. (ed.). Univerzitet u Beogradu, Šumarski fakulteta, Beograd. Kvalitet semena – parametri i metodi njihovog utvrđivanja: 37-63.)

Ivetić V., Milovanović J. (2005): The electrical conductivity test for studying spruce seed. Bulletin of the Faculty of Forestry, Belgrade, 91: 127-133. (Test elektične provodljivosti za ispitivanje semena omorike. Glasnik Šumarskog fakulteta, Beograd, 91: 127-133.)

Milošević M., Zlokolica M., Hrustić M., Gvozdenović Đ., Jocković Đ, (1996): Seed dormancy. Selection and seed production 111 (3-4): 97-104. (Mirovanje semena. Selekcija i semenarstvo 111 (3-4): 97-104.)

Muller C. (1993): Combination of dormancy-breaking and storage for tree seeds: new strategies for hardwood species. In: Edwards D.G.W. (ed.) Dormancy and barriers to germination. Proceedings of an international symposium of IUFRO Project Group P2.04-00 (Seed problems) Victoria, British Columbia, Canada, 23-26 April, 1991. 79-85

Muller, C. & Bonnet-Masimbert, M. 1982. Long term storage of beechnuts: results of large scale trials. In: Wang, B.S.P., Pitel, J.A., (eds.) Proceedings international symposium on forest seed storage; 23-27 Sep. 1980, Canadian Forestry Service Publication, 178-183.

Poter R.H., Durrell M., Romm H.J. (1947): The use of 2,3,5-tiriphenyl-tetrazoliumchloride as a measure of seed germinability. Plant Physiol 22 (2): 149-159.

Pukacka S. (1991): Changes in membrane lipid components and antioxidant levels during natural aging of seeds of Acer platanoides. Physiol Plant 82: 306–10.

Pukacka S., Ratajzcak E. (2004): Production and scavenging of reactive oxygen species in Fagus sylvatica seeds during storage at varied temperature and humidity. Plant Physiol 162 (8): 873-885.

Senaratna T., Gusse J.F., Mc Kersie B.D. (1988): Age-induced changes in cellular membranes of imbibed soybean axes. Physiol Plant 73: 85–91.

Soltani A., 2003: Improvement of Seed Germination of Fagus orientalis Lipsky, Doctoral thesis, Swedish University of Agricultural Sciences, Umeå

Suszka, B. & Zieta, L. 1977. A new presowing treatment for cold stored beech (Fagus sylvatica L.) seed chilled without medium at a controlled hydration level and pregerminated in cold moist conditions. Arboretum Kornickie, 22: 237-255.

Suszka, B. 1974. Storage of beech (Fagus sylvatica L.) seeds for up to 5 winters. Arboretum kornickie 19: 105-128.

Verma, P. and Majee, M. (2013). Seed Germination and Viability Test in Tetrazolium (TZ) Assay. Bio-protocol3(17): e884. DOI: 10.21769/BioProtoc.884.

Vertucci C.W., Ross E.E. (1990): Theoretical basis of protocols for seed storage. Plant Physiol 94: 1019–23.

Walters C. (1998): Understanding the mechanisms and kinetics of seed aging. Seed Sci Res 8: 223–44.

DIFFERENT METHODS FOR BEECH SEED QUALITY TESTING

Ivona KERKEZ, Slavko PAVLOVIĆ, Aleksandar LUČIĆ, Jovana DEVETAKOVIĆ, Mirjana ŠIJAČIĆ-NIKOLIĆ, Vladan POPOVIĆ

Summary

The seed quality is very important in the nursery production from the economic point of view and optimizing storage conditions is one of the major tasks for producers. The seed quality is mostly assessed by the seed germination rate but this method requires a long period of time for carrying out, namely, in extreme case up to 24 weeks (Edwards and Wang, 1995). Also some viable seeds won't germinate due to dormancy which can be removed. Three different methods for seed quality testing were presented in this paper. The aim of this study is to determine the correlation between the electrical conductivity test, tetrazolium test and hydrogen peroxide treatment.

The seed was collected in 12 different seed stands in Serbia that are commonly used for nursery production. The absolute weight and the moisture content of the sampled seed were measured for each population according to SRPS and ISTA standards. The tested seed sample was randomly taken from the total amount of the collected seed.

The analysis of the obtained results included the calculation of the Pearson correlation coefficient in the statistical software package "Statistica7". The correlation was determined between the recorded results of the seed weight and the electrical conductivity (r=-0.15); the seed weight and the tetrazolium test (r=0.51); the seed weight and the hydrogen peroxide treatment (r=0.27); the electrical conductivity and the tetrazolium test (r=-0.46); the electrical conductivity and the hydrogen peroxide treatment (r=-0.26); the tetrazolium test and the hydrogen peroxide treatment (r=0.55).

The electrical conductivity test could be applied in the seed quality assessment, as a quick, simple, materially undesirable and nondestructive, if the relationships between the studied tests and the classical germination test would be determined on a sample which would cover a large number of individuals or populations that are genetically and spatially distant. The standardization of the electrical conductivity test using the tetrazolium test and hydrogen peroxide treatment could contribute to a more quality and more comprehensive determination of the seed quality for commercial purposes.

RAZLIČITE METODE ZA ISPITIVANJE KVALITETA SEMENA BUKVE

Ivona KERKEZ, Slavko PAVLOVIĆ, Aleksandar LUČIĆ, Jovana DEVETAKOVIĆ, Mirjana ŠIJAČIĆ-NIKOLIĆ, Vladan POPOVIĆ

Rezime

U rasadničkoj proizvodnji kvalitet semena je veoma važan sa ekonomskog aspekta i optimizovanje uslova skladištenja semena je jedan od najvažnijih zadataka proivođača. Kvalitet semena se najčešće procenjuje stepenom klijavosti, međutim ovaj metod dugo traje, u ekstremnim slučajevima i do 24 nedelje (Edwards and Wang, 1995). Takođe neka od vitalnih semena neće klijati zbog prisustva dormantnosti koja se može ukloniti. U ovom radu prikazane su tri različite metode za testiranje kvaliteta semena. Cilj istraživanja je utvrđivanje korelacijskih odnosa između testa električne provodljivosti, tetrazolijum testa i tretmana semena vodonik peroksidom.

Seme je sakupjeno iz 12 razllіčitih semenskih sastojina na području Srbije, koje se uobičajeno korsite za sakupljanje semna za rasadničku proizvodnju. Za svaku od populacija

na uzorkovanom semenu izmereni su apsolutna masa semena i vlažnost semena po SRPS i ISTA standardima. Iz ukupne količine sakupljenog semena uzorak za testiranje semena električnom provodljivošću, tetrazolijumom i vodonik peroksidom je nasumično izabran.

Analiza dobijenih rezultata obuhvatila je izračunavanje Pirsonovog koeficijenta korelacije u statističkom program "Statistica 7". Utvrđena je korelacija između zabeleženih rezultata mase semena i električne provodljivosti (r=-0,15); mase semena i tetrazolium testa (r=0,51); mase semena i tretmana vodonik peroksidom (r=0,27); električne provodljivosti i tetrazolijum testa (r=-0,46); električne provodljivosti i vodonik peroksid tretmana (r=-0,26); tetrazolijum testa i vodonik peroksid tretmana (r=0,55).

Kada bi se jasno utvrdili odnosi između ispitivanih testova i klasičnog naklijavanja semena na uzorku koji bi zastupio veliki broj individua odnosno populacija koje su genetički i prostorno udaljene, test električne provodljivosti bi se mogao primenjivati prilikom procene kvaliteta semena bukve, kao brz, jednostavan, materijalno nezahtevan test koji ne oštećuje samo seme. Standardizacija testa električne provodljivosti uz primenu tetrazolijum testa i vodonik peroksid tretmana bi doprinela kvalitetnijem i svobuhvatnijem utvrđivanju kvaliteta semena bukve u komercijalne svrhe.

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY
COLLECTION 77-78, 2018

ODŽIVO ŠUMARSTVO
ZBORNIK RADOVA 77-78, 2018

UDK 630*181.43(23.02 Vidlič)(497.11)
Original scientific paper

FLORISTIC COMPOSITION OF OAK FORESTS AND ORIENTAL HORNBEAM SCRUBS ON Mt. VIDLIČ IN THE FIRST THREE YEARS AFTER A WILDFIRE

Ljubinko RAKONJAC[1], Marija MARKOVIĆ[2], Biljana NIKOLIĆ[1], Aleksandar LUČIĆ[1], Tatjana RATKNIĆ[1]

Abstract: *After a catastrophic wildfire on Vidlič Mountain in 2007, which among other things burned oak forests and hornbeam scrubs, their floristic composition was monitored for three years. Phytosociological surveys were carried out in the field using the Braun-Blanquet method, and the results are presented in the form of a synthetic phytosociological table. It was observed that in the stands in which the vegetation was only partially damaged, a shorter recovery time was required to return to the previous state - as it was before the wildfire. The initial stages of vegetation recovery at sites where complete destruction of vegetation occurred were characterized by a strong presence of annual therophytes: Orlaya grandiflora, Sideritis montana, Geranium dissectum, Althaea hirstuta. The first year after the wildfire was characterized by the dominance of annual species of Bupleurum praealtum, Crepis setosa and Centaurea calcitrap, which were not recorded in the monitored stands in the second and third year after the wildfire. In the second and third year after the wildfire, perennial plants and various grass species assumed dominance. It is necessary to conduct further systematic and continuous monitoring of the floristic composition and structure of the oak forests that completely burned in the wildfire, as well as an analysis of the profitability of the restitution of oak forests damaged by forest fires in Serbia.*

Keywords: wildfire, oak forests, Oriental hornbeam scrub, Vidlič Mountain, vegetation recovery

FlORISTIČKI SASTAV HRASTOVIH ŠUMA I ŠIBLJAKA GRABIĆA PRVE TRI GODINE NAKON POŽARA NA PLANINI VIDLIČ

Ljubinko RAKONJAC[1], Marija MARKOVIĆ[2], Biljana NIKOLIĆ[1], Aleksandar LUČIĆ[1], Tatjana RATKNIĆ[1]

Izvod: *Nakon katastrofalnog požara na planini Vidlič 2007 godine, u kome su između ostalog izgorele hrastove šume i šibljak grabića, praćen je floristički sastav prve tri godine nakon požara. Fitocenološka istraživanja obavljena su na terenu metodom Braun-Blanquet-a, a rezultati predstavljeni u vidu sintetske fitocenološke tabele.U sastojinama u kojima je došlo samo do delimičnog oštećenja vegetacije, zabeleženo je da je potrebno kraće vreme za oporavak i da brže dolazi do uspostavlja prvobitnog stanja, kakvo je bilo pre požara. Početni stadijumi oporavka vegetacije na lokalitetima na kojima je došlo do potpunog uništenja vegetacije karakteristični su velikim stepenom prisutnosti jednogodišnjih terofita: Orlaya grandiflora, Sideritis montana, Geranium dissectum, Althaea hirstuta. Prva godina posle požaraje karakteristična po dominaciji jednogodišnjih vrsta Bupleurum praealtum, Crepis setosa i Centaurea calcitrapa, koje druge i treće godine nisu zabeležene u praćenim sastojinama. Druge i treće godine nakon požara dolazi do dominacije višegodišnjih biljaka i različitih vrsta iz porodice trava. Neophodna su dalja sistematska i kontinuirana praćenja florističkog sastava i strukture opožarenih hrastovih šuma koje su u potpunosti izgorele u požaru, kao i analize rentabilnost rekonstrukcije hrastovih šuma, koje su oštećene šumskim požarima u Srbiji.*

Ključne reči: požar, hrastove šume, šibljak grabića, planina Vidlič, oporavak vegetacije

---

[1]Dr Ljubinko Rakonjac, Dr Biljana Nikolić, Dr Aleksandar Lučić, Dr Tatjana Ratknić Institute of Forestry, Belgrade, Serbia

[2]Dr Marija Marković, University of Niš, Faculty of Science and Mathematics, Niš, Serbia

Corresponding author: Marija Marković, Višegradska 33, 18000 Niš, Serbia, tel.: +381 18533015, e-mail: marijam@pmf.ni.ac.rs

Acknoledgement: This research was conducted as part of a project of the Ministry of Education, Science and Technological Development of the Republic of Serbia TR 31070; OI 171025.

1. INTRODUCTION

The wildfire is a process of uncontrolled burning and it is considered to be the most dangerous natural force that endangers human lives and health, material goods and the environment or natural resources (Glavaš, 2003). Much has been written about the role of wildfire in the evolution and development of society and culture (Pyne, 1997; MacGregor, 2011). At the time when the Europeans reached the central parts of the American West, its forest resources seemed to be inexhaustible. However, besides performing heavy cuttings, the settlers destroyed huge forest complexes simply by burning forests in order to obtain arable land, while they used the wood ash as the first fertilizer (Frančišković, 1963). Fire, the oldest tool in the development of culture and civilization, has today turned into an ever-increasing threat to natural resources, such as forests, soil or water (Dimitrov, 1990). In 95% of cases, fires occur as a result of human action, either intentionally (up to 6% depending from year to year) or unintentionally (about 90%), (Šoštarić, 1989).

We are witnessing climate change that directly increases the risk of fire occurrence. The history of wildfire and the results of simulations warn us that global warming caused by wildfire can have far-reaching effects on the forests of the northern hemisphere (Dimitrov, 2000). Wildfires are behaving differently today than at any other time in human history and thus they pose a great threat to the preservation of biodiversity (TheNature Conservancy, 2004).

Wildfires can damage or in some areas completely destroy a forest ecosystem. However, forests are able to revitalize and regenerate naturally even after catastrophic fire action (Velkovski et al., 2012).

The forests on the territory of the Republic of Serbia recorded a total of 6 043 wildfires and 96 239 ha of burned area in the period from 1956 to 2015. The total deforested area in the period from 1985 to 2015 amounted to 86 753 hectares. Ground fires occurred on 67 542 hectares and high fires on 19 247 hectares. State forests accounted for 56% of the deforested area. The largest deforested area was recorded in beech stands, in the *Fagetum moesiacae montanum* community (40.64%). A large burned area was also recorded in the forest of Hungarian oak and Turkey oak (*Quercetum fraineto-cerris*) and accounted for 29.35% of the total burned surface area (Ratknić, T., 2018).

2. MATERIAL AND METHODS

The thermophilic deciduous forest of Hungarian oak and Turkey oak (*Quercetum frainetto-cerris* Rudski 1949) is a climax community on Vidlič Mountain. However, different degradation stages of Hungarian oak and Turkey oak forests are more widely distributed on the mountain than the forests composed of densely closed stands. Marković et al. (2015) described the floristic characteristics of Oriental hornbeam scrubs - *Carpinetum orientalis serbicum* Rudski 1949., which grow on steep slopes and exposed rocky ridges on southern, warm and dry aspects of Vidlič Mountain. The characteristics of the vegetation growing on the burned areas of oak forests and Oriental hornbeam scrubs were monitored in the first (Marković et al., 2015), second (Marković et al., 2016) and third year after the wildfire (Marković et al., 2018).

Field investigations of burned thermophilic oak forests and Oriental hornbeam scrubs on Vidlič Mountain were conducted in 2008, 2009 and 2010. The result of the field research in the form of herbarized and labelled plant material was deposited in the Herbarium of the Department of Biology and Ecology of the Faculty of Natural Sciences and Mathematics, University of Niš: Herbarium Moesiacum (HMN). The collected plant material was identified according to Josifović M. (ed.) (1970-1986) and Îordanov D. (ed.) (1963-1995), and the nomenclature was harmonized with the Flora of Europe (Tutin, T. G. et al., 1964-1980, 1993).

Phytosociological surveys of the vegetation in the burned oak forest and Oriental hornbeam scrubs in the first, second and third year after the wildfire on Vidlič Mountain were conducted in the field using the Braun-Blanquet method (1964). The results are presented in the form of a comparative synthetic phytosociological table. The life forms of the species recorded were determined by Raunkiaer (1934). Alfa diversity of species in the community was determined using `Flora` software package (Karadžić, B., Marinković, S., 2009). Whittaker`s species diversity was also determined: the mean value of the total number of species and the mean value of the Simpson`s Biodiversity Index (Whitaker, R.H., 1972).

3. RESULTS AND DISCUSSION

The oak forests and their degradation stages in the form of Oriental hornbeam scrubs on Vidlič Mountain are represented by sparse stands. The presence of ash after a wildfire increases the amount of inorganic matter, which makes the burned areas suitable for the growth of many different plants. The depth of soil is important for the growth and development of plants. The increased content of ash derived from burned plants or their parts makes the soil deeper.

There were 284 species of plants recorded on the burned areas of oak forests and Oriental hornbeam scrubs in the first, second and third year after the wildfire (Table 1). There were 139 species in the first year, 202 species in the second year, and 203 species in the third year after the wildfire.

Table 1. *Comparative synthetic phytosociological table of the burned areas of oak forests and Oriental hornbeam scrubs in the first (2008), second (2009) and third (2010) year after the wildfire on Vidlič Mountain.*

Legend: I-V: degree of presence, +-4: number, ch-chamaephytes, g-geophytes, h-hemicryptophytes, p-phanerophytes, t-therophytes.

Species	1st year after the wildfire (2008)	2nd year after the wildfire (2009)	3rd year after the wildfire (2010)	Life form
Tree layer:				
Quercus cerris L.	II_{+-1}	II_{+-1}	II_{1}	p
Quercus pubescens Willd.	I_{2}	I_{2}	II_{2}	p
Acer hyrcanum Fischer & C. A. Meyer	I_{1}	I_{1}	II_{+-1}	p

Carpinus orientalis Miller	I 1	I 2	I 2	p
Fraxinus ornus L.	I 1	I 1	I 1	p
Quercus petraea (Mattuschka) Liebl.	I 1	I 1	I 1	p
Pyrus pyraster Burgsd.	I +	I +	I +	p
Shrub layer:				
Rosa canina L.	IV +	IV +-1	V +-1	p
Crataegus monogyna Jacq.	II +-1	III +	III +	p
Crataegus laevigata (Poiret) DC. subsp. *laevigata*	II+-1	II+-1	II+-1	p
Quercus cerris L.	II +-2	II +-2	II 2	p
Acer hyrcanum Fischer & C. A. Meyer	II +	II +	II +	p
Prunus tenella Batsch	I 3	II 1-4	II4	p
Malus pumila Miller	I 2	I 2	I 2	p
Prunus spinosa L.	I 1	II +-1	II +-2	p
Carpinus orientalis Miller	I 1	I 2	II 2	p
Syringa vulgaris L.	I +	II +-4	II+	p
Chamaecytisus austriacus (L.) Link	I +	I +	II +	p
Cornus mas L.	I +	I +	II +	p
Ulmus minor Miller	I +	I 2	I 3	p
Ononis pusilla L.	I +	I 1	I 1	ch
Ononis spinosa L.	I +	I +	I +	ch
Quercus petraea (Mattuschka) Liebl.	I +	I +	I +	p
Fraxinus ornus L.	I +	I +	I +	p
Viburnum lantana L.	I +	I +	I +	p
Clematis vitalba L.	I +	I +	I +	p
Sorbus torminalis (L.) Crantz	I +	I +	I +	p
Evonymus latifolius (L.) Miller	I +	I +	I +	p
Prunus domestica L. subsp. *insititia* (L.) C. K. Schneider	I +	I +	I +	p
Ligustrum vulgare L.	.	I +	II +	p
Chamaecytisus ciliatus (Wahlenb.) Rothm.	.	I +	II +	ch
Vinca herbacea Waldst. & Kit.	.	I +	II+	h
Cytisus procumbens (Waldst. & Kit. ex Willd.) Sprengel	.	I 1	I 1	p
Ulmus procera Salisb.	.	I +	I 2	p
Rhamnus saxatilis Jacq. subsp. *tinctoria* (Waldst. & Kit.) Nyman	.	I +	I +	p
Quercus pubescens Willd.	.	.	I +-1	p
Pyrus pyraster Burgsd.	.	.	I +	p
Genista sericea Wulfen	.	.	I +	ch
Rubus idaeus L.	.	.	I +	p
Pyrus amygdaliformis Vill.	.	.	I +	p
Ground flora layer:				
Orlaya grandiflora (L.) Hoffm.	V +-2	V +	V +	t
Medicago sativa L. subsp. *falcata* (L.) Arcangeli	IV +-2	V +-2	V +-1	h
Sideritis montana L.	IV +-2	IV +	III+	t
Geranium dissectum L.	IV+-1	III+	III+	t
Althaea hirsuta L.	IV+-1	III+	II+	t
Euphorbia cyparissias L.	III+-1	IV +-2	V+-2	h
Carduus candicans Waldst. & Kit. subsp. *candicans*	III+	IV +-1	V+	h
Asperula purpurea (L.) Ehrend.	III1-2	IV+-1	IV+-1	ch
Dactylis glomerata L.	III+-1	III+-1	IV +-1	h
Brachypodium pinnatum (L.) Beauv.	III+-3	III1-2	III2-4	h
Poa pratensis L.	III+-2	III +-2	III +-2	h
Fragaria vesca L.	III+-2	III+	III+-2	h

Teucrium chamaedrys L.	III$_{+-1}$	III$_{+-1}$	III$_{+-2}$	ch
Helleborus odorus Waldst. & Kit.	III$_{+-1}$	III$_{1}$	III$_{+-1}$	h
Eryngium campestre L.	III$_{+}$	III$_{+}$	III$_{+}$	h
Agrimonia eupatoria L.	II $_{+}$	III$_{+}$	III$_{+}$	h
Coronilla varia L.	II $_{+}$	III$_{+}$	III$_{+}$	h
Convolvulus cantabrica L.	II $_{1-2}$	III $_{+-2}$	III$_{1}$	ch
Linaria vulgaris Miller	II $_{+}$	III$_{+}$	III$_{+}$	h
Galium aparine L.	II $_{+-2}$	II $_{+-2}$	III$_{+-1}$	t
Festuca valesiaca Schleicher ex Gaudin	II $_{+}$	II $_{+-2}$	III$_{+-2}$	h
Vincetoxicum hirundinaria Medicus	II$_{+}$	II$_{+}$	III$_{+}$	h
Lactuca serriola L.	II$_{+}$	II$_{+}$	III$_{+}$	t
Allium scorodoprasum L. subsp. *rotundum* (L.) Stearn	II$_{+}$	II$_{+}$	III$_{+}$	g
Acanthus balcanicus Heywood & I. B. K. Richardson	II $_{+}$	II $_{+}$	III$_{+}$	ch
Carex humilis Leysser	II $_{1-2}$	II$_{2}$	II$_{1}$	h
Helianthemum nummularium (L.) Miller	II $_{+-1}$	II $_{+}$	II $_{1-2}$	ch
Satureja kitaibelii Wierzb.	II $_{+-1}$	II$_{1}$	II$_{1}$	ch
Teucrium montanum L.	II $_{+}$	II $_{+}$	II $_{+}$	ch
Verbascum lychnitis L.	II $_{+}$	II $_{+}$	II $_{+}$	h
Campanula bononiensis L.	II $_{+-1}$	II$_{+}$	II$_{+}$	h
Melica ciliata L.	II $_{+-1}$	II$_{1}$	II $_{+-1}$	h
Thlaspi perfoliatum L.	II $_{+}$	I $_{1}$	III$_{+}$	t
Cuscuta europaea L.	II $_{+-2}$	I$_{+}$	I$_{+}$	t
Cuscuta approximata Bab.	II$_{+}$	I$_{+}$	I$_{+}$	t
Myosotis arvensis (L.) Hill	I $_{+}$	III$_{+}$	III$_{+}$	t
Trifolium alpestre L.	I $_{+}$	III$_{+-1}$	III$_{+-1}$	h
Astragalus onobrychis L.	I $_{+}$	II$_{+-1}$	IV$_{+}$	h
Viola jordanii Hanry	I $_{1}$	II $_{+-2}$	III$_{+-1}$	h
Hypericum perforatum L.	I$_{+}$	II$_{+-1}$	III$_{+}$	h
Leontodon hispidus L.	I $_{1}$	II$_{+}$	III$_{+}$	h
Clinopodium vulgare L.	I $_{+}$	II $_{+-1}$	II $_{1-2}$	h
Thymus pannonicus All.	I$_{+}$	II$_{+}$	II$_{+}$	ch
Thymus glabrescens Willd.	I $_{+}$	II$_{+}$	II$_{+}$	ch
Potentilla recta L.	I$_{+}$	II $_{+}$	II$_{+}$	h
Artemisia alba Turra	I $_{+}$	II$_{+}$	II$_{+}$	ch
Allium sphaerocephalon L.	I$_{+}$	II$_{+}$	II$_{+}$	g
Digitalis lanata Ehrh.	I $_{+}$	I $_{2}$	II$_{+-1}$	g
Achillea millefolium L.	I$_{1}$	I$_{1}$	II $_{+-3}$	h
Cruciata glabra (L.) Ehrend.	I $_{1}$	I $_{1}$	II$_{+-1}$	h
Asperula cynanchica L.	I$_{+}$	I$_{+}$	II$_{+}$	h
Stachys germanica L.	I $_{+}$	I $_{+}$	II $_{+}$	h
Lapsana communis L.	I $_{+}$	I $_{+}$	II $_{+}$	t
Cerastium brachypetalum Pers.	I $_{+}$	I $_{+}$	II $_{+}$	t
Muscari neglectum Guss. ex Ten.	I$_{+}$	I$_{+}$	II$_{+}$	g
Crupina vulgaris Cass.	I$_{+}$	I$_{+}$	II$_{+}$	t
Chrysopogon gryllus (L.) Trin.	I$_{2}$	I$_{2}$	I$_{2}$	h
Trifolium pratense L.	I$_{1}$	I$_{+}$	I$_{+}$	h
Glechoma hirsuta Waldst. & Kit.	I $_{+}$	I $_{+}$	I $_{2}$	h
Poa angustifolia L.	I $_{+}$	I $_{+}$	I $_{1}$	h
Euphorbia seguierana Necker subsp. *niciciana* (Borbás ex Novák) Rech.	I $_{+}$	I $_{+}$	I $_{1}$	h
Geum urbanum L.	I $_{+}$	I $_{+}$	I $_{+}$	h
Carex caryophyllea Latourr.	I$_{+}$	I$_{+}$	I$_{+}$	h
Marrubium peregrinum L.	I$_{+}$	I$_{+}$	I$_{+}$	g
Ornithogalum pyrenaicum L	I$_{+}$	I$_{+}$	I$_{+}$	g
Allium flavum L.	I$_{+}$	I$_{+}$	I$_{+}$	g

Viola alba Besser	I_+	I_+	I_+	h
Verbascum speciosum Schrader	I_+	I_+	I_+	h
Arabis recta Vill.	II_+	I_+	.	t
Ajuga chamaepitys (L.) Schrebersubsp. *chia* (Schreber) Arcangeli	I_+	II_+	.	t
Thesium arvense Horvatovszky	I_+	II_+	.	h
Carduus acanthoides L.	I_2	I_+	.	h
Thalictrum aquilegifolium L.	I_1	I_2	.	h
Dichanthium ischaemum (L.) Roberty	I_+	I_1	.	h
Trifolium scabrum L.	I_+	I_+	.	t
Veronica austriaca L. subsp. *austriaca*	I_+	I_+	.	ch
Linaria genistifolia (L.) Miller subsp. *sofiana* (Velen.) Chater & D. A. Webb	I_+	I_+	.	h
Euphorbia falcata L.	I_+	I_+	.	t
Crucianella angustifolia L.	I_+	I_+	.	t
Campanula trichocalycina Ten.	I_+	I_+	.	h
Bromus commutatus Schrader	I_+	I_+	.	t
Trifolium badium Schreber	I_+	I_+	.	h
Torilis arvensis (Hudson) Link	I_+	I_+	.	t
Crepis foetida L. subsp.*rhoeadifolia* (Bieb.) Čelak.	II_+	.	II_{+-1}	t
Fallopia convolvulus (L.) Á. Löve	I_1	.	I_+	t
Torilis japonica (Houtt.) DC.	I_1	.	I_+	t
Vicia lathyroides L.	I_1	.	I_+	t
Sonchus asper (L.) Hill	I_+	.	I_+	t
Centaurea biebersteinii DC. subsp. *australis* (Pančić) Dostál	.	IV_+	IV_+	h
Medicago lupulina L.	.	II_{+-2}	IV_+	t
Vicia sativa L. subsp. *nigra* (L.) Ehrh.	.	II_+	III_+	t
Agrostis capillaris L.	.	II_{+-2}	II_2	h
Festuca panciciana (Hackel) K. Richter	.	II_{+-2}	II_2	h
Potentilla argentea L.	.	II_+	II_+	h
Medicago minima (L.) Bartal.	.	II_{+-2}	I_2	t
Trifolium campestre Schreber	.	II_+	I_+	t
Viola hirta L.	.	II_+	I_+	h
Viola kitaibeliana Schultes	.	II_+	I_+	t
Stachys recta L.	.	I_+	III_+	h
Fragaria viridis Duchesne	.	I_{+-3}	II_{+-3}	h
Achillea crithmifolia Waldst. & Kit.	.	I_{+-1}	II_+	g
Ajuga laxmannii (L.) Bentham	.	I_{+-1}	II_+	g
Verbascum phlomoides L.	.	I_1	II_+	h
Prunella laciniata (L.) L.	.	I_+	II_+	h
Bromus squarrosus L.	.	I_+	II_+	t
Hypericum rumeliacum Boiss.	.	I_+	II_+	h
Ptilostemon afer (Jacq.) W. Greuter	.	I_+	II_+	t
Origanum vulgare L.	.	I_+	II_{+-1}	g
Muscari comosum (L.) Miller	.	I_+	II_+	g
Galium mollugo L.	.	I_+	II_+	h
Linaria rubioides Vis. & Pančić subsp. *nissana* Niketić & Tomović	.	I_+	II_+	h
Onobrychis alba (Waldst. & Kit.) Desv.	.	I_+	II_+	h
Dasypyrum villosum (L.) P. Candargy	.	I_1	I_1	t
Vicia hirsuta (L.) S. F. Gray	.	I_1	I_+	t
Acinos alpinus (L.) Moench subsp. *Majoranifolius* (Miller) P. W. Ball	.	I_+	I_+	h
Acinos arvensis (Lam.) Dandy	.	I_+	I_+	t
Aethionema saxatile (L.) R. Br.	.	I_+	I_+	ch

Arabidopsis thaliana (L.) Heynh.	.	I +	I +	t
Carex brevicollis DC.	.	I +	I +	h
Carlina vulgaris L.	.	I +	I +	h
Lactuca saligna L.	.	I +	I +	t
Lens nigricans (Bieb.) Godron	.	I +	I +	t
Lotus corniculatus L.	.	I +	I +	h
Melica transsilvanica Schur	.	I +	I +	h
Orobanche loricata Reichenb.	.	I +	I +	g
Plantago argentea Chaix	.	I +	I +	h
Plantago lanceolata L.	.	I +	I +	h
Reseda lutea L.	.	I +	I +	h
Rumex sanguineus L.	.	I +	I +	h
Salvia austriaca Jacq.	.	I +	I +	h
Salvia nemorosa L.	.	I +	I +	h
Sanguisorba minor Scop.	.	I +	I +	h
Scabiosa argentea L.	.	I +	I +	h
Valerianella dentata (L.) Pollich	.	I +	I +	t
Ajuga genevensis L.	.	I +	I +	h
Convolvulus arvensis L.	.	I +	I +	g
Cruciata laevipes Opiz	.	I +	I +	g
Lathyrus venetus (Miller) Wohlf.	.	I +	I +	g
Poa compressa L.	.	I +	I +	h
Sedum acre L.	.	I+	I+	g
Petrorhagia saxifraga (L.) Link	.	I +	I +	ch
Bupleurum praealtum L.	IV+-1	.	.	t
Crepis setosa Haller	III+	.	.	t
Centaurea calcitrapa L.	II +-4	.	.	t
Festuca pratensis Hudson	II +-2	.	.	h
Ononis pusilla L.	II +	.	.	ch
Lepidium campestre (L.) R. Br.	I1	.	.	t
Bromus erectus Hudson	I+-1	.	.	h
Achillea pannonica Scheele	I+	.	.	h
Agropyron cristatum (L.) Gaertner	I+	.	.	h
Calystegia sepium (L.) R. Br.	I+	.	.	ch
Camelina rumelica Velen.	I+	.	.	t
Cirsium arvense (L.) Scop.	I+	.	.	g
Centaurium erythraea Rafn	I+	.	.	t
Coronilla scorpioides (L.) Koch	I+	.	.	t
Daucus carota L.	I+	.	.	t
Festuca heterophylla Lam.	I+	.	.	h
Festuca ovina L.	I+	.	.	h
Galium verum L.	I+	.	.	g
Himantoglossum hircinum (L.) Sprengel	I+	.	.	g
Lathyrus venetus (Miller) Wohlf.	I+	.	.	g
Melica uniflora Retz.	I+	.	.	g
Nigella arvensis L.	I+	.	.	t
Petrorhagia prolifera (L.) P. W. Ball & Heywood	I+	.	.	t
Stellaria media (L.) Vill.	I+	.	.	t
Tamus communis L.	I+	.	.	g
Vicia sativa L. subsp. *sativa*	I+	.	.	h
Vicia tetrasperma (L.) Schreber	I+	.	.	t
Viola odorata L.	I+	.	.	h
Viola tricolor L.	I+	.	.	h
Scleranthus perennis L. subsp. *dichotomus* (Schur) Nyman	.	II+-1	.	h
Erysimum diffusum Ehrh.	.	II+	.	h

*Arenaria serpyllifolia*L. subsp.*serpyllifolia*	.	II_+	.	t
Linaria chalepensis (L.) Miller	.	I_1	.	t
Verbascum pulverulentum Vill.	.	I_1	.	h
Aegilops geniculata Roth	.	I_+	.	t
Anchusa barrelieri (All.) Vitman	.	I_+	.	h
Anthemis cretica L. subsp. *cretica*	.	I_+	.	ch
Anthyllis vulneraria L.	.	I_+	.	h
Cerastium semidecandrum L.	.	I_+	.	t
Cerinthe minor L.	.	I_+	.	h
Cleistogenes serotina (L.) Keng	.	I_+	.	h
Crepis mollis (Jacq.) Ascherson	.	I_+	.	h
Dictamnus albus L.	.	I_+	.	h
Erysimum cuspidatum (Bieb.) DC.	.	I_+	.	h
Filipendula vulgaris Moench	.	I_+	.	h
Geranium columbinum L.	.	I_+	.	t
Globularia punctata Lapeyr.	.	I_+	.	h
Herniaria hirsuta L.	.	I_+	.	t
*Hieracium praealtum*Vill. exGochnatsubsp. *bauhinii* (Besser) Petunnikov	.	I_+	.	h
Lactuca viminea (L.) J. & C. Presl	.	I_+	.	h
Linum austriacum L.	.	I_+	.	h
*Marrubium incanum*Desr.	.	I_+	.	h
Medicago rigidula (L.) All.	.	I_+	.	t
Nonea pulla (L.) DC.	.	I_+	.	h
Onosma visianii G. C. Clementi	.	I_+	.	h
Orobanche gracilis Sm.	.	I_+	.	g
Petrorhagia illyrica (Ard.) P. W. Ball & Heywood	.	I_+	.	ch
Phlomis tuberosa L.	.	I_+	.	g
Plantago media L.	.	I_+	.	t
Senecio vernalis Waldst. & Kit.	.	I_+	.	t
*Scandix pecten-veneris*L.	.	I_+	.	t
Scorzonera hispanica L.	.	I_+	.	h
Thlaspi arvense L.	.	I_+	.	t
Trifolium incarnatum L.	.	I_+	.	t
Valerianella coronata (L.) DC.	.	I_+	.	t
Verbena officinalis L.	.	I_+	.	h
Vicia cracca L.	.	I_+	.	h
Xeranthemum annuum L.	.	I_+	.	t
Arabis hirsuta (L.) Scop.	.	.	II_+	h
Cirsium eriophorum (L.) Scop.	.	.	II_+	h
Galium album Miller	.	.	II_+	h
Lathyrus nissolia L.	.	.	II_+	t
Tragopogon pratensis L.	.	.	II_+	h
Poa trivialis L.	.	.	I_2	h
Alyssum repens Baumg.	.	.	I_+	h
Anthericum ramosum L.	.	.	I_+	h
Anthriscus sylvestris (L.) Hoffm.	.	.	I_+	h
Arrhenatherum elatius (L.) Beauv. ex J. & C. Presl	.	.	I_+	h
Asyneuma canescens(Waldst. & Kit.) Griseb. & Schenk	.	.	I_+	h
Cardaria draba (L.) Desv.	.	.	I_+	h
Cichorium intybus L.	.	.	I_+	h
Conyza canadensis (L.) Cronq.	.	.	I_+	t
Crepis biennis L.	.	.	I_+	h
*Dianthus petraeus*Waldst. & Kit.	.	.	I_+	h

Draba muralis L.	.	.	I+	t
Dorycnium pentaphyllum Scop. subsp.*herbaceum*(Vill.) Rouy	.	.	I+	ch
Epipactis helleborine (L.) Crantz	.	.	I+	g
Epilobium angustifolium L.	.	.	I+	h
Erigeron acer L.	.	.	I+	t
Fumaria officinalis L.	.	.	I+	t
Galeopsis ladanum L.	.	.	I+	t
Geranium sanguineum L.	.	.	I+	h
Hieracium barbatum Tausch	.	.	I+	h
Koeleria nitidula Velen.	.	.	I+	h
Lathyru spallescens (Bieb.) C. Koch	.	.	I+	g
Leontodon crispus Vill.	.	.	I+	h
Logfia minima (Sm.) Dumort.	.	.	I+	t
Minuartia verna (L.) Hiern	.	.	I+	ch
Mycelis muralis (L.) Dumort.	.	.	I+	h
Ornithogalum pyramidale L.	.	.	I+	g
Peucedanum alsaticum L.	.	.	I+	h
Prunella vulgaris L.	.	.	I+	h
Ranunculus illyricus L.	.	.	I+	h
Sherardia arvensis L.	.	.	I+	t
Silene noctiflora L.	.	.	I+	t
Sonchus arvensis L.	.	.	I+	h
Stipa pulcherrima C. Koch	.	.	I+	h
Torilis leptophylla (L.) Reichenb.	.	.	I+	t
Veronica chamaedrys L.	.	.	I+	g
Vicia incana Gouan	.	.	I+	h
Viola arvensis Murray	.	.	I+	t

The tree layer had 7 common species in the first, second and third year after the wildfire. These were: *Quercus cerris, Quercus pubescens, Acer hyrcanum, Carpinus orientalis, Fraxinus ornus, Quercus petraea* and *Pyrus pyraster*. The shrub layer recorded 33 species, 22 of which were present in the first, second and third year after the wildfire, six species were present in the second and third year after the wildfire, and only five species were present in the third year after the wildfire.

The ground flora layer had 67 species present in all three years of monitoring. The first and the second year after the wildfire had 15 species in common. The first and the third year after the wildfire had five common species, while the second and third year after the wildfire had 53 common species. There were 29 species present only in the first year, 39 species only in the second year and 43 species only in the third year after the wildfire.

The species that were found in all three years of monitoring had the greatest share (101 species or 34.95%). They were followed by the group of plants recorded in the second and third year after the wildfire (59 species or 20.42%). A group of plants recorded in the first and second year after the wildfire had a smaller share (15 species or 5.19%), while the plants that were present in the first and third year after the wildfire had the smallest share (5 species or 1.73%).

The mean value of the total number of species and the mathematical value of Simpson`s biodiversity index on the burned area of oak forests and Oriental hornbeam scrubs were growing year by year. Compared to the mean number of species on the areas not affected by the wildfire, they were smaller only in the first year after the wildfire, while in the second and third year after the wildfire they were higher than the mean number of species on the areas not affected by the wildfire (Table 2).

Table 2. *Mean values of the total number of species and Simpson's index of biodiversity of the vegetation of oak forests and Oriental hornbeam scrubs in the first, second and third year after the wildfire on Vidlič Mountain and the comparison with the corresponding areas not affected by the wildfire*

	Vegetation not affected by the wildfire	1st year after the wildfire (2008)	2nd year after the wildfire (2009)	3rd year after the wildfire (2010)
Mean value of the total number of species	38.75	38.5	52.8	53.43
Mean value of Simpson's index of biodiversity	0.968	0.967	0.976	0.977

Source: Marković et al., 2015; Marković et al., 2015; Marković et al., 2016; Marković et al., 2018

An analysis of the percentage share of life forms on the burned areas of oak forests and Oriental hornbeam scrubs in the first three years after the wildfire reveals their hemicryptophytic-therophytic character (Table 3), which is a general characteristic of the flora of the majority of regions in the temperate zone (Diklić, 1984). A higher percentage of annual therophytes was recorded in the first year than in the second and third year after the wildfire. Their seeds can be brought to the burned area by various means (by wind or animals), where they find favorable conditions for their growth. The share of therophytes decreases in the second and third year, and they are replaced by other, perennial plant species.

Table 3. *Overview of the percentage share of life forms on the burned areas of oak forests and Oriental hornbeam scrubs in the first, second and third year after the wildfire on Vidlič Mountain*

Legend: ch-chamaephytes, g-geophytes, h-hemicryptophytes, p-phanerophytes, t-therophytes.

Life form	1st year after the wildfire (2008)	2nd year after the wildfire (2009)	3rd year after the wildfire (2010)
ch (%)	10.71	8.82	8.87
g (%)	9.28	8.82	9.85
h (%)	38.57	46.57	45.81
p (%)	15	12.25	14.29
t (%)	26.44	23.54	21.18

Source: Original

The succession that leads to the restoration of oak forests is a long-term process (Vukićević, 1965). The interpretation of these processes on Vidlič

Mountain depends on the degree of the wildfire damage to vegetation. By monitoring the vegetation in the first three years after the wildfire on Vidlič Mountain we can distinguish two different cases:

1) oak forests that are only partially damaged by the wildfire, and
2) oak forests that are completely damaged by the wildfire.

1) At the sites of Vučje and Visočki Odorovci, where the stands of burned oak forests were studied, oak trees were not completely burned (Figure 1), and the land cover itself was affected only to a small depth. The vegetation was only partially damaged so that these stands could attain faster recovery and needed shorter recovery time to get back to the previous state, or the state before the wildfire. Physiognomy at these sites didn't change significantly compared to the state before the wildfire since oak trees in the upper layer grew green leaves immediately after the wildfire. In the second and third year, green branches appeared in the lower parts of oak trees, which means they were undergoing a gradual recovery.

Nutrients are not washed away to lower altitudes by atmospheric precipitation owing to the dense root system of woody plants. Therefore, diversity increases with the increasing altitude at these sites.

2) The situation is different in the stands in which complete destruction occurred, i.e., oak forests burned completely. Here a completely different physiognomy occurs compared to the state before the wildfire.

Figure 1. *Partially burned oak forest at the site of Visočki Odorovci in the second year after the wildfire*

Source: Original

The burned area is first inhabited by plants that take large quantities of ash as an abundant source of food for their growth and at the same time, they are resistant to the direct influence of sunlight and high temperatures. The groups of plants recorded in places where oak forests and Oriental hornbeam scrubs are completely burned, inhabit newly-formed open communities and belong to xerophilic and heliophilic plant species. Burned areas of oak forests now have different phenology compared to natural stands not affected by wildfires. Due to different conditions, in terms of the increased amount of light and heat, the plants of the burned areas bear flowers and fruit earlier than usual. These new plants emerge at different times. Some of them emerge in the first, while others emerge in the second or in the third year after the wildfire. As one species gives way to another, the vegetation of the burned areas goes through a series of stages, which will alternate until the original forest is restored (Vukićević-Ilić and Veslaj, 1954).

The first stage of the initial succession is characterized by the presence of therophytes. The following plants have the highest degree of presence: *Orlaya grandiflora*, *Sideritis montana*, *Geranium dissectum* and *Althaea hirsuta* (Table 1). The annual *Bupleurum praealtum* is recorded with a high degree of presence in the first year after the wildfire (Table 1), while it is not present in the monitored stands in the second and in the third year after the wildfire. The annual invasive thermophilic species *Crepis setosa* and *Centaurea calcitrapa* occur at low altitudes at the sites with the soil rich in nutrients. They are characterized by a narrow range of distribution and their habitats are rich in nutrients in the vicinity of human settlements. Furthermore, at not so altered sites of medium altitudes, some stands are dominated by the following species: *Sideritis montana* (Figure 2.), *Medicago minima* and *Galium aparine*. In the second year after the wildfire, annual species disappear from the stands, being replaced by various perrenial plants, the most abundant of which are: *Festuca valesiaca*, *Medicago sativa* subsp. *falcata*, *Agrostis capillaris* and others (Marković et al., 2016).

The next phase of the initial succession is marked by the dominance of perennial plants and different grass species, particularly on large surface areas of medium and high altitudes. These two ephemeral phases are important because they are distinguished by different floral composition and thus make two different stages.

Perrenial plants of the burned areas of oak forests and Oriental hornbeam scrubs should be observed as permanent representatives. They were present at these sites before the wildfire. The wildfire destroyed only the aboveground parts of these plants. The belowground parts not destroyed by the wildfire grew new young shoots in the first year after the fire.

In the third year after the wildfire, a large number of shoots or thin stems grew from one root of downy oak (*Quercus pubescens*), which are due to their small heights still classified into the shrub layer. It will take several years to build the oak forest again.

It is necessary to continue the systematic monitoring of the stands in which oak forests burned completely in order to discover when their full natural recovery can be achieved and they can return to the state before the wildfire.

Figure 2. *Dominance of the annual species of Sideritis montana at the site of Vučje in a completely burned oak forest inthe first year after the wildfire*

Source: Original

Ratknić, T. et al. (2017) analyzed the profitability of the restitution of beech forests in Serbia. In addition to the tangible costs and benefits of the restitution, their research included intangible costs and benefits: its impact on the environment, biodiversity, life community and economy. They came to the conclusion that investments in the restitution of beech forests are economically acceptable. Similar research that includes economic analysis is necessary in order to provide a comprehensive approach to the possibilities of human restitution of oak forests and summarize the costs and benefits of the investments in their restitution.

4. CONCLUSION

After the catastrophic wildfire on Vidlič Mountain in the summer of 2007, continuous monitoring in the first three years after the wildfire revealed that the average value of the number of species and the diversity grew from year to year. At sites where vegetation was only partially damaged, a shorter time was noted to be needed to establish the original state, as it was before the wildfire. At sites where the fire swept at a higher speed and did not reach deeper in the soil, perennial plants which were present before the wildfire survived due to their well-developed belowground organs in the form of rhizomes, tubers or bulbs. In the stands in which the oak forest and Oriental hornbeam scrub burned entirely, a completely different physiognomy occurred compared to the state before the wildfire. These sites had a high share of annual plants with considerable coverage recorded in the first year after the wildfire. Their seeds were most often brought to the burned area by wind. In the second and third year after the wildfire, the share of perennial plants increased, especially of different grass species.

Considering the importance of the forest system, it is necessary to continue the systematic and continuous monitoring of the floristic composition and structure of these forest communities. Natural revitalization of oak forests that completely burned in the wildfire would increase their protective role, primarily in erosion control and oxygen production, and it would further recover their natural resources (medicinal and aromatic herbs, forest fruits, edible mushrooms). Revitalization of the oak forests completely burned in the wildfire is a long-lasting process. In this sense, besides the continuous monitoring of the process of restoration of these forests after the wildfire, an economic analysis would also be necessary to determine the profitability of human restitution.

REFERENCES

Braun-Blanquet, J. (1964): Pflanzensoziologie, Grundzüge der Vegetationskunde. (Berlin, itd: Spiringet: Verlag).

Диклић, Н. (1984): Животне форме биљних врста и биолошки спектар флоре СР Србије, У: *Сарић М. (уредник). Вегетација СР Србије 1: 291-316. – Српска академија наука и уметности, Београд*.

Dimitrov, T. (1990): Sistemi ocjenjivanja opasnosti od šumskih požara-pogled u budućnost, Šumarski list CXIV, 395-404.
Frančišković, S. (1963): Šuma i budućnost čovečanstva, Šumarski list 3-4: 155-160.

Glavaš, M. (2003): Šumski požari i protupožarna zaštita na području Uprave šuma Podružnice Senj od 1994-2003, Šumarski list, SUPLEMENT, 79-91.

Йорданов, Д. (Главен редактор) (1963-1995): Флора на Народна Република България I-X, Издателство на Българската Академия на Науките, София.

Јосифовић, М. (ед.) (1970-1986): Флора СР Србије I-X, САН, Београд.

Карацић, Б., Маринковић, С. (2009): Квантитативна екологија, Фонд и Институт за биолошка истраживања.

MacGregor, D.G. (2011): The Future of Fire in Environmental Management (March, 9), Futures Journal, Forthcoming, Available at: SSRN: http:// ssrn.com/abstract=1782219

Марковић, М., Ракоњац, Љ., Пешић, Д., Николић, Б., Лучић, А. (2015): Флористичке карактеристике шибљака грабића на планини Видлич (Floristic characteristics of Oriental hornbeam scrubwood on the mountain of Vidlič), Шумарство 3: 43-56.

Marković, S., Stankov, M., Jovanović, V., Mitić, V., Stamenković, S., Ilić. M., Pešić, D. (2015): Study of oak forests and scrubs of hornbeam vegetation, metals content of *Teucrium chamaedrys* and soils the first year after the wildfire on Vidlič Mountain, Safety engineering Vol. 5, N^{o} 2: 61-68.

Марковић, М., Ракоњац, Љ., Лучић, А. (2016): Храстове шуме и шибљак грабића друге године после пожара на планини Видлич (Oak forests and scrubs of hornbeam in the second year after the fire on Vidlič Mountain), Пиротски зборник 41: 57-71.

Марковић, М., Ракоњац, Љ., Смиљић, М., Паповић, О. (2018): Термофилне храстове шуме и шибљак грабића треће године након пожара на планини Видлич (Thermophilous oak forests and Oriental hornbeam scrubwood in the third year after a fire on Mt. Vidlič), Шумарство 1-2: 99-110.

Министарство животне средине и просторног планирања (2008): Извештај о пожарима у заштићеним ресурсима за 2007. годину.

Pyne, S.J. (1997): Vestal fire, Seattle, WA: University of Washington Press.

Ratknić, T., Milovanović, J., Ratknić, M., Šekularac, G., Subić, J, Jeločnik, G., Poduška, Z. (2017): Analysis of the Profitability of the Restitution of Fire-Affected Beech Forests in Serbia. Appl. Ecol. Env. Res., **15** (4), 1999-2010.

Раткнић, Т. (2018): Интегрални модел заштите и управљање ризицима од шумских пожара у Републици Србији, Докторска дисертација, 1-390.

Raunkiaer, C. (1934): The life forms of plants and statistical plant geography; being the collected papers of C. Raunkiaer, translated into English by H. G. Carter, A. G. Transley and Miss Fausboll, Clarendon, London.

Šoštarić, V. (1989): Požari šuma, Šumarski list CXIII, 168-172.
The Nature Conservancy, World Wide Found for Nature and IUCN (2004): Fire, Ecosystems & People, A preliminary Assessment of Fire as a Global Conservation Issue, October 2004.

Tutin, T.G., Heywood, W.H., Burges, N.A., Moore, D.M., Valentine, D.H., Walters, S.M., Webb, D.A. (Eds) (1964-1980) Flora Europaea, I-V. Cambrige University Press, London.

Tutin, T.G., Burges, N.A., Chater, O.A., Edmondson, J.R., Heywood, V.H., Moore, D.M., Valentine, D.H., Walters, S.M., Webb, D.A. (1993). (Eds.). Flora Europaea 1 (2nd Edition). Cambrige University Press, London.

Велковски, Н., Ацевски, Ј., Василевски, К., Симовски, Б. (2012): Ревитализација на опожарени шумски екосистеми преку природно обновување, 4 Конгрес на еколозите на Македонија со меѓународно учество, Охрид, 12-15 октобар, 2012. Книга на апстракти: 23.

Вукићевић, Е. (1965): Сукцесија вегетације и природно обнављање шума на шумским пожариштима у Србији, Гласник Шумарског факултета, Београд.

Вукићевић-Илић, Е., Веслај, В. (1954): Вегетација и земљиште на пожариштима Мајданпечке Домене, Гласник Шумарског факултета Универзитета у Београду, 8, 251-282.

Whitaker, R.H. (1972): Evolution and measurement of species diversity, Taxon 21 (2\3): 213-251.

FLORISTIC COMPOSITION OF OAK FORESTS AND ORIENTAL HORNBEAM SCRUBS ON Mt. VIDLIČ INTHE FIRST THREE YEARS AFTER A WILDFIRE

Ljubinko RAKONJAC, Marija MARKOVIĆ, Biljana NIKOLIĆ,
Aleksandar LUČIĆ, Tatjana RATKNIĆ

Summary

There are few areas that completely burned on Vidlič Mountain in the wildfire in 2007 and they can be considered as newly-established sites. The largest changes in the composition of vegetation occurred in the areas where closed oak forest communities burned completely. They are located mostly on the terrain with steep slopes, so that wind can bring seeds of different plant species and thus build qualitatively new communities. They are completely different from the forests not affected by the wildfire, i.e. the forest that grew at that site before the wildfire. The presence of ash, which is derived from the burned plant parts, makes the soil deeper and increases the amount of inorganic matter in it, which is suitable for the growth and development of a large number of plants. With the time, the litterfall composed of fallen leaves and branches of woody plants that didn't burn completely during the wildfire increases the amount of organic matter in the soil produced in one season. The smaller the litterfall, the faster the increase.

During the initial stages of monitoring the recovery of the vegetation of oak forests and Oriental hornbeam scrubs, the number of species generally increases from year to year, which sometimes lasts up to the second and sometimes up to the third year after the wildfire. The species that can be found only in one releve with a large number and coverage are most important for the qualitative analysis. The annual invasive thermophilic species of *Bupleurum praealtum*,*Centaurea calcitrapa* and *Sideritis montana* are characteristic for the initial phase of the succession at sites where complete destruction of vegetation occurred. The coverage is the smallest in the first year after the wildfire. The interaction between the plants is small. In the second and third year after the wildfire, the coverage increases as well as the number of perennial plants and various grass species. In the oak stands which were only partially damaged, the tree layer attains a gradual increase in the vegetation height and tree diameters.

Succession, which takes many years in burnt oak forests, is in the form of a gradual alternation of communities until a closed community is built again. The time needed for the recovery depends on the duration and intensity of the wildfire, that is, the speed at which the fire pass through the area, as well as the degree of damage to the vegetation, or whether the vegetation was destroyed partially or completely. In addition, the recovery of vegetation after a wildfire depends on the proximity of the areas not affected by the wildfire, orographic factors, as well as the structure and development of soil in the areas affected by a fire.

FlORISTIČKI SASTAV HRASTOVIH ŠUMA I ŠIBLJAKA GRABIĆA PRVE TRI GODINE NAKON POŽARA NA PLANINI VIDLIČ

Ljubinko RAKONJAC, Marija MARKOVIĆ, Biljana NIKOLIĆ, Aleksandar LUČIĆ, Tatjana RATKNIĆ

Rezime

Na planini Vidlič je malo površina koje su u potpunosti izgorele u požaru 2007. godine i mogu se smatrati novim staništima. Najveće promene u sastavu vegetacije se dešavaju tamo gde su sklopljene hrastove šumske zajednice izgorele u potpunosti. Tu je teren najčešće sa većim nagibom, pa sa vetrom dođe seme različitih vrsta biljaka i dolazi do formiranja kvalitativno novih zajednica. One se u potpunosti razlikuju u odnosu na neopožarenu šumu, koja je na tom mestu bila zastupljena pre požara. Zbog prisustva pepela, koji potiče od sagorelih delova biljaka, povećava se dubina zemljišta i količina neorganske materije, a to pogoduje mnogim biljkama za rast i razvoj. Kako vreme prolazi, povećava se i količina organskih materija u sastavu zemljišta u toku jedne sezone od opalog lišća biljaka i od grana drvenastih biljaka koje nisu izgorele u potpunosti za vreme požara, od sitnih brže, a od krupnijih sporije.

Tokom inicijalnih stadijuma praćenja oporavka vegetacije hrastovih šuma i šibljaka grabića, opšta pojava je povećanje broja vrsta iz godine u godinu posle požara, koja negde ide do druge, a negde do treće godine. Vrste koje se javljaju samo u po jednom snimku sa velikom brojnošću i pokrovnošću su bitne za kvalitativnu analizu. Jednogodišnje invazivne termofilne vrste *Bupleurum praealtum, Centaurea calcitrapa, Sideritis montana* su karakteristične za početnu fazu inicijalnog stadijuma sukcesije na lokalitetima gde je došlo do potpunog uništenja vegetacije. Prve godine posle požara najmanja je pokrovnost. Manji je uticaj biljaka jednih na druge. Druge i treće godine dolazi do povećanja pokrovnosti kao i višegodišnjih biljaka i različitih vrsta iz porodice trava. U hrastovim sastojinama u kojima je došlo samo do delimičnog oštećenja, u spratu drveća iz godine u godinu dolazi do postupnog povećanja visine vegetacije i promera stabla.

Sukcesije, koje na požarištu hrastovih šuma traju duži niz godina, sastoje se u postepenom smenjivanju jednih zajednica drugima do ponovnog formiranja sklopljenih zajednica. Dužina oporavka zavisi od trajanja i intenziteta požara, odnosno od toga kojom je brzinom požar prešao preko podloge kao i od stepena oštećenja vegetacije, odnosno da li je vegetacija uništena delimično ili u potpunosti. Osim toga, oporavak vegetacije posle požara zavisi od blizine neopožarenim površinama, orografskih faktora, kao i od strukture i razvijenosti zemljišta u oblastima zahvaćenim požarom.

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION 77-78, 2018 ZBORNIK RADOVA 77-78, 2018

UDK 551.3.053:630*384(497.11-12)
UDK 630*116.6:630*384.2/.3(497.11-12)
Original scientific paper

EFFECTS OF EROSION CONTROL WORKS IN THE DRAINAGE BASIN OF THE PALOJSKA RIVER (GRDELICA GORGE)

Sonja BRAUNOVIĆ[1], Filip JOVANOVIĆ[2], Milan KABILJO[1], Natalija MOMIROVIĆ[1]

Abstract: *The paper examines the effects of erosion control works performed in the Palojska River Basin, based on a comparative analysis of erosion intensities in 1953 and 2016. Intensive processes of erosion in the basin were reduced by performing technical works in the channel and biological and technical works on the slopes. The effects of the works conducted, accompanied by changes in the land use and socio-demography, are manifested in the reduction of the erosion coefficient from Z = 1.02 (surface excessive erosion) in 1953 to Z = 0.28 (mixed weak erosion) in 2016 and in the reduction of the sediment yield and transport in the basin.*

Keywords: erosion process intensity, erosion control works, Palojska River, Grdelica Gorge, Serbia

[1]Dr Sonja Braunović, MSc Milan Kabiljo, MScNatalija Momirović, Institute of Forestry, 3 Kneza Višeslava, 11030 Belgrade, Serbia.
[2]BSc Filip Jovanović, Faculty of Forestry, University of Belgrade, 1 Kneza Višeslava, 11030 Belgrade, Serbia.
Corresponding author: Sonja Braunović, Institute of Forestry, 3 Kneza Višeslava, 11030 Belgrade, Serbia, +381628838014, e-mail: sonja.braunovic@forest.org.rs

* **Acknowledgements:** The research was realized within the project `The development of technological procedures in forestry with a view to an optimum forest cover realization" (TR31070), 2011-2018, financed by the Ministry of Science and Technological Development of the Republic of Serbia.

EFEKTI PROTIVEROZIONIH RADOVA U SLIVU PALOJSKE REKE (GRDELIČKA KLISURA)

Izvod: *U radu su sagledani efekti izvedenih protiverozionih radova u slivu Palojske reke, na osnovu uporedne analize intenziteta erozije u 1953. i 2016. godini. Intenzivni procesi erozije u slivu sanirani su izvođenjem tehničkih radova u koritu i bioloških i tehničkih radova na padinama. Uspeh izvedenih radova, uz promenu načina korišćenja zemljišta i sociodemografske promene, izražen je kroz smanjenje vrednosti koeficijenta erozije sa Z=1,02 (površinska ekscesivna erozija) u 1953. godini, na Z=0,28 (mešovita slaba erozija) u 2016. godini i smanjenje produkcije i pronosa nanosa u slivu.*

Ključne reči: intenzitet erozionih procesa, protiverozioni radovi, Palojska reka, Grdelička klisura, Srbija

1. INTRODUCTION

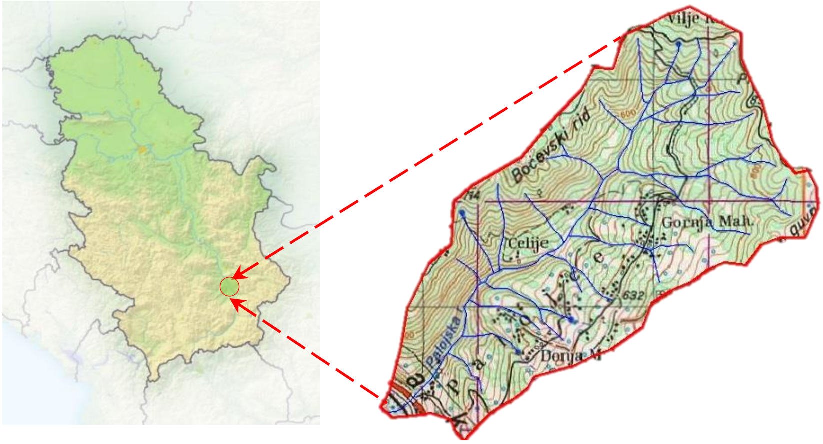
It is a worrying fact that 40% of the territory of Serbia is currently affected by erosion processes of excessive, severe and moderate intensity. There are over 12,000 torrents that endanger the economy, infrastructure, and often human lives. The damage incurred can be viewed from several different aspects - soil erosion and sediment deposition in accumulations and regulated watercourses (water management aspect); reduction of soil fertility and sediment deposition in arable land (agricultural aspect); damage to roads, industrial buildings, human settlements, etc. (economic aspect), chemical and mechanical pollution of watercourses and reservoirs (ecological aspect) (Braunović, 2013; Braunović and Perović, 2017).

The first erosion control works in Serbia are related to those made at the beginning of the 20th century in Grdelica Gorge. A total of 58 basins of Grdelica Gorge were protected against excessive erosion in the period between 1947 and 1977 (Kostadinov et al., 2008; Braunović et al., 2017). Since then, the scope of erosion control works in Serbia had been decreasing so that at the beginning of the 21st century these works were reduced to the rehabilitation of existing structures.

2. MATERIAL AND METHODS

2.1 Research Area

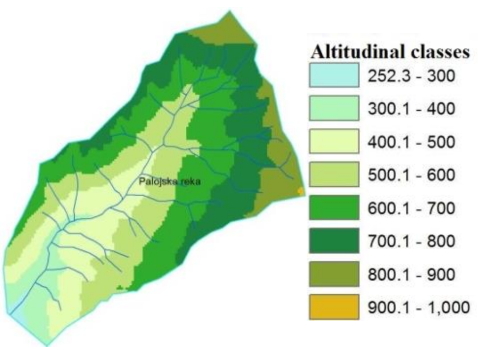
The Palojska River Basin is located in eastern Serbia (northeastern part of Grdelica Gorge) (Picture 1).



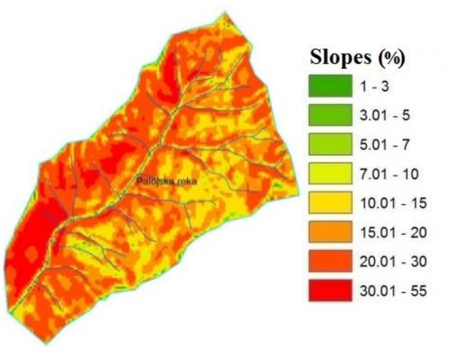
Picture 1. The *geographical position of the Palojska River Basin*

The Palojska River is a right tributary of the South Morava River and it flows through the municipality of Leskovac, i.e., cadastral municipalities Palojce (91.7% of the basin area) and parts of cadastral municipalities of Dedina bara, Boćevica, Novo Selo, Bojišina and Vilje Kolo.

The basin is elongated, stretching on an area of 6.87 km^2 in the northeastern-southwestern direction. The mean width of the basin is 1.5 km. The main stream is 4.6 km long, with the mean drop of 16% (6% in the lower course, 16% in the middle course and 27% in the upper course). The average slope in the basin is 35%, with significantly larger drops and a large number of gullies on the right side of the basin. The source is at 700 m above sea level, and its mouth is at 265 m above sea level, which points to the pronounced energy of relief. The largest portion of the Palojska River Basin (76.27%) lies in the altitudinal zone from 500 m to 1000 m, and 23.73% of the total surface area of the basin is in the zone from 265 m to 500 m (Picture 2). The slope ranges from 1% to 55%. The dominant slopes range from 20% to 30% and they account for 35.64% of the surface area of the basin. The slopes ranging from 15% to 20% account for 31.50% of the total area, and the slopes of 30-55% for 8.62% (Picture 3).



Picture 2. *Altitudinal zones in the basin*



Picture 3. *Slopes in the basin*

The bedrock consists mainly of metamorphic rocks, with a smaller share of sedimentary rocks. The rocks of the Vlasina complex, which originate from the Rifeya-Cambrian Epoch, account for 95.27% of the basin area. These are muscovite-chlorite schists, chlorite-muscovite schists, albite-chlorite-muscovite schists, and albite gneiss with chlorite (Braunović and Ratknić, 2012). These rocks are characterized by processes of intensive surface disintegration, which is proportional to the degree of slope. According to the resistance of rocks to erosion, these rocks belong to the categories of conditionally erodible and very erodible rocks. The soil type of the Palojska River Basin is dystric cambisol (Braunović, 2013).

2.2 Methods

In order to quantify changes in the intensity of erosion, a model of erosion potential - EPM was applied (Gavrilović, 1972), as well as a comparative analysis of the state of erosion processes before and after erosion control works were conducted in the channel and basin. According to Ratknić and Braunović (2016), the effects of natural factors, land use changes and human factors on the changes in the intensity of erosion in the basin were estimated on the basis of field research data (mapping of land use and excessive and severe erosion processes) for the period 2011-2012 and in 2016. Thematic maps (topographic, geological, pedological, land use and erosion maps) were also used. In order to process natural characteristics of the study area, we used a 1:50,000 topographic map (Vlasotince 1 sheet), geological map of Serbia 1:100,000 (Vlasotince sheet), and a pedological map of Grdelica Gorge and Vranje Valley 1:50,000 (1960). Climate characteristics of the area were based on data from 10 meteorological stations (Meteorological Yearbooks, 1961-2015). The types of bedrock can be grouped according to their resistance to erosion destruction in 4 categories (very solid, conditionally solid, conditionally erodible and very erodible rocks). The land use before the erosion control works was reconstructed on the basis of the existing documentation (Main design for the regulation of the Palojska River Basin, 1956; The Register of torrents of the right and left tributaries of the South Morava River on the Grdelica–Vladičin Han section, 1964). The land use after the erosion control works was defined using homogeneous units, within which productive and non-productive areas were distinguished (Braunović et al., 2015). The state of erosion prior to the execution of erosion control works was determined on the basis of the erosion map of Grdelica Gorge and Vranje Valley (1956).

3. RESULTS AND DISCUSSION

3.1 Land use

According to data from 1953, forests (predominantly locust forests and occasionally oak, Turkey oak and Hungarian oak forests) accounted for 1/3 of the basin area and they were characterized by poor protective function. The largest share was in ploughland and barrens (40%), which directly affected the intensity of erosion processes (Braunović and Ratknić, 2010). Smaller areas were occupied by orchards, meadows and pastures, which were affected by processes of excessive and severe erosion.

Table 1. *Types of land use before and after the execution of EC works*

Land use categories	1953		2016	
	Area (ha)	Share in the total area (%)	Area (ha)	Share in the total area (%)
Barren land	89.22	12.99	-	-
Forests	245.15	35.68	474.55	69.07
Ploughland	188.78	27.48	13.10	1.90
Meadows and pastures	92.93	13.53	100.72	14.66
Degraded meadows and pastures	-	-	26.3	3.83
Orchards	70.92	10.32	-	-
Human settlements, road network, water courses	-	-	72.33	10.54
Total	687	100.00	687	100.00

In the period after the erosion control works, the share of forest areas increased by 33.4%, and in 2016 it accounted for 69.07% of the basin area. The share of ploughland decreased by 25.58%, while the share of meadows and pastures decreased slightly (Table 1).

3.2 Socio-demographic characteristics

According to the 2011 Census, there were about 132 households with 500 inhabitants living in the basin. The average household size was 3.43 members (Table 2). This catchment area was characterized by a decrease in the number of inhabitants in the period from 1981 to the present. The average age of the population increased from 29.3 years in 1971 to 41 years in 2011 (Comparative Population Survey, 2014).

Table 2. *Changes in the number of inhabitants and households, household size and population density*

	Census year						
	1953	1961	1971	1981	1991	2002	2011
	Population						
	475	458	446	526	512	484	453
CM Palojce	**Number of households**						
	77	94	101	125	123	142	132
	Average household size						
	6.17	4.87	4.42	4.21	4.16	3.41	3.43
	Population density in the basin						
	69.14	66.67	64.92	76.56	74.53	70.45	65.94

The number of households increased in the period from 1953 to 1981, and the household size declined in all subsequent censuses. The basin had the highest population density in 1953, but it subesequently declined until 1971. In 1981, its rapid increase was recorded, followed by a constant decrease (Table 2).

3.3 Erosion control works performed in the basin

In the period from 1947 to 1977, technical works in the basin of the Palojska River included 0.45 km of regulation and 12 dams and cascades (Jelić, 1978).

Table 3. *Overview of erosion control works performed in the Palojska River Basin*

Technical works in the channel						Biological works in the basin	
Regulations			Transverse structures				
Length (km)	Excavation (m^3)	Wall (m^3)	Number of structures	Excavation (m^3)	Wall (m^3)	Afforestation (ha)	Grassing (ha)
0,450	13100	4578	12	1200	860	89,7	4,7
Tecnical works performed in the basin							
Wattle-work (m)	Terraces (m)	Bench terraces (m)	Dry dams (m^3)		Horizontal walls (m)	Orchard establishment (ha)	Pasture reclamation (ha)
5880	2900	65000	200		1000	61	27

Biological works in the basin included afforestation, orchard establishment on terraces, pasture reclamation and grassing of eroded areas, all on 182.4 ha (27% of the surface area of the basin) (Table 3). Austrian pine plantations were established on bench terraces and terraces. Wattle-work was constructed, as well as horizontal walls and dry dams. Finally, 3 ha were planted with poplar trees.

3.4 Erosion Processes

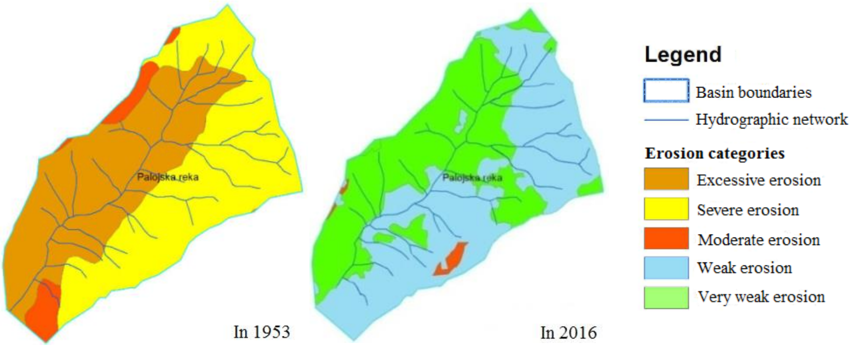
The mean coefficient of erosion in 1953 (i.e., before the erosion control works) was Z_{mean} = 1.02, which means that the basin was affected by excessive erosion processes. The processes of severe erosion endangered half of the basin, the processes of excessive erosion 45.91% and moderate erosion 4.66% of the total area of the basin (Picture 4).

The mean coefficient of erosion for 2016 was Z = 0.28 (weak erosion). The part of the basin area affected by weak erosion processes was 3.30 km^2 (48.03% of the basin area), by very weak erosion 3,09 km^2 (44.98% of the basin area) and by moderate erosion 0.18 km^2 (2.62% of the basin area). Buildings, settlements, watercourses and road networks accounted for an area of 0.1 km^2 (Picture 4).

Table 4. *Sediment yield and transport in the Palojska River Basin*

Year	Sediment yield		Coefficient of retention Ru	Sediment transport	
	specific	total		specific	total
	Wsp $m^3\,km^{-2}god^{-1}$	Wyear m^3year^{-1}		Gsp $m^3\,km^{-2}year^{-1}$	Gyear m^3year^{-1}
1953	2763.86	18987.70	0.24	663.33	4557.05
2016	295.94	2033.12		71.03	487.95

The total amount of sediment yielded in the basin (for the study periods) is shown in Table 4. The values of the mean erosion coefficient and the amount of sediment yielded and transported in the basin for both reference periods show that the processes of erosion have been calming down in the Palojska River Basin.



Picture 4. *The map of erosion before and after the erosion control works*

4. CONCLUSION

The reducing intensity of erosion process and declining total sediment yield (by 16954.58 m^3god^{-1}), along with the increasing forest cover (by 33.4%) and reducing flood risk in the basin in the last 65 years have been the result of the erosion control works and active struggle against erosion. Furthermore, the reduction in the intensity of erosion was affected by the changes in socio-demographic factors, which were reflected on the changes in land use.

The control of erosion processes achieved through the application of adopted laws and decisions at the level of local self-government units is a prerequisite for unhindered traffic and effective protection of existing and future reservoirs, agricultural areas and settlements in Grdelica Gorge. However, besides the obvious effects of the works carried out in this area, the problems associated with investments and regular maintenance of the constructed objects are still evident.

LITERATURE

Braunović, S., Ratknić M., (2010): *The Changes Of Land Use in Grdelicka Gorge and Vranjska Valley*. International Scientific Conference `Forest Ecosystems and Climate Changes`. Institute of Forestry, Belgrade. Proceedings, 83–88

Braunović, S., Ratknić, M. (2012): *Impact of the Parent Rock on Erosion Process Development in Grdelica Gorge and Vranjska Valley*. Sustainable Forestry, 65–66: 65–72

Braunović, S. (2013): *Effects of erosion control works on the state of erosion in Grdelica Gorge and Vranje Valley*. PhD Thesis, Faculty of Forestry, Belgrade (In original: *Braunović, S. (2013): Efekti protiverozionih radova na stanje erozije u Grdeličkoj klisuri i Vranjskoj kotlini. Doktorska disertacija, Šumarski fakultet, Beograd*)

Braunović, S., Ratknić, M., Ratknić, T., Kabiljo, M. (2015): *Changes in Land Use in the Region of Grdelica Gorge in the period 1963-2011*. Sustainable Forestry, 71–72: 77–84

Braunović, S., Ratknić, M., Rakonjac, Lj. (2017): *The Role of Forest Ecosystems in the Risk Management of Torrential Floods (The Grdelica Gorge).* VIII International Scientific

Agricultural Symposium `Agrosym 2017`, Jahorina, University of East Sarajevo, Faculty of Agriculture, Bosnia and Herzegovina. Book of proceedings,1860–1865

Braunović, S., Perović, V. (2017): *Soil Erosion, Changes of Land Use and Migration Trends – Impact on Tourism Development*. Tourism in Function of Development of the Republic of Serbia – Tourism Product as a Factor of Competitiveness of the Serbian Economy and Experiences of Other Countries, University of Kragujevac, Faculty of Hotel Management and Tourism, Vrnjačka Banja. Thematic proceedings II, 306–323

(2014): *Comparative overview of the population 1948, 1953, 1961, 1971, 1981, 1991, 2002 and 2011(Book 20),* Republic Institute of Statistics, Belgrade (In original: *(2014): Uporedni pregled broja stanovnika 1948, 1953, 1961, 1971, 1981, 1991, 2002. i 2011. god. (Knj. 20), Republički zavod za statistiku, Beograd*)

Gavrilović, S. (1972): *Engineering of torrential flows and erosion*. `Izgradnja` Journal, Belgrade (In original: *Gavrilović, S. (1972): Inženjering o bujičnim tokovima i eroziji. Izgradnja, Beograd*)

Jelić, B. (1978): *Erosion control works carried out in the Great Morava River Basin in the period 1947-1977*. `Erozija` Journal, 9: 25–42 (In original: *Jelić, B. (1978): Protiverozioni radovi izvedeni u slivu Velike Morave u periodu 1947-1977. Erozija, 9: 25-42*)

Kostadinov, S., Dragovic, N., Zlatic, M. and Todosijevic, M. (2008): *Erosion Control Works and the Intensity of Soil Erosion in the Upper Part of the River Toplica Watershed*. IOP Conf. Series: Earth and Environment Science 4, 012040, DOI: 10.1088/1755-1307/4/1/012040

(1956): *Main design for the regulation of the Palojska River Basin*. Institute of Forestry, Belgrade (In original: *(1956): Glavni projekat za uređenje sliva Palojska reka. Institut za šumarstvo, Beograd*)

(1956): *Map of the erosion of the area of Grdelica Gorge and Vranje Valley* 1:50,000. Institute of pedology and agrochemistry, Belgrade (In original: *(1956): Karta erozije područja Grdeličke klisure i Vranjske kotline 1:50 000. Institut za pedologiju i agrohemiju, Beograd*)

(1961–2015): *Meteorological Yearbooks*. The Republic Hydrometeorological Service, Belgrade (In original*: (1961-2015): Meteorološki godišnjaci. Republički hidrometeorološki zavod, Beograd*)

(1960): *Pedological map of the area of Grdelica Gorge and Vranje Valley 1:50,000*. Institute of Pedology and Agrochemistry, Belgrade (In original: *(1960): Pedološka karta područja Grdeličke klisure i Vranjske kotline 1:50 000. Institut za pedologiju i agrohemiju, Beograd*)

(1964): *Register of torrential catchments and slopes - Register of torrents of the right and left tributaries of the South Morava River on the Grdelica-Vladicin Han section, Grdelica Gorge*. Regional section for the protection of soil from erosion and torrential flooding, Vladičin Han (In original: *(1964): Registar bujičnih slivova i padina – Popis bujica desnih i levih pritoka Južne Morave na deonici Grdelica-Vladičin Han, Grdelička klisura. Reonska sekcija za zaštitu zemljišta od erozije i uređenje bujica, Vladičin Han*)

Ratknić, M., Braunović, S. (2016): *Study of the state and characteristics of regional erosion by the water of forest and agricultural land, causes, consequences and erosion control measures*. Institute of Forestry, Belgrade. 1–624 (In original: *Ratknić, M., Braunović, S. (2016): Studija Stanje i odlike regionalne erozije vodom šumskog i poljoprivrednog zemljišta, uzroci, posledice i antierozione mere. Institut za šumarstvo, Beograd. 1-624*) (http: //www.forest.org.rs/files/studija.pdf)

EFFECTS OF EROSION CONTROL WORKS IN THE DRAINAGE BASIN OF THE PALOJSKA RIVER (GRDELICA GORGE)

Sonja BRAUNOVIĆ, Filip JOVANOVIĆ, Milan KABILJO, Natalija MOMIROVIĆ

Summary

The Palojska River is a right tributary of the South Morava River. It is located in Grdelica Gorge (southeastern Serbia). The source of the river is at 700 m a.s.l., and its mouth is at 265 m a.s.l., which points to its pronounced energy of relief. The basin is elongated covering an area of 6.87 km^2. It stretches in the northeastern-southwestern direction, with its largest part (76.27%) located in the altitudinal zone of 500-1000 m.

In order to quantify changes in the intensity of erosion, the EPM (model of erosion potential) was applied, as well as a comparative analysis of the state of erosion processes before and after the erosion control works were conducted in the channel and basin. Data were obtained from field investigations (2011-2012; 2016), thematic maps (topographic, geological, pedological, land use and erosion maps) and satellite images.

In the period from 1947 to 1977, technical works in the basin of the Palojska River included 0.45 km of regulation and 12 transverse structures. Biological works were carried out on 27% of the basin area (afforestation, orchard establishment on terraces, pasture reclamation and grassing of eroded areas). Austrian pine plantations were built on bench terraces and terraces, along with wattle-work, horizontal walls and dry dams, while 3 ha were planted with poplar trees. Biological and technical works performed in the basin increased the forest cover by 33.4%, and the intensity of erosion processes in the study period decreased from surface excessive erosion (Z = 1.02) in 1953 to mixed weak erosion (Z = 0.28) in 2016, with a decrease in the sediment yield and transport in the basin. The effects of socio-demographic changes (a decrease in the number of inhabitants and an increase in the average population age) are reflected in the abandonment of agricultural land in the upper parts of the basin.

The reducing intensity of erosion processes and declining total sediment yield and transport (by 16954.58 m^{3}year^{-1}), along with the increasing forest cover in the basin (33.4%) and reducing flood risk in the study period are the result of the erosion control works performed in the basin and partly of the changes in sociodemography. However, besides the obvious effects of the works carried out in this area, the problems associated with the investments and regular maintenance of the constructed objects are still evident.

EFEKTI PROTIVEROZIONIH RADOVA U SLIVU PALOJSKE REKE (GRDELIČKA KLISURA)

Sonja BRAUNOVIĆ, Filip JOVANOVIĆ, Milan KABILJO, Natalija MOMIROVIĆ

Rezime

Palojska reka je desna pritoka Južne Morave i nalazi se u Grdeličkoj klisuri (jugoistočna Srbija). Izvorište ove reke je na 700 m n.v., a ušće joj je na 265 m n.v., što govori o izraženosti energije reljefa. Sliv je izduženog oblika i prostire se na površini 6,87 km^2u pravcu severoistok-jugozapad, pri čemu se njegov najveći deo (76,27%) nalazi u visinskoj zoni 500–1000 m n.v.

Za kvantifikaciju promena intenziteta erozije primenjen je EPM (model potencijala erozije) i komparativna analiza stanja erozionih procesa pre i posle izvođenja protiverozionih radova. Izvor podataka bila su terenska istraživanja (2011–2012; 2016), tematske karte (topografska, geološka, pedološka, karta načina korišćenja zemljišta i karte erozije) i satelitski snimak.

Između 1947. i 1977. god. u slivu Palojske reke izvedeno je 0,45 km regulacije korita, uz 12 poprečnih objekata. Biološki radovi su obuhvatili 27% površine sliva (pošumljavanje, podizanje voćnjaka na terasama, melioracija pašnjaka i zatravljivanje erodiranih površina). Podignute su kulture crnog bora na gradonima i terasama, uz izradu pletera, kao i vodoravnih zidova i rustikalnih pregrada, dok je 3 ha pošumljeno topolom. Kao rezultat izvedenih bioloških i tehničkih radova, učešće površina pod šumom povećalo se za 33,4%, a intenzitet erozionih procesa u posmatranom periodu smanjio se od površinske ekscesivne erozije (Z=1,02) u 1953. god. do mešovite slabe erozije (Z=0,28) u 2016. god., uz smanjenje produkcije i pronosa nanosa u slivu. Posledice sociodemografskih promena (smanjenje broja stanovnika i povećanje prosečne starosti stanovništva) izražavaju se kroz napuštanje poljoprivrednih površina u višim delovima sliva.

Smanjenje intenziteta procesa erozije i ukupne produkcije nanosa (za 16954,58 m^3god^{-1}), povećanje pošumljenosti sliva (33,4%) i smanjenje rizika od poplava u istraživanom periodu, rezultat su izvedenih protiverozionih radova, a delom i promena sociodemografskog faktora. Međutim, i pored značaja efekata ovih radova na datom slivnom području, problem investicija i redovnog održavanja izgrađenih objekata i dalje je izražen.

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION 77-78, 2018 ZBORNIK RADOVA 77-78, 2018

UDK 630*61(497.11 Novi Pazar)
Original scientific paper

THE STATE OF FORESTS IN THE AREA OF NOVI PAZAR FOREST ADMINISTRATION

Sabahudin HADROVIĆ[1], *Milijana CVEJIĆ*[1]

Abstract: This paper presents the state of forests in the area of Novi Pazar forest administration, with the focus on increasing the forest cover area and the volume per area. One of the ways to increase this area is to make it purposeful, *i.e.*, to afforest the land with one single tree species and to put it in the function of biomass production. As can be seen from the paper, the volume per unit of area is small, indicating that the existing stands require adequate measures of forest tending and protection and a strictly defined (projected) allowable cut.

Keywords: volume, surface area, afforestation, stands, increment, preservation

СТАЊЕ ШУМА НА ПОДРУЧЈУ ШУМСКЕ УПРАВЕ НОВИ ПАЗАР

Извод:У раду је приказанано стање шумског фонда на подручју шумске управе Нови Пазар. Поставља се питање како повећати површине под шумом и повећати запремину по површини. Један од начина повећања површине под шумом је да се сво шумско земљиште стави у функцију, односно да се пошуми одговарајућом врстом дрвета и стави у функцију производње биомасе. Из приказаног у раду се види да је запремина по јединици површине мала, што указује на то да постојеће састојине захтевају адекватне мере неге и заштите шума и строго дефинисан (пројектован) сечиви етат који се не сме нарушити.

Кључне речи: запремина, површина, пошумљавање, састојина, прираст, очуваност

[1] *Dr Sabahudin HADROVIĆ*[1], *Mr Milijana CVEJIĆ*[1], *Institute of forestry, Belgrade, Serbia*
Corresponding author: Sabahudin Hadrvić, Kneza Višeslava 3, 11030 Belgrade, Serbia, tel.: +381 11 3553355, e-mail: hadrovicsabahudin@gmail.com

1. INTRODUCTION

`Novi Pazar` Forest Administration manages state forests and performs expert and technical tasks in the privately-owned forests within the administrative boundaries of the municipality of the same name. Despite the fact that together with private forests, which account for 2/3 of the forests in the area, forests cover over 50% of the area of Novi Pazar, the state of state-owned and privately-owned forests is unsatisfactory. Special attention should be paid to increasing the area of forest land, which would subsequently increase the volume per unit area through adequate forest tending measures and gradual conversion of stands into high forests (Aleksić et al, 2007). It is not an easy task to increase the forest cover and the attempts made at the state level have yielded only partial results. Compared to the reference year 1979, the Republic of Serbia has increased its forest cover by 5.2%, which has certainly had a positive impact on the state and quality of the environment. With regard to the population, there is 0.3 ha of forest per capita, which is significantly lower compared to other countries (Russia 11.11 ha per capita, Norway 6.93 ha, Finland 5.91 ha, B&H 1.38 ha, Croatia 1.38 ha) (Banković et al., 2009).

The data obtained at the state level clearly reflect the state in `Novi Pazar` Forest Administration, which is a part of SE `Srbijašume`, Belgrade and faces all the problems that other areas of the Republic of Serbia are confronted with. It is, therefore, necessary that each forest administration within the system intensifies its efforts to protect and conserve forests and gradually increases the forest area and wood volume (Hadrović, Stevović, 2017).

2. MATERIAL AND METHODS

The data obtained from the Forest Management Plan of `Gornji Ibar` Area and six management units managed by `Novi Pazar` forest administration were used for the purpose of this paper. They cover the areas utilized by SE `Srbijašume`, Belgrade. Data on privately-owned forests were obtained from the Forest Management Programme for privately-owned forests.

3. RESULTS

`Novi Pazar` Forest Administration is a user of 16,552.22 ha of forests and forest land and performs expert and technical tasks on 25,724 hectares owned by natural persons. In the area utilized by SE `Srbijašume`, there are 11,761.86 hectares of stocked and 4,790.36 hectares of unstocked land, 4 413.32 hectares of which is forest land. The forests and forest land of this Forest Administration are divided into six management units: Crni Vrh-Deževski, Debeljak-Medenovac, Blizanac-Debelica, Ninaja-Koznik, Turjak-Vršine and Vinorog, with an average surface area of 2,758.70 ha.

Table 1. *The area of forests and forest land by management units in `Novi Pazar` Forest Administration*

MU	Total area	Forests	Forest plantations	Forest land	Barren land	Other	Duration of the Plan
Crni Vrh/Deževski	2805.74	2206.99	123.02	401.84	44.35	29.54	2005-2014
Debeljak-Medenovac	1639.13	1314.16	85.71	170.01	62.01	7.24	2009-2018
Blizanac-Debelica	2381.43	1076.63	197.70	1081.47	5.70	19.93	2008-2017
Ninaja-Koznik	4016.71	2558.88	141.43	1215.40	84.65	16.35	2011-2020
Turjak-Vrsina	3391.57	2538.68	202.03	585.21	55.78	9.87	2008-2017
Vinorog-Paunje	2317.64	1316.55	0.08	959.39	34.06	7.56	2008-2017
Total	16552.22	11011.89	749.97	4413.32	286.55	90.49	

Source: Forest Management Plans for forest administrations of `Crni Vrh-Deževski`, `Debeljak-Medenovac`, `Blizanac-Debelica`, `Ninaja-Koznik`, `Turjak-Vrsina` and `Vinorog-`Paunje`

As can be seen from Table 1, forests and forest plantations occupy 11,761.86 ha. These are the areas which could provide wood biomass, while the forest land with the area of 4,413.32 ha is set aside for potential afforestation which could subsequently increase the area under forest and foster biomass production. Out of the total area of forest land, 26.60% is the land suitable for afforestation.

Table 2 shows the areas that are suitable for afforestation. All of these areas should be put to the purpose of biomass production or some other multiple benefits, such as carbon capture and storage (Hadrović, 2015).

Table 2. *Potential areas for afforestation*

S.N.	*Management unit*	*Total area in ha*	*Area suitable for afforestation*	*Ratio in %*
1	Crni Vrh-Deževski	2.805,74	401,84	14.32
2	Debeljak-Medenovac	1,639.13	170.01	10.37
3	Blizanac-Debelica	2,381.43	1081.47	45.41
4	Ninaja-Koznik	4,016.71	1215.40	30.25
5	Turjak-Vrsina	3,391.57	585.21	17.25
6	Vinorog Paunje	2,317.64	959.39	41.39
	Total	16.552.22	4.413.32	26.60

Source: Forest Management Plan of `Gornji-Ibar` Forest Area

4. DISCUSSION

The total volume in this forest administration amounts to 1,103,036.5 m^3 or 17.5% of the total volume of the state-owned forest area. The current volume increment is 28,193.3m^3 or 17.4%. The average volume of the stocked surface area is 93.8 m^3/ha and the current volume increment is 2.4 m^3/ha, or 2.6% (Hadrović, 2015).

The largest area is covered in coppice forests which account for 17.9% of the area, followed by mixed coppice forests of sessile oak with 12.9%, even-aged high forests of beech with 10.1%, artificially-established stands of spruce with 7.8%, devastated beech forests with 6.1%, mixed coppice forests of Turkey oak with 5.7%, mixed coppice forests of beech with 5.1% and other stand components that occur on small surface areas (below 5.0%).

Broadleaves account for 86.9% of the volume and conifers for 13.1%. Beech is the most common tree species with 57.2% of volume, followed by sessile oak with 17.7%, Turkey oak with 8.6%, Austrian pine with 6.3%, spruce with 4.6%, hornbeam with 2.1 %, while other tree species account for less than 1.0% of the volume. Small-diameter wood accounts for 69.6% of the total growing stock, while the share of medium-diameter wood amounts to 26.1% and large-diameter wood to 4.2%.

This forest administration has 2,423.34 ha (20.6%) of high forests, with an average volume of 171.8 m^3/ha and the current volume increment of 4.1 m^3/ha, which makes the percentage of the volume increment 2.4%. Coppice stands occur on 6,593.74 ha (56.1%), with an average volume of 97.8 m^3/ha and the current volume increment of 2.5 m^3/ha, or 2.6%. Artificially-established stands cover 1,729.98 ha (14.7%), with an average volume of 24.3 m^3/ha and the current volume increment of 1.0 m^3/ha, or 4.0%. Thickets participate with 434.88 ha (3.7%) and degraded thickets with 579.92 ha or 4.9% of the total stocked area of this management unit.

Depending on the level of stand preservation, stands in the investigated area can be divided as follows: 1) well-preserved stands that account for 7,788.44 ha (66.2%), with an average volume of 120.0 m^3/ha and the current volume increment of 3.1 m^3/ha, while the volume increment expressed in the percentage amounts to 2.6%; 2) sparsely-closed stands that occur on 1.520,99 ha (12.9%) with an average volume of 76.4 m^3/ha and the current volume increment of 1.9 m^3/ha, or 2.6% and 3) devastated stands that are found on 1,437.63 ha (12.2%), with an average volume of 36.5 m^3/ha and the current volume increment of 0.7 m^3/ha, or 1.9%.

5. CONCLUSIONS

It seems that the area of `Novi Pazar` Forest Administration is rich in forests. Unfortunately, this is not completely true, but it is true that over 50% of its area is covered in forest. As much as 69.6% of the total growing stock is small-diameter wood, which indicates that the projected assortment structure is unsatisfactory. This is the reason fire wood accounts for as much as 90% of the obtained wood assortment.

The average volume of the stocked area is 93.8 m^3/ha, and the current volume increment is 2.4 m^3/ha or 2.6%, which is far below the average values for Serbia.

Well-preserved high forests account for only 10% of the area. The share of artificially-established stands of spruce and pine amounts to 14.7%. They require tending measures that entail a lot of work and substantial financial resources in order to preserve them. It is evident that afforestation of barren land has been carried out exclusively with coniferous trees, completely neglecting noble broadleaves and fruit trees.

There is a significant share of devastated forests that are on good soil and need to be converted into high forests. These are mostly fodder beech forests that were formed some fifty years ago. They should be removed, avoiding the previous practice of amelioration or species replacement with spruce.

Sparsely-closed stands that cover 1,20.99 ha (12.9%) and devastated stands that are found on 1,437.63 ha (12.2%) should be restocked with noble broadleaves and a sufficient number of forest fruit trees.

There is a large share of unstocked areas suitable for afforestation. Table 2 provides data on the areas suitable for afforestation. This data should be taken with reserve because there are areas that have largely been afforested naturally. The unstocked area has been reduced, but there are still large areas to be afforested in order to put the entire forest land in the function of biomass production and subsequently other multiple forest functions (Hadrović, 2015).

REFERENCES

Aleksić, P., Stingić, M., Milić, S. (2007): The state of the forests and forest land managed by SE 'Srbijašume', `Forestry` Journal, vol. 59, no. 3-4, p. 33-54, Belgrade.

Banković, S., Medarević, M., Pantić, D., Petrović, N. (2009): National Forest Inventory of the Republic of Serbia (Growing Stock of the Republic of Serbia). Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia - Forest Administration, p. 1-244, Belgrade.

Hadrović, S. (2015): Carbon and Nitrogen Accumulation in Organic Litterfall, Forest Soil and Forest Biomass, Ph.D. thesis, `Union - Nikola Tesla` University, Faculty of Ecology and Environmental Protection, Belgrade.

Hadrović S., Stevović S. (2017): Biomass from forest waste in the Novi Pazar region as a renewable energy source - V International Scientific Conference Agribusiness MAK 2017-Europen road - IPARD-2015-2020., 27- 28 January, Kopaonik-Serbia (171-177).

Forest Management Plan for `Gornji Ibar` forest area

Forest Management Plan for `Blizanac-Debelica` Management Unit

Forest Management Plan for `Vinorog-Paunje` Management Unit

Forest Management Plan for `Debeljak-Medenovac` Management Unit

Forest Management Plan for `Ninaja-Koznik` Management Unit

Forest Management Plan for `Turjak-Vršine` Management Unit

Forest Management Plan for `Crni Vrh-Deževski` Management Unit

THE STATE OF FORESTS IN THE AREA OF NOVI PAZAR FOREST ADMINISTRATION

Sabahudin HADROVIĆ, Milijana CVEJIĆ

Summary

The research shows that in the area of forest management Novi Pazar, forests and forest land occupy more than 50% of the area. They are dominated by the forests of mainly red beech and oak (sycamore and zeros), while coniferous tree species (black pine and spruce) are represented in smaller extent between the high and offshore forests is unfavorable, the reason is alarming in private forests. In the last period there is an effort to increase the area under the forest. This is done through afforestation bare. It is a good attempt to produce results in time, in increasing the area and volume of the wood mass.

It is necessary that in the whole area all the surfaces that are now being treated as bare are afforested with an adequate tree species. So far, the practice has been that the afforestation be done exclusively with the seedlings of the conifers. It is necessary to conduct and afforestation also with the species of the trees with mandatory insertion of a certain number of seedlings forest fruit trees.

Privately owned in the area of Novi Pazar there are significant areas that are suitable for afforestation. The problem is that these surfaces are small and divided and that there is a lack of workforce.

СТАЊЕ ШУМА НА ПОДРУЧЈУ ШУМСКЕ УПРАВЕ НОВИ ПАЗАР

Сабахудин ХАДРОВИЋ, Милијана ЦВЕЈИЋ

Резиме

Из приложеног се види да на подручју шумске управе Нови Пазар, шуме и шумско земљиште заузимају више од 50% простора.Доминирају шуме лишћара углавном букве и храста (китњака и цера), док су четинарске врсте дрвећа (црни бор и смрча) заступљени у мањем обиму.Однос између високих и изданачких шума је неповољан , погото је то стање алармантно у приватним шумама .У последњем периоду запажа се напор на повећању површине под шумом.То се ради кроз пошумљавање голети. То је добар покушај који ће временом дати резултате, у повечању површине и запремине дрвне масе.

Неопходно је да на целом подручју све површине које се сада воде као голети пошумити адекватниом врстом дрвећа.До сада је пракса била да се пошумљављављње врши исккључиво садницама четинара.То је потребно напустити и пошумљавање вршити и са лишћарским врстама дрвећа уз обавезно убацивање одређеног броја садница шумских воћкарица.

У приватном власништву на подручју Новог Пазара постоје знатне површине које су погодне за пошумљавање.Проблем је што су те површине уситњене и што недостаје радне снаге која би тај посао обавила.

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION 77-78, 2018 ZBORNIK RADOVA 77-78, 2018

UDK 630*232.12(497.11)
Original scientific paper

MAGNESIUM CONCENTRATION IN THE CANADIAN DOUGLAS-FIR NEEDLES OF DIFFERENT PROVENANCES

Vera S. LAVADINOVIĆ[1], Zoran MILETIĆ[1], Ljubinko RAKONJAC[1], Vukan M. LAVADINOVIĆ[2]

Abstract: *The morphology, anatomy, ecology and physiology of introduced tree species should be tested in order to confirm their autochthonous characteristics and justify their introduction. Douglas-fir (Pseudotsuga mensiesii Mirb/Franco) is a species with a very wide geographical range of distribution and an extensive altitudinal range. Its natural area of distribution stretches from New Mexico to Canada and from the Pacific to the Rocky Mountains. The species should be tested using the model of provenance tests in order to select the most adaptive and promising provenances to be introduced into new ecosystems of Serbia. This paper deals with the content of magnesium in the needles of Douglas-fir in different provenances originating from Canada. Magnesium is the most important mineral for all living organisms and affects a number of biochemical processes in plants.The research was carried out on fourteen different provenances of Douglas-fir originating from Canada on two different soil types - eutric cambisol and vertisol. All the trees of the study provenances were of the same age and grown under the same conditions on two different types of soil. The determined amounts of magnesium in the needles indicate that there are differences in the ability of certain provenances of Douglas-fir to absorb this element of nutrition from the soil.*

Keywords: Douglas-fir, Provenances, Magnesium, Eutric Cambisol, Vertisol

[1] Institute of Forestry, Belgrade, Kneza Višeslava3, Serbia
[2] Faculty of Forestry ,University of Belgrade, Kneza Višeslava 1, Serbia
Email: veralava@eunet.rs

KONCENTRACIJA MAGNEZIUJUMA U ČETINAMA KANADSKE DUGLAZIJE RAZLIČITIH PROVENIJENCIJA

Izvod: *Introdukovane vrste drveća je potrebno morfološki, anatomski, ekološki i fiziološki testirati da bi se potvrdile njihove autohtone karakteristike i opravdao cilj introdukcije. Douglas-fir (Pseudotsuga mensiesii Mirb/Franco) je vrsta sa vrlo širokim geografskim arealom i velikim rasponom nadmorske visine. Prirodni areal duglazije je od Novog Meksika do Kanade i od Pacifika do Stenovitih planina. Vrstu je potrebno testirati modelom provenijeničnog ogleda i odabrati adaptivne i perspektivne provenijencije za introdukciju u nove ekosisteme Srbije. Predmet istraživanja je sadržaj magnezijuma u četinama duglazije različitih provenijancija poreklom iz Kanade. Magnezijum je najvažniji mineral za sve žive organizme i utiče na mnoštvo biohemijskih procesa u biljkama. Istraživanja su obavljena sa četrnaest različitih provenijencija duglazije poreklim iz Kanade, na dva različita tipa zemljišta eutričnom kambisolu i vertisolu. Sva stabla ispitivanih provenijencija bile su iste starosti i uzgajane su pod istim uslovima na dve različite vrste zemljišta. Konstatovane količine magnezijuma u četinama ukazuju da postoje razlike u sposobnosti pojedinih provenijencija duglazije da usvaja ovaj element ishrane iz zemljišta.*

Ključne reči: duglazija, provenijencija, magnezijum, eutrični kambisol, vertisol

1. INTRODUCTION

Its biological characteristics, economic advantages and ecological adaptability have made Douglas-fir a species suitable for introduction and consequently a topic of a great number of research studies (Apple, M., at al., 2002, Gutschick, V.P., 1999, Hermann, R. K., 1987, Hermann R. and Lavender D., 1990, Ian, F., 2001, Kleinschmit, J. and Bastien, Ch., 1992).

In Serbia, Douglas-fir has been introduced into quite different sites. Its monocultures have replaced natural forests from the submontane to the subalpine belt. Douglas-fir has often been used in the reclamation of coppice forests in Serbia. Douglas-fir plantations have replaced autochthonous coppice forests, most often in oak and beech belts.

The study of the changes in soil properties caused by the replacement of autochthonous coppice forests with Douglas-fir plantations has been performed at different sites in Serbia. Previous studies of the effects of Douglas-fir on the changes in soil properties after the replacement of autochthonous forests at different sites in Serbia have provided different results (Lavadinović V., Miletić Z. and Lavadinović V., 2015).

Nutrition is an essential segment in the growth of plants. Plants must consume sufficient quantities of microelements from the soil. Bioelements or biogenic elements are regularly present in the essential components of living organisms either in an inorganic or in an organic form. Apart from carbon, oxygen and hydrogen, the main nutrients of vital importance for plants are nitrogen, phosphorus, sulfur, potassium, calcium and magnesium.

Magnesium, calcium, and potassium are often referred to as macronutrients. Although in many organisms they make up only about 0.1% of organic matter, they are essential for vital life functions.

Magnesium, as an essential component of chlorophyll (bound to nitrogen in the porphyrin core), is one of the minerals indispensable for the growth of plants. Its most important role is to build chlorophyll in the process of photosynthesis, but it also plays a prominent role in the processes in which it makes the synthesis of organic compounds that are useful for the growth and functioning of plants. It performs the synthesis of amino acids, pectin and cell proteins as well as the assimilation and movement of phosphorus in plants.

The deficiency of magnesium interrupts the process of photosynthesis and causes chlorophyll breakdown. It is manifested as chlorosis on the lower leaves (loss of green color between the vessels), with leaf edges bending upwards.

The excess of magnesium is also disadvantageous because it is toxic to plants, and the increased concentration of Mg can further lead to a decrease in Ca concentration in plants because these two elements are antagonistic. The leaves turn orange-red, wilt and fall off (Dubravka Steiner, Slavko Kevresan 2014).

2. MATERIAL AND METHODS

The Institute of Forestry in Belgrade has been carrying out provenance testing of Douglas-fir originating from Canada and America for more than 30 years (Lavadinović, V., et al., 2001, Lavadinović,V., et al., 2010, Lavadinović, V., et al. 2011, Lavadinović,V., et al 2011a, Lavadinović, S.,V., et al., 2011b, Lavadinović,V., et al 2011c, Lavadinović,V., et al., 2011d, Lavadinović,V., et al., 2014, Lavadinović, V., et al., 2015, Vera Lavadinović, et al., 2016).

The material used in this research included seedlings from two different sites (Arboretum of the Faculty of Forestry and a nursery in Sremčica near Belgrade) where provenance testing was carried out using 14 provenances of Douglas fir originating in Canada. Table 1 shows the geographical characteristics of the original seed used to produce the seedlings which served as material for the establishment of the experiment. (Lavadinović, S., V., et al., 2015a).

Table 1. *Geographic characteristics of Douglas-fir test provenances in Canada*

Provenances		Seed zone	Location	Geographical		Altitude
No	Code			latitude	longitude	
1	03333	East Kootenay	Cranbrook	$49^{0}25'$	$115^{0}20'$	1050 m
2	00848	West Kootenay	Inonoaklin	$49^{0}50'$	$118^{0}10'$	671 m
3	30667	Shuswap Adams	Mann Creek	$51^{0}35'$	$120^{0}10'$	600 m
4	05227	East Kootenay	Gavia Lake tfl 14	$50^{0}56'$	$116^{0}35'$	1070 m
5	05226	East Kootenay	Nine Bay TFL 14	$50^{0}58'$	$116^{0}32'$	975 m
6	03356	Thompson Okanagan Arid	Trout Cr	$49^{0}40'$	$119^{0}52'$	884 m
7	03360	Thompson Okanagan Arid	Michell Cr	$49^{0}54'$	$119^{0}37'$	1035 m
8	01198	West Kootenay	Salmo	$49^{0}15'$	$117^{0}30'$	793 m
9	30460	Shuswap Adams	Mara LK	$50^{0}48'$	$119^{0}00'$	488 m
10	00278	Thompson Okanagan Arid	Monte Crk	$50^{0}37'$	$119^{0}52'$	701 m
11	03383	West Wootenay	Sheep Creek	$49^{0}10'$	$117^{0}15'$	1000 m
12	30461	Shuswap Adams	Cooke Creek	$50^{0}38'$	$118^{0}49'$	900 m
13	03389	West Kootenay	Benton Creek	$49^{0}12'$	$117^{0}25'$	933 m
14	05092	East Kootenay	Sun Creek	$50^{0}08'$	$115^{0}52'$	1000 m

Source: (Lavadinović V., et al 2015b)

The distance between the sites where Douglas-fir seedlings of different provenances were produced is 20 km, which implies that they were grown in approximately the same microclimate conditions. The Arboretum of the Faculty of Forestry has eutric cambisol type of soil, while Sremčica Nursery grows trees on vertisol. The seedlings were produced in containers, and at the age of 3 years (3+0), they were transplanted into experimental plots with a distance of 2 x 2 m per 60 plants from each provenance (Lavadinović, S., V., et al., 2015a).

At the age of 11, both sites had samples taken for foliar analysis. The needles required for laboratory analysis were sampled from the upper third of the crown of dormant seedlings. Only the current year needles were sampled. The samples collected were dried to an oven-dry state and then burnt in platinum crucibles, converting the ash into chlorides, and determining the amount of magnesium by complexometric titration.

The standard deviation of each individual value of the magnesium content in Douglas-fir needles was calculated according by the following formula:

$$Z = \frac{Mg - \overline{Mg}}{\sigma}$$

Where:

Mg - concentration of magnesium in the needles of each individual provenance,

$\overline{Mg}$ - the mean value of magnesium in the needles of all provenances on a given type of soil,

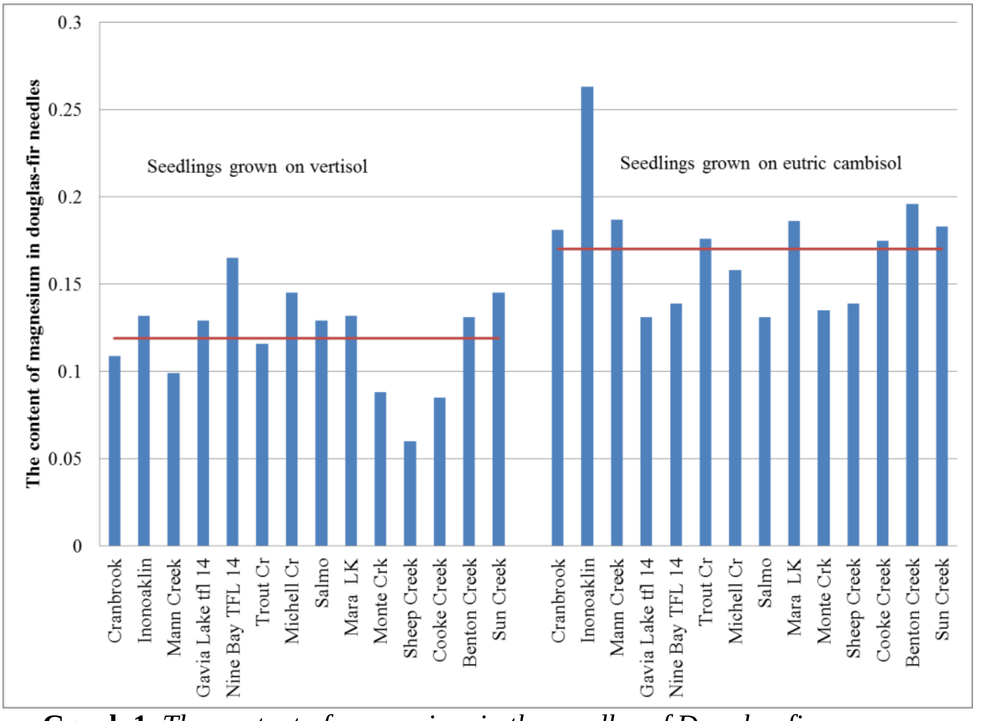
σ - standard deviation.

3. RESULTS AND DUSCISSIONS

The results of the study point to considerable variability in the magnesium content in the needles of Douglas-fir of different provenances originating from Canada under the same site conditions (Table 2, Graph 1).

Table 2. *The content of magnesium in the needles of Douglas-fir **

	Locality of Sremčica - vertisol		Locality of the Arboretum-eutric cambisol	
No. of provenance	Mg (%)	Z	Mg (%)	Z
1	0.109	0.8723	0.181	-0.9041
2	0.132	0.3048	0.263	-2.9037
3	0.099	1.1143	0.187	-1.0329
4	0.129	0.3868	0.131	0.3351
5	0.165	-0.5017	0.139	0.1236
6	0.116	0.6883	0.176	-0.7741
7	0.145	-0.0082	0.158	-0.3339
8	0.129	0.3869	0.131	0.3396
9	0.132	0.3131	0.186	-1.0093
10	0.088	1.3764	0.135	0.2299
11	0.060	2.0599	0.139	0.1361
12	0.085	1.4514	0.175	-0.7606
13	0.131	0.3319	0.196	-1.2648
14	0.145	-0.0142	0.183	-0.9431
Average	0.119		0.170	
S	0.0271		0.0344	
Max	0.165		0.263	
Min	0.060		0.131	



Graph 1. *The content of magnesium in the needles of Douglas-fir grown on vertisol and eutric cambisol*

The same results were obtained by testing the content of magnesium in the needles of Douglas-fir originating from the United States (Lavadinović, et al., 2011b).

Foliar analysis revealed a significantly lower content of magnesium in the needles of Douglas-fir trees grown on vertisol than in the provenances grown on eutric cambisol. The statistical significance of the difference in the magnesium content of the needles of Douglas-fir trees grown on these two types of soil is at the significance threshold of 1% Table 3).

Table 3. *t-test values*

The amount of Mg in the needles of Douglas-fir on	mean	N	σ	t-value	p
Vertisol	0.118929	14	0.028089	4.20783	0.000271
Eutric cambisol	0.170000	14	0.035685		

Regarding vertisol, the highest concentrations of magnesium were found in the needles of provenance 5226 from the site of Nine Bay TFL 14 in East Kootenay seed zone. It was followed by provenances 03360 and 05092 whose natural sites are Michell Cr in Thompson Okanagan Arid seed zone and Sun Creek in East Kootenay seed zone. The lowest concentrations of magnesium in the needles of different provenances of Douglas-fir grown on vertisol were found in provenance 3383, whose natural site is Sheep Creek in West Wootenay seed zone.

Very low amounts of magnesium were also found in provenances 00278 and 30461. The natural site of provenance 00278 is Monte Crk in the seed zone of Thompson Okanagan Arid, while provenance 30461 originates from Cooke Creek in Shuswap Adams seed zone.

By analyzing the multiple regression results (Table 4), it can be concluded that geographical characteristics of natural sites of the tested Douglas-fir provenances originating from Canada (geographical latitude, geographical longitude and altitude) have no effects on the concentrations of magnesium in the needles of Douglas-fir trees.

Table 4. *Multiple correlations of the content of magnesium in Douglas-fir needles to geographical characteristics of natural provenance sites on eutric cambisol*

R= 0.32157809 R²= 0.10341247 Adjusted R²= ----- F (3.10)=.38447 p<.76658 Std. error of estimate: 0.03033						
N=14	Beta	Std. Err. of Beta	B	Std. Err. of B	t(10)	p-level
Independent variable			0.470528	0.981587	0.479354	0.641997
Latitude	0.190702	0.323954	0.006905	0.011730	0.588669	0.569141
Longitude	-0.332015	0.379813	-0.005882	0.006729	-0.874154	0.402540
Altitude	-0.027335	0.391871	-0.000004	0.000060	-0.069756	0.945763

Regarding eutric cambisol, the highest concentrations of magnesium in assimilation organs were found in provenance 00848 from Inonoaklin site in West Kootenay seed zone, followed by provenance 03389 from Benton Creek site in the same seed zone.

The smallest amounts of magnesium in needles of the study provenances grown on eutric cambisol were found in provenance 05227 from Gavia Lake tfl 14 site in East Kootenay seed zone and provenance 01198 from Salmo site in East Kootenay seed zone.

As with the provenances of Douglas-fir grown on vertisol, the analysis of the multiple regression conducted for the provenances grown on eutric cambisol (Table 5) found that geographical characteristics of their natural sites have no effect on the concentration of magnesium in assimilation organs.

Table 5. *Multiple correlations of the content of magnesium in Douglas-fir needles to geographical characteristics of natural provenance sites on vertisol*

R= .48062253 R²= .23099801 Adjusted R²= .00029742 F(3.10)=1.0013 p<.43182 Std.Error of estimate: .03568						
N=14	Beta	Std. Err. of Beta	B	Std. Err. of B	t(10)	p-level
Independent variable			1.451464	1.154885	1.25680	0.237388
Latitude	-0,247753	0.300020	-0.011397	0.013801	-0.82579	0.428187
Longitude	-0,229149	0.351753	-0.005158	0.007917	-0.65145	0.529443
Altitude	-0,604666	0.362920	-0.000117	0.000070	-1.66612	0.126659

4. CONCLUSION

Based on the research carried out within provenance testing of 14 different provenances of Douglas-fir originating from Canada, it can be concluded that there is considerable variability in the content of magnesium in Douglas-fir needles. According to the results of the research conducted on two sites on vertisol and eutric cambisol, it can be concluded that the content of magnesium in the needles of Douglas-fir trees grown on vertisol is lower than the content of the provenances grown on eutric cambisol and that geographical characteristics of the natural sites of the tested provenances of Douglas-fir originating in Canada (latitude, longitude, and altitude) have no effect on the concentrations of magnesium in Douglas-fir needles. In the case of magnesium concentrations in Douglas-fir needles, the differences between certain provenances are genetic, which means that in the selection of provenances suitable for introduction, the genetic quality of Douglas-fir must be taken into account. Genetic quality and the method of ecological selection confirm the adaptability and productivity of introduced species. Therefore, the genetic quality is an inevitable factor in the process of introduction.

Acknowledgment: *This paper was realized as a part of the project `The development of technological processes in forestry in order to realize the optimal forest cover` (TR31070), financed by the Ministry of Education and Science of the Republic of Serbia within the framework of integrated and interdisciplinary research for the period 2011-2017.*

REFERENCES

Apple, M., Tiekotter, K., Snow M., Young, J., Soeldner, A., Phillips, D., Tingey D., Bond B.,J. (2002): Needle anatomy changes with increasing tree age in Douglas-fir. Tree Physiology 22, 129–136. 2002. pp. 129-136. *Heron Publishing - Victoria, Canada*

Gutschick, V.P. (1999). Biotic and abiotic consequences of differences in leaf structure, New Phytol. 143:3-18.

Hermann, Richard K. (1987). North-American tree species in Europe. Journal of Forestry 85 (12):27-32.

Hermann R and Lavender D (1990) *Pseudotsuga menziesii* (Mirb.) Franco. In: Burns RM and Honkala BH (eds) Silvics of North America. Vol I. Conifers. Agriculture Handbook 654, pp 522–540. US Department of Agriculture Forest Service, Washington, DC

Ian Forrest, Helen Tabbener, Joan Cottrell, Tom Connolly (2001): The genetic structures of a range of Douglas-fir provenance collections after planting in different European countries, assessed with two biochemical marker systems. Biochemical Systematics and Ecology.Volume 29, Issue 8, August 2001, Pages 769–792

Lavadinović, V., Isajev, V., Koprivica, M. (2001): Influence of provenances gene pool of Douglas-fir on height increment of trees in experimental test in East Serbia. Genetics, Vol. 33, No. 1-2, pp. 11-17, Belgrade.

Lavadinović,V., Isajev,V., Miletić,Z.(2010): Significance of Genetic Potential of Douglas-fir Introduced Provenances In Serbia For The Ranking of Their Adaptation to Climate Changes. IUFRO and EFI International scientific conference; `Forest ecosystems and climate changes`. Plenary lectures. ISBN 978-86-80439-20-4. Pp 71-80. Belgrade, 9-10 March, Serbia

Lavadinović Vera, Miletić Zoran, Isajev Vasilije, Krstć Milun (2011): Variability Of Nitrogen Content In The Needles Of Douglas-Fir Provenance (*Pseudotsuga menziesii* Mir / Franco) Genetics, Vol. 43, Nº2 (2011). Serbian Genetics Society. ISSN 0534-0012. pp. 407-417. UDC 575:630. DOI: 10.2298/GENSR1102407L. Serbia

Lavadinović,V., Miletić, Z., Isajev,V., Krstć,M. (2011a): Variability of nitrogen content in the needles of Douglas-fir provenance (*Pseudotsuga Menziesii* Mir / Franco), Genetics, Vol. 43, Nº 2 (2011). pp. 407-417, UDC 575:630. DOI: 10.2298/GENSR1102407L.

Lavadinović, S.,V., Miletić, Z., Lavadinović, M.,V., Isajev, V. (2011b): Variability In Magnesium Concetration In Needles Of Different Douglas-Fir Provenances. Journal : Forestry Ideas, 2011, Vol. 17, No. 1. UDC 581.4. pp.74-79. Sofia, Bulgaria.

Lavadinović,V., Isajev,V., Miletić,Z. (2011c): Ecological adaptibility of Douglas-fir provenances in Serbia. First Serbian Forestry Congress: `Future with Forests` 11-13 November, 2010. Faculty of Forestry, University of Belgrade. ISBN 978-86-7299-071-3.COBISS-ID 182189580. Pp 312-319

Lavadinović,V., Miletić,Z., Isajev,V., Rakonjac,Lj., Lučić,A. (2011d): Variability of phosphorus content in the needles of different Douglas-fir provenances. Proceedings of the Biennial International Symposium. Forest and Sustainable Development, `Transilvania` University of Brasov, ISSN 1843-505X. Faculty of Silviculture and Forest Engineering. Brasov 15-16 October, 2010 Romania. pp. 47-52

Vera Lavadinović, Vukan Lavadinović, Ilija Djordjević (2015): Variability of seedlings of Douglas-fir provenances introduced from Canada. Genetics, UDC 575:630, DOI: 10.2298/GENSR1503079L:1079-1090

Lavadinović, S., V., Miletić Z. and Lavadinović M., V. 2015a). Variability of nitrogen and carbon contents in the needles of Canadian Douglas-Fir provenances on two soil types in Serbia. Baltic Forestry, Vol. 21, No 2 (41): 272-278.ISSN 2029-9230

Vera Lavadinović, Vukan M. Lavadinović, Zoran Poduška and Ilija Đorđević, 2015b: Correlation between seedling length and Canadian Douglas-fir height. Archives of Biological Sciences, 2015 67(4):1251-1255. DOI: 10.2298/ABS150323101L

Dubravka Štajner, Slavko Kevrešan (2014). Chemistry, Faculty of Agriculture, (Novi Sad: FB print). – 303 str. : illustr. ISBN 978-86-7520-313-1- Edition of basic student`s books, COBISS.SR-ID 290315271.The Library of Matica Srpska, Novi Sad.

MAGNESIUM CONCENTRATION IN THE CANADIAN DOUGLAS-FIR NEEDLES OF DIFFERENT PROVENANCES

Vera S. LAVADINOVIĆ, Zoran MILETIĆ, Ljubinko RAKONJAC, Vukan M. LAVADINOVIĆ

Summary

Biogenic elements are the most important chemical cell elements needed for the growth and development of all living organisms. The magnesium has multiple roles in the functioning of plants. As a mineral essential for the growth of plants, it plays an important role in chlorophyll building during the process of photosynthesis. It is an integral part of the chlorophyll molecule. It also ensures the movement of phosphorus, the concentration of vitamins A and C, the synthesis of amino acids and cell proteins. The amounts of magnesium in needles reveal the potentials of certain provenances of Douglas-fir to adopt this element of nutrition from the soil. Doulas-fir is a coniferous species with a wide range of natural distribution in North America (from New Mexico to Canada). Therefore, it is necessary to conduct provenance tests before introduction programs are implemented. The paper studied the concentration of magnesium in the needles of Douglas-fir (Pseudotsuga mensiesii / Mirb./ Franco) in the tests conducted at two sites under homogeneous site conditions. Based on the research carried out in the provenance test with 14 different provenances of Douglas-fir originating from Canada, it can be concluded that there is considerable variability in the content of magnesium in Douglas-fir needles. The results of the research conducted at two sites on vertisol and eutric cambisol determined a lower content of magnesium in the needles of Douglas-fir trees grown on vertisol than in the provenances grown on eutric cambisol. The results further point that geographical characteristics of the natural sites of the investigated provenances of Douglas-fir originating from Canada (latitude, longitude and altitude) do not affect the concentration of magnesium in the needles of Douglas-fir. In the case of magnesium concentrations in Douglas-fir needles, the differences between certain provenances are genetic, which means that in the selection of provenances suitable for introduction, the genetic quality of Douglas-fir must be taken into account. Genetic quality and the method of ecological selection confirm the adaptability and productivity of introduced species. Therefore, the genetic quality is an inevitable factor in the process of introduction.

KONCENTRACIJA MAGNEZIUJUMA U ČETINAMA KANADSKE DUGLAZIJE RAZLIČITIH PROVENIJENCIJA

Vera S. LAVADINOVIĆ, Zoran MILETIĆ, Ljubinko RAKONJAC, Vukan M. LAVADINOVIĆ

Rezime

Biogeni elementi su najvažniji hemijski elementi ćelija, neophodnih za rast i razvoj svih živih organizama. Uloga magnezijuma u funkciji biljaka je višestruka. Kao neophodan mineral za razvoj biljaka ima bitnu ulogu u izgradnji hlorofila u procesu fotosinteze. Sastavni je deo molekula hlorofila. Takodje obezbedjuje, kretanje fosfora, koncentraciju vitamina A i C, sintezu aminokiselina i ćelijskih proteina. Utvrđivanje količine magnezijuma u četinama, indikativne su za različite mogućnosti određenih provenijencija duglazije za usvajanje ovog nutritivnog elementa iz zemlje. Duglazija je vrsta četinara sa žirokim prirodnim arealom u Severnoj Americi (od Novog Meksika do

Kanade), pa je neophodno sprovoditi oglede putem provenijeničnog testa pre programa introdukcije. U radu je ispitivana koncentracija magnezijuma u četinam duglazije (Pseudotsuga mensiesii / Mirb./ Franco) u ogledima na dva lokaliteta pod homogenim uslovima na terenu. Na osnovu ispitivanja provedenih u sklopu testa sa 14 različitih provenijencija duglazije, porekom iz Kanade, može se zaključiti da postoje izražene varijabilnosti sadržaja magnezijuma u četinama duglazije. Na osnovu rezultata istraživanja sa dva lokaliteta na vertisolu i eutričnom kambisolu konstatovan je znatno manji sadržaj magnezijuma u četinama duglazije odgajenih na vertisolu u odnosu na provenijencije odgajene na eutričnom kambisolu, kao i da geografske karakteristike prirodnih nalazišta ispitivanih provenijencija duglazije poreklom iz Kanade (geografska širina, geografska dužina inadmorska visina) nemaju uticaja na koncentraciju magnezijuma u četinama duglazije. U slučaju koncentracije magnezijuma u četinama duglazije, razlike između određenih provenijacija su genetski preduslovljene. Što znači da pri izboru provenijencije pri introdukciji mora se voditi računa o genetskom kvalitetu duglazije. Genetski kvalitet i ekolološki selekcioni metod potvrdjuje adaptivnost i produktivnost introdukovanih vrsta i neizbežan je faktor pri introdukciji.

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY COLLECTION 77-78, 2018

ODRŽIVO ŠUMARSTVO ZBORNIK RADOVA 77-78, 2018

UDK 630*1:502.175+630*4(497.11)"2018"
Original scientific paper

E FOREST VITALITY (ICP LEVEL I SAMPLE PLOTS) WITH A SPECIAL EMPHASIS ON BIOTIC AGENTS IN THE REPUBLIC OF SERBIA IN 2018

Renata GAGIĆ-SERDAR[1], Tomislav STEFANOVIĆ[1], Ilija ĐORĐEVIĆ[1], Goran ČEŠLJAR[1], Miroslava MARKOVIĆ[1]

Abstract: *Dieback or degradation of forests is manifested as impaired tree vitality and it is the result of adverse effects of a set of abiotic and biotic factors on trees as living organisms and complex natural processes within forest biocoenoses. The agents classified into one of these two groups can act simultaneously or successively. The group whose share presents a great risk to the health of forests includes destructive insects or pathogenic fungi. Some insects occur together with fungi and their occurrence brings about a chain reaction that leads to a disease of the most common species on Level 1 sample plots - beech. Identification of the processes ongoing in forest ecosystems requires detailed research into environmental factors that lead to the occurrence of harmful insects. They often include changes in the climate. The next steps are to assess the condition of crown which is affected by this state, to determine the species of these organisms and their biology in general and to recognize other important agents that must be kept under control all with the aim of getting a deeper insight into all aspects of their effects on the health state of forest communities. One way to get a better insight into the state of forests and determine necessary improvement measures is to monitor the health state of forests. ICP Forests monitors the effects of harmful anthropogenic (mainly air pollution) and biotic factors on the state and development of forest ecosystems in Europe. Under the coordination of NFC - National Focal Center of Serbia for monitoring at the Institute of Forestry in Belgrade, the forest monitoring system has been integrated into the state forestry environment with a number of institutions and their associates taking part in the programme.*

Key words: forests, impacts, monitoring, pollution, crown condition

[1] Institute of forestry, Knaza Višeslava 3, 11000 Belgrade
Author of correspondence: Renata Gagić-Serdar Institute of forestry, Knaza Višeslava 3, 11000 Belgrade
e-mail:katas96@hotmail.com; serdarrenata79@gmail.com

ВИТАЛНОСТ ШУМА (БИТ НИВО I) РЕПУБЛИКЕ СРБИЈЕ СА ОСВРТОМ НА БИОТИЧКЕ АГЕНСЕ У 2018. ГОДИНИ

Рената ГАГИЋ-СЕРДАР, Томислав СТЕФАНОВИЋ, Илија ЂОРЂЕВИЋ, Горан ЧЕШЉАР, Мирослава МАРКОВИЋ

Апстракт: *Сушење или пропадање шума огледа се кроз нарушену виталност стабала и последица је неповољног деловања комплекса фактора абиотичког и биотичког порекла на дрвеће као живе организме и сложене природне процесе унутар шумских биоценоза. Агенси сврстани у једну од ове две групе могу да делују истовремено или да се сукцесивно смењују. Група чије учешће спада међу оне високог рузика по здравствено стање шума јесу штетни инсекти или патогене гљиве. Неки се инсекти јављају заједно са гљивама и појава су уланчаног деловања које проузрокује честу болест букве, најбројније врсте на БИТ НИВО-а 1. Утврђивање процеса у шумским екосистемима захтева детаљна истраживања еколошких фактора који доводе до појаве штетних инсеката за које су понекад довољне и промена климе, затим одређивање стања крошњи које подлегну њиховом утицају, врстама ових организама и у целости њиховој биологији као важним агенсима који се морају држати под контролом не би ли се потпуно имао увид у све аспекте деловања истих на шумске заједнице. Увид у стање шума ради доношења закључака о потребним мерама унапређења, могуће је установити кроз прађ ење кондиционог стања шума. Предмет рада ICP-а за шуме су праћење антропогеног (превасходно ваздушно загађење) и биотичких штетних фактора на стање и развој шумских екосистема Европе. Под коориднацијом Управе за шуме и НФЦ- националног фокал центра Републике Србије за праћење стања шума у Институту за шумарство у Београду, систем праћења стања шума интегрисан је у државно шумарско окружење, тако да у програму учествује неколико институција са својим сарадницима.*

Кључне речи: шума, утицаји, мониторинг, загађење, стање круна

1. INTRODUCTION

CLRTAP[1] program was established 25 years ago with the aim of reducing air pollution in Europe. Data are collected on over 6000 sample plots in more than 40 countries and used for the purposes of Level I crown condition monitoring. The assessment of crown condition through discolourisation, defoliation, and determination of damage to trees caused by diseases and pests on SPs in 2018 makes a significant contribution to the final conclusions on adverse effects of a complex of abiotic and biotic factors in Serbia, the region and throughout the whole of Europe. These indicators were assessed and the damage was recorded by types on all sample plots in Serbia. This paper is based on data from field reports or forms filled in the field by researchers of the Institute of Forestry. The basic data are supplemented by notes made on the description of vegetation and the agents of diseases and plant pests on the trees sampled on the plots. The National Focal Center at the Institute of Forestry in the Republic of Serbia has been participating

[1] CLRTAP Convention on Long-Range Transboundary Air Pollution

in the international program of ICP Forests with a tendency to expand the work and harmonize it with other working approaches to monitoring of forests and forest ecosystems.

Difficulties in the interpretation of results, as well as their occasional variations emphasize the importance of continuous monitoring of defoliation, as well as additional assessments of various environmental data that can contribute to better understanding of the cause-effect relationships that bring about the so-called `damage` to sample trees. The next step in assessing the condition of sample trees (dieback and chlorosis) is the integral monitoring of the system by determining changes in healthy functioning and phenology, which are caused by factors that can be discovered by additional research. First of all, we should mention a large number of species of forest insects, as well as those species that occur in conjunction with phytopathogens as chain agents of more complex phenomena such as beech disease as the most common species of sample trees on Level I sample plots.

Continuous Level I monitoring of forest condition in accordance with the ICP Manual (2010) and the ICP programme has been implemented on reconstructed sample plots - experimental fields since 2002. The coordination and management of the activities on the ICP Forests programme have been entrusted to the Institute of Forestry (the National Focal Center of the Republic of Serbia for monitoring the condition of forests) by the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia - Forest Directorate. Since 2002, our country has been actively participating in this programme and reporting to the Forest Directorate every year. The Level I monitoring of forest condition is primarily related to the observation and assessment of defoliation and discolouration of tree crowns on certain sample plots, the results of which are published and delivered to the scientific and professional environment.

2. RESEARCH AREA, METHOD AND CRITERIA

Forest condition monitoring is one of the largest forest bio-monitoring systems that is implemented in order to detect changes in forests using key ecological parameters. On the basis of the obtained data, it is possible to determine spatial and temporal trends in the state of forests, i.e., tree species and their crown condition by region. A wider context can include the correlation of the crown condition data with the data obtained from corresponding sample plots as well as external data on natural and human stress factors, which all provide some indications of the interrelations between the forest vitality and stress factors.

In the period from 2002 to 2018, a total of 130 sample plots arranged in 16 x 16 km and 4 x 4 km grids have been established in the territory of the Republic of Serbia. (Nevenić et al., 2006). In 2018, the condition of forest species was assessed on all 130 sample plots in Serbia.

Institute of Forestry teams conducted field visits of sample plots in the area of forest estates in the presence of experts, forest inspectors, forest engineers and technicians responsible for the particular sample plot localities or areas.

Visual monitoring, conducted according to the ICP Forests Manual, was carried out on the sample plots in the territory of the Republic of Serbia. It included crown condition assessment and determination of damage caused by diseases and pests. According to ICP Forests Manual, crown condition assessments are mandatory on all plots once a year, soil condition assessments every ten years as well as the assessment of the nutritional condition of forest trees – foliar analysis.

A sample plot is determined by its coordinates and its center is marked with a metal rod of a vivid colour. Trees are systematically sampled for the purpose of crown condition assessment. As they are selected in 4-point clusters, it makes a total of 24 trees. In the direction of the 4 cardinal points at a distance of 25 m from the center, six closest trees are selected for the purpose of crown condition monitoring. Tree samples include all tree species with a minimum height of 60 cm. The crown canopy classes after Kraft[1] (dominant, co-dominant, subdominant, suppressed and dying), are used as a criterion for selecting trees, excluding trees with significant mechanical injury. The selected trees are permanently marked with numbers for the future continuous assessments. The trees which are removed due to management measures or for some other reasons are replaced with new ones. If a stand is clear-felled, the central point is kept until the establishment of a new stand.

Within the framework of national and transnational research (Level I), the crown condition is assessed by the classes of defoliation, discolouration and combined damage classes. Defoliation is assessed in 5% intervals and it is classified into 5 groups of uneven range (Table 1).

Table 1. *Classes of defoliation according to UN/ECE[2] and EU[3] classification*

Classes of defoliation - dieback	Degree of defoliation	Leaf loss (%)
0	No	0-10
1	Slight	10-25
2	Moderate	25-60
3	Severe	60-100
4	Dead	100

Since 2018, the research has been improved in practice by introducing purposeful forms used in the monitoring of damage and its agents on sample plots. The forms are processed using a code system that gives a deeper insight into the state of each of the trees in terms of the pests or diseases that affect this tree. Abiotic factors are also included because, although they are primary agents, they give rise to secondary damage agents and make it easier for insects and fungi to infest once healthy trees. These are the reasons we have been sampling and monitoring trees all these years trying to put all pieces together and get the whole picture.

---

[1] The modified concept of the crown canopy classification, the traditional measurement of variables used in forestry, first applied by Kraft, in Germany, in the nineteenth century, (1884)

[2] United Nations Economic Commission for Europe

[3] European Union

3. RESULTS ON THE HEALTH CONDITION OF TREES ON LEVEL I SAMPLE PLOTS IN 2018

Health condition, effects of damaging agents – Apart from the results of the tree crown condition assessments, damaging agents, i.e., a great number of disease-causing organisms and pests, (Nevenić et al., 2006) were determined in the forest ecosystems of the established sample plots. Pathogenic epixylic fungi and harmful insects are the accompanying organisms of some natural ecosystems. To minimize their destructive activity, forest management includes tending measures whose aim is to reduce their populations to an acceptable measure, i.e., abundance that will not cause evident damage (Mihajlović, 2008). However, the pollution that occurs in the conditions of climate change makes the agents of diseases and pests change their usual rhythms and bionomy. Some parasites disappear, while others become more active under these altered, new conditions.

The damage to trees was recorded according to the agent and the species of trees where they were detected. The most common agents were harmful insects and fungi, as dominant biotic factors, and human activity (in cutting, felling and hauling, which increases the risk for the damaged trees to be penetrated and infested by diseases and pests in previously healthy trees).

Table 2. *The damage on the sample plots presented by agents in 2018 (%)*

Species	Insects	Fungi	Abiotic agents	Human	Fire	Local pollution	Other damage	Total damage
All species	9,4	9,1	2,8	0,9	0,4	0	6,5	29,1
Broadleaves	10,7	10,1	3	1	0,5	0	6,3	31,6
Conifers	0,3	1,7	1,1	0,3	0	0	8,4	11,8
Beech	9,4	13,4	5,4	2,3	0,6	0	7,1	38,2
Sessile oak	17,7	5,1	1,5	0,5	0	0	10,1	34,9
Turkey oak	9,9	7,7	4,4	0	0,4	0	6,3	28,7
Fir	0	0	3	0	0	0	21,2	24,2
Norway spruce	0	0	1,4	0	0	0	9,7	11,1
Austrian pine	0	9	0	0	0	0	0	9

4. DISCUSSION

The most common species of coniferous forests are Austrian pine, Scots pine, Norway spruce and fir. After the recognition of the above-mentioned forest areas and the identification of the agents of defoliation and discolourisation caused by diseases and pests, the damage can be best described by listing the names and percentages of the most frequent ones (Nevenić et al., 2012). The health status of coniferous forests in 2018 was generally better compared to broadleaved forests.

Of all conifers, Austrian pine had the smallest share of damage (Table 2). Several types of pathogens and a slightly smaller number of epixylic fungi were registered.

A dangerous pathogen - *Micopshaerella pini* Rost.in Munc (1957) occurred in 2018, but only on the previous-year needles of Austrian pine, and on a small scale. In the butt-end, several disease-causing fungi were found, the most common of which was *Fomitopsis pinicola* (Swartz: Fr.) Karst (1871), (Figure 1). Almost 10% of Austrian pine trees had symptoms of attacks of the aforementioned pathogens and wood-decaying fungi.

The needles of Scots pine were affected by *M. pini*, *Lophodermium pinastri* (Schard.:Fr.)Chev(1826) and *Lophodermium seditiosum* Minter, Staley & Millar (1978) - on a small scale. Stems and branches also registered *F. pinicola* and *Trichaptum* sp. The needles of Scots pine also registered the damage typical of the attack of *Diprion pini* L. insect. Several physiologically-weakened trees had visible tunnels of *Buprestidae* (SP 45). Globally, the health status of Scots pine trees was better this year. However, a lot of trees were severely damaged during felling and hauling and the inflicted damage is a threat in the coming period as it makes trees susceptible to the attack of a number of harmful insects and diseases.

In the stands of Norway spruce, the needles were affected by a dangerous pathogen, *Lophodermium piceae*, but on a small scale. It should be noted that Chermes species also occurred on individual trees. Of the significant wood-decaying fungi, a very dangerous root-decaying fungus *Heterobasidion parviporum* Niemelä & Korhonen 1998 was registered, but only on individual trees (Nevenić et al., 2014). The most common pests in Norway spruce forests were the bark beetles - primarily *Ips typographus L.*, (Figure 2), which were found in the locations with dying, hollowed Norway spruce trees (the area of NP Kopaonik, SP in the areas of certain protection regimes).

Figure 1. *SP 65, brown cubic rot in the butt end of a pine tree (Orig.)*

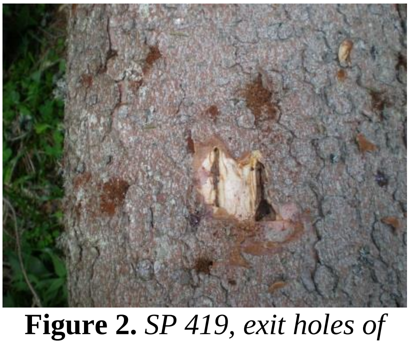


Figure 2. *SP 419, exit holes of bark beetles Ips typographus (|Orig.)*

The most frequent fungi occurring on the fir sample plots were *Cytospora friesii* Sacc. (1884) and *Lirula nervisequa* (DC.ex Fr.) Darker (1967) but only on a small scale. The presence of a number of `witches` brooms` caused by the parasitic fungus *Mellampsorella caryophyllacearum,* Schrot (1864) was registered on three sample plots - SP 401, 402, 418. Of the epixylic fungi that destroy the wood mass, a small-scale presence of *Armillariella ostoyae* (Romang Hering. 1973) was registered. The symptoms of plant diseases and wood destruction caused by the above-mentioned agents were clearly visible in 9.1% of the observed trees. A significant resin bleeding was observed in several fir trees. It can be due to numerous factors, but the final result is the death of trees in a period of two to three years.

The most common broadleaved tree species on sample plots are oaks – sessile oak, Turkey oak and Hungarian oak, and include stands of different ages. Young privately-owned sessile oak coppice forests (*Quercus petraea* L.) are of poor health condition (SP 78), while the sessile oak forests in the territory of `Djerdap` National Park have a satisfactory health state due to the proper implementation of the protection regime and tending measures, (SP 33).

On the leaves of mature trees and young crop, several types of pathogenic fungi were registered, the most common of which were powdery mildews *Microsphaera alphitoides* Griffon & Maubl (1910), (Fig. 3) and *Mycosphaerella maculiformis* (Pers. J. Schrot. 1894) that cause leaf blight. The most common insects causing damage to oak leaves were defoliators (Geometridae) and leaf rollers (Tortricidae. Cynipidae, especially the species *Neuroterus quercus baccarum* L., were found on Turkey oak trees, on a significant scale (SP 36, 38, 39). The most common causes of damage to oak leaves (on almost all Level I sample plots with oak trees) were miners, with *Tischeria* and *Stigmella* being the most common genera on all oaks (Figures 4 and 5). The individual presence of the nests of oak processionary - *Thaumetopoea processionea* L. was also recorded.

Figure 3. *SP 21 Microsphaera alphitoides on young oak trees (Orig.)*

Figure 4. *SP 19 Miners - Ticheria ekebladella on young oak trees (Orig.)*

Several wood-decaying fungi were registered on the branches of Turkey oak trees, but they are represented on a small scale and thus have no significance.

There were several types of damage on the trunks of oak trees, some of which were very important and dangerous. Bacterial tumorous forms that occur on trunks can reach large proportions, but this time they occurred only individually and in untended stands. Oak trees had conks of the wood-decaying fungus *Armillaria* Hartig (1873) on the butt-ends and *Fomes fomentarius* L. ex. Fr. Kickx (1867) on the trunks, as well as the brown central rot which occurred mainly on damaged trees. On sample plots 48 and 60, a very dangerous epixylic fungus *Laetiporus sulphureus* (Bull.ex Fr.Murr (1920), which has the characteristics of both parasites and saprophytes, started its growth on healthy standing trees and continued on felled trees leading to the complete decomposition of wood mass.

Dieback of sessile oak trees was also present. It was caused by the action of a number of detrimental factors, dating from previous years and getting worse every year.

Other biotic agents of damage included parasitic flowering plants - white mistletoe (*Viscum album* L.) and yellow mistletoe (*Loranthus europaeus* Jacq.) on individual branches of oak trees. They caused physiological weakening of trees and made them prone to the attack of dangerous wood destructors and pests.

The forest litter of the sample plots contains fungi that are characteristic of the observed types of forests (Zúbrik et al., 2008), some of which cause rotting in the butt-ends - such as *Armillaria* sp. and *Hypoxylon deustum* Hoffm.Grev. (1828). The damage caused by fungi occurred in almost 30% of trees.

Abiotic factors included frost shake on the bark of Hungarian oak trees, which were present on a small scale, while the damage to the leaves was very pronounced. Mechanical damage to oak trees was registered in more than 25% of the studied trees and they were caused by human factor, i.e. during tree felling and hauling. These injuries pose a potential danger and make trees prone to many harmful insects, disease-causing fungi, as well as wood-destroying organisms (Vajda, 1974).

Besides oaks, a large number of sample plots include beech forests (*Fagus moessaca* L). Despite its good technical characteristics, beech wood is known to be quite susceptible to the attacks of numerous parasitic and saprophytic organisms. Their action makes physiologically weakened and diseased trees an easy target for various primary and secondary harmful insect species, which in the end results in the death of both individual trees and groups of trees (Tabaković -Tošić, Marković, 2004).

Insect damage was registered on beech leaves. It was done mainly by miners *Orchestes fagi* L. and *Lithocolletis faginella* (Zeller, 1864). Gall makers occurred very often, the most common of which were *Hartigiola anullipes* (Hartig, 1939) and *Mycioola fagi* (Hartig, 1939).

Figure 5. *SP 49 damage by miners on Turkey oak (Orig.)*

Figure 6. *SP 58 Nectria sp. on the felled beech log (Orig.)*

The symptoms of fungus attacks on trunks were present in 13.4% of beech trees. *Diatrype disciformis* (Hoffm.) Fr. and cankers were registered on the bark. There were several species of wood-decaying fungi on the butt-end of the stem but on a small scale.

Regarding mechanical factors that caused damage to mature beech trees in 2014, it should be noted that it can be mostly attributed to ice-breaks (SP 413). It is important to note the occurrence of ice-breaks because they initiate a chain action that starts with the destruction of an entire stand due to the canopy opening and bark burn that subsequently arise a whole chain of biotic agents that lead to the complete devastation of beech forests (Češljar et al., 2013).

Figure 7. *SP 51 Trametes versicolor on the felled beech logs (Orig.)*

Figure 8. *SP 61 Fomes fomentarius on the felled beech logs (Orig.)*

The presence of *Diatrype stigma* (Hoffm.) Fr. was registered on the branches and a large number of conks of *F. fomentarius* (Fig. 8) on the felled logs. *Nectria coccinea* was also abundant and together with *Cryptococcus fagisuga*, Lindinger, 1936, caused the so-called \`beech bark disease\`, which is a common occurrence on beech SPs, especially in the ones with an open canopy.

Figure 6 shows the fruiting bodies of *Nectria cinnabarina* (Tode) Fr., (1849). There are a lot of decayed trees attacked by the wood-decaying fungus *Trametes versicolor* L.ex.Fr.Pilat (1936), (Figure 7). Generally, beech is the most common species in our country and it is of good health condition. However, these agents of damage have endangered it in certain localities and made it prone to further spread of dangerous diseases and pests (Marković et al., 2014). Therefore, there is a pressing need for frequent monitoring of the state and proper implementation of forestry measures in order to minimize damage (Marković et al., 2014).

5. CONCLUSIONS

The aim of the crown condition assessment (discolourisation, defoliation and damage) was not only to determine the current cause-effect relationships. The data collected over a long time period and their correlation with stand characteristics will give us a deeper insight into the causes of forest dying and determine its future trends.

Defoliation had similar trends in broadleaves and conifers in 2018, but it was more frequent than discolourisation for both groups of trees. Therefore discolourisation is no longer as a significant parameter as it used to be. The types of damage were also determined and registered. Because of the attack of a large number of the above-mentioned diseases and pests and the greater presence of mechanical injuries, the broadleaves had more pronounced discolourisation, which is why they are briefly presented as more frequent. Harmful agents, numerous agents of diseases, and pests were registered on the trees sampled for monitoring on sample plots.

The vitality of forests depends on environmental conditions and a great number of biotic and abiotic factors, such as climatic characteristics, atmospheric deposition, harmful insects, pathogenic organisms, wood mass destroyers, forest fires, direct atmospheric impacts, game, rodents, (Nevenić et al., 2008). Nevertheless, biotic agents are the most important factor threatening the trees sampled and monitored for more than a decade and a half in continuity. Therefore, further analysis can provide different trends of their direct effects and degrees of their effects. International program for further and more detailed monitoring of the forest condition in the Republic of Serbia (ICP Forests), which is carried out on Level I sample plots, will enable us to determine the vitality of forests both at the local and at the regional level.

Acknowledgments: *This paper is a result of a research carried within the Project "Development of technological methods in forestry in order to attain optimal forest cover" (TR 31070, Led by Ljubinko Rakonjac, financed by the Ministry of education, science and technological development of the Republic of Serbia and Project "Monitoring and assessment of air pollution and it's effects on forest ecosystems in Serbia – Forest condition monitoring", financed by the ministry of agriculture and environment protection of the Republic of Serbia – Forest Directorate).*

REFERENCES

Vajda, Z. (1974): Forest Protection Science, University book, Zagreb, Školska knjiga

Češljar G., Nevenić, R., Bilibajkić S., Stefanović T., Renata Gagić-Serdar R., Đorđević I., Poduška Z., (2013): Viability Of Trees On Level I Sample Plots In The Republic Of Serbia In 2013, *SUSTAINABLE FORESTRY* Collection 67-68, Institute Of Forestry, Belgrade, pp. 69-78

Mihajlović, Lj. (2008): Forest Entomology, University book, Belgrade, Faculty of Forestry

Marković M, Rajković S, Nevenić, R. (2014): The Most Frequent Agents Of Damage Of Trees On The Sample Plots In Serbia: *SUSTAINABLE FORESTRY* Collection Of Papers 69-70, Institute Of Forestry, Belgrade, pp. 85-94

Nevenić et al., (2006): Monitoring of the state of forests in the Republic of Serbia. Annual report for 2006. National Focal Center of Serbia (NFC) ICP Forests – LEVEL 1. Institute of Forestry. Belgrade, Serbia, p.102.

Nevenić et al., (2008): Monitoring of the state of forests in the Republic of Serbia according to the ICP Forest Programme (International Cooperative Programme for

Monitoring the State of the Forests of Europe) and the CLTRAP Convention (Convention on Transboundary Air Pollution Transmission). Annual report for 2008. National Focal Center of Serbia (NFC). ICP Forests - Level I. Institute of Forestry. Belgrade Serbia. p. 15.

Nevenić, R., Tabaković-Tošić M., Rajković S., Rakonjac Lj., Miletić Z., Marković M., Bilibajkić S., Stefanović T., Stajić S., Čokeša V., Radulović Z., Poduška Z., Gagić-Serdar R., Đorđević I., Češljar G., (2012): Assessment and monitoring of the effects of air pollution on forest ecosystems in Serbia. Level I and Level II. ISSN 1425/8576

Nevenić R., Tabaković-Tošić M., Rajković S., Rakonjac Lj., Miletić Z., Marković M., Bilibajkić S., Stefanović T., Stajić S., Čokeša V., Radulović Z., Poduška Z., Gagić-Serdar R., Đorđević I., Česljar G., (2014): Assessment and monitoring of the effects of air pollution on forest ecosystems in the Republic of Serbia. Level I and Level II. (Chapters 4, 5, 6, 7, 9, 10, 13, 16) ISBN 987-86-80439-35-8

Tabaković Tošić, M. and Marković, M., (2004): Effects of phytophagous insects on the health condition of beech forests of Eastern Serbia. Proceedings, Collection 50-51. Institute of Forestry, Belgrade, p.56.

Zúbrik, M., Kunca, A., Novotný, J. (2008): Hmyz Huby, Atlas poškodeni lesných drevin, Institutum Forestale Zvolen

*******(**2010): Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests, United Nations Economic Commission For Europe Convention On Long-Range Transboundary Air Pollution,. Institute for World Forestry. Programme Coordinating Centre of ICP Forests.

FOREST VITALITY (ICP LEVEL I SAMPLE PLOTS) WITH A SPECIAL EMPHASIS ON BIOTIC AGENTS IN THE REPUBLIC OF SERBIA IN 2018

Renata GAGIĆ-SERDAR, Tomislav STEFANOVIĆ, Ilija ĐORĐEVIĆ,
Goran ČEŠLJAR, Miroslava MARKOVIĆ

Summary

National Focal Center at the Institute of Forestry in the Republic of Serbia has been continuously participating in an international program of ICP Forests since 2003 with a tendency to expand the work and harmonize it with other working approaches to monitoring of forests and forest ecosystems. The assessment of crown condition through defoliation and tree damage caused by diseases and pests performed on ICP Sample Plots in 2018 make a significant contribution to reaching the final conclusions on declining forest vitality. It is a result of adverse effects of a complex of abiotic and biotic factors on trees as living organisms and complex natural processes within the forest biocoenoses. The impact of pollutants and climate change factors on the vitality of forests is an evident phenomenon in Serbia, the region and throughout the whole of Europe. These topics are arising great interest and they are yet to be the focus of research both in our country and in the world.

ВИТАЛНОСТ ШУМА (БИТ НИВО I) РЕПУБЛИКЕ СРБИЈЕ СА ОСВРТОМ НА БИОТИЧКЕ АГЕНСЕ У 2018. ГОДИНИ

Рената ГАГИЋ-СЕРДАР, Томислав СТЕФАНОВИЋ, Илија ЂОРЂЕВИЋ, Горан ЧЕШЉАР, Мирослава МАРКОВИЋ

Резиме

Национални фокал центар у Институту за шумарство, за праћење стања шума Републике Србије од 2003. године у континуитету учествује у међународном програму ICP за шуме са тенденцијом даљег усавршавања рада и усклађивања са другим приступима рада на праћењу стања шума и шумских екосистема. Процена стања круна, кроз дефолијацију, и установљавање оштећења на дрвећу од болести и штеточина, на БИТ у 2018. години, допринос је извођењу коначних закључака о нарушеној виталності шума. Она се јавља као последица неповољног деловања комплекса фактора абиотичког и биотичког порекла на дрвеће као живе организме и сложене природне процесе унутар шумских биоценоза. Утицај загађивача и измена фактора климе на виталност шума евидентан као појава, у Србији, региону и читавој Европи. Истраживања ове тематике веома су актулна и тек ће бити предмет рада, код нас и у свету.

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY COLLECTION 76-77, 2018
ODRŽIVO ŠUMARSTVO ZBORNIK RADOVA 76-77, 2018

UDK 630*113+630*423.3(497.11-11)
UDK 630:504.4:551.574.42(497.11-11)
Original scientific paper

DISASTROUS ICE BREAKS IN EASTERN SERBIA – GIS ANALYSIS OF THEIR RELATIONSHIP WITH OROGRAPHIC CHARACTERISTICS

Nenad MARKOVIĆ[1], *Miroslava MARKOVIĆ*[2]

Abstract: *At the end of November/beginning of December 2014, an ice wave hit the whole of eastern Serbia and caused extensive ice and snow breaks in the forest areas managed by SE `Srbijašume` – Forest Estates of Niš, Boljevac, Kruševac, Despotovac and Kučevo. The areas affected were determined by identifying all the affected units of forest division – with the lowest accuracy at the level of forest stands and, where possible by GPS recording in the field in order to ensure greater accuracy. The identified areas were presented in GIS mapping software. The total area affected by ice breaks amounted to 19,419.78 ha. It included 8,301.01 ha of high forests, 8,997.37 ha of coppice forests and 2,121.40 ha of artificially-established stands. Considering the size of the forest area affected by ice breaks on the one hand, and the huge environmental impact of forests on the other hand, this phenomenon may be considered a natural disaster. Having identified the affected forest areas, an analysis of the relationship between orographic characteristics and ice break occurrence was carried out with the use of GIS tools. The following orographic characteristics were studied: the elevation, the terrain aspect and the slope, all obtained from the digital elevation model (DEM) at a resolution of 1 arc-second. Elevation had the greatest influence on the occurrence of ice breaks. The largest area affected (ca.17,000 ha) was in the range from 600 to 900 m above sea level, i.e. in the belt of low-mountain relief. Regarding the aspect of the investigated terrain, the largest areas affected*

[1] Autor za kontakt: Nenad Marković, B.Sc., SE`Srbijašume`, Bulevar Mihaila Pupina 113, 11000 Belgrade, tel. +381648155041, Email: marnen67@gmail.com
[2] Dr Miroslava Marković, naučni saradnik, Institut za šumarstvo, Beograd

Acknowledgment: *The study was carried out within the Project TR 31070 "The development of technological procedures in forestry with a view to an optimum forest realization", financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia (2010-2019).*

by ice breaks had northern (ca. 4,000 ha) and northeastern aspects (ca. 3,500 ha), while the remaining areas were equally distributed in all other aspects. The slope was not found to have any significant effects on the occurrence of ice breaks. This disaster brought about most severe and extensive consequences in broad-leaved and coniferous ecosystems and the environment in general, with long-term adverse effects such as changing soil water regimes, erosion, declining atmospheric oxygen levels and reduced carbon accumulated in biomass.

Keywords: ice breaks, GIS, elevation, aspect, slope, environment

КАТАСТРОФАЛНИ ЛЕДОЛОМИ У ИСТОЧНОЈ СРБИЈИ – ГИС АНАЛИЗА УСЛОВЉЕНОСТИ ОРОГРАФСКИМ КАРАТЕРИСТИКАМА

Извод: *Крајем новембра и почетком децембра 2014. године, ледени талас који је захватио целу источну Србију проузроковао је појаву великих ледолома, ледоизвала и снеголома на површинама којима газдује ЈП „Србијашуме", односно на подручју шумских газдинстава Ниш, Бољевац, Крушевац, Деспотовац, и Кучево. Утврђивање површина захваћених ледоломима и ледоизвалама извршено је дефинисањем свих захваћених јединица просторне поделе шума, најмање тачности на нивоу одсека, а где је то било могуће и прецизније снимањем уз помоћ ГПС апарата. Те површине су картиране у ГИС технологији. Укупна површина државних шума захваћених ледоломима је 19.419,78 ha, од чега на високе шуме отпада 8.301,01 ha, изданачке 8.997,37 ha и вештачки подигнуте састојине 2.121,40 ha. С обзиром на велику површину шума захваћену ледоломима, као и на њен огроман утицај на животну средину, ова природна непогода може се сматрати катастрофалном. После дефинисања површина захваћени ледоломима, ГИС алатима извршена је анализа условљености појаве ледолома орографским карактеристикама. Од орографских карактеристика анализирана је надморска висина, експозиција и нагиб терена. Детаљне орографкссе каракеристике подручја захваћених ледоломима добијене су из дигиталног елевационог модела (DEM) прецизности 1 ARC-second. Највећи утицај на појаву ледолома имала је надморска висина. Највећа површина погођена ледоломима (око 17000 ha) налази се у појасу 600-900 м.н.в. тј у појасу нископланинског рељефа. Што се експозиције тиче, највеће површине погођене ледоломима налазе се на северној (око 4000 ha) и североисточној експозицији (око 3500 ha), док је остатак површина равномерно распоређен по осталим експозицијама. Нагиб није показао значајан утуцај на појаву ледолома. Констатоване су озбиљне и тешке последице, које је природна непогода оставила на четинарски и лишћарски шумски екосистем и животну средину, као и дуготрајне последице: промена водног режима у земљишту, интензивирање ерозије, смањење количине кисеоника, смањење количине угљеника акумулираног у биомаси.*

Кључне речи: ледоломи, GIS, надморска висина, експозиција, нагиб, животна средина

1. INTRODUCTION

Freezing rain brought a lot of trouble to eastern Serbia at the end of 2014. The damage caused by ice breaks in the forests of Serbia in late November and early December was enormous. The ice wave hit the whole of eastern Serbia and made unforeseen damage in the area of forest estates of `Južni Kučaj` - Despotovac, `Severni Kučaj` - Kučevo, `Timočke šume` - Boljevac, `Niš` - Niš and `Rasina` - Kruševac.

Freezing rain is a type of precipitation that starts as snow which melts on the way to the ground as it passes first through a layer of air with temperatures above zero, and then through a layer of cooler air. Raindrops become super-cooled while passing through a sub-freezing layer but they freeze only when they encounter a surface with a temperature below zero. This is exactly what happened in this case - when the raindrops fell on the trees, the ice that formed on the branches bent branches and trees and ultimately caused their breaking or even uprooting of entire trees (Pictures 1 and 2).

Picture 1. *Consequences of freezing rain*

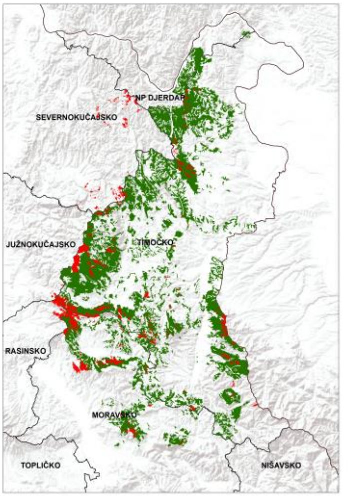
Picture 2. *Consequences of freezing rain*

This paper analyzes the effects of orographic factors on the occurrence of ice breaks and their impact on the environment.

2. MATERIAL AND METHODS

2.1. Identification of the areas affected by ice breaks

In such natural disasters, it is necessary to define the area and the intensity of damage as soon as possible. The areas affected by ice breaks were determined by identifying all the affected units of forest division – with the lowest accuracy at the level of forest stands and, where possible by GPS recording in the field in order to ensure greater accuracy. However, since ice breaks hit large areas of forest, it was enough to identify and map the affected area in the field within the sections that are registered in the geodatabase of the forest division into management units, compartments and forest stands. The identified areas were then mapped in GIS technology. The total area of state forests affected by ice breaks was 19,419.78 ha, where high forests account for 8,301.01 ha, coppice forests for 8.997,37 ha and artificially-established stands for 2,121.40 ha. Picture 3 shows the area affected by ice breaks.

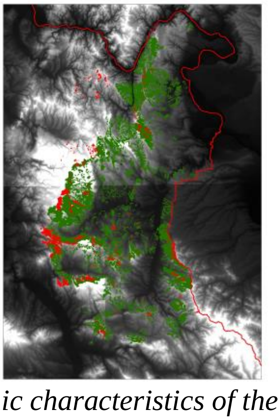


Picture 3. *The area affected by ice breaks*

Although the affected area of state forests is huge (red colored in the figure), the real scope of the disaster can only be seen if we include the damaged areas of privately-owned forests. The overall consequences cannot be determined only through the financial loss, i.e., their impact cannot be valorized solely through the main forest product - wood. The damage is much more significant, extensive and lasting if we take into account its ecological and biological aspects.

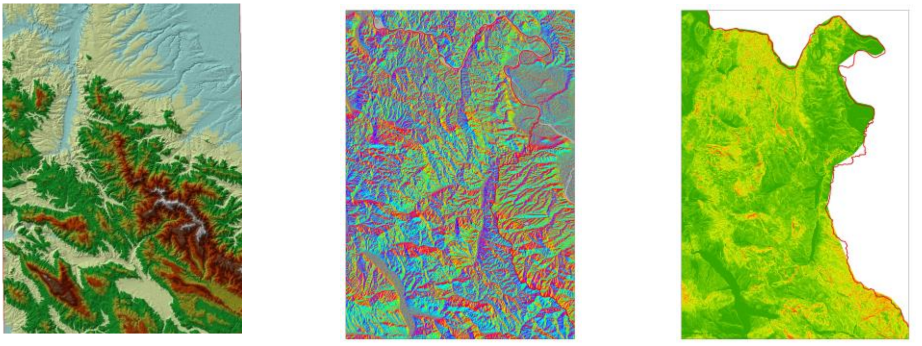
2.2. Orographic characteristics of the affected areas

The analyzed orographic characteristics included the elevation, the aspect and the slope of the terrain. Detailed orographic characteristics of the areas affected by ice breaks were obtained from the digital elevation model (DEM) at a resolution of 1 arc-second (Picture 4).



Picture 4. *Detailed orographic characteristics of the areas affected by ice breaks*

By processing the digital elevation model using GIS tools, we obtained the layers of elevation (Picture 5), aspect (Picture 6) and slope (Picture 7).



Picture 5, 6, 7 – *The elevation layers derived from the digital elevation model*

The digital elevation model was initially converted into the grids of elevation, aspect, and slope, but these grids were in the second step converted into vector layers to facilitate the subsequent analysis and intersection of these layers with the layer showing the damaged areas.

3. RESULTS AND DISCUSSION

3.1. An analysis of the dependence of ice break occurrence on orographic characteristics

The obtained layers of elevation, aspect and slope were first overlapped with the layer that shows the damaged surface areas and then they were intersected with this layer, thus providing new polygon layers which in the attribute table contained data from both layers that participated in the cross-section for each element-polygon. Thus, each element - polygon in the newly obtained layers is accompanied by the data on the type of damage, the area, as well as the elevation, aspect and slope.

This made it possible to determine the size of the damaged area at individual elevations, aspects and slopes.

Elevation had the greatest impact on the occurrence of ice breaks. The largest surface area affected by ice breaks (about 17000 ha) is located in the range from 600 to 900 m a.s.l., i.e., in the belt of low-mountain relief (Table 1).

Table 1. *Area affected by ice breaks*

Relief/	Area (ha)
Hilly	1.676
Low-mountainous	17.570
Medium-mountainous	648

Regarding the aspect, the largest areas affected by ice breaks have northern (about 4000 ha) and northeastern aspect (about 3500 ha). The remaining areas are equally distributed in all other aspects. The slope did not show any significant effects on the occurrence of ice breaks.

Table 2. *Aspect of the areas affected by ice breaks*

Aspect	Area (ha)
Northern	4.013
Northeastern	3.316
Southern	2.619
Southwestern	2.471
Northwestern	2.129
Eastern	1.836
Southeastern	1.797
Western	1.678
Flat	4

3.2. Environmental impact

Although the state forests suffered enormous damage - over 400,000cubic meters of wood, the overall consequences cannot be determined only through the financial loss, i.e., their impact cannot be valorized solely through the main forest product - wood. The damage is much more significant, extensive and lasting if we take into account its ecological and biological aspects. Forest habitats within the forest stand complexes that have suffered a higher intensity of damage are to be changed significantly.

Degradation processes which are yet to occur will cause the regressive succession of forest communities and the impoverishment of the soil that will be inhabited by those tree species that represent the initial stages in the ontogenetic development of the forest stand. All of the above point to the important role of habitat in the development of forests, but it is also interesting to see how the habitat itself can contribute to the occurrence and intensity of damage.

This natural disaster exerted severe and extensive effects on the coniferous and broadleaved forest ecosystem and the environment of the damaged areas and brought about other long-term effects, such as changes in the soil water regime, erosion, declining atmospheric oxygen levels and reduced carbon accumulated in biomass.

4. CONCLUSIONS

The largest area affected by ice breaks (about 17000 ha) is located in the belt between 600 and 900 m a.s.l., i.e., in the belt of low-mountain relief, and the largest areas affected by ice breaks have northern (about 4000 ha) and northeastern aspects (about 3500 ha), while the remaining areas evenly belong to other aspects. The slope did not show any significant impact on the occurrence of ice breaks. This natural disaster exerted severe and extensive effects on the coniferous and broadleaved forest ecosystem and the environment of the damaged areas, but it also brought about other long-term effects, such as changes in the soil water regime, erosion, declining atmospheric oxygen levels and reduced carbon accumulated in biomass. Furthermore, the degradation processes which are yet to occur will cause the regressive succession of forest communities and the impoverishment of the soil that will be inhabited by those tree species that represent the initial stages in the ontogenetic development of the forest stand. All of the above point to the important role of habitat in the development of forests, but it is also interesting to see how the habitat itself can contribute to the occurrence and intensity of damage.

REFERENCES

ArcGisResources: http://resources.arcgis.com/

Earth Explorer, U.S. Geological Survey: http://earthexplorer.usgs.gov

SE Srbijašume (2015): *Action Plan for the Remediation of Damaged State and Privately-owned Forests for the period from 2015 to 2018* http://www.srbijasume.rs/pdf/Akcioni%20plan%20sanacije%202015-2018.pdf

Kolić, Borislav (1988): *Forest eco-climatology with the basics of atmospheric physics*. Scientific Book, Belgrade.

DISASTROUS ICE BREAKS IN EASTERN SERBIA – GIS ANALYSIS OF THEIR RELATIONSHIP WITH OROGRAPHIC CHARACTERISTICS

Nenad MARKOVIĆ, Miroslava MARKOVIĆ

Summary

At the end of November/beginning of December 2014, an ice wave hit the whole of eastern Serbia and caused extensive ice and snow breaks in the forest areas managed by SE `Srbijašume` – Forest Estates of Niš, Boljevac, Kruševac, Despotovac and Kučevo. The areas affected were determined by identifying all the affected units of forest division – with the lowest accuracy at the level of forest stands and, where possible by GPS recording in the field in order to ensure greater accuracy. The identified areas were presented in GIS mapping software. The total area affected by ice breaks amounted to 19,419.78 ha. It included 8,301.01 ha of high forests, 8,997.37 ha of coppice forests and 2,121.40 ha of artificially-established stands. Considering the size of the forest area affected by ice breaks on the one hand, and the huge environmental impact of forests on the other hand, this phenomenon may be considered a natural disaster. Having identified the affected forest areas, an analysis of the relationship between orographic characteristics and ice break occurrence was carried out with the use of GIS tools. The following orographic characteristics were studied: the elevation, the terrain aspect and the slope, all obtained from the digital elevation model (DEM) at a resolution of 1 arc-second. Elevation had the greatest influence on the occurrence of ice breaks. The largest area affected (ca.17,000 ha) was in the range from 600 to 900 m above sea level, i.e. in the belt of low-mountain relief.

Regarding the aspect of the investigated terrain, the largest areas affected by ice breaks had northern (ca. 4,000 ha) and northeastern aspects (ca. 3,500 ha), while the remaining areas were equally distributed in all other aspects. The slope was not found to have any significant effects on the occurrence of ice breaks. This disaster brought about most severe and extensive consequences in broad-leaved and coniferous ecosystems and the environment in general, with long-term adverse effects such as changing soil water regimes, erosion, declining atmospheric oxygen levels and reduced carbon accumulated in biomass. The largest area affected by ice breaks (about 17000 ha) is located in the belt between 600 and 900 m a.s.l., i.e., in the belt of low-mountain relief, and the largest areas affected by ice breaks have northern (about 4000 ha) and northeastern aspects (about 3500 ha), while the remaining areas evenly belong to other aspects. The slope did not show any significant impact on the occurrence of ice breaks. This natural disaster exerted severe and extensive effects on the coniferous and broadleaved forest ecosystem and the environment of the damaged areas, but it also brought about other long-term effects, such as changes in the soil water regime, erosion, declining atmospheric oxygen levels and reduced carbon accumulated in biomass. Furthermore, the degradation processes which are yet to occur will cause the regressive succession of forest communities and the impoverishment of the soil that will be inhabited by those tree species that represent the initial stages in the ontogenetic development of the forest stand. All of the above point to the important role of habitat in the development of forests, but it is also interesting to see how the habitat itself can contribute to the occurrence and intensity of damage.

КАТАСТРОФАЛНИ ЛЕДОЛОМИ У ИСТОЧНОЈ СРБИЈИ – ГИС АНАЛИЗА УСЛОВЉЕНОСТИ ОРОГРАФСКИМ КАРАТЕРИСТИКАМА

Ненад МАРКОВИЋ, *Мирослава* МАРКОВИЋ

Резиме

Крајем новембра и почетком децембра 2014. године, ледени талас који је захватио целу источну Србију проузроковао је појаву великих ледолома, ледоизвала и снеголома на површинама којима газдује ЈП „Србијашуме“, односно на подручју шумских газдинстава Ниш, Бољевац, Крушевац, Деспотовац, и Кучево. Утврђивање површина захваћених ледоломима и ледоизвалама извршено је дефинисањем свих захваћених јединица просторне поделе шума, најмање тачности на нивоу одсека, а где је то било могуће и прецизније снимањем уз помоћ ГПС апарата. Те површине су картиране у ГИС технологији. Укупна површина државних шума захваћених ледоломима је 19.419,78 ha, од чега на високе шуме отпада 8.301,01 ha, изданачке 8.997,37 ha и вештачки подигнуте састојине 2.121,40 ha. С обзиром на велику површину шума захваћену ледоломима, као и на њен огроман утицај на животну средину, ова природна непогода може се сматрати катастрофалном. После дефинисања површина захваћени ледоломима, ГИС алатима извршена је анализа условљености појаве ледолома орографским карактеристикама. Од орографских карактеристика анализирана је надморска висина, експозиција и нагиб терена. Детаљне орографксе каракеристике подручја захваћених ледоломима добијене су из дигиталног елевационог модела (DEM) прецизности 1 ARC-second. Највећи утицај на појаву ледолома имала је надморска висина. Највећа површина погођена ледоломима (око 17000 ha) налази се у појасу 600-900 м.н.в. тј у појасу нископланинског рељефа. Што се експозиције тиче, највеће површине погођене ледоломима налазе се на северној (око 4000 ha) и североисточној експозицији (око 3500 ha), док је остатак

површина равномерно распоређен по осталим експозицијама. Нагиб није показао значајан утуцај на појаву ледолома. Констатоване су озбиљне и тешке последице, које је природна непогода оставила на четинарски и лишћарски шумски екосистем и животну средину, као и дуготрајне последице: промена водног режима у земљишту, интензивирање ерозије, смањење количине кисеоника, смањење количине угљеника акумулираног у биомаси. Највећа површина погођена ледоломима (око 17000 ha) налази се у појасу 600-900 м.н.в. тј у појасу нископланинског рељефа, а највеће површине погођене ледоломима налазе се на северној (око 4000 ha) и североисточној експозицији (око 3500 ha), док је остатак површина равномерно распоређен по осталим експозицијама. Нагиб није показао значајан утуцај на појаву ледолома. Констатоване су озбиљне и тешке последице, које је природна непогода оставила на четинарски и лишћарски шумски екосистем и животну средину, као и дуготрајне последице: промена водног режима у земљишту, ерозију, смањење количине кисеоника, смањење количине угљеника акумулираног у биомаси. Међутим, деградациони процеси који ће тек наступити узроковаће регресију шумских заједница и осиромашење тла на које ће се населити оне врсте дрвећа које представљају сам почетак у онтогенетском развоју шумске састојине. Из свега наведеног јасно се може закључити улога станишта у развоју шуме, али је и занимљиво како станиште може само по себи утицати на појаву и интензитет штета.

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION 77-78, 2018 ZBORNIK RADOVA 77-78, 2018

UDK 630*4(497.11 Beograd)
Original scientific paper

THE ASSESSMENT OF RISK ZONES IN `TOPČIDER` PARK FOREST ON THE BASIS OF THE HEALTH CONDITION OF WOODY PLANT SPECIES

Katarina MLADENOVIĆ[1], Zlatan RADULOVIĆ[1], Vlado ČOKEŠA[1], Đorđe JOVIĆ[1], Ivan MILENKOVIĆ[2]

Abstract*: This paper provides the assessment of the zones of risk for the users of Topčider Forest Park. The assessment was done according to the health condition of woody plant species as determined in 2017, the position of roads, footpaths and parking lots, the age of trees etc. In order to establish the priorities in terms of monitoring and rehabilitation measures within the forest park, four risk zones were distinguished: a very high-risk zone, a high-risk zone, a medium-risk zone and a low-risk zone. The criterion for the identification of trees that pose a potential threat to all forest users (local population, picnickers, recreational athletes, etc.) was the health condition of the leaf mass, branches, trunks, as well as biotic and abiotic damage.*

Key words: risk zones, assessment of health condition, woody plant species, Topčider Forest Park

PROCENA RIZIČNIH ZONA PARK ŠUME TOPČIDER NA OSNOVU ZDRAVSTVENE KONDICIJE DRVENASTIH BILJNIH VRSTA

Izvod: *U radu je data procena rizičnih zona za korisnike park šume Topčider na osnovu zdravstvenog stanja drvenastih biljnih vrsta utvrđenog u 2017. godini, pozicije saobraćajnica, pešačkih staza, parkovskog mobilijara, starosti stabala* itd. *Kako bi se utvrdio prioritet nadzora i mera sanacije unutar park šume izdvojene su četiri zone rizika:*

[1] dr Katarina Mladenović, dr Zlatan Radulović, mr Vlado Čokeša, dr Djordje Jović, Institute of Forestry, Kneza Višeslava 3, Belgrade, Serbia
[2] dr Ivan Milenković, Phytophthora Research Centre, Faculty of Forestry and Wood Technology, Mendel University, Brno, Czech Republic
Corresponding author: Katarina Mladenović, e-mail: katarina.mladenovic@gmail.com

zona vrlo visokog rizika, zona visokog rizika, zona srednjeg rizika i zona malog rizika. Preduslov za evidentiranje stabala koji mogu predstavljati potencijalnu opasnost za sve korisnike šuma (stanovništvo, izletnike, rekreativce itd.) je bilo utvrđivanje trenutne ocene zdravstvenog stanja na osnovu kondicije lisne mase, grana, debla, biotičkih i abiotičkih oštećenja.

Ključne reči: zone rizika, ocena zdravstvenog stanja, drvenaste biljne vrste, park šuma Topčider

1. INTRODUCTION

As a monument of nature, the protected area `Topčider` Forest Park is classified into protection category III – a protected area of local significance (Nature Protection Act, Official Gazette RS, No. 36/09, 88/10, 91/10). Restrictions within the established protection regime do not apply to the activities of maintaining the forest area which are in line with the relevant management plan or to the introduction of new species of trees and shrubs which are according to their biological properties suitable for the environmental conditions and whose properties and aesthetic characteristics match with this area of natural and cultural heritage. They neither apply to the technical measures for the protection against plant pathogens and entomological damage or to the tending measures and removal of woody specimens that do not meet the health, aesthetic and functional criteria of the protected area or the justified replacement of one species with another. According to the Forest Management Plan, this forest park belongs to `Topčider` Forest Management Unit, compartment 3a, which includes a part of the Topčiderska River alluvial plain and belongs to the zone of thermophilic Hungarian oak - Turkey oak forests: *Quercion frainetto* (Stevanović, *et al.,* 1995) or the forests of pedunculate oak and hornbeam: *Carpino-Quercetum roboris* (Gajić, 1952).

Topčider Forest Park has a great historical, aesthetic and recreational value. It is part of the urban system of green areas and at the same time, it is a link between the city and the countryside. The forest park of `Topčider` Protected Area is very sensitive from the aspect of nature and the environment as it is in the center of intensive urban road infrastructure and together with surrounding forests modifies the climate of the city by increasing the humidity and reducing air pollution. After this autochthonous forest had changed its purpose in the mid 20th century, its environmental conditions were altered significantly due to the activities that this change entailed such as concrete reinforcement of the Topčider River channel, introduction of numerous allochthonous species, increased human pressure, *etc*. This altered environment reduced the physiological fitness of woody plant species which made them more susceptible to adverse effects of numerous biotic and abiotic factors. Apart from mechanical injuries, changes can also be caused by the harmful effects of numerous pathogens and pests whose toxic effect can be detected on plant organs. Individual and combined effects of man, pathogens and pests result in defoliation, discolouration, reduced ornamental value and decreasing vitality which in the long run lead to the dieback, uprooting, *etc.*

and pose a potential threat to forest users. The synergistic and/or simultaneous attack of harmful insects and pathogenic fungi leads to the growth reduction, shoot and branch die-back, increased canopy transparency, and crown decline (Agrios 2005; Karadžić 2010; Mihajlović 2008).

2. MATERIAL AND METHODS

In order to determine the zones of risk for Topčider Forest Park users, field investigations were carried out four times during the growing season of 2017.

In order to establish the priorities in terms of monitoring and rehabilitation measures for the trees that pose risk to public safety, four risk zones were distinguished:

- Very high-risk zone - red - close to the roads, playgrounds, restaurants, tram station, most frequent footpaths, parking lots, complete die-back of some trees (grade 1).
- High-risk zone - orange – less frequent footpaths, trees affected the die-back processes (grades 2 and 3).
- Medium-risk zone - yellow - less frequently used sites in the forest park, trees whose health conditioin requires monitoring (grade 3).
- Low-risk zone - green - areas of the forest park with small or limited access, healthy trees or trees with minor injuries (grades 4 and 5).

The following criteria were used to distinguish the risk zones: the proximity to roads (tram tracks, tram stop, footpaths, and parking lots), the available facilities (restaurants, shops, *etc*.), the frequency of the forest park use, and the health condition of the forest park trees (phytopathological, entomological, acarological, and mechanical damage) and the age of the trees.

The inspection of the health condition included the detection of mechanical, phytopathological, entomological and acarological damage to the tree crown, trunk and root collar zone, as well as biotic and abiotic damage determination. The current health condition was assessed and the factors that potentially threaten it were identified using a visual assessment with the following 1 to 5 scale: 1 – a dead tree; 2 – a dying tree with a reduced leaf area and advanced trunk and branch decay which poses a risk to public safety; 3 - a tree with considerable damage, having evident foliar injuries and damaged trunk and branches, dry-topped, decayed trunk and/or branches, requires rehabilitation measures; 4 – a tree with minor injuries, spot damage to the leaf mass, trunk and branches, a small percentage of rotten branches; 5 - a healthy tree with no or few symptoms of leaf mass, trunk and branch damage (Mladenović *et al*., 2016). Young trees were excluded from the assessment.

The inspection included the following plant species: *Acer campestre* L., *A. dasycarpum* Ehrh., *A. negundo* L., *A. pseudoplatanus* L., *Aesculus hippocastanum* L., *Alnus glutinosa* Gaer., *Betula alba* L., *Carpinus betulus* L., *Cornus mas* L., *Crataegus monogyna* Jacq., *Fagus moesiaca* (Domin, Maly) Czeczott., *Fraxinus excelsior* L., *F. ornus* L., *Gleditsia triacanthos* L., *Juglans regia* L., *Picea abies*

Kalrst., *Pinus nigra* Arg., *P. strobus* L., *Pirus communis* L., *Platanus acerifolia* (Ait.) Willd., *Populus alba* L., *P. nigra* L., *Prunus cerasifera* Ehrh., *Quercus cerris* L., *Q, robur* L., *Robinia pseudoacacia L.*, *Salix alba* L., *Samubcus nigra* L., *Syringa vulgaris* L., *Tilia argentea Desf.*, *T. cordata* Mill, *T. grandifolia* Enhr., *Ulmus carpinifolia* Gled., *U. effusa* Willd..

The plant material required to determine the plant diseases and pests occurring in order to assess their significance and contribution to the die-back process was collected by the random selection method or on the basis of the symptoms present in the forest. Harmful organisms were identified by the microscopic method at the entomological and phytopathological laboratory of the Institute of Forestry. The samples had been packed in polyethylene bags and stored in the refrigerator at a temperature of 5°C before they were used for the identification at the laboratory of the Institute of Forestry. Identification of phytopathogenic organisms was done using the light microscope and in pure cultures after the isolation according to numerous different keys: Agrios (2005); Alexopoulos *et al*., (1996); Barnett and Hunter (1998); Breitenbach and Kränzlin (1986); Černy (1989); Davidson *et al*., (1938); Gilbertson (1979); Hagara *et al*., (2012); Jung (2009); Jung *et al*., (1996, 2000); Karadžić (2010); Karadžić *et al*., (2014); Karadžić and Milenković (2014, 2015); Milenković 2015); Murrill (1903, 1908); Overholts (1953); Pegler and Waterston (1968); Ryvarden and Johansen (1980); Stalpers (1978); Wagner and Fischer (2002). In order to identify pests, insects and mites, the following taxonomic literature and keys were used: Amrine *et al*., 2003; Baker *et al*., 1996; Domes 1998; Keifer 1938-1979; Malandraki e*t al*., 2004; Nalepa 1910; Petanović 1988a, b; Shi & Boczek 2000; Baker & Tuttle 1994; Mitrofanov *et al*., 1987; Migeon and Dorkeld (2018); Prichard & Baker, 1955; Reeves, 1963; Rota, 1962; SmithMeyer 1987; Begljarov 1981; Chant 1959; De Moraes *et al*., 1986, 2004; Demite *et al*., 2018; Karg 1993; Alford 1995; Johnson & Lyon 1991; Maceljski 1986, 2002; Mihajlović 2007, 2008; Petrović-Obradović 2003; Tanasijević and Simova-Tošić 1987; Strous & Winter 2000).

3. RESEARCH RESULTS AND DISCUSSION

Most of the observed trees in Topčider Park Forest were found to be in the group of trees with small to considerable damage. The critical trees which were planned to be removed were scored 1 or 2, while there were some critical trees designated as trees for further monitoring that were scored 3. It could be also observed that the vitality of individual trees of certain species varied greatly depending on the position in the stand. The assessment of the health status of trees depending on their position in Topčider Forest Park is given in Table 1.

Table 1: *Average assessment of the health status of trees in Topčider Forest Park*

Woody plant species	Assessment scores of the trees in the busy part of the park	Assessment scores of the trees in the interior of the forest park
Acer campestre	3,5	4,8
Acer dasycarpum	2,0	3,0
Acer negundo	2.2	3.9
Acer pseudoplatanus	4.0	4.2
Aesculus hippocastanum	2.4	3.9
Alnus glutinosa	4.5	4.9
Betula alba	4.1	4.9
Carpinus betulus	3.8	4.2
Crataegus monogyna	4.4	5.0
Fagus moesiaca	3.5	4.4
Fraxinus excelsior	3.7	4.3
Fraxinus ornus	3.3	4.5
Gleditsia triacanthos	2.6	4.0
Juglans regia	4.0	4.0
Picea abies	3.5	4.7
Pinus nigra	2.5	4.5
Pirus communis	4.0	4.0
Platanus acerifolia	4.0	4.0
Populus alba	2.5	3.3
Prunus cerasifera	4.8	5.0
Quercus cerris	4.0	4.6
Quercus robur	3.5	4.3
Robinia pseudoacacia	4.3	4.9
Salix alba	4.0	4.4
Tilia argentea	3.8	4.2
Tilia cordata	3.8	4.3
Tilia grandifolia	3.9	4.1
Ulmus carpinifolia	2.0	2.6
average	**3.5**	**4.2**

It was observed that the most threatened trees of Topčider Park Forest were close to footpaths, parking lots, tram tracks, park furniture, *etc*, and their average score of the health status amounted to 3.5. The negative human effects were particularly visible in the busy part of the Park Forest, while the trees in the interior stands had much better health status, which was confirmed by the higher score of the health status of 4.2. The following tree species showed the greatest difference in the obtained scores depending on their position in the forest park: *A. campestre, A. dasycarpum, A. negundo, A. hippocastanum, F. ornus, G. triacanthos, P. abies* and *P. nigra*. The differences in the health condition of the investigated woody species between the trees in the interior stands and the sites with the high frequency of population was the result of numerous, minor or major mechanical injuries which made entrance holes for pathogenic organisms agents of tree decay that consequently endangered the safety of the forest park users. The most common pathogens were the agents of white and central rot, root decay, leaf spots, mildew, *etc*. The damage caused by parasitic fungi was found to be far greater than the damage caused by the detected insects and mites.

The following tree species had the most favourable health and physiological condition in Topčider Park Forest: *A. campestre, A. glutinosa, B. alba, Prunus* spp., *Q. cerris, R. pseudoacacia, S. alba* and *C. monogyna*. The following species proved to be less resistant to biotic and abiotic damage: *A.*

dasycarpum, A. negundo, A. hippocastanum, G. triacanthos, P. nigra, P. alba i *U.* carpinifolia (Mladenović *et al.*, 2018). Autochthonous species of pedunculate oak, narrow-leafed ash, field elm, alder, white elm, willow, *etc.* should be more common in the park forest in the future. Overmature trees of *P. alba, P. communis, A. negundo etc.*, and the trees of poor health condition, such as *A. dasycarpum, A. negundo, A. hippocastanum, G. triacanthos, P. nigra, P. alba* and *U. carpinifolia,* should be gradually removed from the stands to avoid the preventive measures of reducing the risk of branch breakages or uprooting of entire trees and thus ensure the public safety. Allochthonous species of *A. dasycarpum, A. negundo, G. triacanthos* with poor health status should be replaced with autochthonous species. The abundance of locust, as invasive species, needs to be reduced.

The risk zones distinguished in Topčider Forest Park are shown in Figure 1.

The red zone is the zone of very high risk in the immediate vicinity of the tram tracks and the tram stop, the most frequent footpaths, restaurants and parking lots. The high-risk orange zone is close to less frequent footpaths, the mid-risk yellow zone is part of the forest park that is less frequently visited by the public while the green zone as a low-risk zone has restricted public access.

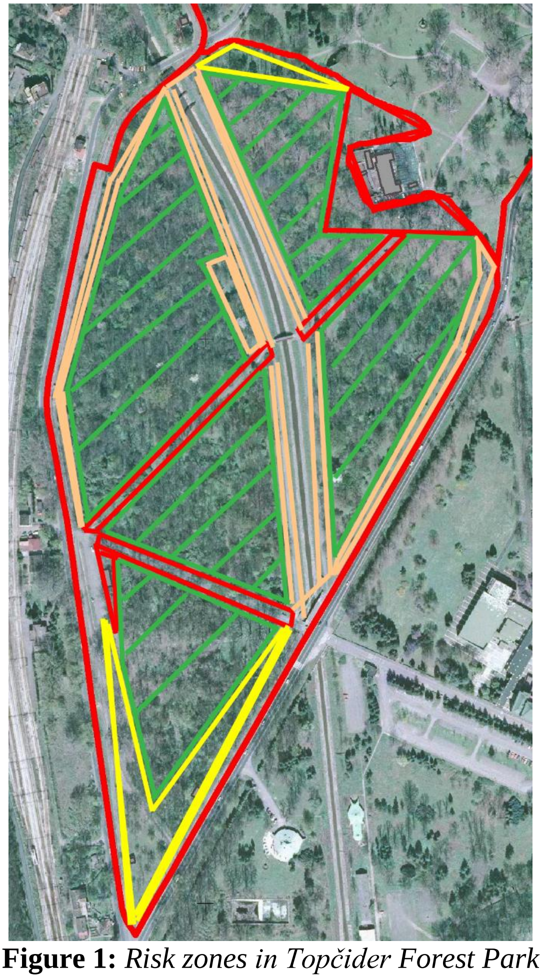


Figure 1: *Risk zones in Topčider Forest Park*

Critical trees include completely decayed trees or the trees in different stages of decay along the footpaths, parking lots, tram stop, tram tracks, park furniture or the edge of the forest. Decayed of decaying trees that are found in the interior forest were not designated as risky trees because they do not endanger the safety while contributing to the improvement and conservation of biodiversity of protected species of insects, birds, rodents, *etc*. which can be found in Topčider Forest Park.

After the rehabilitation, monitoring of the health condition of woody plant species should be focused primarily on the zones marked red and orange.

4. CONCLUSIONS

The research distinguished 4 zones of public risk in Topčider Forest Park: the red zone or the zone of very high risk, the orange zone or the zone of high risk, the yellow zone or the zone of medium risk, and the green zone or the zone of low risk.

Due to the risk of branch breakages or uprooting of entire trees, the trees in the critical areas of very high and high risk are proposed to be removed and replaced as soon as possible to ensure the public safety in the forest park.

There are a large number of trees with minor or greater mechanical injuries in the park. Injuries should be managed adequately in order to avoid further penetration and growth of pathogenic fungi, especially the wood-decaying fungi.

Regarding the damage caused by biotic agents, it can be concluded that phytopathogenic fungi are more serious agents of damage than insects and mites. Intense human pressure was found to be the cause of the greatest number of injuries.

Therefore local population should be educated about the importance of green areas in urbanized city areas in order to reduce the instances of direct damage and destruction of trees.

For the establishment of functional green areas in the city core, we need healthy planting stock, properly selected plant species and appropriate measures of tending and protection, such as removal and replacement of decayed trees, substitution of sensitive species with more resistant ones, pruning of decayed branches, tips and other dead parts of trees and coating of the pruned spots, removal and destruction of fruiting bodies of wood-decaying fungi, collection and burning of leaves of the species susceptible to leaf spots and elimination of pupa that give rise to leaf mines, caterpillar litters, galls, *etc.*, preventive treatment with fungicides in the periods critical for infestation, application of fertilizers to physiologically weak species, avoiding the damage to the root, trunk and branches during the construction of infrastructure facilities, irrigation if necessary, etc.

LITERATURE

Agrios G. N. (2005): Plant Pathology (Fifth Edition). Elsevier Academic Press, Burlington, San Diego, London: 1-922.

Alexopoulos C. J., Mims C. W., Blackwell M. (1996): Introductory Micology (Fourth Edition). John Wiley and Sons, Inc., New York, Chichester, Brisbane, Toronto, Singapore, 1-868.

Amrine, J. W. JR., T. A. Stasny, C. H. W. Fletchmann 2003): Revised keys to world genera of Eriophyoidea (Acari: Prostigmata). Indira Publishing House, West Bloomfield, Michigan, USA, p 244.

Baker, E.W., Kono, J., Amrine, J.W. Jr, Delfinado-Baker, M., Stasny, T. (1996): Eriophyoid Mites of the United States. Indira Publishing House. West Bloomfield, Michigan, USA.

Baker, E.W., Tuttle, D.M. (1994): A guide to the spider mites (Tetranychidae) of the United States. Indira Publishing Hous, pp. 347.

Barnett H. L., Hunter B. B. (1998): Illustrated Genera of Imperfect Fungi (Fourth Edition). APS Press, St. Paul, Minesota: 1-218.

Begljarov, G.A. (1981): Key for identification of the predacious mites Phytoseiidae (Parasitiformes, Phytoseiidae) in the fauna of the USSR. Information Bulletin EPS IOBC, 3, str. 141.

Breitenbach J., Kränzlin F. (1986): Champignons de Suisse. Tome 2. Edition Mycologia, CH-6000 Lucerne 9, 1-412.

Černy A. (1989): Parazitické Drevokazné houby. Vydalo ministerstvo lesniho a vodniho hospodárstvi a drevozpracujiciho prumyslu ČSR ve Statnim zemedelskem nakladatelstvi v Praze., 1-100.

Chant D. A. (1959): Phytoseiid mites (Acarina: Phytoseiidae). Part I. Bionomics of seven species in Southeastern England. 1-44 pp.

Davidson R.W., Campbell W.A., Blaisdell J.D. (1938): Differentiation of wood-decaying fungi by their reaction on gallic or tannic acid medium. Journal of Agricultural Research, Vol.57, no.9, Washington, 683-695.

De Moraes G. J., McMurtry J. A., Denmark H. A., Campos C. B. (2004): A revised catalog of the mite family Phytoseiidae. Zootaxa 434: 1-494.

De Moraes, G. J., J. A. McMurtry, H. A. Denmark (1986): A catalog of the family Phytoseiidae. References to taxonomy, synonymy, distribution and habitat. EMBRAPA, Brasilia, Brazil. 353 pp.

Demite, P.R., de Moraes, G.J., McMurtry, J.A., Denmark, H.A., Castilho, R. de C. (2018): Phytoseiidae Database. www.lea.esalq.usp.br/phytoseiidae.

Domes, R., (1998): A new species of the genus *Anthocoptes* (Phyllocoptinae: Eriophyidae) on *Juglans regia* L. Acarologia 39 (1): 69-71.

Gajić, M. (1952): O vegetaciji Košutnjaka-Glasnik Šumarskog fakulteta 5, Beograd.

Gilbertson R. L. (1979): The Genus *Phellinus* (Aphyllophorales: Hymenochaetaceae) in Western North America. Mycotaxon 9, 51-89, 51-89.

Hagara L., Antonin V., Baier J. (2012): Velký Atlas Hub. Vydalo Ottovo Nakladatelstvi, Praha, 1-432

Johnson, W. T., H. Lyon, (1991): Insects that feed on trees and shrubs. Cornell University Press.

Jung T. (2009): Beech decline in Central Europe driven by the interaction between *Phytophthora* infections and climatic extremes. Forest Pathology 39: 73–94.

Jung T., Blaschke H., Neumann P. (1996): Isolation, identification and pathogenicity of *Phytophthora* species from declining oak stands. European Journal of Forest Pathology 26: 253–272.

Jung T., Blaschke H., Oßwald W. (2000): Involvement of soilborne *Phytophthora* species in Central European oak decline and the effect of site factors on the disease. Plant Pathology 49: 706–718.

Karadžić D. (2010): Šumska fitopatologija. Univerzitet u Beogradu Šumarski fakultet, Beograd, 1-774.

Karadžić D., Milenković I. (2014): Najčešće *Inonotus* vrste u šumama Srbije i Crne Gore. Šumarstvo br. 3-4, Beograd, 1-18.

Karadžić D., Milenković I. (2015): Prilog poznavanju parazitne gljive *Inonotus nidus-pici* Pilát uzročnika rak.rana na stablima lišćara. Šumarstvo br. 1-2, 15-29.

Karadžić D., Radulović Z., Milenković I. (2014): *Ganoderma* vrste u šumama Srbije i Crne Gore. Šumarstvo br. 1-2, Beograd, 1-19

Keifer, H.H. (1938): Eriophyid studies I. BCDA, 27: 181-206.

Keifer, H.H. (1940): Eriophyid studies VIIII. BCDA, 29: 21-46.

Keifer, H.H. (1944): Eriophyid studies XIV BCDA, 33: 18-38.

Keifer, H.H. (1946): A review of the North American economic Eriophyid mites. J. Econ. Entomol. 39: 563-570.

Keifer, H.H. (1952): The Eriophyid mites of California (Acarina: Eriophyidae). Bull Calif Insect Surv 2 (1): 1–123.

Keifer, H.H. (1975): Eriophyoidea Nalepa. Injurious eriophyoid mites. In: Jeppson LR, Keifer HH, Baker EW (eds) Mites injurious to economic plants. University of California Press, Berkeley, pp 327–533.

Keifer, H.H. (1979): Eriophyid studies C-11. ARS-USDA, 24 pp.

Maceljski, M, (1986): Current status of *Corythuca ciliata* in Europe. Bulletin OEPP/EPPO Bulletin 16: 621-624.

Maceljski, M. (2002): Poljoprivredna entomologija. Čakovec: Zrinjski, II dopunjeno izdanje.

Malandraki, E., Petanovic, R., Nikolaos, (2004): Description of Two New Species of Eriophyid Mites (Acari: Prostigmata: Eriophyide) Common in Greece and Serbia, Agricultural University of Athens, Laboratory for Agricultural Zoology and Entomology, Iera Odos 75, 118 55 Athens, Greece.

Migeon, A., Dorkeld, F. (2018): Spider Mites Web: a comprehensive database for the Tetranychidae. Availabe from http://www.montpellier.inra.fr/CBGP/spmweb.

Mihajlović Lj. (2008): Šumarska entomologija, Univerzitet u BeograduŠumarski fakultet, Beograd

Mihajlović, L. (2007): Metcalfa pruinosa (Say) (Homoptera: Auchenorrhyncha) nova štetna vrsta za entomofaunu Srbije. *Glasnik Šumarskog fakulteta*, br. 95, str. 127-134.

Milenković I. (2015): Diverzitet vrsta roda *Phytophthora* i njihova uloga u propadanju stabala u lišćarskim šumama u Srbiji. Univerzitet u Beogradu-Šumarski fakultet, doktorska disertacija, pp. 240.

Mitrofanov, V.I., Strunkova, Z.I., Livshits, I.Z., (1987): Keys to the tetranychid mites (Tetranychidae, Bryobiidae) fauna of the USSR and adjacent countries. SSR, I.o.Z.a.P.E.N.P.T., Dushanbe, Donish: 224 p.

Mladenović, K., Milenković, I., Ćirković-Mitrović, T., Brašanac-Bosanac, LJ. (2016): Evaluation of the Condition of Dendrological Species in Academic Park in Belgrade. Sustainable Forestry, Institute of Forestry, Belgrade, vol.73–74, pp. 19–36.

Murrill W.A. (1903): A Historical Review of the Genera of the *Polyporaceae*. The Journal of Mycology 9 (2): 87-102.

Murrill W.A., Burlingham G.S., Pennington L.H., Barnhart J.H. (1908): North American Flora, (Agaricales) *Polyporaceae-Agaricaceae*. The New York Botanical Garden, Volume 9, Part 2: 73-132.

Nalepa, A. (1910): Eriophyiden Gallmilben, Zoologica, 24 (61): 167-293.

Overholts L. O. (1953): The *Polyporaceae* of the United States, Alaska and Canada. University of Michigan Press. Ann. Arbor, Michigan, 1-466.

Pegler D.N., Waterston J.M. (1968): Descriptopons of Pathogenic Fungi and Bacteria. Set 20, No. 194-197, Commonwealth Mycological Institute, Kew, Surrey, England.

Petanović, R. (1988a): *Rhinotergum*, a new genus, family Diptilomiopidae (Acari: Eriophyoidea). Acarologia (Paris) 29, 4, 319-323.

Petanović, R. (1988b): Eriofidne grinje u Jugoslaviji, 159 pp. Naučna Knjiga, Beograd.

Petrović-Obradović, O. (2003): Biljne vaši (Aphididae, Homoptera) Srbije. Poljoprivredni fakultet Univerziteta u Beogradu.

Pritchard, A.E., Baker, E.W. (1955): A revision of the spider mite family Tetranychidae. Memoirs Series, San Francisco, Pacific Coast Entomological Society, 2: 472 p.

Reeves, R.M. (1963): Tetranychidae infesting woody plants in New York State, and a life history study of the elm mite *Eotetranychus matthyssei* n.sp. Cornell University Agricultural Station Mem.: 99.

Rota, P. (1962): Osservazioni sugli Acari Tetranychidi dannosi alle piante coltivate ed ornamentali in Italia. Bollettino di Zoologia Agraria e di Bachicoltura, 4: 31-136.

Ryvarden L., Johansen I. (1980): A preliminary polypore flora of East Africa. Fungiflora, Oslo-Norway, 1-636

Shi, A., Boczek, J. (2000): Studies on Eriophyoid mites (Acari: Eriophyoidea). XXXV. Bulletin of the polish Academy of Siences, Biological Siences. Vol. 48, No. 3. 241-254.

Smith Meyer M.K.P.S., (1987): African Tetranychidae (Acari: Prostigmata) - with reference to the world genera. Entomology Memoir, Department of Agriculture and Water Supply, Republic of South Africa, 69: 1-175.

Stalpers J.A. (1978): Identification of Wood-inhabiting Aphyllophorales in pure culture. Studies in Mycology, No. 16, Baarn, 1- 248.

Stevanović, V., Jovanović, S, Lakušić, D, Niketić, M. (1995): Diverziitet vaskularne flore Jugoslavije sa pregledom vrsta od međunarodnog značaja. In: Stevanović, V., Vasić, V. (Eds.): Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja. Biološki fakultet i Ecolibri, Beograd.

Strouts, R. G., T. G. Winter, (2000): Diagnosis of ill-health in trees. Forestry Comission.

Tanasijević, N., Simova-Tošić, D. (1987): Posebna entomologija. Beograd: Naučna knjiga.

Wagner T., Fischer M. (2002): Proceedings towards a natural classification of the worldwide taxa *Phellinus s.l.* and *Inonotus s.l.* and phylogenetic relationships of allied genera. Mycologia 94 (6), 998-1016.

THE ASSESSMENT OF RISK ZONES IN \`TOPČIDER\` PARK FOREST ON THE BASIS OF THE HEALTH CONDITION OF WOODY PLANT SPECIES

Katarina MLADENOVIĆ, Zlatan RADULOVIĆ, Vlado ČOKEŠA, Đorđe JOVIĆ, Ivan MILENKOVIĆ

Summary

Based on the health status of woody plant species established in 2017, the proximity to roads (tram tracks, the tram stop, footpaths, and parking lots), the available facilities (restaurants, shops, *etc.*), the frequency of the forest park use, and the age of forest park trees, the zones of risk for the users of Topčider Forest Park were determined.

The research distinguished 4 zones of public risk: the red zone or the zone of very high risk, the orange zone or the zone of high risk, the yellow zone or the zone of medium

risk, and the green zone or the zone of low risk. The current health condition was assessed and the factors that potentially threaten it were identified using a visual assessment with the following 1 to 5 scale The inspection of the health condition included the detection of mechanical, phytopathological, entomological and acarological damage to the tree crown, trunk and root collar zone, as well as biotic and abiotic damage determination.

The priorities were determined in the monitoring and implementation of rehabilitation measures within the forest park. Due to the risk of branch breakages or uprooting of entire trees, the trees in the critical areas of very high and high risk are proposed to be removed and replaced as soon as possible to ensure the public safety in the forest park. Intense human pressure was found to be the cause of the greatest number of injuries.

For the establishment of functional green areas in the city core, we need healthy planting stock, properly selected plant species and appropriate measures of tending and protection.

PROCENA RIZIČNIH ZONA PARK ŠUME TOPČIDER NA OSNOVU ZDRAVSTVENE KONDICIJE DRVENASTIH BILJNIH VRSTA

Katarina MLADENOVIĆ, Zlatan RADULOVIĆ, Vlado ČOKEŠA, Đorđe JOVIĆ, Ivan MILENKOVIĆ

Izvod

Na osnovu zdravstvenog stanja drvenastih biljnih vrsta utvrđenog u 2017. godini, blizine saobraćajnica (šina, tramvajske stanice, pešačkih staza, parkinga), prisustva objekata (restoran, prodavnica), frekventnosti korisnika park šume i starosti stabala izvršena je procena rizičnih zona za korisnike park šume Topčider.

Tokom istraživanja izdvojene su 4 rizične zone za korisnike park šume: crvena zona - zona vrlo visokog rizika, narandžasta zona - zona visokog rizika, žuta zona - zona srednjeg rizika, zelena zona – zona malog rizika. Za utvrđivanje zatečenog zdravstvenog stanja i evidentiranje mogućih faktora koji ga ugrožavaju izvršena je vizuelna ocena prema skali od 1 do 5. Pregled zdravstvenog stanja je obuhvatio detekciju mehaničkih, fitopatoloških, entomoloških i akaroloških oštećenja u krošnji, deblu i u zoni korenovog vrata, evidentirana su oštećenja biotičke i abiotičke prirode.

Utvrđen je prioritet nadzora i mera sanacije unutar park šume. Zbog opasnosti od loma grana i delova stabala kao i izvala čitavih stabala, u kritičnim zonama vrlo visokog i visokog rizika predlaženo je uklanjanje i zamena rizičnih stabala u što kraćem vremenskom periodu kako bi se osigurala bezbednost korisnika park šume. Najveći broj oštećenja je direktna posledica antropogenog faktora.

Za podizanje funcionalnih zelenih površina u gradskom jezgru neophodan je zdrav sadni materijal, adekvatan izbor biljnih vrsta kao i primena odgovarajućih mera nege i zaštite

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY COLLECTION 77-78, 2018

ODRŽIVO ŠUMARSTVO ZBORNIK RADOVA 77-78, 2018

UDK 630*453:595.78(497.11 Novi Pazar)
Original scientific paper

EXAMINATION OF THE CORRELATION BETWEEN THE DEFOLIATION CAUSED BY NUTRITION OF THE BROWN-TAIL MOTH LARVAE AND THE INCREMENT OF INFESTED SESSILE OAK AND TURKEY OAK TREES

Mara TABAKOVIĆ-TOŠIĆ[1], Marija MILOSAVLJEVIĆ[1]

Abstract: *The paper presents the results of the study research on the effect of the leaf mass reduction caused by the intensive nutrition of an oak defoliating insect - the brown-tail moth Euproctis chrysorrhoea on the annual increment of sessile oak and Turkey oak trees in the coppice forests of the Novi Pazar region (SE Srbijašume, FE Šumarstvo Raška, Novi Pazar Forest Administration, FMU Blizanac-Debelica and FMU Ninaja-Koznik).*

Key words: the brown-tail moth, defoliation, sessile oak, Turkey oak, annual increment

ISPITIVANJE KORELACIJE IZMEĐU DEFOLIJACIE IZAZVANE ISHRANOM LARVI ŽUTOTRBE I PRIRASTA INFESTIRANIH STABALA HRASTOVA KITNJAKA I CERA

Izvod: *U radu su prikazani rezultati istraživanja uticaja gubitka lisne mase, usled intenzivne ishrane hrastovog defolijatora – žutotrbe Euproctis chrysorrhoea, na godišnje priraščivanje stabala kitnjaka i cera u izdanačkim šumama Novopazarskog regiona (JP Srbijašume, Šumsko gazdinstvo Šumarstvo Raška, Šumska uprava Novi Pazar, gazdinske jedinice Blizanac-Debelica i Ninaja-Koznik).*

Ključne reči: žutotrba, defolijacija, kitnjak, cer, godišnji prirast

[1]Institute of Forestry, Belgrade, Serbia

1. INTRODUCTION

Autochthonous oak forests in southwestern Serbia are exposed to the harmful effects of a series of biotic and abiotic factors, among which an important place is occupied by numerous species of defoliating insects of the Lepidoptera order (gypsy, brown-tail, winter and green oak moth, mottled umber, oak processionary).

The brown-tail moth, *Euproctis chrysorrhoea* (LINNAEUS, 1758) (Lepidoptera: Erebidae) is native to the Old World where it is found from Algeria in the south to Sweden in the north and from England in the west to the Himalaya Mountains in the east. It is also a common pest of broadleaved forests of central Serbia. The brown-tail moth produces one generation a year. It has four life stages; egg, larva, pupa, and adult. The larval stage lasts for nine months, from August to June. In the autumn, colonies of larvae build winter webs in trees constructed from a single leaf wrapped tightly with large amounts of white silk. A colony consists of 25 to 400 or more larvae.

Although it is extremely polyphagous and feeds on the leaves of most hardwood forest, fruit and ornamental trees (26 genera of forest, fruit, ornamental trees and shrubs belonging to 13 different families), it prefers to consume the leaves of various oak species. It causes the greatest damage in the spring when its larvae feed intensively on the leaves of the host plant and very often cause total defoliation, which leads to decreasing fruiting and a lower growth increment of trees. The continuous repetition of stress, such as defoliation, also reduces the resistance of trees to harmful abiotic and biotic factors and the end result can be the death of attacked trees.

Brown-tail moth occurs periodically in high numbers (outbreaks) on a relatively small area of a few hundred hectares.

Apart from the damage inflicted to forest stands and orchards, the brown-tail moth belongs to a group of insects that cause severe allergic reactions in humans and animals. Outbreaks of the brown-tail moth in 2014 were recorded in the oak stands of Western Serbia in the forest administrations of Priboj (SE Srbijašume, FE Prijepolje) and Novi Pazar (SE Srbijašume FE Raška), on an area of 1367.19 ha. In some localities of Novi Pazar Forest Administration, coppice forests of sessile oak and Turkey oak were affected by complete defoliation in 2015. Therefore more elaborate studies on its effects on the growth increment of infected trees were conducted in these forests.

2. MATERIALS AND METHODS

The intensive research of the possible correlations between the nutrition of the brown-tail moth larvae and the loss in the annual increment of the host tree was conducted in well-preserved oak [*Quercus cerris* L. and *Quercus petraea* (MATT.) LIEBL.] coppice forest stands located in the region of Novi Pazar (State Enterprise \`Srbijašume\`, \`Šumarstvo Raška\` Forest Estate, \`Novi Pazar\` Forest Administration). The main characteristics of the sample plots where the sampling of brown-tail moth caterpillars and their litters was conducted are presented in Table 1.

Table 1. *The main characteristics of the sample plots.*

Plot	Management Unit	Coordinates	Meters above sea level *m a.s.l.*	Slope of the terrain and aspect	Coeno-ecological unit of forest stand
1	Blizanac – Debelica 29/a	X: 4 783 502 Y: 7 454 574	889	6-15° E - NE	*Quercetumpetraeae-cerris*
2	Blizanac – Debelica 30/a	X: 4 784 189 Y: 7 454 691	863	6-15° N - NE	*Quercetumpetraeae-cerris*
5	Ninaja – Koznik 22/a	X: 4 774 038 Y: 7 449 982	930	16-20° JE	*Quercetumpetraeae-cerris*
7	Ninaja – Koznik 84/b	X: 4 774 460 Y: 7 489 220	810	21° E	*Quercetumpetraeae-cerris*
8	Ninaja – Koznik 85/b	X: 4 775 001 Y: 7 448 624	920	16-20° E	*Quercetumpetraeae-cerris*

The population density of the brown-tail moth was determined by using route measurement during the growing season in the period 2014-2016. A detailed quantitative and qualitative analysis of the newly sampled brown-tail moth caterpillar litters was conducted at the laboratory of the Institute of Forestry.

A total of 50 (10 trees x 5 sample plots) randomly selected oak trees of *Quercus petraea* (Mattuschka) Liebl. and *Quercus cerris* L. had bore cores taken at breast height using Pressler's borer. The samples were then processed at the laboratory of the Institute of Forestry, Belgrade, using a specialized ADDO Tree-Ring Measuring Instrument.

Statistical analysis of the obtained results was carried out with the help of the software package STATGRAPHICS, version 5.0, and included analysis of variance, calculation of the mean annual increment, and testing of the least significant difference (LSD test).

3. RESULTS AND DISCUSSION

In the spring (May and June) of 2014 and 2015 in the selected area in Novi Pazar region (oak and beech coppice forest stands in the management units of Turjak – Vršine, Ninaja – Koznik, Blizanac – Debelica and cadastral municipalities of Slatina, Doljani, Zabrđe, Šavci, Sebečevo, Požega, Pustovlah, Sitniče, Ivanča, Kosuriće, Kovačevo), a great increase in the population size of the brown-tail moth was reported on the area covering 613 ha.

Figure 1. *Defoliation of oak and brown-tail moth larvae*

The average number of newly formed caterpillar litters in the period 2014-2015 was 12, or 17 per tree (minimum 6, maximum 23). The average size of the litter on the established sample plots ranged from 5.1 to 8.9 cm (length) and from 2.6 to 4.5 cm (width) (with the maximum length of 19 cm and width of 8 cm).

Generally, defoliation reduces the photosynthetic area and decreases the leaf area per tree (Mattson *et al.*, 2004, Schat & Blossey 2005, Huttunen *et al.*, 2007). The negative effect of severe and prolonged defoliation on the growth rate or final biomass is usually proportional to the removal of fresh biomass while it could be even positive (Mott et al, 1957; Tunnock & Rayan, 1985; Belsky, 1986; McNaughton,1986; Long 1988, Alntekirch and Winkel 1990; Eissenstat & Duncan, 1992; Hoogesteger & Karlsson, 1992; Oesterheld, 1992; Anten&Ackerly, 2001; Ferraro & Oesterheld, 2002; Markkola *et al*., 2004; Tabaković-Tošić *et al.*, 2011; Araminienė *et al*., 2015).

The impact of defoliation on tree growth depends on tree species and individual tree resistance (Muzika & Liebhold 1999). A number of authors have reported that a marked decrease in the tree increment starts when the defoliation exceeds 20-30% (Schweingruber, 1985; Braker & Gaggen, 1987; Soderberg, 1991) or more than 40-50% (Frantz *et al*., 1986; Petraš, 1993; Araminienė *et al.*, 2015).

There are relatively few research studies of the influence of defoliation caused by the larvae of economically significant outbreak species of Lepidoptera order on the annual increment of the Quercus species. Fratin (1970, 1978) states that two years of consecutive canopy defoliation (*Quercus robur*) reduces the increment by 65%. Partial defoliation of 30% brings about a reduction of 12%, while 20% defoliation leads to a 10% reduction. Mirković & Mišković (1960) consider that single defoliation generally causes a 40% decrease in the volume increment of and a 25% decrease in the diameter increment. Radonjić (1962) came to similar findings in poor-quality oak stands on Kosmaj Mountain in Serbia. After significant defoliation, the increment was reduced by 23%. Androić (1978) states that the complete defoliation reduces the volume increment by 20- 50%.

Table 2.*The analysis of the oak diameter increment.*

Plot	Bore core number	Tree ring (annual ring) width in mm				
		Year				
		2011	2012	2013	2014	2015
I	1	3.70	2.64	2.84	1.22	0.68
	2	1.32	1.13	1.21	1.19	1.2
	3	0.87	1.04	1.14	0.98	1.19
	4	1.24	1.34	1.54	2.25	1.79
	5	0.86	0.97	0.86	0.81	0.67
	6	1.09	0.95	1.02	1.08	0.79
	7	0.73	0.58	0.79	0.93	0.42
	8	1.20	1.09	0.89	1.09	0.72
	9	1.30	1.2	1.69	1.43	0.98
	10	0.74	0.84	1.06	1.02	0.79
II	11	1.62	1.57	1.28	1.03	0.94
	12	1.86	0.6	0.63	0.7	0.47
	13	0.80	0.71	0.81	1	0.82
	14	0.97	0.79	0.84	0.74	0.53
	15	0.66	0.94	0.79	0.61	0.61
	16	1.37	0.76	1.44	1.08	0.83
	17	1.33	1.17	1.25	0.99	0.67
	18	0.74	0.66	0.7	0.59	0.38
	19	0.95	0.9	1	0.6	0.6
	20	0.40	0.31	0.32	0.51	0.28
III	21	0.69	0.82	0.95	0.93	0.7
	22	0.91	1.51	1.4	0.9	0.69
	23	1.10	0.88	1.09	1.28	0.72
	24	1.15	1.09	0.81	0.96	0.74
	25	0.54	0.65	0.67	0.75	0.4
	26	1.03	1.02	1.25	0.87	0.7
	27	0.36	0.46	0.31	0.38	0.2
	28	1.60	1.36	1.55	0.93	0.35
	29	1.01	0.96	0.96	1.02	0.93
	30	0.51	0.61	0.37	0.55	0.39
IV	31	4.09	2.74	3.61	3.69	1.49
	32	1.85	1.47	1.92	0.91	0.62
	33	1.18	1.1	1.15	1.07	0.46
	34	0.99	0.87	0.73	1.6	1.05
	35	0.79	0.91	0.74	0.67	0.64
	36	1.18	1	0.68	0.67	0.33
	37	0.81	0.69	0.8	0.98	0.51
	38	0.89	0.87	0.78	0.71	0.33
	39	1.03	1.1	1.5	0.77	0.42
	40	0.86	1.03	1.01	1.69	0.58
V	41	0.61	0.93	0.99	0.59	0.2
	42	1.10	1.22	1.1	1.17	0.8
	43	1.74	1.75	1.28	1	0.59
	44	0.74	0.69	0.84	0.63	0.32
	45	0.68	0.32	0.32	0.34	0.28

Plot	Bore core number	Tree ring (annual ring) width in mm				
		Year				
		2011	2012	2013	2014	2015
	46	0.88	0.65	0.78	0.97	0.42
	47	1.42	1.24	1.02	0.81	0.38
	48	1.49	1.91	1.85	1.87	1.23
	49	1.75	1.76	1.26	1.32	0.78
	50	1.52	1.56	1.49	1.51	0.69
AVERAGE		1,17	1.07	1.11	1.03	0.67

Table 3. *Analysis of Variance.*

Source	Sum of Squares	Degree of freedom	Mean Square	F-Ratio	P-Value
Between groups	7.75704	4	1.93926	6.85	0.000
Within groups	69.3197	245	0.282938		
Total	77.0767	249			

Table 4. *The least significant difference test for the mean growth ring width.*

Year	Mean growth-ring width *(mm)*	Homogeneous group			
		P < 0.05		P < 0.01	
		1	2	1	2
2015	0,67	X		X	
2014	1,03		X		X
2013	1,07		X		X
2012	1,11		X		X
2011	1,17		X		X

In the period from 2011 to 2014, the average increment ranged from 1.03 to 1.17 mm, while at the time of defoliation in 2015, it amounted to 0.67 mm, when its fall could be clearly observed as confirmed by one-way analysis of variance - ANOVA ($p < 0.05$, $p < 0.01$) (Table 4).

The obtained results confirmed the positive correlation between the increment and the outbreak of the brown-tail moth, *i.e.*, the defoliation caused by the nutrition of its larvae.

Acknowledgments: *The study was partly financed by the Ministry of Science of the Republic of Serbia, the Project 31070 - SUBPROJECT: New technological methods in the integral protection of forests with the focus on the entomopathogenic fungus Entomophaga maimaiga, as the possible solution to the problem of frequent occurrences of the outbreak of gypsy moth in the forest ecosystems of Serbia.*

REFERENCES

Altenkirch, W., Winkel, W. (1990): Versuche zur Bekämpfung der Lärchenminiermotte (*Coleophora laricella* Hbn.) mit Hilfe insektenfressen der Vögel. Waldhygiene 18, 233-255.

Androić, M. (1978): Effects économiques et écologiques de la defoliation cause par le Bombyx disparate (Porthetria dispar L.) dans les ecosystems forestiers. Plant prot., 143-144:155-161.

Anten N.P.R., Ackerly D.D. (2001): Canopy level photosynthetic compensation after defoliation in a tropical understorey palm. Functional Ecology, 15: 252–262.

Araminienė, V., Varnagirytė-Kabašinskienė, I., Stakėnas, V. (2015): Defoliation effects on the birch growth: Lithuanian case study. Acta Biol. Univ. Daugavp. 15(1): 9-16.

Belsky A.J. (1986): Does herbivory benefit plants? A review of the evidence. The American Naturalist, 127: 870–892.

Braker O., Gaggen S. (1987): Tree ring Analysis in the Swiss Forest Decline Study. In: Kairiūkštis L., Nilsson S., Straszak A. (eds.): Forest decline and reproduction: Regional and Global Consequences. Laxenburg, Austria. Pp. 124-129.

Eissenstat D., Duncan L.W. (1992): Root growth and carbohydrate responses in bearing citrus trees following partial canopy removal. Tree Physiology, 10: 245–257.

Ferraro D.O., Oesterheld M. (2002): Effect of defoliation on grass growth. A quantitative review. Oikos, 98: 125–133.

Frantz F., Preuchler T., Rohle H. (1986): Vitalitats merkmale und Zuwachsreactionen erkankter Bergwaldbestande in Bayerischen alpenraum. Allgemeine Forstzeitschrift, 41(39): 962-964.

Fratin, A. (1970): Contributii la stabilirea influential defolieror provocate de Lymantria dispar L. asupra productiei arboretelor de Quercinee si la elaborarea masurilor de prevenire a acestor defolieri. Ins. Politechnic, Brasov (Teza de doctorat).

Fratin, A. (1978): Influence des defoliations provoquées par Lymantria dispar sur L'accroissement et la viabilité des peuplements de quercinees. Plant prot. 29,143-144:163-168.

Hoogesteger J., Karlsson P.S. (1992): Effects of defoliation on radial stem growth and photosynthesis in the mountain birch (Betula pubescens ssp. tortuosa). Functional Ecology, 6: 317–323.

Huttunen L., Niemelä P., Peltola H., HeiskaS., Rousi M., Kellomäki S. (2007): Is a defoliated silver birch seedling able to overcompensate the growth under changing climate? Environmental and Experimental Botany, 60: 227–238.

Long, G.E. (1988): The larch case bearer in the intermountain northwest. *In*: Berryman, A.A. (Ed.), Dynamics of Forest Insects and Populations. New York, 1988, pp. 233-242.

Markkola A., Kuikka K., Rautio P., HärmäE., Roitto M., Tuomi J. (2004): Defoliation increases carbon limitation in ectomycorrhizal symbiosis of Betula pubescens. Oecologia,140: 234–240.

Mattson W.J., Kuokkanen K., Niemelä P.,Julkunen-Tiitto R., Kellomäki S.,Tahvanainen J. (2004): Elevated CO_2 alters birch resistance to Lagomorpha herbivores. Global Change Biology, 10: 14021413.

McNaughton S.J (1986): On plant and herbivores. American Naturalist, l28: 765–770.

Mirković, D., Miščević, V. (1960). Uticaj brsta gubara na prirast hrasta. Zaštita bilja, 60: 3-17.

Mott D.G., Nairn L.D., Cook J.A. (1957): Radial growth in forest trees and effects of insect defoliation. Forest Science, 3 (3): 286-304.

Muzika R.M., Liebhold A.M. (1999): Changes in radial increment of host and non host tree species with gypsy moth defoliation. Canadian Journal of Forest Research, 29:1365-1373.

Oesterheld M. (1992): Effect of defoliation intensity on aboveground and belowground relative growth rates. Oecologia, 92: 313–316.

Petraš R., Nociar V., Pajtik J. (1993): Changes in increment of spruce damaged by air pollution. Lesnictvi – Forestry, 39(3-4):116-122.

Radonjić, S. (1962): Uticaj golobrsta gubara (Limantria dispar) na prirast u šumama društvenog vlasništva na teritoriji Šumske sekcije Mladenovac 1953-1957., Šumarstvo, 1-2: 86-90.

Schat M., Blossey B. (2005): Influence of naturaland simulated leaf beetle herbivory on biomass allocation and plant architecture of purple loosestrife (Lythrum salicaria L.). Environmental Entomology, 34(4): 906–914.

Schweingruber F.H. (1985): Abrupt changes in growth reflected in tree ring sequences as an expression of biotic and abiotic influences. In: Schmid-Haas P. (eds.): Inventory and Monitoring Endangered Forests, proceedings of the IUFRO conference. Birmensdorf, Switzerland. Pp. 291-295.

Soderberg U. (1991): The relation between increment and defoliation of Scots pine and Norway spruce in Sweden. In: Proceedings of IUFRO Workshop on Monitoring Air Pollution Impact on Permanent Sample Plots, Data Processing and Results Interpretation. Prahatice, CSFR. Pp. 119-127.

Tabaković-Tošić, M., Tošić, D., Rajković, S., Golubović-Ćurguz, V., Rakonjac, Lj., (2011): Invasion species Coleophora laricella – one of the main limiting factor of Larix decidua during the forest afforestation and recultivation. African Journal of Agricultural Research, Academic Journals, 6(49): 866 – 872.

Tunnock, S., Rayan, R.B. (1985): Larch Case bearer in Western Larch. U.S. Department of Agriculture – Forest Service, Forest Insect & Disease, Leaflet 96, 1-7.

EXAMINATION OF THE CORRELATION BETWEEN THE DEFOLIATION CAUSED BY NUTRITION OF THE BROWN-TAIL MOTH LARVAE AND THE INCREMENT OF INFESTED TREES OF SESSILE OAK AND TURKEY OAK

Mara TABAKOVIĆ-TOŠIĆ, Marija MILOSAVLJEVIĆ

Summary

The defoliation of broadleaved forest tree species is closely related to the outbreak of insects primarily of Lepidoptera species. One of the economically most important species both in Serbia and in other areas of Central and Southeastern Europe is the brown-tail moth *Euproctis chrysorrhoea* Linnaeus, 1758 (Lepidotera: Erebidae). At the beginning of the 20th century, it was considered one of the most harmful allochthonous species in North America. Apart from the damage inflicted to forest stands and orchards, the brown-tail moth belongs to a group of insects that cause severe allergic reactions in humans and animals. It is extremely polyphagous and causes the greatest damage in the spring when its larvae feed intensively on the leaves of the host tree and very often cause total defoliation, which leads to decreasing fruiting and a lower growth increment of trees. The continuous repetition of stress, such as defoliation, also reduces the resistance to harmful abiotic and biotic factors and the end result can be the death of attacked trees.

Outbreaks of the brown-tail moth in 2014 were recorded in the oak stands of Western Serbia in the forest administrations of Priboj (SE Srbijašume, FE Prijepolje) and Novi Pazar (SE Srbijašume FE Raška), on an area of 1367.19 ha. In some localities of Novi Pazar Forest Administration, coppice forests of sessile oak and Turkey oak (Quercion petreae cerris), were affected by complete defoliation in 2015. Therefore more elaborate studies on its effects on the growth of infected trees were conducted in these forests.

A total of 50 randomly selected oak trees of *Quercus petraea* (Mattuschka) Liebl. and *Quercus cerris* L., had bore cores taken at breast height using Pressler's borer. The samples were then processed at the laboratory of the Institute of Forestry, Belgrade, using a specialized ADDO Tree-Ring Measuring Instrument. Statistical analysis of the obtained results was carried out with the help of the software package STATGRAPHICS, version 5.0, and included analysis of variance, calculation of the mean annual increment, and testing of the least significant difference (LSD test).

In the period from 2011 to 2014, the average increment ranged from 1.03 to 1.17 mm, while at the time of defoliation in 2015, it amounted to 0.67 mm, when its fall could be clearly observed as confirmed by one-way analysis of variance - ANOVA ($p < 0.05$, $p < 0.01$). The obtained results confirmed the positive correlation between the increment and the outbreak of the brown-tail moth, *i.e.* the defoliation caused by the nutrition of its larvae.

ISPITIVANJE KORELACIJE IZMEĐU DEFOLIJACIE IZAZVANE ISHRANOM LARVI ŽUTOTRBE I PRIRASTA INFESTIRANIH STABALA HRASTOVA KITNJAKA I CERA

Mara TABAKOVIĆ-TOŠIĆ, Marija MILOSAVLJEVIĆ

Summary

Defolijacija lišćarskih šumskih vrsta drveća, usko je povezana sa prenamnoženjem, pre svega insekata iz reda Lepidoptera, a jedan od ekonomski najznačajnijih, kako u Srbiji, tako i u ostalim područjima srednje i jugoistočne Evrope, je žutotrba *Euproctis chrysorrhoea* Linnaeus, 1758 (Lepidoptera: Erebidae). Početkom 20 veka, smatrana je jednom od najštetnijih alohtonih vrsta u Severnoj Americi. Osim šteta koje nanosi šumskim sastojinama i voćnjacima, žutotrba pripada grupi insekata koji izazivaju jake alergijske reakcije kod ljudi kod životinja. Široko je polifaga, a najveće štete pričinjava u proleće, kada se njene larve intenzivno hrane lišćem domaćina i vrlo često uzrokuju totalnu defolijaciju, koja dovodi do umanjenja plodonošenja i gubitka u priraščivanju stabala. Uzastopno ponavljanje stresa, poput defolijacije, ima za posledicu i umanjenje otoprnosti na štetne abiotičke i biotičk efaktore, a krajnji rezultat može da bude i potpuno sušenje napadnutih stabala.

Prenamnoženje žutotrbe 2014. godine, zabeleženo je u hrastovim sastojinama zapadne Srbije, u područjima šumskih uprava Priboj (JP Srbijašume, ŠG Prijepolje) i Novi Pazar (JP Srbijašume ŠG Raška), na površini od 1367,19 ha. Na pojedinim lokalitetima Šumske uprave Novi Pazar, u izdanačkim šumama kitnjaka i cera (Quercion petrea ecerris), 2015. godine utvrđen je totalni golobrst, pa su tu obavljena detaljnija istraživanja njegovog uticaja na prirast infestiranih stabala domaćina.

Sa 50 slučajno odabranih stabala hrastova kitnjaka *Quercus petraea* (Mattuschka) Liebl. i cera *Quercus cerris* L., uz pomoć Preslerovog svrdla, uzorkovani su izvrtci iz debala (na prsnoj visini), koji su u Institutu za šumarstvo Beograd, laboratorijski obrađeni na specijalizovanom uređaju za merenje godišnjeg prirasta (ADDO). Statistička analiza dobijenih rezultata obavljena je uz pomoć softversko gpaketa STATGRAPHICS, verzija 5.0, a sastojala se od analize varijanse, izračunavanja srednje vrednost igodišnjeg prirasta, kao i testiranja najmanje značajne razlike (LSD test).

Prosečan prirast od 2011. do 2014. godine, kretao se u intervalu od 1,03 do 1,17 mm, dok je u vreme golobrsta (2015.god.) iznosio 0,67 mm, gde se jasno uočava njegov pad, što je potvrđeno i jednofaktorijalnom analizom varijanse - Anova ($p<0,05$). Dobijeni rezultati potvrdili su da postojipozitivna korelacija između prirasta i prenamnoženja žutotrbe, odnosno defolijacije izazvane ishranom larvi.

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY COLLECTION 77-78, 2018

ODRŽIVO ŠUMARSTVO ZBORNIK RADOVA 77-78, 2018

UDK 635.054:718(497.11 Obrenovac)
Original scientific paper

THE STATE AND FUNCTIONALITY OF DENDROFLORA IN THE CEMETERIES IN OBRENOVAC

Suzana MITROVIĆ[1], Nevena ČULE[1], Dušan JOKANOVIĆ[2], Milijana CVEJIĆ[1], Milorad VESELINOVIĆ[1]

Abstract: *Urban cemeteries represent important human-made special-purpose green areas. On the territory of the city area of the Municipality of Obrenovac, there are two urban cemeteries: the New Cemetery (Serbian: Novo Groblje) and the Old Cemetery (Serbian: Staro Groblje). The New Cemetery with an area of 5.4 ha is at 2.84 km west of the center and Staro Groblje with an area of 4.5 ha lies at 2 km from the city center.*

In the framework of the development of the Cadastre of Public Green Areas of the Municipality of Obrenovac, 29 woody species with a total of 271 trees were recorded in the New Cemetery. The Old Cemetery had 32 woody species recorded with a total of 348 trees. The paper studies the vitality, the ornamental value, as well as the functionality and adaptability of the species to the existing environmental conditions.

Keywords: dendroflora, Obrenovac, urban cemeteries, adaptability, vitality, ornamental value.

[1]Dr Suzana Mitrović, Dr Nevena Čule, Mr Milijana Cvejić, Dr Milorad Veselinović Institute of forestry, 3 Kneza Viseslava, Belgrade, Serbia
[2]Dr Dušan Jokanović, Faculty of Forestry Belgrade, University of Belgrade, 1 Kneza Višeslava, Serbia
Corresponding author: Suzana Mitrović, 3 Kneza Višeslava, 11030 Belgrade, Serbia, tel.: +381 62 8838024, e-mail: mitrovicsuzana@yahoo.com

Acknowledgement: The research was partly financed by the Ministry of Education and Science, Republic of Serbia, within the Project 'The study of climate change on the environment: monitoring impacts, adaption and mitigation' III 43007 (2010-2018).

STANJE I FUNKCIONALNOST DENDROFLORE NA GROBLJIMA U OBRENOVCU

Abstrakt: *Gradska groblja predstavljaju značajne antropogene zelene površine specijalne namene. Na teritoriji gradskog područja opštine Obrenovac nalaze se dva gradska groblja: Novo i Staro groblje. Na 2,84 km zapadno od centra nalazi se Novo groblje, površine 5,4 ha, na 2 km Staro groblje površine 4,5 ha.*

U okviru izrade Katastra javnih zelenih površina gradske opštine Obrenovac, na Novom groblju evidentirano je 29 drvenastih vrsta sa ukupno 271 stablom. Na Starom groblju evidetirane su 32 drvenaste vrste sa ukupno 348 stabala.

U radu je izvršena analiza vitalnosti, dekorativnosti, funkcionalnosti i adaptivnosti korišćenih vrsta na postojeće uslove sredine.

Ključne reči: dendroflora, Obrenovac, gradska groblja, adaptivnost, vitalnost, dekorativnost.

1. INTRODUCTION

Cemeteries are important elements of urban areas. Apart from cherishing the memory of the deceased and buried, urban cemeteries also represent important special-purpose green areas (Anastasijević, 2002; Vujković, 2003) with multiple benefits in terms of environmental protection. These areas, connected with other green areas of different categories, constitute the green structure of the city whose functions contribute to the healthier environment of the polluted urban area. The development of the Cadastre of Public Green Areas of the urban municipality of Obrenovac (Veselinović *et al*., 2010) included the inventory of the urban cemetery dendroflora and the study of its state and the functionality.

There are two urban cemeteries on the territory of the urban area of the Municipality of Obrenovac – the New Cemetery and the Old Cemetery.

2. MATERIAL AND METHODS

Within the field surveys conducted in the area of the urban cemeteries, trees were identified in the field and recorded as point objects.

GPS locations were determined using a Trimble® GeoExplorer® series GPS device with the Microsoft® Windows Mobile™ 2003 software platform which communicates with the TruPulse 360 B laser distance meter produced by Laser Technology Inc. These two devices are paired using a Bluetooth connection. The Trimble licensed TerraSync™ software was used for the purpose of data collection. The type of greenery and the species of trees were determined in the field. If there were any doubts, dendrological material was collected (a leaf and a twig), and the species was subsequently determined using the identification key and literature data (Hessayonu, 2001; Hillier, 1982; Idžojtić 2009; Jovanović, 1985; Ocokoljić and Ninić-Todorović, 2003; Vidaković, 1982; Vukićević, 1996; Ward, 2001; Šijak, 2000).

The heights of trees, as well as the heights of trunks and the spread of crowns were measured using the TruPulse 360 B laser distance meter (Veselinović *et al*., 2014).

The diameter of all trees was measured at `breast` height (1.30 m), using a caliper gauge. The diameter was determined as the arithmetic mean of two cross-measured tree diameters.

The presence and the type of damage were determined on the basis of the symptoms observed (Ćirković-Mitrović *et al*., 2016). The damage was classified as mechanical, physiological, entomological or phytopathological based on which the vitality and the ornamental value were assessed.

The vitality of each individual tree was assessed according to the following evaluation scale by the method (literature):

1 – a seriously diseased, damaged or dead tree
2 – a severely diseased or damaged tree or a tree affected by decaying processes but still alive
3 – a vital tree that needs regular tending measures to survive
4 – a vital tree that needs occasional tending to survive
5 – a completely healthy tree, or a tree of exceptional vitality

Each individual tree was further assigned an ornamental value rating. In accordance with the standard characteristics specific for each individual species, the following method was used for the evaluation (literature):

1 – a tree without ornamental features
2 – a tree with poor ornamental features
3 – a tree with a standard habitus but with some defects
4 – a tree with very good ornamental features, a regular habitus and minor defects
5 – a tree with excellent ornamental features, an extremely well-developed habitus and without any visible defects in the appearance

In exceptional cases, trees without the distinguishable characteristics of a species had their ornamental value rated high because they are interesting and draw attention with a curved trunk, twisted branches and or some other characteristics that give an added value to the landscape.

The data collected in the field were transferred from the Trimble® GeoExplorer® series GPS device to the computer. The GPS Pathfinder® Office ver. 4.20 was used for this purpose. The data that were hand-written in purposeful tables were entered into the computer using Microsoft Office Excel 2007.

3. RESULTS AND DISCUSSION

The municipality of Obrenovac is located in the central part of the lower Kolubara River Basin and stretches between 44° 30' and 44° 43' N and 19° 58 ' and 20° 20' E. The largest part of the land is extremely flat.

The largest part of the Municipality of Obrenovac is located in the macro-alluvial fan of the Kolubara River. Alluvial fans are deposits of sediment that belong to a group of accumulative fluvial forms. Macro-alluvial fans were mainly formed during the Quaternary in a particularly humid climate. Obrenovačka Posavina makes the macro-alluvial fan of the Kolubara River pushing the Sava

River to the north about ten kilometers away from its initial flow below the Posavski Section. The macro-alluvial fan of the Kolubara with Tamnava covers a surface area of 288 km^2 (Dragičević and Karić, 2007).

According to the research of the Institute of Soil Science (2009), hydromorphic soils are the most frequent on the territory of the urban municipality of Obrenovac. The area is intersected by the flows of the Sava, Kolubara, Tamnava and Peštan Rivers with the alluvial soil, humofluvisol and humogley being the dominant soil types. The land on which the cemetery was built originally had the humofluvisol, but it has been altered by human activity.

The basic climatic characteristics of the Municipality of Obrenovac are determined by its geographical position, terrain and wide openness to the Pannonian Plain. Obrenovac is located almost in the middle of the north temperate zone, with a climate milder than the typical Pannonian, continental climate. It is characterized by humid continental climate with warm summers and cold winters. The average annual temperature in this area is around 11°C. It is around 22°C in summer and about -1°C in winter, with the maximum range between -28°C and 40°C. Because of its openness to the north, *i.e.*, the Pannonian Plain, the effects of the continental precipitation regime on the area of Obrenovac are evident. Cyclones cause maximum precipitation in late spring and early summer, with the secondary maximum of rainfall in late autumn. The annual amount of precipitation is about 640 liters of water per square meter. It is around 440 in dry years and 940 liters per m^2 in rainy years. During the year, the precipitation is highest in spring and late summer or early autumn. The study area has the surplus of water in the period from January to March, and from May, the evapotranspiration (ETP, ETR) exceeds the inflow of water from precipitation. The dry period, *i.e.* the water deficit (D = ETP-ETR) in the soil occurs in the period from June to September. In October, the water reserves in the soil are gradually being restored. Then, depending on the soil conditions and the precipitation regime, there is a surplus of water (S) which flows into rivers or groundwater either as surface runoff or through the soil (Veselinović *et al.*, 2010).

The New Cemetery is located in the western part of Obrenovac (Figure 1), 2.84 km away from the city center. It is at Rvaćanska bb, in Rvati settlement. It covers an area of 5.4 ha.

Figure 1. *The location of the New Cemetery and the Old Cemetery*

The Old Cemetery, measuring 4.5 hectares, is located in the western part of Obrenovac (Figure 1), 2 km from the city center, at 97 Nemanjina Street.

Table 1. *The participation of broadleaves and conifers in the New Cemetery and the Old Cemetery*

Vegetation type	The New Cemetery		The Old Cemetery	
	ind.	%	ind.	%
Broadleaves	174	64	53	15
Conifers	97	36	295	85
Total	271	100	348	100

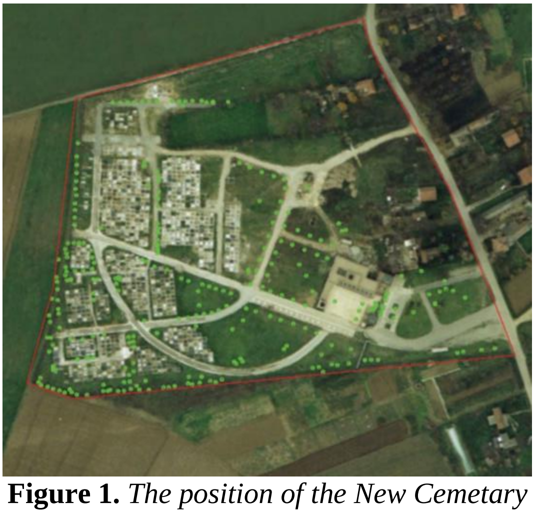


Figure 1. *The position of the New Cemetary*

In the New Cemetery, 271 trees were analyzed (Figure 2), 174 of which were broadleaved and 97 coniferous species. There were 29 different tree species in total.

The most common wood species were *Tilia tomentosa* Mnch. with 40 individuals, *Betula verrucosa* Ehrh. with 37 seedlings and *Chamaecyparis lawsoniana* (Murr.) Parl. with 28 specimens. The ratio of the broadleaves to conifers was 64:36.

Table 2. *Average values of the recorded tree parameters in the New Cemetery*

S. nº	Species	Tree height (m)	Trunk height (m)	Trunk diameter (cm)	Crown spread (m)	Crown height (m)	Vitality score	Ornamental value
1	*Abies alba* Mill.	1.5	0.0	3.0	1.0	1.5	4.0	4.0
2	*Acer campestre* L.	6.5	1.4	17.5	3.6	5.1	4.0	4.0
3	*Acer pseudoplatanus* L.	3.4	1.2	10.3	2.2	2.3	4.0	3.7
4	*Aesculus hippocastanum* L.	4.7	1.3	13.7	3.2	3.3	3.0	3.0
5	*Betula verrucosa* Ehrh.	3.0	0.5	6.7	2.0	2.4	4.0	3.8
6	*Catalpa bignonioides* Walt.	2.0	1.5	4.0	1.0	0.5	3.7	3.9
7	*Cedrus atlantica* Man.	2.3	0.0	7.3	1.4	2.3	4.3	3.7
8	*Cercis siliquastrum* L.	1.5	0.0	3.0	1.5	1.5	3.0	2.0
9	*Chamaecyparis lawsoniana* (Murr.) Parl.	2.1	0.0	5.4	1.1	2.1	3.7	3.6
10	*Cupressus sempervirens* L.	5.0	0.0	10.0	1.0	5.0	4.0	4.0
11	*Fraxinus angustifolia* Vahl.	4.5	1.6	10.3	2.8	2.9	4.0	4.0
12	*Juglans regia* L.	7.0	1.5	41.0	7.0	5.5	3.0	3.0
13	*Juniperus scopulorum 'Skyrocket'* Sarg.	2.7	0.1	5.4	0.8	2.6	3.4	3.9
14	*Koelreuteria paniculata* Laxm.	2.0	0.5	4.0	1.5	1.5	4.0	3.0
15	*Libocedrus decurrens* Torr.	2.6	0.0	8.1	1.2	2.6	3.4	4.3
16	*Liriodendron tulipifera* L.	2.3	1.4	2.9	0.9	0.9	3.9	4.0
17	*Picea abies* (L.) Karst.	3.8	0.3	12.5	2.3	3.5	3.5	3.5
18	*Picea omorika* (Pančić) Purkyne.	2.0	0.0	7.0	1.0	2.0	4.0	4.0
19	*Picea pungens* Engelm.	2.5	0.0	5.0	1.2	2.5	4.0	3.0
20	*Pinus nigra* Arn.	3.6	0.7	16.6	2.6	3.0	4.0	4.0
21	*Platanus acerifolia* (Ait.) Willd.	5.0	1.0	1.5	4.0	4.0	5.0	5.0
22	*Platanus occidentalis* L.	8.3	1.7	23.3	4.3	6.7	3.0	3.0
23	*Prunus avium* L.	1.9	0.7	4.0	1.4	1.2	4.8	4.7
24	*Prunus pissardii* Ehrh.	2.1	0.2	4.5	1.4	1.9	4.2	4.2
25	*Quercus rubra* Michx f.	3.4	1.4	7.5	2.3	2.0	4.8	4.8
26	*Robinia pseudoacacia* L.	3.4	2.0	3.0	1.0	1.4	3.8	3.8
27	*Thuja orientalis* L.	1.8	0.0	4.3	0.7	1.8	4.1	4.1
28	*Tilia cordata* Mill.	3.5	1.3	14.0	3.5	2.3	3.5	3.5
29	*Tilia tomentosa* Mnch.	2.5	1.1	6.6	1.4	1.4	3.9	4.0

The average vitality score of woody species was 3.9. As many as 234 trees received the highest vitality rating (4 and 5). The species with the mean value of the vitality rating above the average were: *Abies alba*, *Acer campestre*, *Acer pseudoplatanus*, *Betula verrucosa*, *Cedrus atlantica*, *Cupressus sempervirens*, *Fraxinus angustifolia*, *Koelreuteria paniculata*, *Picea omorika*, *Picea pungens*, *Pinus nigra*, *Platanus acerifolia*, *Prunus avium*, *Prunus pissardii*, *Quercus rubra*, and *Thuja orientalis*.

Of the registered deciduous species, *Cercis siliquastrum* got the lowest average vitality rating, while *Juniperus scopulorum* 'Skyrocket' and *Libocedrus decurrens* were the conifers with the lowest vitality rating.

The ornamental value of woody species was scored with the average rating of 3.8. As many as 49 trees received the maximum rating for their ornamental value. The following species were rated 5: *Prunus avium* (17 trees), *Chamaecyparis lawsoniana* (10), *Libocedrus decurrens* (4), *Juniperus scopulorum* 'Skyrocket', *Quercus rubra* and *Tilia tomentosa* (3 trees each), *Betula verrucosa*, *Prunus pissardii* and *Thuja orientalis* (2 trees each) and *Cedrus atlantica*, *Pinus nigra* and *Platanus acerifolia (1 tree each)*.

The species with both the vitality score and the ornamental value score above the average were: *Abies alba*, *Acer campestre*, *Cupressus sempervirens, Fraxinus angustifolia, Picea omorika, Pinus nigra, Platanus acerifolia, Prunus avium, Prunus pissardii, Quercus rubra* and *Thuja orientalis.*

Figure 3. *The position of the Old Cemetery*

The Old Cemetery had 348 trees analyzed (Figure 3), 53 of which were broadleaves and 295 conifers. There were 32 different tree species in total. The most common genus was *Picea* sp. with 3 species (*P. abies, P. omorika, P. pungens*). By far the most abundant woody species was *Thuja orientalis* with 166 trees. The ratio of broadleaves to conifers was15:85.

Table 2. *Average values of the recorded tree parameters in the Old Cemetery*

S. nº	Species	Tree height (m)	Trunk height (m)	Trunk diameter (cm)	Crown spread (m)	Crown height (m)	Vitality score	Ornamental value
1	*Abies alba* Mill.	15.0	2.5	23.0	5.0	12.5	3.0	4.0
2	*Betula verrucosa* Ehrh.	10.5	2.9	24.3	5.6	7.7	3.7	3.7
3	*Carpinus betulus* L.	16.5	2.1	32.5	6.8	14.4	3.7	3.7
4	*Catalpa bignonioides* Walt.	9.0	2.1	25.5	7.8	6.9	4.5	4.5
5	*Cedrus atlantica* Man.	18.5	5.2	38.0	9.0	13.3	4.0	4.0
6	*Chamaecyparis lawsoniana* (Murr.) Parl	8.6	2.4	19.4	3.6	6.3	3.3	3.5
7	*Cupressus arizonica* Greene	10.0	1.9	24.7	4.2	8.1	3.3	3.4

S. nº	Species	Tree height (m)	Trunk height (m)	Trunk diameter (cm)	Crown spread (m)	Crown height (m)	Vitality score	Ornamental value
8	*Cupressus sempervirens* L.	10.3	2.0	21.9	3.4	8.3	3.3	3.4
9	*Gleditsia triacanthos* L.	13.6	2.5	29.4	7.0	11.1	4.0	4.0
10	*Juglans regia* L.	11.8	3.3	42.8	8.8	8.6	3.3	3.3
11	*Juniperus excelsa* Bieb.	5.2	1.4	16.0	3.3	3.8	3.3	3.3
12	*Juniperus scopulorum 'Skyrocket'* Sarg.	4.7	0.7	9.5	1.3	4.0	2.8	3.1
13	*Libocedrus decurrens* Torr.	5.0	2.2	8.0	2.8	2.8	3.0	4.0
14	*Magnolia x soulangeana* Soul.-Bod.	5.7	1.5	14.3	5.0	4.2	3.3	3.3
15	*Malus* sp. Mill.	5.0	2.0	11.0	3.5	3.0	3.5	3.0
16	*Picea abies* (L.) Karst.	6.8	2.2	16.1	4.0	4.6	2.8	2.7
17	*Picea omorika* (Pančić) Purkyne.	6.8	3.4	12.5	2.0	3.4	4.0	4.0
18	*Picea pungens* Engelm.	7.0	2.8	17.7	3.7	4.2	3.3	3.3
19	*Pinus nigra* Arn.	9.2	2.8	25.7	5.5	6.4	3.7	3.7
20	*Pinus sylvestris* L.	13.3	4.7	41.0	6.5	8.7	3.3	3.7
21	*Prunus avium* L.	8.0	1.3	25.0	4.8	6.8	3.5	3.5
22	*Prunus cerasus* Ehrh.	5.0	1.7	14.0	3.7	3.3	3.3	3.3
23	*Prunus persica* (L.) Batsch	3.0	1.7	6.0	3.0	1.3	3.0	3.0
24	*Pseudotsuga menziesii* (Mirbel.) Franco	9.8	2.6	21.8	4.3	7.2	3.2	3.5
25	*Pyrus communis* L.	5.3	1.7	17.3	4.0	3.7	3.3	3.3
26	*Quercus robur* L.	17.0	2.5	36.5	7.0	14.5	3.0	3.0
27	*Syringa vulgaris* L.	3.0	0	6.0	2.0	3.0	3.0	3.0
28	*Taxus baccata* L.	6.0	0.5	24.0	5.0	5.5	4.0	4.0
29	*Thuja occidentalis* L.	7.9	2.1	22.8	3.7	5.8	3.3	3.8
30	*Thuja orientalis* L.	5.9	1.6	13.9	3.3	4.2	3.1	3.2
31	*Tilia cordata* Mill.	9.9	2.8	30.6	8,0	7.1	2.8	3.6
32	*Tilia tomentosa* Mnch.	17.0	2.6	75.7	11.7	14.4	4.0	4.0

The average score of the vitality of woody species was 3.4. The following species received the maximum average vitality rating (4): C*edrus atlantica, Gleditsia triacanthos*, *Picea omorika* and *Tilia tomentosa* (species with one or two individuals on the green area were excluded from the study). Two trees had their vitality rated 5 - *Catalpa bignonioides* and *Chamaecyparis lawsoniana*.

The species that had the mean score of vitality above the average were: *Betula verrucosa*, *Carpinus betulus*, *Catalpa bignonioides*, *Cedrus atlantica*, *Gleditsia triacanthos*, *Malus* sp., *Picea omorika, Pinus nigra, Prunus avium, Taxus baccata* and *Tilia tomentosa.*

The ornamental value of woody species was scored with the average rating of 3.5. The above-mentioned species with the maximum average vitality rating (4) also had the maximum average ornamental value rating (4). In total, 5 trees received the rating 5. Besides the common catalpa and Lawson cypress, 3 trees of *Thuja orientalis* had the greatest ornamental value. The following species had the mean rating of the ornamental value above the average: *Abies alba*, *Betula verrucosa*, *Carpinus betulus, Catalpa bignonioides*, *Cedrus atlantica, Gleditsia triacanthos*, *Libocedrus decurrens*, *Picea omorika*, *Pinus nigra*, *Pinus sylvestris*, *Taxus baccata, Thuja occidentalis, Tilia cordata* and *Tilia tomentosa.*

The species with both the vitality score and the ornamental value score above the average were: *Betula verrucosa*, *Carpinus betulus*, *Catalpa bignonioides*, *Cedrus atlantica*, *Gleditsia triacanthos*, *Picea omorika*, *Pinus nigra*, *Taxus baccata* and *Tilia tomentosa.*

Table 3. *The average values of the registered parameters of tree species present at both the New Cemetery and the Old Cemetery*

Loc.	Species	Tree height (m)	Trunk height (m)	Trunk diameter (cm)	Crown spread (m)	Crown height (m)	Vitality score	Ornamental value score	Number of individuals
New	*Abies alba*	1.5	0.0	3.0	1.0	1.5	4.0	4.0	2
Old		15.0	2.5	23.0	5.0	12.5	3.0	4.0	1
New	*Betula verrucosa*	3.0	0.5	6.7	2.0	2.4	4.0	3.8	37
Old		10.5	2.9	24.3	5.6	7.7	3.7	3.7	6
New	*Catalpa bignonioides*	2.0	1.5	4.0	1.0	0.5	3.7	3.9	10
Old		9.0	2.1	25.5	7.8	6.9	4.5	4.5	2
New	*Cedrus atlantica*	2.3	0.0	7.3	1.4	2.3	4.3	3.7	3
Old		18.5	5.2	38.0	9.0	13.3	4.0	4.0	4
New	*Chamaecyparis lawsoniana*	2.1	0.0	5.4	1.1	2.1	3.7	3.6	32
Old		8.6	2.4	19.4	3.6	6.3	3.3	3.5	22
New	*Cupressus sempervirens*	5.0	0.0	10.0	1.0	5.0	4.0	4.0	1
Old		10.3	2.0	21.9	3.4	8.3	3.3	3.4	12
New	*Juglans regia*	7.0	1.5	41.0	7.0	5.5	3.0	3.0	1
Old		11.8	3.3	42.8	8.8	8.6	3.3	3.3	6
New	*Juniperus scop. 'Skyrocket'*	2.7	0.1	5.4	0.8	2.6	3.4	3.9	7
Old		4.7	0.7	9.5	1.3	4.0	2.8	3.1	11
New	*Libocedrus decurrens*	2.6	0.0	8.1	1.2	2.6	3.4	4.3	11
Old		5.0	2.2	8.0	2.8	2.8	3.0	4.0	2
New	*Picea abies*	3.8	0.3	12.5	2.3	3.5	3.5	3.5	2
Old		6.8	2.2	16.1	4.0	4.6	2.8	2.7	29
New	*Picea omorika*	2.0	0.0	7.0	1.0	2.0	4.0	4.0	1
Old		6.8	3.4	12.5	2.0	3.4	4.0	4.0	4
New	*Picea pungens*	2.5	0.0	5.0	1.2	2.5	4.0	3.0	1
Old		7.0	2.8	17.7	3.7	4.2	3.3	3.3	3
New	*Prunus avium*	1.9	0.7	4.0	1.4	1.2	4.8	4.7	20
Old		8.0	1.3	25.0	4.8	6.8	3.5	3.5	2
New	*Thuja orientalis*	1.8	0.0	4.3	0.7	1.8	4.1	4.1	13
Old		5.9	1.6	13.9	3.3	4.2	3.1	3.2	166
New	*Tilia cordata*	3.5	1.3	14.0	3.5	2.3	3.5	3.5	2
Old		9.9	2.8	30.6	8.0	7.1	2.8	3.6	5
New	*Tilia tomentosa*	2.5	1.1	6.6	1.4	1.4	3.9	4.0	40
Old		17.0	2.6	75.7	11.7	14.4	4.0	4.0	6

Out of the total of 45 recorded species, 16 species occurred both in the New Cemetery and in the Old Cemetery. Only two coniferous species, *Picea omorika* and *Pinus nigra*, had the scores of vitality and ornamental value above the average at both sites. The average values of the mean tree and trunk heights, the diameter and crown spread were higher in the species at the site of the Old Cemetery, which was expected because the trees were older. On the other hand, the trees in the New Cemetery site had higher average scores of vitality and ornamental value because they were young and properly tended.

4. CONCLUSIONS

There are 45 species of trees identified at Obrenovac cemeteries. 15 of them are coniferous and 30 are broadleaved. The New Cemetery has 11 coniferous and 28 broadleaved species, while the Old Cemetery has 17 coniferous and 15 broadleaved species. Some specimens in the Old Cemetery have exceptional aesthetic value and represent true natural monuments. The diversity of species adds to the richness of colours of the area throughout the whole year.

The percentage ratio of broadleaved and coniferous species in the New Cemetery is 64:36, while it is 15:85 in the Old Cemetery.

Woody species that have the highest ratings are *Picea omorika* and *Pinus nigra*, so it can be concluded that they are best adapted to the environmental conditions in both cemeteries. In the New Cemetery, the species *Abies alba, Acer campestre, Cupressus sempervirens, Fraxinus angustifolia, Platanus acerifolia, Prunus avium, Prunus pissardii, Quercus rubra* and *Thuja orientalis* have shown extremely great adaptability. Based on the assessment of vitality and ornamental value, it can be concluded that *Betula verrucosa, Carpinus betulus, Catalpa bignonioides, Cedrus atlantica, Gleditsia triacanthos, Taxus baccata* and *Tilia tomentosa* have shown the best adaptability in the Old Cemetery.

Based on the above, it can be concluded that there are a large number of coniferous and broadleaved trees at the sites of the New and Old Cemeteries in Obrenovac, most of which have exceptional ornamental properties and represent special features of the green area of the urban core of Obrenovac.

REFERENCES

Anastasijević, N. (2002): Establishment and cultivation of green areas, Faculty of Forestry, University of Belgrade, Belgrade, 248 (In original: *Anastasijević, N. (2002): Podizanje i negovanje zelenih površina. Šumarski fakultet Univerziteta u Beogradu, Beograd, 248*)

Ćirković-Mitrović T., Brašanac-Bosanac Lj., Mladenović K., Milenković I (2016): The Comparative analysis of the state of dendrological plants in Belgrade parks, Serbia. Sustainable Forestry, Collection 73-74. Institute of Forestry, Belgrade, 11-18.

Hessayon, D.G. (2001): The Flowering Shrub Expert, Mozaik Knjiga, Zagreb, 128 (In original: *Hessayon, D.G. (2001): Cvatući grmovi, Mozaik knjiga, Zagreb, 128*).

Hillier, H.G. (1982): Color dictionary of Trees and Shrubs. Van Nostrand Reinhold Company, New York, 323.

Idjojtić, M. (2009): Dendrology Journal. Faculty of Forestry, University of Zagreb, Zagreb, 903. (In original: *Idžojtić, M. (2009): Dendrologija list, Šumarski fakultet Sveučilišta u Zagrebu, Zagreb, 903*).

Institute of Soil Science (2009): Study on the degree of vulnerability of soil and water to hazardous and harmful substances in local communities on the periphery of ash dumps in the CM Obrenovac, Belgrade. (In original: *Institut za zemljište (2009): Studija o stepenu ugroženosti zemljišta i voda opasnim i štetnim materijama u MZ na obodu deponija pepela na području GO Obrenovac, Beograd*).

Jovanović, B. (1985): Dendrology, Faculty of Forestry, University of Belgrade, Belgrade, 557 (In original: *Jovanović, B. (1985): Dendrologija. Šumarski fakultet Univerziteta u Beogradu, Beograd, 557*).

Ocokoljić, M., Ninić-Todorović, J. (2003): A Handbook of Ornamental Dendrology, Faculty of Forestry, University of Belgrade, Belgrade, 162. (In original: *Ocokoljić, M., Ninić-todorović, J. (2003): Priručnik iz dekorativne dendrologije. Šumarski fakultet Univerziteta u Beogradu, Beograd, 162*).

Dragičević, S., Karić I. (2007): Geospatial characteristics of the urban municipality of Obrenovac. Environmental Protection Fund Obrenovac, Obrenovac. (In original: *Dragičević, S., Karić I. (2007): Geoprostorne karakteristike gradske opštine obrenovac. Fond za zaštituu životne sredine Obrenovac, Obrenovac*)

Veselinović M., Mitrović S., Radulović Z., Dražić D., Čule N., Stanković D., Rajković S. (2014) The condition of *Aesculus hippocastanum* L. trees in the avenues of the central part of the city of Obrenovac. Sustainable Forestry, Collection 69-70. Institute of Forestry, Belgrade, 17-23.

Veselinović, M., Čule, N., Mitrović, S. (2010): The cadastre of public green areas in the urban area of the Municipality of Obrenovac integrated into the GIS, Institute of Forestry, Belgrade, 107 (In original: *Veselinović, M., Čule, N., Mitrović, S. (2010): Katastar zelenih površina javnog karaktera gradskog područja opštine Obrenovac integrisanih u GIS. Institut za šumarstvo, Beograd, 107*)

Vidaković, M. (1982): Conifers: morphology and variability. JAZU, University Press Liber, Zagreb, 707 (In original: *Vidaković, M. (1982): Četinjače: morfologija i varijabilnost. JAZU, Sveučilišna naklada Liber, Zagreb, 707*)

Vujković, Lj. (2003): Landscape Architecture Planning and Design, Faculty of Forestry, University of Belgrade, Belgrade, 224 (In original: *Vujković, Lj. (2003): Pejzažna arhitektura planiranje i projektovanje. Šumarski fakultet Univerziteta u Beogradu, Beograd, 224*).

Vukićević, E. (1996): Ornamental, Faculty of Forestry, University of Belgrade, Belgrade, 585 (In original: *Vukićević, E. (1996): Dekorativna dendrologija, Šumarski fakultet Univerziteta u Beogradu, Beograd, 585*).

Šijak, M. (2000): Multilingual Dendrological Dictionary: Vocabularium dendrologicum multilinguum. Faculty of Forestry, 310 (In original: *Šijak, M. (2000): Višejezični dendrološki rečnik: Vocabularium dendrologicum multilinguum. Šumarski fakultet, 310*)

THE STATE AND FUNCTIONALITY OF DENDROFLORA IN THE CEMETERIES IN OBRENOVAC

Suzana MITROVIĆ, Nevena ČULE, Dušan JOKANOVIĆ, Milijana CVEJIĆ, Milorad VESELINOVIĆ

Summary

Cemeteries are important elements of urban areas, with multiple benefits in terms of environmental protection, connected with other green areas of different categories, constitute the green structure of the city whose functions contribute to the healthier environment of the polluted urban area.

There are two urban cemeteries on the territory of the urban area of the Municipality of Obrenovac. The New Cemetery is located in the western part of Obrenovac, 2.84 km away from the city center, covers an area of 5.4 ha. The Old Cemetery, measuring 4.5 hectares, located in the western part of Obrenovac, 2 km from the city center.

In the New Cemetery, 271 trees were analyzed, 174 of which were broadleaved and 97 coniferous species. There were 29 different tree species in total. The most common wood species were *Tilia tomentosa* Mnch. with 40 individuals, *Betula verrucosa* Ehrh. with 37 seedlings and *Chamaecyparis lawsoniana* (Murr.) Parl. with 28 specimens. The ratio of the broadleaves to conifers was 64:36.

The Old Cemetery had 348 trees analyzed, 53 of which were broadleaves and 295 conifers. There were 32 different tree species in total. The most common genus was *Picea* sp. with 3 species (*P. abies, P. omorika, P. pungens*). By far the most abundant woody species was *Thuja orientalis* with 166 trees. The ratio of broadleaves to conifers was15:85.

Woody species that have the highest ratings are *Picea omorika* and *Pinus nigra*, so it can be concluded that they are best adapted to the environmental conditions in both cemeteries. In the New Cemetery, the species *Abies alba, Acer campestre, Cupressus sempervirens, Fraxinus angustifolia, Platanus acerifolia, Prunus avium, Prunus pissardii, Quercus rubra* and *Thuja orientalis* have shown extremely great adaptability. Based on the assessment of vitality and ornamental value, it can be concluded that *Betula verrucosa, Carpinus betulus, Catalpa bignonioides, Cedrus atlantica, Gleditsia triacanthos, Taxus baccata* and *Tilia tomentosa* have shown the best adaptability in the Old Cemetery.

In the area of research there are a large number of coniferous and broadleaved trees at the sites, most of which have exceptional ornamental properties and represent special features of the green area of the urban core of Obrenovac.

STANJE I FUNKCIONALNOST DENDROFLORE NA GROBLJIMA U OBRENOVCU

Suzana MITROVIĆ, Nevena ČULE, Dušan JOKANOVIĆ, Milijana CVEJIĆ, Milorad VESELINOVIĆ

Rezime

U gradskim sredinama, groblja predstavljaju značajne objekte sa svojim opštekorisnim funkcijama u smislu zaštite životne sredine povezane sa ostalim zelenim površinama različitih kategorija, i sačinjavaju zelenu strukturu grada koja svojim funkcijama utiče na zdravije okruženje zagađene gradske sredine.

Na teritoriji gradskog područja opštine Obrenovac nalaze se dva gradska groblja. Novo groblje se nalazi u zapadnom delu Obrenovca, 2,84 km od centra grada, ukupne površine 5,4 ha. Staro groblje, površine 4,5 hektara, se nalazi u zapadnom delu Obrenovca, 2 km od centra grada.

Terenskim istraživanjima na području gradskih grobalja drveće je evidentirano: na Novom groblju je analizirano 271 stabala, od čega je 174 lišćarskih i 97 četinarskih vrste. Ukupno postoji 29 različitih vrsta drveća. Najzastupljenije drvenaste vrste su *Tilia tomentosa* Mnch. sa 40 jedinki, *Betula verrucosa* Ehrh. sa 37 sadnica i *Chamaecyparis lawsoniana* (Murr.) Parl. sa 28 primeraka. Odnos lišćara i četinara je 64:36.

Na Starom groblju je analizirano 348 stabala, od toga 53 lišćara i 295 četinara. Ukupno postoji 32 različitih vrsta drveća. Najprisutniji je rod *Picea sp.* sa 3 vrste (*P. abies, P. omorika, P. pungens*). Ubedljivo najzastupljenija drvenasta vrsta je *Thuja orientalis* sa 166 stabala. Odnos lišćara i četinara je 15:85.

Drvenaste vrste koje imaju najviše ocene su *Picea omorika* i *Pinus nigra,* i može se konstatovati da su one najbolje adaptirane na uslove sredine na oba groblja. Na Novom groblju vrste: *Abies alba, Acer campestre, Cupressus sempervirens, Fraxinus angustifolia, Platanus acerifolia, Prunus avium, Prunus pissardii, Quercus rubra* i *Thuja orientalis* su pokazale izuzetno veliku adaptivnost. Na osnovu ocena vitalnosti i dekorativnosti može zaključiti da su vrste: *Betula verrucosa, Carpinus betulus, Catalpa bignonioides, Cedrus atlantica, Gleditsia triacanthos, Taxus baccata* i *Tilia tomentosa,* pokazale najbolju adaptivnost na Starom groblju.

Na analiziranim grobljima zastupljen je veliki broj četinarskih i lišćarskih vrsta drveća, od kojih većina imaju izuzetna dekorativa svojstva i predstavljaju značaje zelene površine gradskog jezgra Obrenovca.

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION 77-78, 2018 ZBORNIK RADOVA 77-78, 2018

UDK 630*331.1+630*839.81]:662.63(497.11)
Original scientific paper

IMPROVING THE USE OF FOREST-BASED BIOMASS FOR ENERGY PURPOSES IN SERBIA

Ljiljana BRAŠANAC-BOSANAC[1], Tatjana ĆIRKOVIĆ-MITROVIĆ[1], Saša EREMIJA[1], Snežana STAJIĆ[1], Aleksandar LUČIĆ[1]

Abstract: *Serbia is one of the countries of Southeastern Europe with significant potentials for using biomass from forests and wood processing industry in the form of wood residues for the production of modern fuels. This type of biomass has not been used efficiently. One of the reasons is the traditional use of firewood for domestic heating needs despite its lower energy efficiency compared to pellets and briquettes. According to FAO methodology, the estimated energy potential of the available biomass derived from forests and wood processing industry in Serbia amounts to 1.53 Mtoe/year. According to the Energy Sector Development Strategy of the Republic of Serbia for the period by 2025 with projections by 2030 together with relevant Decisions on the energy balance determination, the degree of the use of potentially available biomass from forests and wood processing industry is around 1.02 Mtoe/year (66.7%). The remaining unused potential of this biomass is estimated at around 0.51Mtoe / year.*

Besides the study of the state of biomass from forests and wood processing industry, the paper provides recommendations on how to increase the utilization rate of this biomass in Serbia.

Key words: forest-based biomass, potential, energy value, Serbia.

UNAPREĐENJE KORIŠĆENJA BIOMASE IZ ŠUMARSTVA U ENERGETSKE SVRHE U SRBIJI

Izvod: *Srbija predstavlja jednu od zemalja u regionu Jugoistočne Evrope koja ima značajne potencijale za korišćenje biomase iz šumarstva i drvno-prerađivačke industrije u obliku drvnog ostatka za proizvodnju modernih goriva. Ovako dobijena biomasa se ne*

[1] Institute of Forestry, 3 Kneza Višeslava, Belgrade, Serbia

koristi efikasno, između ostalog zbog tradicionalnog korišćenja ogrevnog drveta za potrebe grejanja u domaćinstvima, koje ima nižu energetsku efikasnost u odnosu na pelete i brikete. Po metodologiji FAO procenjena energetska vrednost potencijalno raspoložive biomase iz šumarstva i drvno-prerađivačke industrije u Srbiji iznosi ukupno 1,53 Mtoe/godišnje. Prema Strategiji razvoja energetike Republike Srbije do 2025. godine sa projekcijama do 2030. godine, kao i odgovarajućim Odlukama o utvrđivanju energetskog bilansa, stepen korišćenja potencijalno raspoložive biomase iz šumarstva i drvno-prerađivačke industrije iznosi oko 1,02 M toe/godišnje (66,7%). Preostaje neiskorišćeni raspoloživi potencijal ove biomase, koji se procenjuje na oko 0,51Mtoe/godišnje.

U radu će se, pored analize stanja biomase iz šumarstva i drvno-prerađivačke industrije, dati preporuke za povećanje stepena iskorišćenosti ove biomase u Srbiji.

Ključne reči: biomasa iz šumarstva, potencijal, energetska vrednost, Srbija.

1. INTRODUCTION

The demand for energy has been increasing with the increase in the world`s population. In the near future, renewable energy sources (RES) will, therefore, get a key role in the supply of energy at a global level. Compared to oil, coal and natural gas, the share of renewable energy sources in the global energy consumption is only 2.8% in the world today (Statistical review of the world energy, 2016). Serbia also has an extremely low share of RES in the production of energy.

In the broadest sense, biomass is a matter of biological origin or organic matter that can be used in various ways and transformed into various forms of energy (heat, mechanical or electrical), gaseous, liquid or solid fuels (Đurišić-Mladenović, *et al*, 2016).

Forest-based biomass belongs to solid biomass which includes firewood, plant mass of fast-growing plants, branches and wood waste from forests, sawdust, bark and wood residue from the wood-processing industry. Forest-based biomass has a dominant share of around 60% of the total energy produced from renewable sources in Serbia (Decisions on the energy balance determination in the Republic of Serbia for 2018, Official Gazette of the Republic of Serbia, No. 119/17).

Despite its great potential, the use of wood biomass in Serbia has not been efficient. Significant amounts of wood residue produced in the course of tree felling and timber assortment production are left unused in forests. The same applies to fine wood residues (sawdust) produced in the course of wood processing by sawmills in particular. This residue is then disposed of in the stockpiles next to the factories or burnt. Recent years have seen some shifts in the use of coarse wood residues produced by sawmills. They are sold to local people most commonly for domestic heating purposes. However, the scope of these shifts is not satisfactory.

With the aim of improving the use of biomass from forests and wood processing industry, the paper studies resources and gives recommendations for increasing the utilization of forest-based biomass for energy purposes in Serbia.

2. METHODOLOGY

The research was based on the methods of analysis and synthesis used to determine the significance, potential and existing state of forest-based biomass, resulting in the effective solutions and proposals of measures that would increase the use of wood biomass for energy purposes in Serbia, in line with the national and EU legislation.

Data on the potential and actual biomass were obtained from the data analyzed in relevant scientific papers, studies, projects and monographs dealing with this issue, as well as legal regulations and data obtained from the Institute of Statistics of the Republic of Serbia, SE `Srbijašume`, SE `Vojvodinašume` and other sources.

3. RESULTS AND DISCUSSION

The European Union does not prescribe how a state should organize its own forestry, whether there will be one or more enterprises, but it requires the legislation to be in accordance with the principles respected by European countries (the principle of sustainable development, ecological principles, Pan-European Criteria and Indicators, *etc.*). In accordance with the Kyoto Protocol, the Paris Agreement and the EU Directives, and based on the obligation to increase the share of renewable energy sources in the total energy consumption, a lot of EU countries are encouraging the use of biomass as fuel. Some developed countries have strong biofuel markets with a steady increase in demand for biomass as fuel, which creates tempting conditions for the export of biofuels to the EU market. High fossil fuel prices and political decisions directed toward increasing energy security and climate change mitigation provide a strong stimulus to the development of renewable energy sources, especially the wood-based energy.

Potential of renewable energy sources in Serbia - The Republic of Serbia has significant potential of RES. It is estimated at **5.65 Mtoe/year**. Biomass potential accounts for more than 60% of it, which is about 3.45 Mtoe. 2.39Mtoe of it is unused and 1.05 Mtoe used biomass. Of the registered biomass potential, about 1.67 Mtoe is derived from agriculture and food processing industry, while forest-based biomass accounts for 1.53 Mtoe (Table 1).

Table 1. *Available technical potential of renewable energy sources in the Republic of Serbia*

Type of RES	Available realized technical potential (Mtoe)	Unrealized available technical potential (Mtoe)	Total available technical potential (Mtoe)
BIOMASS	***1.054***	***2.394***	***3.448***
Agricultural biomass	0.033	1.637	1.670
Agricultural crop residue	0.033	0.99	1.023
Residue from fruit growing, viticulture and fruit processing	-	0.605	0.605
Liquid manure	-	0.042	0.042
Wood(forest-based) biomass	**1.021**	**0.509**	**1.530**
Energy plantations	-	-	not available
Biodegradable waste	0	0.248	0.248
Biodegradable municipal waste	0	0.205	0.205

Type of RES	Available realized technical potential (Mtoe)	Unrealized available technical potential (Mtoe)	Total available technical potential (Mtoe)
Biodegradable waste (excluding municipal)	0	0.043	0.043
HYDROENERGY	***0.909***	***0.770***	***1.679***
GEOTHERMAL ENERGY	***≈0***	***0.1***	***0.180***
SOLAR ENERGY	***≈0***	***0.240***	***0.240***
WIND ENERGY	***≈0***	***0.103***	***0.103***
Total from all RES	**1.968**	**3.682**	**5.65**

Source: *Energy Sector Development Strategy of the Republic of Serbia for the period by 2025 with projections by 2030*

Potentially available forest-based biomass **-** The energy potential of wood biomass (which is the most common biomass in Central Serbia) originating from forests and wood processing industry (tree felling and wood residues produced during primary and/or industrial wood processing) is 1.53 Mtoe. According to the Energy Sector Development Strategy of the Republic of Serbia for the period by 2025 with projections by 2030 together with relevant Decisions on the energy balance determination, the degree of the utilization of potentially available biomass from forests and wood processing industry is around 1.02 Mtoe/year (66.7%), (Table 2).

Table 2. *Potential and actual wood biomass from forests and wood processing industry: energy potential*

Biomass from forests and wood processing industry	**Energy potential (GJ)**	**Energy potential (toe)**
	Potentially available wood biomass	
	63.960.822	1.527.678
	Degree of potentially available wood biomass utilization	
	42.747.228	1.021.000

Source: *Renewable Energy National Action Plan of the Republic of Serbia (Official Gazette RS, 53/2013) and the Energy Sector Development Strategy of the Republic of Serbia for the period by 2025 with projections by 2030, (Official Gazette of RS, No. 101/2015).*

Based on the results of TCP/FAO project `Wood-based energy for sustainable rural development in Serbia (FAO, 2011), the total annual consumption of wood for domestic heating purposes in 2010 was 6.360.788 m^3. Besides this quantity of firewood, an additional 55.905 m^3 of coarse wood residue originating from wood processing was used for the same purpose (Glavonjić, 2010, 2011).

According to data of the Ministry of Energy, Development and Environmental Protection (2013) on the structure of the domestic primary energy production for 2013, the share of renewable energy sources was 1.835 Mtoe, which was 16% of domestic primary energy production, with the largest share of solid biomass (58%) and hydropower (41%), while biogas, wind, solar and geothermal energy participated with less than 1%.

Projects, scientific papers and studies (Vasiljević, 2015, Glavonjić, 2010, 2016 *etc*.), conducted in the period from 2013 to 2018, in which the real production and consumption of firewood in Serbia were analyzed, point to the fact that the current state of the solid biofuel market in Serbia is characterized by a rapid growth in the production and consumption of all types of wood fuel in the past five years. Furthermore, the largest increase was achieved in the production of wood chips and wood pellets, while the production and consumption of firewood, wood briquettes and charcoal have not changed significantly over the last five years.

Despite the great potential of wood mass in Serbia, both in terms of its biological diversity and in terms of its distribution, forest-based biomass has not been used sufficiently for the purpose of energy production (excluding the use of firewood for domestic heating). There are several reasons: low-cost electricity, unsolved logistics problems in the collection and distribution, the absence of a regulated biomass market and appropriate technologies for its use as fuel. We must further add the poor financial power of potential buyers and expensive commercial loans, as well as the lack of state subsidies for the construction of biomass plants.

There are numerous reasons for the insufficient utilization of potentially available wood biomass, such as:

- Poorly developed forest road infrastructure (insufficiently opened) and difficult accessibility (terrain with extremely unfavorable orographic characteristics and poor access to forest stands). At sites that are characterized by good openness and where machinery can be used in the process of forest utilization, fine branch timber and waste from felling and assortment production can be extracted from the forest with minimum investments. On the other hand, in the areas with extremely unfavorable orographic characteristics and poor access to forest stands, the profitability of the collected products is disputable;
- Inappropriate mechanization for the collection and transportation of wood biomass, *i.e.*, high costs of biomass collection at the felling site for its further manipulation (making the collection of forest residue unprofitable);
- The fragmentation of privately-owned forest plots (on average 0.3 ha in Serbia), and long distances between them affect the felling and extraction of wood resources, which significantly reduces their availability (Ratknić *et al*., 2007);
- Demographic emptying of villages and border settlements, together with the economic underdevelopment of local communities and extreme poverty of the population, especially in the Southern and Eastern Serbia, limits the possibilities of collecting and using this biomass. Namely, the municipalities in Serbia that are rich in forests[2] are demographically poor and economically less developed and these facts make an obstacle to the efficient use of forest-based biomass;
- Through the process of forest resource utilization, it should be ensured that certain quantities of wood are left in stands in order to preserve and improve the quality of soil and the state of biodiversity;

[2] Out of 146 municipalities in Serbia, 28 municipalities have the area covered in forest larger than 40% of the territory of the municipality.

– Considering the use of sawmill timber residue, significant quantities of sawdust from different stockpiles can become unusable because long exposure to adverse atmospheric conditions makes sawdust severely prone to decay. Besides, various types of mechanical waste (stone, metal, sheet metal, *etc*.) are disposed of at such stockpiles, thus additionally complicating the process of biomass use for the production of wood fuels. It is difficult to estimate the amount of sawdust currently found in stockpiles that can be really used for the production of wood-based biomass. In any case, sawdust found in the stockpiles about five years old can largely be used for the production of fuelwood.

In the structure of the final consumption of biomass from forests and wood processing industry, the industry accounts for 13%, households for 84% (use of firewood for heating purposes), and other sectors for 3%, with extremely small amount spent in heating plants (Official Gazette RS, No. 119/17). There are numerous reasons for such a structure of consumption:

- ✓ Rural areas and peripheral parts of suburban areas, where households mostly use firewood for heating purposes, gravitate towards the areas with high production of timber or they are far from other supply sources, while households` low purchasing power makes firewood the most affordable heating alternative;
- ✓ Insufficient incentive measures of the state in the field of biomass and its use for energy purposes (construction of biomass power plants);
- ✓ Limited economic power of potential investors interested in investing money in the biomass sector (construction of power plants, cogeneration plants);
- ✓ Unfavourable commercial loans and loan terms and conditions;
- ✓ Lack of financial resources of households, small businesses and institutions to change the heating mode (to buy pellet boilers), *etc*.

4. CONCLUSIONS

Biomass is the only form of renewable energy source that can be used to produce liquid fuel whose consumption exceeds other energy sources, with projections that it won`t change after 2030 (Đurišić-Mladenović, *et al.*, 2016).

It is necessary that wood and wood biomass be given the right importance, not only in energy balances and official consumption analyses in Serbia but also in the application of methods for estimating its consumption. The methods of firewood consumption estimation must be comprehensive and elaborate, based on recognized scientific and statistical methods. Furthermore, the credibility of data should be checked in both directions, in the direction of wood production and in the direction of its consumption.

Recent years have seen some shifts in the use of coarse wood residues produced by sawmills. They are sold to local people most commonly for domestic heating purposes. However, there are significant amounts of wood residue that are still unused.

Although energy crop plantations have great energy potential (Mitrović *et al.*, 2011), the areas under these crops in Serbia are rather small and the actual biomass derived from energy plants is very small.

How to improve the use of biomass for energy purposes? Although firewood has lower energy efficiency than pellets and briquettes, it will be still used by households in the future due to the low purchasing power of the population, high prices of conventional fuels (fuel oil, liquefied gas, coal), slow development of gas distribution network and costly gas installation (without subsidies and favourable loan conditions), inability of households to afford the purchase of boilers and pellet heating stoves.

These are recommendations for more efficient use of wood biomass for energy purposes:

- state incentive measures to increase the use of pellets and briquettes in households (for the heating of households, auxiliary facilities and greenhouses), industrial plants (for instance in raw material drying) and small boiler rooms for heating buildings and public institutions (*e.g.*, hotels, health centers, schools, kindergartens);
- the use of solid biomass in bio-plants and cogeneration plants in which biomass is used as the primary energy source for the production of electricity and heat;
- the best way to use waste biomass from the wood processing industry for the purpose of energy production in industrial or district heating plants is to use it in the area close to the place of its collection;
- the establishment of intensively managed forest plantations of fast-growing tree species in Serbia should also be considered as a possible solution for meeting the ever-growing energy needs by using renewable energy sources, which would further reduce the pressure on forests (unproductive areas of agricultural and forest land would be given purpose and the engagement of local workforce and professional support would provide additional funding sources);
- potential growers of energy crops are not sufficiently familiar with the comparative advantages of energy crops of the second generation biofuels, nor with the technology of their cultivation, which makes education in this area very important in the coming period.

The use of biomass from forests and wood processing industry in Serbia will not be satisfactory enough until investments are encouraged and stimulated, especially for the establishment of a district pellet heating system. Also, the proposed supply of energy for the use of the biomass will necessitate the improvement of legal regulations and technical standards, introduction of concrete and systematic support measures for the construction of power plants and cogeneration plants, provision of favourable loans for the energy conversion in heating plants, *etc*.

Note: *The paper is part of the results of the project SocioNext SE: More Inclusive, Clean and Affordable Biomass Energy Production from Agricultural Residues and Waste", no. 48-00-00203 / 2014-28-19*

REFERENCES

Đurišić-Mladenović, N., Predojević, Z., Škrbić, B. (2016): Conventional and Advanced Liquid Biofuels, Chemical Industry, vol. 70, no. 3, p. 225-241.

Wood-based energy for sustainable rural development in Serbia, FAO Project, 2011.

Glavonjić, B. (2010): Possibilities, challenges and current progress in the development of the wood biomass market in Montenegro - Final report, Ministry of Agriculture, Forestry and Water Management of Montenegro & LUX - development Luxembourg.

Glavonjić, B. (2011): Woodfuels: types, characteristics and benefits for heating, SNV Montenegro, Podgorica, Montenegro.

Glavonjić, B., Lazarević, A., Čomić, D. (2016): Impact of wood pellets export on the development of their production in Serbia with the effects of substituting enegry from fossil fuels and reduction of carbon dioxide emission, Bulletin of the Faculty of Forestry, no. 114, University of Belgrade, Faculty of Forestry, p. 55-74.

Mitrović, S., Veselinović, M., Vilotić, D., Čule, N., Dražić, D., Nikolić, B., Nešić, M. (2011): Temporary deposited of deposol as the possible area for short rotation plantation establishment - model case, Sustainable Forestry, Collection 63-64, pp. 77-85

Renewable Energy National Action Plan of the Republic of Serbia, RS Official Gazette, No. 53/2013.

Decision on the Energy Balance Determination in the Republic of Serbia for 2018, Official Gazette of RS no. 119/17.

Spatial Plan of the Republic of Serbia 2010-2014-2021, Draft, CD.

Ratknić, M, Rakonjac, Lj., Veselinović, M. (2007): Sustainable use of forests and forest ecosystems - the state of indicators in Serbia. Institute of Forestry Proceedings, 56, Belgrade, pp. 29-56.

Regional Spatial Plan of the Autonomous Province of Vojvodina by 2020, Official Gazette APV no. 22/2011, 2011.

Statistical review of world energy, 2016, http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

Statistical Yearbook of the Republic of Serbia, Statistical Office of the Republic of Serbia, 2017.

Energy Sector Development Strategy of the Republic of Serbia for the period by 2025 with projections by 2030.

Study of the establishment of intensively managed forest plantations for energy and other purposes with the Manual on their establishment, Institute for Forestry, Belgrade, on request of the Forest Directorate, 2016.

Vasiljević, A. (2015): The impact of the wood market on the socio-economic component of the sustainable development of the wood sector in Serbia. Ph.D. thesis, University of Belgrade, Faculty of Forestry, Belgrade, 1-224.

http://www.crops4energy.co.uk/interested-in-growing-woody-energy-crops-free-rokwood-training-course/#!lightbox/2/

https://www.eevrbas.org/korisni-saveti/grejanje/81-grejanje-biomasom

https://www.energetskiportal.rs/obnovljivi-izvori-energije/biomasa/

IMPROVING THE USE OF FOREST-BASED BIOMASS FOR ENERGY PURPOSES IN SERBIA

Ljiljana BRAŠANAC-BOSANAC, Tatjana ĆIRKOVIĆ-MITROVIĆ,
Saša EREMIJA, Snežana STAJIĆ, Aleksandar LUČIĆ

Summary

In the last few years significance of biomass started to grow again, due to exhaustion of fossil fuel reserves and their negative impact on climate and environment. Utilization of biomass in the political context of the modern world enables countries to increase their energy independence. In the Balkans, biomass is the most significant renewable energy source, due to abundance of forests and agricultural areas. Despite its great potential, the use of wood biomass in Serbia has not been efficient. Significant amounts of wood residue produced in the course of tree felling and timber assortment production are left unused in forests. Of the registered biomass potential, about 1.67 Mtoe is derived from agriculture and food processing industry, while forest-based biomass accounts for 1.53 Mtoe. Intensive use of forest biomass requires the establishment of system measures for control and supervision in the chain of use as well as the adaptation of the planning and forest management pattern. On this moment in Serbia legislative and regulatory frameworks and support mechanisms aimed to increase the usage of biomass and other renewable energy sources are developing. Investors interested in biomass utilization in district heating (DH) systems and combined heat and power (CHP) plants are also present. However, despite all potential and advantages of biomass and the existence of potential investors, we cannot be satisfied with the level and modes of utilization for energy production in Serbia. It is necessary that wood and wood biomass be given the right importance, not only in energy balances and official consumption analyses in Serbia but also in the application of methods for estimating its consumption. It must not be allowed for the increase of woody biomass demand to lead to the increased pressure on forests and exceeding of allowed cuts. In that case, positive effects of biomass use on one side could lead to the degradation of forests on the other. In order to improving the use of forest-based biomass for energy purposes in Serbia it is necessary to adopt relevant measures existing in other European countries and the regulations harmonized among decision makers in the fields of agriculture, forestry, energy and environmental protection.

UNAPREĐENJE KORIŠĆENJA BIOMASE IZ ŠUMARSTVA U ENERGETSKE SVRHE U SRBIJI

Ljiljana BRAŠANAC-BOSANAC, Tatjana ĆIRKOVIĆ-MITROVIĆ, Saša EREMIJA, Snežana STAJIĆ, Aleksandar LUČIĆ

Rezime

Zbog iscrpljivanja rezervi fosilnih goriva i njihovog negativnog uticaja na klimu i životnu sredinu, korišćenje biomase poslednjih nekoliko godina opet privlači pažnju javnosti. Korišćenje biomase u političkom kontekstu savremenog sveta omogućava državama da povećaju energetsku nezavisnost. Na Balkanu, biomasa je najznačajniji obnovljivi izvori energije, zbog obilja šuma i poljoprivrednih površina. Uprkos velikom potencijalu, upotreba drvne biomase u Srbiji nije bila efikasna. Značajne količine drvnog ostatka nastalog pri seči drveta i proizvodnji drvnih sortimenata ostaju neiskorišćene u šumama. Od registrovanog potencijala biomase, oko 1,67 Mtoe proizilazi iz poljoprivredne i prehrambene industrije, a biomasa zasnovana na šumama čini 1,53 Mtoe. Intenzivna upotreba šumske biomase zahteva uspostavljanje sistemskih mera za kontrolu i nadzor u lancu korišćenja, kao i prilagođavanje šeme planiranja i upravljanja šumama. U Srbiji se trenutno radi na unapređenju zakonodavnih i regulatornih okvira i mehanizama podrške sa ciljem povećanja upotrebe biomase i drugih obnovljivih izvora energije. Postoje i potencijalni investitori zainteresovani za korišćenje biomase u sistemima daljinskog grejanja (DH) i kombinovanim toplotnim i energetskim postrojenjima (CHP). Međutim, uprkos svim potencijalima i prednostima biomase i postojanju potencijalnih investitora, ne možemo biti zadovoljni nivoom i načinima upotrebe za proizvodnju energije u Srbiji. Neophodno je da se biomasi iz šumarstva da pravi značaj, ne samo u energetskim bilansima i službenim analizama potrošnje u Srbiji, već i u primeni metodologije za procenu njene potrošnje. Ne sme se dozvoliti povećana potražnja drvne biomase dovede do povećanog pritiska na šume i prekomerne seče. U tom slučaju, pozitivni efekti upotrebe biomase sa jedne strane mogu dovesti do degradacije šuma s druge strane. Da bi se unapredilo korišćenje biomase iz šumarstva u energetske svrhe u Srbiji, potrebno je usvojiti relevantne mere koje postoje u drugim evropskim zemljama i prateće propise usaglašene među donosiocima odluka iz oblasti poljoprivrede, šumarstva, energetike i zaštite životne sredine.

INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD

SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION 77-78, 2018 ZBORNIK RADOVA 77-78, 2018

UDK 005.574:630
UDK 316.485.6:630
Original scientific paper

ATTITUDES OF EMPLOYEES ABOUT CONFLICTS IN THE FORESTRY SECTOR

Zoran PODUŠKA[1], Vlado ČOKEŠA[2], Ivana ŽIVANOVIĆ[3]

Abstract: *The paper presents the research results on conflicts in the forestry sector. The theoretical framework of the research is based on the belief that conflicts are a universal phenomenon. The basic constituents of conflicts are elements and aspects. The elements of conflicts are the substance, processes and relations between participants, which affect the social, cultural, institutional and economic aspects. They also include the aspect of natural resources, which is a feature of the forestry sector. Such a theoretical framework gave grounds for the analysis of employees' opinions about the type and significance and the stage in which the observed conflicts were. The opinions of the people employed in enterprises and organizations benefiting from state forests, protected areas and administrative state bodies in the forestry sector were collected through a survey. The data collected were processed using descriptive statistics. A lot of conflicting situations were identified and they were classified into 10 groups. The most serious one is the conflict between regular measures and works in the forest of nature protection. Nine participants were identified in these conflicts. It was found that some conflicts had been resolved, while some were in the latent phase, with the possibility to escalate.*

Keywords: conflict, forestry, nature protection

STAVOVI ZAPOSLENIH O KONFLIKTIMA U SEKTORU ŠUMARSTVA

Izvod: *U radu su prikazani rezultati istraživanja konflikta u sektoru šumarstva. Teorijski okvir istraživanja baziran je na stavu da su konflikti opšta pojava. Sastavni*

[1] Dr sci Zoran Poduška, Institute of Forestry, Kneza Višeslava 3, Belgrade, Serbia; e mail: Zoran.Poduska@gmail.com, phone: +381628838025 – corresponding author
[2] Mr Vlado Čokeša, , Institute of Forestry, Kneza Višeslava 3, Belgrade, Serbia
[3] Dipl. eng. Ivana Živanović Radovanović, Institute of Forestry, Kneza Višeslava 3, Belgrade, Serbia

delovi konflikta su elementi i aspekti. Elementi su:suština, proces i relacije između učesnika, koji utiču na društveni, kulturološki, institucionalni iekonomski aspekt uključujući i aspekt prirodnih resursa što je karakteristika sektora šumarstva. Takva teorijski okvir omogućio je analizu stavova zaposlenih o vrsti i značaju i fazi u kojoj se nalaze opaženi konflikti. Stavovi zaposlenih u preduzećima i organizacijama korisnicima državnih šuma, staraocima zaštićenih područja i upravnim državnim organima iz sektora šumarstva, prikupljeni su anketnim upitnikom. Podaci su obrađeni deskriptivnom statistikom. Utvrđeno je dapostoji više konfliktnih situacija koje su svrstane u 10 grupa.Najznačajniji je koflikt između redovnih mera i radova u šumi izaštita prirode. Uočeno je devet učesnika u konfliktnim sutuacijama. Utvrđeno je da su neki konflikti rešeni, dok su neki u latentnoj fazi, gde se može očekivati eskalacija.

Ključne reči: konflikt, šumarstvo, zaštita prirode

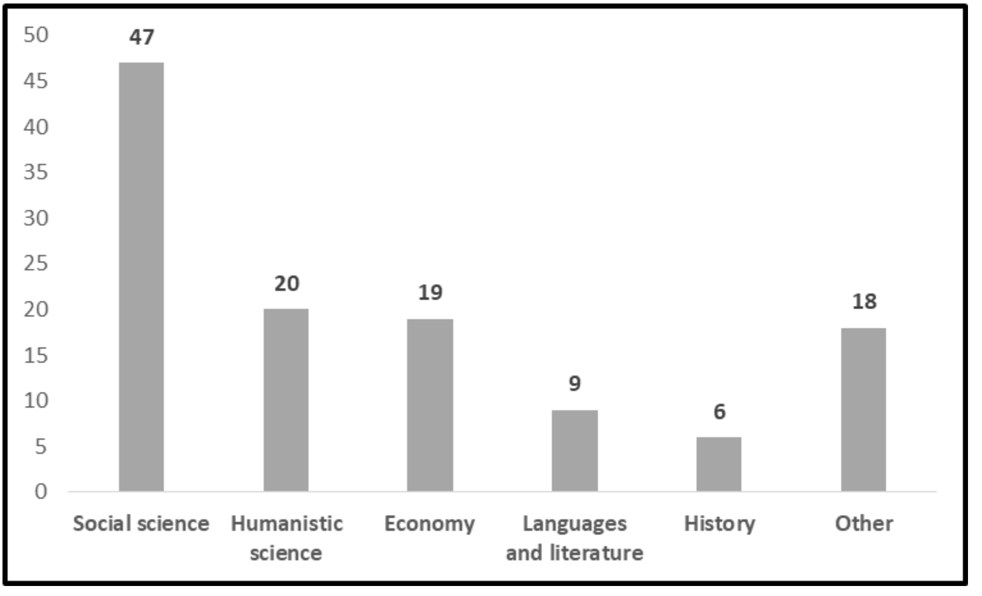
1. INTRODUCTION

Conflicts are as old as mankind. They are a general phenomenon that can occur in all life situations. Conflicts refer to a state of disagreement between individuals or groups of people, and they can be either destructive if they disturb the successful functioning of an individual, group or organization or constructive if they produce new ideas that can lead to the resolution. The absence of a conflict can be considered problematic as it indicates that the decision-making is centralized and there is only one `truth` or that only one party is right (Hellström 2001).

According to “Vujaklija” Dictionary (1986), the word conflict is derived from the Latin word “conflictus” which means disagreement, collision, struggle, dispute, quarrel. For the purpose of this research, conflicts are defined as situations in which mutually dependent parties with opposing interests and goals act in a way that one party interferes with the actions of the other party (Hellström 2001). This definition contains the concepts of awareness, opposition, disturbance, and indicates that the conflict is intentionally provoked. Commonly used terms to express the concept of `conflict` are struggle, pressure, opposition, aspirations, beliefs, interdependence, interaction, cooperation, rivalry, competition.

Scientific and professional literature views the conflict as an important factor of social and political change. By searching the Serbian citation index (SCIndex), 119 articles containing the term “conflict” were found (2010) and present in graph1.

Conflicts in the sector of forestry have been a topic of research in Serbia. So far, the sources of conflict have been identified in the forestry and environmental protection legislation (Poduška *et al*. 2008). Similar research studies point to environmental conflicts (Vuković 2008), analyzing conflicts over water. Malobabić (2003) points to environmental conflicts in rural areas by disputing the common opinion that rural areas are better-preserved environments. The autochthonous and healthy living environment of the village has been increasingly harmed by intensive farming based on chemical fertilizers and mechanization. On the other hand, villages still don`t meet the utility standards, especially the ones related to water supply and drainage. Villages are also endangered by the traffic overload of public roads and inadequate house construction induced by the increasing demands of rural renewal.

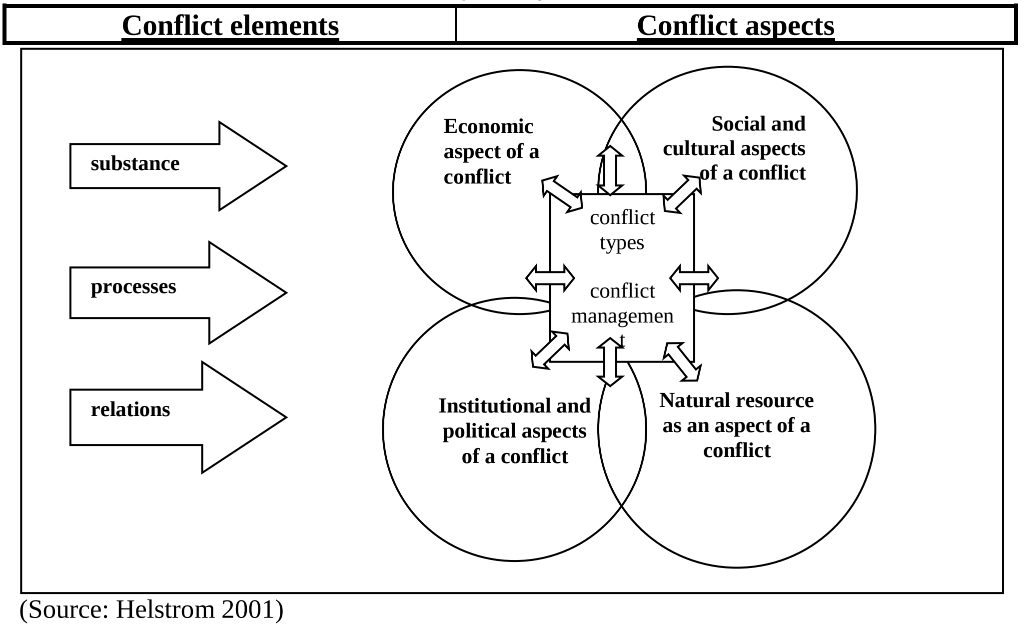


Graph 1. ***The number of articles in SCIndex containing the term `conflict` (2010)***

The conflict between agriculture and the environment (Jevtić, Mirić 1991) was provoked by the market and social changes. It has been then escalating due to the growing demand for food, technological changes and the lack of alternative job offers in rural areas. `It caused degradation of natural resources through deforestation, devastation and disturbance of the biological balance, as well as various types of pollution and contamination of the environment "(*ibidem*). Inadequate municipal waste management is a very common conflict in the territory of Serbia (Nenković-Riznić *et al*., 2009). Municipal waste affects the quality of water (Nikolić *et al*. 2010) and solid packaging becomes an environmental concern (Lazić *et al*. 2009). Due to the improper waste management, pollutants are released in the air, water and soil, which has adverse effects on human health and the environment (Šiljić *et al*. 2009, Curić 2009). Conflicting situations in protected natural resources are rooted in the technological development and entrepreneurial initiatives of private forest owners in national parks. The needs of rural and regional development opposed to the protection of nature in national parks can also be identified. (Grujičić *et al*., 2008, Milijić *et al*. 2009). Conflicts are also the consequence of spatial-environmental problems of industrial cities in transition (Spasić *et al*. 2009, Miletić *et al*., 2009).

The theoretical basis was found in “conflict triangle” (Walker, Daniels 1997) which enables us to recognize a conflicting situation by analyzing at least one of three conflict elements: the substance, the processes or the relations. This theoretical basis provides an analytical framework for data collection and analyze which can be applied in the forestry sector (Hellström 2001). Figure 1 shows the analytical framework of the research of conflicts in the forestry sector.

Figure 1. *The analytical framework for collecting and analyzing data on conflicts in the forestry sector*



(Source: Helstrom 2001)

This analytical framework implies that each conflict consists of elements (substance, processes and relations) and different aspects of the conflict that determine the approach to conflict management. It has been noted that the relations are often so complex that prevent the conflicting situation from being resolved, but at the same time provide the basis for mediation and prevent further escalation. This analytical framework is suitable for the categorization and description of data on conflicts in the forestry sector. However, it does not provide an opportunity to define individual conflict situations (Hellström E. 2001).

Based on the adopted analytical framework, the aim and the purpose of the research were defined. The aim of the research was to identify the types of conflicts, the participants and the state of the observed conflicting situation. The purpose of the research was to get a deeper insight into the causes of conflict, the participants in the conflict, and the conflicting situation management and resolution.

3. RESEARCH METHODS

This research into the conflicts in the forestry sector applied the quantitative research approach, which involves the use of general and specific scientific methods (Šešić 1984; Mihajlović 2004; Miljević 2007). The statistical method, *i.e.*, descriptive statistics was the general method used in the research. The purpose of this method was to collect and process data that can be expressed numerically. Specific methods included analysis, synthesis and generalization. Both primary and secondary data were collected. Primary data were collected through a survey. The population consist employees in from state forest enterprises, protected area managing companies and institutions engaged in the improvement of the natural resources management. To be more precise, the population included experts from state forest enterprises (SE) and forest governance institutions (Table 1). The sample consisted of employees in managerial positions or in the leading positions of respective organizational units. It included 160 experts in the field of forestry and nature protection. Respondents were interviewed using the Dillman survey method (Dillman 2007). Out of 160 surveys sent 109 were returned, which makes the return rate 68%. The structure of respondents is shown in Table 1.

Table 1. *Distribution of the surveys sent and returned*

Enterprise/Institution	**Sample** (number)	**Returned surveys** (number)	**Sample** (%)
SE "Srbijašume "and SE "Vojvodinašume"	142	98	69
Institute for Nature Conservation	3	3	100
National parks „Tara", „Kopaonik", „Đerdap", „Fruška gora"	9	7	78
Forest Directorate	6	1	17
Total	**160**	**109**	**68**

Source: Author

The questionnaire had the following parts:

- introductory text (intended for respondents). It described the research, provided information on the authors and the purpose of the research and reminded the respondents that their attitudes and answers would be completely anonymous;
- questions. Questions were the central part of the survey. They had their structure and position in the questionnaire. According to the structure of the questions, they were divided into i) introductory questions related to the age of the respondents, their education and work experience; ii) questions related to the types, intensity and frequency of conflict; iii) questions related to the management of conflicting situations and suggestions for the development of legislation and institutions in the forestry sector.

The survey was tested before its implementation. It was tested on a smaller group from the population. It was checked whether the respondents understood the questions and whether they were familiar with the topic of conflicts. Simple language was used without incomprehensible phrases and foreign words and expressions. Secondary data were obtained from professional and scientific literature and internet sources.

4. RESULTS

Through the analysis of the responses, we identified the type and significance of conflicts, the participants and the conflict stage. The third group questions reflected the views of the respondents on the type and significance of conflicts. Question 3 was an open-ended question where the respondents defined conflicts in forestry. The answers were encoded and grouped into 11 groups. They are shown in Table 2.

Table 2. *Types of conflicts*

Code	Code meaning / Conflict Type and Significance	%
0	No answer, I don`t know/ I don`t want to answer	21
1	Regular forest measures and works vs. property rights, cadaster, restitution of property to religious communities	19
2	Regular forest measures and works vs. disposal of financial resources, accounts ad encashment	3
4	The impact of politics on the profession	5
5	Forestry vs. Military polygons	3
6	Users (managers) vs. contractors/ other forest users	9
7	Non-compliance with spatial plans	4
8	Regular forest measures and works vs. nature protection	23
9	Forestry vs. tourism	3
10	Regular forest measures and works vs. legislation	6
13	Illegal logging	3
Total		**100**

Source: Author

The relationship between regular forest measures and works and nature protection in protected areas (code 8) was emphasized as the most significant one (23%). According to attitudes of 19% of respondents the conflict over property rights, including the restitution of forests to religious communities (code 1) were ranged on second place. The third most significant (9%) was the conflict between the users of state forests or the managers of protected areas and contractors as well other forest users (code 6). These conflicts included disagreements with other forest users over tree cutting, production and transport of timber assortments and road maintenance as well as grazing and acorn collection. The opinion that there were disagreements over the implementation of regular forest measures and works and the legislation in the broadest sense (code 10) was given by 6% of respondents, while 5% of respondents considered found the impact of daily politics and political organizations conflicting (code 4). According to the frequency of responses, the fifth group of conflicting situations included: non-compliance with spatial plans (code 7, 4%), illegal logging (code 13; 3%), disposal of financing resources (code 2, 3%), and forest and forest land use at sites of military polygons (code 5, 3%), as well as the impact of tourism, including the construction of ski tracks at sites managed by SE (code 9, 3%). No response was given by 21% of respondents, which can be interpreted that they either did not want to answer or did not encounter any conflicting situations at work.

Question 3b. defined the participants in the conflict (Table 3). There were three fields for the response so that the respondent could name more than two participants in the conflict.

State enterprises for forest management (code 1) are the most frequent participants in the forestry sector conflicts (44%).

Table 3. *Participants in the forestry sector conflicts*

Code	Institution	%
0	No answer	17
1	State forest enterprises	44
2	Institute for Nature Conservation	8
3	Courts	1
6	Resposible Ministries	5
9	Religious communities	2
10	Private Forest Owners / local population	5
11	Non-Governmental Organizations	5
12	Local self-government	5
14	Other enterprises managing protected areas	7
TOTAL		100

Source: Author

According to the responses, the Institute for Nature Conservation (8%) and other enterprises of protected area management (7%) make up the second group of participants in conflicts. The third group of conflict participants which accounts for 5% of the responses includes local self-governments, line ministries, NGOs and private forest owners or the local population. The share of religious communities as participants in the forestry sector conflicts amounts to 2% and these conflicts are due to the restitution processes initiated by the Church on the basis of the Law on Return of Property to Churches and Religious Communities (Off. Gazette 46/06). Courts account for 1% of all participants in conflicts.

The stage of conflict was examined by question 3c, where 5 responses and four graded stages of conflicts were given. The results are shown in the table.

Table 4. *The stage of the conflict*

Code	The stage of the conflict	%
0	No answer/ I don`t know	20
1	Latent conflict	9
2	Occurring	49
3	Escalating	16
4	Solved	6
Total		**100**

Source: Author

The respondents believe that the conflicts are most often (49%) in the ”occurring” stage, which indicates that they are visible, in contrast to latent conflicts (9%), which are not obvious. Respondents believe that there are 16% of escalating conflicts with an increasing level of disagreement between the participants. The resolved conflicts account for 6% of all conflicts. A fifth of the respondents did not give a response to the question, which can mean that they either did not want to answer it or they did not encounter a conflict or any of its stages.

5. DISCUSSION AND CONCLUSIONS

Forests are a renewable natural resource that provides numerous functions. These functions are mostly interrelated, but sometimes they can be congflicting too. These conflicting functions occurring at one site make forestry a specific economic activity. The most common and at the same time most opposing functions are the production and the protection ones. Out of the total area of state forests, production forests account for 63.16% compared to the protection forests that cover 36.18% of forest land (Medarević M. 2008). Forests should be exploited in such a way and scope that don't disturb their biodiversity, productivity, renewability, vitality and the potential to perform environmental, economic and social functions in the present and future. These requirements are included in the strategies and laws in the field of forestry and the environment. A large number of laws and by-laws, as well as different management objectives that are often complementary but sometimes competitive and conflicting, inevitably lead to the cohesion or collision in the sector. The impact of local population and non-governmental organizations, as well as private forest owners and other forest users, should not be neglected. Requirements for the use of natural resources are often in opposition with the nature protection tendencies. Tree felling and utilization of forests and forest lands are constantly spotlighted by the general public, media, experts and researchers. Any disagreement over the use of natural resources leads to a conflicting situation. In this regard, it was entirely justified to carry out a survey in which forest users and forest owners would express their views on observed conflicts. It was found that conflicts were present in the forestry sector. A large number of users and owners of forests as well as managers of protected natural resources brings about overlapping interests. Property rights are a source of various conflicts between state forest users and private forest owners and between state-forest managing companies and institutions with overlapping competencies. National parks are a good example of a place where common user interests meet, overlap, and often conflict with the interests of other organizations and private-forest owners. This state of affairs is a research challenge with the aim of analyzing and describing mutual relations. Conflicts are sensitive topics that are difficult to understand and describe.

The common characteristics of the applied theory and the current situation in Serbia were observed. The obtained research results can be further interpreted based on the applied theory. In this regard, it can be pointed out that the conflicts are related to the lack of information, as well as wrong information and different interpretations of the available data. A lot of conflicts between forestry and nature protection are determined by the economic aspect. Owners or users of natural resources have the right to offer their property on the market, regardless of the category of protection or ownership relations. The economic aspect is inseparable from the political one since the sectoral policy decisions aim to reconcile the use of forests with the obligation to protect forests. The socio-cultural aspect indicates that the value of the forest is difficult to measure and compare with economic benefits. The forest is traditionally valued for its great importance for the owner or community. The parties in conflict have different scales of evaluation. What one party finds rational, the other one may find irrational. Natural resources are often a source of conflict. The reasons lie not only in the availability and sustainability of the resources but also in the social milieu and cultural heritage, economic and political situation, differences in people`s opinion and expectations. The issue of ownership and legal property rights may often be a source of conflict. In forestry and nature protection, disagreements, conflicts and disputes occur between individuals, organizations and institutions dealing with forest management and those who manage protected areas.

A conflict can be managed and a conflicting situation solved only if all stakeholders are involved in decision making and the creation of long-term management plans (Niemela, J. *et al*., 2005). This is also indicated by the fact that there are 6% of resolved conflicts and 9% of the latent ones that we can consider to be upcoming, *i.e.* that can manifest in the future.

This research provided a better understanding of conflicts in the forestry sector. It was found that despite the existence of conflicting situations, they are viewed from different and often opposing stands. This means that the interpretation of the research results should rather provide an insight into the expert views on the observed conflicts, rather than means of controlling participants in conflicts. Future research should answer the question of how conflicts should be managed, whether they should be prevented or promoted and openly faced with.

LITERATURE

Curić, E. (2009). Problemi u odlaganju čvrstog komunalnog otpada u Novom Pazaru. Nauka + Praksa, 12(1), 13-17.

Dillman A. D., 2007: Mail and internet surveys – the tailored design method. Wiley, New York, 523.

Helström E., (2001). Conflict Culture – Qualitative Comparative Analysis of Envoronmental Conflicts in Forestry, Silva Fenica, Monographs 2, 109.p.

Jevtić, M., Mirić, M. (1991). Osnovne smernice agroekološkog razvoja u svetu i Jugoslaviji. Ekonomika poljoprivrede, 38(9), 441-448.

Lazić V., Gvozdenović, J., Popović, S. (2009). Ambalaža između potrebe i ekoloških problema. Časopis za procesnu tehniku i energetiku u poljoprivredi / PTEP, 13(3), 226-228.

Malobabić R. (2003). Problemi zaštite životne sredine u ruralnim područjima. Ecologica, 10(39-40), 61-70.

Medarević M., Banković S., Šljukić B., (2008). Održivo upravljanje šumama u Srbiji - stanje i mogućnosti. Glasnik Šumarskog fakulteta, (97), 33-55.

Mihajlović D., (2004). Metodologija naučnih istraživanja. Beograd, Fakultet organizacionih nauka.

Milanović-Trailović M. (2009). Poslovanje na berzi i sudski sporovi. Pravo i privreda, 46(5-8), 528-542.

Miletić R., Miljanović D., Todorović M. (2009). Industrijski gradovi u tranziciji - problemska područja. Glasnik Srpskog geografskog društva, 89(3), 191-206.

Milijić V., Nonić D., Grujičić I., (2009). Vlasnici privatnih šuma i upravljanje zaštićenim područjima - nacionalni park Đerdap. Zaštita prirode, 60(1-2), 97-106.

Miljević M. (2007). Skripta iz metodologije naučnog rada. Pale, Univerzitet u Istočnom Sarajevu Filozofski Fakultet.

Nenković-Riznić M., Pucar M., Simonović S. (2009). Regionalni koncepti zaštite životne sredine i upravljanja otpadom na primerima Južnog Pomoravlja. Arhitektura i urbanizam, (26), 77-87.

Poduška Z., Rakonjac Lj., Gagić R., Petrović N., Čokić D., (2008). Stavovi prema regulativi šumarstva i životne sredine - pristup studije slučaja u Srbiji. Sustainable Forestry: Collection, (57-58), 124-136.

Niemela J., *et al*. (2005). Identifying, managing and monitoring conflicts between forest biodiversity conservation and other human interests in Europe, Elsvier, Forest Policy and Economics 7.

Nikolić V., Nikolić B., Sekulić L., Milovanović D., (2010). Kvalitet vode reke Ralje u gornjem i srednjem toku. Ecologica, 17(57), 48-52.

2010. Srpski citatni indeks. pristupljeno 18.12.2010. na adresi http://scindeks.nb.rs/.

Šešić B. (1988). Opšta metodologija. Beograd, Naučna knjiga.

Šiljić A., Ružić J., Knežević M., Maksimović A., Pocajt V., Ristić M. (2009). Očuvanje prirodnih resursa reciklažom materijala iz komunalnog otpada. Ecologica, 16(54), 169-172.

Spasić N., Džunić G., Đurđević J., (2009). Konflikti i ograničenja u prostornom razvoju rudarskih basena. Arhitektura i urbanizam, (27), 20-34.

Vuković M. (2008). Identifikacija konflikta oko vode i njegovo razrešenje. Facta universitatis - series: Philosophy, Sociology, Psychology and History, 7(1), 81-93.

Walker G.B., Daniels S.E., (1997). Foundation of natural resource conflict: Conflict theory and public policy. In Solberg B, and Miina S,, (eds.) Conflict management and participation in land management (pp 7–36). European Forestry Institute Proceeding No. 14. Joensuu. Finland.

ATTITUDES OF EMPLOYEES ABOUT CONFLICTS IN THE FORESTRY SECTOR

Zoran PODUŠKA, Vlado ČOKEŠA, Ivana ŽIVANOVIĆ

Summary

Conflicts are as old as mankind. They are a general phenomenon that can occur in all life situations. Conflicts refer to a state of disagreement between individuals or groups of people, and they can be either destructive if they disturb the successful functioning of an individual, group or organization or constructive if they produce new ideas that can lead to the resolution. The theoretical basis was found in "conflict triangle" which enables us to recognize a conflicting situation by analyzing at least one of three conflict elements: the substance, the processes or the relations. Primary data were collected through a survey. It included 160 experts in the field of forestry and nature protection. It was found that there are 11 types of conflicting situations. The most important conflict is between regular measures and works in forest and nature protection. A conflict can be managed and a conflicting situation solved only if all stakeholders are involved in decision making and the creation of long-term management plans. This is also indicated by the fact that there are 6% of resolved conflicts and 9% of the latent ones that we can consider to be upcoming, *i.e.* that can manifest in the future.

STAVOVI ZAPOSLENIH O KONFLIKTIMA U SEKTORU ŠUMARSTVA

Zoran PODUŠKA, Vlado ČOKEŠA, Ivana ŽIVANOVIĆ

Rezime

Konflikti su stari koliko i čovečanstvo. Opšta su pojava, koja se može dogoditi u svim životnim situacijama. To je stanje neslaganja između pojedinaca ili grupa ljudi, mogu biti destruktivni – koji ometaju uspešno funkcionisanje pojedinca, grupe ili organizacije ili konstruktivni kada se uočavanjem problema uvode nove ideje za njihovo rešavanje. Teorijska osnova nađena je u „konfliktnom trouglu“ gde je moguće prepoznati konfliktnu situaciju analizirajući bar jedan od elemenata konflikta: suštinu, proces ili relacije. Primarni podaci prikupljeni su putem anketnog upitnika. Uzorak se sastojao iz 160 stručnjaka u oblasti šumarstva i zaštite prirode. Utvrđeno je da postoji 11 tipova konliktnih situacija. Najznačajniji konflikt je između redovnih mera i radova u šumi i zaštite prirode. Upravljanje konfliktom u cilju rešavanja konfliktne situacije moguće je uključivanjem svih zainteresovanih strana u donošenju odluka i izradi dugoročnih planova gazdovanja. Na to nam ukazuje i rezultat da postoji 6% rešenih konflikta, ali i 9% latentnih koji možemo smatrati nadolazećim, odnosno koji mogu da se manifestuju u budućnosti.

A GUIDE FOR WRITING RESEARCH PAPER

SUSTAINABLE FORESTRY is a scientific journal in which are published research papers of forestry scientific disciplines, environmental protection, wood processing, landscape architecture and horticulture and environmental engineering (Erosion Control).

PAPER TITLE IN ENGLISH 11 points, bold

PAPER TITLE should be written with capital letters (**bold**), Font Size 11, centered on the page. Title should be 11 Enter keystrokes below the top margin, and the writing should be started in the fifth row.

11

Name and FAMILY NAME[1] 11 points, italic

Name and the family name of the authors should be written in capital letters (normal), Font Size 11 points italic, centered on the page, with single line spacing below the paper title. With mark 1, in superscript (with command Insert Footnote), above the name of the last author is marked a Footnote in which are indicated title, name and family name, occupation and institution in which some of authors are employed.

11

11

11

Abstract: *The abstract is written in English, Font size 10 points, italic, Justify, with three spaces below the name of the paper author. In abstract are given basic aim of research, materials and methods, more important results and conclusion (maximum 500 characters).*

11

Key words: in English 10 points, normal, minimum 3, maximum 6 words. Below the abstract, Font Size 10 points, normal.

11

PAPER TITLE IN SERBIAN 11 points, bold

11

Abstract: *Text of the abstract in Serbian, 10 points, italic*

11

Key words: in Serbian 10 points, normal

11

The journal **SUSTAINABLE FORESTRY**, which is published at least once a year, publishes original scientific papers, review papers and short communications. The paper should be, in whole, written in English, and Abstract and Summary should be written in English and Serbian. The paper length,

---

[1] Footnote (Insert Footnote):
1Title, name and family name with addresses of all authors.
Author for correspondence: Name and family name, address, phone, e-mail.
* If the paper is a part of a research within a project in acknowledgement are indicated: name of the project, registration number and the full name of the institution that finances the project.

including tables, graphs, schemes, pictures and photographs can have maximum 6 typewritten pages, A4 format (Portrait), with normal line spacing (Single Space). Margins: Top 1.5 cm, Left 1.5 cm, Bottom 1.5 cm, Right 1.5 cm, Gutter 0.5 cm. The text of the manuscript should be typed using Times New Roman font, 11 points. Justify align (Format → Paragraph → Indents and Spacing → Special → First Line 0.0). Without pagination (the system of numbering pages). LAYOUT: header 0.5 cm, footer 0.5 cm. PAPER: width 16,5 cm, height 24 cm. In every new line the size of a Tab is 1.27 cm.

CHAPTER TITLE 11 points, bold

11

The paper should be typed by the guide for writing research paper, in *Word* format, Roman alphabet, using exclusively the *Times New Roman* Font. Successive blank spaces are not to be used for text alignment; instead, ruler alignment control tool and Toolbars are suggested. Only one space follows after any punctuation mark. If special signs (symbols) are used in the text, use the *Symbol* Font.

11

2.1 Subchapter title 11 points, bold

1. INTRODUCTION (**bold**), title left on the page, Font Size 11 points.

11

Text normal, Justify, with single line spacing below the title.

The introduction should be a short review of explanation about reasons that led to the research of specific scientific issue. The introduction contains reference data of published papers that are relevant for the analyzed issue.

11

Subchapter text, 11 points, normal

11

Table 1. 11 points, bold *Table title,* 11 points, italic

	Font size in Tables is 8		

11

Continuation of the text, 11 points, normal

11

Graph 3. 11 points, bold *Graph title,* 11 points, italic

11

Continuation of the text, 11 points, normal

11

Picture 2. 11 points, bold *Picture title,* 11 points, italic

11

Continuation of the text, 11 points, normal

2. MATERIAL AND METHODS (**bold**), title left on the page, Font Size 11.

11

Text normal, Font Size 11, Justify, with single line spacing below the title.

Within this chapter there can be subtitles of first and second line. In the description of material it should be given enough information to allow another researchers to repeat the experiment at a different location. It is necessary to provide information on the material, subject of the study that precisely defines its origin, physical characteristics etc. If a device or instrument is used to obtain experimental results should be specified: name of the device or instrument, model, manufacturer's name and country of origin. If a scientifically recognized method is used it has to be cited in the References, without the explanation of the steps of the used method. If changes were made in a scientifically recognized method should be provided the original literature references that will support –justify those changes.

3. RESULTS (**bold**), title left on the page, Font Size 11.

Text normal, Font Size 11, Justify, with single line spacing below the title.

Within this chapter there can be subtitles of first and second line. The paper results should be presented in the form of text, tables, pictures (diagrams) and, rarely, photographs. From the results should be clear whether the hypotheses have been confirmed or disproved and whether the aim and tasks have been achieved. It should not be avoided the presentation of the negative results or disproving the hypotheses.

4. DISCUSSION (**bold**), title left on the page, Font Size 11.

Tekst normal, Font Size 11, Justify, with single line spacing below the title.

Discussion should not be the simple repeating of obtained results. The results should be discussed by comparing them with the research results of other authors with compulsory citing of literature sources. It is very important to give discussion of the results and the opinion of the authors. Interpretation of perceived ambiguities and illogicalities should be correctly stated.

5. CONCLUSION (**bold**), left on the page, Font Size 11.

Tekst normal, Font Size 11, Justify, with single line spacing below the title.

Conclusions of the paper should be carefully carried out and shown clearly to the reader. Conclusions can be significantly connected with the result discussion, but in them should be given freer and wider interpretation of the paper subject and results. The special quality is the defining of suggestions for future work and identifying the issues need to be resolved.

11

REFERENCES 11points, bold

11

Cite Literature by Guide, Font 10 points

Janković, Lj. (1958): Contribution to the knowledge of gypsy moth host plants in nature during the last outbreak, 1953-1957, Plant protection, 49-50: 36-39 (In original: *Janković, Lj. (1958): Prilog poznavanju biljaka hraniteljki gubara u prirodi u toku poslednje gradacije, 1953-1957. god. Zaštita bilja, 49-50: 36-39*)

10

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

10

SUMMARY – PAPER TITLE IN ENGLISH 10 points, bold

10

Name and FAMILY NAME 10 points, italic

10

Summary 10 points, bold

10

Summary text in English 10 points

10

PAPER TITLE IN SERBIAN 10 points, bold

10

Name and FAMILY NAME 10 points, italic

10

Summary 10 points, bold

10

Summary text in Serbian 10 points

Papers and all enclosures (photos, schemes, pictures and graphs) should be sent to the Editorial Board of the journal in three printed copies and on CD and e-mail.

In this text is given a detailed structured instruction for writing papers. Papers that do not meet the propositions of this guide will not be forwarded for review and will be returned to the author.

Categorization of papers (suggested by the author – determined by Editorial board taking into account the opinion of the reviewer):

Scientific Articles

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

Professional articles

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

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

Papers should be sent to:

Editorial board of the journal "Sustainable Forestry"
Institute of Forestry
Kneza Višeslava 3
11030 Belgrade

Or in Serbian:
Uredništvo časopisa "Sustainable Forestry"
Institut za šumarstvo
Kneza Višeslava 3
11030 Beograd

Tel.: 011/3553454