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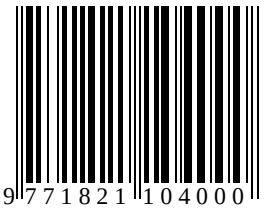

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THE CLIMATE CHANGE – STRATEGIES AND LEGISLATION IN SERBIA

Ljiljana BRAŠANAC-BOSANAC[1]

Abstract: *Climate change is one of the most important subjects in 21st century. In fact, that is no longer just a question of environmental protection and ecological awareness, but along with it some other important themes are imposed: sustainability, economic growth, energy efficiency and energy security. Serbia is one of the countries of Southeastern Europe where climate change is evident, and its manifestations are more frequent and intense. As the consequences of climate change in Serbia in recent years the floods are more intense, landslides and erosion are more active, wind gusts are stronger, periods of drought are more frequent and longer and extreme climate events affect both urban as well as rural areas. In order to plan the sustainable development in areas vulnerable to climate change and, on the other hand, to reduce the effects of global warming and climate change in Serbia it is necessary to adopt and implement new strategies and laws, respecting the already adopted international conventions, declarations and strategies as well as national legislation.*

Key words: climate change, strategies, legislation, Serbia.

KLIMATSKE PROMENE - STRATEGIJE I ZAKONSKA REGULATIVA U SRBIJI

Izvod: *Klimatske promene predstavljaju jednu od ključnih tema u XXI veku. U suštini, one više nisu samo pitanje zaštite životne sredine i ekološke svesti, već se uz njih*

[1] Ph.D. Ljiljana Brašanac-Bosanac, Institute of Forestry, Kneza Viseslava 3, Belgrade, Serbia
e-mail: *brasanlj@yahoo.com*
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nameću i druge bitne teme: održivost, ekonomski rast, energetska efikasnost i energetska bezbednost. Srbija je jedna od zemalja Jugoistočne Evrope u kojoj su promene klime evidentne, a njihove manifestacije sve češće i intenzivnije. Kao posledica klimatskih promena, u Srbiji su poslednjih godina češće i intenzivnije poplave, aktivnija klizišta i erozije, snažniji udari vetra, češći i duži sušni periodi, a ekstremni klimatski događaji pogađaju kako urbana, tako i ruralna područja. U cilju planiranja održivog razvoja na područjima osetljivim na klimatske promene, a sa druge strane smanjenja efekata globalnog zagrevanja i klimatskih promena u Srbiji, neophodno je donošenje i primena novih strategija i zakona, poštujući usvojene međunarodne konvencije, deklaracije i strategije, kao i nacionalnu zakonsku regulativu.

Ključne reči: klimatske promene, strategije, zakonodavstvo, Srbija.

1. INTRODUCTION

Southeast Europe is among the world regions that are highly sensitive to climate change (IPCC, 2007; IPCC, 2009, UNECE, 2007; SEEFCCA, 2012). More frequent extreme climate events such as floods, droughts, strong wind gusts and very cold periods with large amounts of snow, are a good opportunity to test the vulnerability of areas in Serbia to climate change. According to Popovic, T. et al. (2009) estimates based on climate modeling in moderate scenarios indicate that the annual temperature in Serbia will rise 2.6° C by the end of the century. Warming will not be evenly distributed throughout the year: summers will be 3.5° C warmer than they are now as well as autumns 2.2° C, winters 3.2° C and the springs 2.5° C warmer than they are now. It is expected that the heat waves will be increased in frequency, intensity and duration, while the projections for the number of frosty and icy days say that they will continue to decline.

According to Brasanac-Bosanac, Lj., Cirkovic Mitrovic, T. (2013) trend of changes of mean annual air temperature and trend of changes of air temperature during growing season in Serbia (for period from 1949 to 2010) is positive in the most meteorological stations in Serbia (exceptions are Kursumlija and Crni vrh).

The greatest increases of linear trend values have the meteorological stations Rudnik, Loznica, Negotin, Palic, Pozega and Belgrade.

Adaptation to climate change primarily is based on government activities including the legislative framework, regulations and incentive measures for implementation of changes of socio-economic system in order to reduce the sensitivity to climate change (Burton et al., 2002).

In assessing vulnerability to climate change in Serbia there isn't any national strategy document that would define this issue. Some progress has been achieved by starting the process of Serbia's accession to the EU and harmonization of national legislation with EU legislation because the basic principles of the relevant EU legislation are actually based on the principles to fight climate change. However, many documents of the European Union in this area have not yet found a direct implementation in our legislation and strategies, and the Report of the European Commission from October 2014 concluded that in terms of the legislation in Serbia in Chapter 27 which refers to the environment and climate change, there has not been a sufficient progress (Serbia Progress Report, 2014).

2. METODOLOGY

In this paper has been used the analytical method with elements of generalization and inductive-deductive methods. International and national strategies, legislations and supporting documents relating to climate change, energy efficiency and renewable energy sources have been analyzed.

3. RESULTS AND DISCUSSION

International regulations

UN Framework Convention on Climate Change (UNFCCC) was adopted at the UN Conference on Environment and Development in 1992 in Rio de Janeiro, in order to ensure the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The Convention entered into force in March 1994. The Republic of Serbia has been a member of the United Nations Framework Convention on Climate Change since 2001. One of the first national reports on climate change in Serbia is *Initial national communication of the Republic of Serbia under United Nations Framework Convention on Climate Change* (2010).

Kyoto Protocol – is an addition to international agreement on climate change. It entered into force in 2005. The Republic of Serbia ratified the Kyoto Protocol in 2007 and it entered into force in January 2008. The main difference between the Kyoto Protocol and the UNFCCC Convention is that the Convention encourages more economically developed countries to reduce emissions of greenhouse gases, while the Kyoto Protocol obliges them to do so. The Kyoto Protocol promotes and encourages researches, development and increased use of new and renewable energy sources, technologies to control emissions of carbon dioxide and environmentally sound technologies and that directly stimulates the energy efficiency. It defines the obligations of restriction and reduction of emission of six types of gases that cause the greenhouse effect, as well as the rate of emission reduction at the national level for each Member State of the Convention.
Slovenia, Bulgaria and Croatia are in the group of countries that are obliged to reduce their emissions, while Former Yugoslav Republic of Macedonia, Bosnia and Herzegovina and Serbia are in the group of so-called Non-Annex I Parties, which have no obligations with respect to the reduction of emissions, but they can help reduce pollution by realization of projects in the Clean Development Mechanism (CDM).

The National Strategy on the inclusion of Republic of Serbia into Clean Development Mechanism of the Kyoto Protocol (2010) is aimed at identifying methods and possibilities for improvement of the environment in Serbia followed by economic and social development of the country. The general objective of the Strategy is to build capacities and to raise awareness about the possibilities of using CDM projects as methods to encourage sustainable development and to enable faster implementation of the *Kyoto Protocol* in the Republic of Serbia.

National legislation and strategies

National sustainable development strategy of Republic of Serbia (2008) defines a vision of the development of Serbia until 2017. As national priorities for achieving sustainable development in Serbia are identified protection and improvement of the environment and the rational use of natural resources so that they remain available for future generations. The strategy, among other things, distinguishes energy efficiency and renewable energy sources as priority areas. Within it, the climate change and protection of the ozone layer have been identified as the first of the seven major risk factors for the environment. Thermal power stations and heating sources, traffic and part of the housing stock that is heated in this manner have been identified as the main areas where CO_2 has been produced during the burning of fossil fuels.

Spatial Plan of the Republic of Serbia 2010 - 2020 (2010) is one of the first planning documents at the national level, which, among other things, details the climate change issues. This document promotes the climate change issue by establishing an obligation for its inclusion in the planning process. The SWOT analysis in section *Nature, environmental protection and development* identified the potential for reducing emission of greenhouse gases as one of the opportunities while lack of funds for implementation of the program of multidisciplinary studies of climate change effect on particular sectors of the economy, as well as the absence of standards on the implementation of climate data and information in planning and design were mentioned as disadvantages. As opportunities were identified: the identification of climate change as a factor for sustainable development of certain sectors of the economy and the identification of climate change as a factor for the overall economic development, the introduction of EU standards in the field of risk management of natural disasters, renewable energy sources, energy efficiency, design and construction of infrastructure systems that are relevant to various aspects of climate change while as the disadvantages were highlighted: the slowness of strengthening of institutional capacity and inadequate attitude towards the problem of climate change in the education and public information system. Problems have been identified, strategic priorities have been proposed as well as the basic and operative goals with the proposals for the implementation of the Plan, with particular emphasis on the effect of energy consumption on climate change and reduction of CO_2 emissions. The spatial aspects of certain energy sources and their potential in the entire national territory have been elaborated.

Implementation Program of the Spatial Plan of Republic of Serbia from 2010 to 2020 (2011) pointed to the strategic importance of forests and forest ecosystems as a natural resource and as an important link in the protection of the environment in Serbia, especially in terms of climate change.

Biodiversity Strategy of the Republic of Serbia for the period 2011- 2018 (2011) – Section 3: When it comes to the effect of climate change it is stated that there is no systematic monitoring of the effect of climate change on biodiversity in the Republic of Serbia. Current researches and planning are based primarily on global researches, experiences and recommendations of other countries.

The National Environmental Program (2011) – Within the chapter *Economic sectors and their impact on the environment*, it was pointed out that forests are an important ecological, economic and social potential of the Republic of Serbia, and having in mind that they perform the absorption of pollutants from the air or gasses responsible for the greenhouse effect, increasing forest coverage can provide a significant reduction in the concentration of these gases.

Law on Planning and Construction (2014) within the Chapter 3 of Spatial Planning and Land Use Principles points out that the planning, organization and use of space, among other things, are based on "...rational and sustainable use of non-renewable natural resources and optimal use of renewable energy resources (paragraph 4) and to promote energy efficiency by introducing the obligation that a "certificate on the energy performance of the building has to be issued …" (Chapter 4 of *Improvement of energy efficiency*, Article 4).

In order to effectively fight against climate change *Forestry Development Program* (2011) stipulates that it is necessary to "timely detect significant changes in the functioning of forest ecosystems, define their characteristics and perform analysis of the consequences that arise due to climate change; disable and prevent actions that cause the weakening and destruction of forests" etc.

It should be underlined that, although the issue of climate change is present in national laws, planning documents, strategies and programs, the measures for reduction of effects and adaptation are not clearly defined or especially emphasized. It is surprising that many sectors that are highly sensitive to climate change in their strategic documents still do not recognize the need for better and more appropriate planning of implementation.

Harmonization of national legislation with EU legislation

Harmonization of laws is a joint obligation for accessing European Union. This means that countries aspiring to join the European Union should harmonize their national laws, regulations and procedures in a manner that will enable efficient transposition of entire EU legal structure. Since the obligations of harmonization of laws continues after entering EU, the harmonization process becomes a possibility for respective country to better organize its institutions and procedures and to train staff for daily processes and responsibilities of the enactment of legislation in accordance with EU models, as well as their implementation.

The European Union has developed a set of strategic and legal documents related to climate change. Especially important is the EU White Paper on adapting to climate change by which the EU has set a framework for solving the problems of adaptation at the community level and at the same time its members have a commitment to seriously and strategically approach to solving this problem (Pucar, M., 2013).

According to Pucar, M. (2013) the harmonization of national legislation with the European Union legislation in the field of climate change involves the transposition of EU Climate and Energy package. Among the most demanding directives of this package is the *Directive on emissions trading system* (EU Emissions Trading System - EU ETS). Efficient preparation and implementation of

this Directive require the preparation of both legislative and institutional framework. Analyzing the legislation of the European Union in the fight against climate change including the *EU climate and energy package* it is evident that the solution of this problem requires a series of coordinated and sustained actions. Thus the process of harmonization of the Republic of Serbia's legislation with EU legislation and implementation of the requirements certainly improve cooperation between all parties. The fulfillment of the basic requirements of the EU package primarily in terms of increasing the use of renewable energy sources and energy efficiency as well as inclusion in the emissions trading system can provide the placement of domestic products on the EU market.

By ratifying the *Treaty establishing the Energy Community* in 2006, Serbia made a commitment to implement European directive in the field of renewable energy sources and Directive on energy efficiency in the field of energy consumption. This Acts stipulate the harmonization of national laws of the signatory countries with the regulations and norms of the European Union in the fields of energy, competition, environmental protection and the use of renewable energy sources.

At the Sixth Ministerial Conference *Environment for Europe* (E4E) which was held in Belgrade in 2007, it was decided to strengthen the sub-regional cooperation in the field of climate change. The adopted Declaration has recognized the need to develop national plans - the so-called *Climate Change Framework Action Plans* (CCFAPs), but it has also emphasized the need for the establishment of sub-regional Virtual Climate Centre in Belgrade (Đukić, Stupar, 2011).

Draft Strategy for development of the energy sector of Republic of Serbia in the period until 2025 with projections to 2030 (2011-2013) should replace the existing Strategy which has not sufficiently cover the impact of power plants and energy production on the environment. Energy production with lower emissions of greenhouse gases will become a crucial criterion for evaluating energy technologies and possible directions of energy development whereby the norms related to the protection of the environment will constantly be intensified.

Key elements of the transition to sustainable energetics development of the Republic of Serbia are the implementation of energy efficiency measures, using of renewable energy sources and protecting the environment and reducing the impact on climate change (Pucar, M. Monography, climate change).

5. CONCLUSION

The issue of climate change is also present in the current legal and planning regulations in Serbia, but not sufficiently. As in most countries of Eastern Europe excuses for the failure to implement the policy for solving the problem of climate change in Serbia are sought in the absence of regulations and appropriate procedures, lack of institutional capacity and financial resources.

Harmonization with the EU in the field of climate change, renewable energy sources and energy efficiency is a long term process, which involves a joint commitment of all parties, both the state and business, academic and scientific community and international organizations. It is crucial that the Republic of Serbia

urgently engages in development programs of the EU because it takes many years for innovations in the field of climate change and energy to be applied in practice.

In order to adequately and timely respond to negative changes in climate in Serbia and to establish a successful cooperation with the countries of the European Union it is necessary to:

- harmonize national legislation with the ratified, international conventions, agreements and declarations and regulations of the European Union;
- intensify the use of energy from renewable energy sources;
- conduct monitoring and control of environmental quality and prevent adverse effects on the environment and humans;
- design adequate response of health sector to the consequences of global climate change;
- adapt the operations of business entities in the sectors of energetics, industry, transport, agriculture and forestry as well as municipal housing activities to policy of climate protection and fulfillment of international agreements;
- elaborate action plans for adaptation of mentioned sectors to climate change.

Serbia as a candidate for EU has to fulfill these obligations and it is certain that in the future has to be worked intensively on the issue of climate change, especially on adaptations to climate change.

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THE CLIMATE CHANGE – STRATEGIES AND LEGISLATION IN SERBIA

Ljiljana BRAŠANAC-BOSANAC

Summary

The issue of climate change in the international frameworks is not a one-way process. The partnership with the European Union implies the manifold exchange of information, coordination of decisions and policies, as well as participation in international forums, projects and researches. However, to initiate and stimulate initiatives to implement the program of adaptation to adverse effects of climate change, to establish energy efficiency programs and a system of use of renewable energy sources it is required the support of the state with the appropriate strategies, good tax policy, administrative and financial facilities, as well as the technical support. It is necessary to harmonize existing legislation with the European Union Directives which would significantly bring closer our country to the standards that prevail in European countries.

KLIMATSKE PROMENE - STRATEGIJE I ZAKONSKA REGULATIVA U SRBIJI

Ljiljana BRAŠANAC-BOSANAC

Rezime

Pitanje klimatskih promena u međunarodnim okvirima nije jednosmeran proces. Partnerstvo sa Evropskom unijom podrazumeva mnogostruku razmenu informacija, koordinaciju odluka i politika, kao i učešće u međunarodnim forumima, projektima i istraživanjima. Međutim, za pokretanje i stimulisanje inicijativa za primenu programa adaptacije na negativne promene klime, programa uspostavljanja energetske efikasnosti i sistema korišćenja obnovljivih izvora energije, potrebna je podrška države sa odgovarajućim strategijama, dobrom poreskom politikom, administrativnim i finansijskim olakšicama, kao i tehničkom podrškom. Neophodna je harmonizacija postojećih zakona sa direktivama Evropske unije, što bi našu zemlju značajno približilo standardima koji vladaju u zemljama Evrope.

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THE CONDITION OF *AESCULUS HIPPOCASTANUM* L. TREES IN THE AVENUES OF THE CENTRAL PART OF THE CITY OF OBRENOVAC

Milorad VESELINOVIĆ[1], Suzana MITROVIĆ[1], Zlatan RADULOVIĆ[1], Dragana DRAŽIĆ[1], Nevena ČULE[1], Dragica STANKOVIĆ[2], Snežana RAJKOVIĆ[1]

Abstract. *In urban areas treelined paths are the most vulnerable element. According expected functions treelined paths in certain street are unsatisfactory with their appearance and general condition. These are primarily biological, ecological, sociological and aesthetic functions. Because of negative anthropogenic influences trees are with low level condition, very low functionality and the unsatisfactory state of health. Most of the trees exist in very difficult circumstances of streets, there are crowded in the underground and in the aboveground part. In such circumstances, just as individual specimens of trees grow into individuals who manifest themselves in terms of morphology characteristics which are representative of its species. In this paper is presented the state of the avenue of horse chestnut (Aesculus hippocastanum L.) in two central streets of the old part of Obrenovca. The data were analyzed on the basis of the reviewed every tree and with the particular assessing the state of the crown and the state of the trunk. Based on the analysis of the results measures are proposed for the rehabilitation of individual trees as well as measures for the reconstruction of the entire tree line.*

Key words: horse chestnut, treelined path, street, condition

STANJE STABALA *AESCULUS HIPPOCASTANUM* L. U DRVOREDIMA CENTRALNOG DELA OBRENOVCA

Izvod. *U sistemu gradskog zelenila drvoredi su najugroženiji element. Drvoredi pojedinih ulica kod nas svojim izgledom i opštom kondicijom ne zadovoljavaju očekivane funkcije. To su u prvom redu biološke, ekološke, sociološke i estetske funkcije. Pod*

[1]Institute of forestry, Belgrade, Serbia
Translation: Milorad Veselinović

negativnim antropogenim uticajima stabla su niskog stepena kondicije, vrlo niske funkcionalnosti i nezadovoljavajućeg zdravstvenog stanja. Većina stabla egzistira u vrlo teškim uslovima ulice, stešnjena su i u podzemnom i u nadzemnom delu. U takvim okolnostima samo pojedinačni primerci izrastu u individue koje u morfološkom smislu manifestuju reprezentativne osobine svoje vrste. U radu je prikazano stanje drvoreda divljeg kestena (Aesculus hippocastanum L.) u dve centralne ulice starog dela Obrenovca. Analizirani su podaci na osnovu pregledanog svakog stabla posebno ocenjivanjem stanja krune i stanja debla. Na osnovu anlize rezultata predložene su mere za sanaciju pojedinih stabala kao i mere za rekonstrukciju celokupnog drvoreda.

Ključne reči: divlji kesten, drvored, ulica, kondicija biljaka.

1. INTRODUCTION

Rows of trees represent a narrow belt of greenery, which is commonly known as the green line. Treeline paths are one of the most important categories of greenery in urban areas. Functions of avenue tree plants are primarily environmental, commonly branded as sanitary. Fulfilment of these functions is in accordance with the number of plants, quantity and physiological status of the foliage. The second group of functions compiled all the other functions which can be regarded as an indirect function, often defined as aesthetic, psychological or cultural. Their actual fulfilment of the primary and secondary functions is possible only under the condition that the individual tree rows are in excellent or at least very good health and an acceptable aesthetic status (Dobrilovič, 2009). Only healthy plant organisms those individuals whose life functions smoothly and completely performed can fulfil the expected functions (Bunuševac, 1977). The increasingly difficult for rows of trees will be to survive in a form that residents traditionally considered tree-lined (Batala and Tsitsoni, 2007). Most of the trees exist in very difficult conditions of the streets. Most of them squeezed in the underground as well as the above ground part by the human action. There are the rare opportunities that trees as individual specimens in the rows of tree grow into individuals who manifest themselves in terms of morphology characteristics representative of its species.

Ecological very difficult environmental conditions on the streets are reasons why the alley of trees having great ecological importance, but also why this specific category of public greenery adorned with the epithet "the most important secondary element of streets in major cities" (Mumford, 1988). Ttreelined paths, especially those old and luxurious, composed of individuals spanning many decades, rarely to be encountered on the streets of major cities. Where alleys are held as a structural element of the street, they are existing mostly as very young plants. Today for the trees is planning a much shorter time for functioning and existence on the street it is about two to three decades. After this period all of the tree rows tree as a rule will be removed. After that time trees will be replace with the new, young, healthy individuals, by size more directly proper with the available space on the street. Such trees will also be much easier to nurture. So in the future the trees of tree lined paths on the streets of cities will be considered as structure that needs to be constantly improved. Horse chestnut the tertiary relict of the Balkan Peninsula is

very frequently used species at alleys in our cities (Ćalić-Dragosavac et al., 2009). Cadastre of the trees and shrubs at public green space of the metropolitan area of the Obrenovac indicates that this species is very common in the street alleys of the city.

2. MATERIAL AND METHOD

Inventory of the horse chestnut trees in two central streets in Obrenovac was performed by measuring individual trees. Diameters of the trunk at breast height were measured by caliper. The total height of the tree, trunk height to the beginning of the crown, height and crown width were measured by laser rangefinder-hypsometer TruPulse 360 B. Based on the obtained data the analyses of certain parameters were made in relation to the most distribution of trees per diameter class.

In the same time the presence of fruiting bodies of fungi and the presence of insect damage were registered. In the cases when the exact cause of the damage couldn't determine on the ground, in the laboratory were identified using standard phytopathological methods and using appropriate keys: B.C. Suttona (The Coleomycetes, 1980), J.V. Carmichaela et al. (Genera of Hyphomycetes, 1980), R.W.G. Dennisa (British Ascomycetes, 1978), J.A. Arxa (Genera of Fungi Sporulating in pure Culture, 1974), V.H. Kuprevicha i V.G. Tranchela (Rust Fungi, 1970).

3. RESULTS AND DISCUSSION

3.1. Morphometric characteristics of trees

Within the area of public character of the urban area of the Obrenovac horse chestnut was registered 338 times. From that number 96 trees are registered in different green areas categories, and 242 trees in the tree lined path. At the Vuk Karadzić street is located 204 trees and at the Karađorđeva street 34 trees, which represents 98.35% of the total number of horse chestnut trees in strips.

Table 1. *Distribution of trees per diameter class*

Street	Number of the trees distributed per diameter class						Total
	1-10	11-20	21-30	31-40	41-50	51-60	
Vuka Karadžića	23	13	64	85	17	2	204
Karađorđeva	1	1	8	17	5	2	34

The most common diameter classe in both analyzed streets is class 21-30 (3) with a share of 30.39% at Vuk Karadzić and 26.47% in Karađorđeva street. Diameter class of 31-40 (4) with a share of 43.14% at Vuk Karadzić and 47.06% in Karađorđeva street. Diameter class of 41-50 (5) with a share of 7.84% at Vuk Karadzic and 17.65% in Karađorđevoj street. Total analyzed trees at Vuk Karadzic were 166 which amount to 81.37% of the trees of the street and 31 trees at the Karađorđeva street or 91.18% of the trees at the street (Table 1).

Analysis of measured data indicates that in most frequent diameter classes 4 and 5 in both analyzed streets weren't statistically significant differences in the amount of trees, trunk length, height and width of the crown (Table 2). This can be explained by anthropogenic influence when the trees were subjected to various treatments (artificial lifting the crown, the crown pruning, etc.) to adjust their size to the available space of the street and infrastructure objects in it. Compared to them there is a statistical difference for the analyzed parameter in the diameter class of 3 because the trees in this class with their habitus fit in the available space on the streets.

Table 2. *The dependence of morphometric parameters in relation to the diameter increment*

Street	Diameter increment	Total height of the tree	Trunk height	Crown height	Crown width
Vuka Karadžića	**3**	12.5938 ± 1.4787[a]	2.5500 ± 0.7177[a]	6.3333 ± 1. 1764[a]	9.5125 ± 1. 6320[a]
	4	12.7222 ± 1. 8704[a]	3.0813 ± 0.9078[a]	6.8438 ± 1. 4880[a]	9.5889 ± 2. 0643[a]
	5	13.7500 ± 1.6989[a]	3.1333 ± 0.8246[a]	8.6667 ± 1. 3516b[a]	11.2000 ± 1. 8750[a]
Karađorđeva	**3**	9.3952 ± 0.4536[a]	2.5048 ± 0.1666[a]	6.1452 ± 0.3663[a]	6.8903 ± 0.4560[a]
	4	11.7932 ± 0.76711[b]	2.6591 ± 0.2817[ab]	7.3500 ± 0.6194[b]	9.1341 ± 0.7712[b]
	5	12.4688 ± 0.7435[b]	2.8188 ± 0.2730[b]	7.8438 ± 0.6003[b]	9.6500 ± 0.7475[b]

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

3.2. Health condition

Phytopathological disease

Guignardia aesculi (Peck.) Stew. - **Horse chestnut Leaf Blotch.** This is the accompanying disease of horse chestnut, which was established in Europe in 1950. It also occurs on the *A. glabra*, *A. pavia* as well as on the *Aesculus* x *carnea* (hibrid *A.hippocastanum* x *Aesculus pavia*). Kao posledica napada dolazi do ranog opadanja lista što izaziva smanjenje dekorativnosti, a takođe dolazi i do napada sekundarnih parazita i štetočina. As a result of the attack leads is the earlier falling of the leaves which causes a reduce decoration of the trees but also leads to the attacks of secondary pests and parasites. The disease is present on the leaves of mature trees wherein the disturbs the aesthetic appearance of the trees (especially in parks and alleys). Recommended sction against this disease is collection and removal of leaves as a source of infectious inoculum. The disease was detected in all analyzed trees.

Uncinula fraxini Miyake. - **Horse Chestnut Powdery Mildew.** Beside ash tree the disease occurs also at the horse chestnut. As all powdery mildew this species also is an obligate parasite and can only be developed on living plants. This species is the only one horse chestnut tree, and the attack was weak.

Wood decay fungi

Inonotus hispidus (Bull. ex Fr.) Karst. This species is being developed as a parasite weakness in hardwoods. *I.hispidus* develops as a parasite on live trees and causes white-yellow central decay of trunk. Infections achieved through injury on trunk and branches. When trees are infected with this fungus the fractures and

breakage of branches in the crown are very common. It is registered at more than 50% of the analized trees

Ganoderma applanatum (Pers, ex Wallr.) Pat. syn. ***Fomes applanatus*** (Pers.) Wallr. It occurs in lots of hardwoods. At live trees usually attacks the terrestrial part of the stem and roots which causes white-yellow decay of heartwood and partly sapwood Due to the destruction of the heartwood and sapwood the tree loses its firmness and has been frequently damaged by winds. Infection of trees and root occurs through their injuries It is registered at more than 15% of the analyzed trees.

Schizophyllum commune Fr. This fungus is one of most widespread species. On live trees is located on damaged and dead parts causing peripheral white sapwood decay. The destructive activity of the fungi is relatively small so that it retains the decay in the surface layers of wood. It is registered in over 25% of the analized trees.

Trametes hirsuta (Wulf.:Fr.) Pil. It causes perforated white decay. It occurs as a saprophyte in parts of the sapwood live trees which are necrose due to adverse effects of various factorsExtremely can cause soft decay of heartwood of some species. It's common on the analized trees in the avenues.

***Phytophthora* spp.** On the analized trees of horse chestnut in Obrenovac was registrated the presence of three species of the genus *Phytophthora* as follows: *Phytophthora cambivora* (Petri) Buisman, *Phytophthora cactorum* (Lebert & Cohn) J. Schröt. and *Phytophthora citricola* Sawada. They cause root decay and cause bark shoot, dries and falls over large areas on the tree. This may prevent the normal flow of mineral matter which is manifested by drying of individual branches in the crown and wilted of leaves. They appear very often,even on the 48 of the analyzed horse chestnuts in Obrenovac were determined symptoms ("Bleeding canker") that indicate their presence.

Insects

The registered insects occur in very low intensity at the analized trees in the avenues.

Cameraria ochridella Deschka and Dimić**– Horse Chestnut Leaf Miner.** The first time it was discovered in 1984 in the vicinity of Ohrid in Macedonia on the basis of characteristic mines on the leaves of the horse chestnut (*Aesculus hippocastanum* L.) (Simova-Tošić and Filev, 1985). Shortly after that miner is rapidly spreading to the north and occupies the the whole territory of Serbia (Dimic and Mihajlovic, 1993). At a stronger attack leaves are dried and falling. Populations of horse chestnut leaf miner are numerous. Stabla divljeg kestena već u avgustu ostaju bez lišća, a u septembru i oktobru ponovo listaju i cvetaju, što je svojevrsni stres. Horse chestnut trees already in august lose their leaves and in september and october gets leaves and flowers again, which is sign of some kind of stress.

Pulvinaria betulae (L.) **- Cottony grape scale.** The species is occur on a large number of plant species. It does not cause significant damage.

Parthenolecanium corni (Bouche) **- European fruit lecanium.** Occurs in more than 350 plant species. It occurs in gradations and primarily attacks the young

plants. In the years of outbreak causes drying of individual branches and after several consecutive years can lead to drying of whole trees.

4. CONCLUSIONS

Modern European cities nearly 350 years persistently trying to establish and maintain mature individual tree in the functional state at the streets (Harris, et al.1999). Sve češće se zapaža da je i tamo gde se drvoredi još uvek uporno održavaju kao strukturni elemenat ulice, reč uglavnom o vrlo mladim biljkama. Usually where the rows of trees still persistently held as a structural element of the streets it's refers to young plants. In order to maintain their functionality for those trees are planning a much shorter period of existence on the streets. This is illustrated by the results of our research where plants that come under intense anthropogenic impact to keep them in the allowed space are losing their natural habitat characteristics. With invasive measures correcting the size and shape of the crown they lose leaf mass and become susceptible to various diseases and pests. As the functioning of trees intimately associated with morphological, biological and ecological characteristics, it can be certainly to conclude that there is no "natural use" of trees on the street will not be if it comprised the sick, broken and damaged plants. A large number of horse chestnut trees in a small space and the closeness and connection in a tree line allows for easy transmission of the disease and insects from tree to tree. This is supported by the negative influence of abiotic factors and the resistance of plants in the alleys is considerably reduced.

Because of that the trees in the form of a row of trees should be considered as a structure that needs to be constantly improved. For this purpose it can be recommended measures of successive replacement of horse chestnut trees with another species of trees in entire streets of the city of Obrenovac. This would reduce the risk of occurrence of these diseases and pests on the individual horse chestnut trees in surround greenery.

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SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
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Original scientific paper

THE PHOSPHORUS ANALYZES IN NEEDLES OF CANADIAN DOUGLAS-FIR PROVENANCES

Vera LAVADINOVIĆ[1], Zoran MILETIĆ[1], Vukan LAVADINOVIĆ[2]

Abstract: *Douglas-fir (Pseudotsuga menziesii Mir / Franco) is an indigenous and economically the most widespread species of conifers in Canada and North America. It is also the most common introduced species conifer in Europe.*

In Serbia testing of Douglas-fir, began setting up several provenance plots with seeds originating from Canada and North America. The research work carried out at the Institute of Forestry, conducting analysis in order to select the most adaptive and productive provenances for reforestation in Serbia. The seeds transfer of introduced species of trees include testing of all characteristic by provenance test. Genetic feature of trees species show in the new environmental, to confirm the selection of tree type for introduction. One of the methods of assessing the genetic variability of introduced species is the testing using provenance experiment.

The intensity effect of physiological processes of mineral nutrition of tree species is one of the most important indicators of its successful adaptation and production into new environment habitats.

This research analyzes the phosphorus content in the needles of Douglas-fir from different provenances originating from Canada.

Key words: Douglas-fir, seed transfer, provenances, phosphorus, needles,

ANALIZA FOSFORA U ČETINAMA DUGLAZIJE KANADSKIH PROVENIJENCIJA

Apstrakt: *Duglazija (Pseudotsuga menziesii Mir / Franco) je autohtona najrasprostranjenija i ekonomski najvažnija vrsta četinara u Kanadi i Severnoj Americi.*

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

Takođe je najčešća introdukovana vrsta četinara u Evropi. U Srbiji istraživanje na duglaziji, počelo je postavljanjem nekoliko provenijeničnih testova sa semenom poreklom iz Kanade i Severne Amerike. Istraživački rad odvija se u Institutu za šumarstvo, sprovođenjem analiza kako bi se odabrale najvažnije adaptivne i produktivne provenijencije za pošumljavanja u Srbiji. Transfer semena introdukovanih vrsta drveća uključuju ispitivanje svih karakteristika metodom provenijeničnog testa. Genetska karakteristika stabala vrste, u novim životnim sredinama, treba da potvrdite selekciju stabla za introdukciju. Jedan od metoda procenu genetičke varijabilnosti uvedenih vrsta je testiranje pomoću provenijeničnog eksperimenta.

Efekat intenziteta fizioloških procesa mineralne ishrane vrsta drveća je jedan od najvažnijih pokazatelja njene uspešne adaptacije i proizvodnosti u nove životne sredine staništa.

Ovo istraživanje analizira sadržaj fosfora u četinama duglazije iz različitih provenijencija poreklom iz Kanade.

Ključne reči: duglazija, transfer semena, provenijencija, fosfor, četine

1. INTRODUCTION

Nutrient supply is one of the most important criteria when describing the condition of conifers and needle analyses are an efficient method of evaluating the nutrient situation of conifer stands (K. Stefan, F. Herman 1996).

The obstacles that introduced species must be overcome is survival in the new habitat. That means the typical environmental barriers are such as: seed germination, soil pH and nutrient availability.

The seeds transfer of introduced species of trees include testing of all characteristic by provenance test. Genetic feature of trees species show in the new environmental, to confirm the selection of tree type for introduction.One of the methods of assessing the genetic variability of introduced species is the testing using provenance experiment.

The process of introduction is justified only if the introduced species are better or at least the same potential as the native tree species.

Douglas-fir (*Pseudotsuga menziesii* Mir / Franco) is one of the most ecologically and economically important trees in western North America, and is planted as an exotic timber species in Europe, New Zealand, Australia and Chile. It has one of the widest natural ranges of any tree species, extending from the Pacific Coast to the eastern slope of the Rocky Mountains and from 19°N in Mexico to 55°N in western Canada (Hermann, R.K. 1987, Hermann and Lavender, 1990, Rehfeldt GE. 1979, 1982, 1983, 1989;).

Douglas-fir is Canada's largest conifer and the tree that first made British Columbia famous as a producer of exceptionally fine timber. It is found throughout the southern half of the province extending into south-western Alberta. The species reaches its northern limit near the Queen Charlotte Islands. It grows to its magnificent best on the coast in fairly deep, moist sites where it comprises about 10% of the forest. (Website: www.coastforest.org).

The introduction of exotic species is considered one of the most important supplement to the native ecosystem: contributing to the diversity and improve the productivity of wood mass. It's one of the reasons that in Serbia started researching

Douglas -fir as a very promising species of conifers. (Lavadinović, V., Koprivica, M. 1996 a, 2000, Lavadinović 2000, Lavadinović et al 2011)

The primary proces of phosphorous in the physiological processes in trees is the transfer of energy and regulation of metabolic processes, such as photosynthesis, synthesis of the primary and secondary chemical compounds (hydrocarbons, lipids, proteins, nucleic acids, etc).

This element enters phospholipids, which are the necessary components of membrane components in the cell, nucleic acids (RNA and DNA) and nucleoproteins Sarić, M. (1979):. Phosphorous enters phytic acid, the compound which most frequently occurs in seed. The phosphorous from phytic acid transforms during germination and incorporates into different compounds needed for the metabolism of young plants (Đukić M., Isajev, V.1991). It affects them indirectly, by stimulating the development of soil microorganisms, thereby accelerating the mineralization of the nutrients in the soil. Since this element is important for the numerous constituent and functional roles in the life processes of plants, the variability of quantitative and qualitative phosphorous content in plant organisms is used in plant breeding, as the indicator of the inter-individual and population variability (Mika, P.G *et al.*, 1990).

2. MATERIALS AND METHODS

Douglas- Fir seed was collected from the part of natural range in Canada. Collection of seeds from 14 provenances were imported by Canadian Forest Service. Table 1 presents the characteristics of geographic data provenance of Douglas-fir.

In the Institute of Forestry nursery, from the seed it was produced seedlings from which it where formed two experimental plots.

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

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

Soil at one site, where the experimental provenance plots set, is the eutric cambisol , and the second plot it is vertisol. All plants of Douglas- fir were reared under identical site and identical stand conditions, and age of all the analyzed individuals are 12 years.

Both sites, where they placed the trials were flattened surface, without significant exposure and altitude are about the same.

For the determination of phosphorus in the soil at both sites were sampled taken needles of light from the upper third of the crown of Douglas -fir trees. Phosphorus content in the needles of Douglas -fir where determined by analysis of the ash after dry ashing at a temperature of 550 ° C and the translation of nutrition elements in chlorides. Determination was carried out by colorimetric method

Needles to determine the state of nutrition of Douglas- fir were collected during dormancy from the upper third of the tree canopy. Phosphorus content in the needles of Douglas -fir determined by analyzing the ash after burning dry colorimetric method. Linear regression analysis examined the effect of nutrition with phosphorus on the state of growth elements (mean diameter, mean height, basal area, volume and increment) studied provenances of Douglas fir. The amount of phosphorus available plants in the soil was determined with AL- method by Egner-Rihm (Džamić et al 1966).

3. RESULTS AND DISCUSSION

Based on the conducted studies, it can be concluded that conditions of phosphorous nutrition on eutric cambisol are considerably more favourable than the ones on vertisol. The difference in phosporous nutrition is significant at $p < 0.01$. Nearly all Douglas-fir provenances cultivated on eutric cambisol had better phosphorous nutrition in comparison to the provenances cultivated on vertisol (Table 2, Graph 1). The exceptions are the Gavia Lake locality provenance, the East Kootenay seed zone, the code 05227, and the Salmo locality provenance, the West Kootenay seed zone, the code 01198. In both provenances cultivated on vertisol, slightly higher amounts of phosphorous were identified in comparison to the same provenances cultivated on eutric cambisol.

Tabela 2. *The content of calcium on different provenances in Douglas - fir needles*

No	Code	Locality	Vertisol		Cambisol Eutric	
			P	Z	P	Z
			%		%	
1	03333	Cranbrook	0.236	-0.299	0.245	-0.572
2	00848	Inonoaklin	**0.237**	-0.342	0.258	-0.986
3	30667	Mann Creek	0.209	0.546	0.267	-1.283
4	05227	Gavia Lake	0.216	0.344	0.213	0.423
5	05226	Nine Bay	0.222	0.134	0.246	-0.600
6	03356	Trout Creek	0.189	1.183	0.249	-0.715
7	03360	Michell Creek	0.206	0.662	0.272	-1.438
8	01198	Salmo	0.228	-0.050	0.206	0.654
9	30460	Mara Lake	0.215	0.353	0.257	-0.974
10	00278	Monte Creek	0.195	1.005	0.204	0.702
11	03383	Sheep Creek	0.165	1.939	0.221	0.175
12	30461	Cooke Creek	0.228	-0.048	0.257	-0.956
13	03389	Benton Creek	0.182	1.405	0.249	-0.692

14	05092	Sun Creek	0.172	1.732	**0.299**	-2.301
		Average		0.207		0.246
		S		0.02341		0.02694
		min		0,165		0.204
		max		0.237		0.299
		T-value	4.074882			
		P-Value	0.000192 The result is significant at p < 0.01			
For both populations		Average	0.227			
		S	0.03166			
		min	0.165			
		max	0.299			

Although all seedlings at both sites reared under identical site and stand conditions, the same type of soil and climate under identical conditions was found high variability among provenances of phosphorus content in the needles in both provenances were grown on eutric cambisol, and with provenance grown on vertisols.

All conditions that affect physiological processes in plants, and thus the adoption of nutrients from the soil were identical for all provenances, both at the site where the soil is vertisol, and at the site where the soil is Eutric cambisol. Therefore, the variability of phosphorus content in the needles of different provenances consequences of genetically inherited abilities of different provenances to exploit the potential of soil and achieve phosphorus nutrition.

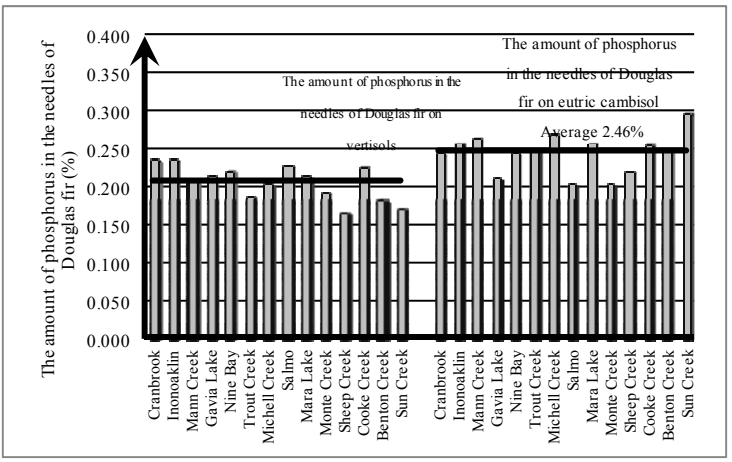

Figure 1. *The amount of phosphorus in the needles of Douglas-fir on vertisol and eutric cambisol*

The inter-provenance variability of phosphorus content in Douglas-fir needles is presented in Table 2 and Graph 2. The highest percentage representation of phosphorus in needles of Douglas-fir cultivated on vertisol (0.237%) was identified in the Inonoaklin locality provenance, the West Kootenay seed zone, the

code 00848, while the lowest percentage representation (0.165%) was determined in the Sheep Creek locality provenance, the West Kootenay seed zone, the code 03383.

Among the Douglas-fir provenances cultivated on eutric cambisol, the highest content of phosphorus was identified in the Douglas-fir needles of the Sun Creek locality provenance, the East Kootenay seed zone, the code 05092. The lowest representation of phosphorus in needles of Douglas-fir cultivated on eutric cambisol was identified in the Monte Creek locality provenance, the Thompson Okanagan Arid seed zone, the code 00278.

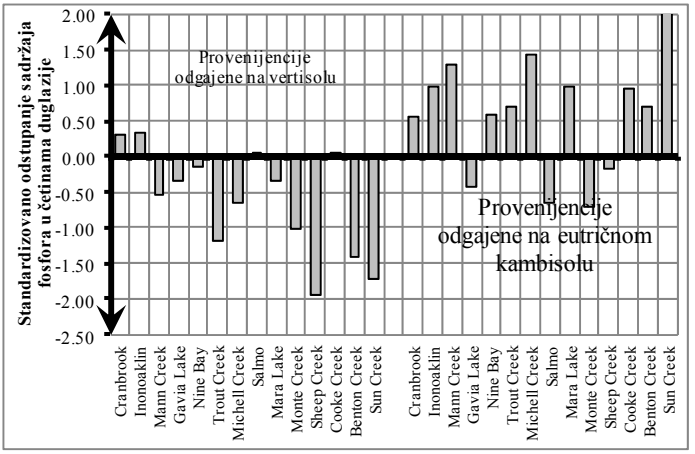

Figure 2. *Standardized deviation of phosphorus content in the needles of Douglas-fir provenances*

4. CONCLUSION

Based on the results of conducted analyses of phosphorus nutrition conditions in 14 Douglas-fir provenances of Canadian origin, it can be concluded that eutric cambisol provides far more favourable conditions for phosphorus nutrition than vertisol. Nearly all provenances cultivated on eutric cambisol assimilated a higher amount of phosphorus in comparison to the same provenances cultivated on vertisol.

Given the uniformity of conditions for soil nutrient assimilation in both provenance trial localities, it can be concluded that there are genetic specificities relating to calcium assimilation process. The inter-provenance variability of calcium content in Douglas-fir needles is an indicator of genetic pool specificity of different provenances with respect to calcium nutrition.

Based on the conducted study, it can be concluded that phosphorus content differences in Douglas-fir needles point out to a variability in the intensity of physiological processes in genotypes of different provenances. Given the fact that the Douglas-fir trees grew and developed in relatively small areas, with uniform general site and stand conditions, it can be concluded that needle phosphorus amounts are determined by different genotypes that constitute the genetic pool of studied Douglas-fir provenances.

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PHOSPHORUS ANALYZES IN NEEDLES OF CANADIAN DOUGLAS-FIR PROVENANCES

Vera LAVADINOVIĆ, Zoran MILETIĆ, Vukan LAVADINOVIĆ

Summary

Among the provenance variability of phosphorus content in the needles of 14 Douglas-fir, from Canada, is presented in this research. Douglas-fir is an indigenous and economically the most widespread species of conifers in Canada and North America. It is also the most common introduced species conifer in Europe. The seeds transfer of introduced species of trees include testing of all characteristic by provenance test. Genetic feature of trees species show in the new environmental, to confirm the selection of tree type for introduction.One of the methods of assessing the genetic variability of introduced species is the testing using provenance experiment. Based on the results of conducted analyses of phosphorus nutrition conditions in 14 Douglas-fir provenances of Canadian origin, it can be concluded that eutric cambisol provides far more favourable conditions for phosphorus nutrition than vertisol. Nearly all provenances cultivated on eutric cambisol assimilated a higher amount of phosphorus in comparison to the same provenances cultivated on vertisol.

ANALIZA FOSFORA U ČETINAMA DUGLAZIJE KANADSKIH PROVENIJENCIJA

Vera LAVADINOVIĆ, Zoran MILETIĆ, Vukan LAVADINOVIĆ

Rezime

Međuprovenijenična varijabilnost sadržaja fosfora u četinama duglazije predstavljena je u ovom istraživanju. Duglazija je autohtona najrasprostranjenija i ekonomski najvažnija vrsta četinara u Kanadi i Severnoj Americi. Takođe je najčešća introdukovana vrsta četinara u Evropi. Transfer semena introdukovanih vrsta drveća uključuju ispitivanje svih karakteristika metodom provenijeničnog testa. Genetska karakteristika stabala vrste, u novim životnim sredinama, treba da potvrdite selekciju stabla za introdukciju. Jedan od metoda procenu genetičke varijabilnosti uvedenih vrsta je testiranje pomoću provenijeničnog eksperimenta. Na osnovu rezultata obavljenih analiza stanja ishrane fosforom 14 provenijencija duglazije poreklom iz Kanade može se konstatovati da eutrični kambisol obezbeđuje daleko povoljnije uslove za ishranu ovim elementom u odnosu na vertisol. Skoro sve provenijencije odgajene na eutričnom kambisolu su usvojile veću količinu fosfora iz zemljišta u odnosu na iste provenijencije odgajene na vertisolu.

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EFFECT OF CONTAINER TYPE ON GROWTH AND DEVELOPMENT OF PEDUNCULATE OAK (*Quercus robur* L.) SEEDLINGS IN THE NURSERY

Vladan POPOVIĆ[1], Aleksandar LUČIĆ[1], Ljubinko RAKONJAC[1]

Abstract: *In this paper are presented the research results of effect of the container type on growth and morphological parameters of Pedunculate oak seedlings. In the experiment were used three types of containers Bosnaplast 18, Bosnaplast 12 and HIKO V265.*

Seed collection was performed in the Pedunculate oak seed stand registration number RS-2-2-qro-12-197 which is managing by FE Kragujevac in autumn 2012 and seed sowing in containers was done in spring 2013 in the seedling nursery of Institute of Forestry in Belgrade.

The analysis of one-year-old seedlings was performed in autumn 2013. The parameters that were measured are height and root collar diameter.

Seedlings produced in containers Bosnaplast 18 with cell volume of 220 cm^3 and HIKO V265 with cell volume of 265 cm^3 have larger dimensions and they are more quality than seedlings produced in containers type Bosnaplast 12 that have cell volume of 120 cm^3. Researches have shown that container volume has positive effect on morphological characteristics of Pedunculate oak seedlings in conditions of seedling nursery.

Key words: Pedunculate oak (*Quercus robur* L.), container, seedling, morphological parameters.

[1] Institut of Forestry, Kneza Viseslava 3, Belgrade, Serbia. E-mail: *vladanpop79@gmail.com*

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УТИЦАЈ ТИПА КОНТЕЈНЕРА НА РАСТ И РАЗВОЈ ЈЕДНОГОДИШЊИХ САДНИЦА ЛУЖЊАКА (*Quercus robur* L.) У РАСАДНИКУ

Извод: *У раду су приказани резултати истраживања утицаја типа контејнера на раст и морфолошке параметре садница лужњака. У огледу су коришћена три типа контејнера, Боснапласт 18 и Боснапласт 12 и HIKO V265.*

Сакупљање семена обављено је у семенској састојини лужњака, регистарски број RS-2-2-qro-12-197 којом газдује ШГ Крагујевац у јесен 2012. године, а сетва семена у контејнере извршена је у пролеће 2013. године у расаднику Института за шумарство у Београду.

У јесен 2013. године извршена је анализа једногодишњих садница. Мерени су висина садница и пречник кореновог врата.

Саднице произведене у контејнерима Боснапласт 18 са запремином ћелија од 220 cm^3 и HIKO V265 са запремином ћелија од 265 cm^3 су већих димензија и квалитетније од садница произведених у контејнерима Боснапласт 12 са запремином ћелија од 120 cm^3. Истраживањима је утврђено да запремина контејнера позитивно утиче на морфолошке карактеристике садница лужњака у расадничким условима.

Кључне речи: лужњак (*Quercus robur L*), контејнер, садница, морфолошки параметри.

1. INTRODUCTION

The dilemma between classical and container seedling production is constantly present in development of nursery production technology. Many scientists have dealt with production of container seedlings (Elam, W.W. 1981; Matic, S. et al. 1996; Ocvirek, M. 1997; Orlic, S. 2000). The seedlings produced in containers have many advantages compared to seedlings produced in the conventional manner: higher survival rate during production and later during replanting, seedlings suffer less replant shock, the period of planting is extended, the production is mechanized, the afforestation of degraded terrains. The main drawback of container production is abnormal development of the root system (Oreskovic, Z. et al. 2006).

For the production of forest species seedlings in our country and in the world are used smaller containers, because they are cheaper, they reduce substrate procurement costs, they are easier to handle and a higher number of plants per unit area can be produced in them. These containers are suitable for the production of species with smaller seed, species of slower growth and less developed root system. For species with larger seed, species of rapid growth and strong root system it is necessary to use larger containers.

The characteristics of containers, volume and size of cells have a major effect on the physiology and morphology of seedlings in the nursery and later in a forest culture. It is therefore important to determine how these characteristics affect the growth and development of seedlings in order to produce higher quality and more developed seedlings that will successfully be used for afforestation.

In this paper was studied the effect of containers on the growth and development of Pedunculate oak one-year-old seedlings in the nursery. The researches were performed in seedling nursery and laboratory of the Institute of Forestry in Belgrade.

2. MATERIAL AND METHOD

The trial was set in four replications in the spring 2012 in the seedling nursery of the Institute of Forestry in Belgrade. Seed of Pedunculate oak (*Quercus robur* L.) was collected in the first week of October 2012 in the seed stand with registration number RS-2-2-qro-12-197, FMU "Rogot", department 2a, Forest administration Kragujevac, FE Kragujevac. Germinated acorns were manually sown in containers in April 2012 in seedling nursery of the Institute of Forestry in Belgrade.

For the trial were used three types of containers that are commonly used in Serbia for seedling production: Bosnaplast 12 with dimensions 36x25, 5x12 cm, with 55 cells in the block and with volume of each cell of 120 cm^3, Bosnaplast 18 with dimensions 32x21, 2x18 cm, with 33 cells in the block and with the volume of each cell of 220 cm^3 and HIKO V265 with dimensions 35,2x21, 6x15 with 28 cells in the block and with volume of each cell of 265 cm^3. The containers were filled with peat used in regular nursery production. Watering was performed regularly as well as protection with shade cloth and protection from diseases. At the end of the growing season in October 2013 was determined the survival rate and the seedling height and root collar diameter were parameters that were measured. Seedling height was measured by a ruler with an accuracy of 1 mm and root collar diameter was measured by a caliper with an accuracy of 0.01 mm.

For all analyzed variables were done descriptive statistics, analysis of variance and for all tests the error of 5% was considered as statistically significant. Statistical analyzes were done using the statistical package Statgraph 5.01.

3. RESULTS AND DISCUSSION

Fundamental laws of nutrition apply for all plants, and a good and healthy growth can only be achieved if all the factors that regulate growth are evenly distributed and in the correct ratio (Bala and Fricker, 1971). The amount of reserve nutrients in the soil (substrate) directly affects the nutritional status of plants (Ćirković-Mitrović, T. et al. 2012).

Growth of seedlings in the first year is particularly important for future survival and development of plants (Larsen, 2007). The studies (Walker and Huntt, 1999) have shown that the seedling height best forecasts the growth while the root collar diameter best forecasts the survival of seedlings after replanting.

The analysis of the survival rate has showed that the type of container did not affect the survival of Pedunculate oak seedlings. The survival rate of Pedunculate oak seedlings produced in containers Bosnaplast 12, Bosnaplast 18 and HIKO V265 ranged from 84.2 to 87.6%. From Table 1 it can be seen that the

seedlings produced in containers with a higher volume of cells have larger dimensions.

Table 1: *Summary statistics, analysis of variance and post-hoc test for root collar diameter and height of seedlings*

Container type	Root collar diameter	Heights of plants
	Average	Average
B12	3,22±0,51[a]	21±4,72[a]
B18	3,96±0,73[b]	22,1±6,98[a]
HIKO V265	4,06±0,63[b]	21,6±4,92[a]
P-value	0,0000	0,3428

In our studies root collar diameter of seedlings differs depending on the type of the container (Figure 1). The seedlings produced in the container type Bosnaplast 12 reach average root collar diameter of 3.22 mm, the seedlings produced in the container type Bosnaplast 18 reach average root collar diameter of 3.96 mm while the seedlings produced in the container type HIKO V265 reach average root collar diameter of 4.06 mm. The analysis of variance showed that there were statistically significant differences in root collar diameter depending on the type of container and this was confirmed by post-hoc test (Table 1).

The container type did not significantly affect the height of the seedlings. The highest mean height of 22.1 cm was measured in seedlings produced in the container type Bosnaplast 18 and the lowest mean height of 21 cm was measured in seedlings produced in the container type Bosnaplast 12. The mean height of 21.6 cm was measured in seedlings produced in containers HIKO V265. The analysis of variance showed that differences in reached mean height of seedlings depending on the type of container were not statistically significant (Table 1).

Similar conclusions that the cell volume of containers has a positive effect on morphometric characteristics of seedlings in their research got Seletković et.al 2011, in a trial with Austrian pine. The morphological parameters of one-year-old seedlings of Common cypress are directly dependent on the volume of container (Topić et.al 2009). In researches on Pedunculate oak and Sessile oak have been found that cell volume of container does not significantly affect the growth of seedlings, but definitely higher volume of container gives the seedlings of larger dimensions (Oreskovic, Z. et al. 2006). Volume of container directly affects the growth of Pinus pinea seedlings meaning that in containers with a maximum volume were produced the best developed seedlings (Topić et.al 2009). In trails on Bald cypress it was found that the volume of containers positively affects morphological parameters of the seedlings (Popovic, V. et al. 2013).

4. CONCLUSIONS

Based on the conducted researches and the obtained results in this paper the following conclusions can be made:

The physical characteristics of the containers did not affect the survival rate of Pedunculate oak seedlings in the nursery.

Researches carried out in this paper have showed that there is the effect of physical characteristics of containers on growth of Pedunculate oak one-year-old

seedlings in the seedling nursery. Seedlings produced in containers with the higher volume of cells Bosnaplast 18 and HIKO V265 reach greater values of height and root collar diameter compared to seedlings produced in containers type Bosnaplast 12, provided that the differences in the reached heights are not statistically significant.

According to our researches, it is recommended that in the production of Pedunculate oak seedlings have to be used containers of greater volume that will provide a sufficient amount of nutrients for plants so that they can have a higher starting height and root collar diameter during afforestation.

By monitoring development and measurement of seedlings in a field trial established from seedlings produced in containers, the data on survival, height increment and radial growth will be collected and this will provide guidelines and recommendations for the use of the appropriate type of container.

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EFFECT OF CONTAINER TYPE ON GROWTH AND DEVELOPMENT OF PEDUNCULATE OAK (*Quercus robur* L.) SEEDLINGS IN THE NURSERY

Vladan POPOVIĆ, Aleksandar LUČIĆ, Ljubinko RAKONJAC

Summary

The seedlings produced in containers have many advantages compared to seedlings produced in the conventional manner: higher survival rate during production and later during replanting, seedlings suffer less replant shock, the period of planting is extended, the production is mechanized and they are used for the afforestation of degraded terrains.

The characteristics of containers, volume and size of cells have a major effect on the physiology and morphology of seedlings in the nursery and later in a forest culture. It is therefore important to determine how these characteristics affect the growth and development of seedlings in order to produce more quality and more developed seedlings that will successfully be used for afforestation.

In this paper has been studied the effect of three types of containers on the growth and development of Pedunculate oak one-year-old seedlings in the nursery.

Based on the conducted researches and the obtained results in this paper it can be concluded that the type the containers did not affect the survival rate of Pedunculate oak seedlings. The physical characteristics of the containers affect the growth of one-year-old Pedunculate oak seedlings in the nursery. Seedlings produced in containers with the higher volume of cells Bosnaplast 18 and HIKO V265 reach greater values of height and root collar diameter compared to seedlings produced in containers type Bosnaplast 12, provided that the differences in the reached heights are not statistically significant.

According to our researches, it is recommended that in the production of Pedunculate oak seedlings have to be used containers of greater volume that will provide a sufficient amount of nutrients for plants so that they can have a higher starting height and root collar diameter during afforestation.

УТИЦАЈ ТИПА КОНТЕЈНЕРА НА РАСТ И РАЗВОЈ ЈЕДНОГОДИШЊИХ САДНИЦА ЛУЖЊАКА (*Quercus robur* L.) У РАСАДНИКУ

Владан ПОПОВИЋ, Александар ЛУЧИЋ, Љубинко РАКОЊАЦ

Резиме

Саднице произведене у контејнерима у односу на саднице произведене класичним путем имају низ предности: већи проценат преживљавања у току производње а и касније приликом пресађивања, мањи шок приликом пресадње, продужење периода садње, механизована производња, пошумљавање деградираних терена.

Карактеристике контејнера запремина, облик и димензије ћелија имају велики утицај на физиологију и морфологију садница у расаднику, а и касније у шумској култури. Због тога је важно утврдити колико ове особине утичу на раст и развој садница, како би се произвеле што квалитетније и развијеније саднице које ће моћи успешно да се искористе за пошумљавање.

У раду је истраживан утицај три типа контејнера на раст и развој једногодишњих садница лужњака у расаднику. На основу обављених истраживања и добијених резултата у овом раду може се закључити да тип контејнера није утицао на проценат преживљавања садница лужњака. На раст једногодишњих садница лужњака у расаднику утичу физичке карактеристика контејнера. Саднице произведене у контејнерима са већом запремином ћелија, Боснапласт 18 и HIKO V265 достижу веће вредности висине и пречника у кореновом врату у односу на саднице произведене у контејнерима типа Боснапласт 12, стим да резлике у достигнутим висинама нису статистички значајне.

Према нашим истраживањима препорука је да се за производњу садница лужњака користе контејнери веће запремине, који ће биљкама обезбедити довољну количину хранљивих материја, како би оне имале већу стартну висину и пречник у кореновом врату приликом пошумљавања.

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Original scientific paper

CHEMICAL CHARACTERISTICS OF GYPSY MOTH LARVAE EXCREMENT AND THEIR POSSIBLE IMPACT ON SOIL PROPERTIES IN THE TOTAL DEFOLIATION PERIOD

Zoran MILETIĆ, Mara TABAKOVIĆ-TOŠIĆ, Snežana STAJIĆ, Zlatan RADULOVIĆ, Saša EREMIJA, Marija MILOSAVLJEVIĆ, Ivana ŽIVANOVIĆ[1]

Abstract: *Chemical properties of gypsy moth larvae excrement were analysed with an objective to ascertain their possible impact on forest ecosystem nutrient cycling. The content of nutrition macro-elements in excrements was determined and compared to the content of nutrition macro-elements in oak leaves. The content of nitrogen mineral forms in excrements and group-fractional composition of humus were determined. It was established that during the total defoliation period there had been no loss of nutrient in the ecosystem. The properties of dropped and incorporated excrements are such that in the period of new leave formation after the total defoliation provide a sufficient amount of nutrients for forest trees.*

Key terms: gypsy moth, excrements, plant nutrients, soil properties

HEMIJSKE KARAKTERISTIKE EKSKREMENATA LARVI GUBARA I NJIHOV MOGUĆI UTICAJ NA SVOJSTVA ZEMLJIŠTA U VREME GOLOBRSTA

Apstrakt: *U cilju sagledavanja mogućeg uticaja golobrsta na kruženje hranljivih materija u šumskim ekosistemima analizirana su hemijska svojstva ekskremenata larvi gubara. Određen je sadržaj makroelemenata ishrane u ekskrementima i upoređen sa sadržajem istih u hrastovom lišću. Određen je sadržaj mineralnih oblika azota u ekskrementima i grupno frakcioni sastav humusa. Konstatovano je da tokom golobrsta nema većeg gubitka hranljivih materija u ekosistemu. Svojstva ekskremenata palih i inkorporiranih su takva da u vreme ponovnog formiranja lišća posle golobrsta obezbeđuju dovoljne količine hranljivih materija za šumsko drveće.*

[1] Institute of Forestry, Belgrade
Translation: Dejan Arsenovski

Ključne reči: Gubar, ekskrementi, biljni asimilativi, svojstva zemljišta

INTRODUCTION

In stable forest ecosystems, a nutrient cycling balance is sustained. Forest trees and other taller plants assimilate soil nutrients soluble mineral forms and convert them into organic forms. The highest concentration of all nutrients assimilated by plants from soil is in assimilation organs, which deciduous trees, at the end of each of vegetation period, discard. Together with litterfall, organically-bound plant nutrients are transported to the soil surface. The soil organic layer, composed mostly of litterfall, is subject to decomposition processes as a result of the activity of saprophytic microorganisms. By means of biochemical decomposition processes, organic compounds of nitrogen, phosphorus, potassium and other elements are decomposed, while plant nutrients appear in mineral and plant available forms. Excessively fast decomposition of organic matter and occurrence of plant nutrients in soluble form have a negative long-term impact on soil fertility and production potential, as the wash-off of soil nutrients occurs, resulting in their withdrawal from ecosystem cycling.

A part of decayed organic plant residue is not mineralised into the final decomposition products, but transformed into humus. Humus is more resistant to decomposition processes in comparison to a decayed organic residue. Its decomposition is protracted, which enables a gradual release of nutrients in smaller amounts and leaves sufficient time for their assimilation by plants.

Assimilation of soil nutrients by forest trees is most intensive in spring season, in the period of phenophase foliation and formation of leaf mass, followed by autumn season, in the phenophase winter bud-filling period. At the same time, the largest number and the most intensive activity of saprophytic microorganisms occur, while nutrient conversion from organic into a plant available form is most intensive. In winter and summer period, the organic matter mineralisation processes are slowed down or completely interrupted, on account of adverse humidity or heat conditions for saprophyte activity.

The nutrient cycling balance in forest ecosystems can be disturbed by over-proliferation of insect defoliators, which consume assimilation organs and cause excrement inflow onto the soil surface. In case of total defoliation, an ecosystem balance is completely upset. A large amount of excrement reaches the soil surface. Over-proliferation of gypsy moth and total defoliation take place in summer period, when biochemical decomposition processes, which are the result of saprophyte activity, are protracted on account of intense desiccation. That means that release of nutrient from organic matter is low, while the need for nutrients is high, as trees are compelled to repeat the foliation phase and restore leaf mass.

The subject of this paper is the study of chemical characteristics of gypsy moth excrement with an objective to ascertain their possible impact on soil and the living part of ecosystem during total defoliation period.

WORK METHOD

The collection of gypsy moth larvae excrement was conducted in laboratory conditions. The consumption material of cultivated caterpillars consisted of leaves of various oak species (sessile oak, downy oak, Hungarian oak and Turkey oak). The gathered material was analysed in air-dry condition, while the obtained values of studied analytes were re-calculated for the absolutely dry condition. The consumption material was analysed as a single homogenised sample of different oak species.

The excrement and consumption material were burnt at 550ºC, and the elements found in the ash were converted into chlorides. From the obtained solution, total elements were determined, namely:

- Calcium and magnesium complexometric
- Potassium flame-photometric
- Phosphorus colorimetric

The total nitrogen and carbon content was determined by the Anstteta's 1956 method, (Ponomareva, Plotnikova 1975), by means of wet combustion in the CrO_3 solution (chromium VI oxide) in sulphuric acid. The carbon content was determined by titration using 0.2 N Mohr's salt solution, while nitrogen was determined by distillation of ammonia and titration using sulphuric acid.

The content of nitrogen mineral forms in gypsy moth excrements was determined by application of the Bramner's method (Džamić et al 1996), whereas the active acidity was determined potentiometrically. The group-fractional composition of excrements humus was determined by the Ponomareva's method (Škorić, Racz 1960).

STUDY RESULTS

Based on the performed analyses, it can be concluded that gypsy moth larvae excrements are characterised by a higher content of ash and lower content of organic matter in comparison to gypsy moth consumption material, which consist of different oak species. With respect to the studied macro-elements of plants nutrition, a higher content of potassium in gypsy moth excrements was identified in comparison to that in the consumption material, whereas the content of total phosphorus, calcium and magnesium was lower (Table 1).

Table 1. *Characteristics of gypsy moth excrements and their consumption material*

	Ash	Organic Matter	pH		Ca	Mg	K	P_2O_5
			H_2O	KCl				
	%	%			%	%	%	%
Excrements	5.43	94.57	4.64		0.70	0.43	1.23	0.20
Consumption material	4.26	95.74	-		0.72	0.61	1.07	0.28

The total nitrogen content, as well as carbon content, in gypsy moth excrements is lower than in their consumption material, while the carbon / nitrogen proportion is broader (Table 2). The broader carbon / nitrogen proportion, according to many authors (Ohta, Kumada 1978, Deqiang et al 2008, Fabiánek 2009), should represent an indication of slower decomposition of organic matter and slower conversion of plant nutrients from organic into mineral and plant available forms. However, a considerably large portion of total nitrogen (Table 2) in analysed excrements already consists of its mineral forms, while in the oak leaves all nitrogen is in organic form. Among the mineral forms of nitrogen in gypsy moth excrements, the ammonia form absolutely dominates (13.85% of the total nitrogen), whereas the nitrate form of nitrogen also constitutes a significant part (4.24%) of the total nitrogen. In natural soils, the largest part of total nitrogen is in organic form, whereas its mineral forms available by plants account for only 1-2% of the total nitrogen (Popović 1989).

Table 2. *Nitrogen content in gypsy moth excrements and in their consumption material*

	C	Total N	NH_4-N	NO_3-N	Mineral	C / N
	g/kg	g/kg	g/kg	g/kg	g/kg	
Excrement	319.16	18.017	2.496	0.7683	3.264	17.715
		100.00 %	13.85 %	4.26 %	18.12 %	
Consumption material	334.40	24.449	-	-	-	13.677

Mineral forms of nitrogen cannot remain in soil for a long time. For that reason, as a result of gypsy moth larvae activities, and particularly during the total defoliation period, a higher loss of nitrogen could be expected from the total nutrient cycling balance in the ecosystem. The nitrate form of available nitrogen is highly soluble and mobile, for which reason it is subject to a rapid wash-off from the soil solum (Savić, Jekić 1975). A favourable circumstance, which mitigates the wash-off caused loss of nitrate during the total defoliation period, is that descendent streams are not very common in that period of year, as there is not much precipitation. The ammonia form of nitrogen is also subject to a wash-off, but to a significantly lower extent, as NH_4 ion is adsorbed into the adsorption complex. The loss of ammonia nitrogen also takes place by volatilisation. It is particularly intensive in neutral and alkaline pedochemical environments, where the adsorption complex is already satiated with other base cations (Savić, Jekić 1975). A particularly strong acid reaction of gypsy moth excrements (Table 1) by means of volatilisation prevents the loss of ammonia from excrements. That means that ammonia nitrogen is lost from excrements through a wash-off, i.e. that it first reaches a soil solution. Subsequent behaviour of ammonia nitrogen depends on soil properties.

In the group-fractional composition of humus of gypsy moth excrements (Table 3), fulvic acids absolutely dominate humic acids. Among isolated fulvic acid fractions, the most highly represented is fraction 1, which is not connected with the mineral component and therefore it easily becomes subject to biological

degradation. A significantly less represented is fulvic acid fraction 2, which is connected with calcium and magnesium and which is more resistant to biological degradation. Its representation in the group-fractional composition of humus accounts for 14.44%. Among isolated fulvic acids, aggressive 1a fraction is also significantly represented. The carbon of aggressive fraction of fulvic acids accounts for 10.97% of the total carbon. A high representation of fulvic acids aggressive fraction explains excrements' acid reaction.

Table 3. *Group-fractional composition of humus of gypsy moth larvae excrements*

Total C	Humic acids			Fulvic acids				∑Chk +∑Cfk	Remain der	Chk/ Cfk
	1	2	∑C hk	1a	1	2	∑C fk			
%	%	%	%	%	%	%	%	%	%	
31.92	1.88	0.17	2.05	3.50	5.26	3.65	12.41	14.46	17.46	0.165
100.00	5.88	0.53	6.41	10.97	16.49	11.44	38.89	45.31	54.69	

The content of humic acids is exceptionally low. The carbon producing isolated humic acids accounts for only 6.41% of the total excrements carbon. The proportion of humic and fulvic acids is exceptionally narrow and amounts to 0.165. Free humic acids (fraction 1), which are not connected with the mineral component and easily become subject to biological degradation are far more represented in the excrements humus in comparison to the grey humic acids (fraction 2). The representation of grey humic acids, which are less susceptible to biological degradation, as they are connected with calcium and magnesium, is negligible.

More than 50% of the total excrements carbon is in the insoluble residue. In natural soils, insoluble residue consists of fractions 3 of humic and fulvic acids, connected with clay and other stable sesquioxides, as well as humins, humus coal and insoluble organic matter of non-specific nature, such as lignin and cellulose. It can be assumed that in the studied excrements this insoluble residue mostly consists of lignin and cellulose's carbon, i.e. the carbon of hard-digesting organic matters which build vascular and mechanical tissues of oak leaves.

CONCLUSION

Based on the performed studies, it can be concluded that chemical characteristics of gypsy moth larvae excrements significantly differ from the consumption material, i.e. oak leaves. That difference is not that much pronounced in the total content of nutrition macro-elements, as it is in forms of their occurrence. In oak leaves, as well as in litter-fall, nutrition macro-elements are found in insoluble organic forms, while in excrements, a large portion of them is in mineral and plant available form. Certain macro-elements, such as nitrogen and phosphorous are less represented in the excrements than in the leaves, as they are used by gypsy moth for building their own cells. However, it does not mean that this portion of macro-elements withdraws from the nutrient cycling within forest ecosystems, as it will appear again on the soil surface following the die-off of gypsy moth.

Although the largest portion of nutrients in excrements is in mineral form, which means in soluble and mobile form, their significant losses from the soil should not be expected, as descending movements of water are not pronounced at the time of a year when gypsy moth is most active. A high amount of plant-available forms of plant nutrients, which in the total defoliation period reach the soil, facilitates the restoration of leaf mass after the total defoliation period, particularly given that mineralisation of organic matter is protracted in this time of year.

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THE EFFECT OF APPLICATION OF MICROBIOLOGICAL PREPARATION ON HEIGHT GROWTH DYNAMICS OF ONE-YEAR OLD SEEDLING OF BLACK WALNUTE (*Juglans nigra* L.)

Tatjana ĆIRKOVIĆ-MITROVIĆ[1]

Abstract: *Trend of organic production of plants that are used for human nutrition binds that when using nutrition preparations which represent significant factor in production of high quality planting material for different purposes microbiological preparations have to be included as well. The effect of the microbiological preparation Bactofil® B 10 on height growth tempo of black walnut seedlings during vegetation period is a subject of research of this paper. Comparative analysis of height increment of seedlings grown in soil treated with this preparation and height increment of control, non-treated seedlings shows the justification of direct application of Bactofil in mass production of high quality planting material of black walnut.*

Key words: Black walnut, nursery production, microbiological preparation *Bactofil® B 10*, height growth.

ЕФЕКАТ ПРИМЕНЕ МИКРОБИОЛОШКОГ ПРЕПАРАТА НА ДИНАМИКУ ВИСИНСКИ ПОРАСТА ЈЕДНОГОДИШЊИХ САДНИЦА ЦРНОГ ОРАХА (*Juglans nigra* L.)

Извод: *Тренд органске производње биљака које се користе за људску исхрану обавезује да код коришћења препарата исхране, који представљају значајан фактор у производњи квалитетног садног материјала за различите намене, микробиолошки препарати треба да буду укључени. Предмет истраживања овог рада је утицај примене микробиолошког препарата Bactofil® B 10 на динамику висинског раста садница црног ораха током вегетационог периода. Упоредна*

[1] Dr Tatjana Ćirković-Mitrović, Institute of Forestry, Kneza Viseslava 3, Belgrade, Serbia, e-mail *tanjacirk@yahoo.com*
Translation: Dragana Popović

анализа висине прираста садница раслих у супстрату и третираних овим препаратом и висински прираст контролних, нетретираних садница показује оправданост директне примене Bactofil-а у масовној производњи висококвалитетног садног материјала црног ораха.

Кључне речи: црни орах, расадничка производња, микробиолошки препарат *Bactofil® B 10*, висински раст

1. INTRODUCTION

Forest fruit trees have an enormous importance and their preservation, improvement and sustainable use in natural habitats are in accordance with the general interest for preservation of the biodiversity in Serbia. Range of many fruit trees in Serbia has declined alarmingly in the past 50 years and production of seedlings and their introduction into existing forests as well as afforestation of bare land contributes to the improvement of natural biological wealth of Serbia.

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

Certain scientific researches have proved that application of nutrition preparations in contemporary seedling production represents not only an additional source of nutrients, but also a powerful mean and important factor in production of high-yielding planting material for various purposes. Trend of organic production of plants that are used for human nutrition binds that when using nutrition preparations which represent significant factor in production of high quality planting material for different purposes microbiological preparations have to be included as well.

2. MATERIAL AND METHOD

For the purpose of research and analysis of heights and height increment during vegetation period of black walnut seedlings and monitoring the effects of the microbiological preparation *Bactofil® B 10* a sample plot was established in the seedling nursery of the Institute of Forestry in Belgrade. The nursery is located at 20° 27’ 44” east longitude and 44° 49’ 14” north latitude.

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

The black walnut seed collected in 2010 was used for establishment of sample plot. Seed was collected from tree, which grows in arboretum of Forest Faculty in Belgrade.

Due to dormancy of embryo, the black walnut seed was held in a wet stratification from November 2010 to the end of March 2011 (at the temperature 3-5 °C). The sowing was performed in April 2011, in rows, 8-10 pieces per linear meter, at the depth of 8 cm.

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

The analysis of height growth was performed on seedlings that were not treated with nutrition preparations, so-called „control seedlings", K, and on seedlings that were treated with microbiological preparation *Bactofil® B 10*, B.

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

Data processing was performed by relevant procedures using statistical software packages (*Statistica 7*).

3. RESULTS AND DISCUSSION

Climatic characteristics

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

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

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

Variation of height increment of one-year-old black walnut seedlings contingent upon treatment by Bactofil B10

The statistical analysis of height of the black walnut seedling upon the treatment by preparations *Bactofil* indicates that after a more or less uniform increase in height at the beginning of the vegetation period comes to an increasing of differentiation of this morphometric marker in plants treated with *Bactofil* in comparison with the control seedlings. (table 1).

At the end of the vegetation period, the seedling with the absolute smallest height was measured in non-treated seedlings, and seedling with the absolute largest height was measured in seedlings treated with *Bactofile*. The smallest seedling has height of 25.0 cm, and the highest seedling has height of 73.8 cm. Also, the larger average height of 52.0 cm have seedlings treated with *Bactofil*. The average height of 21.61 cm have non-treated seedlings (table 1).

Table 1. *Descriptive Statistics for control and treatment with Bactofil (K and B)*

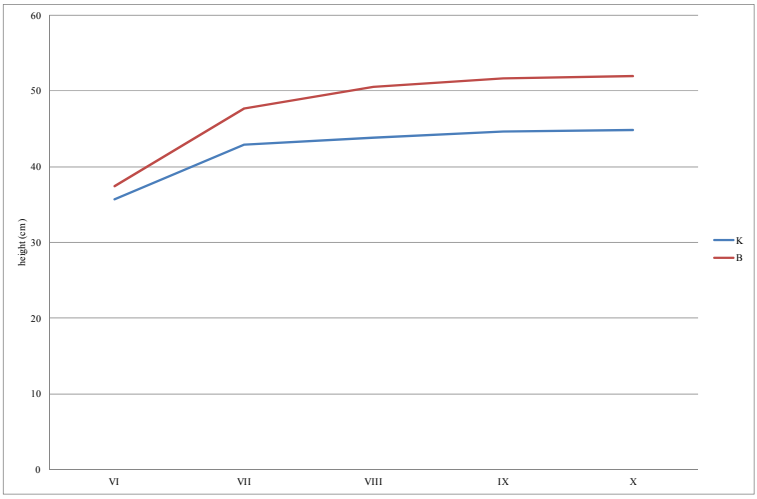
Treatment	Mean	Minimum	Maximum	Variance	Stdand. Dev.	Standard Error
K	44.8[a]	25.0	69.9	96.26932	9.811693	1.034243
B	52.0[b]	27.1	73.8	82.61024	9.089017	0.958067

After intense height increment at the beginning of the vegetative period (until June-July) in treatments, this morphometric parameter began to show a declining trend. the height increment decreases abruptly. Height increment of non-treated seedlings statistically differs significantly from height increment of seedlings from other treatment. At the end of the vegetation period, before the start of vegetative rest, the height increment of all seedlings is uniformed, with no significant differences. The curves of height development also indicate these trends (table 2, 3, Graph 1, 2). In June starts the differentiation of heights of seedlings treated with Bactofil, and by the end of the vegetation period this parameter is significantly different compared to the heights of non-treated seedlings

Table 2. *The difference in the height of black walnut seedlings during the growing season in 2011*

	height (cm) in month:				
Treatment	**VI**	**VII**	**VIII**	**IX**	**X**
K	35.7[a]	42.9[a]	43.8[a]	44.7[a]	44.8[a]
B	37.4[a]	47.7[b]	50.5[b]	51.7[b]	52.0[b]
	F (1.178)=1.3146 p=0.25311	F (1.178)=10.593 p=0.00136	F (1.178)=22.090 p=0.00001	F (1.178)=24.491 p=0.00000	F (1.178)=25.824 0.00000

Mean values in the same column followed by different letters are statistically different for r <0.05 (Post hoc Tukey's HSD test)

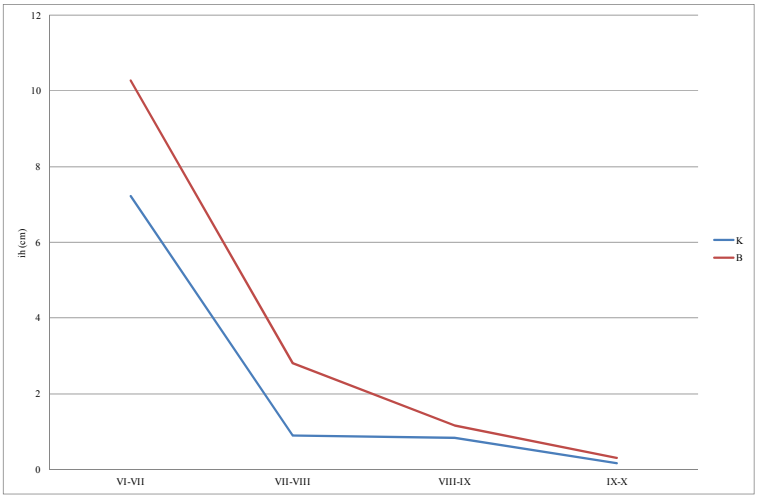


Graph 1. *Development of height of black walnut (Juglans nigra L.) seedlings during the vegetation period*

Table 3. *The difference in the height increment of black walnut seedlings during the growing season in 2011*

	height increment in period:			
Treatment	**VI-VII**	**VII-VIII**	**VIII-IX**	**IX-X**
K	7.23[a]	0.90[a]	0.83[a]	0.16[a]
B	10.28[b]	2.80[b]	1.16[b]	0.31[b]
	F (1.178)=26.059 p=0.00000	F (1.178)=28.308 p=0.00000	F (1.178)=7.84 p=0.00568	F (1.178)=2.6553 p=0.10497

Mean values in the same column followed by different letters are statistically different for r <0.05 (Post hoc Tukey's HSD test)



Graph 2. *Development of height increment of black walnut (Juglans nigra L.) seedlings during the vegetation period*

Based on the obtained results it can be concluded that the microbiological preparation *Bactofil* is suitable for the production of black walnut seedlings.

Oršanić, M. et al. (2007) studied the growth and development of black walnut seedlings during the first growing season and nurseries in Zagreb, and measured at the end of the growing season average height of 31.5 cm, which is lower than the average height of seedlings treatment obtained in these studies.
Average heights of seedling of black walnut in this study were comparable with those heights black walnut seedlings of the same age in terms of medium dense sowing (Jacobs, D. F. et al., 2006).

Woeste, K. E. et al. (2011) from the seeds of the black walnut trees in Indiana (USA) produced seedlings whose average height was 45.6 cm, ranging from 37.4 to 51.3 cm.

4. CONCLUSIONS

Even the 1978 Grey, T. R. G. et Williams, S. T. (1978) found that microorganisms produce growth hormones (gibberellins, auxins) and vitamins and affect the growth and development of plants. The positive influence of the most in this case is reflected in the black walnut seedlings treated exactly the biofertilizer, because they have reached greater heights, as compared to untreated plants. Seedlings treated with *Bactofil* in this study show better results than non-treated seedlings. Bigger average heights and absolutely maximal heights have seedlings of black walnut treated with *Bactofil*.

Microbiological preparation *Bactofil* positively affects the development of seedlings stimulating the development of seedlings height which is of particular importance if one takes into account that height, along with root collar diameter, is one of the most important morphological criteria of quality of deciduous seedlings (Stilinović, S. 1987).

An easy way of application by adding microbiological preparation *Bactofil* directly to the substrate speak in favor of justification of application of this preparation in mass production of high quality planting material for different purposes.

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THE EFFECT OF APPLICATION OF MICROBIOLOGICAL PREPARATION ON HEIGHT GROWTH DYNAMICS OF ONE-YEAR OLD SEEDLING OF BLACK WALNUTE (*Juglans nigra* L.)

Tatjana ĆIRKOVIĆ-MITROVIĆ

Summary

Range of many fruit trees in Serbia has declined alarmingly in the past 50 years and production of seedlings and their introduction into existing forests as well as afforestation of bare land contributes to the improvement of natural biological wealth of Serbia.

Based on these results in this paper it was concluded that used nutrition preparations have influence on the level and dynamic height growth of seedlings of black walnut. Microbiological preparation *Bactofil* positively affects the development of seedlings stimulating the development of seedlings height. The statistical analysis of height of the black walnut seedling upon the treatment by preparations *Bactofil* indicates that after a more or less uniform increase in height at the beginning of the vegetation period comes to

an increasing of differentiation of this morphometric marker in plants treated with *Bactofil* in comparison with the control seedlings.

An easy way of application by adding microbiological preparation *Bactofil* directly to the substrate speak in favor of justification of application of this preparation in mass production of high quality planting material for different purposes.

ЕФЕКАТ ПРИМЕНЕ МИКРОБИОЛОШКОГ ПРЕПАРАТА НА ДИНАМИКУ ВИСИНСКИ ПОРАСТА ЈЕДНОГОДИШЊИХ САДНИЦА ЦРНОГ ОРАХА (*Juglans nigra* L.)

Tatjana ĆIRKOVIĆ-MITROVIĆ

Резиме

Ареал многих воћкарица у последњих 50 година алармантно је смањен, па производња садница и њихово уношење у постојеће шуме и при пошумљавању необраслих површина доприноси унапређењу природног биолошког богатства Србије.

На основу добијених резултата у овом раду констатовано је да коришћење препарата исхране утиче на висину и динамику висинског раста садница црног ораха. Микробиолошки препарат *Bactofil* позитивно утиче на развој садница стимулишући развој висине садница. Статистичка анализа висине садница црног ораха третираних препаратом *Bactofil* указује да после мање више уједначеног пораста висина на почетку вегетационог периода, долази до све веће диференцијације овог морфометријског маркера код садница третираних *Bactofil*-ом у односу на контролне саднице.

Једноставан начин примене додавањем ђубрива директно у супстрат приликом његове припреме, контролисано разлагање које прати потребе биљке и релативно дуг период деловања говоре у прилог оправданости примене овог ђубрива у масовној производњи висококвалитетног садног материјала за различите намене.

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THE STUDIES OF ZINC (Zn) CONCENTRATIONS IN WOODY AND HERBACEOUS PLANTS IN THE REGION OF BELGRADE

Dragica STANKOVIĆ[1], Dragica VILOTIĆ[1],Vladan IVETIĆ[1], Djordje JOVIĆ[2]
Dušan JOKANOVIĆ[1], Jovana DEVETAKOVIĆ[1]

Abstract: *These studies are aimed at the determination of load of the plant ecosystems with the heavy metal (Zn) and the accumulation of it in this area, so that based on the results, if necessary, the appropriate protection measures of this higly-valued area can be appplied. The woody species lime tree and Austrian pine at the plots 1 and 2 in these studies show deficiency or are on the verge of the deficiency. Based on the results, heavy metal zinc is not the adverse factor in the natural protected area "Avala".*

Key words: Woody species, herbaceous species, Avala, level, zinc.

ISTRAŽIVANJA KONCENTRACIJE CINKA (ZN) U DRVENASTIM I ZELJASTIM BILJKAMA NA PODRUČJU BEOGRADA

Izvod: *Cilj ovih istraživanja usmeren je na to da se ustanovi opterećenost ekosistema biljaka teškim metalom (Zn) i njihova akumulacija na ovom području, kako bi se na osnovu dobijenih rezultata, ako je potrebno, mogle blagovremeno preduzeti odgovarajuće mere zaštite ovog visokovrednog područja. Drvenaste vrste lipa i crni bor na lokalitetu 1. i na lokalitetu 2. u ovim istraživanjima pokazuju deficit ili su na samoj granici deficita. Na osnovu svih dobijenih rezultata teški metal Cink ne predstavlja ugrožavajući činilac na području zaštićenog prirodnog dobra „Avala“.*

Ključne reči: Drvenaste vrste , zeljaste vrste, Avala, koncentracija, cink.

[1] Faculty of Forestry, the University of Belgrade, Kneza Višeslava 1, Belgrade, Serbia *(dragica.stankovic@sfb.bg.ac.rs; vladan. ivetic@sfb.bg.ac.rs; dusan.jokanovic@sfb.bg.ac.rs; jovana.devetakovic@sfb.bg.ac.rs;)*
[2] Institute of Forestry, - Belgrade Kneza Viseslava 3,Belgrade, Serbia (*jovicdjm@ yahoo.com*)
Translation: Marija Stojanović

1. INTRODUCTION

It is generally known, and scientifically proved, that the greenery of a contemporary town or city is its integral part which is mainly associated to human health. Based on the above claims, it is needed to point to the necessity of the permanent monitoring of the level of heavy metals in plants, as the indicators of the environmental pollution, which can have adverse effects, not only on the forest ecosystems, but on man, also.

Avala is the mountain situated about 17 kilometers southeast of Belgrade, on the road to Kragujevac. It is the northernmost mountain of the Šumadija Mountain Range and is classified as the low island mountain.

Based on the special forest management (2008-2017), the natural protected area "Avala", covering an area of 489.13 hectares, is located at the territory of the city of Belgrade, in the city municipality Voždovac, 15 kilometers south of the centre of the city. The total area of 74.35 hectares (15.2%) is privately-owned, and 414. 8 hectares (84.8%) refer to the other types of ownership. The agricultural land accounts for 19.9 % of the total natural protected area "Avala". The area of forests aimed at the land protection is 363.62 hectares (75% of the total natural protected area "Avala"), out of which 68% are of the coppice origin, and 32% of artificial origin.

Heavy metals can be found in all environmental media, as the results of different types of human acvities. The origin of the heavy metals in fine particles in the air is double: natural and anthropogenic. There is not sufficient knowledge on their distribution in nature and role in pollution. It is partially known that the emission souces, by the following processes: turbulent diffusion, dry and wet deposition, then by the migration via soil and water, participate in the circulation through the nature, thereby disturbing the natural balance of these elements, which is of the particular significance to the biosphere.

Similarly to other metals, zinc also participate in the activity of enzymes, the most important of which is carboanhidrase (Ohki, 1976) (Aliev, Guliev,1990). Zinc is the necessary component of RNA-polymerase and participates in the synthesis of auxins (Kastori, 1990, Kastori et all, 1993). Heavy metals are constantly absorbed by the plants during the growing season and throughout the year, achieving, as a rule, the highest level by the end of the growing season. (Krstić, et all 2008 , Stanković et al, 2011, 2013).

The high level of Zn, as well as of other heavy metals, has toxic effect in plants. The excess od this elements in plants rarely occurs in nature. The resistance of some plants to the excess of this element is different. Along with the series of physiological disturbances, owning to the lack of zinc, some plant diseases, such as leaf chlorosis, abnormal cell growth, etc, occur (Stanković et al, 2009). The typical symptoms of the lack of zinc in plants are the occurrence of rose rosette and littleleaf diseases. The excess of zinc can be toxic, and in the sufficient quantity it increases the resistance to some diseases (phytophtora).

2. MATERIAL AND METHOD

Having in mind the importance of the quality of environment in the domains aimed at the recreation, the studies regarding the concentration of heavy metals in plant leaves in Avala were conducted.

Three plots in the Avala area of the outstanding features, out of which the samples for the analysis were taken, were selected.

The selected plots, based on the special forest management for Forest Unit "Avala" (2008 - 2017) for Forest Unit "Avala" in the following way:

Plot 1 - on the ascending road in the area of outstanding features "Avala"

Plot 2 - on the top of Avala (near the tower)

Plot 3 - on the descending road (Stari Majdan)

Plot 4 - Control - Bulevar Despota Stefana Street in the centre of Belgrade

Upon the survey of several potential plots, the fourth one, so-called "control" plot in the centre of Belgrade in Bulevar Despota Stefana Street, where the traffic is very frequent, was selected.

During the selection of plants for analysis, the inventory of all plant species in this area was accurately conducted. And for these analyses the following plant species were selected:

1. *Tillia tomentosa Mnch.*- Silver lime
2. *Pinus nigra Arn*.- Austrian pine
3. *Plantago media L.*- Hoary plantain
4. *Taraxacum officinale Web*.- Dandelion

Starting exactly from the fact that the amount of heavy metals in plants directly depend on the distance from the road, the plants were taken at each plot 200-300 meters long, at the depths up to 15 meters. Only the leaves of the plants were sampled. The samples of the leaves were collected and for each species 1-2 kilograms of material were collected from each plot. The samples were dried without the prior washing so that the dry matter was gained. The dry leaves were then dried in the hothouses at 105^0C, grinded and used for the laboratory analyses. (Maksimović et all. 2002):

The content of the heavy metal zinc was determined by using the method of atomic absorption spectrometry, by "Thermo series M" mashine.

The obtained data were processed statistically by using the method of the analysis of variance, by LSD - test. The significance of the mean values was tested by using the Duncan's test. All tests were done at the significance level $p \leq 0.05$. The levels (average values) in the figures marked by the same letters did not differ significantly at the significance level $p = 0.05$. The results were presented in the appropriate graphical way.

The analyses were done in the laboratory of the Department of Biology and Ecology of the Faculty of Natural Science and Mathematics in Novi Sad and the Institute for Biological Research "Siniša Stanković" in Belgrade.

3. RESULTS AND DISCUSSION

Zinc is one of the micronutrients which are very important to the normal life processes in plants and is needed in very small amounts of the order of magnitude μg or ppm (parts per million).

The concentration of zinc in the soil ranges from 10 - 300 ppm and is found in the form Zn2+ ions. The concentration of zinc in the plants is very small (20 to 200 ppm). The level lower than 20 ppm in the dry matter is critical value for most of the plant species (Carroll, Loneragan, 1969). The resistance of some plants to the excess of this element is different, and the symptoms occur when the amount of it in dry matter ranges from 100 to 300 μg Zn g-1. Having in mind the importance of zinc in plant nutrition, considerably greater attention of the world researchers was paid to the lack, than to the excess of it. By the single analysis of variance it was studied if there were statistically significant differences in the mean values of the amount of zinc in all plant species at each observed plot. Since by using the analysis of variance $P=0.0000<0.05$ was gained, it can be claimed that, at the probability level 95%, there are are statistically significant differences in the amount of Zn in the observed plant species at all observed plots.

By using Dancan's test it was studied whether there were statistically significant differences (at the probability level 95%) among the mean values of Zn amounts at the splant species at each of the sites.

At the ascending road towards the area of the outstanding features "Avala", although, generally speaking, there are the statistical differences among the mean values of zinc amounts, based on the results of Dancan's test, it can be claimed that the lime tree and Austrian pines are the homogenous group (i.e. there are no statistically significant differences among the mean values of the amount of zinc between them), and that the mean values of the amount of zinc in hoary plantain and dandelion are statistically significantly different, regarding the differences between them and regarding all other species. (Figure 1).

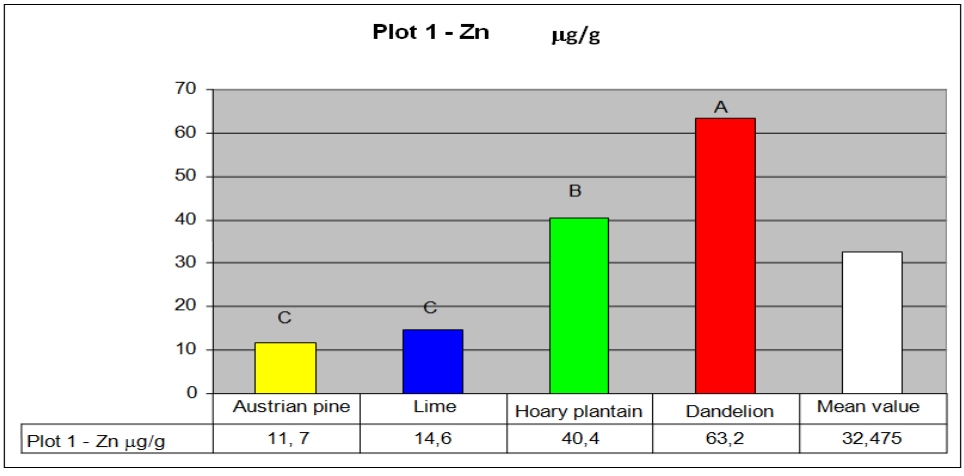

Figure 1 *The amount of zinc in the observed plant species at the site 1*

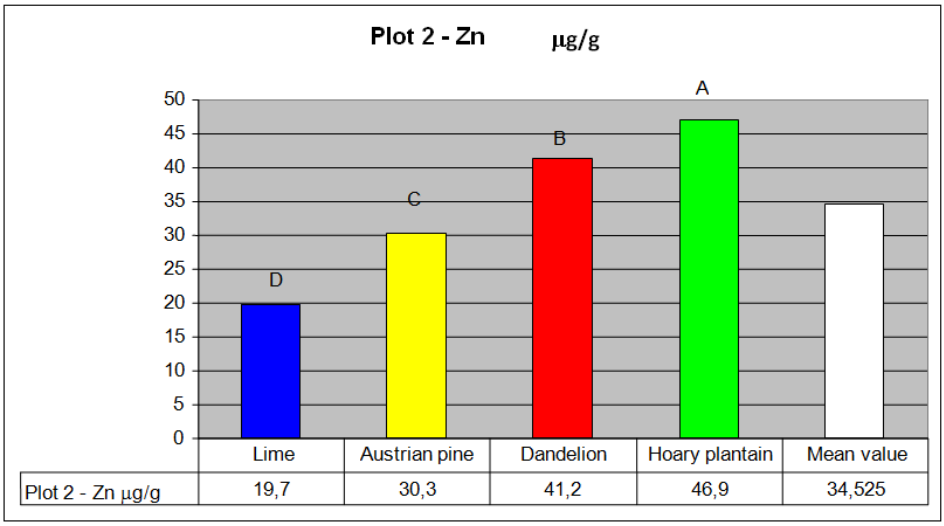

Figure 2 *The amount of zinc in the observed plant species at the plot 2*

Regarding the plant species at the site 2, on the top of Avala, Dancan's test showed that the mean values of the amount of zinc in all observed plant species were statistically significantly different (Figure 2).

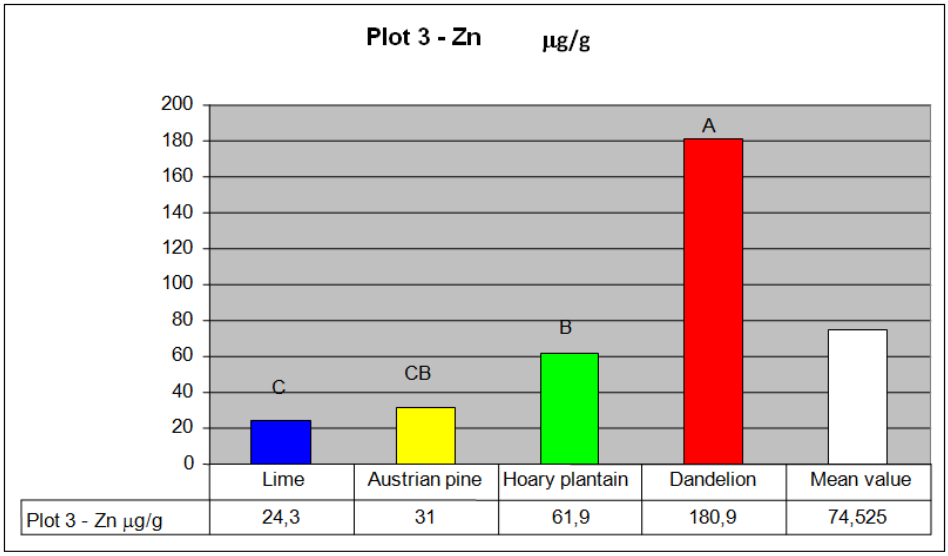

Figure 3 *The amount of zinc in the observed plant species at the plot 3*

At the plot located at the descending road (Stari Majdan), although generally speaking there are statistically significant differences, based on Dancan's test it can be claimed that the lime tree and Austrian pine, Austrian pine and hoary plantain are the homogenous group (i.e. there are no statistically significant diffrences between the mean values of the amount of zinc), and that the mean value of the amount of zinc in the dandelion is statistically significantly different from all other species (Figure 3).

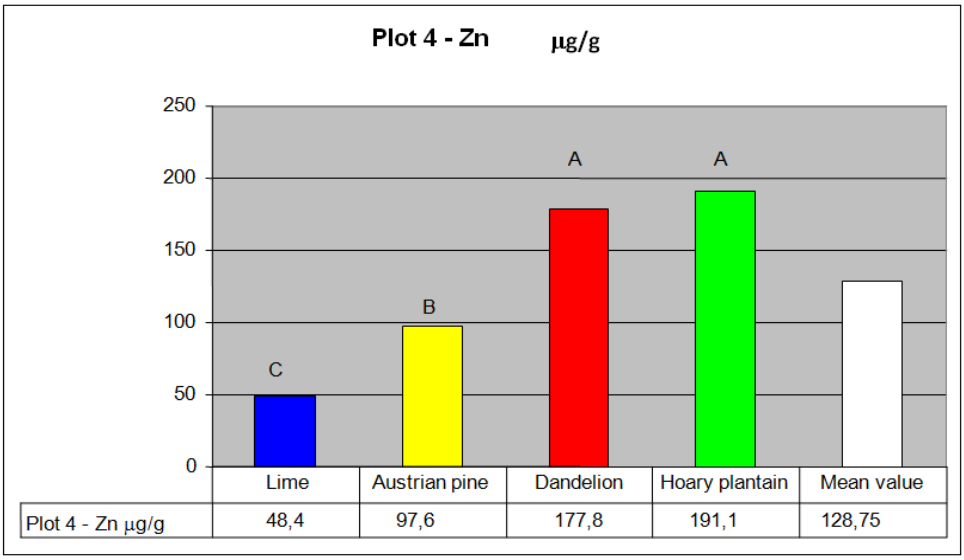

Figure 4 *The amount of zinc in the observed plant species at the plot 4*

At the plot in the Bulevar Despota Stefana Street in the centre of Belgrade, as well at the above plots there are statistically significant differences between the mean values of the amount of Zn. However, based on Dancan's test it is clearly visible that the dandelion and hoary plantain are the homogenous group (i.e. there are no statistically significant difference between them in the mean values of the amount of zinc), and that the mean values of the amount of zinc in the lime tree and Austrian pine are statistically significantly different regarding the differences between them and regarding all other species (Figure 4).

4. CONCLUSION

By comparing the data obtained in these studies with the ones from the references (Figures 1-4), it is visible that the herbaceous species dandelion and hoary plantain absorb more zinc than the observed woody plant species. The woody species lime tree (14.6µg/g) at the plot 1 and Austrian pine (11.7µg/g) at the plot 2 in these studies show the deficiency or are on the very verge on the deficiency. (Figures 1 and 2). By comparing the mean values in all observed plant species on each plot, it is visible that the highest accumulation of zinc was reported at the plot 4, with the value 128,75, and the lowest mean value was 32.47 µg/g at plot 1.

The results which were obtained undoubtedly show that the samples of plant material from all plots were not contaminated by zinc, and that the lack of zinc in the plant was reported at some plots. It is important to note that zinc is not the adverse factor in the observed area of Avala.

Note
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*by the production of agro-energy crops" (*TR 31078) financed by the Ministry of Education and Science of the Republic of Serbia within the program aimed at the technological development for the period 2011-2014.

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ANALYSIS OF TYPES OF DAMAGES AT THE SAMPLE PLOTS OF LEVEL 1 IN 2013 AT THE TERRITORY OF THE REPUBLIC OF SERBIA

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

Abstract: *The vitality of a forest ecosystem to a great extent depends on the effect of different factors of stress, be it of biotic (harmful insects, phytopathogenic fungi, etc.), abiotic (frost, drought, high temperatures, etc.) or of anthropogenic origin (human activities). Some factors owning to their long-lasting effect can lead to the weakening of the individual trees or the whole forest ecosystem and eventually cause the mortality of it.*

The paper presents the results of the research of the types of damages of biotic, abiotic and anthropogenic origin at the sample plot of LEVEL 1 in the Republic of Serbia, conducted during 2013. By the analysis of the data, the results concerning the total number of trees with the identified types of damage, the part of the tree on which the some type of damage occurred most commonly, total number of the trees without any damage, most frequent type of damage and the types of trees with the highest and lowest percentage of damage, were obtained. The results which were obtained present the factual situation regarding the types of the damages for each sample plot and can be beneficial for the further analysis. By comparing these data with the date from other countries, the conclusions about the way in which the vitality of trees depend on the environmental conditions were made.

Key words: sample plots, vitality of trees, types of damages.

[1] Institute of Forestry, Kneza Viseslava 3, Belgrade, Serbia
e-mail: *cesljargoran@gmail.com*
Translation: Marija Stojanović

ANALIZA TIPOVA ŠTETA NA BIOINDIKACIJSKIM TAČKAMA NIVO-A 1 U 2013 GODINI NA TERITORIJI REPUBLIKE SRBIJE

Abstract: *Vitalnost jednog šumskog ekosistema u velikoj meri zavisi od uticaja različitih faktora stresa., bilo da su biotičkog (štetni insekti, fitopatogene gljive itd.), abiotičkog (mraz, suša, visoke temperature itd.) ili antropogenog porekla (ljudske aktivnosti). Pojedini faktori svojim dugotrajnim delovanjem mogu dovesti do slabljenja pojedinačnih stabala ili čitavog šumskog ekosistema i na kraju izazvati njihov mortalitet.*

U radu su prikazani rezultati istraživanja tipova šteta biotičkog, abiotičkog i antropogenog porekla na bioindikacijskim tačkama NIVO-a 1u Republici Srbiji, sprovedenih tokom 2013 godine. Analizom podataka dobijeni su rezultati o ukupnom broju stabala sa identifikovanim tipom štete, najčešće zahvaćenog dela stabla nekim tipom štete, ukupnom broju stabla bez štete, najzastupljenijem tipu štete i vrstama drveća sa najvećim i najmanjim procentom štete. Dobijeni rezultati daju činjenično stanje o tipovima šteta za svaku bioindikacijsku tačku i mogu biti pogodni za dalju analizu. Poređenjem ovih podataka sa podacima durgih zemalja mogu se doneti zaključci o zavisnosti vitalnosti stabala od uslova sredine.

Ključne reči: Bioindikacijske tačke, vitalnost stabala, tipovi šteta.

1. INTRODUCTION

The intensive monitoring of different adverse effects on the forest ecosystems is carried out every year during the growing season within ICP Forests Programme, which implies that based on the crown condition (defoliation and discolouration), which is generally the most widely applicable indicator of vitality of forests, the percentage of damage is determined. The parameters which are assessed during the evaluation of the crown condition imply the damages by the biotic, abiotic and anthropogenic factors detected on all parts of the tree. Based on the damage which was made, it is possible to assess the causes of the damages of the individual tree or the whole forest ecosystem and derive conclusions about the causal relations. Based on the methods by ICP Forests Programme[1], the damages on the trees were assessed in three steps: description of symptoms, determination of causes and the quantification of them (*ICP Forests 2010*). For each tree, several symptoms, which should reflect its health condition, can be described. The description of the symptoms is aimed at the description of the visible types of damages on each individual tree, i.e. pointing to the parts which are damaged, as well as to the type of the observed symptom. The description is focused on the factors which are clearly most dominant and can affect the condition of the whole tree. The symptoms are groupped in categories based on the part of the tree where they occur (*Fischer R., Lorenz M. et al. 2012*): leaves or needles (deformations, indicators of insects, indicators of fungi, etc.), branches or shoots and buds (wounds, deformations, indicators of insects, indicators of fungi, etc.) and bole

[1]International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests.
International cooperative programme aimed at the evaluation and monitoring of the effect of air pollution on forests.

(wounds, such as bark fall, deformations, indicators of insects, indicators of fungi, etc.).

For each description it is needed to determine the cause which is of the key importance to the study of the causal relations. The main causes of some type of damage on the trees can occur due to the direct actions of man, insects, fungi, game and cattle, frost, drought, high temperature, fire, local pollutants and other factors. ICP Forests Programme of monitoring is the only system which provides the harmonized and trans-national data on the harmful agents at the annual level (*Fischer R, et al. 2012*).

Based on the data by *Banković S. et al.* (2009), the total area covered by forests in the Republic of Serbia is 2,252.400 hectares, which accounts for 29.1 % of its territory, the beech (*Fagus moesiaca*) is the most common species, followed by Turkey oak (*Quercus cerris*), sessile oak (*Quercus petraea*), Hungarian oak (*Quercus frainetto*), hornbeam (*Carpinus betulus*), etc. Also, at the sample plots of Level 1, the above mentioned species are equally distributed, except for the Hungarian oak, which is more frequent than the sessile oak. Within the international programme for the monitoring of the forest condition ICP Forests, the grid of the sample plots 16 x16 kilometers of the Level 1 in the Republic of Serbia was established for the first time in 1988 at about 150 sample plots (*Nevenić R. et al 2009*). Afterwards, the forest condition was not evaluated for a long period of time, and the practice was renewed in 2003, and in the following 2004, the new 27 plots in the grid 4 x4 kilometers were added to the existing grid 16 x16 kilometers, in order to gain the most representative data possible on the forest condition in Serbia. Over the previous few years, the studies have been conducted at 121 sample plots, out of which 72 are placed in the state-owned forests, and 49 in the privately-owned forests. Based on the national forest inventory, 49 tree species were determined at the territory of the Republic of Serbia, where the broadleaf species (40) are more dominant than the conifer ones (9). The total number of tree species which are located at the sample plots of the Level 1 and which are subject to the intensive monitoring is 33, out of which 29 are broadleaf species, and 4 conifer ones.

This paper is aimed at the assessment of the types of damages and collection of the as many as possible pieces of information on the causal relations of the damages on the trees in order to enable the better interpretation of the uncharacteristic instances of mortality.

2. MATERIAL AND METHOD

This paper analyses the data collected during the research which was conducted within the regular survey of the Sample plots (Level 1) at the whole territory of the Republic of Serbia in 2013, over the period of the biological activity of the vegetation (June-September). Each individual tree was analysed and each visible change that was detected was reported. The data on the types of damages were reported based on the causes of their occurrence: from the direct action of man, insects, fungi, game and domestic animals, abiotic agents, wildfires, local pollutants and other factors, as well as the damages which were reported but the cause of which was not identified. By the data processing, the results regarding the

total number of trees with the identified type of damage, the part of tree which was most frequently subject to some type of damage, the total number of the trees without any damage, most frequent type of damage and tree species with the greatest and smallest percentage of the damage, were gained. The research was made at all 2,794 trees within the permanent sample plots of the grid of the sample plots of the Level 1, out of which the total number of broadleaf trees was 2,456, and the total number of conifer ones was 338.

3. RESULTS AND DISCUSSION

The causes of damages in forests can be different (biotic, abiotic or anthropogenic) and can be divided into the ones which make the small damages, great or catastrophic ones, the damages that occur frequently or occasionally, and the ones which can occur at small or great territories. Some damages cannot be always interpreted as the damages since it is known that trees is the home to a great number of insects which live and depend on them. However, the insects by their outbreak can significantly contribute to the physiological weakening of the trees which have already been weak, due to, for instance, drought, i.e. lack of moisture and high temperatures, which to a great extent can aggravate and mask the detection of the real cause of the damage. The visible symptoms can play an important role in the detection and assessment of the different factors of stress. Nevertheless, there are numerous difficulties regarding the interpretation of the visible symptoms since they can considerably vary among the different tree species (*Pierre V. et al 2005*). The identification of the diagnosis of a very damage will also depend on the cause, i.e. defion of symptoms. Due to the all above mentioned factors, it is very important to be familiar with the symptoms so that the damage will be the least possible and the necessary measures of protection will be applied.

In 2013 the condition of the trees at 121 sample plots of the Level 1 was assessed. Some types of the damages, based on the cause of occurrence, were reported on the 685 trees, out of the total 2,794 trees, which accounts for 24.5%, whereas no indicators of the damage were reported on the remaining 2,019 trees. The trees on which the damages occurred on the crown accounted for 76.4 %, the trees with the symptoms on the bole accounted for 16.2%, the trees with the symptoms on the butt accounted for 2.6%, the trees with the symptoms on the whole tree accounted for 3.4%, whereas the trees with the symptoms on both bole and crown accounted for 1.5% of trees ***(Figure 1).***

The most damages were reported on the crown (leaves) and were caused by the insects, most frequently by defoliators, mostly by the gypsy moth (*Lymantria dispar L*), which in the year of the study caused the defoliation at the great areas covered by forests in Serbia (*Tabaković-Tošić M. et al 2013*). On the bole the mechanical injuries, occurrred by the use of the mechanisation, used for the works in forests, as well due to the felling and the fall of the trees in vicinity, caused by man. The damages on the roots and butt of the tree, made by the machines used for the felling and transport of logs across the fores, are frequent. Also, a great number of cankers caused by fungi is present on the bole, whereas on some trees the damage was reported, but the cause was not identified so it was classified as other damages ***(Figure 1).***

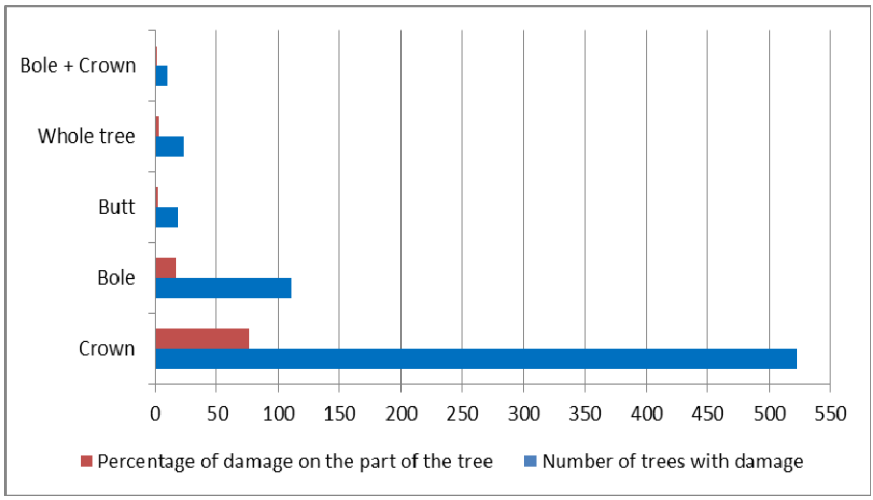


Figure 1. *The frequency of some type of damage at some part of the tree*

Some visible changes, such as cankers, dry branches, swellings, mechanical damages, etc. were also reported over the previous years during the regular survey of the sample plots, but due to the monitoring of their progression were incorporated in the analysis, since they reflect the current condition of each individual tree. It is important to note that the fungi which cause the rot of the living trees penetrated deep in the interior of the trees mostly via surface wounds on the bark, dry branches, ingrown knobs, etc. (*Karadžić D. 2010*). Therefore, these pieces of information reflect the health condition, so the observed symptoms are not merely treated as the damages in the narrow sense.

The insects are most frequent agents of the damages in 2013, since they account for 50 percentage, i.e. reported at the total of 343 trees, followed by the other damages, i.e. the damages which were reported but the cause was not identified, which account for 23%, or the total of 157 trees. Humans, i.e. the activities of them, caused the damages on 58 trees, i.e. they account for 8.5% of the damaged trees. In spite of the great number of wildfires which occurred in the year of the study, the damage made by this agent was reported on only 5 trees of the sample plots of the Level 1, which account for 0.7%. The smallest percentage of the damages on the trees was caused by the game, i.e. 0.1%, or only on one tree. During the year of the study, the increase of the damages caused by the abiotic agents, mainly by the long-lasting drought (*Češljar G. et al. 2013*), which was also reflected in the mass occurrence of the desiccation of the forests, covering 13,885.00 hectares of the whole territory of the Republic of Serbia, (Jančić, 2013), was also observed. The trees with the damages occurred as the result of the abiotic factors account for 7.7%, and the drought and frost are the most frequent agents of the damages in this group of agents. The above mentioned data can be seen in the ***Figure 2.***

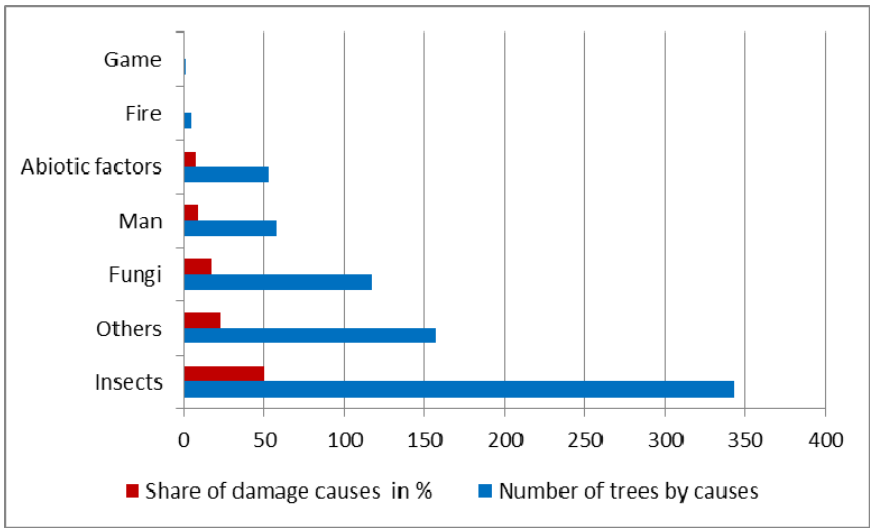


Figure 2. *The agents of damages on the trees*

In the **Figure 3** the tree species with the identified damage and their share in the sample plots are presented, whereas the species on which no changes were detected were classified as the other species. Regarding the number of trees at the sample plots, the most frequent types of the damages were reported on the broadleaf species, such as the beech (Fagus moesiaca) and oaks (Quercus sp.), which implies that the damages are not merely connected to the specific species, but they are more frequent due to the greater density of these species at the sample plots in comparison with other ones. Regarding the conifer trees, the greatest number of some types of damage was reported on the Austrian pines (Pinus nigra) trees, since the small number of trees of the most frequent conifer species at the sample plots, the spruce (Picea abies), sustained some type of damage.

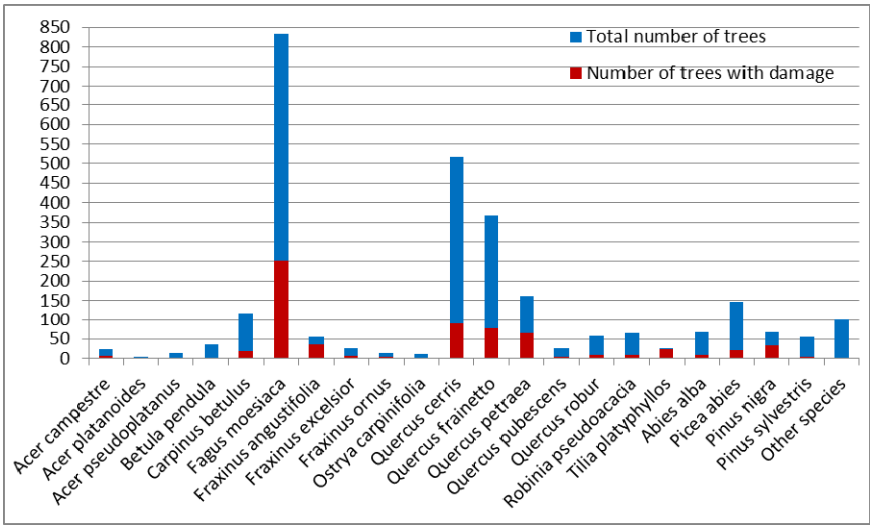
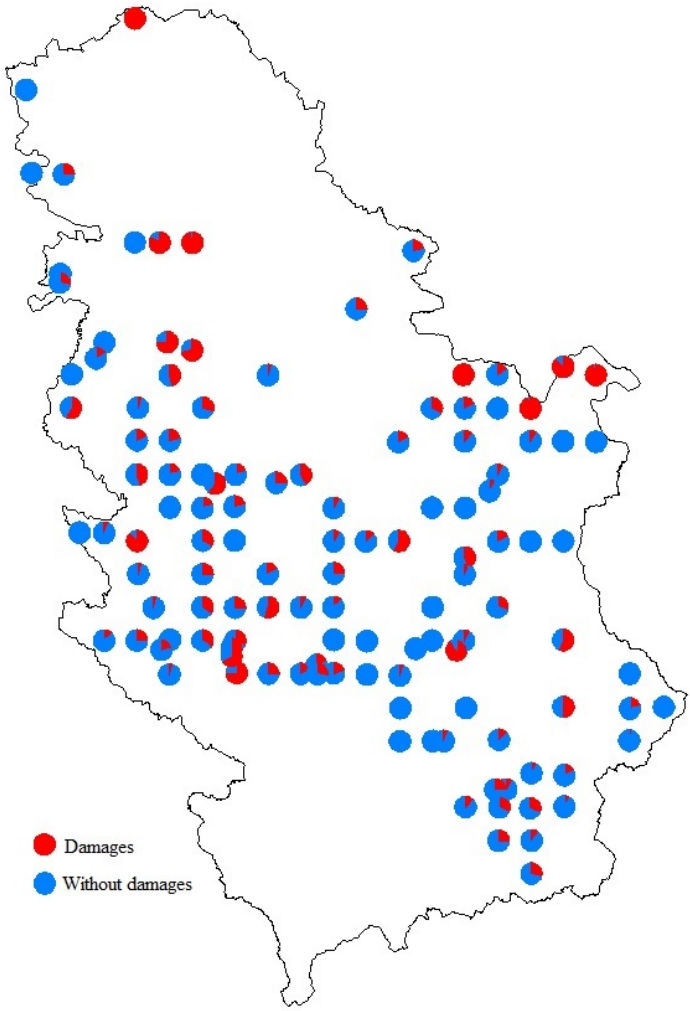


Figure 3. *The total number of tree species and number of trees with the damage at the sample plots*

In the ***Map 1*** the distribution of the sample plots of Level 1 at the territory of the Republic of Serbia with the share of the damages on each of them indvidually is presented. The presented data point to the fact that the sample plots with the greatest share of the damages were mainly caused by the insects, such as the case with Eastern Serbia, where the gypsy moth (Lymantria dispar L) caused great damages. It is also important to note that some insect species enterely depend on certain host plant, thereby their greater occurrence at some sample plots correspond to the spatial range of the plant, which can be also noted for some fungi. However, humans at some sample plots owning to the lack of the necessary silviculture measures, mainly regarding the forests, contributed to the occurrence of the greater damages by the insects and fungi, on the both broadleaf and conifer trees, because of which in the future it is needed to apply more frequent monitoring of the forests and silviculture measures so that the damages will be reduced to the least possible level.



Map 1. *Distribution of the sample plots of the Level 1 with the share of damage*

4. CONCLUSION

The results which were obtained reflect the most frequent types of damages on the trees at the sample plots which to a great extent can present the current condition of forests in the Republic of Serbia. The presence of some types of damages on the trees is the usual process in the forests, but the occurrence of the high percentage of some of them cannot be always considered to be the natural or usual phenomenon, so it can imply the disturbance in the environment. By the survey of the condition of forests using the method of the sample plots in 2013, the results showing that some visible damages on the trees occurred much earlier than over the year of the study, as the result of the activity of a series of factors of biotic and abiotic origins, as well as of the anthropogenic actions, were analysed and gained. On the one hand, some symptoms were hardly visible, but persistant and progressive, by becoming clearly visible only after some years. On the other hand, some symptoms occurred suddenly. In many cases no biotic factor, which would be able to cause the sudden changes of the health condition of trees, was reported, whereas the abiotic factor such as the drought (very high temperatures and lack of precipitation) was very dominant and probably led to the physiological weakening of the trees, which served as the favourable base for the attack of the secondary species.

The analysis of the types of damages and their agents, during the observed period will serve as the starting point for the evaluation of their effect on the health condition of the individual trees and the whole forest ecosystem. Based on the results of the research, it can be concluded that a great number of factors can affect the health condition of trees, since over the previous few years the climate change, i.e. the unusual weather conditions, can be undoubtedly singled out as the most influential ones.

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SUSTAINABLE FORESTRY **ODRŽIVO ŠUMARSTVO**
COLLECTION 69-70, 2014 ZBORNIK RADOVA 69-70, 2014

UDK 630*145.78 Lymantria dispar L.+630*4(497.11-751.2 Đerdap)"1996/2014"=111
Original scientific paper

THE OUTBREAKS OF THE GYPSY MOTH IN THE FORESTS OF NATIONAL PARK ĐERDAP IN THE PERIOD FROM 1996 TO 2014

Mara TABAKOVIĆ-TOŠIĆ[1], Marija MILOSAVLJEVIĆ[2], Nemanja SIMOVIĆ[3]

Abstract: *This paper presents the results of the study of the population levels of the gypsy moth in the forests of National Park Đerdap, over the period 1996-2014. The characteristics of three outbreaks (1996-1997, 2003-2005 and 2009-2014) of the gradogenic character were studied. Since these are forest ecosystems of the natural protected areas in which the special rules and measures aimed at the protection from the adverse effect of the wide range of the biotic and abiotic factors are applied, with the special emphasis on the possible, or impossible, use of pesticides, the paper also analyzes the control measures which were taken, i.e. the reduction of the density of the gypsy moth to the normal population level. In addition, the effect of two species of egg parasitoids, as well as of Entomophaga maimaiga and Lymantria dispar multicapsid nuclear polyhedrosis virus (LdMNPV) - pathogenic worms, on the population level of the gypsy moth in some years of the outbreak was studied.*

Key words: *Lymantria dispar,* outbreak, natural protected area, control, natural enemies.

PRENAMNOŽENJA GUBARA U ŠUMSKIM KOMPLEKSIMA NACIONALNOG PARKA ĐERDAP U PERIODU OD 1996. DO 2014. GODINE

Abstract: *U radu su prikazani rezultati istraživanja visine populacionih nivoa gubara u šumskom području Nacionalnog parka Đerdap, u periodu 1996-2014. godina.*

[1] Ph.D. Mara Tabaković-Tošić, Senior Research Fellow, Institute of Forestry, Belgrade
[2] Marija Milosavljević, M.Sc. and Student of Doctoral Studies of the Faculty of Biology at the University of Belgrade
[3] Nemanja Simović, Student of Doctoral Studies of the Faculty of Forestry at the University of Belgrade
Translation: Marija Stojanović

Analizirane su karakteristike tri prenamnoženja (1996-1997., 2003-2005. i 2009-2014. godina) gradogenog karaktera. Kako se radi o šumskim ekosistemima zaštićenog prirodnog dobra u kojima se primenjuju posebna pravila i mere zaštite od negativnog dejstva čitavog kompleksa biotičkih i abiotičkih faktora, s posebnim osvrtom na moguću, ili nemoguću, upotrebu pesticida, u radu su analizirane i preduzete mere suzbijana, odnosno svođenja brojnosti gubara na normalni populacioni nivo. Takođe, istražen je uticaj dve vrste jajnih parazitoida, te Entomophaga maimaiga i Lymantria dispar multicapsid nuclear polyhedrosis virus (LdMNPV)– patogeni larvi, na populacioni nivo gubara u pojedinim godinama prenamnoženja.

Ključne reči: *Lymantria dispar*, gradacija, zaštićeno prirodno dobro, suzbijanje, prirodni neprijatelji

1. INTRODUCTION

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

The abundance, i.e. the population level of the gypsy moth is conditioned by the characteristics of the species, physiological conditions of some instars, as well as by the biotic and abiotic factors, such as weather conditions, type and quality of host plants, pathogens, natural enemies (Milanović et al., 2006; Tabaković–Tošić, 2011, 2012; Tabaković-Tošić et al., 2013).

In the forests of the Republic of Serbia gypsy moth is the outbreaking species, and the periodical outbreaks most frequently occured in the middle-aged oak and beech stands, since in the younger or older ones, the calamity is the result of the migration of the caterpillars in the search for food.

The oak forests in the National Park Đerpad, regarding the intensity of the multi-annual desiccation of the broadleaf forests of the Balkans Peninsula, is the most endangered area in Serbia. In some years the volume of the desiccated tree was 2-3-fold greater than the current volume increment of some tree species (Marinković, 1992). It should be taken into account that the defoliation caused by the nutrition of the gypsy moth lead to the loss in the increment, lack of the seed production, physiological weakening and desiccation of trees, as well as to the creation of the conditions favourable to the attack of the phytopathogenic microorganisms, fungi and xylophagous insects. In the forests after the defoliation by the gypsy moth the other adverse factors are interconnected so on the newly-formed leaves, during the summer months, powdery mildew occurs almost regularly (*Erysiphe alphitoides,* Griffon & Maublanc), which leads to the premature desiccation and loss of the newly-formed shots, which is the additional stress for the plant. The defoliation of the gypsy moth enables the plenty of the suitable material for the outbreak of the European oak bark beetle (*Scolytus inticatus* Ratz.), thereby the possibility for the formation of the infections by the

fungi from genus *Ophiostoma* is greater. Taking all these facts into account, it becomes clearer how great is the importance of the gypsy moth and the periodic outbreaks of it in the above-mentioned decay of the forests.

2. AREA OF RESEARCH

The National Park Đerdap is located in the northeastern part of the Republic of Serbia, in the Carpathian Mountains and encompasses the following coordinates: 44°42'50" N and 21°40'40" - 22°33'10" E. The area of the National Park (63,608 hectares) is located in the territory of Golubac (18,116.55 hectares), Majdanpek (29,467.15 hectares) and Kladovo (16,024.75 hectares), within 16 cadastral municipalities (Golubac, Brnjica, Dobra, Boljetin, Donji Milanovac, Majdanpek, Mosna, Topolnica, Golubinje, Miroč, Tekija, Petrovo Selo, Sip, Davidovac, Kladušnica, Podvrška) and covers the tight hilly-mountain zone (50 - 800 meters above the sea level), 2-8 km wide, on the right bank of the Danube River.

Based on the climate regions of Serbia, the National Park Đerdap is located in the climate region III where the modified continental climate is dominant. For the analysis of the air temperature there are data of the weather stations in Veliko Gradište, Tekija, Karataš, Brza Palanka ans Turn Severin, as well as the data presented in the maps of the Climate Atlas of the Former Yugoslavia. In the above-mentioned weather stations the air temperatures higher than 20°C occur in July and August, and in Veliko Gradište and Turn Severin in June as well. The lowest mean monthly air temperature in all the stations is in January. In the riparian zone of Đerdap Lake it is −1°C, and in the highest parts of the National Park Đerdap it is about −4°C. The mean air temperature in the warm half of the year is 18°C. The air temperatures higher than 5°C occur in 240 to 260 days a year. In the riparian zone of Đerdap Lake there are 180 days with the temperature higher than 10°C, and in the higher parts of the National Park Đerdap about 170 days. The number of days with the air temperature higher than 15°C ranges from 120 to 160 and it refers to the summer season. There are 100 hot (summer) days with the air temperatures higher than 25°C in the lower parts of the National Park Đerdap, and 50 in the highest part of it. The number of tropical days in which the year temperature is higher than 30°C in the riparian zone of the lake is 30, and in the higher parts it is 20 (Stanković, 2003).

The relative air humidity in the National Park Đerdap is increased, due to the great area of Đerdap Lake and considerable percentage of the forest areas. It is highest in December, and lowest in August. The increased air humidity leads to the lowest levels of insolation (Stanković, 2003).

The current data on the pluviometrics regime points to the fact that the National Park Đerdap gains from 200 to 300 mm precipitation less than the average value for Serbia and Montenegro. The precipitation is most frequent in May and June, and it is least frequent in August and September. The first snow occurs in mid-December, and the last in early April. The average depth of the snow around Đerdap Lake ranges from 30 to 40 cm, and in the higher parts it is 60 cm. The snow deeper than 10 cm lasts from 20 to 40 days per a year. The snow 30 cm deep in the lowest part of the National Park Đerdap lasts for only 5 days a year, and in

the highest part for 20 days. The snow 50 cm deep is a rare phenomenon and lasts from 6 to 10 days per a year. The strongest and most frequent wind in the National Park Đerdap is košava. It occurs in the winter season (Stanković, 2003).

Based on the biogeographical position, the area of Đerdap is located at the border of two floristic regions: Middle European or region of broadleaf forests and Pontic-South Siberian or steppe-forest-steppe region (Stevanović, 1996).

The basic vegetation cover of the Đerdap area of the Danube River, and particularly of the National Park Đerdap, is the forest. The forest phytocoenoses are characterised by the stability and high level of the regeneration, which implies that the environmental conditions are favourable. The National Park Đerdap is characterised by the great complexity and diversity of the forest and accompanying bushy vegetation, as well as by the well-expressed differences in the plant species on the lime and silicate rocks, as well as the differences in the vegetation of gorges and ravines. Forests account for 70% of the total area of the National Park, and 83% are privately-owned (Medarević, M., 2001). In the National Park Đerdap forty autochtonous tree species were reported. The most frequent ones are the beech (63.3 %) and sessile oak (18.4%), followed by the European hornbeam (5.5%) and the lime tree (2.4%). The oak stands are the special value of the area of the National Park. They are most frequently ripening, ripe and overripe, and account for 7.0% of the total area of the state-owned forests (Medarević, 2001). It is the result of the continental climate and peculiar edaphic stand conditions, particularly of the slope of the terrain and exposure.

3. MATERIAL AND METHOD

3.1 Monitoring of the population level of the gypsy moth

Every year in all broadleaf forests (during the outbreak in the conifer as well), regardless of the category of the ownership (state and private), and based by the Prescriptions by the Operators of the reporting-diagnostics-forecast activities in the domain of the plant protection - forest protection, the population level of it was monitored. The monitoring of population level of the gypsy moth in the forests was conducted by using the methods of the permanent (25x25 m) and temporary (10x10 m) sample plots, as well as by using the route method.

The accurate determination of the intensity of the attack and spatial definition of the attacked areas are very important, since these are the key factors for the selection of methods and time of the control: in the egg instar (mechanically or chemically in the period of the leaf fall in autumn, until the beginning of the breaking into leaf in spring) or the larval instar (aerial spraying which is performed in the late April or early May).

The permanent sample plots were monitored every year, and the temporary ones were monitored when it was estimated that there was a risk of the outbreak. The route method was applied as the supplement when the gypsy moth was in the latency phase (low population level), and was obligatory used in the time of the outbreak (Tabaković-Tošić, 2002).

3.2 Quantitative and qualitative analysis of the gypsy moth egg masses

The detailed quantitative and qualitative analysis of the sampled egg masses were conducted in the laboratory of the Institute of Forestry, and depending on the observed parameter, either ocular or the method of the survey by the binocular magnifier was applied. In addition, under the laboratory conditions in the winter period the dynamics of the hatching of imagos of the parasitoids of the gypsy moth eggs from the previosly observed egg masses was monitored. Out of each egg mass a total 100 of the randomly sampled, previously cleaned eggs was placed in the specially prepared test tubes (with the distilled water on the bottom and cotton pads in the middle, in order to prevent the eggs from being soaked). The test tubes with the sampled gypsy moth eggs were kept in the climate chamber. During the experiment, the air temperature and light regime were constant (temperature 19°C, light regime 10 hours by night, 14 hours by daytime)

3.3 Microscopic analysis of the dead gypsy moth caterpillars – detection of the presence of *Ld*MNPV and *Entomophaga maimaiga* Humber, Shimazu & R.S. Soper

From all sites, in the summer and autumn of the period 2010-2014, dead gypsy moth larvae were collected for different laboratory analyses. Each study plot was 1 ha in size and included a minimum of 25 trees. Gypsy moth dead caterpillars were collected manually from foliage in the lower parts of tree crowns and tree branches and trunk, two to three times per year.

Microscopic (magnification 1200 times) analyses of some dead gypsy moth larvae with characteristic symptoms caused by the *LdMNPV* was conducted immediately using the standard method of Giemsa's differential staining.

The dead larvae with characteristic symptoms caused by the entomopathogenic fungus *E. maimaiga* were also placed in Petri dishes and the detailed microscope survey of the dead gypsy moth caterpillars was done later. The evaluation of *E. maimaiga* infections was recorded as positive when azygospores and conidiospores were detected in the cadavers of dead gypsy moth larvae. The species identification was based on the size, shape and structural characteristics of different life forms of the fungus – azygospores, conidiospores and mycelia.

4. RESULTS AND DISCUSSION

In the area of the National Park Đerdap, after the thirty-year period of latency, the significant growth of the gypsy moth population level occurred.

During these studies, when the number of the gypsy moth egg masses per a unit of area (1 hectare) was determined, the attention was paid so that all forest plantations would be encompassed. It is of a special importance for the areas where the attack of a very strong intensity (more than 500 egg masses per a hectare) was reported, since the damages expressed by the damage of the foliage which will be caused by the hatched larvae, are not the same in the case when 501 egg masses

attack per a hectare and when, for instance, 50,000 egg masses attack per a hectare (Tabaković-Tošić, 2005-2006).

Table 1 *Spread of the gypsy moth in the forests of the National Park Đerdap over the period 1996-2014 (egg masses hatched in the late summer season).*

YEAR	INTENSITY OF ATTACK AND THE ATTACKED AREA								TOTAL
	Weak 1-10 egg masses/hectare		Moderate 11-100 egg masses/hectare		Strong 101-500 egg masses/hectare		Very strong more than 500 egg masses/hectare		
	ha	%	ha	%	ha	%	ha	%	
1996	0	0	127.0	29.7	301.0	70.3	0	0	**1428.0**
1997	17739.0	56.3	10155.0	32.2	0	0	3643.0	11.5	**31537.0**
1998-2002 - latency period for the gypsy moth									
2003	10947.0	93.2	801.0	6.8	0	0	0	0	**11748.0**
2004	7599.0	76.0	1307.0	13.1	186.0	1.9	900.0	9.0	**9992.0**
2005	968.8	5.8	1924.0	11.5	4071.2	*24.2*	9803.3	58.5	**16767.4**
2006-2009 -latency period for the gypsy moth									
2010	Forest Unit Porečke šume - weak intensity of the attack								
2011	Forest Unit Pecka bara and Forest Unit Štrbačko korito - weak intensity of the attack								
2012	3783.0	8.6	13566.0	31.0	9239.0	21.1	17176.0	39.3	**43764.0**
2013	0	0	4688.0	10.8	10839.0	24.9	27947.0	64.3	**43474.0**

Based on the data stated in the Table 1 it is seen that the growth of the population level of the gypsy moth in the period 1996-1997 over the observed period did not acquire the typical form of outbreak.

The intensity of the attack was, to a great extent, in the category of weak and moderate ones. The mechanical and chemical controls measures that were taken in the egg instars, as well as the activity of the numerous natural enemies of the gypsy moth, most probably caused such a state and returned the population level of the gypsy moth to the normal value, when it does not cause the economic and ecological damages of the forest tree species.

The period of the latency of gypsy moth in this area lasted for five years, after which the outbreak of it occurred again year 2003), and which will acquire the all characteristics of the outbreak in the following year. The mechanical and chemical measures of the gypsy moth control in the egg instar, taken in the autumn and winter seasons, did not produce the satisfying results, since there was a great number of the egg masses hatched high on the stems and in the crowns. In the autumn of 2004 the newly-laid gypsy moth egg masses were reported on the area of 9992 hectares, and in 2005 on the area of 16767 hectares.

In the spring of 2006, at the area of 10000 hectares, the aerial spraying in the larval instar, by the chemical insecticide of the third generation – Dimilin SC48 (active ingredient diflubenzoron) was done. The control was efficient, so in the autumn of 2006 the newly-laid egg masses were not reported, and in the following year the new period of latency, which lasted for four years, occurred.

The third outbreak of the gypsy moth over the observed period also had all characteristics of the oubreak, but this time the attacked area was 2.6 times greater. The retrogradation phase occurred in the autumn of 2004, and it was the result of the effective aerial control of the gypsy moth in the larval instar by the microbiological preparation Foray 48B, at the area of 33,176 hectares, as well as of the increased activity of the natural enemies of the gypsy moth. It should be noted here that the above-mentioned preparations are highly selective and ecologically

safe, and are applied in the ultra low volumes (ULV) (Tabaković-Tošić and Jovanović, 2007).

Picture 1
June 2013 - partial defoliation of individual trees

Picture 2
June 2013. – total defoliation

Picture 3
Septembar 2013. – newly-laid egg masses

In the observed period, in the Laboratory of the Institute of Forestry, the analysis of the gypsy moth egg masses, collected in the area of the National Park Đerdap (Table 2) was made on a yearly basis.

The average number of eggs in the egg mass ranged from 240.0 (year 2005) to 824.6 (year 2003). The percentage of the vital eggs in the total number of eggs ranged from 79.7 in 2013 to 99.7 in 2011. The average level of parasitisation of the eggs ranged from 0 in 2011 to 19.8% u 2013. These leves of parasitisation should not be considered to be final, owning to the laboratory conditions of the treatment, where the activity of a series of parasites and predators, to which the egg masses were exposed in nature, was disabled.

Table 2 *Laboratory analysis of the gypsy moth egg masses sampled from the represensentative semple plots in the area of the National Park Đerdap.*

Year	The number of egg masses	Average number of eggs in the egg masses						
		Fertilized				Unfertilized		Total
		Vital		Parasitized				
		N	%	N	%	N	%	N
1996	125	296.0	91.5	9.0	2.8	18.5	5.7	323.5
1997	245	329.9	95.9	7.8	2.3	6.4	1.8	344.1
1997-2002 latency period for the gypsy moth								
2003	100	806.0	97.8	15.3	1.8	3.3	0.4	824.6
2004	150	497.0	88.6	62.0	11.1	2.0	0.3	561.0
2005	150	201.7	84.0	33.7	14.0	4.6	2.0	240.0
2006-2008 latency period for the gypsy moth								
2010	80	554.1	94.6	29.3	5.0	2.4	0.4	585.8
2011	150	537.9	99.7	0	0	1.7	0.3	539.6
2012	350	608.6	97.7	14.2	2.0	1.9	0.3	624.7
2013	658	483.0	79.7	118.0	19.8	3	0.5	604.0

The results of the analysed quantitative and qualitative parameters of the gypsy moth egg masses confirm the above claim that in the forest area of the

National Park Đerdap, over the period 1996-2014, the outbreak of the population level of the gypsy moth occurred three times.

The dynamics of the hatching of imagos from the previosly analysed egg masses was monitored in the special experiments. Every year only two species of egg parasites *Anastatus japonicus* Ashmead (syn. *A. disparis* Ruschka) and *Oencyrtus kuwanae* (Howard) were present. Every year the ratio of them was relatively equal: 30:70%, with the clear dominance of *O. kuwanae.*

In the spring of 2012, 2013 and 2014 at some sample plots in the oak and beech forests, the increased mortality rate of the younger and older larval instars in comparison with the expected one was reported. Logically, the following question was posed: What has been killing them? In order to get the answer to this question, the detailed analysis of the possible causes was conducted.

By the detailed study of the dead gypsy moth larvae, two groups of the characteristic symptoms were reported: first - caused by *E. maimaiga*, and second - caused by the *LdMNPV*.

During the field research clear symptoms of a disease caused by baculovirus *LdMNPV* were observed in 5.5 (2012), 13.5 (2013) and 20.1 (2014) percent of the dead larvae. Clear and characteric symtoms of the fungal diseases caused by *E. maimaiga* were at 94.5 (2012), 86.5 (2013) and 79.9 (2014) percent of the reported dead gypsy moth larvae.

By the laboratory studies of the causes of the mortality of the gypsy moth larval instars and by the microscopic analysis of the dead caterpillars, the presence of *LdMNPV* occlusion bodies and the conidiospores and azigospores of the entomopathogenic fungus *E. maimaiga* was confirmed, but the presence of *LdMNPV* was reported only in the dead older caterpillars (L_4-L_6). The reason of such a relation of two studied pathogens lies in the fact that the fungus is active at low, as well as high, gypsy moth population levels. This sets it apart from natural controls such as the *LdMNPV*, a viral disease of gypsy moth which kills caterpillars under stress from high population densities and diminishing food supplies. Research also shows indications of a strong synergistic relation between them.

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THE OUTBREAKS OF THE GYPSY MORH IN FOREST PLANTATIONS OF THE NATIONAL PARK ĐERDAP IN THE PERIOD FROM 1996 TO 2014

Mara TABAKOVIĆ-TOŠIĆ, Marija MILOSAVLJEVIĆ, Nemanja SIMOVIĆ

Summary

In the area of the National Park Đerdap, after the thirty-year period of latency, the significant growth of the gypsy moth population level occurred three times. The growth of the population level of the gypsy moth in the period 1996-1997 did not acquire the typical form of outbreak. The intensity of the attack was, to a great extent, in the category of weak and moderate ones.

The mechanical and chemical controls measures that were taken in the egg instars, as well as the activity of the numerous natural enemies of the gypsy moth, most probably caused such a state and returned the population level of the gypsy moth to the normal value, when it does not cause the economic and ecological damages of the forest tree species.

The period of the latency of gypsy moth in this area lasted for five years, after which the outbreak of it occurred again (year 2003), and which will acquire the all characteristics of the outbreak in the following year.

The mechanical and chemical measures of the gypsy moth control in the egg instar, taken in the autumn and winter seasons, did not produce the satisfying results, since there was a great number of the egg masses hatched high on the stems and in the crowns.

In the autumn of 2004 the newly-laid gypsy moth egg masses were reported on the area of 9,992 hectares, and in 2005 on the area of 16,767 hectares. In the spring of 2006, at the area of 10,000 hectares, the aerial spraying in the larval instar, by the chemical insecticide of the third generation – Dimilin SC48 (active ingredient diflubenzoron) was done. The control was efficient, so in the autumn of 2006 the newly-laid egg masses were not reported, and in the following year the new period of latency, which lasted for four years, occurred. The third outbreak of the gypsy moth over the observed period also had all characteristics of the oubreak, but this time the attacked area was 2.6 times greater. The retrogradation phase occurred in the autumn of 2004, and it was the result of the effective aerial control of the gypsy moth in the larval instar by the microbiological preparation Foray 48B, at the area of 33,176 hectares, as well as of the increased activity of the natural enemies of the gypsy moth.

In the observed period, in the Laboratory of the Institute of Forestry, the analysis of the gypsy moth egg masses, collected in the area of the National Park Đerdap (Table 2) was made on a yearly basis. The average number of eggs in the egg mass ranged from 240.0 (year 2005) to 824.6 (year 2003). The percentage of the vital eggs in the total number of eggs ranged from 79.7 in 2013 to 99.7 in 2011. The average level of parasitisation of the eggs ranged from 0 in 2011 to 19.8% u 2013. These leves of parasitisation should not be considered to be final, owning to the laboratory conditions of the treatment, where the activity of a series of parasites and predators, to which the egg masses were exposed in nature, was disabled.

The results of the analysed quantitative and qualitative parameters of the gypsy moth egg masses confirm the above claim that in the forest area of the National Park Đerdap, over the period 1996-2014, the outbreak of the population level of the gypsy moth occurred three times.

The dynamics of the hatching of imagos from the previosly analysed egg masses was monitored in the special experiments. Every year only two species of egg parasites *Anastatus japonicus* Ashmead (syn. *A. disparis* Ruschka) and *Oencyrtus kuwanae* (Howard) were present. Every year the ratio of them was relatively equal: 30:70%, with the clear dominance of *O. kuwanae.*

In the spring of 2012, 2013 and 2014 at some sample plots in the oak and beech forests, the increased mortality rate of the larvae were reported and analyzed. During the field research clear symptoms of disease caused by baculovirus *LdMPNV* and characteristic symptoms of the fungal diseases caused by *E. maimaiga* were found on dead gypsy moth caterpillars.

By the laboratory studies of the causes of the mortality of the gypsy moth larval instars and by the microscopic analysis of the dead caterpillars, the presence of *LdMNPV* occlusion bodies and the conidiospores and azigospores of the entomopathogenic fungus *E. maimaiga* was confirmed, but the presence of *LdMNPV* was reported only in the dead older caterpillars (L_4-L_6). The reason of such a relation of two studied pathogens lies in the fact that the fungus is active at low, as well as high, gypsy moth population levels. This sets it apart from natural controls such as the *LdMNPV*, a viral disease of gypsy moth which kills caterpillars under stress from high population densities and diminishing food supplies. Research also shows indications of a strong synergistic relation between them.

PRENAMNOŽENJA GUBARA U ŠUMSKIM KOMPLEKSIMA NACIONALNOG PARKA ĐERDAP U PERIODU OD 1996. DO 2014. GODINE

Mara TABAKOVIĆ-TOŠIĆ, Marija MILOSAVLJEVIĆ, Nemanja SIMOVIĆ

Rezime

U području Nacionalnog parka Đerdap, nakon tridesetogodišnjeg latentnog perioda, tri puta je došlo do značajnog povećanja populacionog nivoa gubara.

Povećanje populacionog nivoa gubara u 1996-1997. godini nije poprimilo tipičan karakter gradacije. Intenzitet napada je najvećim delom, bio u kategoriji slabog i srednjeg. Preduzete mehaničke i hemijske mere suzbijanja u stadijumu jajeta, kao i delovanje brojnih prirodnih neprijatelje gubara, su najverovatnije uzrokovale ovakvo stanje i vratile populacioni nivo gubara na normalnu vrednost, kada ne pričinjava ekonoske i ekološke štete šumskim vrstama drveća.

Period latence gubara u ovom području je trajao pet godina, nakon čega ponovo nastupa njegovo prenamnoženje (2003. godina), a koje će u narednim gidinama poprimiti sve osobine gradacije. Mehaničke i hemijske mere suzbijanja gubara u stadijumu jajeta, preduzete u jesenjem i zimskom periodu 2003., 2004. i 2005. godine, nisu dale zadovoljavajuće rezultate, jer se radilo o velikom broju legala položenih visoko na deblima i u krošnjama. U jesen 2004. godine novopoloženih jajnih legala gubara je bilo na ukupnoj površini od 9.992 ha, a 2005. na 16.767 ha. U proleće 2006. godine, na površini od 10.000 ha, preduzeto je aviosuzbijanje u stadijumu larve, hemijskim insekticidom treće generacije - Dimilinom SC48 (aktivna materija diflubenzuron). Suzbijanje je bilo efikasno, pa u jesen 2006. nisu primećena novopoložena jajna legla, odnosno, u narednoj godini nastupio je novi latentni period u trajanju od četiri godine.

Treće prenamnoženje gubara u istraživačkom periodu takođe ima sve osobine gradacije, s tim što je ovaj put napadnuta površina 2,6 puta veća. Retrogradaciona faza je nastupila u jesen 2014. godine, a posledica je uspešnog aviosuzbijanja gubara u stadijumu larve mikrobiološkim preparatom Foray 48B, na površini od 33.176 ha, kao i povećanom aktivnošću prirodnih neprijatelja gubara.

U istraživačkom periodu, u laboratoriji Instituta za šumarstvo, svake godine je obavljana analiza jajnih legala gubara prikupljenih u području Nacionalnog parka Đerdap (Tabela 2). Prosečan broj jaja u leglu se kretao od 240.0 (2005. godina) do 824.6 (2003. godina). Procentualno učešće vitalnih u ukupnom broju jaja prosečno iznosi od 79.7 u 2013. do 99.7 u 2011. godini. Prosečna parazitiranost jaja kretala se od 0 u 2011. godini, do 19,8% u 2013. Ove vrednosti parazitiranosti ne treba shvatiti kao konačne jer se tu radi o laboratorijskim uslovima držanja, gde je onemogućeno delovanje niza parazita i predatora kojima su legla izložena u prirodi. Rezultati analiziranih kvalitativnih i kvantitativnih parametara jajnih legala gubara potvrđuju prethodno navedenu tvrdnju da je u šumskom području Nacionalnog parka Đerdap, u periodu od 1996-2014. godine, tri puta došlo do gradogenog povećanja populacionih nivoa gubara.

Dinamika izletanja imaga parazita iz prethodno analiziranih jajnih legala, praćena je u posebnim ogledima. Svake godine su bile prisutne samo dve vrste jajnih parazita *Anastatus japonicus* Ashmead (syn. *A. disparis* Ruschka) i *Oencyrtus kuwanae* (Howard). Svake godine njihov procentualni odnos bio je relativno ujednačen 30:70%, uz jasnu dominaciju *O. kuwanae.*

U proleće 2012., 2013. i 2014. godine, na pojedinim oglednim površinama u hrastovim i bukovim šumama, uočena je značajno povećana smrtnost larvi gubara, pa su obavljena intenzivna proučavanja mogućih uzroka. U toku terenskih istraživanja, jasni

simptomi oboljenja izazvanih delovanjem bakulovirusa *LdMPNV* i entomopatogene gljive *E. maimaiga,* konstatovani su kod uginulih gusenica gubara.

Laboratorijskim istraživanjima uzroka smrtnosti larvenih stupnjeva gubara, i mikroskopskom analizom uginulih gusenica, dokazano je prisustvo okluzivnih tela *LdMNPV*, te konidija i azigospora entomopatogene gljive *E. maimaiga,* s tim što je pozitivan nalaz *LdMNPV* bio jedino kod starijih gusenica (L_4-L_6). Objašnjenje ovakvog odnosa dva istraživana patogena leži u činjenici da je gljiva aktivna uvek, i pri niskom i pri visokom populacionom nivou gubara, dok je *LdMNPV* aktivan samo pri velikoj populacionoj gustini domaćina, odnosno kada su gusenice pod stresom usled nedostatka hrane. Takođe, ova istraživanja pokazuju naznake snažnog sinergetskog odnosa između ova dva entomopatogena.

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THE MOST FREQUENT AGENTS OF DAMAGES OF TREES AT THE SAMPLE PLOTS IN SERBIA

Miroslava MARKOVIĆ[1], Snežana RAJKOVIĆ[1], Radovan NEVENIĆ[1]

Abstract. *The papers presents the results of the monitoring of damages at 130 sample plots in the grid 16x16 kilometers, which has been continuously conducted in Serbia since 2003. The causes of the damages on the trees can be the consequence of the activity of the series of the adverse agents and owning to it the research of the most significant agents of the damages was made. All damages were classified in the paper by species and types of agents. The occurrence of the mass desiccation of oak forests is to a great extent result of the presence of the agents of powdery mildew. As the example of the use of the data from the database, the spatial arrangement of the plots with the pedunculate oak (which is our most sensitive species) was determined, as well as the infection of them by the powdery mildew. The strongest attack was reported during 2005 and 2006, when 79.3 % and 77.6% of the observed trees was infected. The critical month for the occurrence of the intensive infections by the powdery mildew in Serbia is the first half of July, which is important for the creation of the programmes aimed at the protection.*

Key words: damages, defoliation, chlorosis, powder mildew

НАЈЧЕШЋИ ПРОУЗРОКОВАЧИ ОШТЕЋЕЊА СТАБАЛА НА БИОИНДИКАЦИЈСКИМ ТАЧКАМА У СРБИЈИ

Извод. *У раду су приказани резултати праћења оштећења на 130 биоиндикацијских тачака у мрежи 16x16km, које се у Србији врши у континуитету од 2003. године. Узроци оштећења на стаблима могу бити последица дејства низа штетних агенаса и зато је вршено истраживање најзначајнијих проузроковача штета. Сва оштећења су у раду класификована по врстама и типовима узрочника.*

[1] Institute of Forestry, Belgrade, Serbia. E-mail: *mira013@gmail.com*
Translation: Marija Stojanović

Појава масовног сушења храстових шума је великим делом последица присуства проузроковача пепелнице. Као пример коришћења података из базе, утврђен је просторни распоред тачака са храстом лужњаком (који је наша најосетљивија врста) и њихова зараженост пепелницом. Најјачи напад је констатован током 2005. и 2006. године, када је заразом захваћено 79,3 и 77,6% испитиваних стабала. Критичан период за појаву интензивних инфекција пепелницом у Србији је прва половина јула месеца, што је значајно за прављење програма заштите.

Кључне речи: оштећења, дефолијација, хлороза, пепелница

1. INTRODUCTION

The system of the pieces of information on the health condition of forests is the result of the certain activities within the sustainable forest managent, which is the base for numerous international and national policies. The monitoring of plant diseases and pests is the key element of the ecological policy and without it the standards for the forests and environment cannot be applied (Wulff, 2002). The data processing and reporting are inevitably followed by the uniform methods established by using the international standards (Thomsen et al, 1994; Nevalainen et al, 2010).

The results of monitoring must be available and support the system of biological indicators. The studies and monitoring are conducted by the scientific institutions which prepare the database, evaluations and analyses at the national level (Mues & Seidling, 2003). The Republic of Serbia has been participated in the ICP forests programme since 2003 via its National Focal Centre (NFC), which in cooperation with the National Expert Group (NEG) makes the analyses of the data and inteprets the results, thereby helping in the scientific management of the Programme and participates in International Expert Panels (IEP) and Working Groups (WG) (Group of authors, 2012). The main aim of the monitoring of crown condition is to obtain the periodical insight into the spatial and temporal variations of crown conditions (Meining et al, 2007), regarding the anthropogenic and natural factors of stress in the European and national systemic networks of the the wide-ranging monitoring of (Lindgren et al, 2000).

In the aim of the application of the measures of the integral forest protection, the monitoring of the health condition of forests and population sizes of the most important diseases and pests at the sample plots in the Republic of Serbia is continued within the Level 1 and the monitoring of the Level 2 (which, inter alia, encompasses the very detailed studies of the health condition and continuing monitoring of the environmental conditions - temperature and air humidity, which has the direct effect on the occurrence and development of diseases) was introduced, which will provide the very precise diagnostics and forecast of the development of diseases at the most endangered plots in the following period.

2. MATERIAL AND METHODS

Methods of work are described in the first Manual *as Visual Assessment of Crown Condition* (Eichhorn et al, 2010; Nevalainen and Merilä, 2013) and *Submanual on Visual Assessment of Crown Condition on Intensive Monitoring Plots*. The Manual has been redesigned recently and enables the harmonized data and more flexible approach to the monitoring of crown condition, of the higher and more transparent quality. All parameters described in the latest version of the Manual have been tested in several countries of Europe and North America, and the values of the parameters have been continuously monitored under the control of the international expert panels. Each necessary harmonization will be recommended at the annual *Task meetings Forces) ICP Forests* in the following years.

2.1. Methods of the assessment of trees

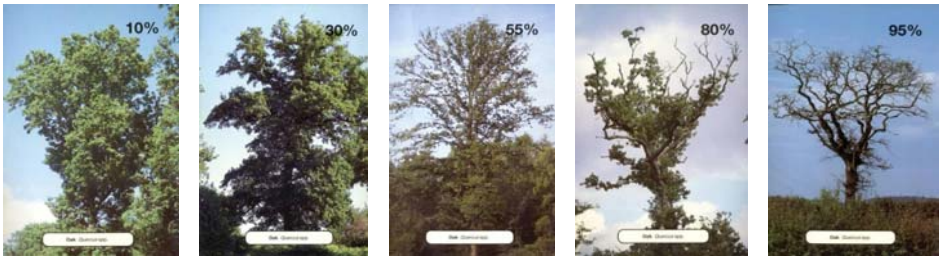
a) The trees are assessed from several directions, if possible (and from two directions, at least).

b) Distance between the observer and the tree should be at least a stem height of observed tree.

c) At the inclined terrain the position of the observer should be above or at the level of the tree.

d) In order to exclude the possibility of sun-blinding and provide as relevant assessment as possible, the observer should avoid to look in the sun during the assessment.

On the marked trees the assessment of the chlorosis (decolorization, loss of colour or the change of the colour of foliage) and defoliation (desiccation of branches) is made on an annual basis in the growing season. The intensity of chlorosis and desiccation is marked by the percentage from 0 to100. In addition, the damages regarding the types and types of the agents are noted in the manuals and marked by the codes: (code 36 marks the enthomologic damages, 38 phytopathological, 40 marks the mechanical damages, etc.). For the biotic agents the Latin name of the agent of damage, phase of the development of the adverse agent, description of the attacked part of plants, age of the attacked needles, etc. are stated along with the code.



Picture 1 **Picture 2** **Picture 3** **Picture 4** **Picture 5**

Picture 1-5.*The visual determination of the categories of the defoliation of trees*

In the note it is stated on which part of the tree the damage was reported (butt or tree height at which the damage was reported), resin flow or exudates, the presence of litchen, etc. In manuals there are also space for the general remark, which includes all the elements which in anyway can affect the health condition of the stand in which the plot is located (the damages on the young crop at the plot, damages at the stand or in the very vicinity of it, the burnt areas in the vicinity the extreme climate conditions, etc., were reported).

In the pictures from 1 to 5 the visual method of the assessment of the defoliation on the oak, expressed in the percentage (10, 30, 55, 80 and 95%) is depicted. Nevertheless, although the defoliation of crowns is the indicator of the assessment of the condition of trees, the causes of defoliation can be nonspecific and the result of the activity of a range of adverse agents, so it is hardly to identify them with certainty (Ferretti, 1998; Eickenscheidt & Wellbrock, 2013). Thus, it is necessary to be familiar with the most significant factors which cause damages on trees.

3. RESULTS AND DISCUSSION

At 130 sample plots which are being monitored, the most frequent species is the beech, followed by the Turkey oak (these two species account for almost half of all observed trees), Hungarian oak, sessile oak and all other broadleaf species acccount for about two-thirds, and all conifers hardly for one sixth of all the trees. Regarding the conifers, spruce is the most frequent (which accounts for almost a half of all conifers), and fir, Scots and Austrian pines which account for the remaining half of the conifer species.

The most frequent damages at the sample plots in Serbia were classified into two groups: 1) *biotic damages* caused by the activity of harmful insects, pathogenic and epixylous fungi; 2) *abiotic and antropogenic damages* caused by the activity of the other adverse agents and man.

3.1 Agents of the most frequent biotic damages

Most damages of the trees at the sample plots were caused by the activity of the biotic adverse agents. These damages, based on the place on the tree where they were located, were classified into 4 groups: 1) on leaves and needles 2) on branches 3) on bark 4) on bole and root ((Marković et al 2005; Marković et al 2011). All damages of the biotic origin were further divided into the damages caused by the activity of harmful insects (entomologic) and damages caused by the activity of fungi (phytopathological) and based on the tree species on which they were reported.

3.1.1 Agents of the most frequent damages on the leaves and needles. Most entomologic damages were reported on the oak by the activity of *Altica quercetorum* Foudras, *Thaumatopoea processionea* Linnaeus, *Lymantria dispar* Linnaeus and *Tischeria ekebladella* (Bjerkander), most phytopathological damages on the beech were caused by *Apiognomonia errabunda* (Roberge ex Desm.) Höhn., then on the oak by *Microsphaera alphitoides* Griff. et Maubl. and *Mycosphaerella*

maculiformis (Pers.) J. Schröt., and on the pine by *Dothistroma pini* Hulbary и *Lophodermium seditiosum* Minter, Staley & Millar.

3.1.2 Agents of the most frequent damages on the branches. Entomologic damages on the spruce *Sacchiphantes viridis* Ratzeburg; and phytopathological on the beech *Diatrype disciformis* (Hoffm.) Fr.

3.1.3 Agents of the most frequent damages on the bark. Entomologic damages on the beech are caused by *Cryptococcus fagisuga* Lindiger, on the pines and spruce by the bark beetles - *Scolytidae sp*., and the most frequent phytopathological damages on the beech are caused by Diatrype stigma (Hoffm.) Fr. and fungus Nectria coccinea Desm. which together with the insect C. fagisuga cause the "beech bark disease".

3.1.4 Agents of the most frequent damages on the bole and root. Entomologic damages are mainly caused by the activity of xylophagous insects, mainly by wood wasps - *Siricidae sp*., and phytopathological ones are caused by the activity of epixylous fungi - *Laetiporus sulphureus* (Bull.) Murrill, *Armillaria melea* (Vahl) P. Kumm., *Armillaria solidipes* Peck and *Heterobasidion annosum* (Fr.) Bref.

3.2 The most frequent damages caused by the activity of other factors

The damages of the trees at the sample plots caused by the activity of the other factors at the sample plots were less frequent, and divided into the anthropogenic and abiotic damages.

3.2.1 Anthropogenic damages caused by the operations during the felling (located on the bole or in the butt – during the extraction and felling).

***3.2.2 Abiotic damages caused by the activities of following elements*:** long-term *drought* (desiccation of the spruce, pine, oak and beech); intensive cases of *insolation* (beech bark disease); *snow* (snow slides and snow throws); *wind* (wind slides and wind throws); *frost* (frostbites on the bole and damages of foliage); *thunder* (thunderbites), etc.

3.3 Practical usage of database of the sample plots

The base in which the data from the Sample Plots of Level 1 are collected can be used by segments, which enables the search by the tree species, diseases, pests, periods, etc. The practical usage of the base can be illustrated by the example of the presence of powdery mildew on the pedunculate oak. The agent of powdery mildew Microsphaera alphitoides is one of the most widely spread pathogens which endangered the survival of forests and process of the sustainable management in Serbia and which together with the gypsy moth (*Lymantria dispar*). and honey fungus (*Armillaria mellea*) is the main cause of the desiccation of the pedunculate oak forests.

The plots in the pedunculate oak forests in central Serbia and Vojvodina are currently most endangered when it comes to the occurrence of the agents of powdery mildew and the special attention should be paid to them in order to provide the appropriate protection from this disease. These plots are marked by the numbers: 103, 423, 425, 426, 427 (located in Vojvodina) and plot 86 (located in central Serbia). The sample plots at which the pedunculate oak trees infected by powdery mildew were reported, are located at the following plots: Sample Plot 86 - Forest Estate "Šuma"Leskovac, privately-owned forest, Lapotince; Sample Plot 103 - Forest Estate Sombor, Forest Administration Odžaci, Forest Unit Branjevina, i.e. 12/a; Sample Plot 423 - Forest Estate Sombor, Forest Administration Bački Monoštor, Forest Unit Kolut-Kozara, i.e. 16/d; Sample Plot 426 - Forest Estate S. Mitrovica, Forest Adminisration Klenak, Forest Unit Grabovačko Vitonajevačko island, i.e. 83/g; Sample Plot 427 - Forest Estate S.Mitrovica, Forest Administration Kupinovo, Forest Unit Kupinovske grede, i.e. 47/i.

In the aim of the easier managing and improved transparency, chlorosis and desiccation are grouped and expressed by the indices in the Table 1: chlorosis was presented by the indices from 0 to 3, and desiccation from the indices from 0 to 4. (The index 0 refers to the change of colour, i.e. the desiccation up to 10%, index 1: 11-25%, index 2: 26-60%, index 3: above 61% and index 4 100%, i.e. completely desiccated tree). The presentation was made based by the data from the base, for the first seven years of study, i.e. from the beginning of the study (2003), until the first overview in 2009, and the next overview is planned for 2016.

Table 1 *Presentation of the percentage of the pedunculate oak trees in the observed categories of health condition*

Year of Monitoring	Chlorosis (%)				Desiccation (%)					Infection by powdery mildew (%)
	0	1	2	3	0	1	2	3	4	
2003	83,3	16,7	0,0	0,0	5,6	44,4	50,0	0,0	0,0	**0,0**
2004	33,9	25,4	35,6	5,1	30,5	20,3	35,6	13,6	0,0	**8,5**
2005	50,0	34,5	13,8	1,7	29,3	31,0	27,6	12,1	0,0	**79,3**
2006	51,7	34,5	12,1	1,7	32,8	41,4	19,0	5,2	1,7	**77,6**
2007	50,9	31,6	12,3	5,3	17,5	47,4	21,1	10,5	3,5	**65,5**
2008	63,2	26,3	1,8	8,8	8,8	49,1	24,6	8,8	8,8	**61,4**
2009	80,4	10,7	0,0	8,9	21,4	39,3	30,4	0,0	8,9	**51,8**

As it is seen in the Table 1, regarding chlorosis, there was the greatest percentage of the pedunculate oak trees in the category 0 (from 33.9% in 2004. to 83.3% in 2003.), but there was also relatively high percentage of the trees in the categories 1 and 2 and reached as much as 35.6%, in the index 2 in 2004, and there were many trees in the index 3 - even 8.8 and 8.9% in 2008. and 2009. Regarding the categories of the pedunculate oak desiccation, the situation is even worse. Most trees were marked by the desiccation index 2, which accounted from 19.0% in 2006, to even 50.0% in 2003. By the index 4 (which implies the completely desiccated trees) from 8.8 and 8. 9% pedunculate oak trees in 2008 and 2009 was marked. By the index 0 only from 5.6% in 2003 to 32.8% in 2006 pedunculate oak trees was marked. The year 2003 generally speaking turned to be very

unfavourable when it comes to the health condition of the pedunculate oak tree, when chlorosis and desiccation are taking into account as the parameters, and the result of it is the occurrrence of the the less strong infection by the powdery mildew in the following year (8.6%). In the following year the culmination phase of the infection, i.e. the strongest attack of the powdery mildew was reported, but over the period of study the infection gradually became less strong, so that in 2009 it reached 51.8%. At the observed pedunculate oak trees the attack of the powdery mildew over the whole period of study is approximately 49.6%.Practically, it can be stated that pedunculate oak in Serbia is most endangered by the attack of the agents of powdery mildew, and the strongest attack was registered in 2005 and 2006 (79.3 and 77.6% of the observed trees was infected). By the monitoring of the health condition of the pedunculate oak at the sample plots, it was reported that the critical period for the occurrence of the intensive infections by powdery mildew in Serbia is the first half of July, which is important for the creation of the programmes aimed at the protection.

4. CONCLUSION

The monitoring of the crown condition is mainly aimed at the provision of the periodical insight into the spatial and temporal variations of the conditions of forests, regarding the anthropogenic and natural factors of stress in the European and national systemic networks of the monitoring of wide range.

In the aim of the application of the measures of the integral forest protection, this paper presents the monitoring of the health condition of forests and population size of the most important diseases and pests at the sample plots in the Republic of Serbia, which provides the very accurate diagnostics and forecast of the development of diseases at the most endangered plots in the following period.

It should be certainly noted that the application of the timely preventive measures, which are aimed at the elimination of the conditions which are favourable to the development of diseases and provide the satisfying resistance and vitality of forest trees. The preventive measures mainly imply the timely regeneration and tending of the forest and forest growing stock, preservation of the biological diversity, professional identification of sites and adequate selection of the appropriate species for the establishment of new forests, selection of the genotypes of forest species resistant to the most significant diseases and pests, use of healthy seeds and seedling material, proper handling of the seedling material, etc.

By the monitoring of the health condition of the pedunculate oak at the sample plots, it was concluded that the critical period for the occurrence of the intensive infections by powdery mildew in Serbia is the first half of July, which is important for the timely creation of the programmes aimed at protection.

The data from the database were used for the presentation of the health condition of the pedunculate oak trees and presence of the powdery mildew, can be similarly used for other tree species as well, other most significant diseases and pests, as well as for other types of the damages of the mechanical and abiotic origin (over the desirable period of time), which opens up great possibilities in the practical application of these studies.

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THE MOST FREQUENT AGENTS OF DAMAGES OF TREES AT THE SAMPLE PLOTS IN SERBIA

Miroslava MARKOVIĆ, Snežana RAJKOVIĆ,Radovan NEVENIĆ

Summary

The papers presents the results of the monitoring of damages at 130 sample plots in the grid 16x16 kilometers, which has been continuously conducted in Serbia since 2003. The damages were classified in the paper by species and types of agents, but the causes of the damages can be the consequence of the activity of the series of the agents and owning to it the research of the most significant agents of the damages on the trees was made. The occurrence of the mass desiccation of oak forests is to a great extent result of the presence of powdery mildew, which is caused by the pathogenic fungus Microsphaera alphitoides Griff. et Maubl., which particularly occurs on the new, young leaves easily affected by the infections. As the example of the use of the data from the dat base, the spatial arrangement of the plots with the pedunculate oak (which is our most sensitive species) was determined, as well as the infection of them by powdery mildew. The strongest attack was reported during 2005 and 2006, when 79.3 % and 77.6% of the observed trees was infected. The critical month for the occurrence of the intensive infections by powdery mildew in Serbia is the first half of July, which is important for the creation of the programmes aimed at the protection. The application of the timely preventive measures is very important for the health condition of forests and is aimed at the elimination of the conditions which are favourable to the development of diseases, by providing the satisfying resistance and vitality of forest trees. The preventive measures mainly imply the timely regeneration and tending of the forest and forest growing stock, preservation of the biological diversity, professional identification of sites and adequate selection of the appropriate species for the establishment of new forests, selection of the genotypes of forest species resistant to the most significant diseases and pests, use of healthy seeds and seedling material, proper handling of the seedling material, etc. The data from the database were used for the presentation of the health condition of the pedunculate oak trees and presence of the powdery mildew, can be similarly used for other tree species as well, other most significant diseases and pests, as well as for other types of the damages of the mechanical and abiotic origin (over the desirable period of time), which opens up great possibilities in the practical application of these studies.

НАЈЧЕШЋИ ПРОУЗРОКОВАЧИ ОШТЕЋЕЊА СТАБАЛА НА БИОИНДИКАЦИЈСКИМ ТАЧКАМА У СРБИЈИ

Мирослава МАРКОВИЋ, Снежана РАЈКОВИЋ, Радован НЕВЕНИЋ

Резиме

У раду су приказани резултати праћења оштећења на 130 биоиндикацијских тачака у оквиру мреже 16x16 km, које се у Србији врши у континуитету од 2003. године. Оштећења су класификована су по врстама и типовима узрочника, али узроци штета могу бити последица дејства низа агенаса и зато је вршено истраживање најзначајнијих чинилаца који проузрокују штете на стаблима. Појава масовног сушења храстових шума је великим делом последица присуства пепелнице коју проузрокује патогена гљива Microsphaera alphitoides Griff. et Maubl., која се нарочито јавља на новом, младом лишћу осетљивом на инфекције. Као пример коришћења података из базе, утврђен је просторни распоред тачака са храстом лужњаком и њихова зараженост пепелницом. Констатовано је да је најјачи напад био током 2005. и 2006. године, када је заразом захваћено 79,3 и 77,6% испитиваних стабала. Критичан период за појаву интензивних инфекција пепелницом у Србији је прва половина јула месеца, што је значајно за прављење програма заштите. Спровођење правовремених превентивних мера има велики значај за здравствено стање шума и има за циљ отклањање услова који погодују развоју болести, обезбеђујући задовољавајућу отпорност и виталност шумског дрвећа. Под превентивним мерама подразумевају се, пре свега, благовремена обнова и нега шума и шумских култура, очување биолошке разноврсности, стручна идентификација станишта и правилан избор одговарајућих врста за подизање нових шума, селекција отпорних генотипова шумских врста на најважније болести и штеточине, употреба здравог семена и садног материјала, правилна манипулација садним материјалом итд. Подаци из базе података који су коришћени за приказ здравственог стања стабала лужњака и присуства пепелнице, могу се на сличан начин користити и за друге врсте дрвећа, остале најважније болести и штеточине, као и друге типове оштећења механичког и абиотичког порекла (у оквиру жељеног временског периода), што отвара широке могућности у практичној примени ових истраживања.

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Original scientific paper

INTENSIVE MONITORING ON THE LEVEL II SAMPLE PLOTS KOPAONIK, CRN VRH I MOKRA GORA IN 2014

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

Abstract: *Monitoring and assessment of the impact of air pollution and its effects on forest ecosystems on the territory of the Republic of Serbia, Level II, began with the establishment of Level II sample plots on Fruska Gora in 2009, on Kopaonik in 2010, in Odzaci in 2011 and on Crni Vrh and Mokra Gora in 2013. Level II Monitoring Programme includes ten working panels from ten different professional fields of forestry grouped according to the research area. All Level II sample plot activities are carried out in accordance with the ICP Forests Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests. The paper presents the results of monitoring crown condition on Level II sample plots on Kopaonik, Crni Vrh and Mokra Gora in 2014.*

Key words: Level II sample plot, crown condition, defoliation, damage, GIS.

INTENZIVNI MONITORING NA OGLEDNIM POLJIMA BIT NIVO-a II KOPAONIK, CRNI VRH I MOKRA GORA U 2014.GODINI

Abstract: *Praćenje i procenu uticaja vazdušnih zagađenja i njihovih efekata u šumskim ekosistemima на mepumopuju Republike Srbije, Nivo II, otpočelo je osnivanjem bioindikacijskih tačka Nivo-a II i to 2009. godine na Fruškoj gori, 2010. godine na Kopaoniku, 2011. godine u Odžacima i 2013. godine na Crnom vrhu i Mokroj Gori. Program monitoringa Nivo-a II obuhvata deset radnih panela iz deset zasebnih stručnih oblasti šumarstva grupisanih prema predmetu istraživanja. Sve aktivnosti na BIT Nivo II sprovode se u skladu sa uputstvima o metodama i kriterijumima za usaglašeno*

[1] Institute of Forestry, Belgrade, Serbia
Translation: Dragana Ilić

uzorkovanje, ocenu, monotoring i analizu uticaja zagađenja vazduha na šume prema ICP Forests Manual-u. U radu su dati rezultati praćenja stanja kruna stabala na oglednim parcelama BIT Nivo-a II na Kopaoniku, Crnom vrhu i Mokroj Gori u 2014. godini.

Ključne reči: BIT Nivo II, stanje kruna, defolijacija, oštećenja, GIS.

1. INTRODUCTION

Level II monitoring of forest vitality is a system of applied comparative research studies that belong to different scientific fields of forestry. It is characterized by a more elaborate multidisciplinary approach. Level II measurements include an extremely greater number of parameters than the Level I measurements. Level II sample plots have been established throughout Europe according to the harmonized methodology of the ICP Forests programme. The primary aim of the programme is to make continuous measurements and to collect data on the state of forests that grow in different environmental conditions.

Serbia joined the European network of Level II sample plots when we established the sample plots in the NP Fruska Gora, NP Kopaonik, Odzaci, Crni Vrh and Mokra Gora.

2. MATERIAL AND METHOD

The intensive monitoring plot – Level II sample plot Kopaonik was established in 2010 in the National Park Kopaonik in a pure spruce stand, *Picea abies* (L.) H.Karst.

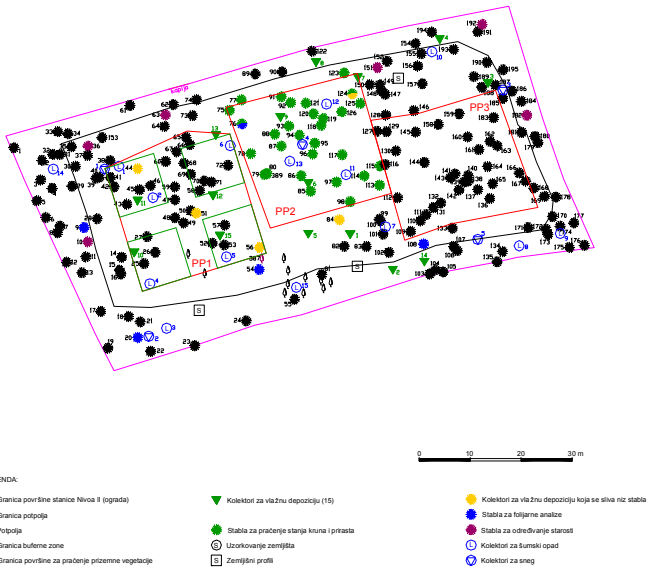


Figure 1. *Field plan*[1] *of the sample plot Kopaonik*

[1] A digital field map was created at the Institute, according to the situation in the field and the initial draft of the sample subplots, created by a Faculty of Forestry team, in 2010.

Another two Level II sample plots were established in 2013 one on Crni Vrh and the other in Mokra Gora.

The Level II sample plot on Crni Vrh was established in a pure stand of beech (*Fagus moesiaca*), while the Level II sample plot in Mokra Gora lies in an artificially- established stand of Scots pine (*Pinus silvestris*).

Each of the three Level II sample plots covers an area of 0.5 ha (100x50m), with three subplots, 25 x 25 m in size, established in the area for the purpose of monitoring (a subplot intended for the crown condition assessment, phenology and and growth, a subplot for soil surveys and a subplot for ground vegetation assessment) and a buffer zone.

The plots are fenced with galvanized wire rope, two meters in height. The fence has two gates, one for vehicles (3.0 m wide) and one for people (1.5 m wide).

The trees within the sample plots are permanently marked with numbers on the bark, and their position is located in the network.

Figure 2. *Digital field map*[1] *of the sample plot Crni Vrh*

[1] A digital field map was created at the Institute in accordance with the situation in the field

The total number of trees within the Level II sample plot on Kopaonik is 195, while it amounts to 150 on Crni Vrh and 450 in Mokra Gora.

Digital field maps, which have been created for each sample plot, show the position of all trees and all measuring instruments as well as the altitude of the presented terrain (Figure 1, 2 and 3).

Figure 3. *Digital field map*[1] *of the sample plot Mokra Gora*

The Level II monitoring programme includes the following groups of parameters: crown condition, foliar analyses, soil chemistry, soil solution chemistry, tree growth, ground vegetation, atmospheric depositions, ozone injuries,

[1] A digital field map was created at the Institute in accordance with the situation in the field

meteorology, phenology, and litterfall. The frequency of parameter monitoring is shown in Table 1.

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

Parameter	Monitoring frequency
Crown condition	At least annually
Foliar analyses	Every two year
Soil chemistry	Every ten years
Soil solution chemistry	Continuously
Tree growth	Every five years
Ground vegetation	Every five years
Atmospheric deposition	Continuously
Air quality	Continuously
Ozone injury	Annually
Meteorology	Continuously
Phenology	Several times a year
Forest litter	Continuously

3. RESULTS AND DISCUSSION

The improved methodological approach to the Level II crown condition assessment can be described as a set of characteristics of dominant tree crowns that are monitored in a similar way. The intensive monitoring scores (Nevenic et al., 2011), obtained for each individual tree whose crown is monitored every year, will after a certain number of replications give answers to different hypothetical assumptions, such as the causes of serious deterioration of forest vitality by identifying the agents and defining their harmfulness.

3.1 Crown condition assessment – intensive monitoring in 2014 – Level II sample plot Kopaonik

Crown condition assessment on the Level II sample plot Kopaonik was carried out on April 22, 2014. The assessment included 30 spruce trees, selected for the purpose of annual crown condition monitoring on subplot 2.

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

Sequence number	Country code	Plot number	Date of survey	Latitude	Longitude	Altitude	Team identification	Other observations
1	67	2	22.04.2014	$+43^0$17'30"	$+20^0$48'50"	35		

The assessment of crown condition included: defoliation rate, mortality–removal of trees, tree social status, crown shading, crown visibility, foliage transparency and other observations (Table 3).

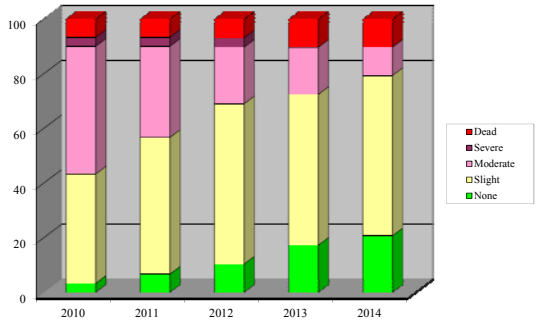
Tables 3 and 4 show the parameters of crown condition and parameters of damage on the sample plot on Kopaonik in 2014.

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

Sequence number of trees	Observation plot number	Date of survey	Tree number	Tree species code	Removals & mortality	Social class	Crown shading	Crown visibility	Defoliation	Foliage transparency	Other observations
1	2	220414	75	118	01	1	2	2	5	15	*U.b.**
2	2	220414	76	118	01	1	1	2	10	15	*U.b.**
3	2	220414	78	118	01	1	2	2	15	25	*U.b.**
4	2	220414	79	118	01	1	1	2	15	20	*U.b.**
5	2	220414	80	118	01	1	1	2	10	15	*U.b.**
6	2	220414	85	118	01	1	2	2	15	25	*U.b.**
7	2	220414	86	118	01	1	3	3	10	20	*U.b.**
8	2	220414	87	118	01	3	3	3	35	65	*U.b.**
9	2	220414	88	118	38	5	6	2	100	99	*U.b.**
10	2	220414	91	118	41						
11	2	220414	92	118	01	2	3	3	20	30	*U.b.**
12	2	220414	93	118	01	1	3	3	15	20	*U.b.**
13	2	220414	94	118	01	3	3	3	40	60	*U.b.**
14	2	220414	95	118	01	2	3	3	20	30	*U.b.**
15	2	220414	96	118	01	1	4	4	20	25	*U.b.**
16	2	220414	97	118	01	1	3	3	15	20	*U.b.**
17	2	220414	98	118	01	1	3	3	15	20	*U.b.**
18	2	220414	113	118	01	1	2	2	15	25	*U.b.**
19	2	220414	114	118	01	1	4	3	20	25	*U.b.**
20	2	220414	115	118	01	1	3	3	25	30	*U.b.**
21	2	220414	117	118	01	1	4	3	15	30	*U.b.**
22	2	220414	118	118	01	1	3	2	20	35	*U.b.**
23	2	220414	119	118	38	5	6	3	100	99	*U.b.**
24	2	220414	120	118	01	1	1	2	30	50	*U.b.**
25	2	220414	121	118	01	1	3	3	20	25	*U.b.**
26	2	220414	124	118	01	1	2	2	20	30	*U.b.**
27	2	220414	125	118	38	5	6	3	100	99	*U.b.**
28	2	220414	126	118	01	1	2	2	10	20	*U.b.**
29	2	220414	77	118	01	1	3	2	10	25	*U.b.**
30	2	220414	123	118	01	1	1	1	15	20	*U.b.**

**Usnea barbata*

Compared to the previous four years, the percentage of trees with no defoliation increased on the sample plot Kopaonik in 2014. The percentage of dead trees slightly increased, while the percentage of trees with moderate defoliation decreased compared to the previous years. Severe defoliation was not detected in the trees selected for crown condition monitoring in 2014.



Graph 1. *Comparative graphic representation of defoliation in the period from 2010 to 2014 – Level II, Kopaonik*

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

Sequence number of tree	Observation plot number	Date of survey	Tree number	Specification of affected part	Symptom	Specification of symptom	Location in crown	Age of damage	Cause	Scientific name of cause	Extent	Other observations
1	2	220414	75									*U.b.**
2	2	220414	76									*U.b.**
3	2	220414	78									*U.b.**
4	2	220414	79									*U.b.**
5	2	220414	80									*U.b.**
6	2	220414	85									*U.b.**
7	2	220414	86									*U.b.**
8	2	220414	87									*U.b.**
9	2	220414	88	32	10	65		1	200	*Pityogenes chalcographus*	2	*U.b.**
10	2	220414	91									
11	2	220414	92									*U.b.**
12	2	220414	93	33	17	60		3	999		3	*U.b.**
13	2	220414	94									*U.b.**
14	2	220414	95									*U.b.**
15	2	220414	96									*U.b.**
16	2	220414	97									*U.b.**
17	2	220414	98									*U.b.**
18	2	220414	113									*U.b.**
19	2	220414	114	32	10	65		1	200	*Pityogenes chalcographus*	2	*U.b.**
20	2	220414	115									*U.b.**
21	2	220414	117									*U.b.**
22	2	220414	118									*U.b.**
23	2	220414	119	32	10	65		1	200	*Pityogenes chalcographus*	2	*U.b.**
24	2	220414	120									*U.b.**
25	2	220414	121									*U.b.**
26	2	220414	124									*U.b.**
27	2	220414	125	32	10	65		1	200	*Pityogenes chalcographus*	2	*U.b.**
28	2	220414	126									*U.b.**
29	2	220414	77									*U.b.**
30	2	220414	123									*U.b.**

**Usnea barbata*

Health inspection of the Level II sample plot Kopaonik was carried out on April 22, 2014. On that occasion, defoliation was assessed, damage recorded by types and agents and all other relevant observations recorded. The inspection was performed on 30 trees selected within the plot.

It was then observed that 3 trees were dead and infested by bark beetles (trees 88, 119 and 125). Tree 114 was also attacked by bark beetles. Plant diseases were present only in the form of branch decay in tree 113.

3.2 Crown condition assessment – intensive monitoring in 2014 – Level II sample plot Crni Vrh

Crown condition assessment on the Level II sample plot Crni Vrh was carried out on June 17, 2014. The assessment included 30 beech trees, selected for the purpose of annual crown condition monitoring on subplot 2.

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

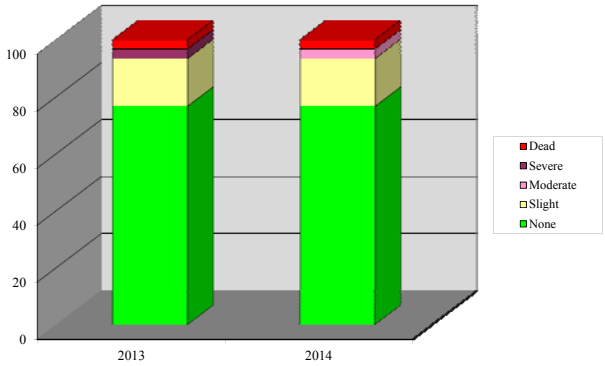
Sequence number	Country code	Plot number	Date of survey	Latitude	Longitude	Altitude/Code	Team identification	Other observations
1	67	4	17.06.2014	+44^{0}07'55"	+21^{0}58'38"	19		

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

Sequence number of trees	Observation plot number	Date of survey	Tree number	Tree species code	Removals & mortality	Social class	Crown shading	Crown visibility	Defoliation	Foliage transparency	Other observations
1	4	170614	57	018	01	1	4	2	0	10	
2	4	170614	58	018	01	1	4	2	0	5	
3	4	170614	62	018	01	1	1	1	10	15	
4	4	170614	64	018	01	1	4	1	5	5	
5	4	170614	65	018	01	1	4	1	5	5	
6	4	170614	66	018	01	1	4	1	10	10	
7	4	170614	67	018	01	1	4	2	15	15	
8	4	170614	68	018	01	1	4	2	100	99	
9	4	170614	69	018	01	1	4	2	0	5	
10	4	170614	71	018	01	1	4	2	10	10	
11	4	170614	72	018	01	1	4	2	35	25	
12	4	170614	73	018	01	1	4	1	15	5	
13	4	170614	74	018	01	1	4	1	0	5	
14	4	170614	75	018	01	1	4	1	5	5	
15	4	170614	76	018	01	1	3	1	0	5	
16	4	170614	77	018	01	1	5	1	10	15	
17	4	170614	78	018	01	1	3	1	15	10	
18	4	170614	79	018	01	1	5	1	0	5	
19	4	170614	87	018	01	2	1	1	0	5	
20	4	170614	88	018	01	1	4	1	10	5	
21	4	170614	89	018	01	1	3	1	15	15	
22	4	170614	90	018	01	2	3	1	0	10	
23	4	170614	91	018	01	2	4	1	5	10	
24	4	170614	92	018	01	1	3	1	20	15	
25	4	170614	94	018	01	1	4	2	5	5	
26	4	170614	95	018	01	1	4	1	10	10	
27	4	170614	96	018	01	1	4	1	10	10	
28	4	170614	97	018	01	2	4	2	5	5	
29	4	170614	98	018	01	1	4	1	0	10	
30	4	170614	100	018	01	1	4	2	10	5	

Defoliation was not recorded in 76.67% of sample trees (subplot 2), while 16.67% of trees showed signs of slight defoliation and 3.33% of moderate defoliation. Strong defoliation was not detected in the trees selected for crown condition monitoring.

The percentage of dead trees and trees with no or slight defoliation on the sample plot Crni Vrh in 2014 was the same as in the previous year.



Graph 2. *Comparative graphic representation of defoliation in the period 2013-2014 - Level II, Crni Vrh*

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

Sequence number of tree	Observation plot number	Date of survey	Tree number	Specification of affected part	Symptom	Specification of symptom	Location in crown	Age of damage	Cause	Scientific name of cause	Extent	Other observations
1	4	170614	57									
2	4	170614	58									
3	4	170614	62	14	01	33	3	3	210		2	
4	4	170614	64									
5	4	170614	65	14	01	33	3	3	210		2	
6	4	170614	66									
7	4	170614	67	14	01	33	3	3	210		2	
8	4	170614	68									
9	4	170614	69									
10	4	170614	71									
11	4	170614	72	14	01	33	3	3	210		2	
12	4	170614	73	14	01	33	3	3	210		2	
13	4	170614	74									
14	4	170614	75									
15	4	170614	76	32	11	57		3	300	*Nectria coccinea*	2	
16	4	170614	77									
17	4	170614	78									
18	4	170614	79									
19	4	170614	87	32	11	57		3	300	*Nectria coccinea*	2	
20	4	170614	88									
21	4	170614	89									
22	4	170614	90									
23	4	170614	91									
24	4	170614	92									
25	4	170614	94									
26	4	170614	95									
27	4	170614	96	14	01	33	3	3	210		2	
28	4	170614	97									
29	4	170614	98									
30	4	170614	100	14	01	33	3	3	210		2	

Health inspection of the level II sample plot Crni Vrh was carried out on June 17, 2014.

Plant pathogens affected two trees (76 and 87), on which the presence of the fungus *Nectria coccinea* uredopustules was registered. Together with the insect *Cryptococcus fagisuga* it causes a very serious `beech bark disease`. In addition,

we recorded wood-rotting fungi on the branches and knots (of trees 62, 65, 67, 72, 73, 96 and 100) as well as the central trunk rot (on tree 90).

The damage caused by insects included mainly slight or moderate defoliation, caused probably by gypsy moth, since this year saw the outbreak of gypsy moth in the area.

3.3 Crown condition assessment – intensive monitoring in 2014 – Level II sample plot Mokra Gora

Crown condition assessment on the Level II sample plot Mokra Gora was carried out on July 30, 2014. The assessment included 30 Scots pine trees selected for the purpose of annual crown condition monitoring on subplot 2.

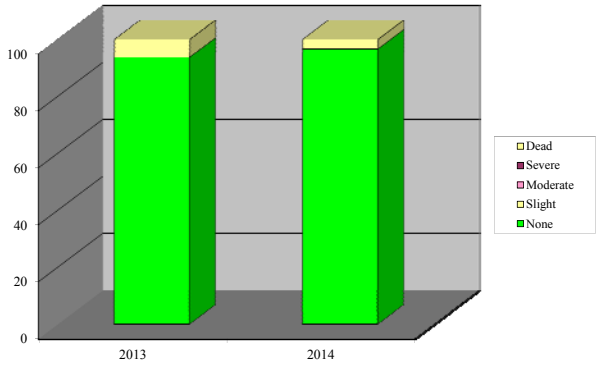
Table 8. *(PLT) Data on the plot selected for crown condition assessment, Level II, Mokra Gora*

Sequence number	Country code	Plot number	Date of survey	Latitude	Longitude	Altitude/Code	Team identification	Other observations
1	67	5	30.07.2014	+43^{0}45'27"	+19^{0}29'00"	12		

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

Sequence number of trees	Observation plot number	Date of survey	Tree number	Tree species code	Removals & mortality	Social class	Crown shading	Crown visibility	Defoliation	Foliage transparency	Other observations
1	5	300714	82	134	1	2	2	1	0	30	
2	5	300714	83	134	1	1	1	1	10	30	
3	5	300714	84	134	1	2	2	1	5	30	
4	5	300714	105	134	1	1	3	1	10	20	
5	5	300714	106	134	1	1	2	1	15	30	
6	5	300714	107	134	1	2	1	1	0	20	
7	5	300714	113	134	1	1	1	1	0	25	
8	5	300714	114	134	1	1	4	1	10	50	
9	5	300714	140	134	1	2	2	1	5	25	
10	5	300714	141	134	1	1	2	1	0	10	
11	5	300714	142	134	1	2	2	1	0	20	
12	5	300714	143	134	1	2	2	1	5	15	
13	5	300714	144	134	1	2	2	1	5	20	
14	5	300714	165	134	1	2	1	1	0	15	
15	5	300714	166	134	1	2	2	1	0	10	
16	5	300714	167	134	1	2	2	1	5	15	
17	5	300714	168	134	1	2	3	1	5	15	
18	5	300714	183	134	1	1	1	1	10	15	
19	5	300714	184	134	1	2	2	1	0	20	
20	5	300714	185	134	1	3	3	2	0	25	
21	5	300714	193	134	1	1	1	1	0	10	
22	5	300714	194	134	1	1	2	1	0	10	
23	5	300714	213	134	1	2	2	1	0	15	
24	5	300714	214	134	1	3	3	1	0	10	
25	5	300714	215	134	1	3	2	1	0	10	
26	5	300714	223	134	1	1	2	1	5	10	
27	5	300714	224	134	1	3	2	1	0	10	
28	5	300714	320	134	1	2	2	1	10	20	
29	5	300714	359	134	1	1	2	1	10	10	
30	5	300714	407	134	1	1	2	1	0	5	
31	5	300714	82	134	1	2	2	1	0	30	
32	5	300714	83	134	1	1	1	1	10	30	

Defoliation in 2014 was not recorded in 96.67% of the trees selected for crown condition monitoring (subplot 2) on the Level II sample plot Mokra Gora. Slight defoliation was detected in 3.33% of sample trees. As in the previous year, strong defoliation was not observed on the sample trees.



Graph 3. *Comparative graphic representation of defoliation in the period from 2013 to 2014 – Level II, Mokra Gora*

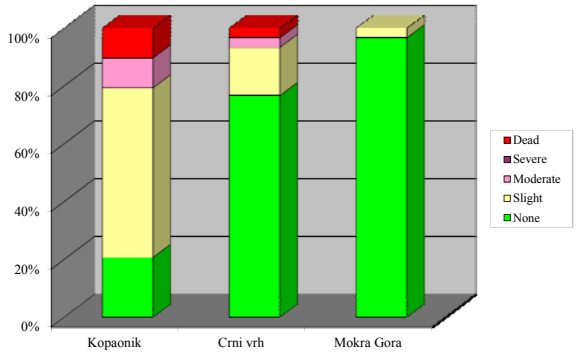
Health inspection of the Level II sample plot Mokra Gora was carried out on 32 Scots pine trees on the subplot 2.

At the time of inspection, the stand was healthy, free from diseases or pests.

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

Sequence number of tree	Observation plot number	Date of survey	Tree number	Specification of affected part	Symptom	Specification of symptom	Location in crown	Age of damage	Cause	Scientific name of cause	Extent	Other observations
1	5	300714	82									
2	5	300714	83									
3	5	300714	84									
4	5	300714	105									
5	5	300714	106									
6	5	300714	107									
7	5	300714	113									
8	5	300714	114									
9	5	300714	140									
10	5	300714	141									
11	5	300714	142									
12	5	300714	143									
13	5	300714	144									
14	5	300714	165									
15	5	300714	166									
16	5	300714	167									
17	5	300714	168									
18	5	300714	183									
19	5	300714	184									
20	5	300714	185									
21	5	300714	193									
22	5	300714	194									
23	5	300714	213									
24	5	300714	214									
25	5	300714	215									
26	5	300714	223									

Sequence number of tree	Observation plot number	Date of survey	Tree number	Specification of affected part	Symptom	Specification of symptom	Location in crown	Age of damage	Cause	Scientific name of cause	Extent	Other observations
27	5	300714	224									
28	5	300714	320									
29	5	300714	359									
30	5	300714	407									
31	5	300714	408									
32	5	300714	412									



Graph 4. *Defoliation rate in 2014 – Level II sample plots*

Of all three sites, the highest percentage of trees selected for crown condition monitoring without signs of defoliation was as in 2013 recorded in Mokra Gora. There were no trees with moderate or severe defoliation on this sample plot.

3.4. GIS application for forest condition monitoring in the Republic of Serbia in 2014

GIS approach is a general procedure commonly applied in the whole programme of ICP Forests. Large-scale forest areas are monitored at a national level, but the use of this application enables us to represent all data in one common coordinate system. GIS applications are used from the very first stage of monitoring for determining the location of sample plots and marking them in the field using GPS (Global Position System) handheld devices to entering the obtained data into the GIS system, making analyses and models and storing them (Nevenić at al. 2011).

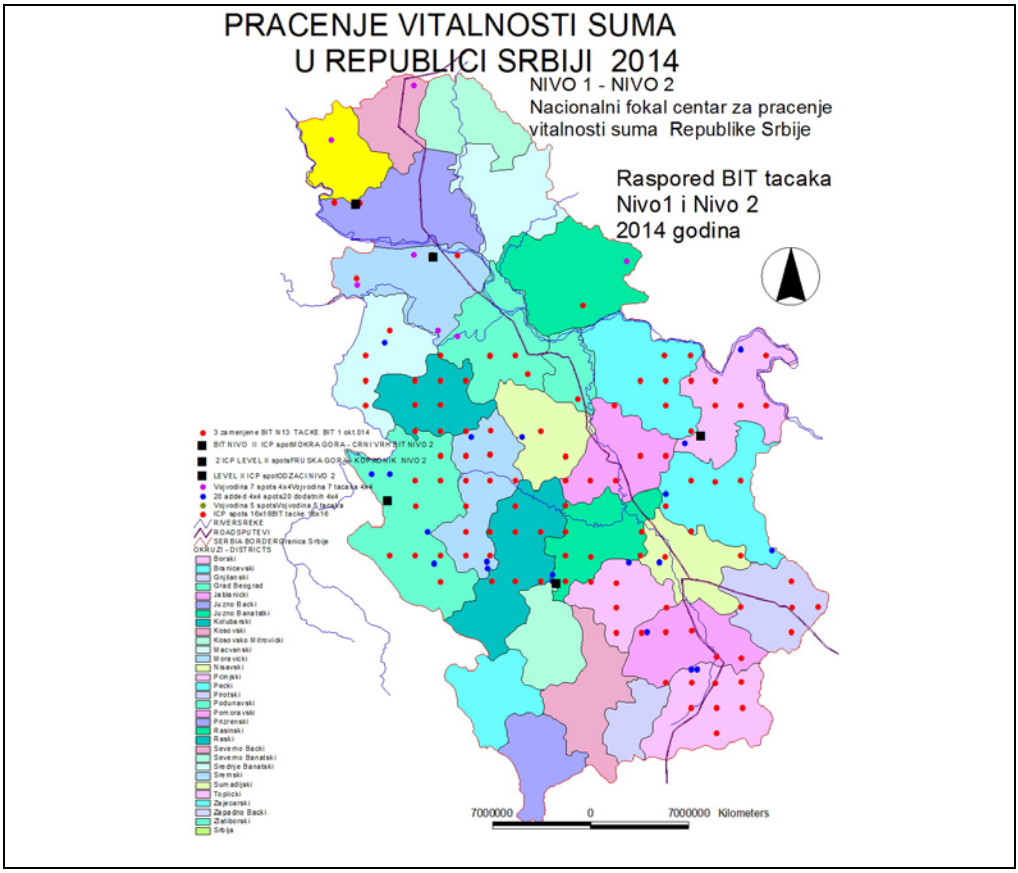


Figure 4. *Arrangement of Level and Level II sample plots on the territory of the Republic of Serbia in 2014 – Geographic Information System Application*

All Level I and Level II sample plots on the territory of the Republic of Serbia have been entered into the Geographic Information System with the required data and under specific topics. Figure 4 shows the arrangement of Level I and Level II sample plots.

By selecting the appropriate topic or desired data within the appropriate GIS programme, we can obtain a clear representation of all relevant alphanumeric and spatial data.

4. CONCLUSION

In 2014, the surveys with parameters that are monitored continuously and annually were carried out on the Level II sample plots Kopaonik, Crni Vrh and Mokra Gora.

In comparison with the previous four years, the percentage of trees with no defoliation increased on the sample plot Kopaonik in 2014. The percentage of dead trees slightly increased, while the percentage of trees with moderate defoliation decreased compared to the previous years. The percentage of trees affected by defoliation of higher intensity (moderate, severe defoliation and dead trees) has

been decreasing from year to year.

Health inspection of the trees on subplot 2 revealed that out of four trees attacked by bark beetles three were dead and one tree showed signs of branch decay.

Defoliation was not recorded in 76.67% of the trees on the Level II sample plot on Crni Vrh, while 16.67% of trees showed signs of slight defoliation and 3.33% of moderate defoliation. The percentage of trees with no or slight defoliation and the percentage of dead trees was the same as in the previous year.

Plant pathogens affected two trees (76 and 87), on which the presence of the fungus *Nectria coccinea* uredopustules was registered. In addition, we registered wood-rotting fungi on branches and knots (on 7 trees) as well as the central trunk rot (on 1 tree).

Defoliation in 2014 was not recorded in 96.67% of the trees on the Level II sample plot Mokra Gora. Slight defoliation affected 3.33% of sample trees. Strong defoliation was not observed on the selected trees of this sample plot.

At the time of inspection, the stand was healthy, free from diseases or pests.

Generally speaking, the trees on the Level II sample plot Mokra Gora were again least affected by defoliation.

New data are regularly entered into the GIS system of the NFC of Serbia every year and they will make a valuable database for the future scientific research since a multi-year analysis of the vitality of the forest in Serbia is planned to be carried out in a few years.

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A METHOD FOR DETERMINING THE FOREST FIRE THREAT LEVEL

Mihailo RATKNIĆ[1], Goran ĐORĐEVIĆ[2], Mileta BOJOVIĆ[3], Tatjana RATKNIĆ[4]

Summary: *Articles 20, 22, 23, 24 and 27 of the Law on Fire Protection ('Official Gazette of RS', No 111/09) stipulate who and in what manner must prepare fire protection plans and what these plans must contain. The Regulation on classification of buildings, activities and land into a fire threat category ('Official Gazette of RS' No. 76/2010) prescribes a method of categorisation of fire protection subjects, stipulating that the legal entities classified into the first and the second fire threat category must prepare fire protection plans. A novelty in sub-legal regulation is the adoption of a special rulebook on preparation method and content of fire protection plans of autonomous provinces, local self-government units and subjects classified into the first and the second fire threat category ('Official Gazette of RS' No. 73/10). This sub-legal act prescribes the method and guidelines for preparation of fire protection plans, which is a substantial step forward in creation of a uniform procedure on preparation of fire protection plans. A serious shortcoming of this rulebook is that it only takes into account buildings, whereas the Law also stipulates categorisation of land and good-quality forested areas, as well as preparation of forest fire protection plans. Furthermore, the preparation of forest fire protection plans substantially differs from the preparation of fire protection plans for buildings. Creation of a planning act, such is a forest fire protection plan, entails development of methodologies that will provide the basis for the assessment of threat, or a fire occurrence risk, in a specific forest area.*

[1] Mihailo Ratknić PhD, Institute of Forestry, Kneza Viseslava 3, Belgrade
[2] Goran Đorđević PhD, Emergency Sector, Požarevac Department
[3] Mileta Bojović, graduate engineer of geodesy, Energoprojekt – Hidroinžinjering, Mihaila Pupina 12, Belgrade
[4] Tatjana Ratknić MSc, Faculty of Applied Ecology 'Futura' Belgrade
Translation: Dejan Arsenovski

METODA ODREĐIVANJE STEPENA UGROŽENOSTI ŠUMA OD POŽARA

Rezime: *Zakonom o zaštiti od požara (''Sl.glasnik RS'' br.111/09) svojim članovima 20,22,23,24 i 27 reguliše ko mora i na koji način da donese planove zaštite od požara i šta ti planovi moraju da sadrže. Uredbom o razvrstavanju objekata , delatnosti i zemljišta u kategoriju ugroženosti od požara (''Sl.glasnik RS'' br.76/2010) daje se način kategorizacije subjekata zaštite od požara , prema kojoj pravni subjekti razvrstani i prvu i drugu kategoriju ugroženosti od požara moraju da izrade plan zaštite od požara. Kao novina u podzakonskoj regulativi je donošenje posebnog pravilnika o načinu izrade i sadržaju Planova zaštite od požara autonomnih pokrajina, jedinica lokalne samouprave i subjekata razvrstanih u prvi i drugu kategoriju ugroženosti od požara (''Sl.glasnik RS'' br.73/10).Ovaj podzakonski akt daje način izrade planova zaštite od požara i smernice za izradu planova, što je suštinski pomak u jedinstvenom postupanju prilikom izrade planova zaštite od požara. Ono što je veliki nedostatak ovog pravilnika je to što on uzima u obzir samo građevinske objekte, dok Zakon definiše i kategorizaciju zemljišta i površina pod kvalitetnom šumom, i izradu planova zaštite šuma od požara koji se drastično razlikuju od izrade planova zaštite od požara za građevinske objekte. Da bi se izradio jedan planski akt kao što je plan zaštite šuma od požara, moraju se odrediti metodologije po kome će se određivati ugroženost , odnosno rizik od nastanka požara na određenom šumskom području.*

1. INTRODUCTION

The Regulation on classification of buildings, activities and land into a fire threat category ('Official Gazette of RS' No. 76/2010) stipulates classification of land, that is, certain plan-covered areas, into the following fire threat categories:

- Category 1.7.: protected and high-quality forest areas with a surface area greater than 10,000 ha
- Category 1.8.: protected and high-quality forest areas with a surface area greater than 500-10,000 ha
- Category 2.1.: protected and high-quality forest areas with a surface area greater than 800-5,000 ha
- Category 2.2.: protected and high-quality forest areas with a surface area greater than 800 ha

The above-mentioned land categorisation entails preparation of forest fire protection plans not stipulated by the Rulebook on preparation of fire protection plans.

One of the key elements in preparation of fire protection plans is a fire threat assessment, the preparation of which requires development of a threat assessment methodology. Presently, a fire threat assessment in Serbia is performed in a manner in which only impact element taken into account is vegetation, without considering other elements that affect forest fire threat. However, this type of assessment method often does not provide a true picture of potential danger. Consequently, there was a need for preparation of a specific methodology for

determination of forest fire threat, which would include all the elements that affect forest fire threat and be adjusted to domestic conditions of forest management.

A level of forest fire threat is not the same for all forests. It depends on a number of factors whose impact determines the individual level of threat. The statistics indicates that there is a continuous increase in number of forest fires and extent of burnt areas. The increase of forest fires correlates with numerous factors, the most important being the frequency and duration of drought periods, increased presence of people in forests, etc. A preventive and repressive action directly depends on a level of forest fire threat. Identifying this level enables timely and effective forest fire protection. The extent of burnt areas is directly related to the organisation and preparedness of subjects participating in forest fire prevention. Identifying a forest fire threat level entails anticipating potential dangers and determining forest fire prevention measures to be taken in a certain period. The main objective of this method, which may be subject to further enhancement, is to provide a technique and tactic for preparation of an effective forest fire prevention plan.

The increasing number of forest fires requires more organised and professional approach to forest fire protection. The risk of forest fire occurrence is defined as a probability function of adverse event occurrence and possible consequences. The probability of forest fires occurrence is always present; however, by taking certain preventive and organisational measures these adverse events can be anticipated and appropriate preventive measures can be taken. This can be achieved primarily by implementation of risk management in forest fire protection. Risk management involves a group of prevention measures and procedures, preparedness and responses to an occurred event, as well as remediation of adverse event effects with a view to reducing risk and creating conditions under which the risk level becomes tolerable. In risk management applied in forest fire prevention, preventive protection and a group of measures and activities aimed at preventing fire represent a particularly important segment in an effective forest fire protection. A forest fire threat assessment represents the first and primary segment in determining the initial risk of forest fire occurrence in a particular area. Professional services involved in forest fire protection must be well-acquainted with a forested area, particularly with all adverse changes taking place in that area; they must monitor those changes, record them in a timely manner and, based on the relevant parameters, take relevant prevention measures at the appropriate time.

1.1. FOREST FIRE THREAT ASSESSMENT

Forest fire as an ecological factor has a large impact on stability of ecological system. A number of forest fires and burnt areas are constantly increasing. It is associated with numerous factors, the most important being the frequency and duration of drought periods, climate changes, increased presence of people in forests, violation of legal regulations, etc. A large number of fires inflict a considerable damage, both material, relating to burnt wood mass, and ecological, social and other damage. If an excuse can be provided for an increased number of forest fires, the same cannot be the case with the scope of damage, as it is directly

related to organisation and protection measures applied in forest fire protection. If forest fire protection measures are implemented timely, professionally, and in an organised manner, it can be expected that a number of burnt areas becomes lower, fire and dangers are timely foreseen and their number reduced, and the damage caused by forest fires is significantly decreased.

The main objective of a forest fire threat assessment is:

1. To present an accurate picture of a level of forest fire threat to the institutions involved in forest fire protection.
2. To determine and classify dangers arising from forest fires in a monitored area.
3. To point out to possibility of forest fire protection in a particular area and application of additional protection measures.
4. To point out to specificities and fire dangers in a monitored area to specialised agencies involved in fire protection and fire suppression.
5. To find models of additional protection measures and more effective fire suppression when a fire occurs in a particular area.
6. To present a methodology for performance of a fire threat assessment as the most important element in creation of planning acts such are forest fire protection plans, adjusted to the climate and characteristics of the area.

Parameters used in a forest fire threat assessment

Parameters that produce an impact on forest fire threat are numerous, but for the purpose of practical application of the threat assessment method, it will include only the parameters considered the most important and producing the strongest impact on forest fire threat. The key parameters used in forest fire threat assessment are:

a) vegetation and combustive material
b) natural phenomena producing an impact on fire occurrence
c) anthropogenic factor (human-induced risk)
d) climate characteristics
e) length of drought period
f) geological layer and pedological characteristics
g) orographic characteristics
h) openness of forest complex
i) a development level of an area for tourist and outing activities
j) other biotechnical protection measures
k) Fire record in the monitored area

a) Vegetation and combustible material

Vegetation, which consists of represented tree species and various types of combustible material in forest, represents the basis that is subject to direct or indirect impact of all other factors that create different levels of fire threat.

Forests can be classified according to different criteria (types of trees, silvicultural method, age, function, etc); however, they are most commonly divided into: coniferous forests, deciduous forests and mixed forests. Furthermore, specific forms, such as thicket, scrub, maquis, garrigue, degraded forests are also taken into account due to their specificity in terms of fire sensibility. Under further vegetation classification, cultures in artificially established plantations are singled out as a specific category, regardless of their age, since the age does not affect a level of forest fire threat (in natural forests, as the age increases, the level of forest fire threat decreases), while in case of cultures, that difference is negligible.

A further division of natural coniferous, mixed and deciduous forests was conducted according to a forest's need for light and its age, although certain other properties of specific forest types also affect their fire threat level (content of resin, tannin, etheric oils, forest canopy, ground vegetation).

The main vegetation parameters used for determination of a forest fire threat level are presented in the Table 1

Table 1. *Vegetation parameters used for determination of a forest fire threat level*

FOREST TYPE	Number of points
Category I	
Xerothermal and mesothermal coniferous forests (natural and artificial) type with a high resin content	200
Natural and artificially established black pine forests	200
Natural and artificially established white pine forests	200
Category II	
IIa – Xerothermal broadleaf forests	180
Downy oak forests	180
Flowering ash forests	180
Oriental hornbeam forests	180
Turkish oak forests	180
IIb – Mesothermal broadleaf forests in warmer exposures	180
Hop hornbeam forests	180
Sessile oak forests	180
Dalechampii oak forests	180
Category III	160
Mesophilic and frigoriphilic forests (natural and artificial); type with a lower resin content	160
Fir forests	160
Spruce forests	160
Serbian spruce forests	160
Macedonian pine forests	160
Artificially established larch stands	160
Artificially established Douglas-fir stands	160
Artificially established eastern white pine stands	160
Artificially established abies grandis stands	160
Artificially established stands of other species of the same characteristics	160
Category IV	140
IVa – Broadleaf and coniferous mesophilic and frigoriphilic mixed forests (natural and artificial)	140
Fir forests	140
Spruce forests	140
Beech forests	140
IVb – Mesophilic and mesothermal broadleaf mixed forests	140
Common hornbeam and sessile oak forests	140
Category V	120
Forests dominated by mesophilic deciduous species	120

Beech forests	120
Common hornbeam forests	120
Birch forests	120
Aspen forests	120

Stand condition based on a degradation level	**Number of points**
Degraded stands	100
Thickets	160
Scrubs	160

Stand age	**Number of points**
Under 30 years of age	80
31 to 60 years of age	60
Above 60 years of age	40

Barren land condition	**Number of points**
Category II	
Barren land in warmer exposures, thickly covered with ground vegetation	180
Category III	
Barren land on shady side, thickly covered with ground vegetation	140
Barren land on sunny side, sparsely covered with ground vegetation	
Category IV	
Barren land thickly covered with ground vegetation, dominated by Vaccinium myrtilis, Vaccinium vitis-ideus, Vaccinium uliginosum, Arictostaphillos uva-ursi and similar perennial plants	120
Category V	
Barren land mainly without ground vegetation	40
Barren land in ground vegetation dominated by moss (particularly Sphagnum sp. and Hylocomium sp.) or ferns Equisetum sp.	20
Marshy smaller areas regardless of a coverage level and vegetation composition	10

b) Natural phenomena that have an impact on forest fire occurrence

Although natural phenomena that cause forest fires account for only 1% of the total fire causing agents in forests, this occurrence requires a particular attention. There are areas exposed to activity of certain natural phenomena, which can become frequent causing agents of forest fire occurrence in a particular period. The most common natural phenomena causing forest fires are atmospheric discharge and thunderbolt, along with the effect of sun heat, when the heat acquires certain focus and leads to ignition of combustive material, most frequently in form of dry grass. An increasing attention has been given to a theory that many forest fires occur by the agency of 'sun winds'; however, this theory has not been scientifically proved yet, therefore it will not be considered in the framework of this methodology. A natural phenomenon that occurs as a causing agent of a forest fire is atmospheric discharge.

Parameters identified on the basis of observation and the relation between danger and atmospheric discharge traces on trees are presented in Table 2.

Table 2. *Parameters used for determination of forest fire threat caused by atmospheric discharge*

Number of atmospheric discharge traces on trees within a 5 km^2 surface area	Danger of tree and forest fire occurrence	Number of points
above 10	considerable danger	20
under 5	danger exists	10
under 2	low danger	0

Atmospheric discharge is more common in higher than in lower mountain regions, as the tree height increases with an altitude. Discharges into high broadleaf trees are more frequent than discharges into coniferous trees.

c) Anthropogenic factor – human-induced risk

Nearly 98% of forest fires are directly or indirectly related to human activity. The presence of man in forests as a shepherd, tourist, forest fruit collector or hunter increases a specific forest fire threat. A particular threat arises from a man's activity related to fire ignition: burning of stubble or plant litter and use of fire in forests for any other type of purpose. Therefore, the anthropogenic threat occupies an important position among the forest fire threat factors.

Some of the indicators of anthropogenic impact on the forest fire threat level are presented in Table 3

Table 3. *Parameters of anthropogenic impact on forest fire occurrence*

Category 1	Number of points
Tourist and recreation forests; forests in the vicinity of agricultural land and waste disposal sites	60
Category 2	
Forests intersected by public roads, long-distance power lines or forests used as pasture	40
Category 3	
Forests in which forest fruit collection takes place, forests used for hunting and fishing and forests in which silvicultural works are performed	20

If it is possible to classify forests into several categories according to a human-induced risk, than the impact of these factors on forest fire threat will be expressed by a total number of points.

d) Climate and climate impact on forest fire threat

Climate produces a joint effect with all other factors that have an impact on forest fire threat. Despite the fact that numerous climatic parameters have an impact on desiccation of combustible material (air temperature, relative air humidity, precipitations, wind, cloud cover, drought periods, etc.), only the tree most important parameters are used in a forest fire threat assessment: mean annual air temperature, mean annual amount of precipitation and mean annual relative humidity. When using these parameters, it is also necessary to include the duration

of drought periods and their distribution in the course of a year into the assessment of climate impact on forest fire threat.

Some of the parameters used for assessment of climate impact on forest fire threat are presented in Table 4

Table 4. *Parameters used for determination of the impact of climatic elements on forest fire*

Climate characteristics	Number of points
Mean annual air temperature	
above 12°C	30
9,1-12,0°C	20
below 9,0°C	10
Mean annual amount of precipitation	
below 800 mm	30
801-1200 mm	20
above 1200 mm	10
Mean annual relative air humidity	
below 70%	30
71-80%	20
above 80%	10

e) Drought period and its impact on forest threat

A drought period and duration of drought period are also important in the assessment of level of forest fire threat. Duration of drought period, expressed by a number of days, is one of the most important elements used for determination of a level of forest fire threat. In order to identify the real danger and threat of forest fire, a classification into four three-month periods according to a corresponding level of danger, has been conducted, since the threat level is not the same in January or February, for instance, as it is July or August, when that danger is higher as a result of high air temperature. Furthermore, a number of dry days is also important for determination of a level of forest fire threat, since the length of duration of drought period is a relevant factor – it is natural that the danger is higher when a drought period is longer, particularly in months when the air temperature is extremely high - July, August and September, and when that danger is most serious.

Classification and division of drought periods based on months and number of days, along with a drought period impact on forest fire threat level expressed by points, are presented in Table 5.

Table 5. *Drought period parameters used for determination of a level of forest fire threat, [44]*

Number of dry days as per months	Number of points
FIRST PERIOD - January, February, March	
under 10 days	10
10 - 20 days	20
more than 20 days	30
SECOND PERIOD - April, May, June	
under 10 days	40

10 - 20 days	50
more than 20 days	60
THIRD PERIOD - July, August, September	
under 10 days	70
10 - 20 days	80
more than 20 days	90
FOURTH PERIOD - October, November, December	
under 10 days	10
10 - 20 days	20
more than 20 days	30

f) A layer (parent substrate and soil type) and its impact on forest fire threat

A layer, i.e., parent substrate and soil type, also has an impact on forest fire threat. The moisture content in combustible material (needles, leaves, twigs), along with a soil type, has an impact on condition and retention of water in ground and inner layers, which affects combustibility and the threat arising from combustible material in forests.

Classification of soil into categories and the corresponding fire threat level are presented in Table 6.

Table 6. *Classification of soil and its impact on a level of forest fire threat*

Soil type	Subtype	Number of points
A. Automorphic soils		
I – (A)-C or (A)-R undeveloped		
Stone field (Lithosol)	On acid rocks	80
	On neutral and basic rocks	80
	On peridotite	80
	On limestone and dolomite	80
Sierozem on loose substrate (Regosol)	Siliceous	80
	Siliceous-calcareous	80
	Sand-dolomite	80
Eolic 'quicksand' (Arenosol)	Quartz	80
	Siliceous	80
	Siliceous- calcareous	80
Colluvial soils (Colluvium)	Distric-siliceous	80
	Calcareous	80
	With fossil soil	80
II – A-C or A-R (Humus-accumulative)		
Limestone – dolomite black soil (Calcomelanosol)		60
Rendzina	On marl and marly and soft limestone	80
	On loess and loess-like sediments	80
	On moraine	80
	On dolomite regolith	80
	On calcareous sand	80
	On calcareous gravel	80
Humus-siliceous (Ranker)	Eutric	80
	Dystric	60
Chernozem	On loess and loess-like sediments	80
	On carobonate eolic sand	80
	On alluvial deposits	60
Smonitza (Vertisol)	Calcareous	60
	Non-calcareous	60
	Brownish	60

III – A-(B)-C or A-(B)-R (Cambic)		
Eutric brown (Eutric cambisol)	On loess and loess-like sediments	40
	On basic and neutral eruptive rocks	40
	On peridotite and serpentinite	40
	On pond sediments On alluvial, colluvial and eolic deposits	40
	On claystone	40
	On amphybolite shales	40
Distric brown or acidic brown (Distric cambisol)	Deep	40
	Very deep	20
Brown on limestone and dolomite (Calcomelanosol)	Shallow and medium deep	60
	Deep	40
Red soil (Terra rossa)		60
IV – A-E-B-C or A-E-B-R (Fluvial illuvial)		
Ilimerised or loess affected (Luvisol)	On limestone	40
	On siliceous rocks	40
Podzol		40
Brown podzolic (Brunipodzol)	On quartz sandstone	20
	On quartz	20
	On hornstone	20
	On acidic eruptive rocks	20
	On phyllite	20
	On sand	20
V – P-C (Anthropogenic)		
Rigolano soil (Rigosol)		
Garden soil (Hortisol)		
VI – Technogenic I, II, III		
Disposal site soil (Deposol)		
Flotation material (wastewater deposits – Flotisol)		
Air precipitates (Aeroprecipitate)		

B. Hydromorphic		
I – A-E/g-Bg-C – (Pseudogley)		
Pseudogley		40
II – Layers or (A)-G ili (A) – C (Undeveloped)		
Fluvial or alluvial (Fluvisol)	Calcareous	20
	Calcareous gleyed	20
	Calcareous gleyed, saline and alkaline	20
	Non-calcareous	20
	Non-calcareous gleyed	20
	Non-calcareous gleyed, saline and alkaline	20
III – A-C-G – (Semi-gley)		
Fluvial meadow (Humofluvisol)		20
IV – A-G – (Gley)		
Pseudogley		40
Marsh black soil (Humogley)		20
Marsh gley (Eugley)		20
V – T-G – (Peat)		
High peat		40
Combined high and low peat		20
Low peat (Planohistosol)		20
VI – P-G – (Anthropogenic)		
Rigolano peat		0
Rice field soils		0
Hydromeliorated		0

C – Halomorphic soils		
I – Asa-G or Asa- CG – (Saline)		
Solonchak		40
II – A/E-Asa-BT,na-C (Solonetzs)		
Solonetz		40

g) Orographic characteristics

Among orographic characteristic, an altitude, inclination and terrain exposure have a pervasive impact. On terrains with a different altitude, exposure and inclination, the duration and intensity of sunrays are different and, consequently, so are the conditions for drying of combustive material (Table 7).

Table 7. *Orographic parameters that have an impact on a level of forest fire threat*

Orographic characteristics	**Number of points**
Exposure	
South and level land	20
East and West	10
North	5
Altitude	
below 500 m	15
501-800 m	10
above 800 m	5
Inclination	
above 45%	15
31-45%	10
15-30%	5

h) Forest complex openness

Openness of a forest complex for roads is the basis for a successful prevention of forest fire occurrence. That includes a proper maintenance of fire prevention clearance area, where twig removal and twig pruning are carried out, as well as thinning and reduction of combustible material.

Forest complex openness	**Number of points**
Forest complex is open (a large area of forest complex is accessible through a developed road network, fire prevention rail tracks are regularly maintained)	5
Forest complex is partially open (larger areas of forest complex are poorly accessible, or accessible by forest roads unsuitable for fire trucks; fire prevention rail tracks are poorly maintained)	20
Forest complex is not open, there are no fire prevention rail tracks	40

i) the development level of an area for tourist and outing activities

Development level	**Number of points**
Forest complex is well-developed for tourist and outing activities (areas designed for fire making are properly marked and their safety is ensured, barrels with sand for extinguishing smaller fires	5

in the initial phase are provided, forest fire danger signs are properly placed)	
Forest complex is partially developed for tourist and outing activities (forest fire danger signs are properly placed)	20
Forest complex is fully undeveloped for tourist and outing activities (there are no marked areas for making fire nor forest fire danger signs)	40

j) Other biotechnical protection measures

Development level	Number of points
Forest complex has provided biotechnical protection measures (representation of mixed forests, combustible material that is less susceptible to fire, construction of fire protection rail tracks, condition and maintenance of water supply stations, construction of observation points and organisation of forest monitoring system, creation and implementation of a fire occurrence assessment system)	5
Forest complex has no biotechnical protection measures	40

k) Fire record and its impact on forest fire threat

Fire record, or number of fires in a particular time interval in a specific area, has an impact on determination of the forest fire threat level. More specifically, the number of fire in a monitored area indicates what part of an area is more susceptible to fire occurrence and how increased a fire threat is. Furthermore, combustible material is not the same in areas with frequent fire occurrence, since the weather conditions that produce an impact on condition of combustible material susceptible to ignition, also change in that area. Some characteristics used for determination of a forest fire threat level, related to fire frequency in a monitored area within 10 years, are presented in Table 10.

Table 8. *Fire record parameters that have an impact on a level of forest fire threat*

Number of fires in an area within a 10 year period	Number of points
5 and above	40
2 – 4	20
below 2	10

4.3. A level of forest fire threat

Based on the above-mentioned parameters used for the assessment of forest fire threat, the points earned from the represented parameters are added; a level of forest fire threat is determined according to the total number of points.

Categorisation of forest fire threat based on the number of points is presented in Table 9.

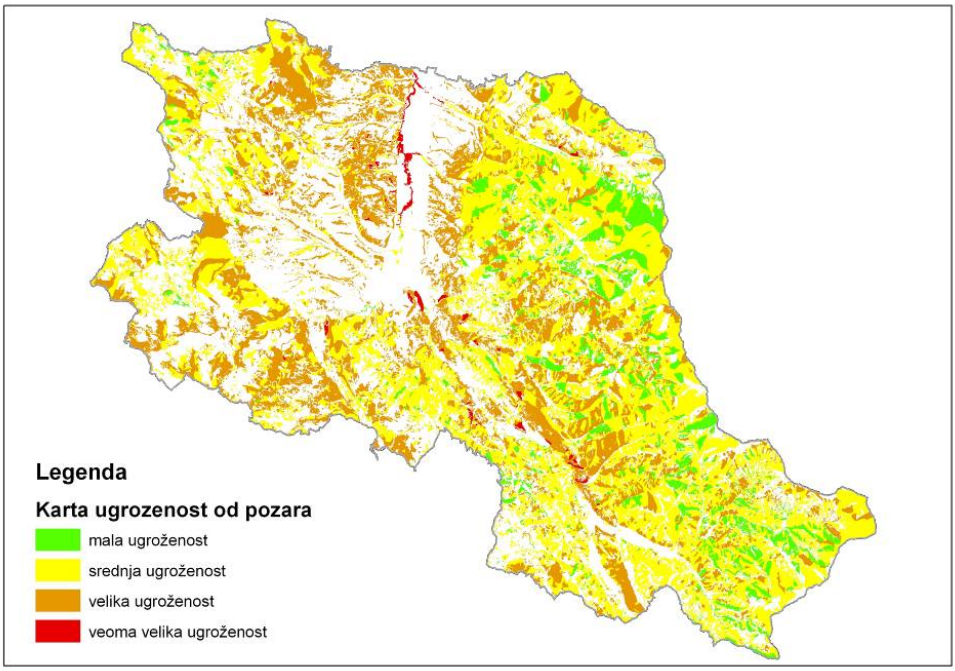
Table 9. Forest fire threat categorisation

Forest fire threat level	Total number of points	Colour
Level one – extremely high threat	631-705	red
Level two – high threat	556-630	orange
Level three – medium threat	481-555	yellow
Level four- low threat	405-480	green

Based on certain numeric indicators of forest fire threat, fire threat maps are created in which areas exposed to fire threat are presented in relevant colours.

CONCLUSION

An increasingly frequent occurrence of forest fires and extensive burnt areas require a timely preventive forest fire protection. A type of forest fire threat assessment, which would include all elements that constitute and have an impact on forest fire threat, has not been conducted in Serbia by now, except for the threat assessment that is based on representation of tree species, while other parameters were not taken into consideration. A successful risk management in forest fire protection requires a first-hand knowledge and proper treatment of forests, particularly the understanding and observance of all adverse changes in forests, their timely recording and implementation of relevant fire prevention measures based on relevant parameters. Therefore, a timely detection of harmful occurrences requires a thorough knowledge of events that might cause forest fires, which is gained thorough a constant monitoring, data gathering and certain findings. A method for forest fire threat assessment has for its aim to determine, at any moment and based on a number of significant parameters, a level of forest fire threat in the observed area. Together with the system for forest fire threat assessment, the method for forest fire threat assessment provides the basis for an organised and professional approach to forest fire protection. A method for forest fire threat assessment must be the basis for any risk management applied in forest fire prevention. As any other, this method is also subject to changes and enhancement; however, in its present form, it provides a good basis for an appropriate assessment of forest fire threat. By means of application of this method, forest fire threat in any area can be determined in a more adequate manner. This type of method provides the basis for preparation of planning acts on classification of soils into categories according to forest fire threat. These plans fundamentally differ from the plans for building fire protection and therefore the current Rulebook on preparation of fire protection plans needs to be amended, primarily by defining the content and manner of preparation of these plans, as well as by defining a threat assessment method for preparation of forest fire protection plans.



A threat map created by means of application of the above-presented methodological procedures

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