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PROTECTED AREAS - AS MAIN AND VERY IMPORTANT SPACE FOR BIODIVERSITY EVALUATION AND THEIR CONSERVATION

Etleva CANAJ[1], Elvana RAMAJ[2], Hajri HASKA[3], Eneida HASKA[4]*

Abstract: *In the diversity of pearl of the nature in Albania, known for its richness in particular underpin comprehensive biodiversity values, land and sea ecosystems, habitats and species of flora and fauna, which extend from the marine-coastal belt up to the field-montane and most in-depth, high in the mountains has a national and international importance. The high diversity of ecosystems and habitats offers rich habitats for a variety of plants and animals. This diversity is attributable to the country's geographic position as well as geological, hydrological, climatic, soil and relief characteristics.*
About 36% of the country's territory is covered by vegetation. There are still natural and semi-natural areas, where the degree of human intervention is almost absent or less sensitive. These areas, even preserve their true values of natural, both require special attention and care.

For these reasons, Albania as part of the Balkan region as an area of global importance for biodiversity, referred to as a hot-spot of global biodiversity and that attention to this region is required to be pronounced by competent institutions and the entire community.

Nature protection and biodiversity conservation is ensured through a number of legal and institutional mechanisms, which in Albania, especially in the last decade have taken a dimension oriented by principles stemming from international conventions in the field of nature and biodiversity. These mechanisms are already being further consolidate and being adapted to European Union standards.

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Key words: Albania, biodiversity, protected areas, ecosystem, human.

INTRODUCTION

Traditionally, one of the most effective and most widely used to achieve the objectives of nature conservation and biodiversity, is the establishment and management of protected areas. Nowadays protected areas plays an important role in supporting local, national and international policies for biodiversity. They also serve as a place for scientific research, conservation of wild flora and fauna, providing environmental services such as education, tourism and recreation, protection of natural and cultural features and sustainable use of biological resources. In these 20 years we have heard mentioned often phrase "biodiversity and protected areas". Unfortunately, only that, since the facts speaks otherwise. Their condition and care, are not at the level required. Awareness, civil behavior and concrete actions are completely lacking.

Biodiversity and protected areas are one of the greatest heritages that humanity can leave to future generations to ensure that our descendants have access to natural resources, material and immaterial benefits that they provide. However, biodiversity and protected areas exist in an environment which rapidly changing and facing with numerous challenges.

A number of issues are evident, which represent an opportunity and real threats to biodiversity and protected areas. Reflecting these, environmental pollution, damage to habitats and species, foreign types, fragmentation of natural landscapes, cutting forests, fires, hunting, grazing, overfishing, climate change, increased urbanization, construction without criteria, tourism irresponsible, infrastructure development, construction of hydropower plants, quarries, increasing the needs for natural resources, etc. and growing demand for land and water, initiated by the lusts of business unfriendly with nature and biodiversity.

In many cases such partnerships is extremely harmful for nature and biodiversity. Their destruction and alienation affects significantly to the development of the country. Such examples are numerous. While instant profits are fat, but later never will be so profitable, and never will be a valuable approach for future generations. So, such a partnership are contrary to sustainable development, balanced by socio-economic progress of the community, the uses of bio-natural resources, without respecting any management and uses standards.

MATERIAL AND METHODS

As in all sectors, even in the field of nature and biodiversity are being implemented several measures in the framework of the national plan for the implementation of the Stabilisation and Association Agreement between Albania and the European Union.

Thus, in the field of nature conservation are drafted a legislative package oriented by European legislation with 5 basic laws such as the Law “On Protection of biodiversity”, the Law “On Protected Areas”, the Law "On the rules and procedures for international trade of threatened species of wild fauna and flora ", the Law" On protection of wild fauna "and the Law" On hunting ", and a number of regulatory bylaws, in wich are approximated the main EU directives in the field of nature protection and for preserving wild birds and habitats.

RESULTS

Biodiversity and Protected Areas, containing some of the greatest values of the country from economic and ecological point of view, where except protective and guarantor of the diversity of the living world, serve as a source of existence, of material goods and income for the community. Already, the declaration of protected areas, not just selected territories with forests, pastures, but also agricultural areas, water lagoons, mountains, even populated, with a tradition of sustainable use of natural resources and an important activity socio-economic development. Knowledge of ecological values of biodiversity and put them under a protection status is a new development for all residents who live and develop their activities socioeconomic in respective areas.

Protected areas embody the important of cultural and historical values, some of them reflected traditional practices and sustainable use of land and natural resources as in the case of the national park "Butrint", which is included in the list of UNESCO World Cultural Heritage -s, (1992). Now the efforts carried out for the establishment of Transboundary Biosphere stocks for the Prespa-Ohrid region, approved in June 2014 by the UNESCO Secretariat as well as the approval of Lake Shkoder watershed.

Albanian Government in collaboration with all stakeholders and major donors, in the framework of national priorities, has taken several actions for natural conservation and biodiversity and to establish or expand protected areas in large areas, pristine or very few fragmented, with unique natural values or in the areas that are threatened or provide maximum protection of threatened species.

It compiled a list of invasive species, red list, legal framework for Stocktaking and monitoring of biodiversity. In Red Book recorded 405 species of flora and 575 species of wild fauna threatened status, ie a state of their own serious. While domestic and foreign scientists announce quite new discoveries species of wild flora and fauna of Albania.

For conservation and management of this natural resource based on the principle of sustainable development has been established a protected ecological network, with an area of 460 thousand ha or 15.5% of the national territory, among which we emphasize national parks as areas with special importance for biodiversity conservation and development, but also for ecotourism. The objective is that the surface of protected areas in 2020 to reach 17% of the territory and 10% of sea, reaching levels close to EU member countries.

For the values to carrying on life, health and human welfare, protection of nature, conservation of nature and biodiversity, to improve and promote the values of sustainable development, development of efficient bio service and the ecosystem in harmony with socio-economic, touristic and cultural developments etc., should be considered essential for Albania and the international community, and therefore the return of attention to the creation and support structures for the administration and management.

This problem is still not resolved properly decades. Donors have embedded to reform the administration of the PA, seeking their secession by the Forestry Service. Even reforms in Forestry sector, based on regions according to the law was not done in proper time and effectiveness since 2005.

"Representative network of protected areas requires a functional authority for the management and administration of protected areas. Along with the efforts to expand their surface, it was necessary to take measures to increase and strengthen the capacities of the respective management structures ", for this reason the Council of Ministers in February 2015 has approved the Decision on "Establishment of National Agency of Protected Areas", National Agency of Protected Areas will have a staff of 224 people, of whom 21 in the central office and 203 in the Regional Administration of the Protected Areas.

The agency has a duty to manage functional network of protected areas and other natural networks such as Natura 2000 under the management plans drawn up, monitor and inventory flora and fauna in these areas, and a very important aspect, generate income from services to others, and to use the proceeds to invest in the same areas. With this establishment of this structure Albania join the other Balkan countries, which already have such structures.

For the country's future integration challenges and leading efforts in the field of nature protection will be focused on the identification, evaluation and creation of Natura 2000 network, one of the major obligations in this area and as a comprehensive process that requires commitment and commitment of all specialists in the field. Good management of protected areas network is one of the current challenges of the MOU and the structures responsible. It is worth mentioning that in this national ecological network will work, among other things, for the identification, evaluation and mapping of special conservation areas, special areas of conservation, and areas of international importance for the European Community (Natura 2000). The process of establishing Natura 2000 network is an almost scientific process, even assessment that will make the European Commission identified areas will be made on the basis of scientific sessions that will take place.

The decade 2011-2020 was proclaimed by the General Assembly of the United Nations, as decades of Biodiversity, as a period that states and state structures and society to take measures for the conservation and sustainable use of biodiversity and natural values. As members of actions within this decade, European policy orientated in this field, Albania remains committed to pursue and implement the fulfillment of obligations for conservation of nature and biodiversity as a precious asset for the country.

CONCLUSIONS

Biodiversity and landscape diversity is not yet considered as a particular source of economic development and tourism. Endangering and the alienation of coastal and marine landscape, Ionian and Adriatic Riviera or and hilly landscape, mountain and rural, is not a smart solution. To Landscape, human behavior and especially the business are meaningless. We should work, for the community awareness and for the expand their participation in governance and decision-making for conservation of biodiversity and landscape, to strengthen the control and improvement of legality. Moreover, in many protected areas lacking political support, have insufficient financial and human resource.

Establishment of the Agency of the protected areas it was one of the challenge of the Government for better management of this areas. The Agency should manage network of protected areas, habitats and natural and semi natural species with conservation interest, obliged by national and international conventions and agreements.

Nature conservation policy, in collaboration with all stakeholders, should be based on principles of protection and sustainable use of natural resources, in partnership developments in order to provide a social prosperity, promotion and improvement of management system of nature and protected area with a new concept.

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- ✓ Amendment of the Law “On protected areas”, no. 9868, of 4.2.2008;
- ✓ Law “On international trade of endengered species of wild flora and fauna” no. 9867, of 31.1.2008;
- ✓ The red list of fauna and flora species approved by Ministerial Order in 2007.

The work has therefore advanced with the approximation of the legislation, namely the Habitats Directive by the amendment of the law “On Protected Areas”, of 2008 and two laws: “On wild fauna protection” of 2008 and “On Hunting’ of 2010 with the Wild Birds Directive.

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REDUCTION THE MECHANICAL PROPERTIES OF OAKWOOD UNDER THE INFLUENCE OF EPYXILOUS FUNGUS

Miroslava MARKOVIC [1], Snezana RAJKOVIC [1], Ljubinko RAKONJAC [1]

Abstract. *Within the scope of field research on diagnostics of harmful organisms in Serbia in the year 2015, in the area of Forest Estate Boljevac, the presence of epixylous fungus Coniophora puteana (Schumm. ex Fr.) Karst was found on dead oak trees following the icebreak. In order to give a more accurate forecast of prospective spread of the pathogen, i.e. determine the speed of the process, the laboratory of the Institute for Forestry conducted the testing of the rate of reduction of the oak tree modulus of elasticity after 2, 4 and 6 months of exposure to the fungus. Testing samples were collected from the medulla of healthy oak trees, from the association of Quercetum montanum. Over the periods of 2, 4 and 6 months the wood samples were exposed to influence of the mycelia of the fungus Coniophora puteana (Schumm. ex Fr.) Karst. After 2, 4 and 6 months under the effect of the fungus, the static modulus of elasticity of oak wood substantially decreased compared to the initial value (100%) and amounted to 61.07%, 60.61% and 51.38% respectively. The regression line obtained through data processing opened the possibility to prognosticate the changes of wood properties in certain time periods of the effect of the fungus under the unchanged external conditions, which is significant for practical purposes in terms of taking protective measures and wood usability.*

Key words: Modulus of Elasticity, *Coniophora puteana*

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СМАЊЕЊЕ МЕХАНИЧКИХ СВОЈСТАВА ДРВЕТА ХРАСТА ПОД УТИЦАЈЕМ ЕПИКСИЛНИХ ГЉИВА

Мирослава МАРКОВИЋ, Снежана РАЈКОВИЋ, Љубинко РАКОЊАЦ

Извод. *У оквиру теренских истраживања на пословима дијагностике штетних организама у Србији у 2015. години, на подручју ШГ Бољевац, на мртвом дрвету храста после ледолома, констатовано је присуство епиксилне гљиве Coniophora puteana (Schumm. ex Fr.) Karst. Да ширења овог патогена, односно утврдила брзина тог процеса, у лабораторији Института за шумарство, извршена су испитивања брзине смањења једног механичког својства дрвета (чврстоће на савијање) након 2, 4 и 6 месеци излагања дејству ове гљиве. Испитивања су вршена на здравом дрвету храста из асоцијације Quercetum montanum, након 2, 4 и 6 месеци излагања дејству Coniophora puteana (Schumm. ex Fr.) Karst. После 2, 4 и 6 месеци дејства гљиве, статичка чврстоћа на савијање храста у односу на иницијалне вредности (100%) износи 61,07%, 60,61% и 51,38%. Регресиона линија отвара могућност прогнозе промене својстава дрвета у одређеном времену дејства под утицајем гљива, при непромењеним условима спољне средине, што је веома значајно у практичној примени, особито приликом заштите дрвета у циљу очувања његове употребне вредности.*

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Кључне речи: чврстоћа на савијање, *Coniophora puteana*

1. INTRODUCTION

Development of the wood processing industry is causing growing demand for high-quality wood raw materials [14, 18]. This calls for preservation and extension of wood durability, which is directly linked to preservation of physical, chemical, mechanical, aesthetical and other properties, according to several authors [7, 8, 15, 21]. Basic structural constituents of wood (cellulose, hemicellulose and lignin) are distributed in different percentages in different species and parts of trees. There is thus more cellulose in soft than hard species of trees, in bolewood more than in branchwood, in early successional species more than in late ones, as discussed by Miric and Popovic [16].

Oak as a host is colonized by a large number of microorganisms, where a special place belongs to the research on impact of fungi, particularly those attacking the core (srcika) as the technically most valuable part of a tree [1, 3, 4]. Through its enzyme system, the epixylous fungi break down the constituents of wood cell walls, modify the percentage of their participation and thus directly induce changes of the wood properties [2, 6, 11]. The agents of brown prismatic rot (to which the researched fungus *C. puteana* belongs*)* disintegrate primarily cellulose, while the disintegration of lignin occurs in a far smaller extent.

This paper presents the course of alteration (decrease) of the presence of lignin in the cell wall, reflected in the decrease of wood bulk modulus of *Q. petraea* agg. under the influence of the fungus *C. puteana* after 2, 4 and 6 months of the incubation [26, 20, 17].

1.1. Basic Biological Features of the Fungus *C. puteana*

C. puteana most frequently occurs in humid rooms, such as basements, which is how it got its colloquial name. It often occurs in mines, warhouses, bridge constructions, pillars, attacking the timber of both coniferous and broadleaved species. It causes quick rot on decumbent trees that are not properly insulated. *C. puteana* is a saprophyte and the most widely distributed fungus in America and Europe causing wood decay in buildings, second only to *Merulius lacrymans* (Jacq.) Fr. (Syn. *Serpula lacrymans* Wulfen Fr.).

According to reference sources, the percentage of rot caused by this fungus in buildings in Europe has risen sharply over the last several years [19, 18]. This might be a consequence of a hard struggle against this fungus, given that it its highly resistant to antiseptics and hence among the organisms used in testing biological efficiency of wood protection agents. In forests it occurs on dead, fallen trees, causing typical brown rot which in the final stages of decomposition turns the tree almost black. Sometimes the rot may develop only in the inner part of timber so that the surface layers remain more or less intact. Cracks in trees caused by exposure to *C. puteana* are somewhat milder in the cross section, and although the tree does not disintegrate like under the influence of *M. lacrymans,* it does turn so fragile and brittle that it breaks when touched. In addition to carpophores, fanlike mycelia with thin black rhizomorphs invariably forms on the surface of trees, making the symptoms of attack easily noticeable [19].

2. MATERIAL AND METHOD

The substrate used in the research was a 110-year-old healthy tree of Sessile oak *Q. petraea agg.*, 19 m tall and 35 cm in diameter at breast height. The tree had been cut in Eastern Serbia, at the altitude of 550 m, on the southern exposition and in association *Quercetum montanum* [25]. The analyses were conducted on a log 3.5 m in length (from the lower part of the trunk to the first live branch), which was according to the relevant pattern cut into specimens using the standard prescribed dimensions 2x2x32 cm. The fronts of specimens were smeared with antiseptic paste so as to prevent penetration of hyphae from that direction, given the small dimensions of the specimens representing a large beam used for practical purposes. Since the development of cross-section hyphae is the fastest, if the penetration of hyphae was enabled from that side, the small specimens would quickly rot and the relevant results would not be obtained.

The specimens were dried in a classic drying chamber at the temperature of $103\pm1\ ^{0}C$ and measured with the accuracy of 0.01 g. On control specimens (healthy wood), the modulus of elasticity was measured on universal machine for testing wood properties [23, 24]. The specimens to be exposed to the mycelia were conditioned at approximately 12% humidity. Mycelia *C. puteana* was resown into plastic Petri dishes containing malt-agar growing medium of standard concentration. The experiment used sterilized plastic vessels with lids into which Petri dishes with fully developed mycelia *C. puteana* were placed. The petri dishes served as glass carriers (dimensions 9 x 22 x 35 cm) in order to prevent excessive soaking of moisture from the growing medium, onto which wood specimens of Sessile oak were placed. On the top of the stack were petri dishes with 5% water solution of boric acid intended to induce high relative air humidity.

The dishes were kept in a closed sterilized chamber in the total darkness, and the temperature was controlled by thermograph throughout the experiment. Over most of the duration of the research the temperature in the chamber was at about 20°C, with brief time intervals at about 28°C, which are roughly optimal temperatures for the development of the researched species. Upon the expiration of the relevant period of incubation (2, 4 and 6 months), the specimens were taken out of the dishes, cleaned from the surface mycelia, dried in a classic drying chamber at the temperature of 103±1°C.

By definition, modulus of elasticity is the resistance of a tree to the effect of concentrated, evenly distributed or combined forces that strive to bend or distort it. Therefore, the bending pressure is a complex strain consisting of a thrust pressure in the part of the carrier closer to the action point and the strain pressure at the opposite side. Between these two zones there is a neutral axe which under the impact of the load moves towards the side of the strain pressure [22]. Given that the flexural strength is calculated relative to the cross section of a tree at the point of effect of the force, before measuring the strength all test tubes were measured across the middle using a micrometer, with the accuracy of 0.01 mm. The distance between braces was 280 mm, while the test tubes were exposed to the action of a single concentrated force in the middle of the distance between braces. Modulus of elasticity investigated with machine for the testing wood properties (TIRA test 2300) with a rotund force transfer suppressor and a 15 mm radius. The speed of the action of force was uniform, in the total duration of approximately 2 minutes. All data obtained were processed by applying the standard statistical methods; destruction results were compared using the single factor analysis of variance and the least significant difference test for the control group and the duration of the fungus impact (2, 4 and 6 months).

Statistical data processing was done on absolute amounts - N/mm^2, while a correlation analysis was performed in order to prove the existence of a link between the time of action of the fungus as the independent variable and change of modulus of elasticity as the dependent variable.

3. RESULTS AND DISCUSSION

During the course of their development, the epixilous fungi feeding on basic constitutional components of the tree alter not only its chemical composition but also its entire inner structure, which results in a change, i.e. decrease in its mechanical, physical, aesthetical and other properties. Brown rot agents in wood cause analogous chemical changes created during the hydrolysis of the tree by mild acids [20]. Through metabolic processes, fungi modify the nutritious matter down to the molecules suitable to their own life functions.

In order to analyze the changes of wood properties under the influence of epixilous fungi, it is necessary to provide a brief explanation of the fungi’s need for nutrients, chemical composition of the tree, as well as changes that occur in the chemical composition and tree structure under their influence. All wood-decay fungi are able to use finished products such as free sugars, lipids, peptides and other primary metabolites. These substances have a crucial impact in the initial phase of tree colonization. Carbohydrates are the most significant source of carbon in nutrition of the epixilous fungi. A rich source of carbon lies in the basic structural elements of the wood cell walls (hemicellulose, cellulose and lignin). Cellulose, which is the most widely present element on earth, builds the skeletal substance of the cell wall and represents the most important constituent of wood. The fungus *C. puteana* in a tree dissolves primarily cellulose (over 50%), as well as lignin but to a far lesser degree (approximately 10%) [9, 12].

Dissolution of cellulose does not occur evenly throughout the affected tree, since hyphae are individual and unorganized. Thus only a few cells are attacked at first, but their number gradually rises [13]. Moreover, dissolution of cellulose goes quickly at first and later on slows down, which is a consequence of the effect of the fungus that first demolishes the free cellulose in the middle layer of the secondary wall, given that this layer has virtually no impregnation with lignin. As soon as the fungus gets into the parts of cellular membrane with a higher lignin content, the dissolution slows down, so that the dissolution of cellulose in the primary wall is the slowest, as this is where the largest portion of total lignin is incorporated [5]. Changes of the tree structure are reflected primarily in the modulus of elasticity, with the process being roughly 2 to 3 times faster in brown rot agents. Basic parameters of the modulus of elasticity of *Q. petraea agg.* samples that were exposed to the effect of the species *C. puteana* for 2, 4 and 6 months compared to the control are presented in table 1 and expressed in absolute values.

Table 1. *Modulus of elasticity Reduction (%) under the Influence of the Fungus C. puteana*

	0 months	2 months	4 months	6 months
Number of measurements	30	30	29	30
Minimum amount	109.74	47.76	50.64	29.11
Maximum amount	205.98	146.98	138.12	120.96
Arithmetic mean	**156.12**	**95.34**	**94.62**	**80.21**
Standard deviation	28.65	27.44	21.90	25.52
Variation coefficient	18.35	28.78	23.15	31.82

The table 1 demonstrates that the smallest dissipation of data (variation coefficient) occurs in the control group of samples (18.35), while the highest is after 2 and 6 months of exposure to the species *C. puteana* (28.78 and 31.82), which is a consequence of non-homogenous tree structure and uneven colonization of the tree by the fungus. The average modulus of elasticity amounts to 156.12 in the control group of samples, 95.34 after 2 months of exposure to fungus *C. puteana,* 94.62 after 4 months, and 80.21 N/mm^2 after 6 months of exposure. The percentage of decrease of the modulus of elasticity of *Q. petraea agg.* under the influence of the species *C. puteana,* compared to the control, is presented in table 2.

Table 2. *Differences in modulus of elasticity of trees (%) exposed to fungus C. puteana*

Period of exposure	0 months	2 months	4 months	6 months
Modulus of elasticity(%)	100.00	61.07	60.61	51.38
Difference of modulus of elasticity (%)	38.93		0.46	9.23
	39.39			
	48.62			

On the basis of results presented in table 2, it is clear that the greatest decrease of the modulus of elasticity occurs in the first 2 months, i.e., in this period the modulus of elasticity drops by 38.93% compared to the control. In the period between months 2 and 4, the process of destruction (decrease of the modulus of elasticity) slows down and the loss amounts to only 0.46%. In the period between months 4 and 6 the destruction mildly rises and the modulus of elasticity drops by another 9.23%.

Therefore, the greatest decrease of the modulus of elasticity of *Q. petraea agg.* exposed to the fungus *C. puteana* occurs during the first 2 months, after which the process slows down. According to Rayner and Boddy [20], changes of tree properties under the influence of most brown rot agents are primarily reflected in changes of the modulus of elasticity and occur immediately following the appearance of first signs of rot, which is in this case particularly evident. Based on results of T- test, shown in table 3, it is clear that significant differences occur as early as first 2 months of the influence of the fungus *C. puteana* and apply to all tested sample groups, except for the period between months 2 and 4.

Table 3. *Modulus of elasticity Reduction under the Influence of* C. puteana *(T test)*

	0 months	2 months	4 months	6 months
0 months	-	60.7787	61.4962	75.9107
2 months		-	0.717529	15.1320
4 months			-	14.4145
6 months				-

- Significant difference at the level of 0.05

This means that over this period there is no significant loss of the modulus of elasticity, with the differences being only the consequence of high variability of data, not exposure to the fungus. Based on the analysis of breakages of test tubes of Sessile oak exposed to *C. puteana* during the process of measuring the modulus of elasticity, it was found that in the first 2 months a large number of test tubes had smooth breakages in addition to short-fiber ones. Kruzsik [10] states that a tree with a higher modulus of elasticity has a long-fiber breakage, with a medium modulus short-fiber breakage, and with a low modulus a smooth breakage.

Table 4. *Correlation analysis of Exposure time to Fungus and Wood Properties*

Tested property	Model type	Correlation coefficient (r)	Regression equation
Modulus of elasticity (σ_s)	Square function (x)	±0,967378	$\sigma_s = 151,514 \pm 30,6573 \text{ x } \sqrt{T}$

The obtained results lead to conclusion that after 6 months of exposure to the fungus the process of destruction of the tree, although highly advanced, is probably not completed, meaning that there is a possibility that the cell membrane layers may still contain the sufficient quantity of cellulose that provides the modulus of elasticity. Correlation analysis was performed in order to establish a correlation link between the tested tree properties depending on the time of exposure to the fungus (Tab. 4).

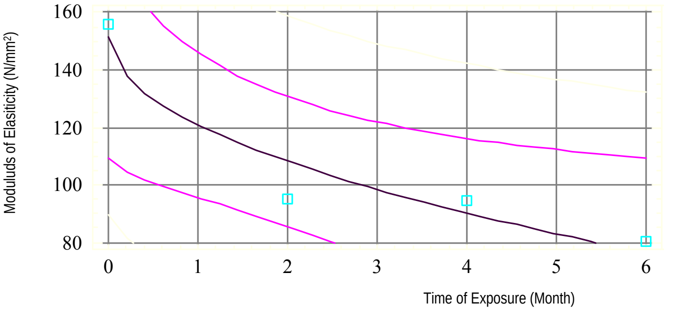

Figure 1. Regression lines decrease Modulus of elasticity Reduction of wood *Q. petraea* in dependent exposed time *C. puteana*

The performed correlation analysis of changes in wood properties *Q. petraea agg.* depending on the time of exposure to fungus *C. puteana* leads to conclusion that there is a strong correlation link between the variables. The regression line presented in picture 1 makes it possible to predict changes in wood properties over certain time periods of exposure to fungus, at unchanged environmental conditions.

This is significant for the purposes of practical application, i.e. for protection measures and wood utility. According to literature sources [18, 20] this property represents the quickest and clearest indication of destruction under the influence of epixilous fungi. To this effect, appropriate chemical analyses of wood exposed to influence of fungi could provide a clearer definition from both qualitative and quantitative aspect, allowing a comprehensive insight into the course and consequences of development of fungi in trees.

4. CONCLUSIONS

Based on the research presented, the following most relevant conclusions can be inferred:

After 2, 4 and 6 months under the effect of the fungus *C. puteana*, the static modulus of elasticity of oak wood substantially decreased compared to the initial value (100%) and amounted to 61.07%, 60.61% and 51.38% respectively. In the period between 2 and 4 months the process of destruction slowed down and the loss amounted to only 0.46%. In the period between the months 4 and 6 the destruction mildly rose and the modulus of elasticity dropped by another 9.23%.

Correlation analysis showed a strong correlation link between the changes (decrease) in wood properties of *Q. petraea* agg. and the time of the influence of the fungus *C. puteana.* This opens the possibility to use the regression equation in forecasting modifications in wood properties, depending on the time of exposure to a fungus, under unchanged environmental conditions.

If a future research would carry out similar experiments on our most significant tree species against the greatest and most dangerous wood destructors, over a larger number of monitoring periods, the obtained results could serve as basis for creation of relevant tables (standards). By cross-referencing the obtained data and conducting their statistical analysis, we would arrive at the closest approximation of values to be inserted into relevant tables and applied in practice.

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REDUCTION THE MECHANICAL PROPERTIES OF OAKWOOD UNDER THE INFLUENCE OF EPYXILOUS FUNGUS

Miroslava MARKOVIC, Snezana RAJKOVIC, Ljubinko RAKONJAC

Summary

Within the scope of field research on diagnostics of harmful organisms in Serbia in the year 2015, in the area of Forest Estate Boljevac, the presence of epixylous fungus Coniophora puteana (Schumm. ex Fr.) Karst was found on dead oak trees following the icebreak. In order to give a more accurate forecast of prospective spread of the pathogen, i.e. determine the speed of the process, the laboratory of the Institute for Forestry conducted the testing of the rate of reduction of the oak tree modulus of elasticity after 2, 4 and 6 months of exposure to the fungus causing cubical brown rot on oak Coniophora puteana. Testing samples were collected from the medulla of healthy oak trees, from the association of Quercetum montanum. Over the periods of 2, 4 and 6 months the wood samples were exposed to influence of the mycelia of the fungus Coniophora puteana (Schumm. ex Fr.) Karst. Results of the research have demonstrated that the lowest dispersion of data (coefficient of variation) occurred in the control group of samples (18.35), while the highest was after 2 and 6 months of exposure to C. puteana (28.78 and 31.82), which is a consequence of the non-homogenous wood structure and uneven colonization of wood by the fungus. After 2, 4 and 6 months under the effect of the fungus, the static modulus of elasticity of oak wood substantially decreased compared to the initial value (100%) and amounted to 61.07%, 60.61% and 51.38% respectively. The regression line obtained through data processing opened the possibility to prognosticate the changes of wood properties in certain time periods of the effect of the fungus under the unchanged external conditions, which is significant for practical purposes in terms of taking protective measures and wood usability.

СМАЊЕЊЕ МЕХАНИЧКИХ СВОЈСТАВА ДРВЕТА ХРАСТА ПОД УТИЦАЈЕМ ЕПИКСИЛНИХ ГЉИВА

Мирослава МАРКОВИЋ, Снежана РАЈКОВИЋ, Љубинко РАКОЊАЦ

Резиме

У оквиру теренских истраживања на пословима дијагностике штетних организама у Србији у 2015. години, на подручју ШГ Бољевац, на мртвом дрвету храста после ледолома, констатовано је присуство епиксилне гљиве Coniophora puteana (Schumm. ex Fr.) Karst. Да ширења овог патогена, односно утврдила брзина тог процеса, у лабораторији Института за шумарство, извршена су испитивања брзине смањења једног механичког својства дрвета (чврстоће на савијање) након 2, 4 и 6 месеци излагања дејству ове гљиве. Испитивања су вршена на здравом дрвету храста из асоцијације Quercetum montanum, након 2, 4 и 6 месеци излагања дејству гљиве која проузрокује мрку призматичну трулеж - Coniophora puteana (Schumm. ex Fr.) Karst. Резултати истраживања показују велико расипање података (варијациони коефицијент) у контролној групи узорака (18,35), а након 2 и 6 месеци дејства гљиве C. puteana износе (28,78 и 31,82), што је последица нехомеогене структуре дрвета и колонизације под дејством гљиве. После 2, 4 и 6 месеци дејства гљиве, статичка чврстоћа на савијање храста у односу на иницијалне вредности

(100%) износи 61,07%, 60,61% и 51,38%. Регресиона линија отвара могућност прогнозе промене својстава дрвета у одређеном времену дејства под утицајем гљива, при непромењеним условима спољне средине, што је веома значајно у практичној примени, особито приликом заштите дрвета у циљу очувања његове употребне вредности.

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EFFECT OF FERTILIZERS ON CONCENTRATION OF PHOTOSYNTHETIC PIGMENTS IN JUVENILE SEEDLINGS OF EASTERN BLACK WALNUT (*Juglans nigra* L.)

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

Abstract: *The paper presents the results of the effect of different fertilizers on concentration of photosynthetic pigments in leaves of juvenile seedlings of eastern black walnut (Juglans nigra L.). The seedlings were produced in 2014 in the seedling nursery of Institute of forestry in Belgrade. The trial was set up in a random block system with three types of fertilizers and a control in three replications. Three types of pigments have been examined: chlorophyll* ***a****, chlorophyll* ***b*** *and carotenoids. The leaf sampling was carried out in the beginning of June 2014. The highest concentration of photosynthetic pigments was found in the leaves of seedlings treated with the preparation Osmocote® Exact Standard 5-6 M and the lowest in the seedlings which were not treated. The highest mean value had chlorophyll* ***a*** *(0.522mg/g) in treatment with Osmocote® Exact Standard 5-6 M and the lowest mean value had chlorophyll* ***b*** *(0.213mg/g) in the control sample. The results showed that the concentration of photosynthetic pigments in leaves of eastern black walnut juvenile seedlings varied depending on the fertilizer that was applied. Based on the obtained results it can be concluded that the proper fertilizer can increase the concentration of photosynthetic pigments in leaves and therefore the intensity of photosynthesis which contributes to increasing the biomass production.*

Key words: eastern black walnut, fertilizer, photosynthetic pigments.

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УТИЦАЈ ПРЕПАРАТА ИСХРАНЕ НА САДРЖАЈ ФОТОСИНТЕТИЧКИХ ПИГМЕНАТА ЈУВЕНИЛНИХ САДНИЦА ЦРНОГ ОРАХА (*Juglans nigra* L.)

Извод: *У раду су приказани резултати утицаја различитих препарата исхране на садржај фотосинтетичких пигмената у листовима јувенилних садница црног ораха (Juglans nigra L.). Саднице црног ораха су произведене у расаднику Института за шумарство у Београду у 2014. години. Оглед је постављен по случајном блок систему са три варијанте прихране и контролом у три понављања. Од фотосинтетичких пигмента истраживани су: хлорофил а, хлорофил б и каротеноиди. Узорци листова за мерење садржаја фотосинтетичких пигмената узети су у првој половини јула 2014. године. Највећи садржај фотосинтетичких пигмената утврђен је у листовима садница које су третиране препаратом Osmocote® Exact Standard 5-6 M, а најмањи код садница које нису третиране. Највећу просечну вредност имао је хлорофил а (0,522 mg/g) у третману Osmocote® Exact Standard 5-6 M, а најмању хлорофил б (0,213 mg/g) у контролном узорку. Добијени резултати показују да се садржај фотосинтетичких пигмената у листовима садница црног ораха мења у зависности од коришћеног препарата исхрана. На основу добијених резултата може се констатовати да се правилном исхраном биљака може повећати садржај фотосинтетичких пигмената у листу, а тиме и интензитет фотосинтезе, што доприноси повећању продукције биомасе.*

Кључне речи: црни орах, препарат исхране, фотосинтетички пигменти.

1. INTRODUCTION

The role of photosynthetic pigments in plant organism is reflected in the absorption of light necessary for the process of photosynthesis. Chlorophylls are the primary photosynthetic pigments. They reflect green part of the spectrum of visible light, while carotenoids reflect yellow, orange or red part of the spectrum. The ability to absorb certain wavelengths of light is more important for the process of photosynthesis than the ability of reflection of the part of the light (Popović et al., 2015). Due to different size and shape as well as different concentration of pigments, the leaves have different ability to absorb visible light and to transform it into energy of chemical bonds (Čivić et al., 2005). The use of various nutrition preparations can significantly influence the concentration of photosynthetic pigments and thus on photosynthesis as a whole (Janmohammadi et al., 2012).

Determination of concentration of photosynthetic pigments in leaves is justified having in mind that the intensity of photosynthesis largely depends on that. In this paper was researched the effect of three different nutrition preparations on concentration of photosynthetic pigments in leaves of juvenile, one-year-old seedlings of eastern black walnut (*Juglans nigra* L.).

2. MATERIAL AND METHOD

The seed of eastern black walnut collected in 2013 in micro-population in Arboretum of Faculty of forestry in Belgrade was used for trial set up. Due to embryo dormancy the walnut seed was moist stratified from November 2013 until end of March 2014 (at the temperature 3-5 °C). The sowing was performed in rows at a depth of 5 cm in April 2014 in the seedling nursery of the Institute of forestry in Belgrade. The seed was planted in TrefTPS fine brown substrate. The trial was set up in three replications. Except the control block which was not treated with nutrition preparations, three blocks of trial fields were treated with three types of fertilizers: the controlled release fertilizer Osmocote® Exact Standard 5-6 M, the microbiological preparation Bactofil® B 10 and the complex NPK mineral fertilizer Florin 2, the dosage is recommended by the manufacturers (Ćirković-Mitrović, T., 2014).

Leaf sampling of eastern black walnut seedlings was conducted at 10th July 2014. The concentration of photosynthetic pigments was determined on the same day in the laboratory of the Institute of forestry. A sample of 1 g was homogenized using a mortar and pestle. For better homogenization of the sample 2 g of quartz sand was added in the mortar before mechanical grinding. The paste was for 3 minutes treated with 15 ml of 80% acetone. To this mixture was added 1 mg of $MgCO_3$ in order to prevent acidification of the solution. The resulting green solution was applied by a small glass rod on a glass filter and using a water spray vacuum pump it was filtered into the vacuum test tube. The resulting filtrate was the pigment extract which is transferred from the test tube to the regular 25 ml vessel and supplemented with 80% acetone to the line. To perform reading in a spectrophotometer the obtained extract has to be diluted. 1 ml of the obtained extract was taken by pipette and into that was added 9 ml of acetone and then it was transferred to the test tube. Thus prepared extract was poured into the cuvette and read on the spectrophotometer, the absorption was at the wavelengths 662, 644 and 440 nm. The formula of Holm and Wetsttein was applied to calculate the concentration of the pigment in the extract in mg/dm^3.

Preparation and reading on the spectrophotometer as well as calculation was performed using standard methods (Oljača, R., Srdić, M., 2005).

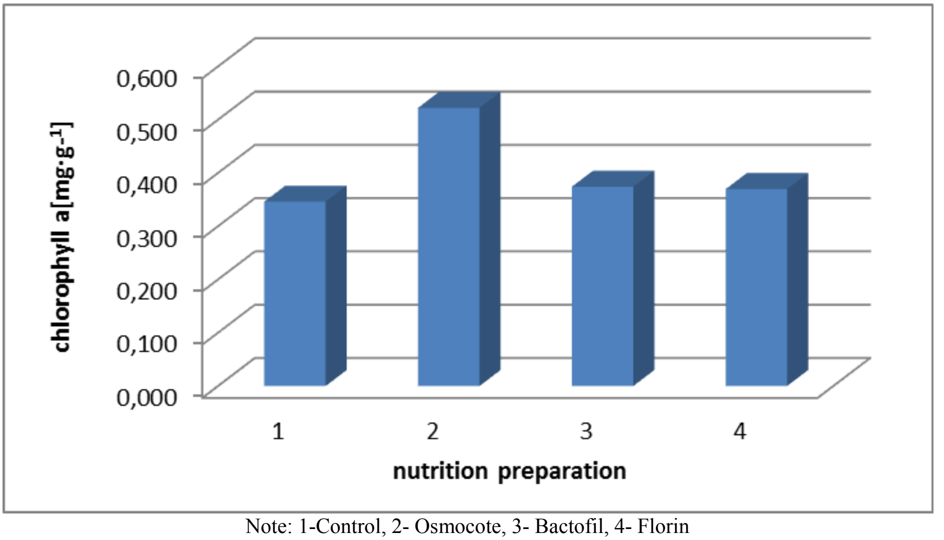
3. RESULTS AND DISCUSSION

Table 1 presents the concentration of photosynthetic pigments in eastern black walnut leaves depending on the applied nutrition preparation. Based on these results it can be concluded that the concentration of photosynthetic pigments in leaves of seedlings treated with nutrition preparations was increased compared to control seedlings.

The greatest concentration of chlorophyll **a** in the amount of 0.522 mg/g was measured in the seedlings treated with Osmocote and the lowest in the control seedlings in the amount of 0.346 mg/g. The concentration of chlorophyll **b** was in the range of 0.213 to 0.349 mg/g. The highest concentration was measured in the seedlings treated with Osmocote and the lowest in the seedlings that were not treated with fertilizers. The concentration of carotenoids was ranging from 0.227 mg/g which was measured in the seedlings that were not treated with fertilizers to 0.400 mg/g as measured in the seedlings treated with Osmocote (Table 1, Graphs 1, 2, 3).

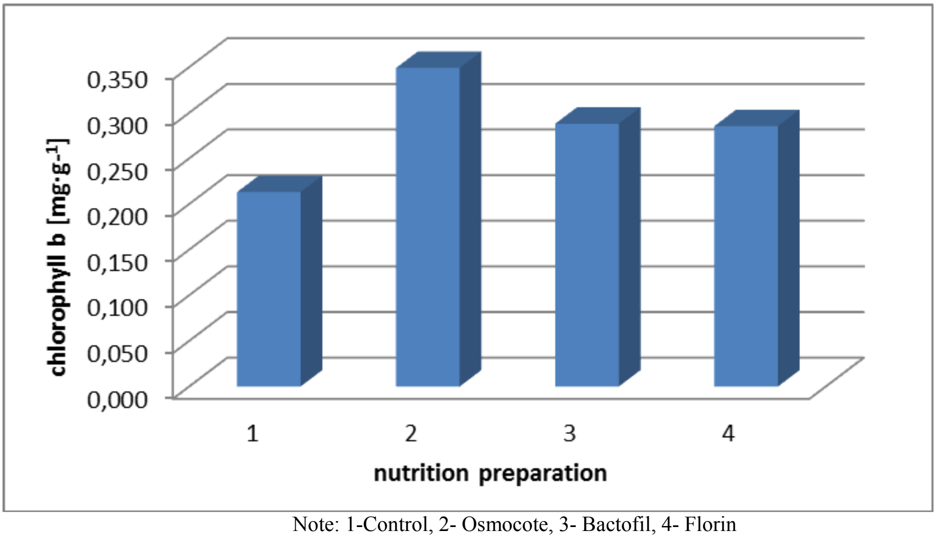
Table 1. *Concentration of photosynthetic pigments in eastern black walnut leaves depending on nutrition preparation type*

Fertilizer	Chlorophyll **a** mg/g	Chlorophyll **b** mg/g	Carotenoids mg/g
Control	0.346	0.213	0.227
Osmocote	0.522	0.349	0.400
Bactofil	0.374	0.288	0.386
Florin	0.370	0.285	0.341



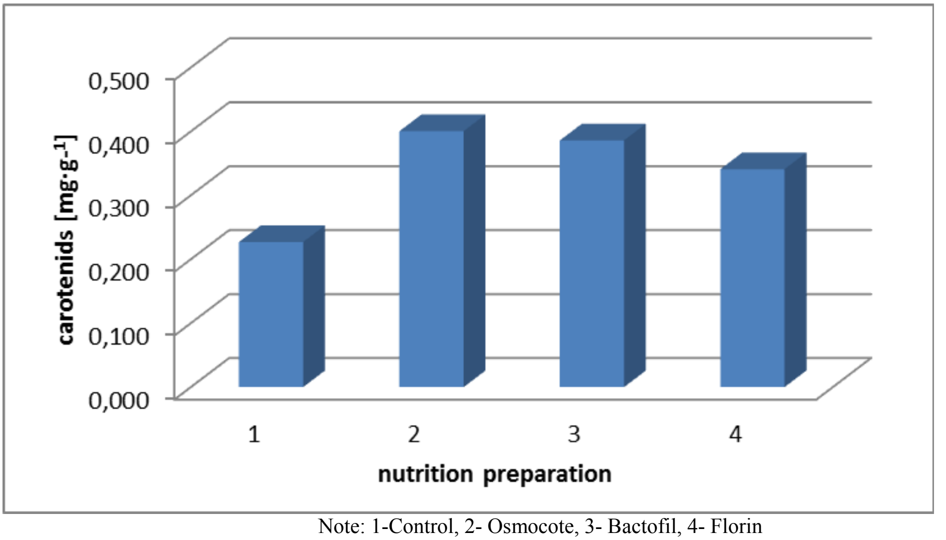
Note: 1-Control, 2- Osmocote, 3- Bactofil, 4- Florin

Graph 1.*Concentration of chlorophyll* ***a*** *in eastern black walnut leaves depending on nutrition preparation type*



Note: 1-Control, 2- Osmocote, 3- Bactofil, 4- Florin

Graph 2. *Concentration of chlorophyll* ***b*** *in eastern black walnut leaves depending on nutrition preparation type*



Note: 1-Control, 2- Osmocote, 3- Bactofil, 4- Florin

Graph 3. *Concentration of carotenoids in eastern black walnut leaves depending on nutrition preparation type*

The results showed that the addition of the nutrition preparations in the substrate in the first year of eastern black walnut seedlings growth had positive effect on the concentration of photosynthetic pigments in the leaves of these plants. The highest concentration of photosynthetic pigments was determined in juvenile eastern black walnut seedlings treated with Osmocote® Exact Standard 5-6 M. Positive effect of this nutrition preparation reflected also on development and morphometric characteristics of seedlings. Other applied nutrition preparations also positively affected concentration of photosynthetic pigments in the seedlings' leaves but the measured values are slightly lower. Untreated seedlings have the lowest concentration of measured photosynthetic pigments and compared to treated seedlings they lagged behind development.

A foliar concentration of the main photosynthetic pigments chlorophyll **a** and **b** is considered to be a bio-indicator of the total primary production of biomass (Gitelson, A., Merzlyak, M. N., 1994). The research results of some authors also showed that the fertilization has a positive effect on concentration of photosynthetic pigments and quality of plants (Bravdo et al., 1993, Tojnko et al., 2001, Nellsen et al., 2003, Čivić et al., 2005). Nutrition has the positive effect on the concentration of photosynthetic pigments in walnut seedlings (Popović et al., 2015). Also, the nutrition preparations have the positive effect on the quality and morphometric characteristics of one-year-old seedlings of eastern black walnut (Ćirković-Mitrović, T., 2014a). The positive effect of microbiological preparations on the quality, morphometric characteristics and yield of plants was also determined in researches of authors Kristek, C. et al. (2010), Dolijanović, Ž. et al. (2014), etc.

4. CONCLUSIONS

Based on the conducted researches it can be concluded that the applying of nutrition preparations has the positive effect on concentration of photosynthetic pigments in leaves of eastern black walnut seedlings and on their growth and development. Usage of mineral fertilizer Osmocote® Exact Standard 5-6 M which gave the best results in terms of increasing the concentration of photosynthetic pigments can be recommended for a regular nursery production because this is slow release fertilizer so the fertilization is achieved throughout the vegetation season. When using fertilizers it has to be taken into account dosage because excessive intake of mineral substances which is characteristic of conventional production can adversely affect the general condition and development of the plants.

A simple, quick and inexpensive way of using this type of fertilizer by adding directly to substrate during its preparation, as well as controlled decomposition which look after the needs of the plants and the relatively long duration of effect justify its use in the mass production of high quality planting material for different purposes.

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EFFECT OF FERTILIZERS ON CONCENTRATION OF PHOTOSYNTHETIC PIGMENTS IN JUVENILE SEEDLINGS OF EASTERN BLACK WALNUT (*Juglans nigra* L.)

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Summary

The role of photosynthetic pigments in plant organism is reflected in the absorption of light necessary for the process of photosynthesis. Chlorophylls as the primary photosynthetic pigments reflect green part of the spectrum of visible light, while carotenoids reflect yellow, orange or red part of the light spectrum.

This paper researched the effect of different nutrition preparations on concentration of photosynthetic pigments in leaves of juvenile seedlings of eastern black walnut (*Juglans nigra* L.). The following photosynthetic pigments were examined: chlorophyll **a**, chlorophyll **b** and carotenoids.

The results showed that the addition of the nutrition preparations in the substrate in the first year of eastern black walnut seedlings growth had positive effect on the concentration of photosynthetic pigments in the leaves of these plants. The highest concentration of photosynthetic pigments was determined in juvenile eastern black walnut seedlings treated with Osmocote® Exact Standard 5-6 M. Positive effect of this nutrition preparation reflected also on development and morphometric characteristics of seedlings. Other applied nutrition preparations also positively affected concentration of photosynthetic pigments in the seedlings' leaves but the measured values are slightly lower. Untreated seedlings have the lowest concentration of measured photosynthetic pigments and compared to treated seedlings they lagged behind development.

Based on the conducted researches it can be concluded that the proper nutrition can increase the concentration of photosynthetic pigments in leaves of eastern black walnut seedlings and also the intensity of photosynthesis and thus their growth and development.

УТИЦАЈ ПРЕПАРАТА ИСХТРАНЕ НА САДРЖАЈ ФОТОСИНТЕТИЧКИХ ПИГМЕНАТА ЈУВЕНИЛНИХ САДНИЦА ЦРНОГ ОРАХА (*Juglans nigra* L.)

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Резиме

У биљном организму фотосинтетички пигменти су задужени за апсорпцију светлости неопходне за одвијање процеса фотосинтезе. Хлорофили као примарни фотосинтетички пигменти рефлектују зелени део спектра видљиве светлости, док каротеноиди рефлектују жути, наранџасти или црвени део спектра светлости.

У раду је истраживан утицај различитих препарата исхране на садржај фотосинтетичких пигмената у листовима јувенилних садница црног ораха (*Juglans nigra* L.). Од фотосинтетичких пигмента истраживани су: хлорофил а, хлорофил б и каротеноиди.

Резултати истраживања показали су да додавање препарата исхране у супстрат у првој години раста садница црног ораха позитивно утиче на садржај фотосинтетичких пигмената у листовима ових биљака. Највећи садржај фотосинтетичких пигмената утврђен је код јувенилних садница црног ораха које су третиране препаратом Osmocote® Exact Standard 5-6 M. Позитиван утицај овог препарата исхране одразио се на развој и морфометријске карактеристике садница. Остали примењени препарати исхране такође позитивно утичу на садржај фотосинтетичких пигмената у листовима садница, стим да су измерене вредности нешто ниже. Саднице које нису прихрањиване имају најмањи садржај мерених фотосинтетичких пигмената, а у односу на прихрањиване саднице заостају у порасту.

На основу обављених истраживања може се констатовати да се правилном исхраном биљака може повећати садржај фотосинтетичких пигмената у листу садница црног ораха, односно интензитет фотосинтезе, а тиме и њихов раст и развој.

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IMPACT OF EXTREME WEATHER CONDITIONS ON THE POPULATION DYNAMICS OF BARK BEETLES IN THE FORESTS OF EASTERN SERBIA

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Abstract: *The paper presents the results of a one-year study of population dynamics of bark beetles by the method of bark beetle trapping using pheromone traps with the following pheromone dispensers - aggregation pheromones: IAC Ecolure (for Ips acuminatus and I. sexdentatus), IT Ecolure (for I. typographus) and PC Ecolure (for Pityogenes chalcographus), after the ice storm that hit the region of Eastern Serbia, especially the forest estate Timočke šume Boljevac (State enterprise Srbijašume) in November 2014. The population levels of the monitored bark beetle species in the controlled area in 2015 were generally within the limits of normal conditions.*

Keywords: ice-breaks, *Ips typographus, I. acuminatus, I. curvidens, Pityogenes chalcographus,* pheromone traps, monitoring

UTICAJ EKSTREMNIH KLIMATSKIH USLOVA NA POPULACIONU DINAMIKU POTKORNJAKA U ŠUMAMA ISTOČNE SRBIJE

Izvod: *U radu su prikazani jednogodišnji rezultati istraživanja populacione dinamike potkornjaka metodom lova pomoću feromonskih klopki uz korišćenje feromonskih dispenzera – agregacionih feromona tipa IAC Ecolure (za Ips acuminatus i I. sexdentatus), IT Ecolure (za I. typographus) i PC Ecolure (za Pityogenes chalcographus), a nakon ledenog talasa koji je zahvatio područje Istočne Srbije, posebno Šumsko gazdinsvo Timočke šume Boljevac (Javno preduzeće Srbijašume), u novembru 2014. godine. Populacioni nivoi posmatranih vrsta potkornjaka u kontrolisanom području u 2015. godini, bili su uglavnom u granicama normalnog stanja.*

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Ključne reči: ledolomi, *Ips typographus, I. acuminatus, I. curvidens, Pityogenes chalcographus,* feromoske klopke, monitoring

INTRODUCTION

The structure and the relations among their members make forests one of the most complex ecosystems on earth. The stability of forest ecosystems greatly depends on the impact, i.e. presence of different harmful abiotic and biotic factors both at the global and at the local level. At the local level, these factors include plant diseases, economically harmful living organisms, climate factors, local environment pollution, whereas at the global level they refer to the climate change, reflected in the global warming which is the result of the ozone layer depletion.

The climate is regarded as the main ecological abiotic factor and it is inextricably bound to some ecosystems, i.e. their existence depends upon climate, therefore, it is of utmost importance for their development and stability. Climate parameters affect soil fertility, vitality of plants, aggressiveness and pathogenicity of the fungi that inhabit certain tissues of host plants, and population dynamics of so-called "beneficial and harmful" forest insects.

About 90% of all natural disasters which have occurred since 1980 are directly or indirectly attributed to the weather and climate. About 95% of the economic losses caused by catastrophic events are the result of climate-related disasters. The annual number of disasters caused by extreme weather and climate in Europe increased by about 65% over the period 1998-2007 compared to the average annual number for 1980. It is estimated that in the next decades the losses caused by natural disasters will be dominant, and that in the second half of the next century the effects of the climate change on the economy will be more pronounced (Rosenzweig et al., 2001).

A severe ice storm accompanied by heavy rainfall hit the area of central Serbia (State Enterprise Srbijašume: Forest Estates Niš, Timočke šume Boljevac, Južni Kučaj Despotovac, Rasina Kruševac, Severni Kučaj Kučevo; 18,500 ha of state forests) in late November and early December 2014 and caused unprecedented ice breakages in artificially-established conifer stands, mostly of spruce and Austrian pine. The most vulnerable area was the Forest Estate Timočke šume Boljevac with 10,060.72 hectares (Srbijašume estimate: 979,682 m^3 of damaged or dead trees).

Spatial and temporal scales of insect outbreaks increase due to dry summers and mild winters at high elevations. In the last decade, intense outbreaks of bark beetles (Coleoptera: Curculionidae, Scolytinae) were recorded on spruce and silver fir trees in the southeast of Europe. *Ips typographus* (Linnaeus, 1758), distributed throughout the Palearctic region (Weslien, 1992), is mostly a secondary biotic agent, affecting only weakened trees. As a result, it is possible to assess the level of risk of forest infestation for this species according to the combination of environmental traits that are present, and on the management aims. However, *I. typographus* is currently expanding its range and interestingly, outbreak risks are similarly high outside its natural range as in non-managed old-growth spruce stands. Spruce forests on the territory of southeastern Europe have been heavily attacked by *I. typographus* and *Pityogenes chalcographus* (Linnaeus, 1761) and Austrian and Scots pine forests have been mostly affected by forest fires followed by outbreaks of *Ips sexdentatus* (Börner, 1767) and other bark beetles. In Europe, mass propagation of the spruce bark beetle, *I. typographus* L, following windthrows and drought poses a serious threat to mature spruce forests. Fresh windthrown spruce trees are suitable as brood trees for *I. typographus,* thereby causing a significant increase of the bark beetle attacks on living spruce trees. This makes *I. typographus* rank among the major insect pests of European forests. (Christiansen and Bakke, 1988). In Europe, 8% of the total forest damage between 1850 and 2000 was caused by bark beetles, mainly *I. typographus* (Jönsson et al., 2007).

Most bark beetles are biologically adapted to the physiological stress of the host, which means that they bore only into physiologically weakened trees. Under suitable circumstance, a small number of species are capable of attacking completely healthy, vital trees and thus becoming primary pests. *I. typographus* and *P. chalcographus* are known to have the ability of dramatic outbreaks.

MATERIALS AND METHODS

A great number of methods and procedures for monitoring the population density and studying the qualitative characteristics of bark beetles have been developed. The current trend in this field is the application of various biotechnological methods which control the population density of these organisms and keep them below the risk levels. A revolution was brought about by the discovery of the mechanisms of chemical communication within individual species of bark beetles, i.e. very coherent and uniform, but often complex chemical information transfer and its impact on the behavior of insects. The fact that trees are many times more attractive in the initial stage of bark beetle colonization results from their bioproduction of aggregation pheromones. A lot of synthetic products that are available in the market are actually direct imitations or copies of such substances. Selectivity is one of the key features of these substances i.e. they attract only the members of related species of bark beetles, or even just one specific species. Technological purity of the product usually leads to their restricted biological efficiency. For example, when correctly applied and under ordinary conditions (no competition by large windthrows or by an active attack simultaneously at hundreds of spruce next to a trap line) the complete control system is able to reduce infestation of living spruce by 70-100% compared to tree mortality where the system is run without traps (Niemeyer, 1997).

The control of I. *typographus*, *I. acuminatus* (Gyllenhaal, 1827), *I. sexdentatus* population density and the ice breakage in the autumn of 2014, in four forest administrations (Zaječer, Negotin, Boljevac, Knjaževac) of the Forest Estate Timočke šume Boljevac was carried out by the method of capturing beetles into specially-designed pheromone traps of Ecotrap type. Monitoring of the number of captured specimens of these species was performed at 15 day intervals from May to September 2015, at the locations listed in Table 1.

Table 1. *Pheromone trap locations*

Forest administration	Management unit	Compartment	Subcompartment	Artificially-established stand of
Zaječar	Šaška – Studena – Selačka reka	6	a	Austrian pine
		22	b	Austrian pine
		27	a	Austrian pine
		28	c	Austrian pine
		33	a, g	Austrian pine
		40	c	Austrian pine
		41	a	Austrian pine
	Vrška Čuka – Baba Jona – Treći Vrh	40	j	Austrian pine
Negotin	Deli Jovan 2	44	c	Austrian pine
		45	h	Austrian pine
		47	a, b	Austrian pine
		49	a	Austrian pine
		50	a	Austrian pine
		51	a	Austrian pine
		52	b	Austrian pine
Boljevac	Markov Kamen	9	b	Austrian pine
	Bogovina 1	88	a, b	spruce
		87	a, c, d, e, f	spruce
		32	b, c	spruce
	Južni Kučaj 3	76	a	spruce
	Južni Kučaj 2	84	c	spruce
	Rtanj	12	c	Austrian pine
	Čestobrodica	3	b	Austrian pine
Knjaževac	Tupižnica	7	a, b	Austrian pine, spruce
		8	a	Austrian pine
		12	d	spruce
	Zaglavak I	27	a, b	Austrian pine
		40	b	Austrian pine
		41	b, c, g	Austrian pine
		47	a, d, e, h, i	Austrian pine
		49	b	Austrian pine
		96	a	Austrian pine
		97	a	Austrian pine
		98	a, d, g, h	Austrian pine
	Tresibaba	17	b	Austrian pine
		23	a	Austrian pine
		47	c	Austrian pine
		48	a, b, c	Austrian pine
		51	b, c	Austrian pine
		52	b	Austrian pine
	Zaglavak II	24	a	Austrian pine
		25	a, d	Austrian pine
		26	a	Austrian pine

Forest administration	Management unit	Compartment	Subcompartment	Artificially-established stand of
		26	b	Austrian pine
		26	d	Austrian pine
		69/	d, e	Austrian pine
		68	d	Austrian pine

RESULTS AND DISCUSSION

Based on the Directive on the protection and rehabilitation of the forests damaged by ice-breaks and icethrows (Ministry of Agriculture and Environmental Protection – Forest Directorate), in line with the adopted Action Plan (SE Srbijašume), Forest Estate Timočke šume Boljevac set 127 ECOTRAP pheromone traps (Universal unidirectional selective barrier pheromone trap for monitoring and mass trapping of Bark beetles) on the total area of 467.8 ha of conifer forests, using the following pheromone dispensers: IAC Ecolure (for *I. acuminatus* and *I. sexdentatus*), IT Ecolure (for *I. typographus*) and PC Ecolure (for *P. chalcographus*). The results of the five-month monitoring are shown in Table 2.

Table 2. *Monitoring of bark beetles in conifer forests damaged by ice-breaks, within the Forest administrations of Boljevac, Zaječar, Knjaževac and Negotin (SE Srbijašume, Forest estate Timočke šume Boljevac) in 2015*

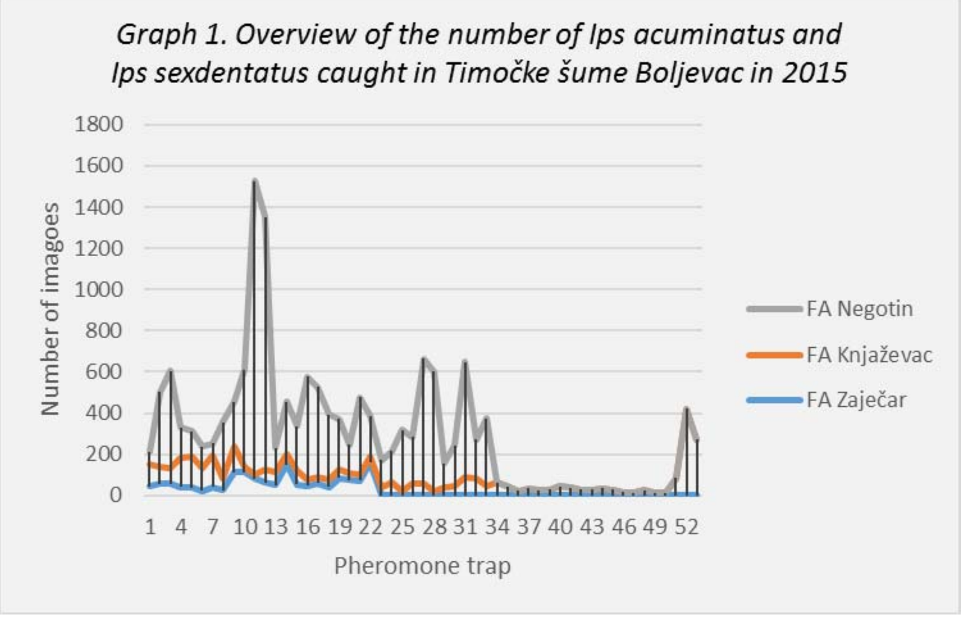
Number of traps	Type of pheromone	Locality			Total number of captured specimens		
		Management unit	Compartment subcomp.	*The area of the pheromone effect(ha)*	*Ips typographus*	*Pityogenes chalcographus*	*Ips acuminatus Ips sexdentatus*
Forest administration Boljevac							
1	PC Ecolure	Bogovina	87/e,f	4.56		242	
1			32/b,c	2.18		52	
1		Južni Kučaj III	76/a	2.97		1636	
2		Južni Kučaj II	84/c	3.86		46 (20, 26)	
1	IAC Ecolure	Čestobrodica	3/b	4.55		1324	
2		Markov kamen	9/b	3.37	1472 (737, 735)		
1	IT Ecolure	Bogovina I	88/a,b	4.14	683		
1			87/a	2.63	748		
1			87/c	2.03	61	187	
1			87/d	5.06	67	193	
12 traps in total				35.35	3031	3680	
Forest administration Zaječer							
3	IAC Ecolure	Šaška –Studena – Selačka reka	6/a	12.94			158 (44, 56, 58)
5			22/b	19.58			170 (40, 38, 24, 41, 27)
2			27/a	5.92			228 (114, 114)
1			28/c	2.05			83
5			33/a	21.91			365 (64, 49, 151, 55, 46)
1			33/g	2.68			61
2			40/c	6.15			126 (42, 84)
2			41/a	6.21			146 (75, 71)
2		Vrška Čuka – Baba Jona – Treći Vrh	40/j	9.40			268 (161, 107)
22 traps in total				86.84			1605
Forest administration Knjaževac							
1	IAC Ecolure	Zaglavak I	27/a	2.48			41
2			27/b	6.83			158 (81, 77)

Number of traps	Type of pheromone	Locality			Total number of captured specimens		
		Management unit	Compartment subcomp.	*The area of the pheromone effect(ha)*	*Ips typographus*	*Pityogenes chalcographus*	*Ips acuminatus Ips sexdentatus*
1			40/b	4.99			141
2			41/b,c,g	10.06			262 (150, 112)
2			47/a,d,e,h	7.76			212 (153, 59)
1			49/b	4.6			122
5			96/a	19.09			220 (23, 19, 63, 63, 52)
7			97/a	26.81			262 (65, 30, 30, 32, 41, 36, 28)
3			98/a,d,g,h	10.69			117 (42, 47, 28)
1		Tresibaba	17/b	2.27			26
1			23/a	2.43			38
1			47/c	3.51			65
2			48/a,b,c	7.12			82 (22, 60)
2			51/b,c	2.48			83 (61, 22)
2			52/b	6.83			87 (40, 47)
4		Zaglavak II	24/a	15.00			280 (88, 82, 48, 62)
6			25/a,d	24.93			197 (43, 22, 35, 25, 29, 43)
1			26/a	3.29			39
2			26/b	6.23			59 (30, 29)
3			26/d	12,29			82 (35, 30, 17)
2			69/d,e	6.47			40 (13, 27)
2			68/d	9.48			26 (12, 14)
2		Tupižnica	7/a	7.50			507 (86, 421)
1			8/a	4.42			273
1	PC Ecolure		7/b	3.76		597	
1			12/d	4,08		258	
60 traps in total				222.5		855	3 583
Forest administration Negotin							
1	IAC Ecolure	Deli Jovan II	45/h	3,65			60
1			44/c	3.64			365
3			47/a	11.51			744 (471, 149, 124)

Number of traps	Type of pheromone	Locality			Total number of captured specimens		
		Management unit	Compartment subcomp.	*The area of the pheromone effect(ha)*	*Ips typographus*	*Pityogenes chalcographus*	*Ips acuminatus Ips sexdentatus*
2			47/b	6.76			161 (101, 60)
7			49/a	26.7			3985 (271, 219, 475, 1424, 1226, 118, 252)
4			50/b	13.97			1472 (218, 499, 436, 319)
6			51/a	21.33			1247 (247, 137, 378, 200, 135, 150)
9			52/a	35.55			3092 (297, 225, 603, 579, 117, 196, 559, 190, 326)
33 traps in total				123.11			11 126

Seven traps with PC Ecolure aggregation pheromone - pheromone dispenser captured 2831 imagos of *P. chalcographus* (averagely 404.43 individuals per trap) in 5 months (May-September 2015). The maximum number of captured insects (1,636 adult beetles) was achieved in the Forest Administration Boljevac, management unit Južni Kučaj III, compartment 76/a, and the minimum of 20 individuals in the management unit Južni Kučaj II, compartment 84/c of the same forest administration. Only four pheromone traps of IT Ecolure type were placed in MU Bogovina I, compartments 87 and 88 (Table 2), and a total of 1,559 beetles of *I. typographus* (averagely 389.75; maximum capture: 748 in compartment 87/a) and 380 of *P. chalcographus* were captured.

The largest number of traps (116) contained a synthetically produced aggregation pheromone of IAC Ecolure type that primarily attracts *I. acuminatus* and *I. sexdentatus* imagos. During the five-month monitoring a total of 16314 individuals, or an average of 140.64 per trap were captured. The maximum capture [3985 (271 + 219 + 475 + 1424 + 1226 + 118 + 252) imagos] was achieved in the Forest administration Negotin, management unit Deli Jovan II, compartment 49/a, and the minimum (12) in the forest administration Knjaževac, MU Zaglavak II, compartment 68/d (Table 2, Graph 1).



Population levels of the monitored species of bark beetles in the study area in 2015 were generally within the limits of normal conditions. In several compartments of the management units Markov kamen and Bogovina I of the Forest Administration Boljevac, the population density of *I. typographus* (Table 2) has started to increase but it is still below the critical level. However, this level is likely to be reached in the coming period unless necessary control measures are taken. The situation is the same with *I. acuminatus* and *I. sexdentatus* in compartment 49/a, Management unit Deli Jovan II, Forest Administration Negotin (Table 2, Figure 1).

This relatively small number of captured bark beetles could be attributed to several different factors (tall grass around the traps which made them inconspicuous, faults in technology of dispensers, inadequate trap location, trap type (wet or dry), degree of selectivity (simultaneous capture of bark beetle natural enemies - predatory species of Coleoptera and parasitic species of Hymenoptera - attracted by the same odours, which in their case act as kairomones, rather than pheromones) (Borden, 1977; Baier, 1994; Lobinger and Feicht, 1998; Pavlin, 1991).

A successful bark beetle attack is accomplished in two steps – firstly, pioneering individuals exhaust the host, then they colonize the whole tree (Lieutier, 2002). Bark beetles are principally attracted by kairomones, but there are various factors that can increase the intensity of the attack. If we apply these scientific facts to the results of this study, it can be concluded that the time between the ice-break and the applied control measures was too short (only a few months) for the previously established populations of the four species of bark beetles to recognize the broken trees as physiologically weakened. In other words, they didn't make a positive correlation (due to negligible or insufficient production of kairomones).

CONCLUSIONS

The population density of the four of bark beetle species (*I. typographus*, *I. acuminatus*, *I. sexdentatus* and *P. chalcographus*) in artificially-established conifer stands damaged by ice-breaks in 2014, in the area of forest administrations of Zaječar, Boljevac, Knjaževac and Negotin, on the total surface area of 467.8 ha was managed using 127 traps with specific pheromone dispensers – synthetically produced aggregation pheromones.

The obtained results, with the above-stated exceptions, generally do not indicate an increase in their abundance. However, in the future, weather conditions favourable for their development (mild winters) in the absence of urgent control measures may turn these species into a calamity of bigger proportions.

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AIR POLLUTION IMPACT ASSESSMENT AND MONITORING, ITS EFFECTS ON THE FOREST ECOSYSTEMS IN THE TERRITORY OF THE REPUBLIC OF SERBIA IN 2015

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Abstract: *In 2015 research observations of permanent monitoring of forests in the Republic of Serbia on permanent experimental plots were carried out in accordance with the Instructions of the International Cooperative Programme on Forest Condition Monitoring and data were collected for the necessary analyses. Experimental fields (FSP) are systematically arranged in 16x16 km or 4 x 4 km grid systems. Basic parameters evaluated in the plots were: presence of pests, phytopahtological changes, as well as of other types and causes of forest damage. The aim of this paper was to correlate these factors that affect the vitality of forests and analyses of adverse influences affecting the forest ecosystems, the degree of defoliation and color changes (chlorosis on forest vegetation), and above all, the extent of damage to forests in Serbia in 2015.*

Key words: Integrated Pest Management, Defoliation, ICP Forest Sample Plots, Crown Condition Monitoring, Serbia

1. INTRODUCTION

Forest ecosystems form the basis of a healthy environment and are key factors for its preservation and improvement. Forests and forest areas provide numerous generally beneficial functionalities that are not related to the production of wood as the main forest produce. Serbia is a country with a multitude of diverse

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living species and is literally more than rich in biodiversity, which is primarily found in forest ecosystems.

Forest ecosystems are exposed to both abiotic and biotic impacts the synergy of which maintains the ecosystem balance. In addition to the favorable effects, the adverse influence of harmful abiotic and biotic factors cannot be ignored as they result in diminished vitality of individual trees, forest stands and ultimately the forest ecosystem (Marković, M., Rajković, S. and Nevenić, R., 2014) .

In view of the aforesaid, Serbia has recognized significance of forest health monitoring and monitoring of the harmful abiotic and biotic factors impact on forests.

From 2013 up to 2015 130 sample plots were defined and set up in the territory of the Republic of Serbia, arranged in 16x16 km or 4 x 4 km grid systems (Nevenić et al., 2006). In 2015 forest species condition was assessed at all 130 sample plots in Serbia. Defoliation and discoloration assessment and monitoring of damages caused by both biotic and abiotic factors were conducted on the total of 2,910 trees. Such continuous large-scale or appropriate-scale monitoring may warn of forest damage, caused by both biotic and abiotic factors.

Biomonitoring is based on the dense network of permanent experimental sites, called sample plots, where every vegetation season health and vitality of individual pre-sampled trees are assessed (Nevenić et al., 2011).

2. METHOD AND CRITERIA

Visual field observations were made at sample plots in the territory of the Republic of Serbia in accordance with the ICP Forests Manual[2] as follows: assessment of the crown condition and identification of damage on trees caused by diseases and pests. ICP Forests Manual prescribes that the crown condition be assessed at all sample plots each year and that the soli condition and nutrition of forest trees – foliar analyses – be assessed every 10 years.

Based on the coordinate grid of sample plots, a sample plot is established and designated with the bright colored metal stick placed in the middle of the plot. Tree samples for crown condition assessment are systematically selected in clusters of 4 sites. In each of the cardinal directions, at a distance of 25 m from the central point (the metal stick), the nearest six trees are selected (the total of 24 trees) and defined as the assessment sample. The sampled trees include all tree species provided their height is over 60 cm. Crown classes according to Kraft[3] (predominant, codominant, intermediate, suppressed, dying) determine the trees considered for assessment, yet these trees ought to be without significant mechanical damage. The selected trees are permanently bark-marked with numbers for future assessment purposes. Trees removed due to undertaken forest management measures or for other reasons are replaced with new selected trees. If

[2] Manual – rules of procedure http://www.icp-forests.org/Manual.htm

[3] Modified concept of forest tree crown classification, traditional measurement of variables used in forestry, initially implemented in Germany in the 19th century, Kraft (1884)

a stand is removed by cutting only, the central point is left until a new stand is formed (Nević et al, 2008).

Within national and international research (Level I), crown condition is expressed in terms of defoliation classes, discoloration and combined damage classes. Defoliation is assessed in 5% intervals and grouped in 5 classes of uneven ranges (Table 1). Foliage discoloration is a significant diagnostic indicator of the crown condition and may be assessed according to the classes provided in Table 2. The combined damage class is presented in Table 3.

Table 1. *Defoliation classes as per UN/ECE[4] and EU[5] classification*

Defoliation – drying - class	Defoliation extent	Foliage loss (%)
0	None	0-10
1	Slight	10-25
2	Moderate	25-60
3	Severe	60-100
4	Dead	100

Table 2. *Discoloration classes as per UN/ECE and EU classification*

Discoloration –chlorosis - class	Discoloration extent	Share of the foliage chlorosis (%)
0	None	0-10
1	Slight	10-25
2	Moderate	25-60
3	Severe	60-100
4	Dead	100

Table 3. *Combined damage assessment*

Defoliation – drying-class	Discoloration – chlorosis- class			
	0	1	2	3
	Damage class results			
0	0	0	1	2
1	0	1	2	2
2	1	2	3	3
3	2	3	3	3

Combined assessment of defoliation, discoloration and damage is presented in Table 3 above, where causal relations of the three mutually dependent factors are shown. For example, in instances of non-existent defoliation (drying) and discoloration value of 1, it was not possible to identify significant damage on trees (0), whereas severe defoliation (3) and severe chlorosis (3) were indicative of the existence of acute damage designated with number 3.

In addition, phonological monitoring of visible developments in the life cycle of plants as per methodological approach yields parameters that contribute to the establishment of phenomena in forest ecosystems. Information on the timing and duration of certain developments in plants provide valuable data on their condition as well as on potential impact of the environment on the plants, such as the impact of climate fluctuations (ICP Forests Manual, 2010).

[4] United Nations Economic Commission for Europe
[5] European Union

At each Level II sample plot 15 trees of the predominant species were selected for phonological observations, where the following parameters were detected and monitored: foliation, discoloration of leaves/conifer needles, defoliation, significant indicators of damage in leaves/conifer needles or crowns, other damages (branch and trunk breakage and trunk uprooting) and secondary budding and blooming.

EVENT: 1. foliation; 2. discoloration; 3. defoliation; 4. foliage damage; 5. other damages; 6. water sprouts; 7. blooming

EVENT REGISTRATION – FOLIATION, DEFOLIATION AND BLOOMING:
1 - < 1%; 2 - 1-33%; 3 - 33-66%;4 - 66-99%; 5 - > 99%

BLOOMING AND DAMAGES:
6 – absence; 7 – presence; 7.1 – rare; 7.2 – moderate; 7.3 – thick, severe

The above listed parameters were monitored in trees situated in the sample plot and for the entire plot in general, as from the first field visit.

Long-term observation of phonological developments and interpretation of the results obtained using the method of time series analysis enable identifying patterns of deviation from the usual. At the level of significant shift in phenological phenomena (blooming or fruit maturing seasons, etc.) elements of global climate changes are recognized.

By processing data obtained using the most contemporary technological approach in phenological monitoring (placement of devices for recording or taking photographs) predictive models are arrived at for even clearer estimates.

3. RESULTS

At most common tree species at Level 1 sample plots causes of damage were recognized, determined (designated with scientific names) and associated with damages in certain number-designated sample plots across Serbia.

This so-called ***overall status*** in 2015 comprised:

Field work → Tree species→ Sample plot name and number → cause of damage → Damage or disease occurred → Damage or disease progress or assessment through the use of standard parameters → final result of “monitoring” per experimental field → 2015 results presented in this paper are shown in Tables 4 and 5.

Table 4 highlights the agent and sample plot number, while Table 5 presents the share (percentage, %) in the total number of trees at all 130 sample plots in the fields established for this purpose (soil chemistry analyses were also conducted and those of foliar chemism features).

All of this represents an elaborate set of tasks with a tendency for improvement year on year as well as a more detailed and more comprehensive reporting system – identical operations are synchronized on the local level and in the region. Everything is focused on the general objective – monitoring is becoming a prediction mechanism for estimating risk and localizing critical problems of forest drying and instrument of the current applicable integral approach in forest protection. For each sample plot the cause of damage or disease of the affected tree is stated per tree species. The tables include the most common species (most present in Level I experimental fields in the territory of the Republic of Serbia excluding the territory of AP of Vojvodina in 2015) in the territory with plot grids (16 x 16 and 4 X 4 km).

At Level I sample lots the predominant tree species is beech. In 2015 vitality of beech forests was acutely endangered primarily by insect defoliators. As in prior years, in 2015 a mild attack by gall midges and leaf-miners was identified on foliage.

These are *Mikiola fagi* (Htg.), beech gall midge, which form galls on beech leaves (which are then deformed). FE Leskovac and FE Ivanjica are specific in this respect as their huge areas were attacked and beech trees were in severe jeopardy from innumerate mines on assimilation leaf surfaces. The situation was the same in 2014. Such heavy infestation will certainly affect the growth and the overall condition of beech trees and their resistance to other pathogens. Deformed and covered leaves will have severely harmed vitality of beech forests for the upcoming period as well, until the midge population becomes stable or reduced by parasitoids. In addition, leaf-miners such as *Hartigola annulipes* Hartig and *Phyllonorycter messaniella* Zell (Figure 2) were also observed. Beech leaf-miners (Lepidoptera. Gracillaridae) proved to be the most common pests affecting the sample beech trees, as demonstrated by the results of observations at sample plots in the same regions of Serbia in 2015, for plots 76, 77 and 78 in particular.

Leaf-miner *Rhynchaenus fagi* L. (Syn. *Orchestes fagi* L.) – beech leaf-mining weevil – was identified at several sample plots, where in a number of beech trees attacks recorded ranged from mild to severe. From the Cecidomyidae family of gall midges, *Dryomia circinnans* Girauld species is frequently found on the back of leaves of both beech and oak trees at sample plots. These galls resemble the above mentioned species except that they are covered with fine hair. They are equally harmful as they cause physiological disorder in leaves and young plants stagnate due to general deformity.

Figure 1. Sample plots 428, 429: fir trees, completely dry and broken *(original photo of the Author)*

Figure 2. Sample plot 32: Beech leaf-miner (Lepidoptera. Gracillaridae)*(original photo of the Author)*

Table 4. *Damage causes, host plant tree species*

Damage / Tree species / Sample plot / Cause	***Insects*** *defoliators, chewers, leaf-miners, gall midges, leaf-rollers and bark beetles* ***/sample plot number***	***Fungi*** *bark canker, wounds, stem rot, spots, freckles, carpophores, root rot, complete* ***drying / sample plot number***	***Abiotic agents*** *ice ruptures, frost cracks, bark cracks, drought* ***/sample plot number***	***Man-made*** *mechanical damage from pullout force (bark stripped off, breakage, various injuries)* ***/ sample plot number***	***Forest fires / sample plot number***	***Other causes / sample plot number***
Beech	*Leaf-miners / 32*	*Several causes combined / 9, 13, 50, 52, 55, 58, 85, 91, 98, 99, 87, 407, 412*	*Ice ruptures, frost cracks / 412, ∑ 7 trees, 413 ∑15 trees*	*Mechanical injury / 4, 50; severe mechanical injury / 51, 69, 90*	*10 severely damaged trees / 96 (as well as C.sativa)*	
Hornbeam		*Central rot / 55*				
Turkey oak	*Leaf miners /29, 34, 36; Altica quercetorum / 39*		*Several causes combined / 6,70,92*			*Bulge /30 Bacterial tumor /38*
Hungarian oak	*(Torticidae) / 2, 17 ,20 29, 39 and 88*	*Microsphaera maculiformis / 17, 20*	*Frost ribs / 17, 20*			*V.album; L.europeus / 60*
Sessile oak	*Leaf-miners / 75, 77*	*Microsphaera alphitoides / 107*	*Severe drought / 78*			
Fir		*Armillaria ostoyae / 415, 418*	*Severe drought / 428, 429*	*Mechanical pullout injury / 401,402*		
Spruce	*Bark beetles / 73,74*	*Heterobasidion annosum / 419*		*Mechanical pullout injury / 406*		
Austrian pine	*Bark beetles / 419*	*Dotistroma pini; Diprion pini / 65*				
Black locust	*Gall midges, leaf-miners / 428*					
Scots pine	*Bark beetles / 45, 59*	*Lophodermium sp. (both most common species) / 53*				

Table 5. *Damage causes per host plant tree species and sample plot number*

(%)	Defoliation (%)	Wildlife	Insects	Fungi	Abiotic agents	Man-made	Fire	Local pollution	Other damages
All species	11,48	0,00	8,04	5,50	3,33	0,62	0,24	0,00	4,19
All conifers	12,78	0,00	0,30	9,47	2,66	0,30	0,00	0,00	8,58
Fir	11,30	0,00	1,45	1,45	8,70	1,45	0,00	0,00	10,14
Spruce	7,71	0,00	0,00	0,00	2,05	0,00	0,00	0,00	13,70
Austrian pine	27,54	0,00	0,00	25,37	0,00	0,00	0,00	0,00	0,00
Scots pine	10,14	0,00	0,00	25,00	0,00	0,00	0,00	0,00	3,57
All deciduous trees	11,31	0,00	9,06	4,98	3,42	0,66	0,27	0,00	3,62
Hornbeam	7,13	0,00	0,00	2,63	0,00	0,00	0,00	0,00	6,14
Beech	8,10	0,00	10,63	0,07	4,13	0,01	0,83	0,00	4,37
Turkey oak	12,52	0,00	11,93	3,18	1,99	0,20	0,00	0,00	4,97
Hungarian oak	8,41	0,00	11,58	2,11	1,84	0,53	0,00	0,00	2,37
Sessile oak	13,31	0,00	5,43	4,35	1,63	0,00	0,00	0,00	2,72

At sample plots with black locust as a dominant tree species a locust gall midge *Obolodiplosis robiniae* Hald. was identified. This is a species introduced in the region and it appears in massive numbers causing frequent and large-scale damages, as recorded at sample plots in 2015 (Figure 3).

Figure 3. a) Black locust gall midge - *Obolodiplosis robiniae* Hald. And locust leaf-miners b)*Phyllonorycter robinie* Clem.; c) *Parectopa robiniella* Clem. *(original photo of the Author)*

Figure 4. A tree typically affected by early oak defoliators *(original photo of the Author)*

To all oak as well as other deciduous forests, whether they be sprout forests or high forests, single-species or mixed-species, defoliators (insects from various families feeding on leaves) are particularly significant. Through their trophic attachment to oak leaves they cause partial or total defoliation (loss of foliage)

(Figure 4), which in turn results in a series of adverse effects, physiological decline of the host plant, among others, i.e., creation of favorable conditions for action of a number of secondary harmful factors and can therefore be fatal to certain trees and entire stands (Nevenić et al., 2009).

Most common oaks found in forests within Level I sample plots are Sessile oak, *Quercus petraea* (Matt.) Lieblein, Turkey oak, *Q. cerris* L., and Hungarian oak, *Q. frainetto* Tenore. These trees are feeding plants for about 120 insect species most commonly from orders of Homoptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera. These insects spend a part of their life or their certain development stages on various parts of trees and are trophically linked to trees. They chew leaf assimilation tissues, leaf buds and flower buds, young sprouts and twigs, or suck on the plant saps, can be xylophages or form galls where their larvae grow.

Only 10% of these species are forestry pests from the economic viewpoint as their oversized populations can heavily affect health and vitality of trees and considerably disbalance forest stands and cultures. Economically most significant among them is the gypsy moth – *Lymantria dispar* L. (Lepidoptera: Lymantriidae). The population numbers are measurable in many ways and each indicator of increase in gypsy moth numbers is among the highest forest management priorities. 2013 was the year of gypsy moth gradation in vast areas, primarily in the eastern region of Serbia. Since 2013 changes in oak stands specific for post-gradation period have been monitored – numbers of parasitoids, which are gypsy moth's natural enemies, and the reactions of trees that were severely affected (Češljar et al. 2013).

Early season oak defoliators are gradation-prone species, which, overporpagated for a few consecutive years, make physiologically weakened trees become prey to secondary pests. In case of trees stripped bare, tree growth is significantly reduced, there is no acorn production and the process of natural oak forest restoration is practically at a standstill. Such large-scale damages are most commonly caused by calamity species of oak leaf-roller moths and winter moths-gooseberries (Glavendekić M. and Medarević M., 2010).

Species most commonly detected at sites where in prior years severe infestations were recorded are: green oak leaf-roller – *Tortrix viridana* L., yellow oak leaf-roller – *Aleimma loeflingiana* L. (Lepidoptera: Tortricidae), gooseberries *Colotois pennaria* L., *Agriopis* spp., and winter moths – *Erannis defoliaria* L.. *Alsophila* spp. and *Operophtera brumata* L.

In a large number of Turkey oak trees Cynipidae were observed, particularly *Neuroterus quercus baccarum* species and *Ticheria ekebladella* L. leaf-miners. Sessile oak sprout forests in bad condition (sample plot 78) displayed in mature trees, crowns and young plants presence of oak powdery mildew *Microsphaera alphitoides* Grif.& Maubl (sample plot 21) and *Mycosphaerella maculiformis* Mougou, A.; Dutech, C.; Desprez-Loustau, M. -L. (2008) pathogen. Of epixyl fungi there were wood rotting fungi on branches and severe central prism-shaped brown rot decay of the trunks. A small-scale presence of tumor-like shapes and rot in Turkey oak branches was identified.

Figure 5. Sample plot 46: *Phellinus igniarius* L. ex Fr. on a Sessile oak (*original photo of the Author)*

Figure 6. Central rot along a beech tree trunk (*original photo of the Author)*

Out of other biotic damage causes, in individual oak branches we detected the presence of parasitic flowering plants – white-berried mistletoe (*Viscum album* L.) and yellow misteltoe (*Loranthus europaeus* Jacq.), which cause physiological weakening of trees making them prone to attacks of hazardous pests (Kinver, 2010). In Hungarian oak trees rotting fungi carpophores were detected – *Coriolus versicolor* (Fr.) Pil., *Fomes annosus* and central rot of different origins (Figure 7).

With regard to the beech forest disease causes, in individual trees the presence of carpophores or central rot along the entire trunk was detected, and tree litter showed plenty of carpophores of *Fomes fomentarius* (L.: Fr.), (Syn. *Ungulina fomentaria* / Linn. /Pat) *Ungulina fomentaria*. Beech tree trunks displayed central rot (Figures 5 and 6), canker wounds on the bark with recorded different development stages of *Cryptoccocus fagisuga* L. and several tree foot rotting. In the vicinity of sample plots with beech trees, there were a lot of rotten trees with carpophores of *Trametes versicolor (Fr*.) Pil. (Syn. *Coriolus versicolor* L. Et Fr.) Quel.). *Nectria* spp., was also frequently observed, recognized by its bright colored fruiting bodies (Karadžić, D. 2010).

Certain trees had severe injuries from tree cutting and pull-out, which are entryways for hazardous insect infestation and diseases (Nevenić et al., 2006).

Most common species in coniferous forests at sample plots are Austrian pine, Scots pine, spruce and fir trees. Following the 2015 assessment, one fifth of the total trees marked displayed visible injury caused by diseases (Figure 8) or pests. In spruce stands, there was a hazardous pathogen *Chrysomyxa abietis* (Wallr.) Unger on the needles (sample plots 419 and 420) but to a small extent, while in fir tree needles *Cenangium ferruginosum* Fr. (Syn. *Cenangium abietis* (Pegs.) Duby. and *Lirula nervisequa* (DC ex Fr.) Darker (Syn. *Lophodermium nervisequim* (DC ex Fr.) Rehm.) were detected. Completely dry and broken trees with lichens were also (Figure 1).

Scots pine needles were slightly infested with fungi *Dothistroma pini* Hulbary; (Syn. *Scirrhia pini* Funk et Parker) and *Lophodermium pinastri*, *Lophodermium seditiosum* as well as *Cyclaneusma minus* and *Sclerophoma* sp. and rotting fungus *Fomitopsis pinicola* (Fr.) P. Karst. (Taković- Tošić, M. et al 2014).

Figure 7. Sample plot 55: Carpophores of *Fomes annosus* and central rot (*original photo of the Author)*

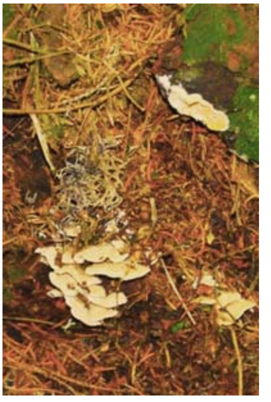


Figure 8. Sample plot 419: Carpophores of *Heterobasidion annosum* – the most hazardous pathogen of conifer forest at spruce tree foot; (*original photo of the Author)*

In 2015 *Dothistroma pini* slightly infested last year's Austrian pine needles. Scots pine needles showed presence of *Diprion pini* L., while in the bark there were fly-out openings of Siricidae and mechanical damages.

Ips typographus L. appears wherever there are dry uprooted spruce trees. In the root system it is then easy to observe the most hazardous pathogen of conifer tree stands – *Heterobasidion annosum* (Figure 8, sample plot 419).

Other deciduous species with recorded damages caused by diseases and pests are hornbeam, field maple, sycamore, raywood ash, birch and wild fruit trees. Ash weevil (*Stereonychus fraxini* Deg.) wasdtected in raywood ash trees at sample plot 11.

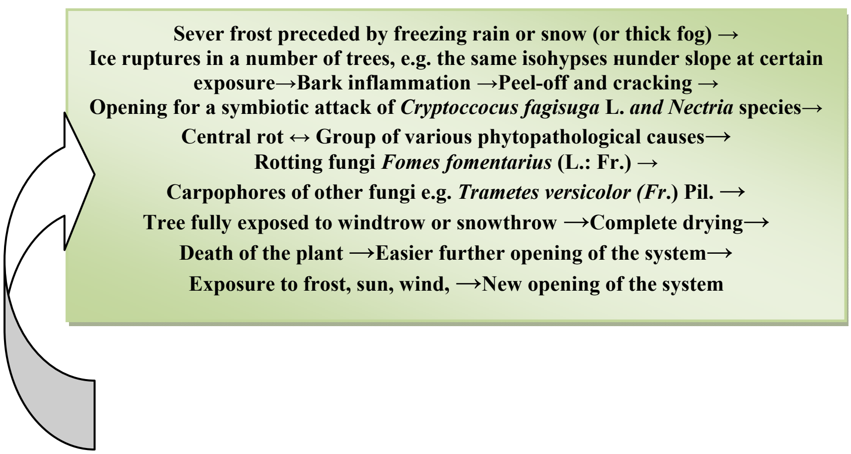
Abiotic damages recorded included bulges of other than parasitic origin in the bark of individual beech trees. Frost cracks were clearly visible along the entire trunks. In 2015 there was no precipitation from the beginning of summer and in this rather dry year trees displayed yellow chlorotic crowns prematurely, as if the autumn drying commence das early as August, although the leaves remained on branches.

Beech trees at sample plot 7 showed damage and injury from tree cutting and pull-out. In this plot entire quadrants were missing, while some trees had injuries of unknown origin and about ten trees had bark inflammation (Chira, D., F. Chira, 1998). Mechanical damages caused by birds were detected in spruce trees at sample plot 420. Some Turkey oak trees suffered bark damage during tree marking. Man-made mechanical damages were identified in in about ten oak trees per sample plot, resulting from tree cutting and pull out. Such injuries pose a risk of entry of numerous hazardous insects and fungi, which can cause severe diseases. The share of such trees in the total number of trees assessed is 0.62%.

Bulges of non-parasitic origin were detected in beech tree bark at sample plots 30 and 96. Frost cracks stretched along the entire beech tree trunks. In one fir tree a lightning scar stretched along the entire trunk. Mechanical damages to sessile oak tree peaks were recorded in 4% of trees. Such damages occurred during tree cutting and pull-out. Frost cracks and other mechanical damages were present in Hungarian oak trees as well at 3 sample plots.

In a number of fir trees abundant sap secretion was observed and, according to the historical experience, all such trees are likely to dry the following year. A large-scale presence of lichen *Usnea barbata,* reflecting a healthy habitat, was perceived. There were also completely dry and broken trees fully covered with lichen (sample plots 415 and 416).

It is important to underline that in 2015 specific symptoms of an intense and widely spread phenomenon – ice ruptures – were clearly recognized and frequently observed in high, primarily beech forests. Such quantitatively and qualitatively severe injuries of trees occurred during dormancy in winter 2014/2015, in periods of bitter frost preceded by precipitation or merely high humidity at certain altitudes of Homolje Mountain Range. Geographically, eastern parts of the country were most affected (sample plots in Eastern Serbia, exceptionally sample plot 70 – Lukovo, sample plot 35 - Jabukovac, and sample plot 412 - Tisovac). Sanitation must commence with sanitation tree cutting and further growth measures for a number of reasons. The injured trees are an easy prey for secondary pests and diseases. It is necessary to prevent them, i.e., to eliminate favorable conditions for incidence of possible pest calamities. Wherever an opening appeared, it is necessary to protect the exposed layers (risk of bark inflammation) and put an end as soon as possible to complex yet possible scenarios of cycles of linked and chained damages (an exemplary pattern of a beech stand decay after initial ice rupture as an abiotic factor is presented in Graph 1):



Graph 1: *Example of the pattern of beech stand decay after the initial effect of a harmful agent (ice rupture) as an abiotic factor*

In 2015 forest fires broke out (0.24% trees affected) at several sample plots (e.g. sample plot 96), which resulted in total absence of assimilation organs in trees. Thereafter, the fire bed is occupied by pioneer vegetation, and more successful in succession are either invasive (blackberry) or economically and productively low graded species (birch, aspen, etc.).

At Level II sample plot Kopaonik 15 spruce trees (*Picea abies* L.) were selected for annual phenological observations. Phenophases were observed continuously, in succession. In the other two test fields, Mokra Gora and Crni Vrh, analyses were conducted using the same methodology.

Tables 6, 7 and 8 provide details obtained by phonological observations at Level II sample plot Kopaonik, as from the first field visit.

Table 6. *Table for registration of trees selected for intensive phenological monitoring – sample plot Kopaonik*

No.	Plot no.	Species code	Placement date	Tree no.	Visible crown part	Observation direction	Observation position	Other observations
1	2	118	16.09.10	75	3	4	1	
2	2	118	16.09.10	76	3	4	1	
3	2	118	16.09.10	78	3	4	1	
4	2	118	16.09.10	79	3	4	1	
5	2	118	16.09.10	80	3	4	1	
6	2	118	16.09.10	85	3	4	1	
7	2	118	16.09.10	86	3	4	1	
8	2	118	16.09.10	87	3	5	1	
9	2	118	16.09.10	88	2	6	1	
10	2	118	16.09.10	98	3	4	1	
11	2	118	16.09.10	114	2	6	1	
12	2	118	16.09.10	118	2	4	1	
13	2	118	16.09.10	120	1	7	1	
14	2	118	16.09.10	121	1	5	1	
15	2	118	16.09.10	124	2	8	1	

Table 7. *Phenological phenomena monitoring – sample plot Kopaonik*

No.	Plot no.	Species code	Event	Observation date	Registered event	Other observations
1	2	118	3	27.04.15	2	
2	2	118	1	27.05.15	2	
3	2	118	1	28.06.15	4	
4	2	118	1	16.07.15	5	
5	2	118	1	10.08.15	5	
6	2	118	2	11.09.15	1	
8	2	118	2	14.10.15	2	
9	2	118	2	21.10.15	3	
10	2	118	3	13.11.15	1	

Table 8. *Phenological phenomena records – sample plot Kopaonik*

No.	Plot no.	Tree no.	Event	Observation date	Registered event	Observation method used	Other observations
1	2	75	3	27.04.15	2	1	*Usnea barbata*
2	2	76	3	27.04.15	2	1	*Usnea barbata*
3	2	78	3	27.04.15	2	1	*Usnea barbata*

No.	Plot no.	Tree no.	Event	Observation date	Registered event	Observation method used	Other observations
4	2	79	3	27.04.15	2	1	*Usnea barbata*
5	2	80	3	27.04.15	2	1	*Usnea barbata*
6	2	85	3	27.04.15	2	1	*Usnea barbata*
7	2	86	3	27.04.15	2	1	*Usnea barbata*
8	2	87	5	27.04.15	7	1	*Bark beetles*
9	2	88	5	27.04.15	7	1	*Bark beetles*
10	2	98	3	27.04.15	2	1	*Usnea barbata*
11	2	114	5	27.04.15	7	1	*Bark beetles*
12	2	118	3	27.04.15	2	1	*Usnea barbata*
13	2	120	3	27.04.15	2	1	*Usnea barbata*
14	2	121	3	27.04.15	2	1	*Usnea barbata*
15	2	124	3	27.04.15	2	1	*Usnea barbata*
1	2	75	1	27.05.15	2	1	*Usnea barbata*
2	2	76	1	27.05.15	2	1	*Usnea barbata*
3	2	78	1	27.05.15	2	1	*Usnea barbata*
4	2	79	1	27.05.15	2	1	*Usnea barbata*
5	2	80	1	27.05.15	2	1	*Usnea barbata*
6	2	85	1	27.05.15	2	1	*Usnea barbata*
7	2	86	1	27.05.15	2	1	*Usnea barbata*
8	2	87	5	27.05.15	7	1	*Bark beetles*
9	2	88	5	27.05.15	7	1	*Bark beetles*
10	2	98	1	27.05.15	2	1	*Usnea barbata*
11	2	114	5	27.05.15	7	1	*Bark beetles*
12	2	118	1	27.05.15	2	1	*Usnea barbata*
13	2	120	1	27.05.15	2	1	*Usnea barbata*
14	2	121	1	27.05.15	2	1	*Usnea barbata*
15	2	124	1	27.05.15	2	1	*Usnea barbata*
1	2	75	1	28.06.15	4	1	*Usnea barbata*
2	2	76	1	28.06.15	4	1	*Usnea barbata*
3	2	78	1	28.06.15	4	1	*Usnea barbata*
4	2	79	1	28.06.15	4	1	*Usnea barbata*
5	2	80	1	28.06.15	4	1	*Usnea barbata*
6	2	85	1	28.06.15	4	1	*Usnea barbata*
7	2	86	1	28.06.15	4	1	*Usnea barbata*
8	2	87	5	28.06.15	7	1	*Bark beetles*
9	2	88	5	28.06.15	7	1	*Bark beetles*
10	2	98	1	28.06.15	4	1	*Usnea barbata*
11	2	114	5	28.06.15	7	1	*Bark beetles*
12	2	118	1	28.06.15	4	1	*Usnea barbata*
13	2	120	1	28.06.15	4	1	*Usnea barbata*
14	2	121	1	28.06.15	4	1	*Usnea barbata*
15	2	124	1	28.06.15	4	1	*Usnea barbata*
1	2	75	1	16.07.15	5	1	*Usnea barbata*
2	2	76	1	16.07.15	5	1	*Usnea barbata*
3	2	78	1	16.07.15	5	1	*Usnea barbata*
4	2	79	1	16.07.15	5	1	*Usnea barbata*
5	2	80	1	16.07.15	5	1	*Usnea barbata*
6	2	85	1	16.07.15	5	1	*Usnea barbata*
7	2	86	1	16.07.15	5	1	*Usnea barbata*
8	2	87	5	16.07.15	7	1	*Bark beetles*
9	2	88	5	16.07.15	7	1	*Bark beetles*
10	2	98	1	16.07.15	5	1	*Usnea barbata*
11	2	114	5	16.07.15	7	1	*Bark beetles*
12	2	118	1	16.07.15	5	1	*Usnea barbata*
13	2	120	1	16.07.15	5	1	*Usnea barbata*
14	2	121	1	16.07.15	5	1	*Usnea barbata*
15	2	124	1	16.07.15	5	1	*Usnea barbata*

No.	Plot no.	Tree no.	Event	Observation date	Registered event	Observation method used	Other observations
1	2	75	1	10.08.15	5	1	*Usnea barbata*
2	2	76	1	10.08.15	5	1	*Usnea barbata*
3	2	78	1	10.08.15	5	1	*Usnea barbata*
4	2	79	1	10.08.15	5	1	*Usnea barbata*
5	2	80	1	10.08.15	5	1	*Usnea barbata*
6	2	85	1	10.08.15	5	1	*Usnea barbata*
7	2	86	1	10.08.15	5	1	*Usnea barbata*
8	2	87	5	10.08.15	7	1	*Bark beetles*
9	2	88	5	10.08.15	7	1	*Bark beetles*
10	2	98	1	10.08.15	5	1	*Usnea barbata*
11	2	114	5	10.08.15	7	1	*Bark beetles*
12	2	118	1	10.08.15	4	1	*Usnea barbata*
13	2	120	1	10.08.15	5	1	*Usnea barbata*
14	2	121	1	10.08.15	5	1	*Usnea barbata*
15	2	124	1	10.08.15	5	1	*Usnea barbata*
1	2	75	2	11.09.15	1	1	*Usnea barbata*
2	2	76	2	11.09.15	1	1	*Usnea barbata*
3	2	78	2	11.09.15	1	1	*Usnea barbata*
4	2	79	2	11.09.15	1	1	*Usnea barbata*
5	2	80	2	11.09.15	1	1	*Usnea barbata*
6	2	85	2	11.09.15	1	1	*Usnea barbata*
7	2	86	2	11.09.15	1	1	*Usnea barbata*
8	2	87	5	11.09.15	7	1	*Bark beetles*
9	2	88	5	11.09.15	7	1	*Bark beetles*
10	2	98	2	11.09.15	1	1	*Usnea barbata*
11	2	114	5	11.09.15	7	1	*Bark beetles*
12	2	118	2	11.09.15	1	1	*Usnea barbata*
13	2	120	2	11.09.15	1	1	*Usnea barbata*
14	2	121	2	11.09.15	1	1	*Usnea barbata*
15	2	124	2	11.09.15	1	1	*Usnea barbata*
1	2	75	2	14.10.15	2	1	*Usnea barbata*
2	2	76	2	14.10.15	2	1	*Usnea barbata*
3	2	78	2	14.10.15	2	1	*Usnea barbata*
4	2	79	2	14.10.15	2	1	*Usnea barbata*
5	2	80	2	14.10.15	2	1	*Usnea barbata*
6	2	85	2	14.10.15	2	1	*Usnea barbata*
7	2	86	2	14.10.15	2	1	*Usnea barbata*
8	2	87	5	14.10.15	7	1	*Bark beetles*
9	2	88	5	14.10.15	7	1	*Bark beetles*
10	2	98	2	14.10.15	2	1	*Usnea barbata*
11	2	114	5	14.10.15	7	1	*Bark beetles*
12	2	118	2	14.10.15	2	1	*Usnea barbata*
13	2	120	2	14.10.15	2	1	*Usnea barbata*
14	2	121	2	14.10.15	2	1	*Usnea barbata*
15	2	124	2	14.10.15	2	1	*Usnea barbata*
1	2	75	2	23.10.15	3	1	*Usnea barbata*
2	2	76	2	23.10.15	3	1	*Usnea barbata*
3	2	78	2	23.10.15	3	1	*Usnea barbata*
4	2	79	2	23.10.15	3	1	*Usnea barbata*
5	2	80	2	23.10.15	3	1	*Usnea barbata*
6	2	85	2	23.10.15	3	1	*Usnea barbata*
7	2	86	2	23.10.15	3	1	*Usnea barbata*
8	2	87	5	23.10.15	7	1	*Bark beetles*
9	2	88	5	23.10.15	7	1	*Bark beetles*
10	2	98	2	23.10.15	3	1	*Usnea barbata*
11	2	114	5	23.10.15	7	1	*Bark beetles*
12	2	118	2	23.10.15	3	1	*Usnea barbata*

No.	Plot no.	Tree no.	Event	Observation date	Registered event	Observation method used	Other observations
13	2	120	2	23.10.15	3	1	*Usnea barbata*
14	2	121	2	23.10.15	3	1	*Usnea barbata*
15	2	124	2	23.10.15	3	1	*Usnea barbata*
1	2	75	3	13.11.15	1	1	*Usnea barbata*
2	2	76	3	13.11.15	1	1	*Usnea barbata*
3	2	78	3	13.11.15	1	1	*Usnea barbata*
4	2	79	3	13.11.15	1	1	*Usnea barbata*
5	2	80	3	13.11.15	1	1	*Usnea barbata*
6	2	85	3	13.11.15	1	1	*Usnea barbata*
7	2	86	3	13.11.15	1	1	*Usnea barbata*
8	2	87	5	13.11.15	7	1	*Bark beetles*
9	2	88	5	13.11.15	7	1	*Bark beetles*
10	2	98	3	13.11.15	1	1	*Usnea barbata*
11	2	114	5	13.11.15	7	1	*Bark beetles*
12	2	118	3	13.11.15	1	1	*Usnea barbata*
13	2	120	3	13.11.15	1	1	*Usnea barbata*
14	2	121	3	13.11.15	1	1	*Usnea barbata*
15	2	124	3	13.11.15	1	1	*Usnea barbata*

During the first visits to the test sample plot Kopaonik in 2015 (on January 28 and March 19) phenophase was not assessed as the trees were covered with snow. Examination of trees conducted on April 27, 2015 revealed needle fallout at the 1-33% level. The following examination of trees (on May 27) revealed growth of the current year's needles at the 1-33% level, while new needle growth reached 66–99% on June 28. The same situation was recorded upon examination on August 10. Discoloration was perceived on September 11 to the extent below 1%, while on October 14 it reached 33%. On October 23, discoloration level was in the 33-66% range. Needle fallout below 1% was determined upon examination on November 13, 2015. Upon each examination performed in 2015, bark beetle damages were observed in trees no: 87, 88 and 114.

Kopaonik: Phenolog. trunk no.75; 13/11/2015


Kopaonik: Phenolog. Crown no.75; 13/11/2015

Kopaonik: Phenolog. trunk no.76; 13/11/2015


Kopaonik: Phenolog. Crown no.76; 13/11/2015

Kopaonik: Phenolog. trunk no.78; 13/11/2015

Kopaonik: Phenolog. Crown no.78; 13/11/2015

Kopaonik: Phenolog. trunk no.79; 13/11/2015

Kopaonik: Phenolog. Crown no.79; 13/11/2015

Kopaonik: Phenolog. trunk no.80; 13/11/2015

Kopaonik: Phenolog. Crown no.80; 13/11/2015

Kopaonik: Phenolog. trunk no.85; 13/11/2015

Kopaonik: Phenolog. Crown no.85; 13/11/2015

Kopaonik: Phenolog. trunk no.86; 13/11/2015

Kopaonik: Phenolog. Crown no.86; 13/11/2015

Kopaonik: Phenolog. trunk no.87; 13/11/2015

Kopaonik: Phenolog. Crown no.87; 13/11/2015

Kopaonik: Phenolog. trunk no.98; 13/11/2015

Kopaonik: Phenolog. Crown no.98; 13/11/2015

Kopaonik: Phenolog. trunk no.114; 13/11/2015

Kopaonik: Phenolog. Crown no.114; 13/11/2015

Kopaonik: Phenolog. trunk no.118; 13/11/2015

Kopaonik: Phenolog. Crown no.118; 13/11/2015

Kopaonik: Phenolog. trunk no.120; 13/11/2015

Kopaonik: Phenolog. Crown no.120; 13/11/2015

Kopaonik: Phenolog. trunk no.121; 13/11/2015

Kopaonik: Phenolog. Crown no.121; 13/11/2015

Kopaonik: Phenolog. trunk no.124; 13/11/2015

Kopaonik: Phenolog. Crown no.124; 13/11/2015

Figures 9-36. Trees selected for phenological observations at sample plot Kopaonik, November 13, 2015 (*original photo of the Author)*

Installation of solar collector at Level II sample plot Kopaonik enabled phenology monitoring using the most contemporary approach. In October 2015 a camera was placed on tree no. 86 for 24-hour recording of all events on the tree selected for phenological observations. The recorded material (on a film) is stored in the recorder placed in the shed for equipment and instruments. To avoid interruptions in recording, two recorders were obtained. Once a month a recorder with the recorded material was delivered to the laboratory of the Forestry Institute where the recordings were processed and the recorded with the empty memory was placed to record events during the following month.

Figure 37**.** Camera recording on Oct 22, 2015 at 2.00 p.m.

Figure 38. Camera recording on Oct 22, 2015 at 2.14 p.m.

Figure 39. Camera recording on Oct 22, 2015 at 2.31 p.m.

Figure 40. Camera recording on Oct 22, 2015 at 2.43 p.m.

Figure 41. Camera recording on Oct 22, 2015 at 2.51 p.m.

Figure 42. Camera recording on Oct 22, 2015 at 2.59 p.m.

Figure 43. Solar panel for electricity generation Level II sample plot Kopaonik (*original photo of the Author)*

4. DISCUSSION

Continuous monitoring of forest health condition at sample plots applying scientifically confirmed methods vouches for active and ongoing supervision of the forest ecosystem conditions. Monitoring results are used as integral parts of legislative documents and international conventions whose objective is maintenance and improvement of the existing conditions. Public availability of and free access to information related to the condition of forests and forestry and their timely communication are a basis for adequate decision making on and understanding of forestry issues by the public. Introduction of the system for monitoring the forest health condition and vitality in accordance with UN/ECE and EU methodology enables increased contribution of the forestry industry to the overall economic and social development of the Republic of Serbia.

Forest drying is a result of adverse complex effects of several factors, both abiotic and biotic in nature, which may act simultaneously or consecutively. The final outcome of such changes does not always imply that the primary agent is the sole cause of the consequences or that the final agent in succession is the most significant (Halmschlager, E., 1998).

A forest ecosystem, as an extremely complex entity, is characterized by different parameters subject to constant variation due continuous and inseparable effects of abiotic and biotic factors.

Challenges and objectives of a research approach such as this involve several years of analyses in order to be able to draw conclusion on the phenomenon of forest drying across Europe and define more clearly the “cause and effect” system for all monitored phenomena.

Assessment criteria applied in intensive monitoring are all compatible and defined in such a manner that upon recording and statistical analysis, the obtained data are easily compared analytically and logically, providing the basis for a variety of comparative studies. By perceiving similarities and dissimilarities, assumptions on the primary causes of the disturbed natural equilibrium in the forest biocenoses are rejected or accepted, further progress of the changes is anticipated and further degradation of forests as invaluable natural entities is prevented strategically, from the aspects of multiple applied forestry disciplines.

5. CONCLUSION

Air pollution impact assessment and monitoring of its effects on the forest ecosystems in the territory of the Republic of Serbia without AP Vojvodina in 2015 (Level I) and intensive monitoring of forest vitality (Level II) projects at locations within the remit of Public Company “Kopaonik”, Management Unit “Samokovska Reka”, Public Company “Srbijašume”, Forest Estate “Užice”, Management Unit “Mokra Gora – Panjak” and Forest Estate “Timočke Šume” Boljevac, Management Unit “Crni Vrh”, are aimed at creation and advancement of both national and pan-European monitoring system over forests and forest ecosystems. Continuous monitoring is a basis for preparation of the relevant information on the condition of forest ecosystems to which we are obligated under the National Forest Action Programme and international environment protection conventions signed. Crown condition assessment involved determining defoliation extent as an indicator of the assimilation organ drying, tree drying and removal, tree status, crown shade, crown visibility and foliage transparency.

Injuries were also detected in selected trees. For each tree where injury/damage was identified, location, symptom, cause and intensity of injury/damage are stated. There is a visible trend of mild drying in trees observed since 2012, attributed primarily to entomological causes (Stefanović, T., et al 2012).

Noticeable presence of bark beetles was identified at sample plots. Bark beetles are secondary pests infesting already diseased and physiologically weakened trees. However, unless the infested trees are removed, bark beetles spread cyclically to other trees as well. Within several sample plots (outside of the trees examined in detail) complete drying of trees was observed with stripped bark and severe bark beetle infestation. Therefore the percentage with moderate defoliation in Europe may be described as reduced as compared to 2014 (“The Condition of Forests in Europe, 2014 Executive Report”). In 2015 severe defoliation was not recorded in any of the trees – no deterioration was identified.

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1. Assessment and monitoring of the impact of air pollution and its effects on the forest ecosystems in the Republic of Serbia without AP Vojvodina in 2015 (Level 1) and implementing intensive monitoring (Level 2) at locations which are located in the area of PE "Kopaonik" Management Unit "Samokovska Reka”, Srbijašume, PE "Uzice" Management Unit "Mokra Gora - Panjak", PE “Timocke Sume” Boljevac, Management Unit "Crni Vrh", financed by the Directorate of Forests, Ministry for Agriculture and Environment Protection of the Republic of Serbia, Contract No: 401-00-001085/2015-10, 18. 05. 2015. Year;
and

2. Project TP-31070: “The Development of Technological Methods in Forestry in order to Attain Optimal Forest Cover”, financed by the Ministry of Education and Science of the Republic of Serbia.

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AIR POLLUTION IMPACT ASSESSMENT AND MONITORING, ITS EFFECTS ON THE FOREST ECOSYSTEMS IN THE TERRITORY OF THE REPUBLIC OF SERBIA IN 2015

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Summary

For many years research in the field of monitoring the vitality of forests has been carried out in our country according to the international guidelines and the same methodology is applied in other European countries.

The National Focal Centre for Forest Monitoring in the Republic of Serbia, within the Institute of Forestry of the Republic of Serbia is actively participating in the ICP Forests international program, with a tendency of improving their work activities alignment with modern international approaches. The results of work and research indicate the vitality of forests in terms of the first occurrence of defoliation, representing primarily determined regularity; especially those that are severe stress agents in forest trees. Impairment and injuries were recognized and their causes determined in 2015. Fluctuations in the state of crowns of trees were monitored through several parameters, and the most significant findings summarized and presented as a major and important indicators of health and fitness of forests in Serbia in 2015 in particular.

ПРОЦЕНА И ПРАЋЕЊЕ УТИЦАЈА ЗАГАЂЕЊА ВАЗДУХА И ЕФЕКАТА ИСТОГ У ШУМСКИМ ЕКОСИСТЕМИМА НА ТЕРИТОРИЈИ РЕПУБЛИКЕ СРБИЈЕ У 2015 ГОДИНИ

Рената ГАГИЋ СЕРДАР, Томислав СТЕФАНОВИЋ, Горан ЧЕШЉАР, Светлана БИЛИБАЈКИЋ, Радован НЕВЕНИЋ, Илија ЂОРЂЕВИЋ, Зоран ПОДУШКА

Резиме

Дугогодишња истраживања, у домену праћења виталности шума, се спроводе према међународном упутству у нашој земљи а, по истој методологији раде и остале државе Европе.

Национални Фоцал Центар за мониторинг шума у Републици Србији, у оквиру Института за шумарство Републике Србије је активно учествује у међународном програму ICP Forest, са тенденцијама унапређења својих радних активности и њиховог усклађивања са модерним страним приступима. Резултати рада и истраживања указују на виталност шума са аспекта прво појаве дефолијације, представљајући прво.одређене правилности; посебно оне који су озбиљни агенси стреса код шумског дрвећа. Оштећења су препозната и детерминисан је њихов узрок у 2015 години. Флуктуације у стању круна дрвећа праћене су кроз неколико параметара а најважнији налази сумарно су представљене као главни и значајне показатеље здравствено-кондиционог стања шума Србије у конкретно за 2015. годину

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STATE OF ARTIFICIALLY-ESTABLISHED STANDS OF INTRODUCED CONIFERS ON THE SITE OF SESSILE OAK IN MU \`CER-VIDOJEVICA\`

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Abstract: *The paper presents the results of a study on the state of artificially-established stands of Douglas-fir and white pine on the site of sessile oak with hornbeam (Querco-Carpinetum moesiacum Rud. 1945), in Podrinje-Kolubara forest area in MU \`Cer-Vidojevica\`. The stands of Douglas-fir and white pine are 51 years. The main task of the paper was to examine extensive data on forest estimation elements obtained from the measurements carried out on the selected sample plots in order get a deeper insight into the structure (diameter structure, distribution of basal area, volume, height curve) and productivity (volume and volume increment) of the stands. With the aim of achieving comparability of the results, one sample plot was established in a 70-year old indigenous coppice stand of sessile oak. The knowledge of these characteristics will provide better understanding of the issues of forest management in these artificially-established stands and help define short-term and long-term management goals and measures for their implementation.*

Keywords: artificially-established stands stand state, stand structure, Douglas-fir, white pine, sessile oak.

“STANJE VEŠTAČKI PODIGNUTIH SASTOJINA ČETINARSKIH EGZOTA NA STANIŠTU HRASTA KITNJAKA U GJ “CER-VIDOJEVICA”

Izvod: *U radu su prikazani rezultati proučavanja stanja veštački podignutih sastojina duglazije bora, na staništu kitnjaka sa grabom (Querco-Carpinetum moesiacum Rud. 1945), na i vajmutovog Podrinjsko-kolubarskom šumskom području u GJ „Cer-*

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Vidojevica". Starost sastojina duglazije i borovca iznosi 51 godinu. Osnovni zadatak rada je da se na osnovu podataka detaljnog premera na oglednim poljima sagleda strukturna izgrađenost (debljinska struktura, distribucija temeljnice, zapremine, visinske krive) i proizvodnost (nivo zapremine i zapreminskog prirasta) ovih sastojina. Radi poređenja rezultata, jedno ogledno polje postavljeno je i u autohtonoj izdanačkoj sastojini hrasta kitnjaka starosti 70 godina. Upoznavanjem ovih karakteristika, biće moguće realnije sagledavanje problema gazdovanja u ovim veštački podignutim sastojinama, kao i definisanje kratkoročnih i dugoročnih ciljeva gazdovannja i mera za njihovu realizaciju.

Ključne reči: veštački podignute sastojine, sastojinsko stanje, strukturna izgrađenost, duglazija, borovac, hrast kitnjak.

INTRODUCTION

The substitution of indigenous broadleaved tree species with conifer monocultures in the given study area is a focus of special attention. Since these are broadleaved sites, the justification of this action is disputable. After the World War II, extensive afforestation and land reclamation of degraded and coppice broadleaved stands were performed in Serbia. Different methods of pure or partial felling with the introduction of allochthonous, mostly conifer tree species were applied. However, when selecting trees for afforestation, little attention was paid to the complex characteristics of forest ecosystems and on that account conifer monocultures were often established on unsuitable sites.

The most frequently used conifers belonged to native species, such as: Austrian pine (*Pinus nigra* Arn.) and Scots pine (*Pinus silvestris* L.), to a lesser extend spruce (*Picea abies* L) and fir (*Abies alba* Mill.). Since the 1970s, the following exotic and allochthonous - fast-growing conifers have been increasingly used for the afforestation of highly productive sites: white pine (*Pinus strobus* L), Douglas-fir (*Pseudotsuga menziesii (*Mirb.) Franco), larch (*Larix decidua* Mill.), white fir (*Abies concolor* Engelm) and other species. Since the afforestation has been carried out without any previous experience to rely on and without any previous testing of the suitability of the given species for the specific sites, the achieved results have not always been the same.

Artificially-established conifer stands make 456.31 ha or 12% of the total surface area of MU \`Cer-Vidojevica\`. This share is similar in most other management units (10-15%). The dominant conifer tree species is Austrian pine which participates with 42%. It is followed by spruce with 31%, Scots pine with 13%, white pine with 8% and Douglas-fir with 5% of the total volume of conifers. The age structure of these artificially-established conifer stands shows the dominance of middle-aged stands, with 63% of the area belonging to age classes III and IV. There is a significant percentage of old stands (36%), while the youngest stands participate with a negligable share of 1% (Special forest management plan for MU \`Cer-Vidojevica\`, 2013-2022).

"The substantial share of artificially-established conifer stands in the growing stock points to the prime importance of the knowledge of biological and ecological characteristics of the species and the dominant features of the sites they grow on. Without this knowledge, the management of these forests becomes even more complex, especially due to the risk of fires, windthrows and windfalls", Medarević, M., *et al.* (2002). The same author states that one of the strategic issues of Serbian forestry is related to the significant share of artificially-established stands in the total forest area because they call for urgent silvicultural and protection measures, while their unfavorable age and diameter structures make them economically unfavourable.

According to Stojanović, Lj. *et al.* (2010), artificially-established stands of introduced conifer species and the problem of species substitution in Serbia have been the focus of interest of many authors: Vrcelj-Kitić, D. (1982); Vučković, M. *et al*. (1990); Stamenković, V. (1994); Dražić, M. (1994); Koprivica, M. *et al*. (2002); Krstić, M. (2006); Stojanović, Lj. *et al.* (1994) (2006); Stajić, S. *et al*. (2006); Bjelanović, I. *et al.* (2010) and others. Furthermore, research studies have been conducted on the productivity and structure, mainly of spruce, Scots pine and Austrian pine plantations, while there have been only partial studies of non-native conifer species.

The main task of the paper was to use extensive data obtained from detailed measurements of trees on the sample plots established in the process of substitution of coppice forests of sessile oak trees in the area Vidojevica in 1960s to study the structure (diameter structure, distribution of basal area, volume, height curves) and productivity (volume and volume increment) of these stands and to determine whether it was a rational decision to introduce exotic species into these sites.

RESEARCH AREA, MATERIALS AND METHODS

The research was carried out in 2014 in the northwest of Serbia, *i.e.* on the mountain of Vidojevica which makes the northwestern part of the mountain Cer. Cer is a low mountain that completely belongs to the belt of oak forests. Montane beech forests have a significant share in the zone of oak forests. Nine sample plots were established, four in each artificially- established stand of Douglas-fir and white pine on the site of sessile oak with hornbeam **(***Querco-Carpinetum moesiacum* Rudski), aged about 50 years, and one sample plot was established in the sessile oak coppice stand, aged 70 years.

Forest estimation elements were measured by using conventional measurement methodology. Having established and marked sample plots and permanently marked the selected trees, we carried out detailed measurements of trees and stands in order to determine their structure (diameter structure, distribution of basal area, volume, and height curves) and productivity (volume and volume increment). The quality and health status of trees on the sample plots was also estimated during the research (Spasojević, B. 2014) as well as the development dynamics of individual trees and whole stands. Data processing was carried out by the methods usual for this type of research.

The study site is at the altitude ranging from 150 to 200 *m* a.s.l., and the average slope gradient is about 15º. The study stands have different aspects. The parent rock consists of crystalline schists and phyllites. SP 1 and SP 9 have medium-deep, leached acid soil (luvisol on acid silicate parent rock), which is the deepest soil in the study area. The other sample plots have medium deep acid brown soil. The mean annual air temperature is 11.1ºC. July is the warmest month with the mean annual air temperature of 20.9ºC, and January is the coldest with 0.1°C. The mean temperature of the growing period is 17.4ºC on average. The mean annual rainfall total is 825.8 mm, while it averages 476.2 mm in the growing period. Cer is considered to be a mountain at the transition from the dry climate of the extreme eastern parts of our country to the humid climate of the western parts. These climate characteristics had a significant impact on the development of soil and vegetation of this forest complex.

RESULTS AND DISCUSSION

It should be noted that due to intensive die-back of the investigated artificially-established stands, frequent sanitary fellings have been performed in the past ten years. They have in turn created gaps on large areas. Sample plots were established in homogeneous areas so they do not represent the general state of the entire territory of MU `Cer-Vidojevica`.

Basic data on the investigated stands are presented in Table 1, 2 and 3 and Figures 1-5.

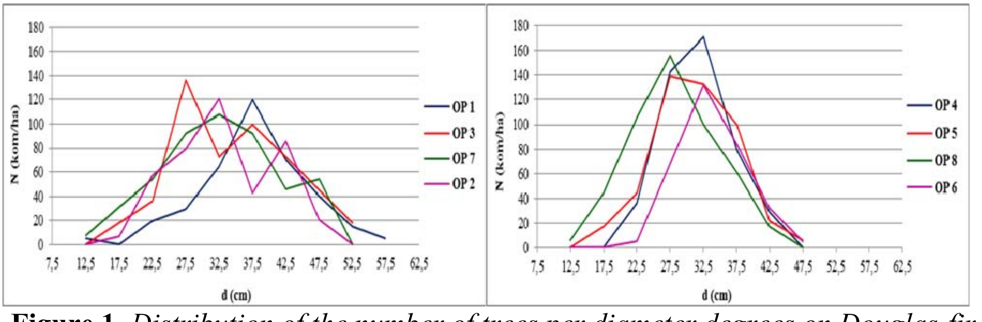

Figure 1. *Distribution of the number of trees per diameter degrees on Douglas-fir and white pine sample plots*

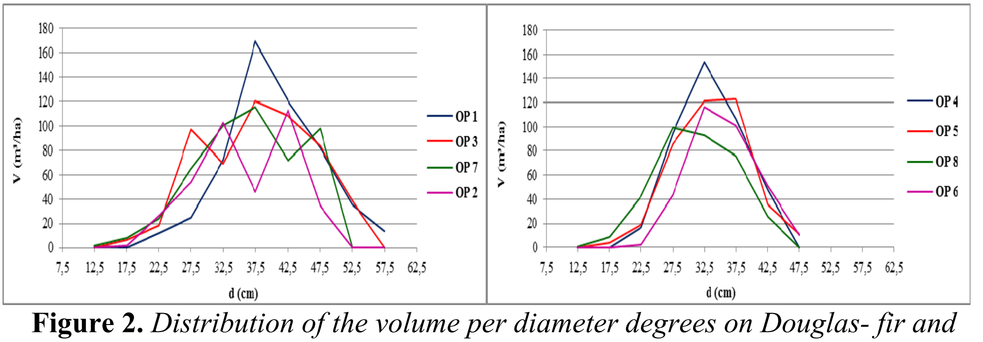

Figure 2. *Distribution of the volume per diameter degrees on Douglas- fir and white pine sample plots*

Artificially-established stands of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) on the site of sessile oak with hornbeam (*Querco-Carpinetum moesiacum* Rud. 1945), on acid brown and leached acid soil (dystric cambisol and luvisol on acid silicate parent rock):

The investigated Douglas-fir stands are 51 years old. They belong to different site classes (I-VI). The number of trees ranges between 370 and 499 trees per ha. The curves of distribution of trees per diameter degrees show that most of the trees are in the diameter degrees of 32.5 and 37.5 cm. The mean stand diameter is 33.0 to 37.6 cm, and the mean height amounts to 23.9 - 32.1 m. The wood volume ranges between 380 m^3/ha and 541.9 m^3/ha, with the average volume being 483.90 m^3/ha. The volume increment ranges from 5.57 m^3/ha to 7.05 m^3/ha and the average increment is 6.54 m^3/ha. The curve of distribution of volume per diameter degrees follows the distribution of the number of trees, so the maximum volume is also concentrated in the diameter degrees of 32.5 and 37.5 cm. The curve of distribution of basal area has the same shape as the distribution of trees per diameter degrees and the basal area of Douglas-fir ranges from 37.82 m^2/ha – to 49.24 m^2/ha, with the average value of 43.39 m^2/ha. The values of basal area and volume point to high productivity of these stands.

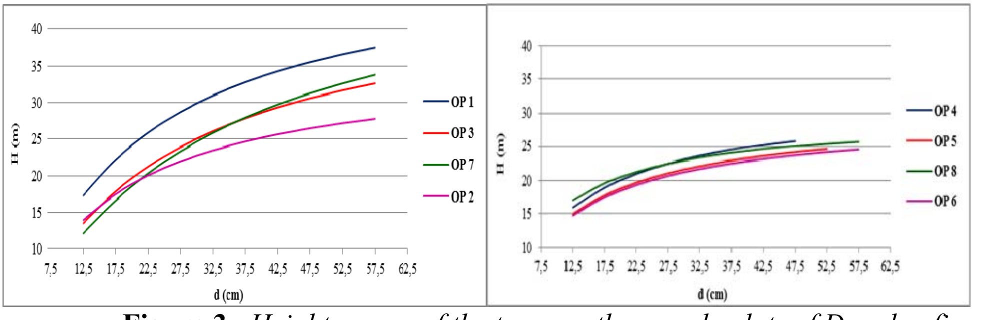

Figure 3. *Height curves of the trees on the sample plots of Douglas-fir and white pine*

Artificially-established stands of white pine (*Pinus strobus L.*) on the site of sessile oak with hornbeam (*Querco-Carpinetum moesiacum* Rud. 1945) on acid brown soil:

The investigated white pine stands are 51 years old. They belong to different site classes (I-IV). The number of trees ranges between 326 and 490 trees per ha. The curves of distribution of trees per diameter degrees show that most of the trees are in the diameter degrees of 27.5 and 32.5 cm. The mean stand diameter is 27.8 to 34.1 cm, and the mean height amounts to 22.2 – 23.2 m. The wood volume ranges between 324 m^3/ha and 419.0 m^3/ha, with the average volume being 372.5 m^3/ha. The volume increment ranges from 4.31 m^3/ha to 6.62 m^3/ha and the average increment is 5.4 m^3/ha. The maximum volume is concentrated in the diameter degrees of 27.5 to 37.5 cm. The curve of distribution of basal area has the same shape as the distribution of trees per diameter degrees and the basal area for white pine ranges from 29.88 m^2/ha – 36.93 m^2/ha, with the average value of 33.87 m^2/ha. The distribution of basal area and volume per diameter degrees shows that the trees with diameters above the mean stand diameter are the holders of volume, and the values of basal area and volume point to relatively high productivity of these stands.

Table 1. *Basic data on the investigated Douglas-fir stands*

Diam.degree. (cm)	Artificially-established stand of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) on the site of sessile oak with hornbeam (*Querco-Carpinetum moesiacum* Rud. 1945), on acid brown and leached acid soil (luvisol on acid silicate parent rock)																			
	SP 1 (Compartment and subcomp.: 11/b)					**SP 3** (Compartment and subcomp.: 10/c)					**SP 7** (Compartment and subcomp.: 10/c)					**SP 2** (Compartment and subcomp.: 10/c)				
	Slope: 11°-15°; Aspect: E					Slope: 20°- 25°; Aspect: SW					Slope: up to 10°; Aspect: W					Slope: 5°-10°; Aspect: W				
	Elevation: 148 m					Elevation: 185 m					Elevation: 177 m					Elevation: 168 m				
	N		**G**	**V**		**N**		**G**	**V**		**N**		**G**	**V**		**N**		**G**	**V**	
	per ha	%	m²/ha	m³/ha	%	per ha	%	m²/ha	m³/ha	%	per ha	%	m²/ha	m³/ha	%	per ha	%	m²/ha	m³/ha	%
12.5	5	1.4	0.06	1.2	0.2						8	1.7	0.10	1.5	0.3					
17.5						18	3.6	0.43	6.4	1.2	31	6.4	0.75	8.2	1.7	7	1.7	0.17	2.0	0.5
22.5	20	5.4	0.79	12.2	2.3	36	7.2	1.43	18.4	3.4	54	11.1	2.15	24.3	5.0	57	13.8	2.27	26.7	7.0
27.5	30	8.1	1.78	24.6	4.6	136	27.3	8.07	97.5	18.0	92	19.0	5.46	65.0	13.4	79	19.1	4.69	53.7	14.1
32.5	65	17.6	5.39	72.1	13.6	73	14.6	6.05	68.9	12.7	108	22.3	8.95	100.8	20.8	121	29.2	10.03	103.2	27.2
37.5	120	32.4	13.25	169.7	32.0	100	20.0	11.04	120.7	22.3	92	19.0	10.16	115.5	23.8	43	10.4	4.75	46.2	12.2
42.5	70	18.9	9.93	120.5	22.7	73	14.6	10.35	108.2	20.0	46	9.5	6.52	71.2	14.7	86	20.8	12.19	113.3	29.8
47.5	40	10.8	7.08	81.6	15.4	45	9.0	7.97	83.4	15.4	54	11.1	9.56	98.3	20.3	21	5.1	3.72	34.9	9.2
52.5	15	4.1	3.25	35.4	6.7	18	3.6	3.89	38.4	7.1										
57.5	5	1.4	1.30	13.4	2.5															
∑	**370**	**100**	**42.83**	**530.7**	**100**	**499**	**100**	**49.24**	**541.9**	**100**	**485**	**100**	**43.65**	**484.8**	**100**	**414**	**100**	**37.82**	**380**	**100**
	Site class I	dg = 37.6 cm hg = 32.1 m dgmax = 47.9 cm hgmax = 35.7 m Iv = 5.57 m³/ha				Site class III	dg = 34.6 cm hg = 26.7 m dgmax = 47.0 cm hgmax = 30.3 m Iv = 7.05 m³/ha				Site class IV	dg = 33.0 cm hg = 25.3 m dgmax = 45.2 cm hgmax = 30.0 m Iv = 6.51 m³/ha				Site class VI	dg = 33.5 cm hg = 23.9 m dgmax = 44.4 cm hgmax = 26.1 m Iv = 7.03 m³/ha			

Table 2. *Basic data on the investigated white pine stands*

Diam. degree. (cm)	Artificially-established stand of white pine (*Pinus strobus L.*) on the site of sessile oak with hornbeam (*Querco-Carpinetum moesiacum* Rud. 1945) on acid brown soil																			
	SP 4 (Compartment and subcomp.: 10/d)					**SP 5** (Compartment and subcomp.: 10/d)					**SP 8** (Compartment and subcomp.: 3/g)					**SP 6** (Compartment and subcomp.: 10/d)				
	Slope: 5°- 10°; Aspect: NW					Slope: do 5°; Aspect: NW					Slope: 15°- 20°; Aspect: NE					Slope: 5°- 10°; Aspect: NW				
	Elevation: 200 m					Elevation: 194 m					Elevation: 146 m					Elevation: 160 m				
	N		**G**	**V**		**N**		**G**	**V**		**N**		**G**	**V**		**N**		**G**	**V**	
	per ha	%	m²/ha	m³/ha	%	per ha	%	m²/ha	m³/ha	%	per ha	%	m²/ha	m³/ha	%	per ha	%	m²/ha	m³/ha	%
12.5											6	1.2	0.07	0.7	0.2					
17.5						17	3.7	0.41	4.2	1.1	44	9.0	1.06	8.8	2.5					
22.5	36	7.9	1.43	16.8	4.0	44	9.5	1.75	18.9	4.7	106	21.6	4.21	43.1	12.4	5	1.5	0.20	2.5	0.8
27.5	143	31.2	8.49	94.8	22.6	139	30.2	8.25	85.7	21.4	156	31.8	9.26	99.2	28.6	68	20.9	4.04	43.7	13.5
32.5	171	37.3	14.18	153.3	36.6	133	28.9	11.03	121.1	30.3	100	20.4	8.29	92.8	26.8	132	40.5	10.94	116.5	35.9
37.5	79	17.3	8.72	106.6	25.4	100	21.7	11.04	123.3	30.8	61	12.5	6.73	76.1	22.0	84	25.8	9.27	100.7	31.0
42.5	29	6.3	4.11	47.5	11.3	22	4.8	3.12	35.3	8.8	17	3.5	2.41	25.9	7.5	32	9.8	4.54	50.6	15.6
47.5						6	1.3	1.06	11.5	2.9						5	1.5	0.89	10.5	3.24
52.5																				
57.5																				
∑	**458**	**100**	**36.93**	**419**	**100**	**461**	**100**	**36.66**	**400**	**100**	**490**	**100**	**32.04**	**346.6**	**100**	**326**	**100**	**29.88**	**324.5**	**100**
	Site class I	dg = 31.8 cm hg = 23.2 m dgmax = 39.6 cm hgmax = 24.9 m Iv = 6.14 m³/ha				Site class II	dg = 31.2 cm hg = 22.2 m dgmax = 38.6 cm hgmax = 24.1 m Iv = 6.62 m³/ha				Site class II	dg = 27.8 cm hg = 22.6 m dgmax = 36.8 cm hgmax = 23.6 m Iv = 4.31 m³/ha				Site class IV	dg = 34.1 cm hg = 22.15 m dgmax = 41.4 cm hgmax = 23.4 m Iv = 4.56 m³/ha			

The analysis of the adequacy of the introduction of exotic conifer species into the sessile oak sites in this area included the study of the structure and productivity characteristics of an indigenous stand of sessile oak with hornbeam.

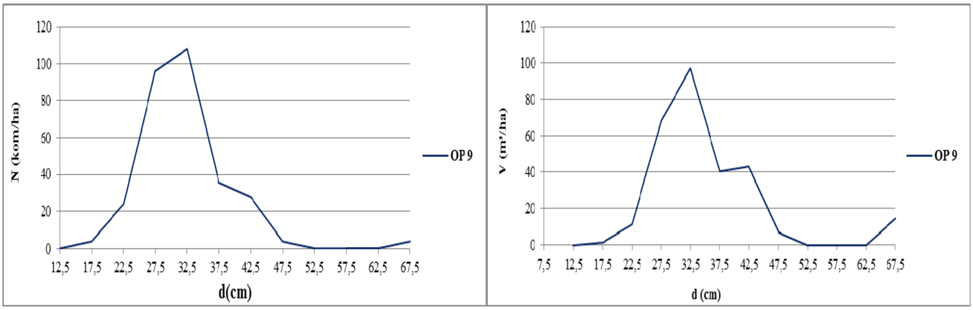

Figure 4. *Distribution of the number of trees and volume per diameter degrees on the sessile oak sample plot*

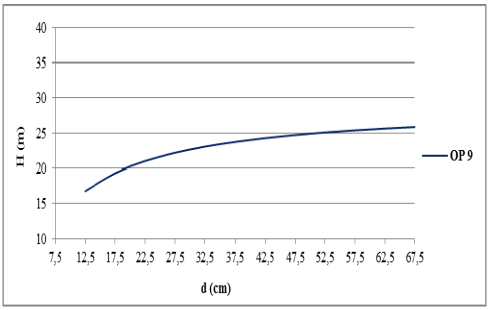

Figure 5. *Height curve of the trees on the sessile oak sample plot*

Mesophilic coppice forest of sessile oak with hornbeam (*Quercetum montanum subass. Carpinetosum betuli*) on leached acid soil (luvisol on acid silicate parent rock):

The investigated stand is 70 years old. It belongs to site class II. There are 304 trees per ha. The trees are distributed in the diameter degrees of 17.5 to 47.5 cm, but the greatest number of trees is in the diameter degrees of 27.5 cm to 32.5 cm (67%). The mean stand diameter is 31.98 cm, and the mean tree diameter of the dominant layer amounts to 37.6 cm. The mean stand height is 23.0 m. The distribution of forest estimation elements per diameter degrees forms a normal bell-shaped curve, with a small number of predominant trees in the diameter degree of 67.5 cm. These trees should certainly be removed in the preparatory cutting which must be taken in these stands. The distribution of the number of trees per diameter degrees resembles the distribution of basal area and volume, so the trees are mostly concentrated in the diameter degrees of 27.5 cm and 32.5 cm. The values of basal area (25.79 m^2/ha), volume (283 m^3/ha) and volume increment (2.40 m^3/ha) are significantly lower compared to the fast-growing conifers on its site.

Table 3. *Basic data on the investigated stand of sessile oak*

Diam. degree (cm)	Mesophilic coppice forest of sessile oak with hornbeam (*Quercetum montanum subass. Carpinetosum betuli*) on leached acid soil (luvisol on acid silicate parent rock)				
	SP 9 (Compartment and subcomp: 13/c); Slope: 13°-17°; Aspect: N; Elevation: 180 m;				
	N		**G**	**V**	
	per ha	%	m²/ha	m³/ha	%
17.5	4	1.32	0.10	1.30	0.46
22.5	24	7.89	0.95	11.00	3.89
27.5	96	31.58	5.70	68.30	24.13
32.5	108	35.53	8.95	97.20	34.35
37.5	36	11.84	3.97	40.60	14.35
42.5	28	9.21	3.97	43.30	15.30
47.5	4	1.32	0.71	7.00	2.47
67.5	4	1.32	1.43	14.30	5.05
∑	**304**	**100,00**	**25.79**	**283.00**	**100.00**
Site class II	dg = 31.98 cm; hg = 23.0 m		dgmax = 37.6 cm; hgmax = 23.5 m	Iv = 2.40 m³/ha	

The growing stock of this stand is significantly higher than the estimated optimum for Serbia, which according to Milin Ž. *et al.* (1987) amounts to 200 m³/ha. The volume increment is below the optimum estimated for coppice sessile oak forests in Serbia (according to Milin, Ž. *et al*., 1987-5 m³/ha) as well as below the average for the sessile oak forests established for production purposes which, according to Aleksić (2005) amounts to 3.7 m³/ha.

CONCLUSIONS

Based on detailed research conducted in 50-year old stands of allochthonous fast-growing conifers (white pine and Douglas-fir), established on the site of sessile oak and in a 70-year old indigenous coppice stand of sessile oak with hornbeam in the area of MU `Cer-Vidojevica`, the following conclusions were reached:

Artificially-established stands of Douglas-fir and white pine are highly productive. At the age of 50 years, they are three times more productive than indigenous sessile oak stands of the same age. The investigated artificially-established stands had a very intensive development by the age of about 40 years. The height and diameter increments were pronounced. The stands were very vital, with high quality and good health. In the last ten years, increment has been declining, vitality decreasing and die-back has been getting larger proportions (Spasojević, B. 2014). When young, these species did not show their mesophilic character and the site could meet their requirements. With age, as they grew in size, their requirements grew, too. Trees needed increasing amounts of water in the soil and humidity in the air which weren`t available.

Therefore, these sites can only serve for the growth of the investigated species on intensive short rotation plantations. They are unsuitable for longer rotation periods, especially in terms of rainfall and soil water capacity. Relative air humidity is another important environmental factor. Between the two studied species, Douglas-fir, however, proved to be a more suitable and more resistant species. White pine is vulnerable to various pathogens, so the growing conditions in Serbia are not suitable and they lead to its extensive die-back. Furthermore, the wood of this species is brittle, fragile and of low quality. Therefore the stands are unstable and easily affected by adverse abiotic factors (wind, snow and ice).

Sessile oak is also prone to die-back, both in coppice and in high stands. However, sessile oak as the primary species of this site should not be given up. Its sites should not be allowed to be taken over by native species that occur naturally and make an integral part of this community (hornbeam and lime), let alone the species such as flowering ash, hawthorn, wild rose, blackthorn and blackberry.

The problem with sessile oak forests cannot be solved by its replacement with introduced tree species since their introduction into an autochthonous ecosystem can have more serious adverse effects on the biodiversity and the site in general than clear-cutting or fire. The solution lies in the measures to improve their state and structure. Coppice forests should be transformed into high forests by conversion or artificial reconstruction, or by a combination of different methods. However, this is an extremely expensive and time-consuming process difficult to implement without frequent additional measures, given the increasingly rare seed crop and abundant weed growth.

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STATE OF ARTIFICIALLY-ESTABLISHED STANDS OF INTRODUCED CONIFERS ON THE SITE OF SESSILE OAK IN MU `CER-VIDOJEVICA`

Branka SPASOJEVIĆ, Vlado ČOKEŠA, Đorđe JOVIĆ

Summary

Die-back of both individual trees and entire stands of white pine and Douglas-fir established on the sites unsuitable for their growth (small altitude of 150-200 m, southern aspect, lack of moisture) was recognized as one of the biggest problems not only in the area of MU `Cer-Vidojevica` but also in most of Serbia. Severe droughts have led to physiological weakening of trees and made them predisposed to attacks of various pathogens. Since episodes of die-back had already been recorded in this forest complex before and the state of the stands has been getting worse over the last ten years, it can be concluded that the introduction of the given species was not a reasonable decision. Natural stands are less prone to damage which occur only sporadically there, and provided that they are tended regularly and properly, these stands are more resistant to the harmful effects of the stated climate elements.

Based on the aforementioned, we can conclude that the artificially-established white pine and Douglas-fir stands showed good productivity in these conditions, but based on the general state of the plantations, their weakened vitality and intensive die-back of individual trees and entire stands, these species are not recommended for further substitution of coppice forests of sessile oak in the area. After the planned rotation, it is recommended to perform reconstruction - the restore native species, which are in any case more adapted to bio-ecological conditions of these sites. Indigenous sessile oak stands are more acceptable from the aspect of ecology and natural ecosystems are more stable in the long run (having a more favorable impact on the site and conservation of biodiversity of other species).

In case coniferous species are used (native or non-native), it is recommended to plant them on smaller areas, taking into account bio-ecological characteristics of the selected conifers. When using exotic species in the reconstruction of coppice oak forests, special care must be taken in the selection of provenances. We must select the provenances that have proved resistant to the effects of different abiotic and biotic factors that threaten the vitality of these species in our conditions. These species can be used for the establishment of intensive short rotation plantations in similar soil conditions of deforested areas.

“STANJE VEŠTAČKI PODIGNUTIH SASTOJINA ČETINARSKIH EGZOTA NA STANIŠTU HRASTA KITNJAKA U GJ “CER-VIDOJEVICA”

Branka SPASOJEVIĆ, Vlado ČOKEŠA, Đorđe JOVIĆ

Rezime

Kao najveći problem, koji je i ranije konstatovan na području GJ „Cer-Vidojevica“, ali i na području gotovo cele Srbije, treba istaći sušenje kako pojedinačnih stabala, tako i čitavih sastojina borovca i duglazije podignutih na neodgovarajućem staništu (mala nadmorska visina 150-200 m, južna ekspozicija, nedostatak vlage). Jake suše su poslednjih godina dovele do fiziološkog slabljenja stabala i njihove predispozicije za napade raznih patogena. S obzirom da je pojava sušenja konstatovana i ranije u ovom šumskom kompleksu, a stanje ovih sastojina se poslednjih deset godina samo pogoršava, ukazuje da se unošenje navedenih vrsta u ovim uslovima nije pokazalo opravdanim. U prirodnim sastojinama, štete se javljaju samo sporadično, a ako su uredno i na pravi način negovane, pokazuju veću otpornost na štetne uticaje navedenih klimatskih elemenata.

Na osnovu svega izloženog, možemo konstatovati da su veštački podignute sastojine borovca i duglazije pokazale dobru proizvodnost u ovim uslovima, ali da se na osnovu opšteg stanja kultura, oslabljene vitalnosti i intenzivnog sušenja stabala i čitavih sastojina, ove vrste ne mogu preporučiti za dalje radove prilikom supstitucije izdanačkih šuma hrasta kitnjaka na ovom području. Nakon predviđene ophodnje, predlaže se ***rekonstrukcija*** – vraćanje autohtonih vrsta, kojima u svakom slučaju bioekološki više i bolje odgovaraju uslovi ovih staništa. Autohtone sastojine hrasta kitnjaka su ekološki prihvatljivije, a prirodni ekosistemi su, gledajući dugoročnije, stabilniji (povoljnije utiču na stanište i očuvanje biodiverziteta drugih vrsta).

U slučaju da se koriste četinarske vrste (domaće ili unešene), preporuka je da se to radi na malim površinama, vodeći pri tome računa o bioekološkim karakteristikama pomenutih četinara. Pri korišćenju egzota u rekonstrukciji izdanačkih hrastovih šuma, posebno treba voditi računa o izboru odgovarajućih provenijencija, koje su se pokazale

otpornim na delovanje različitih abiotičkih i biotičkih činilaca, a za koje je dokazano da ugrožavaju vitalnost ovih vrsta u našim uslovima. Njihova primena ne treba da se isključi za formiranje intenzivnih zasada sa kratkom ophodnjom u sličnim edafskim uslovima na obešumljenim površinama.

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CHANGES IN LAND USE IN THE REGION OF GRDELICA GORGE IN THE PERIOD 1963-2011

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Abstract: *A land use is the sole erosion factor that can be controlled and governed by man. Since an inadequate land use can cause intensification of erosive processes, it is possible to reduce their intensity by its change.*

The paper presents the changes in land use in the region of Grdelica Gorge in the period between 1963 and 2011 and the impact of the changes on the intensity of erosive processes. The identification of wooded land, arable land, meadows, pastures, orchards, vineyards and infertile land performed in 2011 was based on field works and the analysis of high resolution satellite images. The comparison of the obtained results with the data for 1963 proved that the categories of barren land, forest, meadow and pasture underwent most intensive changes. The above-mentioned changes, along with performance of biological and technical works, resulted in reduction of intensity of erosive processes in the observed period.

Key words: land use, erosive processes, erosion coefficient (Z)

PROMENE NAČINA KORIŠĆENJA ZEMLJIŠTA NA PODRUČJU GRDELIČKE KLISURE U PERIODU 1963-2011

Način korišćenja zemljišta predstavlja praktično jedini faktor nastanka erozije koji čovek može da kontroliše i da upravlja njime. Pošto neadekvatna upotreba zemljišta izaziva intenziviranje erozivnih procesa, moguće je promenom načina korišćenja zemljišta smanjiti intenzitet razvoja erozije.

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U radu su prikazane promene načina korišćenja zemljišta u regionu Grdeličke klisure u periodu između 1963. i 2011. godine, kao i uticaj nastalih promena na intenzitet erozionih procesa. Kartiranje površina pod šumama, oranicama, livadama, pašnjacima, voćnjacima, vinogradima i neplodnim zemljištem obavljeno je 2011. godine na osnovu terenskih radova i analize satelitskih snimaka visoke rezolucije. Poređenje dobijenih rezultata sa podacima za 1963. godinu pokazalo je da su kategorije goleti, šuma, livada i oranica pretrpele najintenzivnije promene. Gore pomenute promene, zajedno sa izvedenim biološkim i tehničkim radovimaa, rezultirale su smanjenjem intenziteta erozionih procesa u posmatranom periodu.

Ključne reči: način korišćenja zemljišta, erozioni procesi, koeficijent erozije (Z)

1. INTRODUCTION

In the mid 20th century, the region of Grdelica Gorge and Vranje Valley represented the epicentre of development of the most intense erosion processes. Devastating torrential streams threatened human lives, motorways and the Belgrade-Skopje-Thessaloniki railway, arable land, etc. The study of changes of intensity of erosive processes provides the insight into the causes of their mitigation, which took place in the period between 1963-2011.

Land use, in addition to analysis of meteorological and climate conditions, relief, geological and pedological layer, the degree of representation of the observed erosion processes, represents one of the key factors in identification and mapping of erosion processes. Through use of land and other natural resources for the purpose of social and economic development, human activities can either disturb and endanger the naturally established balance or preserve it and enhance it. This is the reason why a manner of land use, as a significant anthropogenic erosion factor, is the central focus of this study. The paper presents the change in land use in the region of Grdelica Gorge in the period 1963-2011.

2. WORK METHOD

Based on the available topographic maps, field mapping and use of satellite images of the study area, the manner of land use in 2011 was analysed and defined (Braunović, Ratknić, 2010). The structural composition of the area was determined by means of identification of homogenous plots (Image 1). The selection of primarily productive and unproductive areas within the homogenous wholes was performed. The productive areas include forests, degraded forests, meadows and pastures, orchards, house adjacent plots and gardens. The unproductive areas include gullies, stone fields, gravel, road networks, water courses and building land in settlements. According to the above categories, 1,780 homogenous plots were identified in the study area. Based on the above-mentioned systematisation of the study area, a digital map of land use was created and percentage representation of productive and unproductive areas, according to above categories, was calculated.

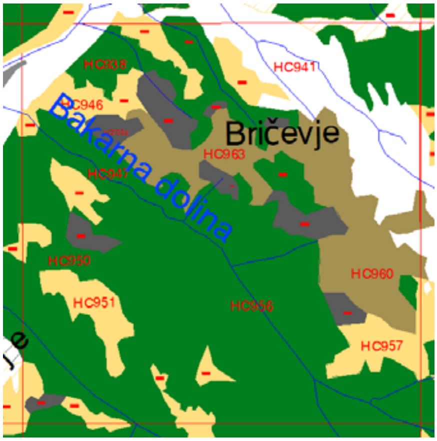

Image 1. *A detail of 2011 land use map*

3. RESULTS AND DISCUSSION

The Grdelica Gorge is situated in the northernmost part of the Južna Morava River catchment basin, in the stretch between Grdelica and Vladičin Han. Its catchment area is bound by mountain massifs: from the east by Mt Čemernik (1,638 and 1,592 metres), Mt Ostrozubska Čuka (1,546 metres), from the north-east by Mt Jastrebac (1,330 metres), from the west by Mt Kukavica (1,404 metres) and Mt Jelova Glava (1,114 metres), while in the south it is open towards the Vranje Valley. In administrative terms, the region of Grdelica Gorge belongs to the municipalities of Grdelica and Vladičin Han, except for a smaller part of the Džepska River catchment basin, which territorially belongs to the municipality of Surdulica.

The total surface area of the river catchment basin is 430.44km^2, out of which 427.61km^2 are torrential catchments, while 2.83km^2, out of torrential catchment, are situated in the inner area of towns Vladičin Han and Surdulica. The area is of an asymmetrical shape, as the right side is more developed (Image 2).

Image 2. *Grdelica Gorge –Zla Dolina River catchment basin,* Photo: Braunović, S., 2011

The right tributaries of the Južna Morava River, in the section from Grdelica to Vladičin Han (the Sejanička, Predejanska, Krpejska and Džepska River), run through so-called 'green schists', composed of different types of brittle schists (chlorite, serecite and other), which are very susceptible to the impact of water. Most of the springs of the above rivers are linked to outflow contact of dacitic rocks with schists. For that reason, these torrent streams have precipitous upper sections, since dacites are hard rocks. In some places, where dacite outflows are located in the lower stream, as it is the case with the Džepska River, this stream section also has steep sides (Braunović et al., 2010). The left tributaries of the Južna Morava River (the Letoviška River, Bistrica, Lepenica, Repiška, Kalimanska) are in most parts of their streams cut into granite gneisses and gnaisses, which results in significant descents of their river beds. Their springs are mainly linked to the contact of granite-gneisses with granites and andesites, where impenetrable hardness of rocks causes increased descents. The lower sections of these torrent streams are cut into neogene non-resistant sediments and have mild descents. The hydrographic and topographic characteristics of Grdelica Gorge are presented in the Table 1.

Table 1. *Hydrographic and topographic characteristics*

Parameter	Designation	Grdelica Gorge
Surface area of the catchment basin	F (km^2)	430.44
Circumference of the catchment basin	O (km)	99.57
Length of the main stream	L (km)	29.50
The most upstream elevation point of the main stream	K_v (metres)	324.00
The most downstream elevation point of the main stream	K_u (metres)	253.00
Stream winding coefficient	K_k	0.69
Number of torrential tributaries		137
Average descent at the section	I_p (%)	2.41
The total length of hydrographic network	ΣL (km)	277.01
The density of hydrographic network	G ($km \cdot km^{-2}$)	0.64
The mean width of the area	$S_š$ (km)	14.59
Catchment basin's coefficient of asymmetry	a	0.82
Shape coefficient of the catchment basin	A	0.54
Highest elevation spot of the catchment basin	(metres)	1638.00
Mean altitude of the catchment basin	N_{sr} (metres)	789.57
Mean altitude difference of the catchment basin	D (m)	536.57

Source: General project of torrential stream anti-erosion management in the region of Grdelica Gorge (2008)

The average descents of torrential tributaries are large and range between 6-38%. All tributaries in this catchment basin have typical torrential characteristics: a developed spring area, large descents in upper and middle streams, 1-3% descents in lower streams, strongly pronounced or strongly developed river deposits (Table 2).

Table 2. *Hydrographic and orographic characteristics of large tributaries of the Južna Morava River in Grdelica Gorge*

Name of catchment basin	F (km^2)	Shape of catchment basin	Flow direction	L (km)	$S_š$ (km)	Δh (m)	Stream descent (%)
LEFT TRIBUTARIES							
Kozarska River	101.0	Elongated	SE-NW	3.15	3.63	1190	37.78
Bistrička River	29.18	Elongated	SE-N	9.20	3.00	680	7.39
Jastrebačka River	9.84	Elongated	NW-SE	4.68	1.92	500	10.68
Letoviška River	19.60	Elongated	NW-SE	8.40	2.26	680	8.10
Rdovska River	19.36	Elongated	NW-SE	10.75	1.76	980	9.12
RIGHT TRIBUTARIES							
Palojska River	6.87	Elongated	NE-SW	4.60	1.52	480	10.43
Predejanska River	19.58	Fanlike	E-W	7.45	2.68	620	8.32
Džepska River	91.88	Fanlike	E-W	20.40	4.50	1200	5.88
Koznica	21.57	Elongated	E-NW	11.50	1.83	680	5.91

Source: General Plan for Management of Grdelica Gorge and Vranje Valley
A: Natural conditions and relief, 1956

Data on land use for 1963 were calculated based on the available data from 'List of torrent streams of right and left tributaries of the South Morava River in the stretch Grdelica – Vladičin Han, Register of torrential catchments and descents', prepared by the Regional section for protection of soil against erosion and torrent stream regulation, Vladičin Han, 1964. By the synthesis of the above-mentioned data, it was established that forests accounted for 33.19%, ploughed land 32.80%, meadows and pastures 7.39%, orchards 1.46%, house adjacent plots and gardens 0.43 % of the total catchment basin's surface area, that is, the productive areas constituted 75.27% of the study area's total surface area. In 1963, barren land accounted for 22.38% of the catchment basin, that is, over 1/5 of the study area.

When the share of the areas encompassed by the term 'non-catchment areas' (built up areas, asphalted roads and watersheds) is added to the share of barren land, it can be concluded that non-productive areas occupied 24.73%, or one quarter of the total Grdelica Gorge surface area (Table 3).

Table 3. *Land use in Grdelica Gorge (1963)*

Category	Surface area ha	Share %
Forests	14286.30	33.19
Meadows and pastures	3180.95	7.39
Ploughed land	14118.43	32.80
Orchards	628.44	1.46
House adjacent plots and gardens	185.09	0.43
Productive areas	32399.22	75.27
Barren land	9633.25	22.38
Non-catchment areas[2]	1011.53	2.35
Non-productive areas	10644.78	24.73
Total	43044.00	100.00

Source: List of torrential streams of right and left tributaries of the Južna Morava River in the stretch Grdelica – Vladičin Han, 1964

[2] Built-up areas, asphalted roads, water courses

Table 4. *Land use in Grdelica Gorge (2011)*

Category	Surface area ha	Share %
Forests	23526.18	99.43
Degraded forests	134.36	0.57
Forests	23660.50	54.97
Meadows and pastures	10772.61	100.00
Degraded pastures	-	-
High mountain meadows and pastures	-	-
Meadows and pastures	10772.6	25.03
Ploughed land	2727.59	6.34
Vineyards	68.26	0.16
Orchards	127.75	0.30
House adjacent plots and gardens	1296.97	3.01
Productive areas	4220.57	89.80
Settlements (construction zone)	698.37	1.62
Gullies	-	-
Stone fields	23.79	0.06
Gravel	81.96	0.19
Road network and water courses	3586.16	8.33
Non productive areas	4390.28	10.20
Total	43044.00	100.00

Source: Braunović, S (2013)

In 2011, the productive areas in the region of Grdelica Gorge constituted 89.8% of the study area's total surface area (Table 4). Within productive areas, forests covered 55% of the total surface area. Degraded forests, mainly oak stands, most frequently in the proximity of settlements, were also identified. Meadows and pastures covered 25% of the total area, out of which 5% were occupied by degraded pastures and 9% by high-mountain meadows and pastures. Ploughed land occupied 21% of the productive area, stretching along the valley of Južna Morava River and the lower streams of its large tributaries. Very small stretches of ploughed land are situated on higher altitudes and high-inclination slopes. Non-productive areas covered 10.2% of the total area. The highest percentage of these areas consist of road networks and water courses, followed by building land, stone fields and gullies.

In the period between 1963 and 2011, a significant decrease of ploughed land (28% of the productive area) took place in the studied area. The share of ploughed land in the total surface area dropped, that is, ploughed land was abandoned and naturally 'transferred' into the category meadows and pastures, the share of which increased by 18%. A 13.4% increase of afforested areas was identified in comparison to 1953, resulting in 45% afforestation percentage in 2011. In comparison to 1963, non-productive areas decreased by nearly 15%.

From the aspect of development of erosion processes, the changes in land use that took place in the observed period, contributed to their stabilisation. The value of the mean erosion coefficient in the region of Grdelica Gorge, calculated by means of use of the Prof Gavrilović's methodology (Gavrilović, 1972), in 1963 amounted to Zsr = 0.67 (moderate erosion processes), whereas in 2011 it was reduced to Zsr = 0.34 (low erosion processes).

4. CONCLUSION

Based on a map of manner of land use, created in 2011, it was established that the productive area constitutes 89.8%, whereas the non-productive area accounts for 10.2% of the total surface area of Grdelica Gorge. In addition to its primary purpose, the created map of manner of land use, was used as the basis for drawing up of an erosion map of the studied area.

The comparison of the obtained results with the results obtained in 1963, indicated that the most significant changes in manner of land use took place within the categories of barren land, forests, meadows and pastures. A decrease of barren land, ploughed land, meadows and pastures occurred as a result of rehabilitation, performed in the 1960s, of areas affected by intensive erosion processes (performance of technical works in river beds and bio-technical and biological works on catchment slopes).

Another reason for these changes is the migration from high-hilly areas to urban centres, which resulted in abandonment of agricultural areas, which were spontaneously covered by vegetation over the time. The changes in manner of land use in the observed period, in addition to other factors, had an impact on reduction of intensity of erosion processes. In 1963, the mean erosion coefficient in the region of Grdelica Gorge was Zsr = 0.67, whereas in 2011 Zsr = 0.34, which means that moderate erosion processes were reduced to the category of low erosion processes.

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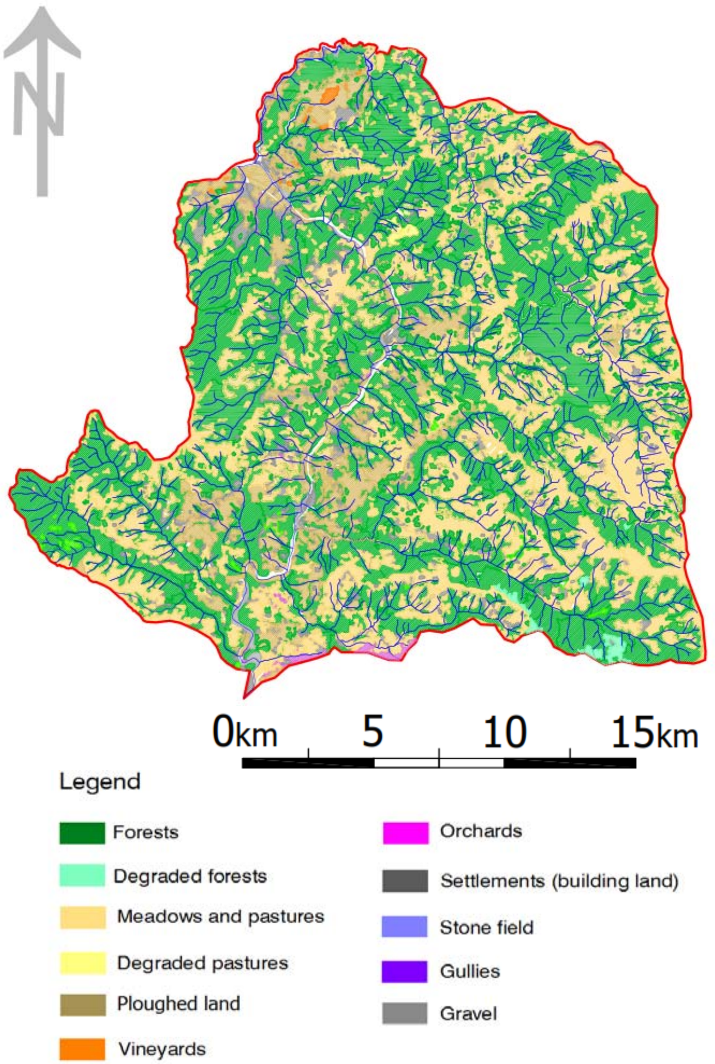

Image 3. A map of manner of land use – Grdelica Gorge 2011

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Original scientific paper

THE RESULTS OF THE STUDY OF DEFOLIATION AT BIOINDICATION POINTS IN THE REPUBLIC OF SERBIA IN 2014

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Abstract: *The Forest Condition Monitoring Project (ICP Forests) operates as an international European project where annual monitoring of forest condition, along with recording of data on defoliation, changes in colour and presence of other forms of tree damage, are performed on a network of bioindication points. The main aim of the programme is monitoring of forest condition in permanent, representative areas, distributed in a systematic European network. The paper analyses data on defoliation, as a part of the results of work on monitoring of forest condition at bioindication points in the Republic of Serbia in 2014. The assessment of defoliation at the points is performed regardless of the cause of leaf loss, thus the obtained results do not aim at determining casual-resultive connection, but only at representing the state of defoliation at the bioindication points in 2014.*

Key words: defoliation, bioindication points, assessment of crown condition

REZULTATI ISTRAŽIVANJE DEFOLIJACIJE NA BIOINDIKACIJSKIM TAČKAMA U REPUBLICI SRBIJI U 2014. GODINI

Izvod: *Projekat Praćenja stanja šuma (ICP Forests) funkcioniše kao međunarodni evropski projekat u kome se, na mreži bioindikacijskih, svake godine prati stanje šuma i beleže podaci o defolijaciji, promeni boje i prisustvu ostalih šteta na stablima. Glavni cilj programa je praćenje stanja šuma na stalnim, reprezentativnim površinama, raspoređenim u sistematsku mrežu na površini Evrope. U ovom radu analizirani su podaci o defolijaciji, kao deo rezultata rada na praćenju stanja šuma na bioindikacijskim tačkama u Republici Srbiji u 2014. godini. Na tačkama se ocena defolijacije vrši bez obzira na uzrok gubitaka*

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lišća, pa dobijeni rezultati nemaju za cilj utvrđivanje uzročno-posledičnih odnosa, već samo reprezentuju stanje defolijacije na bioindikacijskim tačkama u 2014. godini.

Ključne reči: defolijacija, bioindikacijske tačke, procena stanja krošnji

1. INTRODUCTION

The Forest Condition Monitoring Project (ICP Forests) operates as an international European project where annual monitoring of forest condition, along with recording of data on defoliation, changes in colour and presence of other forms of tree damage, are performed on a network of bioindication points. The main aim of the programme is collection of data on forest condition based on a uniform methodology and obtainment of data on spatial and temporal variation of the condition of forests in European countries (Stefanović, T., 2003.). Continuous monitoring of forest condition is performed at two levels of monitoring, of different intensity. The level 1 includes monitoring of forest condition at the bioindication points distributed in a 16x16 or 4x4 km system network.

The first assessment of forest condition, in line with the above programme, in the Republic of Serbia was performed in 1988. During 2003, the network of points was restored, while the majority of bioindication points had to be re-established. In 2004, it was observed that 103 reconstructed bioindication points in the 16 x 16 km network did not fully represent the condition of vegetation coverage in Serbia and, for that reason, another 27 points in a 4 x 4 km network were established (Stefanović, T., 2013). In previous years, clear cuts were performed on the localities of certain bioindication points, while from some points necessary data were not obtained continuously, on account of technical reasons. For that reason, another reconstruction of bioindication points was performed in 2014, where some points were excluded from the programme, and new ones were defined instead.

This paper analyses the data on defoliation, as a part of the result of work on monitoring of forest condition at bioindication points in 2014.

2. MATERIAL AND METHOD

In order to ensure viability of the ICP goals, the methods and data must be uniform, that is, it is necessary to comply with prescribed procedures and standards upon collection and processing of data. In the above-mentioned project, the condition of crowns is expressed by the classes of leaf mass loss. The assessment of crown condition is performed every year on permanent sample plots named bioindication points.

A permanent sample plot or bioindication point consists of the centre, which is determined based on coordinates and is clearly marked by metal bars. Sample plots were established at the distance of 25 metres from the centre, in the direction of four cardinal points. Within each sample plot, six trees were selected and marked by numbers from 1 to 6. The selected trees were permanently marked by numbers, while trees removed for any reason were replaced by new selected trees (Stefanović, T., 2013).

Defoliation, or loss of needles or leaves in a crown, is assessed for each tree in permanent sample plots in intervals of 5%, while the results are grouped into five classes of unequal scope (Table 1). The assessment is performed regardless of the cause of leaf (needle) loss. The assessment of crown condition is performed at all points and every year, in the period in which leaves and needles are fully developed.

Table 1. *Defoliation classes*

Class	Defoliation level	Percentage of leaf/needle loss
0	None	0-10 %
1	Low	10-25 %
2	Moderate	25-60 %
3	Strong	60-100 %
4	Dead	100 %

3. RESULTS AND DISCUSSION

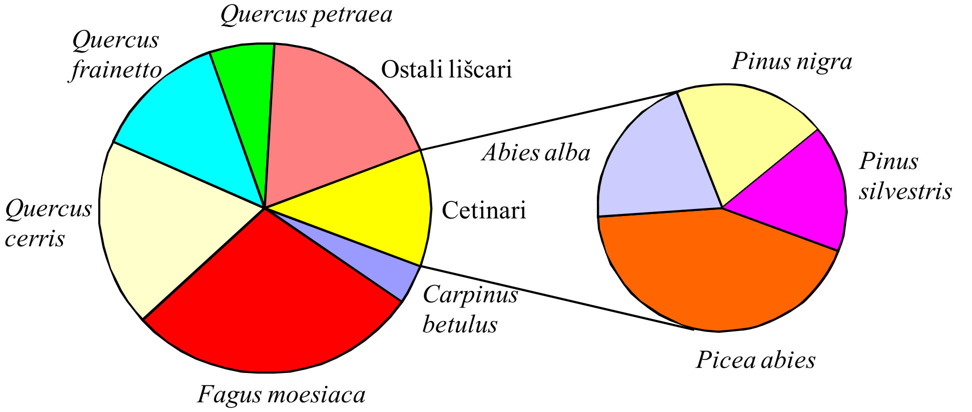
In 2014, the assessment of the forest condition on the territory of Republic of Serbia was performed at 128 bioindication points. The field work on data collection (observations and measurements) was performed in the period June-September.

The points were distributed in the altitudinal belt of 75-1,558 metres, where the highest number of points was in the altitudinal belt of 200-400 and 400-600 metres, 27 points in total (Table 2).

Table 2. *Distribution of bioindication points as per altitudes*

Altitude (metres)	0 - 200	200 -400	400 -600	600 -800	800 -1000	1000-1200	1200-1400	1400-1600	Total
Number of points	19	27	27	17	9	13	11	5	128

The defoliation assessment is performed on the total of 2,943 trees, out of which 2,607 were broadleaf and 336 coniferous species. The most represented tree species at the bioindication points are *Fagus moesiaca* (841 trees), *Quercus cerris* (543), *Quercus frainetto* (382), *Quercus petraea* (186) *and Carpinus betulus* (114). Among coniferous trees, the represented species include *Abies alba* (68 trees), *Picea abies* (145), *Pinus nigra* (67) and *Pinus silvestris* (56) (Graph 1).



Graph 1. *Represented tree species*

The assessment of defoliation level was performed in all bioindication points, while the level of exposure to defoliation processes of the most represented broadleaf and coniferous tree species is presented in Tables 3 and 4.

In 2014, beech had the highest percentage of trees without identified signs of defoliation (81.6%). At the same time, sessile oak proved the least resistant species, since defoliation of various degrees was identified on more than a half of the total number of its trees.

Table 3. *Defoliation – broadleaves in 2014*

	Horn beam	Beech	Turkey Oak	Hungarian Oak	Sessile Oak	Other	Broad leaves
None	74.5	81.6	64.6	69.6	48.9	58.4	68.9
Low	14.9	12.6	21.7	19.1	33.9	21.8	19
Moderate	5.3	3.2	10.3	7.3	16.2	14.2	8.6
Strong	5.3	2.4	2.8	3.2	0.5	3.2	2.7
Dead	0	0.2	0.6	0.8	0.5	2.4	0.8

In 2014, defoliation (needle cast or needle drop) was not detected in 89.7% of fir trees, 80.0% of spruce trees and 87.4% of white pine trees. As in previous years, in 2014 black pine proved drastically the most sensitive and susceptible to defoliation processes, that is, needle drop. 13.4% of black pine trees were affected by strong defoliation, 29.9% was affected by moderated defoliation, 20.9% was affected by low defoliation, while in only 34.3% of black pine trees defoliation was not detected.

Table 4. *Defoliation – conifers in 2014*

	Fir	Spruce	Black Pine	White Pine	Conifers
None	89.7	80	34.3	87.4	74.1
Low	0	14.5	20.9	5.4	11.3
Moderate	1.5	4.8	29.9	1.8	8.6
Strong	7.3	0.7	13.4	5.4	5.4
Dead	1.5	0	1.5	0	0.6

In 2014, as in previous years, broadleaves were more strongly affected by defoliation than conifers. In 74.1% of conifers there was no defoliation, while 68.9% of the total number of broadleaf trees was not affected by defoliation.

4. CONCLUSION

The Forest Condition Monitoring Project (ICP Forests) operates as an international European project where annual monitoring of forest condition, along with recording of data on defoliation, changes in colour and presence of other forms of tree damage, are performed on a network of bioindication points.

The paper analyses data on defoliation, as a part of the results of work on monitoring of forest condition at bioindication points in the Republic of Serbia in 2014. During this year, the assessment of crown condition was performed in 128 bioindication points, on the total of 2,943 trees. The field work on collection of data (observations and measurements) was performed in the period June-September.

As regard the broadleaf species, in 2014, as in previous years, beech and hornbeam proved to be the species more resistant to defoliation processes in comparison to oaks. Sessile oak proved to be the most endangered among broadleaf species at bioindication points in 2014. Among coniferous species, fir, white pine and spruce proved more resistant, while black pine trees were the species by far the most endangered by these processes of all species identified at the bioindication points.

The assessment of defoliation at bioindication points is performed regardless of the cause of leaf loss, thus the obtained results do not aim at determining casual-resultive connection, but only at representing the state of defoliation at the bioindication points in 2014. The conducted studies represent an underlying basis for monitoring of changes in forest condition, while linking these results to other indicators of environmental condition will enable obtaining concrete findings and drawing conclusions on dependence of plant vitality on environmental conditions.

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THE RESULTS OF THE STUDY OF DEFOLIATION AT BIOINDICATION POINTS IN THE REPUBLIC OF SERBIA IN 2014

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Summary

The Forest Condition Monitoring Project (ICP Forests) operates as an international European project where annual monitoring of forest condition, along with recording of data on defoliation and presence of all forms of tree damage are performed on a network of bioindication points. The main aim of the programme is monitoring of forest condition in permanent, representative areas, distributed in a systematic European network. In order to ensure the viability of the goals, the methods and data must be uniform, that is, it is necessary to comply with prescribed procedures and standards upon collection and processing of data and their submission in prescribed forms. The paper analyses the data on defoliation, as a part of the results of work on monitoring of forest condition at bioindication points in the Republic of Serbia in 2014. The assessment of crown condition was performed at 128 bioindication points and the total of 2,943 trees, out of which 2,607 were broadleaves and 336 conifers. The most represented tree species in the bioindication points are *Fagus moesiaca* (841 trees) and *Quercus cerris* (543 trees). Among broadleaf species, beech proved the most resistant to defoliation processes in the observed period (81.6% of trees without any signs of defoliation identified). Among coniferous species, it is fir with 89.7% of trees without visible damage.

Sessile oak proved to be the most endangered species among broadleaves in the bioindication points in 2014, where over 50% of trees are threatened by defoliation of various degrees. Among conifers, black pine is the species most endangered by these processes. As in previous years, in 2014 black pine proved drastically most sensitive and most susceptible to defoliation processes, that is, to needle cast. 13.4% of black pine trees is affected by strong defoliation, 13.45 by moderate defoliation, 29.9% by low intensity defoliation, while only on 34.3% of trees defoliation was not detected. Black pine trees are by far most threatened by these processes of all species identified in bioindication points. The assessment of defoliation in bioindication points is performed regardless of the cause of leaf loss, thus the obtained results do not aim at determining casual-resultive connection, but only at representing the state of defoliation in the bioindication points in the observed period. The conducted studies represent an underlying basis for monitoring of changes in forest condition, while linking these results to other indicators of environmental condition will enable obtaining concrete findings and drawing conclusions on dependence of plant vitality on environmental conditions.

REZULTATI ISTRAŽIVANJE DEFOLIJACIJE NA BIOINDIKACIJSKIM TAČKAMA U REPUBLICI SRBIJI U 2014. GODINI

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Rezime

Projekat Praćenja stanja šuma (ICP Forests) funkcioniše kao međunarodni evropski projekat u kome se, na mreži bioindikacijskih tačaka, svake godine prati stanje šuma, beleže podaci o defolijaciji i evidentiraju sva oštećenja na stablima. Glavni cilj programa je praćenje stanja šuma na stalnim, reprezentativnim površinama, raspoređenim u sistematsku mrežu na površini Evrope. Da bi ciljevi bili ostvarivi metode i podaci moraju biti uniformni, odnosno neophodno je pridržavanje propisanih procedura i standarda prilikom prikupljanja podataka, njihove obrade i dostavljanja u propisanim formama.

U ovom radu analizirani su podaci o defolijaciji kao deo rezultata rada na praćenju stanja šuma na bioindikacijskim tačkama, na području Republike Srbije, u 2014. godini.

Procena stanja kruna izvršena je na 128 bioindikacijskih tačaka i na ukupno 2943 stabla, od toga 2607 lišćarskih i 336 stabala četinarskih vrsta. Najzastupljenije vrste drveća na bioindikacijskim tačkama su *Fagus moesiaca* (841 stabalo) i *Quercus cerris* (543 stabala).

Kod lišćarskih vrsta, bukva se, u obrađivanom periodu, pokazala kao najotpornija vrsta procesima defolijacije (81.6 % stabala na kojima nisu registrovani nikakvi znakovi defolijcije). Kod četinara to je jela sa 89.7 % stabala bez vidljivih oštećenja. Kao najugroženija vrsta među lišćarima, na bioindikacijskim tačkama u 2014. godini pokazao se hrast kitnjak, kod koga je više od 50 % stabala ugroženo defolijacijom različitog stepena. Među četinarima stabla crnoga bora su najugroženija ovim procesima. Kao i predhodnih godina i u 2014. godini crni bor se pokazao drastično najosetljivi i najpodložniji procesima defolijacije, odnosno opadanju četina. Jakom defolijacijom zahvaćeno je 13.4 %, umerenom defolijacijom 29.9 %, defolijacijom slabog inteziteta 20.9 %, dok na samo 34.3% stabala crnog bora nije registrovana defolijacija. Stabla crnoga bora daleko su najugroženija ovim procesim od svih vrsta registrovanih na bioindikacijskim tačkama.

Procena stanja kruna, odnosno ocena defolijacije na bioindikacijskim tačkama, vrši se bez obzira na uzrok gubitaka lišća (četina), pa dobijeni rezultati nemaju za cilj utvrđivanje uzročno-posledičnih odnosa, već samo reprezentuju stanje defolijacije na bioindikacijskim tačkama u obrađivanom periodu. Sprovedena istraživanja predstavljaju tek polaznu osnovu za praćenje promena stanja šuma, a povezivanje ovih rezultata sa drugim pokazateljima uslova sredine omogući će konkretnija saznanja, i donošenje zaključaka o zavisnosti vitalnosti biljaka od uslova sredine.

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Original scientific paper

LOCALITY 'JOZICA KOLIBA' IN SERBIA-THE FOREST COMMUNITY CHARACTERISTICS

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Abstract: *The memorial complex "Jozića Koliba" is situated within the boundaries of Obrenovac Reserve forest complex. A special value of this locality is its group of protected pedunculate oak trees, which consists of six protected trees aged approximately 200 years with their crown projections. The idea to protect not only the trees themselves, but also their immediate surroundings of which the forest community forms a part, imposed the need for studying and describing the community. The study of current forest vegetation was performed according to the principle of French-Swiss school Braun-Blanquet, J (1921,1928). In total, 33 species were identified in the forest community. In the tree storey, three species were identified: Quercus robur L., Fraxinus angustifolia Vahl. and Acer campestre L. In the herb layer, two legally protected species were identified: Ruscus aculeatus L. and Viola odorata L. The presence of nine different areal types, dominated by species of sub central-European flora element, was established by means of a phytogeographic analysis. According to the results of the analysis of life-form representation, this community is of a phanerophyte-hemicryptophyte type, with an increased presence of geophytes.*

Key words: forest vegetation, natural resources, Obrenovac Reserve

1. INTRODUCTION

The memorial complex "Jozića Koliba" is situated within the boundaries of Obrenovac Reserve forest complex. It encompasses a natural property under the III category of protection, which consists of a natural monument with six protected

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pedunculate oak trees (*Quercus robur* L., syn: *Quercus pedunculata* Erh) with their horizontal crown projection (Official gazette...). The protected tree group represents a remnant of autochthonous Serbian pedunculate oak and ash communities (*Querceto-Fraxinetum serbicum* Rudski) (Gajić, 1984). The principal aim of the protection was precisely preservation of pedunculate oak trees, as edificators of once broadly-widespread autochthonous forest communities. The Kolubara River is in the immediate vicinity of the complex, while between the River and the complex itself, there is an embankment, which serves as a protection from high water-levels and it stretches along the left bank. Within this locality, there is a forest community which forms a spatial whole with protected trees. For the purpose of initiating the procedure of placing this part of the memorial complex under protection, the forest community was the subject of the study.

2. METHODOLOGY

The vegetation mapping was performed based on a standard methodology for the study of current vegetation, according to the principles and methodology of the French-Swiss school (Braun-Blanquet, J.,1921,1928).

The analysis of stand conditions involves defining soil characteristics, based on the samples collected in the forest community. The identification of soil types was performed on the basis of soil classification (Škorić et al, 1985).

Based on the phytocoenological records, the floristic-structural phytocoenological tables were created. The spectra of floristic elements (the percentage representation of groups of floristic elements and the representation of individual floristic elements) for each community were prepared in accordance with the Gajić's systematisation of plant-geographic elements (Gajić, 1984) and Diklić, N. (1984). The biological plant spectra (the percentage representation of individual life-forms) were prepared according to Kojić. M. et al. (1977) and Diklić, N (1984), based on the classification of life-forms into types (Raunkiaer, 1934).

3. RESULTS

Ecological conditions of habitat

Sedimentary rocks of Cenozoik age are well-represented on this territory. Neogene deposits lay transgressively over older Paleozoic and Mesozoic deposits. Sands, gravels and loams are placed along the spacious Kolubara river bed.

The area is characterised by moderate continental climate with warm summers and cold winters. The average temperature is 11^0C. As a result of its openness to the north and Pannonian Plain, the impact of continental pluviometric regime can be felt. The maximum amount of precipitation is in late spring, whereas the secondary maximum is in late autumn. Winters are cold, windy and dry. The annual amount of precipitation is about 640mm. In the dry period, the average amount is 440, while in the rainy period it is 940mm. The mean relative humidity is 74%. The wind most frequently blows from south-east. North winds rarely bring precipitation. A large impact on direction of air currents is exerted by the valleys of rivers Drina and Kolubara (Radovanović, 2001).

At the locality 'Jozića Koliba', meadow black soil evolves under automorphic conditions (the processes of argillogenesis occur, that is, brownisation of lower parts of A horizon) and it is transformed into eutric cambisol. The most common locations for such soils are loess terraces, loess plateaux and alluvial plains. The primary pedogenetic process is humification and humization, which take place under the favourable soil humidity conditions. For the purpose of determining soil characteristics of the studied locality, the analysis of samples was performed by determining physical and chemical properties of the substrate.

Table 1. *Physical properties of soil*

Lrb	Client designation	Coarse sand	Fine sand	Powder	Clay	Total sand	Total clay	Texture class
		%	%	%	%	%	%	
118/10	1	1.90	14.70	32.50	50.90	16.60	83.40	Clay
119.00	2	1.40	14.90	31.30	52.40	16.30	83.70	Clay
120.00	3	1.10	13.40	32.50	53.00	14.50	85.50	Clay
121.00	4	1.10	14.70	29.00	55.20	15.80	84.20	Clay

Physical properties of all four analysed soil samples are characterised by a very heavy textural composition. All samples belong to a clay texture class. The texture composition is dominated by fraction of particles smaller than 0.002mm, while the total clay is represented by 80%. That means that the soil represented by these samples has low water permeability and is very poorly aerated.

Table 2. *Chemical properties of soil*

LRB	Client designation	pH		Adsorptive complex					Total			Accessible	
				T	S	T-S	V	Y1	humus	N		P_2O_5	K_2O
		H_2O	KCl	ekv.m.mol/100g			%	cm3	%	%	C/N	mg/100g	
118/10	1	5.55	4.81	62.09	41.68	20.41	67.12	31.41	8.54	0.77	6.45	24.03	65.65
119/10	2	5.49	4.67	58.58	39.05	19.53	66.67	30.04	7.05	0.63	6.51	17.31	41.41
120/10	3	5.50	4.64	51.55	34.68	16.86	67.28	25.94	5.10	0.55	5.34	17.79	35.62
121/10	4	5.67	4.68	51.06	37.74	13.31	73.92	20.48	3.93	0.54	4.21	7.99	21.27

Chemical properties of soil are characterised by acid reaction of soil solution. As a result of a heavy textural composition of soil, dominated by the most sorption-active fraction of clay, the total adsorption capacity is very high. In addition to a heavy textural composition, a large quantity of humus also produces an impact on the high total adsorption capacity. In addition to the high total adsorption capacity, the sum of adsorbed based cations is high in all analysed samples. According to the level of saturation by base cations of the adsorptive complex, the studied soils belong to the euteric soil type.

The content of humus is high in all samples. The samples marked by 1, 2 and 3, according to their total humus content, represent highly humus-rich types of soil, while the sample 4 represents a very humus-rich type of soil. In addition to high humus content, the content of total nitrogen is also high in all four analysed profiles. This ensures a close C/N relation, which means that the character of organic matter is not the cause of stoppage of mineralisation of organic nitrogen and its transformation into forms accessible to minerals and plants.

In the soil represented by sample 1, the content of plant-easily accessible forms of phosphorus is within the limits of very well-supplied, according to the limit values for the AL method. The soils represented by samples 2 and 3 are medium well-supplied, whereas the soil represented by sample 4 is poorly supplied by the plant-easily accessible forms of phosphorus. All four analysed samples are very well-supplied by the plant-easily accessible forms of potassium.

Vegetation

Phytocoenological records are presented in Table 3. Phytocoenological table contains 33 species.

Table 3. *Phytocoenological records of the community Fraxino angustifolie-Quercetum roboris Jov. et Tom. 1979.*

Association	*Fraxino angustifolie-Quercetum roboris Jov. et Tom. 1979.*	
Record number	1	2
Date of recording	2 October 2010	2 October 2010.
Locality	Jozića Koliba	Jozića Koliba
Place	Veliko Polje	Veliko Polje
Size p.p. (m^2)	300	300
Altitude (m)	78.2	78.2
Geological layer	River sediments	River sediments
Soil	Meadow black soil	Meadow black soil
Tree storey		
Canopy (%)	70	70
Height-mean (m)	23	25-28
Diameter-mean (cm)	45	40
Distance (m)	4	3
Quercus robur	1.2	1.2
Fraxinus angustifolia	1.1	1.1
Acer campestre	+.1	
Shrub storey		

Canopy (%)	50	60
Height-mean (m)	3	5-7
Cornus mas	1.2	1.2
Ruscus aculeatus	1.2	1.2
Acer campestre	1.1	1.1
Prunus domestica	1.1	1.1
Rosa canina	+.1	1.1
Fraxinus angustifolia	+.1	+.1
Ulmus carpinifolia	+.1	+.1
Cornus saguinea	3.2	
Prunus spinosa		2.2
Helianthus tuberosus		1.3
Evonimus europaea		1.2
Craaegus monogyna	1.2	
Tilia platyphyllos		0.1
Herb layer		
Coverage (%)	70	60
Hedera helix	3.2	2.2
Convallaria majalis	3.3	1.1
Arum maculatum	3.3	+.1
Viola silvestris	1.1	+.1
Quercus robur	+.1	2.2
Ligustrum vulgare	+.2	1.1
Crategus monogyna	+.1	+.1
Ruscus aculeatus	+.1	+.1
Ulmus carpinifolia	+.1	+.1
Ranunculus repens	+.1	+.1
Linaria vulgaris	+.1	+.1
Galanthus nivalis	3.3	
Allium ursinum	2.3	
Viola odorata	1.1	
Rumex acetosa	+.2	
Geum urbanum	+.1	
Polygonum aviculare	+.1	
Tamus communis	+.1	
Veronica chamaedrys	+.1	

In river alluvia, pedunculate oak and narrow-leafed ash forests (*Querceto-Fraxinetum serbicum)* occupy the belt between hygrophilic willow-poplar forests, of the *Salicion albae* alliance, in riverine areas, and mesophilic pedunculate oak-hornbeam forests, of the *Carpinion betuli* alliance, situated beyond the reach of flood waters (Tomić & Rakonjac, 2012).

The community is characterised by abundance of dendroflora and a rich, densely covered shrub layer. In the tree storey, in addition to edificators pedunculate oak (*Quercus robur*) and narrow-leafed ash (*Fraxinus angustifolia*), field maple (*Acer campestre)* can also be found. In the rich shrub storey, the following species are present: *Cornus mas, Ruscus aculeatus, Acer campestre,* *Rosa canina, Ulmus carpinifolia, Cornus sanguinea, Prunus spinosa, Helianthus tuberosus, Euonymus europaeus Crataegus monogyna, Tilia platyphyllos.*

The coverage of herb layer ranges between 0.6 and 0.7. A characteristic group of species consists of *Hedera helix*, *Convallaria majalis*, *Arum maculatum*, *Viola silvestris*, *Quercus robur*, *Ligustrum vulgare, Crategus monogyna*, *Ruscus aculeatus* and *Ulmus carpinifolia.* A significant number of mesophilic species occurs in the herb layer; however, there is an occasional presence of xero-mesophilic species, which indicates more xherothermic variant of pedunculate oak-ash forests.

Spectrum of areal types

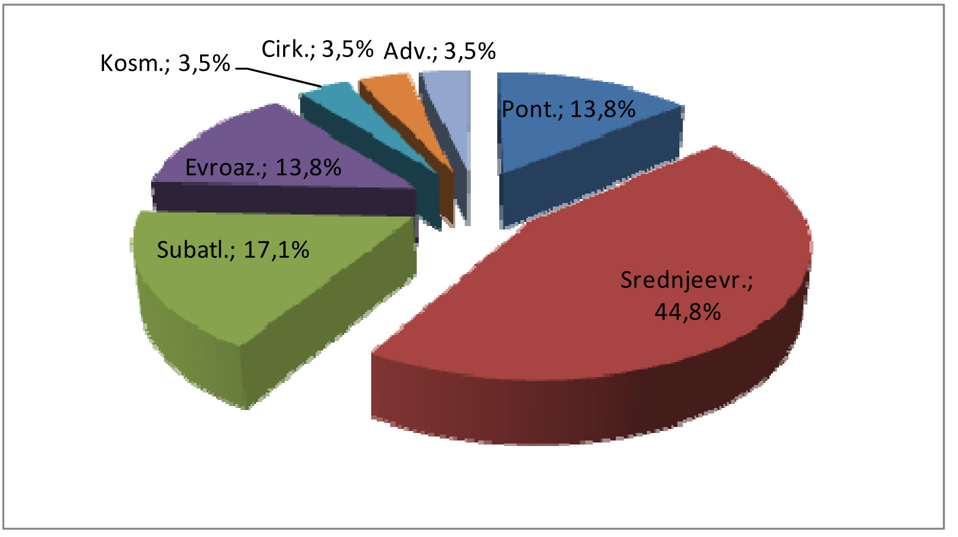
The spectrum of areal types in the community *Querceto-Fraxinetum serbicum*. is presented in Table 4.

Table 4. *Spectrum of areal types in the community Querceto-Fraxinetum serbicum*

Individual areal types	**Number**	**Representation (%)**	**Collective areal types**	**Representation (%)**	
SUBPONTIAN	1	3.5	PONTIAN	13.8	13.8
PONTIAN-SUBMEDITERRANEAN	3	10.3			
CENTRAL-EUROPEAN	4	13.8	CENTRAL-EUROPEAN	44.8	61.9
SUBCENTRAL-EUROPEAN	9	31.0			
SUBATLANTOC-SUBMEDITERRANEANI	5	17.1	SUBATLANTIC	17.1	
EURO-ASIAN	4	13.8	EURO-ASIAN	13.8	17.3
COSMOPOLITAN	1	3.5	COSMOPOLITAN	3.5	
CIRCUMPOLAR	1	3.5	CIRCUMPOLAR	3.5	3.5
ADVENTIVE	1	3.5	ADVENTIVE	3.5	3.5
TOTAL:	29	100	TOTAL:	100	100

By means of a phyto-geographic analysis, the presence of nine different areal types was identified. Dominating species are the sub-central-European floristic element (31.0%), followed by plants of sub-Atlantic-sub-Mediterranean (17.1), central-European (13.8%), pontian-sub-Mediterranean (10.3%) and Euro-Asian areal type (13.8%).

Plants of sub-pontian, cosmopolitan and circumpolar areal type, along with adventive plants, are equally represented and account for 3.5%.



Graph 1. *Spectrum of areal types of the community Querceto-Fraxinetum serbicum*

Generally speaking, the most represented are mesophilic plants, which account for 61.9%, (of central-European and sub-Atlantic areal types). In terms of representation, they are followed by the plants of a broad ecological amplitude, which account for 17.3% (of Euro-Asian and cosmopolitan areal types), then by xero-thermophilic species, (of a pontian areal type), accounting for 13.8%.

Adventive flora includes those species which were introduced into our country as a result of human activities, and are more or less well-adapted to local conditions. In this case, the presence of only one such species was identified (3.5%).

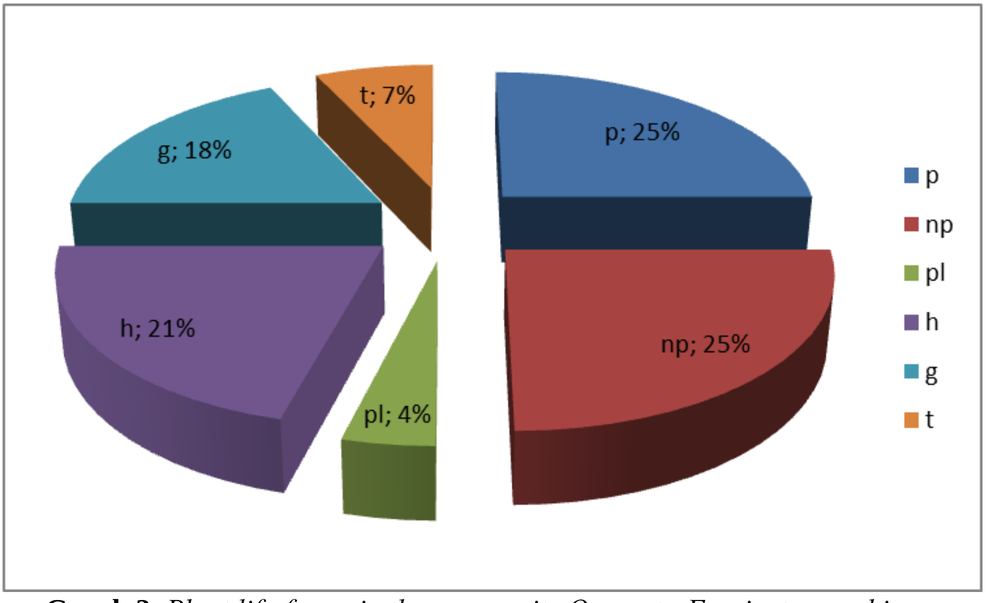
Spectrum of life-forms

The correlation between plants and life-forms in the community *Querceto-Fraxinetum serbicum* is presented in Table 5.

Table 5. *Plant life-forms in the community Querceto-Fraxinetum serbicum*

<table>
<tr><th>Phanerophytes</th><th>Nano-phanerophytes</th><th>Phanaerophytic lianas</th><th>Hemi-cryptophytes</th><th>Geophytes</th><th>Terophytes</th></tr>
<tr><td>P</td><td>np</td><td>pl</td><td>H</td><td>g</td><td>t</td></tr>
<tr><td>25%</td><td>25%</td><td>4%</td><td rowspan="2">21%</td><td rowspan="2">18%</td><td rowspan="2">7%</td></tr>
<tr><td colspan="3">54%</td></tr>
</table>

The differences in living conditions are most clearly reflected in the structure of plants, proving their obvious adaptedness to the environment in which they live. Illustration of living conditions, the climate in particular, which prevail in a certain area, reflects the percentage representation of all plant life-forms in flora of that area, that is, its biological spectrum (Diklić, 1984).



Graph 2. *Plant life-forms in the community Querceto-Fraxinetum serbicum*

By the analysis of life-forms in the community *Querceto-Fraxinetum serbicum,* it was established that phanerophytes (P) account for 54% of the total flora of this community. This community is typical for having large number of woody species, which can also be seen from the biological spectrum (pure phanerophytes, nano-phanerophytes and phanerophyte lianas constitute 54% of the life spectrum). The second most numerous species among life-forms is hemicryptohytes (H), which are also the most numerous life-form in the moderate climate belt and Serbia, and which constitute 21% in this community. The plant life-form geophytes (G) also have a high representation, as many as 18%, which points out to more humid and edaphic conditions in this community.

The least represented are perennial plants therophytes (T), which account for 7%. No plants from the chamaephytes (Ch) group was identified.

It can be concluded that this community is of a phanerophyte-hemicryptophyte type, with an increased representation of geophytes.

4. CONCLUSION

The forest community contains 33 species. Generally speaking, the most represented species are mesophil plants, which account for 61.9% (of central-European and sub-Atlantic areal types). They are followed by plants of a broad ecological amplitude, which account for 17.3% (of Euro-Asian and cosmopolitan areal types), then by xero-thermophilic species, (of a pontian areal type), accounting for 13.8%.

Adventive flora includes those species which were introduced into our country as a result of human activities and are more or less well-adapted to local conditions. In this case, the presence of only one such species was identified (3.5%).

By the analysis of life-forms in the community *Querceto-Fraxinetum serbicum,* it was established that phanerophytes (P) account for 54%, while hemicryptophytes (H) constitute 21% of this community. As a result of humid climatic conditions, geophytes (G) account for as many as 18%, which indicates that this community is of a phanerophyte-hemicryptophyte type, with an increased representation of geophytes.

The species identified in the forest community include legally protected *Ruscus aculeatus* L. and *Viola odorata* L. Placing this community under protection would also mean better safeguarding of protected species from the anthropogenic impact, which is intensive in this area as a result of proximity of town, but also a popular outing spot, frequently visited by the inhabitants of towns Obrenovac and Ub.

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Graph 3. 11 points, bold *Graph title,* 11 points, italic

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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*)

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