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

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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 Fruška 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 na 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*

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uzorkovanje, ocenu, monitoring i analizu uticaja zagađenja vazduha na šume prema ICP Forests Manual-u. U radu su dati rezultati praćenja stanja krana 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 plan¹ 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 map¹ 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 map¹ 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°17'30"	+20°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 on 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	<i>U.b.*</i>
2	2	220414	76	118	01	1	1	2	10	15	<i>U.b.*</i>
3	2	220414	78	118	01	1	2	2	15	25	<i>U.b.*</i>
4	2	220414	79	118	01	1	1	2	15	20	<i>U.b.*</i>
5	2	220414	80	118	01	1	1	2	10	15	<i>U.b.*</i>
6	2	220414	85	118	01	1	2	2	15	25	<i>U.b.*</i>
7	2	220414	86	118	01	1	3	3	10	20	<i>U.b.*</i>
8	2	220414	87	118	01	3	3	3	35	65	<i>U.b.*</i>
9	2	220414	88	118	38	5	6	2	100	99	<i>U.b.*</i>
10	2	220414	91	118	41						
11	2	220414	92	118	01	2	3	3	20	30	<i>U.b.*</i>
12	2	220414	93	118	01	1	3	3	15	20	<i>U.b.*</i>
13	2	220414	94	118	01	3	3	3	40	60	<i>U.b.*</i>
14	2	220414	95	118	01	2	3	3	20	30	<i>U.b.*</i>
15	2	220414	96	118	01	1	4	4	20	25	<i>U.b.*</i>
16	2	220414	97	118	01	1	3	3	15	20	<i>U.b.*</i>
17	2	220414	98	118	01	1	3	3	15	20	<i>U.b.*</i>
18	2	220414	113	118	01	1	2	2	15	25	<i>U.b.*</i>
19	2	220414	114	118	01	1	4	3	20	25	<i>U.b.*</i>
20	2	220414	115	118	01	1	3	3	25	30	<i>U.b.*</i>
21	2	220414	117	118	01	1	4	3	15	30	<i>U.b.*</i>
22	2	220414	118	118	01	1	3	2	20	35	<i>U.b.*</i>
23	2	220414	119	118	38	5	6	3	100	99	<i>U.b.*</i>
24	2	220414	120	118	01	1	1	2	30	50	<i>U.b.*</i>
25	2	220414	121	118	01	1	3	3	20	25	<i>U.b.*</i>
26	2	220414	124	118	01	1	2	2	20	30	<i>U.b.*</i>
27	2	220414	125	118	38	5	6	3	100	99	<i>U.b.*</i>
28	2	220414	126	118	01	1	2	2	10	20	<i>U.b.*</i>
29	2	220414	77	118	01	1	3	2	10	25	<i>U.b.*</i>
30	2	220414	123	118	01	1	1	1	15	20	<i>U.b.*</i>

**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	<i>Pityogenes chalcographus</i>	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	<i>Pityogenes chalcographus</i>	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	<i>Pityogenes chalcographus</i>	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	<i>Pityogenes chalcographus</i>	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°07'55"	+21°58'38"	19		

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

Sequence number of trees	Observation on 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	<i>Nectria coccinea</i>	2	
16	4	170614	77									
17	4	170614	78									
18	4	170614	79									
19	4	170614	87	32	11	57		3	300	<i>Nectria coccinea</i>	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°45'27"	+19°29'00"	12		

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

Sequence number of trees	Observed on 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).

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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***** Forms and Explanatory Items to be applied for data submission 2013 onwards
Version n8 Last update: 16 May 2013. <http://www.icp-forests.org/page/data-submission>

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