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SUSTAINABLE FORESTRY ODRŽIVO ŠUMARSTVO

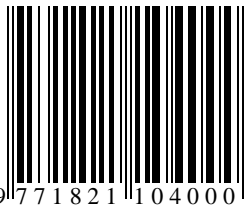
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VIABILITY OF TREES ON BIO-INDICATOR PLOTS LEVEL -A 1 IN REPUBLIC OF SERBIA IN 2013

*Goran ČEŠLJAR¹, Radovan NEVENIĆ¹, Svetlana BILIBAJKIĆ¹,
Tomislav STEFANOVIĆ¹, Renata GAGIĆ SERDAR¹,
Ilija ĐORĐEVIĆ¹, Zoran PODUŠKA¹*

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

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

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

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

¹ Institute of Forestry, Kneza Visislava 3, Belgrade, Serbia

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

Ključne reči: Bioindikacijske tačke, oštećenja stabala, suša.

1. INTRODUCTION

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

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

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

¹ International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests.

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

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

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

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

2. MATERIAL AND METHOD

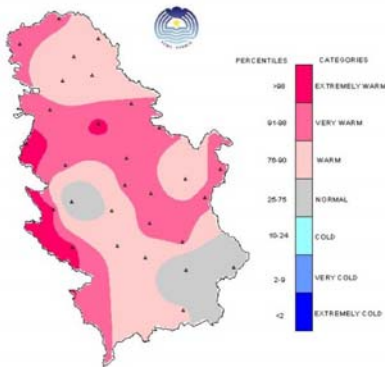
This paper analyzes the data of climatic and meteorological conditions in the Republic of Serbia based on the Republic Hydrometeorological Institute report, as indicators of large temperature extremes that occurred in 2011 and continued throughout 2012. Based on data obtained from bio-indicator plots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

3. RESULTS AND DISCUSSION

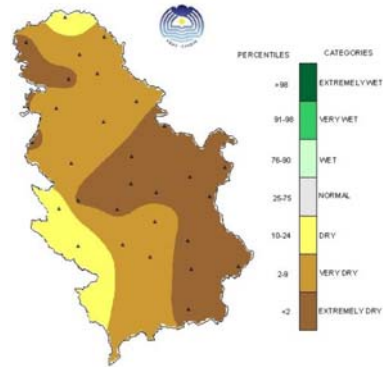
Analysis of climatic and meteorological characteristics of the Republic of Serbia began with the appearance of the first major extreme temperatures during the summer 2011 which was one of the 10 warmest in the whole territory of Serbia since the beginning of the measurements. During the summer 2011 the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

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

Map 1. *Categories of normality of mean annual temperature in 2011¹.*

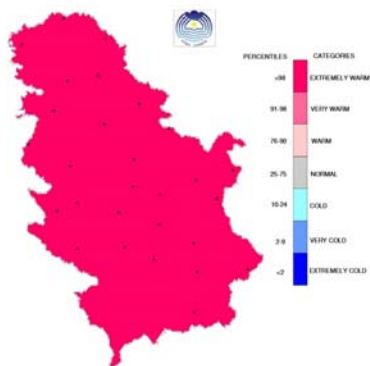


Map 2. *Categories of normality of annual amount of precipitation in 2011.*

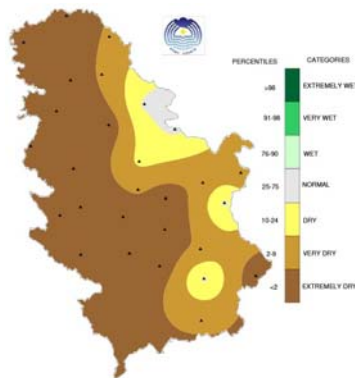


¹ Maps 1-4: Source- Republic Hydrometeorological Institute - www.hidmet.gov.rs

Map 3. Air temperature during summer 2012.



Map 4. Amount of precipitation during summer 2012.



The emergence of large-scale forest dieback in the Republic of Serbia in the 2013 was recorded at 13,885.00 hectares, individual tree dieback on the area of 12,084.00 hectares, dieback of group of trees on the area of 1,800.81 hectares, while dried timber volume was 81,631.61 m³ (Jančić, 2013). Encompassing all the forests in the Republic of Serbia it was recorded a higher percentage of dieback in coniferous than in broadleaf species. However, on the bio-indicator plots of Level 1 was observed the reverse state and the main reason for that is much smaller number of conifers, which are continuously monitored, with respect to the broadleaf species (Table 1 and 2). The most common broadleaf species on bio-indicator plots are Balkan beech (*Fagus moesiaca*), Turkey oak (*Quercus cerris*), Hungarian oak (*Quercus frainetto*), Sessile oak (*Quercus petraea*) and Hornbeam (*Carpinus betulus*) (Table 1), while the most present conifers are Silver fir (*Abies alba*), Common spruce (*Picea abies*), Austrian pine (*Pinus nigra*) and Scots pine (*Pinus silvestris*) (Table 2). Bio-indicator plots are arranged in a zone of 75 - 1558 meters above sea level, while the majority of them is in the area of 400 meters above sea level – at 600 meters above sea level (Stefanovic et al. 2012). Map 5 shows the distribution of bio-indicator plots on the territory of the Republic of Serbia.

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

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

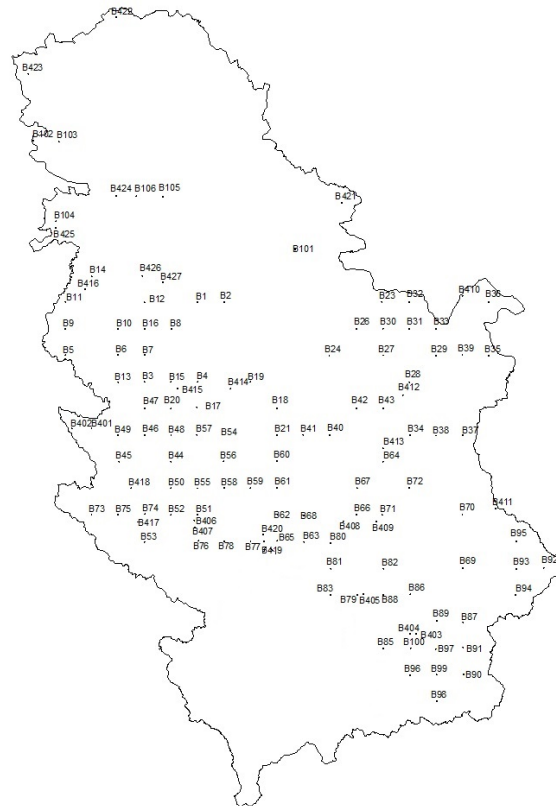
Table 2. Presence of conifer species on bio-indicator plots

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

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

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

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



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

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

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

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

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

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

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

4. CONCLUSION

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

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

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