ISBN 978-86-80439-21-1
ISBN 978-86-90439-23-5 (vol. 2)

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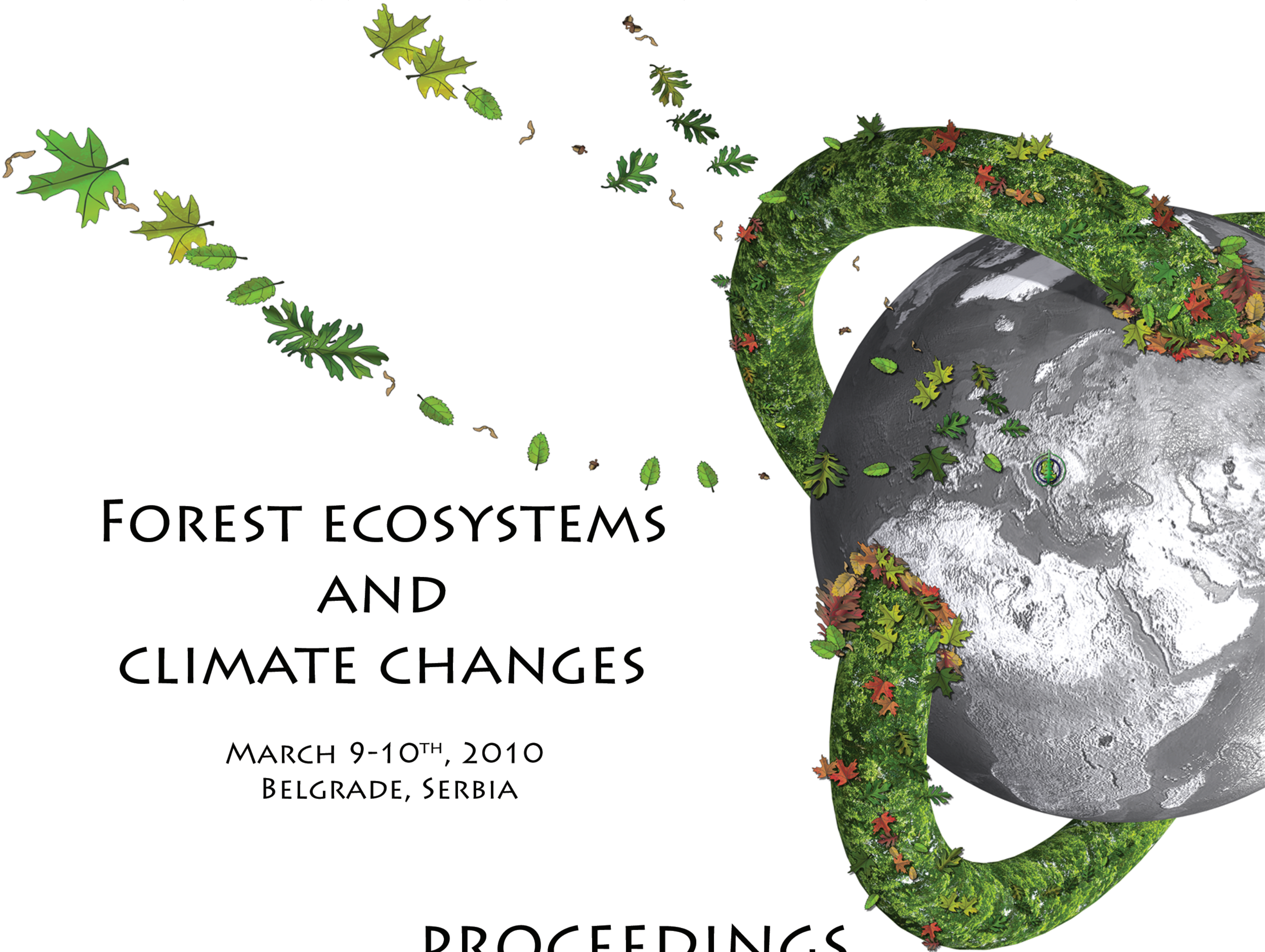

FOREST ECOSYSTEMS AND CLIMATE CHANGES

MARCH 9-10TH, 2010
BELGRADE, SERBIA

PROCEEDINGS

VOLUME 2

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INTERNATIONAL UNION OF FOREST RESEARCH ORGANIZATIONS

EFI ASSOCIATED EVENT

International Scientific Conference

FOREST ECOSYSTEMS AND CLIMATE CHANGES

PROCEEDINGS
Volume 2

Organised by:
INSTITUTE OF FORESTRY, BELGRADE

IN COOPERATION WITH

IUFRO
EFI
MINISTRY OF SCIENCE AND TECHNOLOGICAL DEVELOPMENT, REPUBLIC OF SERBIA
MINISTRY OF AGRICULTURE, FORESTRY AND WATER MANAGEMENT – DIRECTORATE OF FORESTRY, REPUBLIC OF SERBIA
MINISTRY OF ENVIRONMENT AND SPATIAL PLANNING, REPUBLIC OF SERBIA
PE „SRBIJAŠUME“
SOCIETY OF FORESTRY ENGINEERS AND TECHNICIANS OF SERBIA

Belgrade
March 9-10th, 2010.

Citation
International Scientific Conference
Forest ecosystems and climate changes

Publisher
Institute of Forestry
Belgrade, Serbia

Chief Editor
Ph.D. Ljubinko Rakonjac

Technical Editor and layout
M.Sc. Tatjana Ćirković-Mitrović

Cover design
Nevena Čule, B.Sc.
Suzana Mitrović, B.Sc.

Printed in
200 copies

Printing
KLIK PRINT, Belgrade

Belgrade
March, 2010

Address of the Organizer
Institute of Forestry
Kneza Višeslava 3
Belgrade, Serbia
www.inforserb.org

Complete set of two volumes: ISBN 978-86-80439-21-1
Volume 1: ISBN 978-86-80439-22-8
Volume 2: ISBN 978-86-90439-23-5

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

630*42(082)
551.583(082)
504.7

INTERNATIONAL Scientific Conference Forest Ecosystems and Climate Changes (2010 ; Beograd)
Proceedings. #Vol. #2 / International Scientific Conference Forest Ecosystems and Climate Changes, Belgrade, March 9-10th, 2010 ; organized by Institute of Forestry, Belgrade ... [et al.] ; [chief editor Ljubinko Rakonjac]. - Belgrade : Institute of Forestry, 2010 (Belgrade : Klik print). - 342 str. : ilustr. ; 30 cm

Tiraž 200. - Napomene uz tekst. - Bibliografija uz svaki rad. - Rezimei.

ISBN 978-86-80439-23-5
1. Institut za šumarstvo (Beograd)
a) Шуме - Климатски утицаји - Зборници b) Климатске промене - Зборници
COBISS.SR-ID 176326156

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Passive terrestrial optical measurements for assessing climate change impacts on forest canopies

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Abstract

A new method for processing digital hemispherical images for leaf area index and canopy cover estimation was tested. Common subjective image thresholding procedure for canopy and sky separation is replaced by creating the real transmittance image. Method does not require an open place sensor for reference images, instead, sky reference image is created by using information that exists in canopy gaps. Forest canopy characteristics were estimated from 15 images from naturally developed pine forests growing on sand dunes in Mändjala, Estonia. Penetrated photosynthetically active radiation over vegetation period was estimated using obtained canopy transmittance images. To reveal a possible relationship between irradiation and the amount of carbon gained via mycorrhizal fungi on pyroloid species (*Ericaceae*) soil properties were studied in respect to canopy opennes calculated from images. Humus thickness (cm) depth was found negatively correlated with canopy openness (-0.84, $p<0.001$) and positively with nutrient content and number of pyroloid species (0.66, $p<0.01$).

Introduction

Influence from environmental factors and growth in forest ecosystems expresses through constant changes in the forest structure. Our interest concerning these changes is related to ecosystem sustainability and production of different services. Assessment of the driving factor(s) influence on the ecosystem can be based only on high quality information about forest structure and structure changes. Plot based monitoring systems coupled with database analysis and remote sensing tools provide a basic system for handling data from large territories. However, neither regular forest inventory systems nor plot based statistical forest inventories do not include measurements about two very important variables of forest ecosystems- leaf area index (LAI) and canopy cover (CC) (Nilson and Peterson, 1994) to support more efficient integration of remote sensing methods.

Since the first definition of LAI by Watson (1947) several alternative definitions in respect to leaf area determination have been proposed. In forests, LAI is usually defined as the ratio of total projected leaf area to the site area. The term canopy cover is often mixed with canopy closure which depends on view angle width whereas canopy cover is the ratio of union of the crown projection areas to the site area (Jennings *et al.*, 1999, Korhonen *et al.*, 2006). Canopy cover is estimated in some forest inventories for forest non-forest classification (Päivinen, 1997) but measurements on each plot/stand are usually not carried out.

On the other hand, our representation of forest (ecosystem) and also decisions are based on models describing structure, intrinsic relationships and system development (growth). In different forests models, of course, a long list of input parameters exists - species composition and species related variables, number of trees per unit area, height and breast height diameter (and their distribution), soil fertility descriptors, water regime descriptors, light use efficiency, etc. Usually, LAI and tree crown projection or CC are usually estimated via regression models using tree trunk diameter at breast height, tree height and live crown length (Zianis *et al.*, 2005; Lang *et al.,* 2007). However, the regression models are specific to the site conditions and geographic location. Even more, they produce biased results when growth conditions, which are basically the environmental and climate factors, are changing.

Among different methods for leaf area index assessment hemispherical cameras and similar optical tools are widely being used. The basic idea to obtain LAI estimate from hemispherical images is to calculate canopy cap fraction angular dependence and then effective plant area index which is further converted to green leaf area index using model inversion (Jonckheere *et al.*, 2004). Obtaining a true green leaf area index estimate is, however, not a trivial procedure and can not be successful without having unbiased and precise measurement data and objective methods (Chen *et al.*, 1991; Gower *et al.*, 1999; Nilson and Kuusk, 2004; Weiss *et al.*, 2004). The models that are inverted assume the input quantity - canopy gap fraction to be a continuous variable. However, for some reasons the usual procedure of estimating gap fraction angular dependence or transmittance $t(\theta)$ from digital hemispherical images has been based upon applying a threshold on image brightness values to classify image to sky and plant classes (e.g. Baret and Weiss, 2004; Frazer *et al.*, 1999). This approach mimics closely the original idea of inclined point quadrats by Wilson (1960) for LAI estimation, but suffers on the problems related to the mixed pixels, illumination variability and threshold dependence on operator subjective decision and camera settings (Inoue *et al.* 2004). Studies on automatic thresholding methods have revealed that it is very difficult to choose appropriate method because the results are very variable and often contradictory to that of human operator decision (Jonckheere *et al.*, 2005).

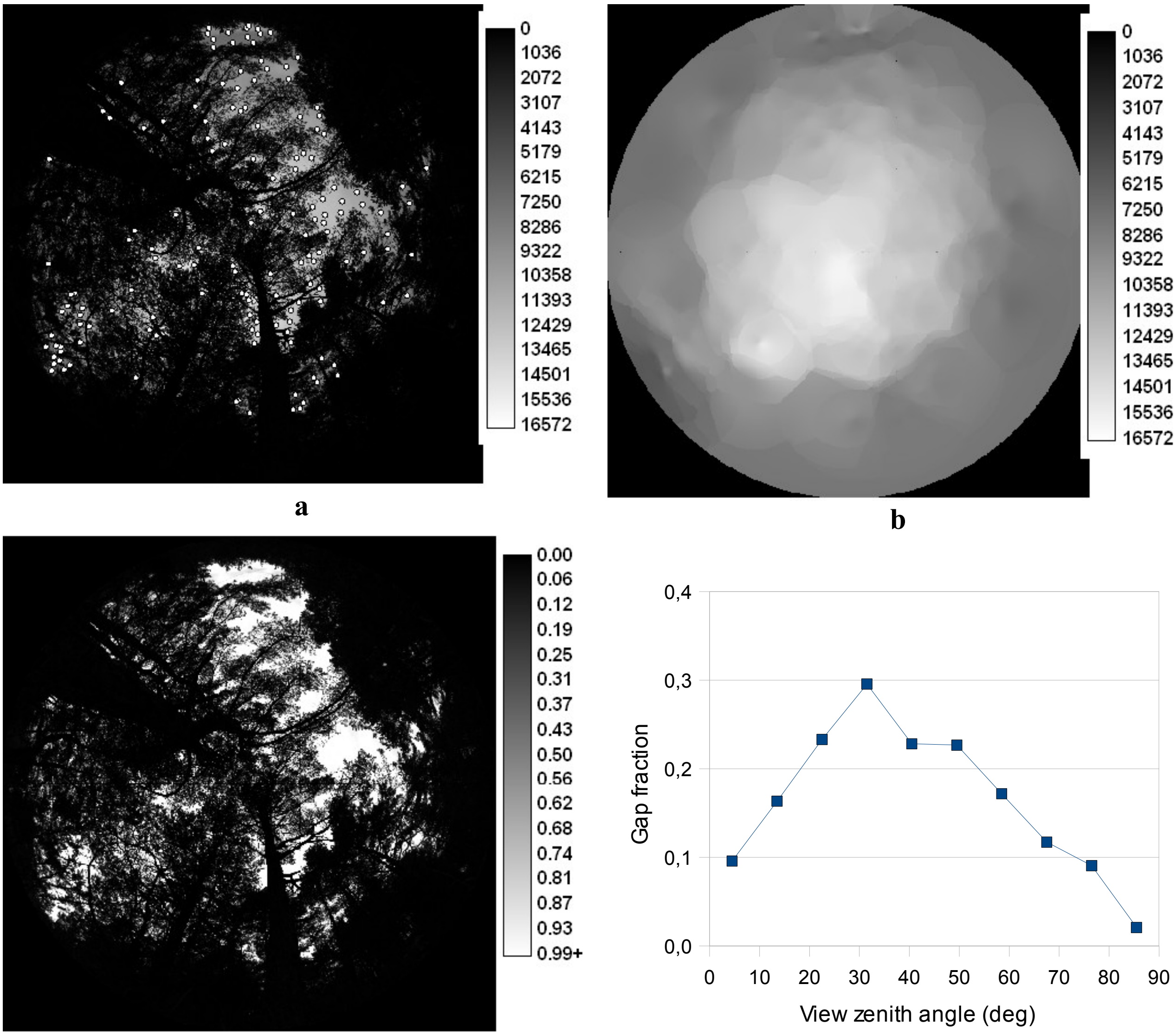
New method for processing digital hemispherical images to estimate leaf area index is is presented by Lang *et al.* (2010). The method is based on ideas of Cescatti (2007) and does not include thresholding by subjective brightness level (which introduces a great degree of uncertainty), handles changes in illumination variability, can be applied to single below canopy images (avoiding two sensor issues) and is easy to implement. Outcome of the method is angular dependence of forest canopy transmittance which is further used in leaf area index calculation algorithms.

Here we present an example application of the new digital hemispherical image processing method to estimate illumination conditions for forest understorey vegetation and to assess pyroloid species (*Ericaceae*) richness in Mändjala, Estonia.

Material and Methods

Cescatti (2007) published the proof that modern digital cameras can be used as measurement devices similar to the classical tool LAI-2000 Plant Canopy analyser, and described a method called LinearRatio. However, the presented common two sensor approach (one camera in open place and one camera operated below canopy) is difficult to use for practical applications in forests for many reasons. Therefore Lang *et al.* (2010) developed methodological solution for using the LinearRatio method of Cescatti (2007) with only one - below canopy operated sensor.

Modern digital cameras have CCD or CMOS sensors which are pixel matrices. The output signal of each pixel is linearly dependent on incident radiation. The cameras collect and store store this data into so called raw form and this data are usually further processed to create nice naturally looking colour images for human vision. However, for obtaining canopy gap fraction estimate only the raw signal is in interest. After the extraction of true blue pixels and correcting for lens projection model and lens and camera vignetting above canopy reference can be created by using sky radiance information from canopy gaps. Sky reference image can be created with FitSky program (available from authors) by using interpolation between marked canopy caps and sky radiance model to account for systematic changes in sky radiance (Figure 1) according to Lang *et al.* (2010).



a **b**

c **d**

Figure 1: Hemispherical image 1382 from Mändjala test site and processing steps to obtain canopy gap fraction. ***a)*** *Extracted and corrected true blue below canopy hemispherical image of 1400x1400 pixels with white markers for open sky pixels;* ***b)*** *above canopy image created by interpolation and sky radiance model using FitSky utility;* ***c)*** *gap fraction image calculated as image_a/image_b;* ***d)*** *gap fraction dependence of view zenith angle using nine degrees wide rings. Legend on a and b subfigures relates the image tone to the recorded radiance in digital numbers.*

Recently, evidence of mixotrophic nature in carbon acquisition by pyroloids (*Ericaceae*) has been suggested (Tedersoo *et al.*, 2007; Zimmer *et al.*, 2007). To reveal a possible relationship between irradiation and the amount of carbon gained via mycorrhizal fungi, sites with more than one pyroloid species were chosen. Mändjala in the Saaremaa island (W Estonia, Baltic Sea, 58°13' 19"N, 22°19' 13"E) was among the sites chosen for comparative analysis between pyroloid taxons. In a coastal sand dune forest of *Pinus sylvestris* 15 plots were sampled in an area of approximately 3 ha. The limit of the area was determined by the distribution of the populations of *Chimaphila umbellata*, *Orthilia secunda*, *Pyrola chlorantha* and *Moneses uniflora*. At each plot the thickness of humus was measured, leaves of the species under study sampled, and hemispherical images were aquired using Canon EOS 5D camera and Sigma 8mm F3.5 DX fisheye lens under overcast (diffuse) illumination. Camera was levelled on ground and also oriented in respect to north direction. Chemical parameters of the soil (pH, contents of N, C, NO_3-N, NH_4-N, extractable P, extractable K) were analysed in the lab. In the current paper mainly the soil and light data are used.

After having created true unbiased gap fraction images according to Lang *et al.* (2010) we used GLA (Frazer *et al.*, 1999) to calculate radiation fluxes through the forest canopy for each image. GLA works with 8-bit bmp or jpeg format images and is based on subjective thresholding. To use the radiation calculation procedure of GLA without having to determine subjective threshold, all 15 images were binarized prior GLA input using a objective rule to retain the original gap fraction estimate. Each image was divided into 100 view zenith rings and a threshold was iteratively found for each ring by minimizing difference between the transmittance estimate from gap fraction image and binarized image. In GLA the standard settings for atmosphere and illumination conditions were used for Mändjala test site geographic location and elevation above mean sea level was 6 m. Vegetation period range was defined from beginning of April to the end of October. Solar position calculation step interval was set to 15 minutes. Sky was divided into 90 azimuth sectors and 36 zenith sectors which is the maximum resolution in GLA. Output of GLA contains also canopy openness which is 1- canopy closure (see Jennings *et al.*, 1999 for definition) that is important variable in characterizing canopy radiation regime.

Results and discussion

Climate changes caused impacts can express through an abrupt or an slow continuous alternations in ecosystem. Severe disturbances like those aused by fire, storms, pest and insect outbreaks are accompanied with longterm processes in soil-plant continuum, are driven mainly the local relief, precipitation, temperature, available photosynthetically active radiation. In ecosystems itself are present several positive and negative feedbacks to the developement (growth). We need scientifically justified precise and accurate measurements to judge if the observed phenomena are caused by climate change or are just related to the natural development stage of the ecosystem.

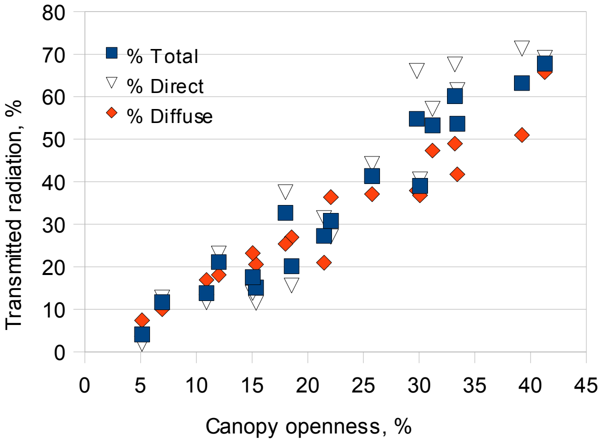


Figure 2. Canopy openness and percentage of seasonal (from April to October) transmitted photosynthetically active total, direct and diffuse radiation through tree layer canopy. Transmitted direct radiation depends on the location of the canopy gaps in respect to Sun path. Transmitted radiation is used by forest understorey vegetation plants.

Transmitted PAR (photosynthetically acticve radiation) was dependent on the forest canopy openness (Figure 2). Transmitted direct PAR is related to the location of canopy gaps in respect to Sun path. This determines in a great extent the amount of sunflecks on the forest floor and influences, soil temperature, understory species composition and morphological properties of plants in this particular location.

The isotopic data of the plant samples were not available yet. The thickness of humus in the site varied between 1.0 - 7.0 cm, pH 4.1 – 5.8 and LOI (440 °C) between 6.4 – 30.8 %. The soil element concentrations ranged from 0.1 to 0.5 % of N, 3.7 to 15.1 % of C, 82.5 to 229.1 mg kg^{-1} of K and 16.2 to 51.9 mg kg^{-1} P (lactic acid extractions for K and P). The amount of NO_3-N in the soil varied between 0.2 – 0.9 mg kg^{-1} and NH_4-N 0.1 – 3.8 mg kg^{-1}. Canopy openness ranged from 5.1 % to 39.2 % (Figure 2). Correlations are shown in Table 1.

Table 1. Spearman Rank Order Correlation coefficients between soil variables and Canopy openness, and number of pyroloid species in the plot (pyroloid species richness).

Soil variable	*Canopy openness*	*No of pyroloid species*
pH	0.13	0.45
Humus thickness (cm)	-0.84***	0.66**
N (%)	-0.74**	0.12
C (%)	-0.81***	0.19
P (mg kg^{-1})	-0.75**	0.27
K (mg kg^{-1})	-0.89***	0.29
NO3-N (mg kg^{-1})	-0.39	-0.26
NH4-N (mg kg^{-1})	-0.06	-0.11
LOI (%)	-0.84***	0.21
Canopy openness (%)	-	-0.43

n = 15, * p< 0.05, ** p< 0.01, *** p<0.001

Canopy openness was negatively correlated with most of the soil variables, while the chemical soil variables were significantly positively correlated with the thickness of the humus layer (not shown). The coastal soils on dunes are thin and relatively young. In less illuminated spots the microclimate may have favoured accumulation of nutrients and organic matter. That the number of pyroloid species was in a good positive correlation with humus thickness and not correlated with soil nutrient contents, may refer to putative mycorrhizal fungal support in pyroloids nutrition.

Conclusions

New method for processing digital hemispherical images for forest assessing canopy radiation regime and estimating structural characteristics like LAI and canopy cover or canopy closure was sucessfully used. The method is free from fundamentally problematic thresholding step on which present manual or automatic methods are based. The outcome of the method is reliable forest canopy transmittance image which can be used in modeling or estimating ecosystem radiation regime for remote sensing or other projects dealing with monitoring of climate change impacts.

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ECOLOGICAL INDEXES OF THE COMMUNITIES IN SOUTHWESTERN SERBIA

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Abstract: *This paper presents the results of the researches of the ecological indexes of the forest communities in southwest Serbia. The ecological indexes for the humidity, chemical soil reaction, nutrients, light and temperature were determined. The following forests were researched, on the total of 93 samples: the sessile oak and Turkey oak forests, silver birch forests, European poplar and silver beech forests, beech forests, beech and fir forests, black alder forests, grey alder forests, grey willow forests, Austrian pine forests, Scots pine forests, Balkan sessile oak forests, beech-fir and spruce forests, mountain maple and spruce forests, and spruce forests. The studied sites are located at the altitudes ranging grom 1,010 meters to 1,500 meters above the sea level. The communities were registered on the dystric ranker, dystric cambisol, eutric ranker, eutric cambisol, fluvisol, gley, colluvium, limestone cernozem, luvisol, pseudogley, and brown limestone soil. The ecological indexes for the humidity ranged from 2.13 to 3.47, for the chemical soil reaction from 2.23 to 3.45, for the nutrients from 2.11 to 2.99, for the light from 2.11 to 3.39, and for the temperatures from 2.96 to 3.42.*

Key words: ecological indexes, forest communities, humidity, chemical reaction, nutrients, light, temperature.

EKOLOŠKI INDEKSI ZAJEDNICA NA PODRUČJU JUGOZAPADNE SRBIJE

Izvod: *U radu su prikazani rezultati istraživanja ekoloških indeksa šumskih zajednica na području jugozapadne Srbije. Utvrđeni su ekološki indeksi za vlažnost, hemijsku reakciju zemljišta, hranljive materije, svetlost i temperaturu. Istražene su šume kitnjaka i cera, šume kitnjaka i graba, šume breze, šume jasike i breze, šume bukve, šume bukve i jele, šume crne jove, šume sive jove, šume sive vrbe, šume rakite, šume crnog bora, šume belog bora, šume balkanskog hrasta kitnjaka, šume bukve-jele i smrče, šume planinskog javora i smrče i šume smrče, ukupno 93 uzorka. Istraživane sastojine se nalaze u visinskom dijapazonu od 1010 do 1500 metara nadmorske visine. Zajednice su konstatovane na distričnom rankeru, distričnom kambisolu, eutričnom ranker, eutričnom kambisolu, fluvisolu, gleju, koluvijumu, krečnjačkoj crnici, luvisolu, pseudogleju i smeđe krečnjačkom zemljištu. Ekološki indeksi za vlažnost se kreću i interval od 2.13 do 3.47, za hemijsku reakciju zemljišta od 2.23 do 3.45, za hranljive materije od 2.11 do 2.99, za svetlost od 2.11 do 3.39 i za temperature od 2.96 do 3.42.*

Ključne reči: ekološki indeksi, šumske zajednice, vlažnost, hemijska reakcija, hranljive materije, svetlost, temperatura

1. INTRODUCTION

Plants have great power of indicating ecological habitat conditions. Plant communities schedule as complex in the horizontal and vertical direction indicate the environmental conditions and the pace of development of living conditions of areas. They also allow some negative effects of anthropogenic activities related to the degradation and devastation of flora and vegetation.

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Acknowledgement: The study was partly financed by the Minstry of Science and Technological Development of the Republic of Serbia, the Project – TR 20056 „High-resolution satellite images in the collection and processing of spatial information on forests and forest ecosystems"

The development of monitoring and allows access to the habitat changes caused by environmental conditions and other climate change and thus provide insight into the changes that are often not possible to measure or instrument for determining the changes required a longer period of time.

2. FIELD RESEARCH

The Pešter plateau with Sjenica valley is on 43°16,5''north latitude and 20° east longitude. The area is located in the middle of the Old Vlachs and is enclosed by a surrounding high mountains. The central segment is Sjenička valley, Pešter field, and the surrounding mountains in the northeast are Golija (1833 m) and Radočelo (1634 m), in the north Javor and Mučanj (1534 m), Zlatar to the northwest (1627 m), on the west Jadovnik (1734 m) and Ozren (1652 m), and the border zone toward Metohija, Mokra planina and Mokra gora. The total surface area is 1058.6 square kilometers. Of forest and forest cultures there are a total 28,365 hectares, of which 19 390 hectares are state-owned, and 8975 hectares of forest in which there is a right of ownership. Of the total area of 54% of high forest is degraded, while the total area of degraded coppice forest make 38%. In the lower parts of the Pester is present moderate continental climate, and higher areas prevailing mountain climate. The average annual temperature is 6.2°C. Minimum temperature down to the –38.0°C in higher areas and the maximum not to exceed 33 °C. Relative humidity is high all year round, and cloudiness. By classify affiliation regional-climate of Pešter plateau is characteristic of a particular variant boreal forest-snow climate (Kepen) or continental climate of moderate latitudes (Alisov genetic classification). The peculiarity of Pester plateau climate are generally lower temperatures than "normal" in the region, due to valley type and inversion of cold air, and a smaller total amount of rainfall (only 700 mm at 1100 m altitude). Both have an adverse effect on the forest vegetation. Insufficient rainfall particularly adverse effect on the any limestone aforested complex, where the trickling of the most intensive (there are underground streams), in good measure to neutralize the ravines, where it is due to the impervious clay horizon form pseudo clay and thus increases the soil moisture.

3. MATERIALS AND METHODS

Analyzed a total of 17 habitat, including 7 belong to the broadleaf deciduous forest, 5 larch, 3 mixed deciduous and coniferous forests and 2 shrubby habitat. The samples are stored at altitudes from 1010 to 1500 meters. Floristic spectrum of elements (percentage of group elements, and participation of floristic units elements) of the communities are built in accordance with the systematization of floristic geographical elements (Gajic, 1980, 1984). Biological spectrum (percentage of life unit forms) of plants were done by Kojic et al. (Kojic et al., 1997), based on the division of the types of life forms (Raunkiaer,1934). Determination made according to the habitat floristic composition, structural characteristics and compared with similar habitats of the wider area. Habitat classification system is based on the EUNIS habitat classification system. The concept of habitat is defined as "a place inhabited by plant and animal species, which is characterized primarily by physical characteristics (topography, plant or animal physiognomy, soil, air, water quality, etc.), or species of plants or animals that live there".

Differentiation of plant species as indicators site conditions was carried out on the basis of environmental floristic indexes of Serbia (Kojic et al, 1997). Analyzed the ecological indices of soil humidity, acidity, amount of nitrogen in the soil (mineral wealth), to light and temperature. To determine the ecological habitat index values were used weighted distribution of individual species. In particular, the extracted species that are specific to the extremely dry (kserophites), extremely hot (termophite) and extremely light (heliopfite) habitats.

The survey was conducted environmental index on 78 permanent experimental area. Investigation were done in the following habitat:

Habitat Code Name	Habitats	Number of samples
G1.1211	Mountain mono dominant gray alder galleries (*Alnus incana*)	8
G1.2121	Southeast-European forest of black alder (*Alnus glutinosa*) along the fast river	2
G1.6952	Moesian subalpien beech forest with the Greek Maple (*Acer heldreichii*)	7
G1.752	Moesian oak forests (*Quercus dalechampii*)	5
G1.923	Mountain habitat of *Populus tremula*	6
G1.91B	Balkan birch (*Betula*) forests on the none wet lands	6
G1.A1C1	Moesian sessile oak-hornbeam (*Quercus petraea*) - (*Carpinus betulus*) forests	5
G3.4C1	Dinaric Scotch pine forests on limestone eight	8
G3. 4C2	Dinaric Scotch pine forests on serpentinites	1
G3.5221	Austrian pine forests (*Pinus nigra*) on serpentinites with the heather (*Erica carnea*)	4
G3.1E41	Balkan acidophilic spruce forests (*Picea abies*)	4
G3.1E42	Balkan calcidophilic spruce forests (*Picea abies*)	2
G4.611	Mixed beech-fir forests on silicate	4
G4.62	Mixed beech-fir forests	5
G4.612	Mixed beech-fir forests on carbonates	7
F9.111	Orogens shrubby gray willow vegetation (*Salix eleagnos*)	1
F9.112	Orogens shrubby willow vegetation of (*Salix purpurea*)	3
	Total number of samples	78

4. RESEARCH RESULTS

4. 1. Spectrum of life forms

As an important indicator of the importance of local flora in terms of its diversity and the need for protection, significant analysis of the number of species belonging to life forms whose representatives are the most important architects of the entire ecosystem of the region floristic (Lakušić, D. 1996). Life forms are defined on the basis of exposure to offspring the impact of environmental factors during the most unfavorable climatic periods of the year (heat, frost, wind, drought) (per Raunkiaer-in, 191,934). Every life form is the result of adaptation of plants in a particular climate zone and is a good indicator of climate and soil conditions.

In the analysis of the life forms indicated as: p- pfanerophites; np-nanopfanerophites; w- woody chameropfites; h- herbaceous chameropfites; h-hemicripropfites; g-geopfites; t-teropfites, th-teropfites/hamepfites (plants that are act as theropfytes in dry years or in hot areas, but in our conditions are usual two-year perennial and survive in the form of rosettes).

Table 1. *Life forms*

Phanerophyta	Nanophanerophyta	Chamerophyta		Hemycryptophyta	Geophyita	Therophyta	Therophyta/Chamephyta
p+pl	np	w	h	h	g	t	th
6.50+0.12	6.26	2.09	6.15	57.66	5.45	7.08	8.70
12.88		8.24					

The greatest part is Hemycryptophyta (57.66%). Part of Phanerophyta is 12.88%. Participation of Geophyta is 5.45%, Chamerophyta - 8.24%; 7.08% for Terophyta, and Terophyta /Chamephyta are represented with 8.70%.

4. 2. Spectrum of floristic elements

At present research area a there is a large number of individual areal types (76), indicating the right of floristic richness of the Pešter plateau. Most are represented in the Central Europian (25.29%), Euroasian (20.92%) and Pontian-Central Asian floristic elements (14.36%).

Table 2. *Spectrum of floristic elements*

Group of floristic elements	Floristic element	Part in %	
1. Floristic element of Northean(Boreal) habitats			
Arctic floristic elements	Arctic	0.42	
Boreal floristic elements	Sub Boreal	0.10	
	Boreal Circum Polar	1.04	
	Sub Boreal-European-West Siberian	0.10	
	Sub Boreal - Circum Polar	1.04	
	Boreal Eurasian	0.62	
	Sub Boreal Eurasian	0.31	
	Sub Boreal Sub Eurasian	0.10	3.75
2. Central European floristic elements			
Central European	Central European	7.28	
And European	Sub Central European	14.88	
	Sub Central Russian	0.52	
	Alpine- Carpathian	1.98	
	Carpathian	0.10	
	Nordica-(sub) Alpine	0.31	
	Sub Central European Sub Mediterranean	0.21	25.29
3. Sub Atlantic floristic elements			
Sub Atlantic and Atlantic	Sub Atlantic	0.31	
	Sub Atlantic - Sub Mediterranean	3.54	
	Euro African	0.21	4.06
4. Sub Mediterranean floristic elements			
Sub Mediterranean	Sub Mediterranean	7.91	
	Mediterranean -Mountain	0.10	
East - Sub Mediterranean	East - Sub Mediterranean	2.08	
	Sub Eucken	0.52	
Balkan and	Moesian	0.94	
Balkan-Apennine	Submoesian	0.52	
	Iliric	0.83	
	Subiliric	1.25	
	Scardian-pindian	0.21	
	Subscardian-pindian	0.42	
	Moesian Scardian- pindian	0.10	
	Moesian dacian	0.21	
	Moesian subdacian	0.10	
	Sub Moesian -carpatian	0.42	
	Sub Moesian Sub-carpatian	0.10	
	Sub Moesian -subpanonic	0.10	
	Iliric-scardian-pindian	0.10	
	Iliric - Apennine	0.21	
	Iliric south central - Apennine	0.10	
	Subiliric-(sub) Apennine	0.10	
	Central Balkan	0.21	
	Sub Central Balkan	0.62	
	Central Balkan - Apennine	0.21	
	Central Balkan – South Apennine	0.21	
	Central Balkan- Central Apennine	0.10	
	Central Balkan South Central Apennine	0.10	

Group of floristic elements	Floristic element	Part in %	
	Balkan	0.21	19.25
	Sub Balkan	0.62	
	Balkan South Central Apennine	0.21	
	Balkan South Apennine	0.10	
	Sub Balkan Apennine	0.10	
	Sub Dacian	0.21	
5. Pontian-central Asian floristic elements			
	Ponthian-central Asian	1.14	
	SubPonthian-central Asian	1.77	14.36
	Ponthian-central -Asian Sub Mediterranean	1.35	
	SubPonthian-central Asian -Sub Mediterranean	0.21	
Pontian	Pontian	1.14	
	Sub Pontian	2.19	
	Pontian - Sub Mediterranean	1.87	
	Sub Pontian- Sub Mediterranean	1.87	
	Pontian -Panonian	1.56	
	Sub Pontian -Sub Panonian	0.42	
Panonian	Sub Panonian	0.73	
	Subiliric Subilirsko- Sub Panonian	0.10	
6. Desest area floristic elements			
	Iranian-euxinian	0.10	0.31
	Sub Iranian -east Sub Mediterranean	0.10	
	Subtaurinian	0.10	
7. Euro Asian floristic elements			
	Sub south Siberian	3.12	20.92
	Euro Asian	11.55	
	Central Europe Pontian South Siberian	0.10	
	Sub Euro Asian	6.14	
8. Sircum Polar and Cosmopolitan floristic elements			
	Sircum Polar	5.72	9.16
	Sub Sircum Polar	1.35	
	Cosmopolitan .	2.08	
9. Endemic, subendemic			
	Endemic	2.19	2.71
	Relict endemic	0.21	
	Sub endemic	0.31	
10. Adventive			
	Adventive	0.21	0.21
Total		100.0	100.0

An interesting phenomenon is floristic desert landscape elements (0.31% or 31 species) that indicate the area of climate change in the direction of warming.

4.3. Affiliation and relationship types to environmental factors

Relationship to soil moisture - Environmental humidity index (V) represents the average (mean) soil moisture during the vegetation period. Smaller values indicate a lower humidity and greater numbers of higher soil moisture. Board ecological index values the humidity habitats ranging from 1.95 (in Austrian pine forest) to 3.54 (in the forest of *Salix purpurea*). Relationship between the chemical reaction of land - Environmental Index for the chemical reaction of the soil (K) is characterized by the content of free H-ions in the soil. Low values of this index indicates acidic soil, poor database, and high values correspond to high contents of base (neutral to basic lands). The value of ecological communities to the index of soil reaction varies in the range of 2.69 (in the forest of beech, fir and spruce) to 3.71 (in the forest of Austrian pine).

Relationship to nutrient - Environmental Index for nutrients (N) indicates the relationship in terms of content in the soil of nutrients (especially nitrogen). Low values of this index indicate a small and high values of a nutrient content. The value of ecological communities to index nutrients in the soil varies in the range of 1.91 (in the forest of black pine) to 3,21 (in the forest of gray alder). Relationship between the chemical reaction of land - Environmental lightness (etiolman) index (S) is characterized by volume light, when the plant can grow well during its vegetation period. Lower index values mean less demand on the light, and higher demand mean higher plants to this very important environmental factor. The value of ecological communities to the index of light moves within the range of 1.94 (in the spruce forest) to 3.61 (in the sessile oak forests and Turkey oak). Relation to temperature - Ecology index of temperature (T) is characterized by high fever, which submitted the best plant during its vegetation period. Lower index values indicate distribution at higher positions, a higher numerical value of the index indicate that plant growth at the lower (warmer) places. The value of ecological communities to index temperature is within the range of 2,59 (in the forest of beech and fir) to 3.58 (in the forest of Austrian pine).

Table 3. *Sizes environmental index (minimum, maximum and medium) in different habitats*

Habitat	Number of species	Plants (%) per ecological groups					Kserophites
		1	2	3	4	5	
G1.1211	187	3.7	18.7	54.5	19.3	3.7	Cerastium brachypetalum, Echium italicum, Isatis tinctoria, Leontodon crispus, Minuartia setacea, Thymus serpyllum, Veronica spicata
G1.2121	53	0	13.2	69.8	15.1	1.9	Achillea millefolium, Cerasus fruticosa, Festuca heterophylla, Hypericum montanum, Hypericum perforatum, Prunus spinosa, Verbascum lanatum
G1.6952	44	0	13.6	81.8	4.5	0	-
G1.752	66	10.6	36.4	53.0	0	0	Chamaecytisus supinus, Echium vulgare, Festuca valesiaca, Galium corrudifolium, Melica transsilvanica, Thymus serpyllum, Veronica austriaca
G1.923	117	6.8	14.5	71.8	6.8	0	Potentilla inclinata, Leontodon crispus, Medicago orbicularis, Polygala major, Potentilla recta, Seseli annum, Festuca vallesiaca, Festuca vallesiaca
G1.91B	107	12.1	28.0	54.2	3.7	1.9	Dorycnium herbaceum, Allium pulchellum, Bupleurum praealtum, Echyum vulgare, Koeleria gracilis, Leontodon crispus, Potentilla recta, Festuca valesiaca, Leontodon crispus, Teucrium chamaedrys, Cerastium brachypetalum, Polygala major, Festuca valesiaca
G1.A1C1	136	10.3	29.4	56.6	3.7	0	Asperula cynanchica, Bupleurum sibthorpianum, Cerasus mahaleb, Cotoneaster integerrimus, Cotoneaster integerrimus, Dorycnium herbaceum, Galium corrudifolium, Leontodon crispus, Medicago orbicularis, Minuartia hybrida, Polygala comosa, Rhamnus saxatilis, Teucrium chamaedrys, Vicia incana
G3.4C1	34	14.7	35.3	47.1	2.9	0	Galium corrudifolium, Koeleria gracilis, Linum capitatum, Polygala major, Teucrium chamaedrys
G3. 4C2	136	10.3	39.7	45.6	4.4	0	Bupleurum praealtum, Bupleurum sibthorpianum, Dorycnium herbaceum, Festuca valesiaca, Galium corrudifolium, Leontodon crispus, Melica

							transsilvanica, Polygala major, Potentilla arenaria, Scabiosa ochroleuca, Seseli annum, Sesleria rigida, Teucrium chamaedrys, Thymus serpyllum
G3.5221	104	16.3	46.2	35.6	1.9	0	Aira caryophyllea, Allium pulchellum, Artemisia lobelii, Bromus tectorum, Bupleurum sibthorpianum, Cotoneaster tomentosus, Dorycnium herbaceum, Echium vulgare, Euphorbia glabriflora, Festuca valesiaca, Galium lucidum, Koeleria gracilis, Leontodon crispus, Sesleria rigida, Teucrium chamaedrys, Thymus striatus, Vicia onobrychoides
G3.1E41	125	3.2	28.0	62.4	6.4	0	Festuca vallesiaca, Galium corrudifolium, Polygala comosa, Thymus serpyllum
G3.1E42	87	5.7	27.6	62.1	4.6	0	Cotoneaster tomentosus, Festuca vallesiaca, Leontodon crispus, Polygala major, Teucrium chamaedrys
G4.611	69	1.4	15.9	72.5	10.0	0	Cotoneaster tomentosus
G4.62	63	1.6	15.9	76.2	6.3	0	Festuca vallesiaca
G4.612	125	3.2	28.0	62.4	6.4	0	Bupleurum sibthorpianum, Festuca valesiaca, Plantago argentea, Thymus serpyllum
F9.111	44	9.1	13.6	61.4	15.9	0	Asperula cynanchica, Cerasus machaleb, Teucrium chamaedrys, Thymus serpyllum
F9.112	49	14.3	42.9	36.7	4.1	2.0	Achillea millefolium, Anemone sylvestris, Carduus nutans, Cynanchum vincetoxicum, Galium silvaticum, Hypericum perforatum, Prunus spinosa

Table 4. *Sizes of environmental indexes (minimum, maximum and medium) in habitats*

Habitat	Sizes of ecological (environmental) indexes														
	Humidity			**Chemical reaction**			**Nutrient**			**Chemical reaction**			Temperature		
	min	**max**	**med.**	**min**	**max**	**med.**	**min**	**max**	**med.**	**min**	**max**	**med.**	**min**	**max**	**med.**
G1.2121	3.17	3.25	3.21	3.05	3.18	3.11	2.94	2.96	2.95	2.91	2.97	2.94	3.10	3.15	3.12
G1.1211	2.94	3.27	3.20	3.12	3.37	3.27	2.84	3.21	2.99	2.74	3.28	3.01	2.88	3.07	2.98
G1.752	2.25	2.37	2.32	2.94	3.26	3.12	2.18	2.43	2.31	2.82	3.31	3.11	3.20	3.49	3.36
G1.923	2.74	2.86	2.77	2.67	3.34	3.08	2.35	2.76	2.58	3.00	3.32	3.14	2.97	3.31	3.14
G1.91B	2.57	2.93	2.73	2.87	3.35	3.06	2.31	2.64	2.41	3.02	3.36	3.31	3.02	3.36	3.31
G1.A1C1	2.47	2.77	2.57	3.15	3.36	3.24	2.31	2.59	2.48	2.83	3.39	3.19	3.06	3.46	3.36
G3.4C1	2.16	2.78	2.49	2.96	3.47	3.23	2.03	2.45	2.25	2.96	3.52	3.30	2.95	3.42	3.17
G3. 4C2			2.41			3.32			2.03			3.47			3.24
G3.5221	1.95	2.36	2.13	3.27	3.71	3.45	1.91	2.40	2.11	2.80	3.54	3.42	3.20	3.58	3.42
G3.1E41	2.63	3.06	2.82	2.69	3.32	3.10	2.50	2.87	2.68	2.08	2.97	2.36	2.54	3.07	2.81
G3.1E42	2.46	2.93	2.73	2.78	3.35	3.04	2.36	2.88	2.64	1.94	3.00	2.67	2.71	3.19	2.96
G4.611	2.77	2.94	2.89	2.95	3.16	3.05	2.68	2.90	2.80	2.34	2.58	2.48	2.65	2.92	2.81
G4.612			2.75			3.26			3.53			2.97			3.04
G4.62	2.90	3.00	2.96	2.71	3.15	2.97	2.55	2.65	2.69	2.28	2.60	2.39	2.59	3.07	2.84
F9.111			2.89			3.36			2.71			3.09			3.15
F9.112	3.40	3.54	3.47	3.26	3.42	3.37	2.89	3.08	2.98	3.28	3.33	3.30	3.10	3.12	3.11

5. GENERAL FINDINGS

It was found that its plant in complex horizontal and vertical direction indicate the environmental conditions and the pace of development of living conditions of the area. The applied method in the area of the Pešter plateau allowed the determination of certain negative effects of anthropogenic activities related to the degradation and devastation of plants and vegetation. Development of monitoring that was based on ecological indices provide insight into the ecological conditions of habitat changes caused by climate and other changes. All mentioned are in order to provide insight into the changes that are often not possible to measure, or using as an instrument for the assessment of these changes which require a longer period of time.

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SOME OBSERVATIONS ON THE EFFECT OF SUMMER DROUGHT IN THE FOREST OF HUNGARIAN OAK AND TURKEY OAK IN SERBIA

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Abstract: *Forest of Hungarian oak and Turkey oak - Quercetum frainetto-cerridis Rudski (1940) 1949 is a climatogenic community in Serbia. It ranges over the flattened positions and undulated hilly terrains up to the altitude of 600 m on different parent rocks. Most often, it grows on the Tertiary lacustrine deposits. The community is differentiated into several associations and subassociations. This paper deals with the macroclimate effect over a long time period on a climatogenic Hungarian oak and Turkey oak forest in Serbia, with special reference to summer drought.*

Key words: Forest of Hungarian oak and Turkey oak, climate changes, summer drought, Serbia.

1. INTRODUCTION

Over the last two centuries, man by his activities caused major disturbances in the global climate system, and the greatest changes were observed in the atmosphere. By the mid seventies, there was a significant human effect on climate, reflected in a sharp growth in the concentration of atmospheric gases: carbon dioxide (CO_2), methane (CH_4), nitrogen suboxide (N_2O), water vapour, and ozone (O_3), and their long lasting stay in the atmosphere. The above natural gases allow the short-wave solar radiation to pass through, and absorb the long-wave infrared Earth's radiation, thus causing the greenhouse effect (Spasova, 2007).

During the twentieth century, the average global air temperature increased from 0.6 ^{0} C to 0.7 ^{0} C, and the greatest increase occurred after 1976. The increase in air temperature causes the melting of glacier ice on the poles and is a contributing factor to sea level rise. On the land, the temperature and precipitation regimes change. Some of the significant aspects of climate change are the effects of longer periods of high temperature on ecosystems and human life.

The effects of climate change on forest ecosystems are reported by numerous authors (Kadović, 2007; Kadović, Medarević, 2007; Dacić, 2007).

This paper deals with the effect of climate change over a long time period on a climatogenic Hungarian oak and Turkey oak forest in Serbia, with special reference to summer drought.

2. MATERIAL AND METHOD

The literature sources for this study present the systematised meteorological measurements in the area of Serbia over a several-decade long period. Special emphasis was placed on the effect of climate and other ecological factors on Hungarian oak and Turkey oak forests. The geographical variants of the forest of Hungarian oak and Turkey oak were related to climate zones in the area of Serbia and the summer drought. Special analysis was focused on the results of micro-station research of summer drought effect on Hungarian oak and Turkey oak forests.

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3. DISCUSSION AND CONCLUSIONS

Summer drought period in Serbia

According to Koppen climate classification, a greater part of Serbia has a temperate continental climate. The montane parts above the altitude of 1000 m have a continental climate. Temperate continental climate is characteristic of submontane and lowland areas in Serbia. There are four seasons with hot summers and cold winters (Popović, 2007).

The climate in Serbia is characterised by summer droughts. Drought period is distinguished by high summer air temperatures, low relative humidity and in some parts by dry warm winds. Summer drought is characterised not only by the lack of precipitation, but also by dry air and high temperature. Rainy and drought periods have alternated from the beginning of meteorological measurements in Serbia to date (Opra, 1998). Based on the selected 20 weather stations in Serbia (with monitoring period from 1925 to 1940) and Belgrade (with monitoring period from 1887 to 1949, with some breaks), it was concluded that the greatest number of drought periods was in July and August. The absolute maximal lengths of warm drought periods in July were as follows: Belgrade 26 days, Kragujevac 25 days, Paraćin 44 days, Niš 25 days, Vranje 61 day (Milosavljević, 1951). The absolute maximal air temperatures in Serbia, in the period 1925 - 1940 were measured in July: Novi Sad 39.0^0 C, Belgrade $39,4^0$ C, Zaječar 41.4^0 C, Kragujevac 41.7^0 C, Kruševac 42.2^0 C, Niš 41.6^0 C and Vranje 39.0^0 C (Milosavljević, 1948). The meteorological measurements in the period 1951 - 2005 at 37 weather stations in Serbia show that, on two thirds of Serbian territory, mean summer temperature increased by more than 1^0 C/100 years. The analysis of summer temperature trends over the period 1981 – 2005 indicates that the trend in Serbia is greater than 6^0 C/100 years (Popović, 2007). The increase in annual air temperature in Serbia started in 1983, and over the last fifty years, the precipitation in summer periods has shown the decreasing trend. The negative tendencies are greater in eastern parts of the country. In the period 1951 - 2005 in Negotinska Krajina, annual precipitation decreased by more than 30% in 50 years (Popović, 2007).

Significant results are obtained by the analysis of heat waves using climate index for Belgrade and Niš. The length and intensity of heat waves was determined based on daily maximal values of air temperature in winter (December, January and February) and summer seasons (June, July and August). Heat Wave Duration Index is defined as "the period of five successive days with the value of maximal air temperature (Tmax) higher by 5^0C than the mean Tmax for the period 1961 – 1990" (Drljača, et al. 2009). Based on the above results, it can be concluded that the climate in Belgrade and Niš is continental climate. This is pointed to by a higher annual temperature amplitude compared to maritime type and a higher quantity of precipitation in summer than in winter. The analysis of heat waves over the period 1948 – 2007 shows that the shortest waves of 6 days had the greatest frequency. In Niš, there was a higher number of heat waves both in winter and in summer. These waves lasted longer and were more intensive than heat waves in Belgrade, because of the more expressed continentalness in Niš. It is significant that, from mid eighties, heat waves are more frequent and occur averagely each year. The most significant heat wave was recorded in Niš in 1952. It lasted for 21 days and reached the value of 100.3 ^{0} C. From 1985, some waves in Niš lasted for 14 and 15 days. An especially severe wave was recorded in Niš from July 15th to July 24th 2007 and it reached 74.8^0 C. In Belgrade, there were frequent heat waves after 1985, but none of them exceeded 100^0 C (Drljača, et al. 2009).

Effects of climate and other environmental factors on Hungarian oak and Turkey oak forests in Serbia

The alliance of Hungarian oak and Turkey oak (*Quercion frainetto* Ht. 1954) consists of thermophilous broadleaf forests of Hungarian oak and Turkey oak which make the zonal vegetation of South-eastern Europe. This alliance includes the entire Moesian Province: Serbia, Macedonia, Bulgaria, southern Romania, parts of eastern Bosnia and northern Greece (Horvat, et al. 1974; Jovanović, 1997; Tomić, 2004). These forests range over the hilly terrains up to the altitude of 600 m, on flat lands and gentle slopes outside the humid effects of river valleys.

Forest of Hungarian oak and Turkey oak – *Quercetum frainetto-cerridis* Rudski (1940) 1949 is a climatogenic community in Serbia. It occupies predominantly the flat and undulated hilly lands up to the altitude of 600 m, on different parent rocks, most often over the Tertiary lacustrine deposits. The soils are: brown forest soils, leached brown forest soils, acid brown soils, eutric brown soils, smonitzas (Tomanić, 2004).

According to Koppen climate classification, Serbia has a temperate continental climate. However, many climatologists consider that the climate in Serbia is highly differentiated. According to the latest climate zonation in Serbia, there are three climate zones which are divided into several sub-zones (Ducić, Radovanović, 2005). Continental climate prevails in Vojvodina, the Peri-Pannonian fringe, Pomoravlje and eastern Serbia as far as the river Nišava. Temperate continental climate prevails south of the continental climate to the border of Metohija. The third climate zone has a modified Mediterranean climate (Rakićević, 1980). This climate zone covers Metohijska Kotlina, Šara and Prokletije.

The survey of forest vegetation syntaxa in Serbia (Tomić, 2006) shows a great number of associations of the Hungarian oak and Turkey oak community. There are five geographical variants which can be related to the above mentioned climate zones. The geographical variant is represented by a part of the association range, which by its physiognomy and floristic composition, reflects the specific climate and floral-geographical features.

Forest of Hungarian oak and Turkey oak with butcher's broom – *Quercetum frainetto-cerridis* Rudski (1940)1949 var. geograph. *Ruscus aculeatus* B. Jovanović 1951 (sin. *Rusco-Quercetum frainetto-cerris* B. Jovanović 1951) is distributed in northern Šumadija and north-eastern Bosnia on the shore of the former Pannonian Sea. This forest is characteristic of Belgrade and its surroundings (Košutnjak, Lipovica, Avala). This community is distributed in the zone of continental climate. The community is characterised by the presence of butcher's broom (*Ruscus aculeatus*) which belongs to the Sub-Mediterranean floral-geographical element.

Forest of Hungarian oak and Turkey oak with eastern hornbeam – *Quercetum frainetto-cerridis* Rudski (1940) 1949 var. geograph. *Carpinus orientalis* B. Jovanović 1953 (sin. *Carpino orientalis-Quercetum frainetto-cerris* (Knapp (1944) B. Jov. 1953) is a climate-zonal community in eastern and north-eastern Serbia (Jovanović, 1954, 1956, 1997). The characteristic climate region of this forest is between Niš, Pirot and Leskovac. This community ranges within the climate zone with continental climate, but it is much more thermophilous than the community of Hungarian oak and Turkey oak with butcher's broom.

The differential species of the community is eastern hornbeam (*Carpinus orientalis*) which prevails in the shrub layer. By regressive succession – degradation, these forests of Hungarian oak and Turkey oak degrade into eastern hornbeam low forests and brushwood.

The community of Hungarian oak and Turkey oak with walnut - *Quercetum frainetto-cerridis* (Rudski 1940) 1949 var. geograph. *Juglans regia* Vukićević 1974 (sin. *Juglando-Quercetum frainetto-cerris* Vukićević 1974) is distributed in the region of the river Drina, on its right side from Bajina Bašta downstream to Mali Zvornik and Banja Koviljača. The climate is temperate continental. The forest occurs on limestone up to the altitude of 500 m.

Forest of Hungarian oak and Turkey oak with hop hornbeam – *Quercetum frainetto-cerridis (*Rudski 1940) 1949 var. geograph. *Ostrya carpinifolia* Vukićević 1979 (sin. *Ostryo-Quercetum frainetto-cerris* E. Vuk. (1976) 1979) ranges in western Serbia and on Gučevo (Vukićević, 1976). The climate is temperate continental, conditioned by orographic-edaphic factors. It grows over limestone and dolomite. The soil is brownised rendzina.

Kosovsko-Metohijska forest of Hungarian oak and Turkey oak – *Quercetum frainetto-cerridis* (Rudski (1940) 1949 var. geograph. *Moltkia doerfleri* Krasniqui 1972 (sin. *Quercetum frainetto-cerris scardicum* Krasniqui F. 1972) is a climate-zonal community of Kosovo and Metohija (Krasniqui, 1972), with a modified Mediterranean climate (Rakićević, 1980).

In addition to five geographical variants of Hungarian oak and Turkey oak forests, forest of Hungarian oak of the Moesian region – *Quercetum frainetto* B. Jovanović 1976 (sin. *Quercetum frainetto moesiacum* B.Jov. (1967) 1976 s.l.) is also significant. Its range is in the far north-east of Serbia, in Negotinska Krajina, in the area of Brza Palanka and Zaječar (Jovanović, et al. 1982). This forest is distributed on leached soils at the altitude of 100 – 300 m. Because of very contrasting continental climate in this part of eastern Serbia, with very low winter temperatures and excessive summer droughts, the community of Hungarian oak in this part of Serbia has a zonal character.

In addition to the typical climate-zonal forest of Hungarian oak and Turkey oak (*Quercetum frainetto-cerridis* Rudski (1940) 1949) in Serbia, there are numerous subassociations representing different ecological variants of the typical forest: subass. *hieracietosum, nudum, carpinetosum betuli, quercetosum roboris.*

It should be mentioned that the spatial map of the former Yugoslavia, included the biome of Sub-Mediterranean forests with oaks (Hungarian oak and Turkey oak) in Serbia, which was characterised by the communities: *Quercetum frainetto-cerris* Rudski (1940) 1949 and Moesian forest of Hungarian oak - *Quercetum frainetto moesiacum* B. Jovanović, 1976. (Matvejev, Puncer, 1989).

Effect of summer drought on Hungarian oak and Turkey oak forest

The study of microclimate in different Hungarian oak and Turkey oak stands shows that summer drought desiccates the surface soil layers, and that relative air humidity has low values in the layer of herbaceous plants and shrubs. The complex biocoenological research of the community of Hungarian oak and Turkey oak on Avala shows that summer drought affects the CO_2 release from the soil and the abundance of microorganisms in the soil. In some cases, it can lead to physiological drought. The excessive transpiration can lead to plant dying. For this reason, many plant species in the herbaceous plant layer in the community of Hungarian oak and Turkey oak flower and fructify in June, before summer droughts (Borisavljević, et al. 1974).

The principal edificators of the Hungarian oak and Turkey oak community are adapted to summer drought conditions. Hungarian oak is a xerothermic species. It can tolerate sharp temperature fluctuations and it is resistant to low and high temperatures. During the summer drought, it preserves water within certain limits, which is concluded based on the low variations in transpiration in summer months (Janković, et al. 1967). Hungarian oak thrives best on deeper soils, such as brown forest soil over siliceous bedrock. It avoids limestones and loess, so the absence of Hungarian oak in the forest communities does not indicate forest degradation, but the fact that this species cannot grow on such sites. Thus, for example the absence of Hungarian oak on loess on Mt. Fruška Gora points to the presence of a much more xerothermic plant community of the type *Orno-Quercetum cerris virgilianae* Jov. et Vuk. 1977, which is described by Z. Tomić (1991) as a xerophilous potential vegetation in southern Pannonia. In contrast to Hungarian oak, Turkey oak grows also on limestone and on siliceous bedrock and it has a larger ecological-coenological range. It grows within the most thermophilous communities with lilac (in Đerdap) and the most mesophilous forests with hornbeam and beech. However, in Negotinska Krajina, Turkey oak regeneration is poor in the community *Quercetum frainetto* B. Jovanović 1976. In the continental climate of Krajina, Turkey oak is vital only in the gullies in the community of Hungarian oak and Turkey oak (Jovanović, et al. 1982; Kalinić, et al. 1984; Dinić, 1994).

During summer drought, the surface soil layers are desiccated, which leads to a higher competition among the plants for soil moisture. In this period, Hungarian oak and Turkey oak form fruits and their moisture demands are higher. The greatest competition is in the top soil layer to the depth of 20 cm, with a great quantity of physiologically active roots (Dinić, Mišić, 1973). In such conditions, many plant species die. If summer drought period lasts for several days, it causes foliage dying on flowering ash and cornelian cherry. Oak foliage does not die, although the transpiration is reduced, its foliage just turns yellow. It is significant to note that, in addition to considerably reduced moisture in the soil, the allelopathic effect of dominant species of herbaceous plants and shrubs increases. In the facies composed of *Lonicera caprifolium,* there is a great concentration of active metabolites from the foliage, stems and roots of this species during summer drought period (Mišić, et al. 1978). In the conditions of submontane climate in Serbia (summers warm and dry), in Hungarian oak and Turkey oak forest, a large quantity of choline accumulates on the foliage of the species *Lonicera caprifolium*, which can be seen with naked eye in the form of fine white powder. During summer drought, when the competition for soil moisture increases significantly, there is a possibility of the inhibitory effects of active substances on other herbaceous plants in the community and the reduction in their abundance (Dinić, 1984, 1994).

The above observations show that thermophilous species in the community of Hungarian oak and Turkey oak are adapted to summer drought, and in this way also to some climate changes which can be expected in future.

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AIR POLLUTION EFFECTS ON STOMATAL DENSITY OF HORSE CHESTNUT AND LIME IN BANJALUKA CONDITIONS

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Abstract: *The aim of this paper is to determine the air pollution impact on the stomatal density of investigated woody species horse chestnut and lime in the tested conditions of air pollution of the Banja Luka city. City of Banja Luka is a city known for the greenness and famous green alleys. There were tested listed species because they are in the alleys and parks in the city. Tests were conducted in the West transit, where a daily flow of cars was 23 750 in May 2008. and in Šeher where it is estimated a lower half flow of cars.*

Keywords: Stomatal density, horse chestnut, lime, air pollution.

EFEKTI AEROZAGAĐENJA NA GUSTINU STOMA DIVLJEG KESTENA I LIPE U USLOVIMA BANJALUKE

Izvod: *Cilj rada je da se utvrdi uticaj aerozagađenja na gustinu stoma ispitivanih drvenastih vrsta divljeg kestena i lipe u ispitivanim uslovima aerozagađenja grada Banjaluke. Grad Banjaluka je poznati grad po zelenilu i čuvenim zelenim alejama.Ispitivane su navedene vrste iz razloga što se nalaze u drvoredima i parkovima grada. Ispitivanja su vršena na Zapadnom tranzitu gdje je dnevni protok automobila bio 23 750 u maju 2008. godine i u Šeheru gdje se procjenjuje da je upola manji protok automobila.*

Ključne riječi: Gustina stoma, kesten, lipa, aerozagađenje.

1. INTRODUCTION

Environmental pollution is growing with rapid technical and technological expansion, intensive development of traffic and rapid urbanization (which applies to the observed city of Banja Luka), whose effect becomes significant and great problem in the world frames. Atmospheric air pollution adversely affects the plant world. Air pollution, especially with SO_2, acting on plants especially at high humidity, high light intensity and in the presence of other pollutants in the atmosphere. Author Dässler (1976) states that the openness of stomata and in the presence of large light amounts, SO_2 appears as assimilation retardant which impairs photosynthesis. Gas SO_2 affect the functioning of stomatal apparatus. Concentration of 0,1-0,5 ppm induces stomatal opening. SO_2 causes a stomatal opening in the dark, and this leads to a distortion of a day-night rhythm of stomatal opening and closing, water balance and matter exchange with the external environment. According to data by Caiazza & Qvinn quoted by Dimitriva & Ninova (1994) the stomal number (density) in mm^2 of some plant species is a good indicator of environmental pollution. The analysis of anatomic-morphological structure of plants that grow in terrains of urban environment, show works by Kosev-Čakalova (1992), who procesed issues of structural changes in photosynthetic apparatus of horse chestnut (A.

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hippocastanum) in urban polluted conditions, as well as works by Kosev (1994) , Jordan-Gudeski (2002/2003).

2. MATERIAL AND METHODS

In this work is used plant material from two woody species: horse chestnut (Aesculus hippocastanum) and lime (Tilia). Work consisted of two parts: field and laboratory part. Field part of the research, which consisted of collecting plant material, conducted 25 May 2008. in Banja Luka. Samples were taken from two sites with different air pollution:

- The first location is West transit, where air pollution is very high, due to the large number of cars that pass that roads.
- The second location is Šeher, where pollution is less, because passing about a third of cars in relation to West transit.

Daily flow of vehicles in West transit is 2375[1]

Air pollution data for May 2008. amounts:
CO - 0.526 mg/m^3, SO$_2$ - 22.718 μg/m^3, NO - 8.765 μg/m^3, NO$_2$ - 15.302 μg/[2],
Soot - 16.246 μg/m^3, Dust - 23.444 μg/m^3.[3]

Leaves samples were taken from two positions on the tree: the first position with the external parts of tree crown (the light) that are with complete lighting of leaf; second position from the interior of crown tree (darkness), with less light.

With the back of selected leaves of horse chestnut and lime (10 leaves x 3 per preparation) stomatal samples are taken by standard method (Petrović, Štrbac, 1996). Thus made preparation can be stored and used for several years. Prepared preparations were observed under light microscope, where stomatal number in the visual field is determined, the size of the visual field is determined. Based on the counted stomatal number in the visual field, as well as established size of the visual field, stomatal density of investigated woody plant species with different ecological habitats was calculated. After calculation, the obtained results were statistically analyzed, and significance of interaction relations between modalities were analyzed by multifactorial analysis method based on the model 2 x 2 x 2 (Hadživuković, 1977).

3. RESULTS AND DISCUSSION

Results of the study, stomatal density on the leaves of examined species horse chestnut and lime in various conditions of air pollution will be exhibited in two parts:

- tabular overview of tested indicators,
- graphical representation of the observed and tested indicators.

Number 1*, 2* 3* in Table 1 represents the average of 30 individual values of stomatal density.

Reviewing data from the 1st table shows that the minimum value of stomatal density was observed in the lime on W. transit in darkness (136), while the largest was observed in chestnut of Šeher in the light (390).

Analysis of stomatal density variance on leaves of examined species horse chestnut and lime shows a statistically high significant effect of place (geographical location) and leaf position on the tree.

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[1] Administrativna služba grada Banjaluka, odsjek za saobraćajne poslove

[2] Zavod za ekologiju i zaštitu đivotne sredine, Banjaluka.

Interactive effects in relationship location x site show highly significant statistical impact, while the interactive relationship species x site shows that the differences manifested in the stomatal density of the examined species are statistically significant, while other interactive relationships species x location and species x location x position do not show statistical significance.

Table 1. *Stomatal density in leaves of examined species horse chestnut and lime*
Tabela 1. *Gustina stoma na listovima ispitivanih vrsta divljeg kestena i lipe*

<table>
<tr><th>Species (A)
Vrsta (A)</th><th colspan="4">Horse chesnut / Kesten</th><th colspan="4">Lime/ Lipa</th></tr>
<tr><th>Place (B)
Mjesto (B)</th><th colspan="2">W.transit
Z.tranzit</th><th colspan="2">Šeher</th><th colspan="2">W.transit
Z.tranzit</th><th colspan="2">Šeher</th></tr>
<tr><th>Location (C)
Položaj (C)</th><th>light svjetlo</th><th>shade tama</th><th>light svjetlo</th><th>shade tama</th><th>light svjetlo</th><th>shade tama</th><th>light svjetlo</th><th>shade tama</th></tr>
<tr><td>1*</td><td>200</td><td>163</td><td>390</td><td>173</td><td>227</td><td>136</td><td>345</td><td>137</td></tr>
<tr><td>2*</td><td>227</td><td>168</td><td>281</td><td>200</td><td>318</td><td>154</td><td>336</td><td>154</td></tr>
<tr><td>3*</td><td>190</td><td>178</td><td>327</td><td>210</td><td>326</td><td>228</td><td>358</td><td>209</td></tr>
<tr><th colspan="9">Interaction of first rate/ Interakcija I reda</th></tr>
<tr><th colspan="2">Species
Vrsta</th><th colspan="3">Place
Mjesto</th><th colspan="4">Location
Položaj</th></tr>
<tr><td>Horse ch
Kesten .</td><td>225,58</td><td colspan="2">W.transit
Z.tranzit</td><td>209,58</td><td colspan="2">light
svjetlo</td><td colspan="2">293,75</td></tr>
<tr><td>Lipa
Lime</td><td>243,50</td><td colspan="2">Šeher</td><td>259,92</td><td colspan="2">shade
tama</td><td colspan="2">175,75</td></tr>
<tr><th colspan="9">Interaction of second rate / Interakcija II reda</th></tr>
<tr><th colspan="3">AB</th><th colspan="3">AC</th><th colspan="3">BC</th></tr>
<tr><th>Place
Mjesto</th><th>Horse ch. Kesten</th><th>Lime
Lipa</th><th>Location
Položaj</th><th>Horse c.
Kesten</th><th>Lime
Lipa</th><th>Location
Položaj</th><th>W.tra.
Z.tran</th><th>Šeher</th></tr>
<tr><td>W.transit
Z.tranzit</td><td>187,67</td><td>231,50</td><td>light svjetlo</td><td>269,17</td><td>318,33</td><td>light svjetlo</td><td>248,00</td><td>339,50</td></tr>
<tr><td>Šeher</td><td>263,50</td><td>256,33</td><td>shade tama</td><td>182,00</td><td>169,50</td><td>shade tama</td><td>171,17</td><td>180,33</td></tr>
</table>

Table 1a. *Analysis of stomatal density variance in leaves of examined species horse chestnut and lime*
Table 1a. *Analiza varijanse gustine stoma na listovima ispitivanih vrsta divljeg kestena i lipe*

Sour. of variation Izvori varijacija	Deg. of freed. Step. slobode	Mean squar. Sred.kvad.	F – test	F		F-sign.
				0,05	0,01	
Blocks/Blokovi	2	2198,00	1,80	3,44	5,72	nz
Species/Vrsta (A)	1	2016,67	1,65	4,30	7,94	nz
Place/Mjesto (B)	1	15200,67	12,43	4,30	7,94	**
Location/Položaj (C)	1	83544,00	68,34	4,30	7,94	**
AB	1	3901,50	3,19	4,30	7,94	nz
AC	1	5704,17	4,67	4,30	7,94	*
BC	1	10168,17	8,32	4,30	7,94	**
ABC	1	600,00	0,49	4,30	7,94	nz
Error/Pogreška	14	1222,52				
Total/Ukupno	23					

not statistically significant/ ^{nz} статистички није значајно
statistical significance/* статистичка значајност
high statistical significance / **статистички висока значајност

In interactive relationship of stomatal density on leaf of examined species horse chestnut and lime (graph 1.) is seen higher stomatal density on lime leaf (243,92) compared to the horse chestnut (225,58), regardless of geographical location and leaf position on the tree.

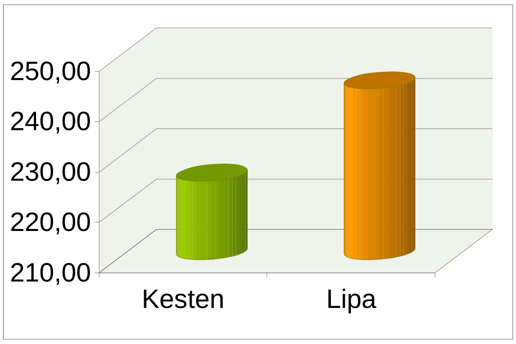

Chart 1. *Stomatal density in the interaction relation of examined species*
Grafikon 1. *Gustina stoma u interakcijskom odnosu ispitivanih vrsta*

The observation of interaction relationship of stomatal density on examined species leaf depending on the geographic location of the examined species (chart 2.) is seen higher stomatal density on leaf in Šeher (259,92) compared to W. transit (209,58) regardless of examined species and leaf position on the tree, which agrees with the results by Kosev, Čakalova (1992).

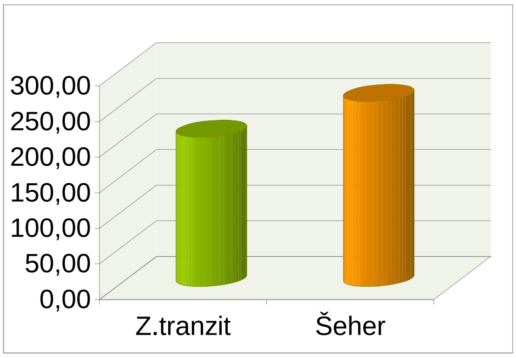

Chart 2. *Stomatal density in the interaction relation of examined rearing places*
Grafikon 2. *Gustina stoma u interakcijskom odnosu ispitivanih mjesta gajenja*

If is observed interactive relationship of stomatal density on examined species leaf depending on the leaf position on the tree (chart 3.), is seen higher stomatal density on leaf in the light (293.75) compared to the dark (175.75), regardless of species and geographic location of examined species.

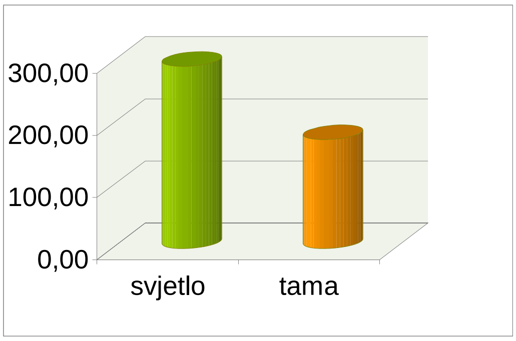

Chart 3. *Stomatal density in the interaction relation compared to the leaf position at the tree*
Grafikon 3. *Gustina stoma u interakcijskom odnosu položaja lista na stablu*

In interactive relationship of stomatal density of examined species horse chestnut and lime, and geographic location (chart 4.) is seen that the stomatal density is higher in both examined species in Šeher (263.,50 and 256,33) and less on W. transit (187,67 and 231,50), regardless of leaf position on the tree, which agrees with the results by Kosev, Čakalova (1992).

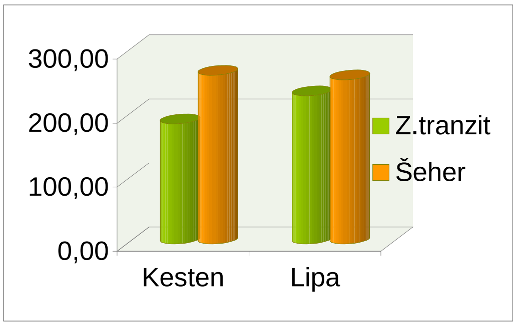

Chart 4. *Stomatal density in the interaction relation of examined species and rearing places*
Grafikon 4. *Gustina stoma u interakcijskom odnosu ispitivanih vrsta i mjesta gajenja*

If is observed interactive relationship of examined species and leaf position on the tree (chart 5.) is seen higher stomatal density on leaf of horse chestnut and lime in the light (269,17 and 318,33) in relation to the horse chestnut and lime in the dark (182,00 and 169,508), regardless of geographic location of examined species.

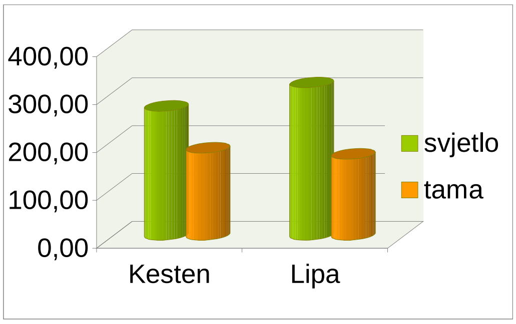

Chart 5. *Stomatal density in the interaction relation of examined species and position at the tree*
Grafikon 5. *Gustina stoma u interakcijskom odnosu ispitivanih vrsta i položaja na stablu*

Observed interactive relationship of geographical location and leaf position on the tree shows that the stomatal density on leaf of examined species (chart 6.) is higher in the light in W. transit and Šeher (248,00 and 339,50) in comparison to the darkness at the same locations W. transit and Šeher (171,17 and 180,33), regardless of examined species horse chestnut and lime.

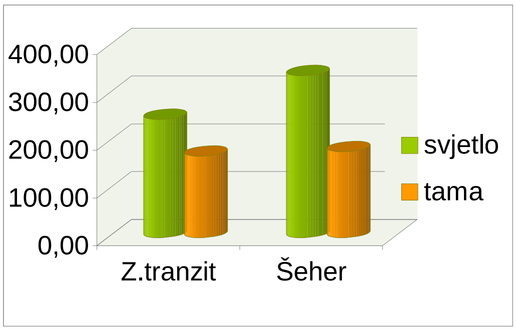

Chart 6th. *Stomatal density in the interaction relation of rearing places and the position at the tree*
Grafikon 6. *Gustina stoma u interakcijskom odnosu mjesta gajenja i položaja na stablu*

4. CONCLUSION

City of Banja Luka is a city known for the famous greenness and green alleys. Listed species are examined because they are in alleys and parks in the city. Environmental pollution is growing with rapid technical and technological expansion, intensive development of traffic and rapid urbanization (which applies to the observed city of Banja Luka), whose effect becomes significant, a great problem in the world frames. Atmospheric air pollution adversely affects the plant world.

Based on testing, behavior of examined species horse chestnut and lime in different polluted areas of Banja Luka city, it can be concluded that:

- Geographical location (W. transit and Šeher) shows a highly significant dependence of stomatal density on leaves of examined woody species (horse chestnut and lime) from air pollution
- Leaf position on the tree (light and darkness) shows a highly significant dependence of stomatal density on leaves of examined woody species (horse chestnut and lime) from air pollution.
- Interaction relationship species x position shows a significant dependence of stomatal density on leaves of examined woody species (horse chestnut and lime) from air pollution.
- While the interactive relationship site x position shows a highly significant dependence of stomatal density on leaves of examined woody species (horse chestnut and lime) from air pollution.

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ANALYSIS OF MORPHOLOGICAL PARAMETERS OF THE LEAF OF WILD CHERRY (*PRUNUS AVIUM* L.) FROM BOSNIA AND HERZEGOVINA

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Abstract: *The objective of this investigation has been to obtain a clear insight into the individual and population variability of the leaf of wild cherry (Prunus avium L.) by means of statistical analyses. Attempts have been made to avoid the pitfalls observed in the works of other authors and those encountered in the course of the preliminary investigation.*

Based on the conducted investigation, recommendations have been made for selection of trees and a methodology has been designed for collecting leaf samples for further analyses.

The collected materials (20 populations, around 30 trees per population and around 30 leaves per tree) were subjected to multivariate, univariate and descriptive analyses in order to obtain a clear insight into the variability of wild cherry on the territory of Bosnia and Herzegovina. Among examined populations five of them were control populations from Switzerland, Slovenia, Croatia and Serbia.

Multivariate analysis was found to be most convenient for data processing. The UPGMA method of clustering exhibited the best fit with the original matrix of distances (r0 = 0.43). This method showed that the 15 clusters may be divided into 3 groups and 3 subgroups. The cluster analysis indicated that individual groups comprised geographically distant populations. Site and vegetation analyses showed that the clusters contained elements that characterized them as thermophilous phytocoenoses. The first and third cluster contained mesophilous floristic elements.

The descriptive analyses exhibited similarities with the multivariate analysis. The PCA method turned out to be unsuitable for this kind of research since the analyzed populations could not be classified on the basis of the analyzed characteristics.

The purpose of this investigation is to provide a better insight into the genetic diversity of the local wild cherry populations in order to make plans relative the establishment of seed bases and maintenance of the wild cherry gene fund of Bosnia and Herzegovina.

Key words: wild cherry, population, leaf, gene fund, seed basis

1. INTRODUCTION

Genus Prunus L. consists of numerous species (around 200), mostly broadleaved, that are naturaly distributed in the northern hemisphere (Russel, 2003).

The wild cherry (Prunus avium L.) is especially important among others for high economic value. Many important cultivars of domestic cherry are derived from wild cherry. It is one of the oldest economically utilized fruit trees. It attracted attention of humans by pleasant taste and early ripening of fruits in far past. The wood of wild cherry is valuable on the market, as an imitation of mahogany in furniture production. It is suitable for the establishment of wind shelters as it is decorative, attractive to bees, with nutritional and pharmaceutical value, and with well valued wood.

According to its biological properties of income and yield, the wild cherry is grouped in fast-growing species, with the rotation of 40-60 years. From ecological aspect, it is very important for its high adoptability. It is distributed from riparian zones up to the area of mountainous beech, at the high boundaries of the forest vegetation. It is mostly abundant on the

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edges of forests and on the places occupied by bird that preformed very important part in the seed spreading.

The first work on the variability of wild cherry in Bosnia and Herzegovina started in 1990 but they were interrupted by war (Mikić, 1991). However, several studies have been done in past 10 years, mostly on few local populations, based on morphological and molecular markers (Ballian 2000, 2002, 2004). Multivariate approach based on morphological leaf characters in forest tree species are intensified on the area of former Yugoslavia in last decade of 20th century (Franjić 1996, Kovačević et al., 1999)

2. MATERIAL AND METHODS

2.1. The area of research

Wild cherry material was collected from the main ditribution areas of wild cherry in Bosnia and Herzegovina,from three main phytogeografic province. Leaves for morphometric analysis come from 15 populations of wild cherry in Bosnia and Herzegovina, one from eastern Serbia, one from central Switzerland, one from southwestern Slovenia, and two populations from western Croatia. Following population were examined:

- in Bosnia and Herzegovina: in Mrkovići (43°52'N18°26'E, 785 m.a.s.l.), Trnovo (43°44'N18°49'E, 980 m.a.s.l.), Ilijaš (43°57'N18°15'E, 485 m.a.s.l.), Kakanj (44°07'N18°06'E, 550 m.a.s.l.), Tomislav Grad (43°41'N17°19'E, 890 m.a.s.l.), Bosansko Grahovo (44°11'N16°22'E, 864 m.a.s.l.), Cazin (44°56'N15°57'E, 385 m.a.s.l.), Ključ (44°32'N16°46'E, 290 m.a.s.l.), Sanski Most (44°46'N16°38'E, 160 m.a.s.l.), Goražde (44°39'N19°36'E, 515 m.a.s.l.), Čelić (44°42'N18°49'E, 180 m.a.s.l.), Olovo (44°09'N18°32'E, 530 m.a.s.l.), Srbac (45°05'N17°33'E, 180 m.a.s.l.), Kladanj (44°14'N18°45'E, 550 m.a.s.l.), Uskopolje (43°56'N17°35'E, 710 m.a.s.l.)
- in Swizerland: Cirih (47°28'N08°33'E, 450 m.a.s.l.)
- in Serbia: Bor (44°08'N22°09'E, 275 m.a.s.l.)
- in Croatia: Gospić (44°31'N15°25'E, 750 m.a.s.l.), Karlovac (45°28'N15°26'E, 190 m.a.s.l.)
- in Slovenia: Kočevski rog (45°32'N14°53'E, 650 m.a.s.l.)

According to the previously developed methodology, particularly in pedunculate and sessile oak, only short fertile shoots were used for leaves sampling in this research. Only normal, healthy and fully developed leaves were examined. The leaves were collected in the second half of the growing period (in August), from the trees on the edge of forest or solitary trees, mostly from south insolated side of the crown. After collecting the leaves the additional selection was performed in order to eliminate not-fully-developed, damaged or leaves that deviate from the normal phenotype for the genotype or population. The solitary or trees on the edge of the forest, for only those trees can express their genotype completely. In this case, the differences are mainly influenced by genotype and habitat.

In total: 20 populations of wild cherry with 571 trees and 15,998 leaves were analyzed.

2.2. Methods

On each leaf following parameters were measured: length of leaf blade (DL), length leaf petiol (Dp), width of leaf (ŠL), the lateral vein insertion angle (Kn) and the number of teeth on 2 cm of leaf edge (BZ). All parameters except BZ were measured with an accuracy of 1 mm.

The data analysis included analysis of variance – nested design and Cluster analysis with UPGMA linkage method.

3. RESULTS

3.1. Results of analysis of variance

According to analysis of variance for all five examined populations, there was significant variation among and within examined populations of wild cherry.

Differences among trees and populations for the length of leaf blade (DL), length of leaf petiole (Dp), leaf width (ŠL), insertion angled for lateral vein (Kn) and number of teeth on 2 cm of leaf edge (BZ), are examined by analysis of variance – nested design. As the F-tests are significant, it could be concluded that there are significant differences among populations as well as among genotypes within populations for all analyzed parameters (Tab. 1).

Table 1. *Results of analysis of variance – nested design for five examined leaf parameters of wild cherry*

Parameter	Source of origin	Degree of freedom	Sum of Squares	Mean Squares	F-test
Length of leaf blade (DL)	Population	19	864259,2	45487,32	296,36**
	Genotype (within population)	552	844847,4	1630,52	9,97**
Length leaf petiol (Dp)	Population	19	125680,1	6614,74	320,36**
	Genotype (within population)	552	213398,9	386,59	18,72**
Width of leaf (ŠL)	Population	19	255073	13424,89	401,48**
	Genotype (within population)	552	296082,5	536,38	16,04**
Lateral vein insetrion (Kn)	Population	19	136865,2	7203,43	337,46**
	Genotype (within population)	552	122625,9	222,15	10,41**
Number of teeth on 2 cm of leaf edge (BZ)	Population	19	10624,38	559,18	393,72**
	Genotype (within population)	552	11527,55	20,88	14,70**

Also, F-ratio suggests far higher differences among population than among trees within populations. The significance of differences among populations are confirmed also by Duncan tests (data not shown).

Correlation coefficients among five examined parameters: DL, Dp, SL, Kn and BZ were mostly low or moderate (data not shown) suggesting that all of them contribute specific information to the discrimination of examined populations. In that sense all of them were included in further multivariate analysis.

Table 2. *Results of one-way analysis of variance for five examined leaf parameters of wild cherry (factor – all trees i.e. genotypes)*

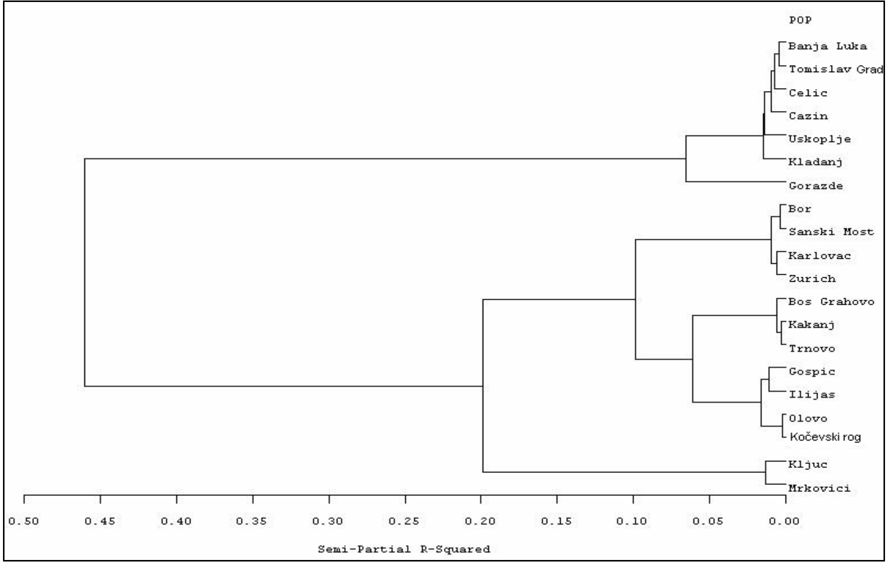
Parameter	Degree of freedom	Error	F-test	Contribution of genotype to the total expected variance (ratio)
Length of leaf blade (DL)	571	15287	9,40**	0,42
Length leaf petiol (Dp)			28,98**	0,52
Width of leaf (ŠL)			28,98**	0,52
Lateral vein insertion (Kn)			21,48**	0,44
Number of teeth on 2 cm of leaf edge (BZ)			27,48**	0,51

From the results of single analysis of variance (analysis of variance for each parameter analyzed population) is visible that there is considerable variability among leaves within trees, which makes it harder to differentiate populations and trees within populations. The contribution of genotypes to the total expected variation for all examined leaf parameters varied from 40-50%, which means that 50-60% of the variability may refer just to the differences among leaves within genotype. However, as the differences among populations and trees within populations were statistically significant it could be said that the applied method of sample formation in this work was appropriate (Tab.2).

3.2. Results of cluster analysis

Cluster analysis was performed in order to present relations and grouping among examined population according to this examined leaf parameters (Graph 1).

Graph 1. *UPGMA-linkage dendrogram for examined populations of wild cherry according to leaf parameters*



This method allows one to condense the data in order to present relations among objects in a clear and simple way. The UPGMA linkage method was applied because the cofenetic correlation coefficients, the coefficients that show correlation between distances among populations before and after the linkage method is applied (r_c = 0.43). Also, UPGMA method is the most or at least one of the most applied linkage methods in population studies.

According to cluster analysis examined population can be divided into three homogenous groups. In the first cluster are grouped following populations: Banja Luka, Tomislav Grad, Čelić, Cazin, Uskoplje, Kladanj and Goražde. The second group is divided into three subgroups as follows: IIa - Bor, Sanski Most, Karlovac and Zurich, IIb - Bosansko Grahovo, Kakanj and Trnovo, IIc - Gospić, Ilijaš, Olovo and Kočevski Rog. In the third group were classified only two populations: Ključ and Mrkovići.

4. DISSCUSION

Bosnia and Herzegovina and Dinara mountains are very specific in environmental conditions, for on a very small area there is great diversity of climate, soil, relief and other factors that directly affect the differentiation, both individual and population. Therefore, experts believe that the kinds of forest trees with Dinaric areas show great variability, which is also confirmed by results of analysis of variance in work. Our results showed considerable differences among examined populations that are also found in previous research (Rakonjac, 1993; Gomory and Paule, 2001; Ballian 2002, 2004; Ducci, 2005).

According to the results of cluster analysis it appeared that the most distant populations like: Bor, Sanski Most, Karlovac and Zurich are grouped in the same cluster (IIa). We suspect that the reason for this is in dispersion of seeds of cultivated cherries by humans and birds, and in that way their spreading and hybridization with wild cherries.

Analysis of habitat and vegetation showed that these populations were found floristic elements that characterize termophilic associations. That is particularly clear for populations like Bor, Bosnia Grahovo and Kakanj. In populations of first and third clusters were found mesophilic floristic elements.

Relatively small, isolated populations, primarily populations Tomislav Grad and Bosansko Grahovo, showed no difference at morphological level comparing to the populations of the central parts of Dinaric Mountains. Also, these populations preserved significant variation within them, although they suffered the greatest degree of degradation and anthropogenic activities. It could suggest the effectiveness of the selfpolination incompatibility described by Bošković and Tobutt (2001).

In the population studies of wild cherry it should always kept in mind that the key role in seed dispersion of wild cherry is played by birds and mammals that feed on wild cherry fruit. These birds are not migratory and mammals live and breed usually in a narrow area, their activity is constant and crucial for the spread of wild cherry after the last glaciation ended about 11,000 before year. As some previous research on the role of birds in seed dispersion found that the area of their activity exceed the range of greater than three kilometers, the spread of wild cherry should had been at least or even faster than it was found for silver fir (300 m per year towards north).

Humans also played a considerable role in dispersion of wild cherry seed, while birds and mammals were dispersing cherry around the settlements. That is especially case for domestic cultivars of cherry. The good example is the introduction of more or less cultivated species in Europe by Alexander the Great, after the conquest of Persia and the Caucasus. Among various fruits there were domesticated cherries.

In our research, it could not be found any influence of relief components like altitude or exposition on specificities of differentiation of examined populations. The importance of the influence of relief factors on genetic distancing between populations can be detected in many species but we have not found much evidence for our populations. The logical explanation is contained in the broad abundance of cultivated cherries, which are grown in all ecological conditions. The mechanism of survival (adaptation) the same as for wild and cultivated cherry varieties and it practically leads to uniformity of many morphological traits. That could be the reason of the fact that no specificities were found in grouping of populations found on acidic soils or limestone. Also, the clinal variation among populations related to the spread after the last period of glaciation was not found.

On the basis of said it could be assumed that there are large differences among populations but it was hard to relate them to the differences in the ecology of habitat condition. Thus, for the more detailed classification of the examined populations some other markers should be examined.

5. CONCLUSIONS

According to the results of the research following conclusions could be made:

1. This work was carried out on statistical methods of analysis of variance and cluster analysis of leaf parameters of wild cherry populations, which tried to get a clear picture of the variability of wild cherry in B&H. The analysis included a total of 20 populations of wild

cherry, that come from different bioclimatic areas (15 populations from Bosnia and Herzegovina, one population from Switzerland, one from Serbia, two from Croatia and one from Slovenia). Analysis of variance showed significant differences among examined populations and genotypes within populations, and where the variation among populations was more intense than within populations. For more detailed conclusions and work on population studies the influence of environmental factors should be taken in consideration.

2. Cluster analysis performed with UPGMA linkage method allowed concise analysis of grouping of examined populations. By this method 20 population are divided into three groups and three subgroups. The second group of clusters belonging to populations those are geographically very distant to each other. In this group includes the following population: Bor, Sanski Most, Karlovac, Zurich, Bosansko Grahovo, Kakanj, Veliko Tarnovo, Gospić, Ilijaš, Olovo and Kočevski Rog. The termophilic floral elements were primarily characteristic of population of the second cluster (particularly populations Bor, Bosansko Grahovo and Kakanj), while the mesophilic elements characterized populations of the first and third cluster.

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TECHNICAL GUIDELINES FOR SESSILE OAK GENETIC CONSERVATION STRATEGIC PRIORITIES IMPLEMENTATION IN SERBIA

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Abstract: *Sessile oak (Quercus petraea agg. Ehrendorfer 1967) and its populations have significant economic importance in the forestry of Serbia, but also high level of endanger because of forest drying effects caused by acid rains influence. Multidisciplinary approach of the species variability assessment has been applied in this research and considered as a complex of two categories: adaptive variability, affected by environmental factors, and neutral variability, which is not affected. The species genetic variability was estimated applying cpDNA universal primer pairs and five different haplotypes were detected in the analyzed sample material from populations in Serbia. The baseline for genetic conservation strategic priorities programming and implementation has been established by defining of Sessile oak genecological zones, specific genecological regions and high variability level populations with rare haplotypes appearance. The areas in West and Southwest Serbia, with all their specificities, represent an exceptional potential for the conservation of Sessile oak variability, which can have a very significant role for the enhancement of the species adaptability to global climate changes, which are apparently unavoidable. According to the Sessile oak (Quercus petraea agg. Ehrendorfer 1967) Genetic Conservation Strategy general and specific goals, presented in previous researches, Technical guidelines for the species genetic conservation strategic priorities implementation have been established. These Technical Guidelines are intended to assist those who cherish the valuable Sessile oak gene pool and its inheritance, through conserving valuable seed sources or use in practical forestry. The focus is on conserving the genetic diversity and rare haplotypes of the species, especially within specific populations for genetic conservation purposes, selected according to cpDNA variability research results. The Guidelines are based on the available knowledge of the species variability and on widely accepted methods for the conservation of forest genetic resources.*

Key words: sessile oak, Conservation strategy, Technical guidelines

1. INTRODUCTION

Sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) and its populations have significant economic importance in the forestry of Serbia, but also high level of endanger because of forest drying effects caused by acid rains influence. Therefore, multidisciplinary approach of the species variability assessment, as a complex of two categories: adaptive variability, affected by environmental factors, and neutral variability, which is not affected, is considered as necessity for conservation purposes. According to the guidelines for forest genetic resources national program establishment (KJAER and GRAUDAL, 2000), the Genetic Conservation Strategy for sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) in Serbia has been developed (MILOVANOVIĆ, 2009) and contains following general elements: a) Introduction information on strategy modeling necessity and justification; b) Target species explanations (importance, horology, historical data, reproductive biology, ecological and genetic variability with clearly defined replicable methodology of assessment, conservation status and seed material transfer and similar information); c) General and specific strategic goals; d) Recommended conservation methods; e) Precise activities in the area of species genetic conservation (cooperation, partnerships, public awareness and capacity building); and f) Conclusion remarks.

The baseline for genetic conservation strategic priorities programming and implementation has been established by defining of Sessile oak genecological zones, specific

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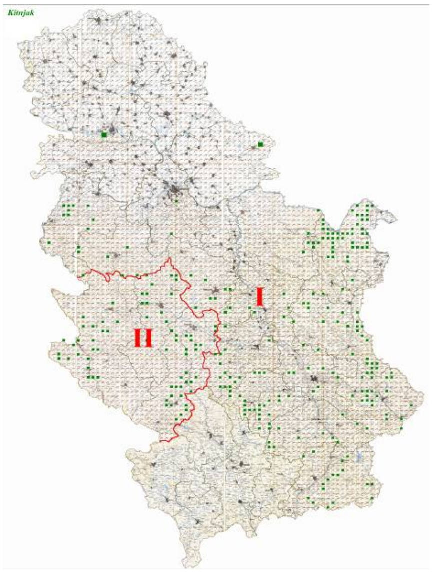
genecological regions (Map 1) (ŠIJAČIĆ-NIKOLIĆ *et al.*, 2009a) and high variability level populations with rare haplotypes appearance (ŠIJAČIĆ-NIKOLIĆ *et al.*, 2009b). The species genetic variability estimation, applying cpDNA universal primer pairs (ŠIJAČIĆ-NIKOLIĆ *et al.*, 2009c), and detection of five different haplotypes in the analyzed sample material from populations in Serbia preceded. According to previous researches, the region of West and Southwest Serbia, with all its specificities, appears as an exceptional potential for the conservation of Sessile oak variability, which can have a very significant role for the enhancement of the species adaptability to global climate changes, which are apparently unavoidable.

The aim of this paper is to implement one of the specific goals of the Genetic Conservation Strategy for sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) in Serbia which implies "rare haplotypes conservation through definition of the Technical guidelines for the species specific genetic conservation populations management".



Map 1: *Genecological regions of sessile oak (Quercus petraea agg. Ehrendorfer 1967) in Serbia (Region II – West and Southwest Serbia)*

2. MATERIALS AND METHODS

Development of the Technical guidelines for sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) genetic conservation populations management in Serbia followed model of technical guidelines for conservation and use of most valuable European forest species established by EUFORGEN (DUCOUSSO and BORDACS, 2004), improved with additional data and information collected through realized researches on the species eco-genetic variability and current conservation status on national level.

Following sections considered as necessary to be included in the Guidelines: I Basic information; II Genetic conservation population ecological characteristics; III Population genetic variability; IV Genetic conservation populations management goals; V Genetic conservation population management program; VI Stakeholders role, responsibilities and rights and VII Monitoring and evaluation.

3. RESULTS AND DISSCUSION

Technical Guidelines for Sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) Genetic Conservation Population Management in Serbia

I Basic information

The Genetic Conservation Strategy for sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) in Serbia has a specific goal on "rare haplotypes conservation through definition of the Technical guidelines for the species specific genetic conservation populations management".

Sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) populations on localities Zlatibor, Goč and Prijepolje, within the genecological region of West and Southwest Serbia, according to the results of cpDNA polymorphism assessment, are characterized with rare haplotypes appearance, specific only for these populations. Therefore, the species populations from mentioned localities are selected as target populations for inclusion into the genetic conservation program.

Sessile oak populations on the territory of Zlatibor and Prijepolje are managed by the PE "Srbijašume", while management of populations at Mt Goč is responsibility of the Faculty of Forestry University of Belgrade.

II Genetic conservation population ecological characteristics (summary)

Populations of Sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) from the localities Zlatibor, Goč and Prijepolje within the Region II are characterized, according to the results of cpDNA polymorphism analyses, with rare haplotypes appearance. Therefore, following populations deserve special attention in future conservation activities:

- Zlatibor (MU „Čavlovac", Zaton – 600-800 m altitude; MU „Čavlovac", Krstina – 800-1000 m altitude; MU „Čavlovac", Ljeskovac – above 1000 m altitude);
- Goč (populations between 400 and 800 m altitude);
- Prijepolje (MU „Šerbetovac", department 25, division c – above 1000 m altitude).

III Population genetic variability (summary)

Five different haplotypes were detected in the analyzed sample material from Sessile oak populations within defined genecological zones, applying restriction fragment length polymorphism analyses for the AS and DT segments of cpDNA, with fully described methodology within the Genetic Conservation Strategy for sessile oak.

Applying cpDNA variability assessment of individuals from Zlatibor area, appearance of two haplotypes has been detected – **haplotype 1**, in presence on the whole territory of Serbia, and **haplotype 2**, specific for mountains Zlatibor and Goč.

Populations from Mt Goč are even characterized with three different haplotypes – haplotype 1, haplotype 2, specific for Zlatibor and Goč and **haplotype 5**, in presence only in these populations.

Sessile oak stand in Prijepolje is also characterized with three different haplotypes – haplotype 1, **haplotype 3** and **haplotype 4**, detected only at this locality.

Haplotype 2, 3, 4 and 5 are characterized as rare parts of the species gene pool, because of their appearance at restricted, narrow localities, unlike haplotype 1 which is detected in all populations in Serbia.

IV Genetic conservation populations management goals

All specific genetic conservation populations of sessile oak in Serbia, with rare haplotypes appearance, can be related to two main conservation goals (KRUGMANN, 1984; LEDIG 1986; ZIEHE *et al*., 1989):

- conservation of environmental adaptability and
- conservation of genetic diversity and genetic adaptability.

Because the genetic structure of a population is seen as the result of long lasting selection driven by environmental factors, local genetic resources are believe to be adapted to current habitat conditions and therefore are viewed as the most valuable resources. This may especially be the case for populations occurring under extreme habitat conditions. Object of conservation are therefore autochthonous gene pool while other genetic resources are of inferior value from this perspective (ROTACH, 2005). This conservation goal is of special consideration for populations at localities Zlatibor and Goč, characterized with specific geological base (serpentinite and peridotite) and, therefore, complete habitat conditions.

The second conservation goal is focusing on the conservation of genetic adaptability of the species or the conservation of a maximum of genetic diversity within the aggregate. Genetic adaptability conservation is the main goal for the population of Sessile oak in Prijepolje, characterized with rare haplotype appearance but of usual habitat conditions for Sessile oak forests. In addition, phenotypic (genetic) variation is also important for both improvement of economically important traits in the future and protection of these products by breeding for resistance traits against all kind of negative influence of abiotic and biotic factors. In order to capture as many genes as possible, especially rare or unique genes, populations to be conserved for this goal are commonly selected among autochthonous gene pools which possibly sample a variety of different environments and have experienced little human influence (ROTACH, 2005).

V Genetic conservation population management program

According to the Genetic Conservation Strategy for sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) in Serbia, conservation and sustainable use of the species most valuable genetic resources have to be realized as follows:

in situ – through rare haplotypes selection within specific populations and new seed objects establishment within the Region II (genecological zone of West and Southwest Serbia);

ex situ – establishment of provenance trials, live archives, clonal and generative seed orchards.

Management regime of specific populations at localities Zlatibor, Goč and Prijepolje should be in relation with *in situ* conservation rules and expectations. Appropriate conservation method for these populations is “Natural populations in normal management regime”, which implies conversion of population to seed stands or selection of individual or groups of individual trees within the populations, with implementation of regular management measures defined in the management plan. Therefore, population function has to be changed from production to protection or seed production for the next management period (especially for the population in Prijepolje, with the main function of technical wood production while there is no technical wood amount in this population, according to the official management plan). Selection of individual trees or groups of trees should be based on haplotypic identification, applying cpDNA variability assessment methodology described in the Strategy with the specific goal on “further assessments of intrapopulation genetic variability at specific localities, applying described methodological approach, with the aim of rare haplotypes marking and individual level variability defining”. Individuals identified as rare haplotypes (haplotypes 2 and 5 in Zlatibor and Goč, and haplotypes 3 and 4 in Prijepolje) should be under special attention.

Seed transfer should be organized within the same provenance region with the aim of genetic variability specificity of the region conservation. In some cases, seed transfer between regions could be positive, if seed is transferred from Region II to other areas in Serbia, because genetic variability level of the species populations could be increased and the area of rare haplotypes appearance become wider.

Regeneration of the species genetic conservation populations is one of the main questions in management process. Rare haplotypes inheritance is very important, especially through natural regeneration, but artificial regeneration is also desirable if the effects of natural regeneration process are not sufficient. Regeneration process should be followed with periodical molecular research because genetic differences between mature and young individuals, applying adequate silvicultural measures, could be reduced to minimum extent. Vegetative regeneration could be applied in population in Prijepolje, because it is coppice forest. Air or soil laying, cuttings and grafting can be possible vegetative regeneration techniques. However, this way of regeneration should be applied with the aim of rare haplotypes lifetime extension only if research activities are not completed or generative regeneration is not realized.

Individual variability assessment is a step forward to “modeling of possible *ex situ* conservation methods for rare haplotypes of sessile oak”. Individuals with identification as rare haplotypes should be selected for progeny trials establishment with the aim of inheritance level and frequency defining for main characteristics. Also, beside adaptability importance, it is necessary to determine rare haplotypes phenotypic traits of economic interest, if there is some, with the aim of implementation of strategic specific goal “inclusion of genetic conservation into the species breeding and improvement commercial programs”. Individuals with positive and desirable traits noticed in progeny trials should be used for generative seed orchards establishment (which is confirmed through unfavorable spatial distribution of existing seed objects of the species described in the Strategy) and live archives. With the aim of further commercialization of genetic conservation, establishment of vegetative orchards for seed production with known ancestry from rare haplotypes should not be avoided.

VI Stakeholders roles, responsibilities and rights

Stakeholders in the process of Sessile oak genetic conservation activities establishing in Serbia are: owners and users of special genetic conservation populations and all other populations of the species at the territory of Region II, even at the whole territory of Serbia; wood industry and nursery production; scientific-research institutions in the area of forestry and environmental protection; civil associations in the area of biodiversity protection; media and local community.

Stakeholders role is public-spirited and contributes to conservation and improvement of public good of extremely importance for humankind, such genetic resources are. Owners and users of the species populations, especially those with rare haplotypes appearance, and all members of local community can play very important role in adaptability conservation process and its improvement with the aim of adequate response to newly established ecological conditions caused by global climate changes. Afforestation of degraded terrains will be more difficult in future because of temperature increasing and precipitation decreasing, especially in case of specific stands on serpentinite and peridotite as geological base, such as natural stands of sessile oak. Afforestation process will demand genotypes resistant to extreme ecological conditions. Also, Sessile oak forests in Serbia are in poorly condition because of already evident and measurable forest drying consequences which requires regeneration with resistant genotypes adapted to local ecological conditions, which implies selection from natural populations. High variability level is very important for selection process because of necessity to conserve adaptability to wide range of ecological conditions. The main role of scientific-research institutions is in the process of intraspecific and individual variability level assessment, determination of relations between genetic and economic importance of traits and inclusion of genetic conservation into commercial streaming. Civil associations and media have crucial role in public awareness raising on forest genetic resources importance and conservation for nowadays and future generations sake.

Beside public-spirited importance of conservation, economic aspects are still very respectable and stakeholders could have significant benefit from their engagement in this area. Selected seed and seedling material of high quality and known ancestry, from rare haplotype as mother tree adapted to extreme ecological conditions or other desirable traits, has significantly higher price at the market. Wood produced from the material of such quality has higher price also but, in the same time, wood industry disposes with quality raw material and final product will have higher valorization. Scientists have opportunity to valorize their research work through different project activities, on national or international level, having in mind that genetic resources conservation is one of most important goals of world science development. Last, but not least, local community get opportunity to conserve and improve own life environment for themselves but also for significant number of tourists. In that way, sustainable forest ecosystems in their surroundings will get real economic valorization.

VII Monitoring and evaluation

Monitoring of condition and genetic variability of specific populations of Sessile oak and measurable indicators for evaluation of strategic goals implementation success are indispensable part of technical guidelines. In the opposite, it will be impossible to detect changes in time intervals and to make decisions on further activities.

Having in mind that specific populations are in regular management regime, monitoring of ecological conditions, stand condition, species relation and other parameters is realized at the beginning of new forest management period. Intrapopulation genetic variability assessment at molecular level should be introduced into this process. Firstly, cpDNA polymorphism assessment should be applied for further identification of rare haplotypes and its frequency, and molecular marking techniques which identify pollen ancestry could be conducted later (exp. RAPD, VNTR).

Sampling methodology for monitoring purposes, according to the cpDNA variability assessment process described in the Strategy, should be based on at least 50 individuals within the population, with minimum distance of 50 meters. It is necessary to mark every individual determined as rare haplotype (with permanent paint or stripe), but also all sampled trees to avoid double analyses. Band pattern on gels is defined for every haplotype in the Strategy and should be used for further identification.

Applying this approach, every forest management plan for special genetic conservation populations will contain necessary data on existing rare haplotypes and their status in population. Genetic variability assessment should be indispensable part of forest management plan development process for specific populations.

4. CONCLUSION REMARKS

Technical Guidelines for sessile oak (*Quercus petraea* agg. Ehrendorfer 1967) genetic conservation populations management in Serbia are intended to assist those who cherish the valuable Sessile oak gene pool and its inheritance, through conserving valuable seed sources or use in practical forestry. The focus is on conserving the genetic diversity and rare haplotypes of the species, especially within specific populations for genetic conservation purposes, selected according to cpDNA variability research results. The Guidelines are based on the available knowledge of the species variability and on widely accepted methods for the conservation of forest genetic resources.

In situ conservation methods should be generally preferred. If natural regeneration methods are not sufficient, an adapted and specified *ex situ* conservation programme including a controlled autochthonous reproductive material system (e.g. clonal seed orchards) should be used as well to preserve the endangered gene pool.

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A COMPARISON BETWEEN ANTHER CULTURE AND MICROSPORE SUSPENSION CULTURE OF *AESCULUS FLAVA*

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Abstract: *Anthers of A. flava were isolated from disinfected flower buds and cultivated on solid callus induction medium (CIM), containing Murashige and Skoog's (MS) mineral solution with 1 mg/l 2,4 dichlorophenoxyacetic acid (2,4 D) and 1 mg/l 6 furfurylaminopurine (Kin). A half of anthers was kept on solid CIM medium and the other half was macerated 3-5 days later, to create microspore suspension cultures. The microspores released from anthers were suspended in liquid CIM medium, sieved through a 50 µm mesh and shaken on a platform shaker. Eight weeks later, anthers were transferred to regeneration induction medium (RIM) containing MS salts, 0.01 mg/l 2,4 D and 1 mg/l Kin. Microspore suspensions were mixed with equal volumes of cooled RIM and the mixture was dispensed in Petri dishes. Embryo emergence from both types of cultures had been monitored over a 2-month period. The difference in embryogenic potential of anthers positioned along the inflorescence's axis was observed and it declined acropetally. Anthers isolated from basal third of inflorescence (A-anthers) exhibited the highest frequency of embryo formation (36.6%), comparing to anthers from the middle third of inflorescence (B-anthers) and particularly the top third anthers (C-anthers). The embryo average number per anther did not differ significantly between A- and B-anthers, whereas it was significantly lower in C-anthers. The same tendency was observed in microspore suspension cultures. Microspore suspension culture was more efficient method for embryo induction, as it yielded twice more embryos then anther culture. Androgenic embryos obtained by both techniques were maintained and multiplied by repetitive somatic embryogenesis on solid RIM medium.*

Key words: androgenesis, anther culture, microspore suspension, yellow buckeye

1. INTRODUCTION

The members of the genus Aesculus are deciduous ornamental trees or shrubs, commonly planted for shade and ornamental purposes in parks, arboreta and home landscapes. The genus Aesculus (Hippocastanaceae) comprises 13 species distributed throughout the temperate parts of the northern hemisphere. Seven species are native to North America, one species to Europe and five species to Asia. In addition, Aesculus species crossed in nature and were cultivated and bred by man, consequently leading to a number of varieties, cultivars and interspecific hybrids (Chanon, 2005). A. hippocastanum is the only species native to the Balkan Peninsula, but some other members of the genus (A. carnea, A. flava and A. parviflora) are grown as ornamentals in parks of Serbia.

Most temperate trees are characterized by a long reproductive cycle with several years of a juvenile phase. They are highly heterozygous, outbreeding species, propagated asexually or by seeds. For these reasons, their genetic improvement by conventional methods is time-consuming (Höfer and Lespinasse, 1996). Classical breeding may be enhanced and accelerated by exploiting in vitro approaches. Androgenesis is a morphogenic pathway that can be used for this purpose. The process of androgenesis represents a shift from the gametophytic to the sporophytic pathway of microspore development, eventually leading to the formation of a new embryo without fertilization. As microspores undergo recombinations during meiosis, genetic variability of the acquired embryo lines is tremendously high. Haploids obtained this way enables recessive traits to be expressed. As haploid plants are sterile, obtaining of dihaploids, either spontaneously or

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colchicine-induced, is essential. By using this techniques, homozygous plants may be obtained in a few months.

Androgenesis can be achieved by anther culture or isolated microspore culture. Although anther culture is less laborious method than microspore suspension culture, the latter has a number of advantages. The main disadvantage of anther culture is the coincidence of callus and embryo formation from somatic anther tissue, leading to the formation of a mixed population of diploids and haploids. Furthermore, microspore suspension allows more accurate and highly controlled experimentation for studying both fundamental and applied aspects of androgenesis.

Up to date, androgenesis was induced from anther culture of horse chestnut (Radojević, 1978), red horse chestnut (Radojević et al., 1989) and yellow buckeye (Ćalić et al., 2005a). This study aimed at the establishment of A. flava microspore suspension culture and its comparison to anther culture in terms of the efficiency of androgenic embryo production.

2. MATERIALS AND METHODS

Plant material

Inflorescences were collected from A. flava tree growing in the Botanical Garden "Jevremovac", University of Belgrade. The inflorescences were washed with running water and a few drops of detergent and sterilized by immersing in 96% and 70% ethanol for 3 min and 5 min, respectively and rinsed with plenty of sterile deionisated water. Sterilized inflorescences were divided in thirds: the basal third designated A-anthers, the middle B-anthers, and the top C-anthers. Anthers were isolated under aseptic conditions from closed flower buds of 4 5 mm and immediately placed on solid callus induction medium (CIM), containing MS (Murashige and Skoog, 1962) mineral salts, 1 mg/l 2,4 dichlorophenoxyacetic acid (2,4 D) and 1 mg/l 6 furfurylaminopurine (Kin).

Basal medium

The media contained MS mineral solution and 20 g/l sucrose, 100 mg/l myo-inositol, 200 mg/l casein hydrolysate, 2 mg/l thiamine, 5 mg/l nicotinic acid and 2 mg/l adenine, 10 mg/l panthotenic acid. The media were gelled with 0.7% (w/v) agar (unless is differently specified), and pH was adjusted to 5.8 before sterilization. Media were sterilized by autoclaving at 114ºC for 25 min.

Anther culture and microspore suspension establishment

Anthers were kept on CIM in darkness for eight weeks and then transferred to solid regeneration induction medium (RIM) containing MS mineral salts and 0.01 mg/l 2,4 D + 1 mg/l Kin.

The anthers that were used for microspore suspension initiation were incubated on solid CIM for 3-5 days, and then noncontaminated anthers were picked out, macerated with a sterile blade, suspended in 50 ml of liquid CIM and sieved through a 50 □m mesh. The cultures were shaken on a platform shaker (85 rpm) in darkness for eight weeks. Cell suspensions were then mixed with equal volumes of cooled RIM medium (30 °C) with 0.8% agar and dispensed in Petri dishes (5 plates per a suspension culture). The cultures were maintained under cool white fluorescent tubes with a photon flux density of 55 □mol m-2 s-1 and a 16 h day length at 25 ± 2ºC.

Recordings and statistical analysis

All cultures were placed in a completely randomized design. For anther culture, the experiment was performed in three replicates with 3 samples (Petri-dishes) and 20 subsamples (anthers) for each inflorescence segment (n = 180). For microspore suspension culture, twenty anthers were used per a suspension, and three suspensions were prepared per each segment. The experiment was performed in triplicate (n = 9).

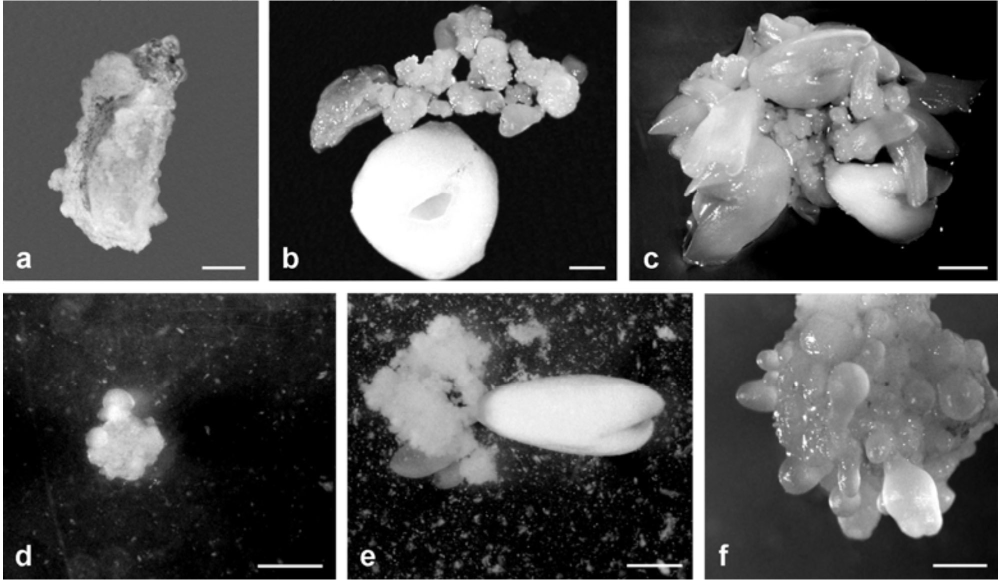
The callus formation rate was recorded after eight weeks of anther culture and the embryo appearance had been monitored over a 2-month period upon the transfer of anthers to RIM, without subcultivation. The frequency of anthers differentiating embryos and the number of embryos per anther were recorded in 2-week intervals, with the aid of a stereomicroscope. For suspension cultures, the number of embryogenic clusters and the number of embryos per cluster have been monitored in 2-week intervals after suspensions' planting over a 2-month period.

All percentage data were subjected to angular transformation before analysis. The data were subjected to standard analysis of variance (ANOVA) and the means were separated using Duncan's test at $P \leq 0.05$. For the presentation, the percentage data were inverse-transformed.

3. RESULTS

Anthers cultivated on CIM turned dark yellow and swelled (Fig. 1a). The frequency of callus formation ranged from 45% to 63% (Table 1) and the differences in response to CIM treatment among A-, B and C anthers were not significantly different (p= 0.5542). Upon transfer to RIM, the anthers burst to release androgenic embryos and embryogenic callus (Fig. 1b).

Figure 1 (a-f). *Sequential phases of androgenic embryo differentiation from A. flava anther culture and microspore suspension culture. (a) Anther forming callus after 8 weeks on callus induction medium (CIM). (b) Androgenic embryos released from burst anther after 4 weeks on regeneration medium (RIM). (c) Androgenic embryos regenerated from anther at the cotyledonary stage of development. (d) Androgenic embryos regenerating from microcallus that was formed from a microspore suspension after 8 weeks on CIM and two weeks on RIM. (e) An androgenic embryo at cotyledonary stage of development after four weeks on RIM. (f) Androgenic embryos at different stages of development regenerated from a microspore suspension culture. Bar a-f = 1 mm.*



First embryos were observed two weeks following the transfer to RIM. They completed development on this medium (Fig. 1c) and even germinated. The highest embryogenic response (36.6%) was observed in A anthers, and decreased in B and particularly in C anthers. However, the mean embryo number per anther was not significantly different between A- and B-anthers, while in C anthers it was significantly lower. The overall embryo number obtained from A anthers was three times higher then from B anthers (Table 1).

In microspore semisolid culture, new cell aggregates were observed ten days after suspension planting, and five days later first androgenic embryos emerged from microcalli (Fig. 1d). One to two weeks later the embryos at the cotyledonary stage of development were observed (Fig. 1e) and they multiplied further on (Fig. 1f). As the microspores were suspended, the embryogenic clusters were numerous, reaching 111.67 clusters per suspension derived from A anthers (Table 2). However, the mean number of embryos per cluster was rather low (1.57-5.96 on average). As was observed in anther culture, the embryogenic response of microspore declined from A- to C anthers. In addition, the mean embryo number was not significantly different between A and B microspores, but it was also significantly higher than in C microspores (Table 2).

Table 1. *Callus formation frequency of anthers isolated from A, B and C inflorences' segments of A. flava after 8 weeks of cultivation on solid MS medium supplemented with 1 mg/l 2,4 D + 1 mg/l Kin and androgenic embryo differentiation from A. flava anthers during 8-week culture on a medium for the induction of regeneration (0.01 mg/l 2,4 D + 1 mg/l Kin).*

Segment	**Callusing anthers (%) Mean ± SE**	**Time (weeks)**	**Embryogenic anthers (%) *Mean ± SE***	**Embryos per anther Mean ± SE**	**Overall embryo number**
A	50.1 ± 1.0a	2	10.6 ± 0.1 **bc**	18.7 ± 4.3 **ab**	56
		4	17.3 ± 0.4 **abc**	20.2 ± 5.9 **ab**	155
		6	30.2 ± 0.2 **ab**	25.8 ± 4.7 **ab**	182
		8	36.6 ± 0.6 **a**	30.3 ± 6.1 **ab**	333
B	44.9 ± 0.2 a	2	3.2 ± 3.2 **c**	12.0 ± 0 **ab**	12
		4	3.2 ± 3.2 **c**	25.0 ± 0 **ab**	45
		6	11.2 ± 0.4 **abc**	33.0 ±13.4 **ab**	66
		8	16.8 ± 1.0 **abc**	31.3±13.2 **ab**	94
C	62.9 ± 0.3 a	2	0	0 **c**	0
		4	0	0 **c**	0
		6	0	0 **c**	0
		8	4.4 ± 4.4 **c**	2.0 ± 0 **c**	2

Data in the Table present means ± standard error (SE). The sample size was n = 180 for each inflorescence segment. Treatments denoted by the same letter in a column are not significantly different ($P \leq 0.05$) according to Duncan's test.

Table 2. *Androgenic embryo differentiation from A. flava microspore suspension culture, during eight-week period cultivation on solid MS medium containing 0.01 mg/l 2,4 D and 1 mg/l Kin.*

Segment	**Time (weeks)**	**Embryogenic cluster per suspension Mean ± SE**	**Embryos per cluster Mean ± SE**	**Overall embryo number**
A	2	1.67 ± 0.44 **b**	2.00 ± 0.32 **ab**	11
	4	22.00 ± 5.79 **b**	3.13 ± 0.70 **ab**	89
	6	26.33 ± 5.99 **b**	3.32 ± 0.48 **ab**	111
	8	111.67 ± 30.75 **a**	5.96 ± 0.97 **a**	510
B	2	3.50 ± 0.67 **b**	1.57 ± 0.30 **ab**	15
	4	10.00 ± 2.24 **b**	2.80 ± 0.54 **ab**	35
	6	12.00 ± 2.68 **b**	3.12 ± 0.57 **ab**	41
	8	23.00 ± 5.81 **b**	5.37 ± 0.95 **ab**	173
C	2	0 **c**	0	0
	4	0 **c**	0	0
	6	0 **c**	0	0
	8	1.0 ± 0.22 **c**	1.0 ± 0 **b**	1

Data in the Table present means ± standard error (SE). The sample size was n = 9 for each inflorescence segment. Treatments denoted by the same letter in a column are not significantly different ($P \leq 0.05$) according to Duncan's test.

As the initial sample size was the same for both the techniques used, we compared the embryo yield from anther culture and suspension culture. Although ANOVA showed no significant difference ($p = 0.947$) between the two ways of embryo acquisition, the overall embryo number was twice higher from the microspore suspension culture as compared to anther culture (Tables 1, 2).

Androgenic embryos originating from both anther and microspore suspension culture were maintained and multiplied by secondary (also called repetitive or recurrent) somatic embryogenesis. The somatic embryo cultures are still available, four years after androgenic embryo initiation. Flow cytometry analysis revealed that majority of tested embryos were diploid (not shown).

4. DISCUSSION

We reported here on efficient and reproducible embryo regeneration from both anther culture and microspore suspension culture of A. flava. In a previous study we reported on successful embryo regeneration from anther culture of A. flava (Ćalić et al., 2005a). In this experiments the regeneration system was improved further by employing microspore suspension technique.

One of decisive factors influencing the efficiency of androgenesis is the stage of microspore development. However, for its routine identification it is essential to determine an associated morphological marker. For efficient androgenesis in A. flava the uninuclear stage of microspore development was optimal, and the associated morphological marker was the flower bud length of 4-5 mm. It was demonstrated that the majority of A. flava microspores isolated from flower buds of this size were at the uninuclear stage of development (Ćalić-Dragosavac et al., 2009). These findings are in agreement with results obtained in A. hippocastanum (Radojević, 1978) and A. carnea (Radojević et al., 1989), as well as for many woody species (Höfer and Lespinasse, 1996).

Embryogenic response of A. flava anthers was rather high (up to 36.6 %) and comparable to other members of the genus. In A. carnea Radojević et al. (1989) obtained up to 38% and in A. hippocastanum 52.7 % (Radojević, 1991) of embryogenic anthers. By contrast, Höfer and Lespinasse (1996) reported on rather low the frequency of embryogenic anthers (up to 6.4 %) in apple.

In this study we obtained a gradient of embryogenic capacity along the inflorescence axis. The embryogenic capacity declined from A to C anthers. Our findings are in agreement with the results of Radojević et al. (2000), who reported on the same phenomenon in A. hippocastanum anther culture. Flowers of A , B and C segments of A. hippocastanum, although being all bisexual, differ physiologically (Radojević et al., 2000), so that C flowers never set seeds (Heywood, 1978).

Microspore suspension culture was more efficient method for embryo induction in A. flava, as it yielded twice more embryos then anther culture. The same result was obtained in apple by Höfer et al. (1999), and in horse chestnut it was even more pronounced (Ćalić et al., 2003).

Androgenic embryos obtained in this study by both the techniques were healthy and able for further development, although some malformations were also noted. They readily developed until late cotyledonary stage of development and even germinated on RIM medium. Embryos multiplied by secondary somatic embryogenesis, enabling the maintenance of acquired embryogenic lines for a long period of time. This feature is well known for A. hippocastanum (Ćalić et al., 2005b) and A. carnea (Zdravković-Korać et al., 2008). Formation of diploid embryos, as was shown by flow cytometry, may point to spontaneous diploidization during culturing, at least for those formed from microspore suspension, as no somatic cells could be present after filtration through a 50 µm mash. Spontaneous polyploidization was demonstrated in androgenic embryos of horse chestnut (Ćalić-Dragosavac et al., 2006), even on plant growth regulator free medium.

To conclude, an efficient and reproducible method for androgenic embryo induction was developed in A. flava. The efficiency of this process was doubled by employing microspore suspension culture. Obtained embryos were healthy and able to develop further. Further studies of molecular markers suitable for homozygote/heterozygote discrimination are needed and are in progress in our lab.

Acknowledgements: *This work was supported by the Ministry of Science and Technological Development of the Republic of Serbia, Contract No. 143026B.*

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MATURATION OF *AESCULUS FLAVA* (MARSHALL) ANDROGENIC EMBRYOS

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Abstract: *Nevertheless, cultivated A. flava tree, about 15 years old, growing in the Botanical Garden "Jevremovac" of the Belgrade University. Closed flower buds (4-5 mm long) with premature anthers were harvested from A. flava tree. Androgenesis was induced in anther culture on solid MS (Murashige and Skoog, 1962) medium with 2,4-dichlorophenoxyacetic acid (2,4-D) and kinetin (1.0 mg* l^{-1}*of each). Globular androgenic embryos were appeared after two months. However, after globular embryos, heart, torpedo-like and cotyledonal embryos were appeared.*

Feature development and multiplication of androgenic embryos proceed on a solid medium with reduced concentration of 2,4-D (0.01 mg l^{-1}*) and same concentration of kinetin. After medium for multiplication embryos were cultured on media for embryo maturation supplemented with various concentrations (0.1, 0.5, 1, 2 and 3 %) of activated charcoal.*

The effect of activated charcoal has been attributed to the absorption of inhibitory substances, such as phenolic compounds which are produced embryos, from the medium.

The best results of germination and maturation of A. flava androgenic embryos were obtained on medium supplemented with 1 % activated charcoal. Also, the greatest number of secondary somatic embryos and the lowest number of albino embryos were noticed on the same medium.

This is the first report about induction and maturation androgenic embryos originating from A. flava anther culture.

Key words: anther culture, androgenesis, germination, maturation, yellow buckeye

1. INTRODUCTION

Aesculus flava (syn. *A. octandra*) is a species of buckeye native to eastern North America. *A. flava* is, as most of trees, characterised by a long reproductive cycle and a high level of heterozygosity. This makes genetic improvement by classical breeding difficult. The production of homozygous (doubled-haploid) plants *via* androgenesis *in vitro* can contribute to more efficient breeding. Not only can large, uniform embryo populations be generated, but these are for the most part free of genetic anomalies since embryos of tree species develop directly from microspores without an intermediate callus phase (Radojević 1991, Germana *et al*. 1994, Capuana and Deberg, 1997, Radojević *et al*. 1998, Ćalić *et al*. 2003).

Haploid plants are increasingly used in the breeding of many crop species to obtain isogenic lines in a faster and reliable way as an alternative to the classic genetic crosses. Woody species in general, and forest trees in particular, have shown to be extremely recalcitrant in anther cultures, and only few examples of successful regeneration of plantlets, from confirmed microspore origin have been reported (Höfer *et al*. 2002). The induction of haploid embryos in anther cultures, from corkoak (*Quercus suber* L.), 20–30 days after application of specific stress conditions has been reported by Bueno *et al.* (1997). However, some embryos are formed up to 10–12 months later, with diploid genomes. These facts raised the question of the cellular origin of the embryos and their *in vitro* development as the occurrence of diploid clonal embryos could limit in some way the feasibility of the method for use in regeneration and breeding programs.

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2. MATERIAL AND METHODS

Inflorescences were harvested from of *A. flava* tree (about 15 years old) growing in the Botanical garden "Jevremovac" of Belgrade University. Anthers were excised from closed flower buds (about 4-5 mm). In fact, a high correlation has been shown between flower lenght and phase of pollen development. In buds of 4-5 mm microspores were at the uninucleate stage of development. Determining the correct developmental stage of the microspores, were performed with 0.1 mg l^{-1} 4',6-diamidino-2-phenylindole (DAPI). Pollen dimorphism determined with aceto-carmine while microspore viability with fluorescein diacetate (FDA).

The selected buds from three segments (*A*-female; *B*-bisexual and *C*-male flowers) of inflorescence was surface sterilized with 95 % ethanol and 70 % ethanol for about 5 min, followed by three rinses in sterile distilled water. Induction of androgenic embryos of *A. flava* was achieved on solid MS medium contained Murashige and Skoog's (1962) mineral salts, 2 % sucrose, 0.7 % agar, and was supplemented with the following (mg L^{-1}): panthotehenic acid 10.0, nicotinic acid 5.0, vitamin B_1 2.0, adenine sulphate 2.0, myo-inositol 100, casein-hydrolysate 200, 2,4-dichlorophenoxyacetic acid (2,4-D) 1.0 and kinetin (Kin) 1.0. The MS_1 medium for embryo multiplication consisted reduced concentration of 2,4-D (0.01 mg L^{-1}) and the same concentration of Kin (1.0 mg L^{-1}).

Anthers were inoculated in each culture tube containing 8 cm^3 of the MS induction medium. Embryo development and multiplication of androgenic embryos from anther culture proceeded on MS_1. After medium for multiplication embryos were cultured on A_0 media without hormone, as well as A_1-A_5 media with 0.1, 0.5, 1, 2 and 3 % of activated charcoal (AC). Filter sterilized L-glutamine (Glu) was added 400 mg l^{-1} to improve embryo maturation in later stages of their development.

3. RESULTS

Microspores isolated from flower buds (Table 1, Fig.1) after aceto-orceine (Table 1, Fig.2), and fluorescein-diacetate (Table 1, Fig.3-5) stained showed different size. However, DAPI treated microspores had uninuclear stage of development (Table 1, Fig.6).

The development of androgenic embryos was asynchronous, so that embryos at their globular, heart-shaped, torpedo-like and cotyledon stages were observed in the same culture, on MS_1 medium (Figs. 1-2). Rapid differentiation of androgenic embryos was obtained in *in vitro* culture over the second months, producing embryos with different cotyledon numbers. Great numbers of these embryos were irregular, hypertrophy, with abnormal cotyledons or without hypocotyls.

After medium for multiplication embryos were cultured on hormone-free medium, as well as on maturation media supplemented with various concentrations (0.1, 0.5, 1, 2 and 3 %) of activated charcoal.

The effect of activated charcoal has been attributed to the absorption of inhibitory substances (abscisic acid, phenolics) from the medium.

Percentage germination of androgenic embryos was followed after 30, 60 and 90 days of growing on different maturation media.

The best results of androgenic embryos germination on media supplemented with 1 % AC (His. 1). Also, androgenic embryos on media with 1, 2 and 3 % AC showed a rapid development of green embryos (Table 2, Fig.1) in the cotyledonary stage, the greatest number of secondary somatic embryos (Figs.7-11) and lower percentage of albino embryos (Table 1, Table 2, Fig.3). Himeric androgenic embryos were only appeared on hormone-free medium (Table 1, Table 2, Fig.2).

Secondary embryos appeared on the radiculi of androgenic embryos grown on the MS hormone-free medium and maturation media (Table 1, Figs.7-12). Some embryos formed root and epicotyls (Table 1, Fig.12).

The largest number of *A. flava* embryos per anther formed from female buds (segment A). These results are in agreement with previous reports on the induction in anther culture of horse chestnut (Radojević *et al.* 2000) and *A. flava* (Ćalić *et al.* 2005). The goal of the work was mass production of haploid androgenic embryos from anther culture and induction of secondary somatic embryogenesis and plantlets formation of *A. flava* in order to develop efficient *in vitro* regeneration methods to be used in genetic transformation experiments applicable in the pharmaceutical industry.

4. DISCUSSION

The smaller *A. flava* microspores (Ćalić-Dragosavac *et al.* 2008, 2009) in uninucleate stage are known to be crucial for androgenesis as well as in all other trees (Ćalić *et al.* 2003).

Establishment of anther culture in woody plants is generally rather complicated. This is the first reported succesful plant maturation in anther culture of yellow buck. The described protocol for an efficient haploid induction in anther culture of *A. flava* can be used in genetic manipulation to secondary metabolism.

Acknowledgments: *This work was supported by the Ministry of Science and Environmental Protection of Serbia, grant* N_0*. 143026.*

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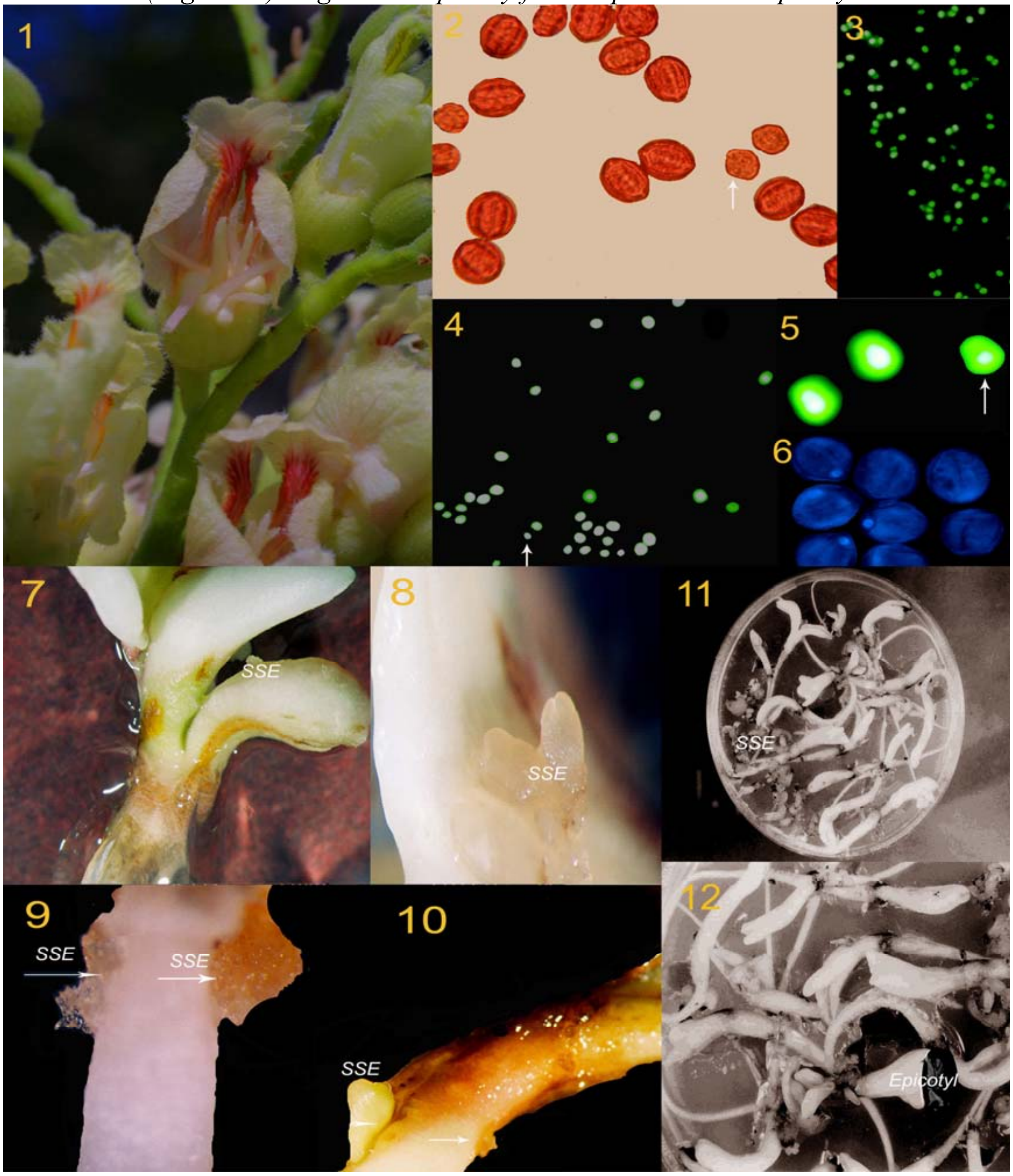
Table 1. *Percentage of green, albino and himeric androgenic embryos on different maturation media.*

Medium	Type of embryos (%)		
	Green	Albino	Himeric
A_0=MS	87	12	1
A_1=A_0 + AC 0.1 %	90	10	0
A_2= A_0 + AC 0.5 %	93	7	0
A_3= A_0 + AC 1 %	95	5	0
A_4= A_0 + AC 2 %	96	4	0
A_5= A_0 + AC 3 %	96	4	0

Table 1. **Figures 1-12.** *Flower buds (Fig.1); aceto-orcein (Fig.2.), fluorescein diacetate (Figs.3-5), DAPI (Fig.6) treated microspores; secondary somatic embryos (SSE) on cotyledon (Fig.7) and roots (Figs.8-12). Fig.12. Completely formed plantlet with epicotyls and root.*



Histogram 1. *Influence of AC on androgenic embryo germination, after 3, 6 and 9 weeks.*

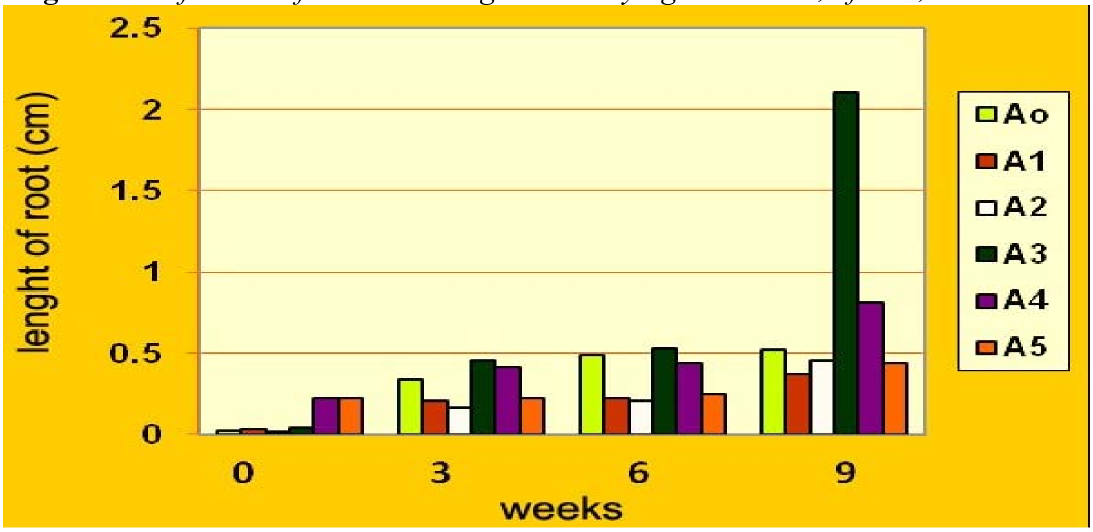
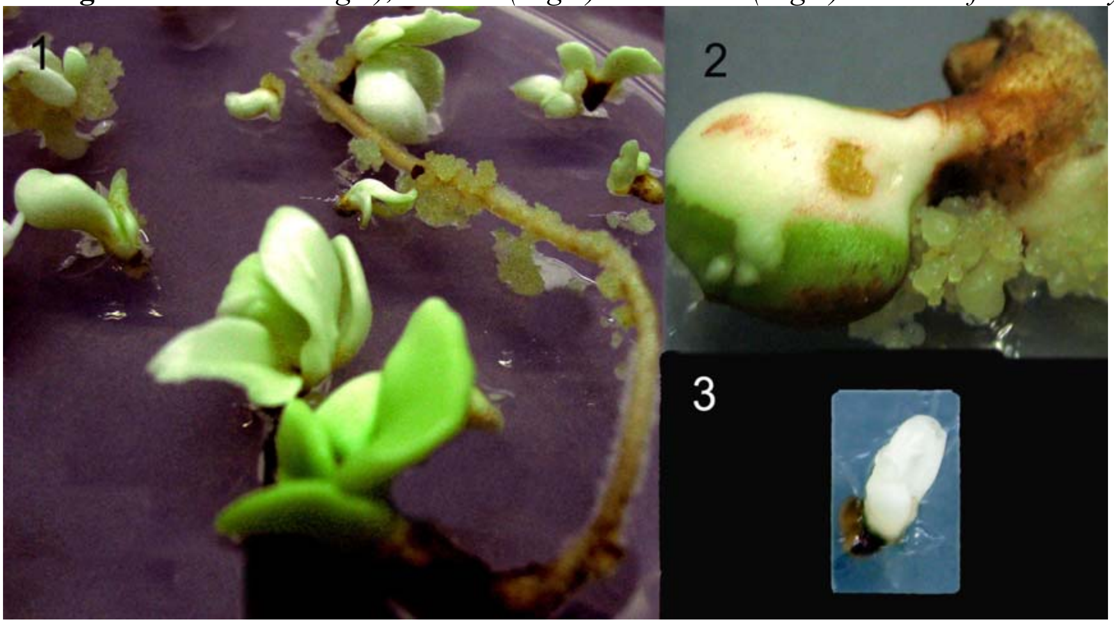


Table 2. Figures 1-3. *Green Fig.1), himeric (Fig.2) and albino (Fig.3) Aesculus flava embryos.*



CHEMICAL-ANATOMICAL CHARACTERISTICS OF *FRAXINUS ANGUSTIFOLIA VAHL. SSP. PANNONICA SOO & SIMON* IN THE REGION OF MOROVIĆ

Jasmina POPOVIĆ[1], Gordana RADOŠEVIĆ[1]

Abstract: *Anatomical and chemical characteristics of wood depend on various factors, first of all on the tree species and within the species on site conditions, that is climate factors as well as soil quality. These differences, which are the results of natural factors combination - genetic characteristics, the influence of the environment and the xylem age are shown in the form of type, quantity and kind of cells that form the wood, and the base of all are the differences regarding the chemical constituents of wood, both structural and secondary.*

This study shows the results of the research of anatomical and chemical structure of the subspecies Fraxinus angustifolia Vahl. ssp. Pannonica Soo & Simon in the forest type of ash and common oak (Fraxineto-Quercetum typicum) on moderately moist hydromorphic black soils in the swampy area of Morović region.

Key words: cellulose, lignin, mean numerical fibre length, mean mass fibre length, Runkel's number

1. INTRODUCTION

Previous research shows that chemical composition of wood depends on many factors, first of all on the tree species and within the species on site conditions, but also on climate factors as well as soil quality. These differences which are the results of the combination of natural factors - genetic characteristics, environmental impacts and the xylem age are shown in the form of type, quantity and kind of cells that form the wood. The base of all are the differences regarding the chemical constituents of wood, both structural (cellulose, hemicellulose and lignin) and secondary substances (Stevanović-Janežić, 1993).

Among climate factors which affect the development of vegetation, warmth occupies the first place. Each plant requires a certain amount of warmth for its development from the beginning to the end of the vegetation period. Plant life is supported by the temperature between 0^0C and 40^0C. The effect of temperature is mainly reflected on the sustaining of chemical processes in the plant sap. Also, temperature affects the solubility of solid matter, as well as the exchange of liquids through the cell membranes. In addition, too low or too high temperatures can have a harmful effect on plant life (Milosavljević, 1982).

Rainfall has a physical and chemical effect on the soil. Rainfall dissolves the minerals in the soil which are essential to plants for the formation of tissues. In addition, rainfall bring to the soil the nitrogenous compounds in the form of nitrates and ammonium compounds, which are necessary for plant growth and development. Moreover, rainfall is the main source of soil moisture (Milosavljević, 1982).

Therefore, it can be concluded that the occurrence and survival of vegetation, in addition to other ecological conditions, depends also greatly on the climate characteristics of the region.

Narrow-leaved ash, with its numerous varieties, is distributed in the area of the Mediterranean and the Black Sea, then in Portugal and Western France along the Atlantic Coast, but also in North Africa. On the Balkan Peninsula, narrow-leaved ash occupies a wide area along the sea coast and in the river valleys in Albania, Greece, Romania and Bulgaria. In Serbia, narrow-leaved ash occurs in the alluvial forests along the major rivers, most often in association with common oak (*Querco-Fraxinetum serbicum* Rud.). The subspecies of narrow-leaved ash -

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Fraxinus angustifolia Vahl. ssp. Pannonica Soo & Simon, which is the subject of this study, is distributed in Pannonia.

Ash wood is highly evaluated, thanks to its properties – great elasticity, hardness and density. It is used in the production of sawn and peeled veneer, furniture, parquet, as the construction timber, for the production of sport equipment, in shipbuilding, airplane and machine industry. Under favourable conditions, a tree can attain the height above 30 m and diameter at breast height above 1 metre.

This paper studies the anatomic and chemical characteristics of wood fibres of the subspecies *Fraxinus angustifolia Vahl. ssp. Pannonica Soo & Simon,* growing in the area of the Forest Administration Morović. These are important quality parameters of wood as the raw material in chemical and mechanical processing.

2. MATERIJAL AND METHOD

The study material is *Fraxinus angustifolia Vahl. ssp. Pannonica Soo & Simon* belonging to the forest type of ash and common oak (*Fraxineto-Quercetum typicum*) in the are of FA Morović, management unit "Neprečava-Varoš-Lazarica". This management unit is located in the unflooded area between the rivers Studva and Bosut, at the altitude of 79 to 81 m. The main characteristic of the relief is the flat terrain with minimal altitudinal differences between the lowest and the highest parts, and the alteration of shallow depressions, which are mainly oval and round.

Parent rock of this management unit consists of alluvial deposits of sand of different structure. The soil types are gley soil, hydromorphic black soil, meadow black soil and eutric cambisols depending on the moisture regime which affects directly the production potential of these soils, i.e. the productivity of forest tree species.

The forests in this management unit are completely in the unflooded area, which means that surface waters do not affect the main ecological characteristics. On the contrary, the groundwater level is one of the principal factors which influence the ecological and productivity characteristics of the soil, i.e. forest stands.

The climate conditions are presented based on the measured data at the permanent weather station in Sremska Mitrovica, located at the altitude of 80 m, for the period 1982-2003. Mean monthly values of temperature and rainfall in the area are analysed as the vital climate elements significant for the development of vegetation.

The samples for the analysis of anatomical and chemical characteristics of wood were made from three felled representative trees of the subspecies *Fraxinus angustifolia Vahl. ssp. Pannonica Soo & Simon*, aged 70-73 years, height about 30 m. From the felled trees, the samples were taken at breast height (1.3m) in the form of disks about 3 cm thick. The standard specimens were prepared for the analysis of the following anatomic characters: mean numerical fibre length and mean mass fibre length and Runkel′s coefficient. Anatomical characteristics were analysed on one half of the wood specimen cut from the pith to the bark. The other half of the specimen was used for the analysis of the chemical composition.

Fibre dimensions were measured on the samples taken from the parts of the specimens which include several youngest growth rings (near the pith), several oldest growth rings (near the bark), and the growth rings in the middle of the wood specimen, the cut fragments had the thickness of a match.

The samples were macerated using the Schultz reagent (Bertolet salt and nitrogenous acid). The result of this reaction is the decomposition of the intercellular substance in the aim of getting the individual cells of wood tissue. After rinsing with distilled water, the macerated wood fragments were transferred with anatomic needle to glass slides and observed under the microscope.

The system consisting of the microscope Leica DMLS and the camera Leica DC300, with Leica IM1000 software, in the Laboratory for Electronic Microscopy of the Faculty of Agriculture in Belgrade, was used for the digital images of the preparations and very precise electronic measurements of fibre length, cell wall thickness and lumen diameter of anatomic elements.

From each samples the length of 100 fibers was measured with a magnification of 50 X. These values wre then expressed as the Mean numerical fiber length (Clark, 1985) calculated by the formula:

$$\text{Mn}=\frac{\sum LN}{\sum N} \qquad (1)$$

and Mean mass fibre length by formula:

$$\text{Mm}=\frac{\sum L^3 N}{\sum L^2 N} \qquad (2)$$

where L is - the fibre length and
N - number of measured fibres.

Quality wood fibers is expressed by Runkel′s number (RR^3), as one of the frequently used indicators of the fiber quality, which characterizes the morphology of fibers cross-section, and is calculated from the relationship of the double cell wall thickness and lumen diameter (Wagenfur, R., 1984). Ranke coefficient value was obtained by measuring 50 fibers from each sample (thickness of cell wall and lumen diameter) with a magnification of 200 X.

Analysis of chemical composition included: determination of moisture content, cellulose, the Klason lignin, ash, substances extracted from wood dissolved in organic solvent mixture, and in hot water.

Preparation of samples for analysis of chemical composition was performed using standard method TAPPI T 11 WD-76. After cutting the standard tubes from the core to the bark, the tubes were chipped, and grinded using Willey mill (Culatti), and then sieved on a series of vibrational sieves. Wood fractions ranging in size from 0.5 to 1.0 mm were used for chemical analysis.

Moisture content was determined using method of wood raw material drying at temperature of 103 ± 2^0C according to TAPPI T 12 wd-82 method (also Browning, B.L., 1967a).

Wood ash content was determined as a residue after annealing at temperature 575 ± 250C according to standard methods of TAPPI 15 WD -80 (also Browning, BL, 1967).

Cellulose content was determined by Kurschner-Hoffer's method, (Browning, B.L., 1967b).

Lignin content was determined using modified Klason's method (Solar Energy Research Institute, 1991).

Content of extracted components was determined using mixture of toluene: ethanol = 2:1 in Soxlet apparatus, according to standard TAPPI T 6 os-50 method.

Determination of the content of components extracted in hot water was done using standard TAPPI T1 os-50 method (also Browning, BL, 1967a).

Obtained results of the analysis of chemical composition were related to the absolutely dry wood substance.

3. RESULTS AND DISCUSSION

One of the most important climate indicators is air temperature. Table 1 presents the mean values of air temperature per months.

Table 1. *Mean value of air temperature (^0C)*

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
-0.1	0.8	6.0	11.5	16.7	19.0	21.1	20.5	16.9	11.5	5.0	1.5

Mean annual temperature	Amplitude	Mean temperature veg.period	Mean spring temperature	Mean summer temperature	Mean autumn temperature	Mean winter temperature
10.9	21.2	17.6	15.7	19.5	6.0	2.2

The lowest mean monthly temperature is -0.1 ^{0}C in January, and 21.1 ^{0}C in July is the highest mean monthly air temperature over the period 1982-2003.

Mean air temperatures of spring, summer, autumn and winter are presented in Table 1. Mean annual air temperature is 10.9 ^{0}C.

Mean air temperature over the vegetation period amounting to 17.6^0 C is favourable for the development of forest vegetation.

Table 2 presents mean rainfall per months (R) and mean number of days with precipitation (Dp). Mean rainfall per seasons and for the vegetation period is presented in Table 3.

Table 2. *Mean monthly precipitation (P) and mean number of days with precipitation (Dp)*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
R(mm)	33.6	26.3	40.9	50.4	52.1	82.3	75.5	51.8	31.7	53.3	52.1	29.6
Dp	13.2	11.5	11.6	13.2	14.1	13.6	10.4	9.4	8.7	11.5	12.0	14.5

Table 3. *Mean precipitation by seasons (P), for the growing season, and mean number of days with precipitation (Dp)*

	Annual	Vegetation period	Spring	Summer	Autumn	Winter
R(mm)	579.6	343.8	184.8	159.0	135.0	100.8
Dp	143.7	69.4	40.9	28.5	38.0	36.3

Annual precipitation over the study period is 579 mm. Maximal average rainfall in the study period amounts to 82.3 mm in June, and minimal rainfall occurs in February and attains 26.3 mm. The greatest number of days with precipitation occurs in December (14.5 days).

The most rainy season is spring, with the greatest number of days with precipitation – 40.9 and the highest average rainfall quantity amounting to 184.8 mm, while the lowest atmospheric rainfall occurs during winter. The abundant rainfall quantity over the vegetation period, with mean 343.8 mm, is favourable to the development of forest vegetation.

The depth of snow cover per months is presented in Table 4.

Table 4. *Mean monthly depth of snow cover (cm)*

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
cm	23,1	23,3	11,5	1,0	-	-	-	-	-	-	6,0	7,3

Maximal depth of snow cover is in January and February with mean values 23.1 and 23.3cm respectively.

The data on anatomic characteristics and chemical composition, as important indicators of wood quality, for each sampled tree, and their mean values are presented in Table 5.

The percentage of cellulose is the highest in the tree No. 2 and amounts to 47.32%. The tree No. 3 contains the highest percentage of lignin, 23.47%. The tree No. 1 contains the maximal content of mineral substances (0.42%) and the extractives soluble in hot water (6.20%). The content of the extractives soluble in organic solvents is mainly uniform in all three study trees.

Mean numerical fibre length and mean mass fibre length of 1.135 and 1.191mm respectively, and the values of Runkel′s coefficient of 0.94, are the highest in the tree No. 1. The tree No. 2 has the lowest values of mean numerical fibre length and mean mass fibre length, 0.903 and 0.952mm, respectively, while the values of cell wall thickness of 5.25μm and lumen diameter of 12.23μm are the highest.

Table 5. *Fraxinus angustifolia Vahl. ssp. Pannonica Soo & Simon - chemical-anatomical characteristics*

tree	1	2	3	*Average value*
Cellulose, %	46.59	47.32	46.19	**46.70**
Lignin, %	21.74	22.04	23.47	**22.42**
Ash, %	0.42	0.26	0.30	**0.33**
Extractives (toluene/ ethanol), %	4.30	4.97	4.59	**4.62**
Extractives (hot water), %	6.20	5.60	4.96	**5.59**
Mean numerical fiber length, (mm)	1.135	0.903	1.111	**1.050**
Mean mass fibre length, (mm)	1.191	0.952	1.175	**1.106**
Cell wall thickness, (μm)	4.73	5.25	4.21	**4.73**
Lumen diameter, (μm)	11.27	12.23	9.14	**10.88**
Runkel′s number	0.94	0.86	0.92	**0.91**

Taking into account the absence of data on narrow-leaved ash chemical composition, the study values were compared to common ash (*Fraxinus excelsior* L.) from the area of north-eastern Romania, which has the most similar chemical and anatomic characteristics.

Common ash (*Fraxinus excelsior* L.) aged 52 and 102 years has lower values of the cellulose content: 41.58 and 43.81% (Bodîrlău et al., 2007), than mean values of cellulose content in the study narrow-leaved ash, which is 46.70%. The values of lignin content are higher in common ash: 26.39 and 23.18% (Bodîrlău et al., 2007), and the mean value of lignin content in narrow-leaved ash is 22.42%.

The contents of mineral substances of 0.66 and 0.93% in common ash (Bodîrlău et al., 2007) are also higher compared to arrow-leaved ash (0.33%).

The percentage of the extractives soluble in hot water of 4.99% is the lowest in common ash aged 102 years, and the highest, 6.38% in common ash aged 52 years (Bodîrlău et al., 2007), while in narrow-leaved ash this value accounts for 5.59%.

In the area of Morović, as well as in northeastern Romania, air temperatures show the highest mean values over the summer period, from July to September, and minimal in winter period (from December to February). Mean annual temperature in the area of Morović attaining 10.9 ^{0}C is somewhat higher than in the area of northeastern Romania, where it is 9.6 ^{0}C.

The minimal value of precipitation was measured over the summer period, i.e. from June to August in northeastern Romania, and from July to September in the area of Morović. The area of northeastern Romania has a somewhat lower average annual precipitation amounting to 474.4 mm compared to the area of Morović, where it amounts to 579.6 mm.

In contrast to Morović, which is located in non-flooded area, northeastern Romania is characterised by occasional floods.

4.CONCLUSION

This paper presents the results of the study of anatomic structure and chemical composition of subspecies *Fraxinus angustifolia Vahl. ssp. Pannonica Soo & Simon,* in the forest type of ash and common oak (*Fraxineto-Quercetum typicum*) in the area of Morović.

The area of Morović is characterised by the following climate conditions: mean annual air temperature is 10.9 ^{0}C, and mean temperature over the vegetation period is 17.6 ^{0}C, which is favourable for the development of forest vegetation. Annual precipitation over the study period is 579 mm. Mean rainfall over the vegetation period is 343.8 mm, which is also favourable for the development of forest vegetation.

Both, the area of Morović and Northeastern Romania are characterised by temperate continental climate.

Mean value of cellulose percentage in narrow-leaved ash researched in this study, which accounts for 46.70% is higher than that of common ash (*Fraxinus excelsior* L.) from the region of northeastern Romania aged 52 and 102 years: 41.58 and 43.81% respectively (Bodîrlău et al., 2007). The values of lignin content are higher in common ash: 26.39 and 23.18% (Bodîrlău et al., 2007), and mean value of lignin content in narrow-leaved ash is 22.42%.

The values of the percentage of mineral substances accounting for 0.66 and 0.93% in common ash (Bodîrlău et al., 2007) are also higher compared to narrow-leaved ash (0.33%).

The content of the extractives soluble in hot water accounting for 4.99% is the lowest in common ash aged 102 years, and the highest 6.38% in common ash aged 52 years (Bodîrlău et al., 2007), while the content in narrow-leaved ash is 5.59%.

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A RAPID PROTOCOL FOR IN VITRO PROPAGATION OF WHITE POPLAR (*POPULUS ALBA* L.)

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Abstract: *Poplars have been planted widely in temperate zone because of their fast growth and utilisation for biomass production. Poplars also serve as a material for reforestration of destroyed infertile lands. Collection of species and varieties of poplar could be a start in sellecting clones resistant to different environmental stresses, while micropropagation provide s rapid production and maintenance of selected clones. We present rapid protocol for micropropagation and ex vitro aclimatization of two clones of P. alba. Shoot induction medium consisted of MS medium suplemented with BAP (2.25 mg L-1), NAA (0.186 mg L-1). For shoot multiplication BAP (0.1 mg L-1) and NAA (0.1 mg L-1) were used, while rooting of produced shoots were performed on hormone free half strength MS medium. Two clones differed in both, shoot lengt (39.9 ±1.8 and 26.1 ± 2.3) and multiplication index (5.4 ± 0.4 and 2.7 ± 0.3), while rooting was 100%. Acclimatization for both clones was 70 - 80%, the time period from initiation of shoot buds to ex vitro acclimatized plantlets being 4 months.*

Key words: in vitro, micropropagation, Populus alba.

1. INTRODUCTION

The genus *Populus* contains approximately 30 species of woody plants exhibiting some of the fastest growth rates observed in temperate trees (Taylor, 2002). *Populus* is becoming a "model" woody plant, complement to *Arabidopsis,* for investigations unique for woody plants such as dormancy, secondary wood formation and seasonality (Taylor, 2002; Jansson and Douglas, 2007). This is the first woody plant with sequenced genome as a plant with relatively small genome size, and the plant easy to propagate, which makes it ideal model plant for studies in breading, physiology, biochemistry and molecular biology (Jansson and Douglas, 2007).

Populus alba is a widespread species throughout Mediterranean basin, Central Europe and Middle East. It is a species with a good potential for fast growth and biomass production. It also represents a genetic resource to improve tolerance to different environmental stresses, especially drought and salinity stress enhanced by climate changes.

Micropropagation provides rapid production and conservation of clones selected for resistance to environmental stress. The use of plant clones in experimental purposes, enable avoidance of individual genetic differences that can mask the effect of the applied treatment. In this paper we present a rapid protocol for *P. alba* micropropagation and *ex vitro* acclimatization developed in our laboratory, as a "model" woody plant for further physiological and biochemical studies.

2. MATERIAL AND METHODS

Plant material: Plant material was taken in March 2007. and 2008. from selected trees from two different localities: Belgrade surroundings with typical continental climate and Ub surroundings with strong influence of Mediterranean climate.

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Apical and lateral vegetative buds, still protected by scale-leaves, were taken from adult trees. They were rinsed in tap water for 30 min, surface sterilized for 20 min in commercial bleach containing 4% NaOCl and rinsed in sterile distilled water three times.

Culture media: Basal medium consisted of MS (Murashige and Skoog, 1962) mineral and vitamin solution, 30 g L^{-1} sucrose and 7 g L^{-1} agar.

For shoot induction basal medium was supplemented with BAP (2.25 mg L^{-1}) and NAA (0.186 mg L^{-1}). Surface sterilized apical and lateral buds were placed on shoot induction medium. After subculture on this medium (8 weeks in total) formed adventitious shoots (20 mm) were transferred to shoot multiplication medium.

For shoot multiplication we used BAP (0.1 mg L^{-1}) and NAA (0.1 mg L^{-1}). After 4 weeks of culturing on this medium formed shoots were counted and measured aseptically and transferred to rooting medium.

Rooting was performed on half strength MS hormone free medium with 6 g L^{-1} agar, for 4 weeks. The media were adjusted to pH 5.8 before autoclaving at 114° C for 25 min.

Growth conditions: Temperature in the growth room was 25 ± 2 °C, photoperiod of 16/8 h and irradiance 33.5 - 46.5 µmol $m^{-2}s^{-2}$ provided by white fluorescent tubes.

Acclimatization: Rooted plantlets were planted in the mixture of peat and perlite (1:1) and grown in high relative humidity in growth room for one week. For following 3 weeks humidity was gradually reduced. For following 4 weeks of acclimatization, plantlets were transferred in greenhouse.

3. RESULTS AND DISCUSSION

A number of species from genus Populus have been successfully micropropagated (Kim et al., 1981; Rutledge and Douglas, 1988; Taylor, 2002). We present clone propagation of two selected P. alba genotypes with contrasting phenotypes from different localities.

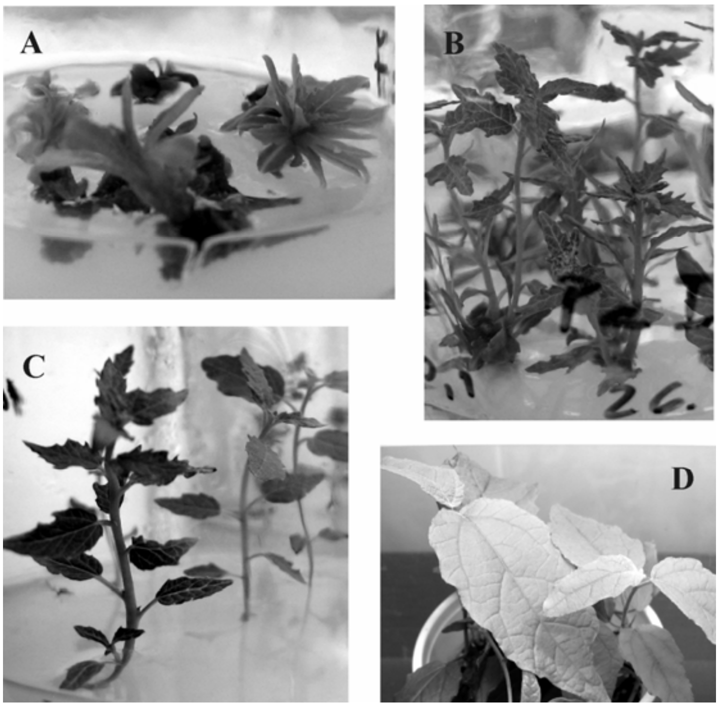

Figure 1. *Populus alba micropropagation, clone I: (A) adventitious shoots at the base of primary explants after 8 weeks on shoot induction medium, (B) shoot multiplication after 4 weeks on BAP (0.1 mg L^{-1}) and NAA (0.1 mg L^{-1}), (C) spontaneous rooting after 2 weeks on MS/2 hormone free medium, (D) acclimatized plants after 7 weeks of acclimatization.*

70-80% of apical and lateral vegetative buds produced adventitious shoots at the base of primary explants after 8 weeks on shoot induction medium (Fig. 1A). A compact callus was formed at the base of explants.

Adventitious shoots (20 mm in length) were transferred on shoot multiplication medium and cultured for 4 weeks. Two clones differed in both, shoot multiplication index and length of produced shoots (Tab. 1). Although clone I showed higher shoot multiplication index (Fig. 1B) and shoot length, those two clones showed no difference in rooting and in acclimatization process. Spontaneous rooting (100%) for both clones was obtained (Tab. 1) in 4 weeks on MS/2 hormone free medium (Fig. 1C).

Table 1. *Populus alba in vitro shoot multiplication and rooting.*

clon	Multiplication index	Shoot length (mm)	Root formation (%)
I	5.4 ± 0.4	39.9 ±1.8	100
II	2.7 ± 0.3	26.1 ± 2.3	100

Acclimatization of plantlets (Fig. 1) to ex vitro conditions for the first 4 weeks performed under increased humidity in growth room and for further 4 weeks in greenhouse conditions was 70-80% for both clones (Fig. 1D).

Selected clones will be kept in tissue culture system. Once shoot induction was obtained, presented protocol enable production of required number of *in vitro* rooted *Populus alba* plantlets in 2 months, or acclimatized young plants in 4 months, any time of the year.

Acknowledgements: *This work was supported by a grant (No. 143043) from the Ministry of Science of the Republic of Serbia.*

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THE EFFECT OF GENOTYPE ON ANDROGENESIS INDUCTION OF *AESCULUS HIPPOCASTANUM* L.

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Abstract: *Influence of different genotype, age of trees and environmental temperature on induction of androgenesis and apperance albino horse chestnut embryos were studied. Efficiency of in vitro androgenesis via anther and microspore culture were investigated using the same closed flower bud material. Androgenic response of different genotypes was measured and compared. Anther induction rates were from 5 % to 37.6 % depending of genotype. Under optimal conditions, the number of embryos per isolated anther varied between 0.5 to 5.0 embryos in anther culture, while in microspore culture varied between 3.0 to 27 embryos, depending of genotype. A microspore culture was 5-6 times efficiency than anther culture for same genotype.*

Age of the trees had no influence on androgenesis induction. Temperature of about 4-5 ^{0}C was optimal for androgenic embryo induction.

Flow cytometric analysis of embryos and regenerated plants showed that the most of the androgenic embryos were haploid, corresponding to their microspore origin, while a half of these were diploid, after 6 months in culture. However, diploid, tetraploid and octaploid embryos were observed after 3 years in subculturing.

Key words: age of tree, androgenic embryos, genotype, horse chestnut, ploidy stability

1. INTRODUCTION

Horse chestnut (*Aesculus hippocastanum* L., *Hippocastanaceae*) represent a relict species of the tertiary flora and endemit of Balkan peninsula. The development of anthers with uninuclear pollen grains leading to androgenesis and haploid plants orginating from one genotype has been described for *Aesculus hippocastanum* (Ćalić et al. 2003). Anther culture has been used in recent years as a tool for producing haploid plants in a varyety of higher plants, but the low frequencies of microspore-derived plants restrict the use of the technique in plant breeding. There are several factors affecting androgenesis in many species, such as genotypes, growth of donor plants, pretreatments of anthers, composition of medium and culture conditions (Assani et al. 2003; Hofer 2004). Androgenic response is genetically controlled and is affected by environmental factors. Genotype is the most crucial factor for androgenic response *in vitro* androgenesis in apple (Höfer 2004; Höfer *et al*. 2008). Also the developmental stage of microspores within anthers is an important factor for success in anther cultures (Perera et al. 2008; 2009). The anthers containing microspores at the uninuclear stage and the first pollen mitosis are determined to be optimal for the induction androgenesis for many woody plant species (Marinković and Radojević 1992; Assani et al. 2003; Germana 2006; Hofer 2004; Pintos et al. 2007). Radojević (1978, 1991) determined that horse chestnut anthers taken from buds at the size beetwen 3 and 7 mm containing microspores at the uninuclear stage and gave good results. Besides green embryos, albino embryos were also obtained, but their development in culture was slow. Although the occurrence of albino plants is a general phenomenon, extensive and systematic studies are presently lacking on this subject. The problem is particularly significant for plant breeding.

Stress treatments play a major role in androgenesis. The influence of temperature and nutrition in different crop species is well documented (Shariatpanahi et al. 2006).

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Most trees are characterized by a long reproductive cycle with several years of a juvenile phase, a tendency to allogamy and a large tree size. They are generally highly heterozygous, outbreeding species, which are asexually propagated (Zdravković-Korać, 2008). For this reasons, their genetic improvement by conventional methods is time/consuming and limited by space for field experiments. The production of haploids offers new possibilities for genetic studies and breeding (Hofer 2005). Biotechnological methods can improve the efficiency and increase the speedy of breeding. Anther culture is a widely used method to generate genetic variability. Production of haploid plants from anther cultures is specially useful for regeneration and breeding of forest trees, since the long regeneration time and strong inbreeding depression of these species makes the traditional breeding methods impractical. No extensive study has been done to characterise the process of determining the cellular origin of those late embryos, in long term-cultures, as well as ascertaining in which proportion the haploid condition occurs and genetic variability is present. Only recently has the been some preliminary data reported in *Q. suber* microspore-derived embryos (Bueno et al. 2000). It is well known that the use of *in vitro* techniques to induce androgenesis has significantly facilitated the production of doubled haploids in plant breeding programs, leading to the early release of homozygous lines. Several methods (e.g., anther and microspore culture) have been developed for the *in vitro* production of doubled haploids and these have been used in breeding programs of many plant species. Since the introduction of anther culture for the production haploid plants, the production of haploid plants has increased considerably (Bueno et al. 2003; Ćalić et al. 2003; Höfer 2004).

Flow cytometric analysis was used to verify the ploidy stability of the horse chestnut androgenesis process.

2. MATERIALS AND METHODS

Plants materials

Inflorescences were harvested from ten different genotypes (an approximately 20 and 100-years-old) of *Aesculus hippocastanum* L. trees growing in the Botanical garden "Jevremovac" of Belgrade University. Anthers were excised from closed flower buds (size 5 mm). In fact, a high correlation has been shown between flower lenght and phase of pollen development. In buds of 5 mm microspores were at the uninucleate stage of development. Determining the correct developmental stage of the microspores, were performed with 0.1 mg l^{-1} 4',6-diamidino-2-phenylindole (DAPI). Dimorphism determined with aceto-carmine while microspore viability with fluorescein diacetate (FDA).

Anther and microspore culture

The selected closed buds with uninucleate microspores were surface sterilized with 95 % ethanol (3 min) and 70 % ethanol (5 min) and three rinses in sterilized water. Basal medium (BM) contained MS mineral salts (Murashige and Skoog 1962), 2 % sucrose, 0.7 % agar, 100 mg l^{-1} myo-inositol, 200 mg l^{-1} casein-hydrolisate, 2 mg l^{-1} vitamin B_1, 10 mg l^{-1} pantothenic acid, 5 mg l^{-1} nicotinic acid and 2 mg l^{-1} adenine sulphate. Uninucleate microspores cultured in MS liquid medium (MSL) while anther culture establish on same solid medium (MSS) with 0.7 % agar. Liquid and solid MS media contained BM and 2,4-dichlorphenoxyacetic acid (2,4-D) and kinetin (Kin) about 1 mg l^{-1}. A fifthy dissected anthers with uninucleate microspores per Erlenmeyer flask with filter (100 μm) and 50 ml MSL medium for androgenesis induction. The microspore suspension was refreshed every 4 weeks with MSL medium. After 8 weeks, the suspension was plated by Bergmann technique (1959) on a solid MSS_1 medium reduced concentration of 2,4-D 0.01 mg l^{-1} and Kin 1 mg l^{-1}. Anthers were cultured on petri dish containing about 30 ml MSS induction medium. Development and multiplication of androgenic embryos orginating from anther and microspore culture proceeded on MSS_1 medium. All media were sterilized by autoclaving at 0.9 x 10^5 Pa and 114 ^{0}C for 25 min. Suspension cultures were grown on a horizontal shaker (85 rpm) at temperature of 23 ± 1 ^{0}C for one month in the dark. All other cultures were grown at the same temperature with irradiance of 33-45 μmol $m^{-2}s^{-1}$ produced by cool white fluorescent tubes. Androgenic embryos were growth on MS hormone-free medium a 16/8 h light/dark and 8/16 h light/dark photoperiod.

Determination of ploidy level

Nuclear suspension from androgenic embryos in cotyledonary stage of development was prepared. Young leaf material of horse chestnut was used as control. Plant material was macerated with a sharp razor blade in a ice-cold neutral buffer, and placed in plastic Petri dishes. Neutral DNA buffer (pH 7) with 15 mM Hepes, 1 mM EDTA, 80 mM KCl, 20 mM NaCl, 0,5 mM spermine, 300 mM sucrose, 0.2 % Triton X-100, 15 mM DTE (Dithiothreitol) and 2 mg l^{-1} DAPI was used. After maceration, the buffered mixture (ca. 2 ml), was passed through a nylon filter of 40 μm mesh size, stained with DAPI, and analysed in a flow cytometer. Fluorescence levels were determined by a photomultiplier and coverted in voltage pulses that were processed with PC. Ploidy level of androgenic embryos was evaluated by flow citometry, using a PAS II cytometer (Partec GmbH), equipped with a high pressure mercury lamp (OSRAM HBO 100 W/2) and using the excitation filters UG-1, BG-31, KG-1 and TK-420 and emission filters TK560 and GG435.

Statistics and repetition

Influence of ten horse chestnut genotypes on androgenic embryo induction was investigated during one year. The sample size was about 201-210 embryos for each of ten genotypes. The number of obtained embryos per one anther and percentage of responding anthers were used as indicators of the efficiency of androgenesis. The results were assessed using the variation analysis. The means were compared by the SNK (Student Newman-Keuls test; significance level α= 0.05).

3. RESULTS

Genotypes JT_1 - JT_5 were 20 years old, while genotypes OT_1 - OT_5 were 100 years old. Anthers originating from young YT_1 and YT_3 genotypes had higher embryogenesis potential (3.0 and 2.7 embryos/anther) than those originating from genotypes YT_2, YT_4 and YT_5 (1.0; 0.9 and 1.6 embryos/anther, respectively), Table 1. However, anthers originated from old genotype OT_1 produced the largest number (5.0 embryos/anther), while anthers isolated from genotypes OT_3 and OT_5 produced the less number of androgenic embryos (1.0 and 0.5 embryos/anther; respectively), Table 1. All horse chestnut genotypes were having a high, but different androgenic responses. Results shown in Table 1, confirmed that microspore culture was 5-6 times efficient method for androgenesis induction than anther culture for all investigated genotypes. The number of embryos per isolated anther varied between 0.5 to 5.0 embryos in anther culture, while in microspore culture varied between 3.0 to 27 embryos, depending of genotype (Table 1). The frequency of albino androgenic embryos in hormone-free medium was also monitored. Similarly, the number of albino embryos produced per 210 anthers ranged between 4–14 % (LD) and 15–25 % (SD) in anther culture, while present of albino embryos in microspore culture was between 1-11 % (LD) and 11-24 % (SD), depending of genotype (Table 2). It was also observed that albino androgenic embryos formation is significantly increased in the short, in comparison to a long day.

Cytogenetic analysis of androgenic embryos originating from anther and microspore culture was done after a first generation of regenerants and after 3 years of subculturing. All androgenic embryos the first generation from microspore culture were haploid. Immediately after germination, 50 % of the regenerants originating from anther culture were haploid, and the other half diploid. After 3 years of subculturing, there were no haploid regenerant from anther culture, while 8.5 % were diploid, 81 % tetraploid and 10.5 % octaploid. Unlike those from anther culture, all regenerants originating from microspore culture were haploid immediately after germination, but only 10 % embryos retained haploidity after 3 years subculturing, while 10.5 % were diploid, 73.5 % tetraploid and 6 % octaploid.

4. DISCUSSION

The smaller horse chestnut microspores (Ćalić et al. 2003) in uninucleate stage are known to be crucial for androgenesis as well as all other plant species (Zheng 2003; Ćalić-Dragosavac et al. 2008, 2009).

In all horse chestnut genotypes examined, the number of embryos formed in the induction media was around five times higher in the suspension of single-nucleus microspores. Our results that the genotype is the most crucial factor for induction androgenic embryo in horse chestnut are correlated with results Höfer (2004) and Höfer et al. (2008).

The maintenance of a low proportion of haploid embryos growth on hormone free medium indicates that significant alternations in the ploidy level had occurred during long-term culture (up to 3 years). The absence of plant growth regulators in the maintenance media of our microspore and anther cultures reduces the possibility of embryo induction from the diploid tissue of the anther wall, favoring the hypothesis of spontaneous diploidisation. Results in other genera, such as *Populus* (Baldursson et al. 1993), *Triticum* (Löschenberger and Heberle-Bors 1992) and *Quercus* (Bueno et al. 2003) corroborate these findings.

Also, the presence of trihoms on cotyledons of androgenic embryos can be explained by the appearance of polyploidy (existence of intensive endoreduplication) in horse chestnut cells, which is in line with results in other plant species (Traas et al. 1998; Joubés and Chevalier 2000).

To the best of our knowledge, this was also the first report on horse chestnut androgenic embryos, presenting influence different genotype on induction androgenesis and flow cytometry data.

Acknowledgments: *This work was supported by the Ministry of Science and Environmental Protection of Serbia, grant N*$_0$*. 143026.*

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Table 1. *Effect of different genotype (YJ_1-JT_5 and OT_1-OT_5) and age of tree on the induction of androgenic embryos in horse chestnut using anther and microspore culture on MS_1 medium.*

Anther culture						***Microspore culture***	
Genotype	**Age of trees (years)**	**Total N^o of cultivated anthers**	**Embriogenic anthers**		**N^o of embryos/ isolated anthers**		
			N^o	**%**		**N^o anthers**	**embryos/ embryogenic anthers**
YT_1	~ 20	206	35	17.0	3.0^{b}	100	16.0^{b}
YT_2		210	27	12.9	1.0^{c}		4.5^{d}
YT_3		203	12	5.9	2.7^{b}		9.0^{d}
YT_4		209	19	9.1	0.9^{c}		5.0^{e}
YT_5		201	10	5.0	1.6^{bc}		7.0^{de}
OT_1	~ 100	208	47	22.6	5.0^{a}		27.0^{a}
OT_2		210	79	37.6	2.0^{bc}		11.0^{c}
OT_3		210	68	32.4	1.0^{c}		6.0^{de}
OT_4		205	75	36.6	1.7^{bc}		9.0^{d}
OT_5		206	28	13.6	0.5^{c}		3.0^{e}

*values in each column marked by different letters are significantly different at 0.05 using the SNK test.

Table 2. *Influence of horse chestnut genotypes (YT_1-YT_5 and OT_1-OT_5) and age of tree on appear of albinism in anther and microspore cultures on hormone free medium, on long day (LD) and short day (SD).*

Genotype	Age of tree (years)	Medium	Albino embryos (%)			
			Anther culture		Microspore culture	
			LD	SD	LD	SD
YT_1	~ 20	hormone free	11.0^{b}	23.0^{b}	9.0^{b}	20.0^{b}
YT_2			9.0^{b}	19.0^{c}	7.0^{b}	17.0^{c}
YT_3			7.0^{c}	17.0^{c}	5.0^{c}	15.0^{c}
YT_4			6.0^{c}	15.0^{d}	3.0^{d}	12.0^{d}
YT_5			14.0^{a}	27.0^{a}	11.0^{a}	24.0^{a}
OT_1	~100		4.0^{d}	15.0^{d}	1.0^{e}	11.0^{e}
OT_2			9.0^{b}	22.0^{b}	6.0^{bc}	17.0^{c}
OT_3			7.0^{c}	19.0^{c}	5.0^{c}	15.0^{c}
OT_4			5.0^{d}	17.0^{c}	3.0^{d}	13.0^{d}
OT_5			11.0^{b}	25.0^{a}	8.0^{b}	19.0^{b}

*values in each column marked by different letters are significantly different at 0.05 using the SNK test

THE CREATION OF THE SITE INDEXES FOR AUTOCHTONOUS CONIFER SPECIES: AUSTRIAN PINE, SCOTS PINE AND SPRUCE

Mihailo RATKNIĆ[1]

Abstract: *The created site indexes for the Austrian pine were marked as following: , 12, 14, 16, 18, 20 and 22, for the Scots pine: 14, 16, 18, 20, 22, 24 and 26, and for the spruce: 15, 17, 19, 21, 23, 25 and 27. This classification of the site productivity by the site indexes is a result of the fact that the previous researches showed that there was a great disharmony between the developmental-productive characteristics of the cultures in Serbia with the increment-yield tables. The heights, diameters, basal area, volume and volume increment of the Austrian pine are significantly greater than the data from the tables by Nedjalkov (1962). The similar situation is typical for the Scots pine (in comparison with the tables by Wiedemann) and spruce (in comparison with the tables by Schwapach and Wiedemann). It points to the absolute uselessness of the current increment-yield tables for the conifer cultures in Serbia, which is partly caused by the fact that these tables were based on the models of the development of the natural stands. Their uselessness is particularly emphasized in the cultures established with 2,000-2,500 seedlings per a hectare. The model of the development of the trees enables the easy parametarization or reparameterization of the models, under the conditions of the climate change. The paper presents the dependance of the site indexes on the ecological and stand conditions.*

Key words: site indexes, Austrian pine, Scots pine, spruce, cultures

IZRADA STANIŠNIH INDEKSA AUTOHTONIH VRSTA ČETINARA: CRNOG BORA, BELOG BORA I SMRČE

Apstract: *Izrađeni stanišni indeksi za crni bor imaju oznake: 10, 12, 14, 16, 18, 20 i 22, za beli bor: 14, 16, 18, 20, 22, 24 i 26, i za za smrču: 15, 17, 19, 21, 23, 25 i 27. Razlog za bonitiranje preko stanišnih indeksa sadržan je u činjenici da su dosadašnja istraživanja pokazala veliko neslaganje razvojno-proizvodnih karakteristika kultura u Srbiji sa prirasno-prinosnim tablicama. Za crni bor visine, prečnici, temeljnica, zapremina i zapreminski prirast su daleko iznad veličina koje daju tablice Nedjalkova (1962). Ista situacija je i za beli bor (u odnosu na tablice Wiedemann-a) i smrče (u odnosu na tablice Schwapach-a i Wiedemann-a). To ukazuje na apsolutnu neupotrebljivost postojećih prirasno-prinosnih tablica za kulture četinara u Srbiji. Jedan od razloga je i taj što su ove tablice konstruisane na bazi modela razvoja prirodnih sastojina. Njihova neupotrebljivost naročito dolazi do izražaja u kulturama osnovanim sa 2000-2500 sadnica po hektaru. Modeli razvoja stabala omogućavaju laku parametarizaciju ili reparametarizaciju modela, u uslovima promene klime. U radu su date i zavisnosti veličine stanišnih indeksa od ekoloških i sastojinskih uslova.*

Ključne reči: stanišni indeksi, crni bor, beli bor, smrča, kulture

1. INTRODUCTION

Flows of tree growth increase greatly differ from our understanding of and consisting of models, but we are still far from being fully adapt to new conditions in the first place climate. The transformation of existing models through correctional factors or making new growth and yield tables on old principles, can not be achieved with satisfactory results. There is a

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Acknowledgement: The study was partly financed by the Minstry of Science and Technological Development of the Republic of Serbia, the Project – TR 20056 „High-resolution satellite images in the collection and processing of spatial information on forests and forest ecosystems“

huge risk that the plates after development, which is very complex, time-consuming and expensive, are quickly outdated because of the changing conditions for growth (Schmidt, 1971, by Vučković, 1993). The future belongs to the growth models that provide their easy parametrical and re parametrical, models that allow incorporation of new information on increment without reconstruction of the whole model. These models enable the creation of different scenarios of action and disturbing stimulating factor on the principle of "if-then": If the conditions of growth occur, then the next expected growth rate. These models are oriented on individual trees. This allows the production of tables yielding pure and mixed stands on new principles. For this, we need a rich and reliable database, base on data on growth conditions and characteristics of major forest tree species. The construction of models of new principles enabled the production of ecological indexes.

2. MATERIALS AND METHODS

For the construction of the ecological index for conifer species indigenous cultures used the data from the region or localities of Gornji Milanovac, Kremna, T. Bare, Zlatibor, Mačkat, Magleš, Šargan, Sjenica, Priboj, Golija, Bratljeva, Katići, Divčibare, Lomnička river, Cer, T. Bobije, Crni Vrh, Vidlič, Knjaževac, Goč, Kopaonik, Kušići, Bjelovar, Gučevo, Deliblatska sands and partial samples from Kosovo and Metohija. To create ecological index for Austrian pine was used sample in a total of 150 trees, 120 for Scots pine trees and 98 spruce trees.

3. RESEARCH RESULTS

Habitat (ecological) indexes are models of development. As one of the main reasons for the construction of the ecological indexes in next series of benefits that have the more complete classification of ecological units in wood producing sense of the source types and that, as habitats for quality improvement cultures so far used only with the solvency of space environment is often completely different. This led to errors in estimating species selection for reforestation, planning and introduction of the production process.

To determine the habitat index, it is necessary to culture, as well as development of individual trees to satisfy certain conditions. We can conclude that the development level of a particular habitat may be affected more extremely dense or extremely open stands, while in the stands with the "management of normally does not occur, for practical uses, the significant differences in the ostrich reached total height trees. As the habitat index gained based on the dominant trees of the analyzed high floor, it is presented findings of great importance in the production method according to habitat differentiation ecological index. Habitat indexes is independent of the density of associations for most species of trees (Haglud, 1981). Since the habitat index value of the empirical properties of habitat characteristics, measurable and expressed reached the top height of stands is necessary to determine ecological index tree stands and meet the following conditions:

- In the stands to dominate tree species which is determined by the habitat index;
- Stands to have a closed circuit trees;
- Trees in the stands may not have by biotic and abiotic factors caused damage.

Made habitat indexes (Ratknić, 1994) for a Austrian pine with labels: 10, 12, 14, 16, 18, 20 and 22, the Scots pine: 14, 16, 18, 20, 22, 24 and 26, for Douglas fir and Weymouth Pine : 18, 20, 22, 24, 26, 28 and 30, for the spruce: 15, 17, 19, 21, 23, 25 and 27, and for Larch 14, 16, 18, 20, 22 and 26.

The reason for quality evaluation over ecological index is contained in the fact that the recent research has shown a great discrepancy development and production characteristics of culture in Serbia tree volume growth-yield tables (Vučkovic, 1989, Tomanić, 1990). For Austrian pine height, diameter, basal area, volume and volume growth are far above the size of that return tables Nedjalkova (1962). The same situation is for Scots pine (compared to the Wiedemann plates) and spruce (compared to the plates of Schwapach and Wiedemann) (Tomanić, 1990). This indicates the absolute impracticability of existing volume growth yielding conifer culture plates in Serbia. One reason is that as these plates are designed on the basis of models of development of natural stands. Their inapplicability in particular is expressed in cultures established from 2000-2500 trees per hectare. Abscise axis represent high and ordinate axis age of trees.

Chart 1. *Site indices for Austrian pine*

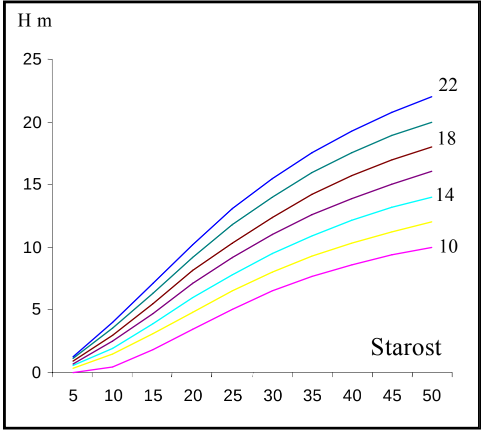


Chart 2. *Site indices for Scotch pine*

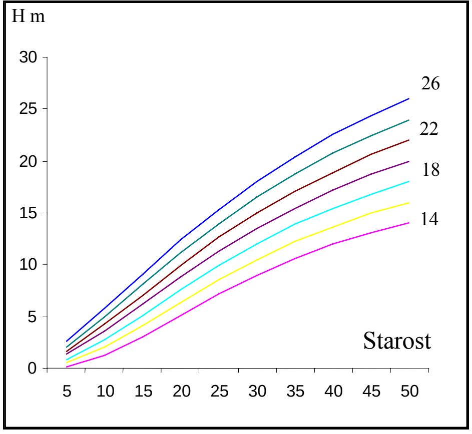
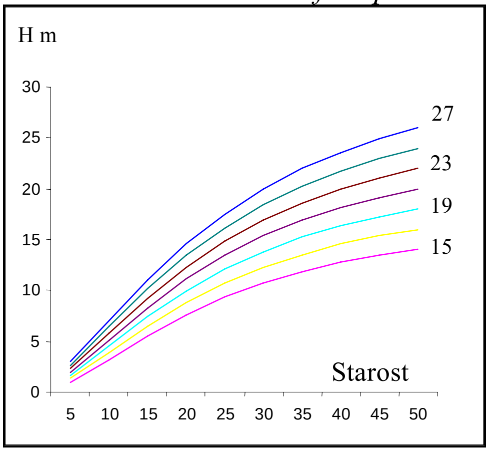


Chart 3. *Site indices for spruce*



4. ADDICTION OF CULTURE DEVELOPMENTAL CHARACTERISTICS FROM HABITAT CHARACTERISTICS AND ECOLOGICAL INDEX

Given the necessary fulfillment of the requirements for establishing ecological index for detailed analysis were used in the area where are noted full forest stands set, or where the number of trees was more than half the number of trees used at the time of planting. Only in this way is possible to determine the dependence of production of personal and developmental characteristics of stands and trees. One of the tasks is to determine whether there are and what are the practical importance of differences in culture stands structure. Of the elements of the structure of stands of trees were analyzed, obesity, and you son-trees, basal area, volume and growth. These structural elements are used for mutual comparison of cultures of different habitats.

Development and growth of trees in height. Achieved the height of trees in a given age are the best indicator of habitat conditions and can be a good indicator of the environmental characteristics of production, and habitat especially in comparative research. From the research results can be seen that certain types of land between the difference occurs at an early age. From this it can be concluded that a decisive influence on the development of height with habitat factors.

Austrian pine on limestone mold has a different height development of dominant trees floors depending on the depth of soil. By the age of about seven more height development is quite consistent that in the shallower soils. When your existing height of this period began to fall behind.

A similar conclusion can be drawn with an acidic brown soil where the difference in development floor height of dominant trees, depending on the depth of the soil the more pronounced, and differentiation starts much earlier. At the age of 18 years is around 2 m. Culture of red pine on eutric ranker have a significantly smaller development amount of over eutric brown soil.

Development height of dominant trees of Scots pine is the weakest in the mold, then the brown limestone soil. Vertical growth is the fastest of which luvisols confirm to land development phase is important. With land holdings that have profile A-(B)-C can be concluded that the overall development of the weakest level in brown limestone soil, then brown soil eutric the serpentinites and the fastest in the acid brown soil. Culture of Scots pine in pseudo clay mainly achieved greater heights of culture luvisols through out the observed development period. At this stage of development of white pine root system has not yet reached the impermeable pseudo clay horizon.

The development of dominant height of trees to spruce floors sour brown soil crucial role of depth profiles. For something deeper brown acid soil (over 100 cm) height growth dynamics is more intense than in the shallower acid brown soil (50 cm). It was found that a culture of distric ranker same depth as the shallower acid brown soil (50 cm) is, with minor fluctuations, the same dynamics of the total amount. For all three types of land part of the s-oid curve is identical to the age of 8 years. After this period, there is a strong influence of soil depth on the development of overall height.

Eutric culture built on brown soil (A-(B)-C) have a significantly faster development of high altitude and achieve greater heights of culture on acid brown soil, which until eight years have significantly lower height.

The development of spruce trees and luvisol pseudo clay, with occasional fluctuations, is quite uniform. And in these cultures is observed period decreased height of development until the age of 8 years. The investigated cultures of Austrian pine current height growth has not yet reached its maximum. Culture of Scots pine have reached the culmination of the current height increment and in the best habitats (habitat index of 24) in 8 years and the worst (habitat index of 18) for 15 years.

Culture spruce also show regularity in terms of height increment culmination of the current depending on the requirements expressed by ecological index. Index 21 reached a culmination in the age of 16. With habitat Index 18-19 in that year, whereas in habitats with lower solvency (for spruce) is not the culmination occurred. A large range in age when height increment culminates, with respect to rational knowledge of breeding treatment must relate to the large vertical growth phase (M. Vučkovic, 1991, Ratknić M, 1993), shows that one can not apply a single breeding rights, especially in terms of repeating and frequency measures of care. Development and growth of trees in the thickness yield depends significantly on the type and depth of soil. Austrian pine trees in the deeper limestone mold achieve greater thickness than in shallow mold. Luvisol is the value of the diameter between shallower and deeper into the limestone mold to deviate from the conclusions obtained from the development level. On a deeper brown acid soil were achieved greater diameters than shallower. For eutric ranker reached the lower value of the diameter compared to eutric brown soil.

The culmination of the ongoing thickness yield growth habitat index 20, 18, 16 and 14 occurred in the period 12-15 years, and has not been noted for the habitat index 12. Growth of Austrian pine at the moment culmination largest habitat index for the 20 (1.45 cm) while in other habitat indices of 1.2 to 1.3 cm.

He also established the dependence of achieved size in chest diameter of Scotch pine of different soil conditions. On the limestone soils of the highest value on the chest diameter luvisol, then brown limestone soil and the lowest was in the mold. Eutric brown luvisol and have achieved almost the same size at the age of 18 years. The highest values were established in cultures of acid brown soil and pseudo clay.

With increasing ecological index in cultures of Scots pine is coming to an increase chest diameter. This differentiation is at ecological index of 18 and 22 is evident from the very beginning of the development of culture, while the ecological index 20 and 22 the difference appears in the age of 18.

The thickness in growth culminates in a period of 10 to 15 years. Scots pine growth during the culmination of the largest in habitat index 24, and most smaller index - 18. The development of spruce diameter also indicates a dependence on soil conditions. For better habitats to achieve larger size of trees diameter of dominant floor.

The culmination of the current thickness yield increases noted in ecological index 21 in the 15th years, suggesting the culmination of ecological index 19 in 20th year while the ecological index 17 and 15 has not yet been achieved.

5. CONCLUSION

Generally, it was concluded that the better habitats (expressed through ecological index) development and growth of individual trees in diameter prior to culminate and achieve greater value at the time of culmination.

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THE CHANGES OF LAND USE IN GRDELICKA GORGE AND VRANJSKA VALLEY

Sonja BRAUNOVIĆ, Mihailo RATKNIĆ[1]

Abstract: *By the use of satellite photos of the high resolution the areas covered by forests, arable land, meadows and pastures, orchards, vineyards and barren soil in Grdelica gorge and Vranska valley were singled out. These data serve as a base for the creation of the erosion map of the researched area and at the same time enable the creation of the model of the adequate use of the space and the protection of it. Based on the methods of land use maps made for 2010th found that productive land covers 88.70%, and 11.3% fruitless. Reduce the area under arable land, meadows and pastures there was a remedy for areas affected by erosion processes. Another reason for this change are migration movements from high hill areas to urban centers. It was found to increase forest areas compared to 1953 th to 17.6%, and increase no fertile land, mostly in villages and roads by 3.6%.*

Key words: satellite photos, land use, erosion processes

PROMENE NAČINA KORIŠĆENJA ZEMLJIŠTA NA PODRUČJU GRDELIČKE KLISURE I VRANJSKE KOTLINE

Izvod: *Korišćenjem satelitskih snimaka visoke rezolucije izvršeno je izdvajanje površina pod šumom, obradivim zemljištem, livadama i pašnjacima, voćnjacima, vinogradima i neplodnim površinama na području Grdeličke klisure i Vranjske kotline. Ovi podaci predstavljaju osnovu za izradu karte erozije područja istraživanja i istovremeno omogućavaju izradu modela adekvatnog korišćenja prostora i njegove zaštite. Na osnovu karte načina korišćenja zemljišta urađene za 2010. godinu utvrđeno je da produktivno zemljište pokriva 88,70%, a neplodno 11,3%. Do smanjenja površina pod oranicama, livadama i pašnjacima došlo je zbog saniranja površina zahvaćenih erozionim procesima. Drugi razlog ovih promena su migraciona kretanja iz visokobrdskih područja ka urbanim centrima. Konstatovano je povećanje šumovitosti područja u odnosu na 1953 godinu za 17,6%, kao i povećanje neplodnog zemljišta, uglavnom u kategoriji naselja i puteva za 3,6%*

Ključne reči: satelitski snimci, način korišćenja zemljišta, procesi erozije

1. INTRODUCTION

Way of land use, in addition to analysis and meteorological climate conditions of relief, geological and soil characteristics of substrate, as well as the representation of the observed erosion processes, is one of the key factors for the identification and mapping of erosion processes. Using land and other natural resources for the social and economic development of man can their activities to disturb or endanger the natural balance or established to preserve and enhance. That is why the way land use is considered a significant element of anthropogenic erosion.

The paper deals with the change of land usage in the area of Grdelicka gorges and Vranjska valley from 1953 to 2010.

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Acknowledgement: The study was partly financed by the Minstry of Science and Technological Development of the Republic of Serbia, the Project – TR 20056 „High-resolution satellite images in the collection and processing of spatial information on forests and forest ecosystems“

2. RESEARCH AREA

Part of the South Morava River basin, which included the Law on Organization of Grdelica gorges and Vranjska valley (1952nd year) is located between 42 ° 22 'and 42 ° 55' north latitude and 19 ° 21 'and 20 ° 0' east longitude from Greenwich. Direction of providing the area is generally southwest-northeast, and the length is about 60 km. Basin area, which belongs to this section of the flow of South Morava is 173 261 ha. The main river in the region is the South Morava, which typically has torrential tributaries. The greatest number of torrent flow tributaries into the Southern Morava in the sector of the Grdelica Gorge (143) and Vranjska valley (more than 80). Two very important communication lines cross the South Morava valley in this area and connect Europe with Greece and the Mediterranean, namely the Split - Skoplje - Athens (Greece) road and railway line.

3. RESEARCH METHOD

We used the method of applying high-resolution satellite imagery that provides a minimum of expensive field work in collecting data, while providing enough getting accurate and practically useful information. In the field are based on satellite imagery and entered land plots identified a homogeneous whole in which they carried out additional field measurements. It is possible that most of the information obtained on the basis of satellite images that provides sufficient accuracy for understanding how to use the land on each homogeneous whole.

Today's generation of satellites allow mapping in the ratio of up to 1:5000.

- satellite systems only provide cost-effective, broad and periodically recording a certain area. Periodicity of monitoring is every few days (aero photos are cost efficient in cycles of 5-10 years), which is of great importance because it gives the possibility of monitoring the various ecosystems during short periods of biological cycle;
- multi spectral scanner is the only system that provides thermal data, which enables the detection and monitoring of various changes and differences in space: provides sorting areas according to types of plant cover, defines ways to use and clearly defines the boundaries between them. Rating accuracy ranging from 99-100%;
- enabled the separation surface with varying degrees of soil erosion; detect the infrastructure - temporary and permanent road network and others.

Used the incorporation of satellite imagery data telex orchestrated conventional cartographic displays such as topographic maps, slope and exposure maps, hydrographic maps, pedology, petrologic, geological, maps and other erosion in a unique geographical information system (GIS). In this way, made a multi-disciplinary integration that provides answers to the most complicated issues concerning the use of prototype, environmental and other disciplines.

4. PROCESSING SATELLITE IMAGES

Performed the following activities:

a) choice of clips
b) determining the number of shots that cover work area
c) field recording (basic determination and control points)

Image processing procedure was conducted in several phases:

- Preprocessing of satellite images
- generate multi spectral recordings from individual files (layer stacking)

- increase multi spectral resolution images (resolution Merge)
- aerial triangulation block
- Orthogonal rectification
- 3D visualization.

In the process of preprocessing of satellite images made a leveling of contrast and brightness of each image. As the multi spectral channels delivered as 4 individual single-channel recording (red, blue, green and near infrared) made their merger into a four-channel recording. This was done by the method of "stacking layer", which received four-channel multi spectral image resolution 4 meters. In the next stage, using a 1m resolution image pan chromatic done is to increase the resolution multi spectral clip by "resolution merge", the multi applicative methods. At the same cubic convolution technique used for extrapolation of pixels. The result of this phase of processing multi spectral satellite image is the image resolution of 1 meter. Aerial triangulation technique using a block method of block adjustment (method of least squares of deviations) as a functional model to define the mathematical relationship between the image coordinate system and the state coordinate system. This part of the process involved the following steps:

- Add an image processing program
- Enter parameters push broom sensor model of IKONOS
- Enter the internal orientation parameters using the RPC coefficients (Polynomials Rational Coefficients)
- Create a layer of pyramidal
- Identification of orienteering points

All the raw satellite images were subjected to the process orthogonal rectification . As input parameters were used to process external orientation elements obtained from the process block Aerial triangulation and DMT. As a result of a process orthogonal rectification images were obtained with the corrected raw images, geometric distortions arising due to sensor orientation, topographic terrain and the influence of systematic errors. Orthogonal rectification images were obtained, which represent the elements of space in their right, orthographic, plan metric positions.

For the purposes of reuse, especially in the separation of homogeneous units, the digital orthogonal photo was made in the natural color (Natural Color) using red, green and blue channels in false color (False Color) using near infrared, green and blue channels. Raster format is a TIFF file with TWF, which allows use in almost all GIS and CAD software. Coating process orthogonal rectification satellite image over a digital terrain model (so-called beige image) created a 3D visualization for more realistic perception of space and presentation of project results.

4. 1. Determination of control points

To translate the satellite image of the state coordinate system are determined by the orientation points (Ground Control Points). Approximate point has been clearly and unambiguously identifiable on satellite images and field work. Apart from a certain point orienteering and a few control points (Check Points) which are used to control the proceedings orthogonal rectification clip. These points are determined according to the same parameters and with the same accuracy as well as orientation points.

To determine the orienteering control points used and the method of global positioning (GPS).As a measuring device was used Trimble Geo XH Geo Explorer that provides accurate measurements of 10-10 cm in the measurement of the subsequent processing. Processing of measurement data are used with the permanent stations. For the transformation of the state coordinate system used in the global transformation parameters for Serbia by the Republic

Geodetic Authority. Achieved accuracy ranges from 0.2m to 0.5m.

4. 2. Production of digital terrain models

In order to remove topographic effect in the process of recording satellite orthogonal rectification made a digital terrain model (DTM). As a source of data for high performance, were used 1:10000 scale topographic maps (with equidistance of 10 m) and map scale of 1:5000 (with equidistance of 5m). In order to get DMT implemented the following activities:

- scanning of analog cards
- rectification and geo referential of scanned maps
- Plotter altitude performance
- Preparation of DMT

Scanning tickets is made with 400 dpi resolution scanning. The cards are scanned in color, in TIFF format without compression. After the scan was performed removal of linear and nonlinear deformation of scanned content rectification procedure using all grinding points cards. Rectification was carried out by the method of second-order polynomial transformation. Rectification applied on all maps are with an error of less than 01 * scale factor, i.e. with an error of less than 1m for map scale of 1:10000, that is an error of less than 0.5m for a map scale of 1:5000.

An altitude Plotter following data:

- Contour line (using semi-automatic vectorization)
- altitude points (using manual vectorization on the screen) and
- structural lines (using manual vectorization on the screen).

Digital model was created in the format of TIN. Minimum height of DMT is 252 m maximum 1923 m. Due to the need orthogonal rectification made the conversion in grid format, or in a matrix of pixels in which each grid cell has a height attribute in the state system height. Grid resolution is 1m.

Except for orthogonal rectification, DMT is used for making maps of terrain aspect and slope. On the basis of these data shall be attributed methods of geo processing homogeneous whole.

Homogeneous zones were established, by way of land use necessary for the further processing of data, and interpreted in the video.

During the analysis and interpretation of data from satellite images were used two classification process:

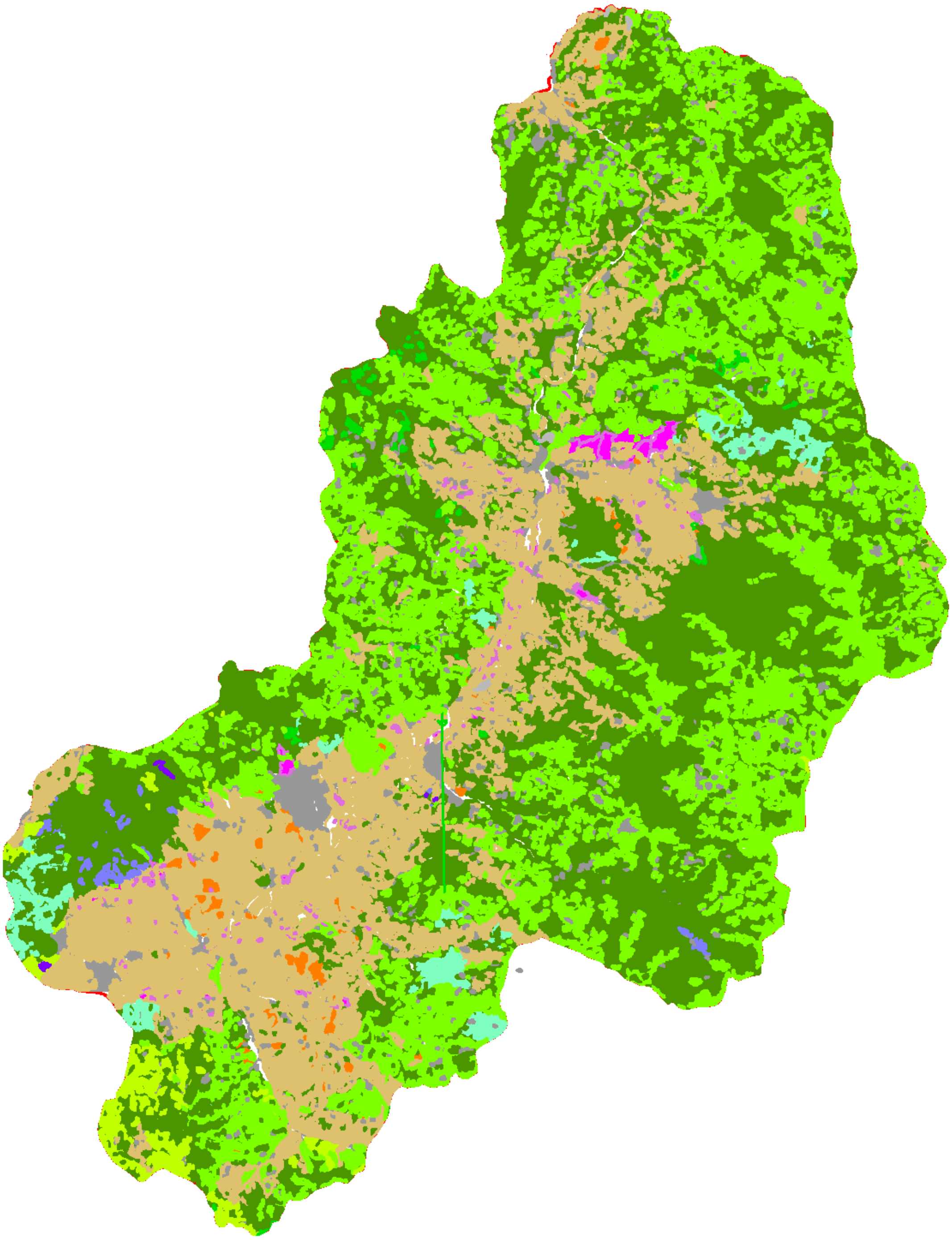
- Supervise classification process information on how to use the land, which takes into account the data collected by field measurements and perform a comparison with data obtained using this classification process.
- Unsupervised classification process data on how land use, taking into account updated information from topographic and other maps and compare them with data obtained using this classification process.

5. METHOD OF CLASSIFICATION

Details of classification are adapted to the needs and specifics of how to use the prototype as well as the details of which can be obtained from satellite images. Effective classification using satellite imagery is required prior preparation of materials and calculating the measured factors. The footage marked the effective surface, and work on the classification are made only within that part of the image. Boundary lines are identified with the help of details such as fields, roads, watercourses, and more. This is done in combination of computer overlying satellite image from scanned topographic maps.

In the satellite image detection are identified and classified by area of usage. The first step consisted in the classification in the marking of border areas are different ways of use. Large homogeneous units later split to other criteria or schema mapping.

The accuracy of the interpretation and periodically checked. Interpretation the results are checked often enough to set the boundaries of acceptable errors.



Land use map 2010th – Grdelicka gorge and Vranjska valley

6. CHANGING OF LAND USE

Based on the methods of land use maps made for 2010. year found that productive land covers 88.70%, 11.3% and fruitless. Reduce the area under arable land, meadows and pastures there was a remedy for areas affected erosion processes. Another reason for this change are migration movements from high hill areas to urban centers. It was found to increase forest areas compared to 1953 *rd* to 17.6%, and increase infertile land, mostly in villages and roads by 3.6%.

Table 1: *Land use in 1953rd and 2010th*

Culture	Area (ha) in 1953	% share	Area (ha) in 2010	% share
Fields	51419.21	29.7	31094.69	17.9
Orchards	1777.82	1.0	1766.85	1.0
Vineyards	2231.92	1.3	1184.08	0.7
Forests	53864.83	31.1	84300.84	48.7
Natural forests			81684.99	
Degraded forests			2217.51	
Anthropogenic forest			398.33	
Meadows and pastures	50605.99	29.2	35314.90	20.4
Meadows and pastures			33981.95	
Degraded pastures			1332.95	
Unfertile	13360.84	7.7	19599.23	11.3
Rocky			340.24	
Gullies			25.79	
Settlements			9839.85	
Gravel			104.93	
The rivers			248.19	
Roads and rivers			9040.20	
Total	173260.60	100	173260.60	100

7. CONCLUSION

The manner of use of land erosion is the only factor that man can manage and control it. Inadequate land use is directly linked to the emergence of intensified erosion process known as "anthropogenic erosion". As an irregular manner of land use intensification can cause erosion, so it is possible to change usage reduced its intensity. Diagnosed as major changes in how land use in the period 1953-2010, which had resulted in reducing the intensity of erosion processes.

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THE SATELLITE PHOTOS OF THE HIGH RESOLUTION IN THE DEFINION OF THE CHANGES IN THE ECOSYSTEMS USING THE HILLY-MOUNTAIN ROGOZNA AREA AS AN EXAMPLE

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Abstract: *The adequate biodiversity protection at the species and genetic level is not possible without the adequate site protection. The climate change causes the increase in the air temperature (increased evapotranspiration), decrease in the quantity of precipitation, as well as the deterioration of the soil physical characteristics. The deterioration of the water-air soil characteristics will lead to the deterioration of the structure caused by the decrease of the nutrient content. The protective role of the vegetation will be reduced, the soil erodibility will increase, as well as the number of the wildfires, whereas the site conditions will deteriorate drastically. The global changes also affect the smaller regions, owning to which the monitoring of them is of a particular importance for the changes in the ecosystems. For this purpose we use the satellite photos of the high resolution, and by the use of GIS technology the method of the monitoring of the periodical changes in the ecosystems was developed. The collected data will enable the creation of the model which contain the dynamics of changes in the natural ecosystems. This paper analyzes the hilly-mountain Rogozna area. The classification based on EUNIS sistem of the site classification was applied. By the use of the satellite photos of the high resolution (pixel size 1m) for Rogozna area the spacial distribution of the sites was defined. By the periodical recording of the characteristic areas in Serbia the spacial distribution of the ecosystems, as well as the changes in their composition and structure, will be monitored.*

Key words: ecosystem, biodiversity, climate change, site, GIS

SATELITSKI SNIMCI VISOKE REZOLUCIJE U DEFINISANJU PROMENA U EKOSISTEMIMA NA PRIMERU BRDSKO-PLANINSKOG PODRUČJA ROGOZNE

Izvod: *Bez adekvatne zaštite staništa nema adekvatne zaštite biodiverziteta na specijskom i genetičkom nivou. Klimatske promene dovode do povišenja temperature vazduha (povećane evapotranspiracije), smanjenja količine padavina kao i do pogoršanja fizičkih osobina zemljišta. Pogoršanje vodno-vazdušnih osobina zemljišta usloviće pogoršanje strukture izazvane smanjenjem sadržaja organske materije. Smanjiće se zaštitna uloga vegetacije, povećati erodibilnost zemljišta i broj šumskih požara, a drastično će se pogoršati stanišni uslovi. Globalne promene se odražavaju i na područja manjih regija, zbog čega je njihovo praćenje od izuzetnog značaja na promene u ekosistemima. U tu svrhu koristimo satelitske snimke visoke rezolucije, a uz primenu GIS tehnologije razvijen je metod praćenja periodičnih promena u ekosistemima. Prikupljeni podaci omogućiće izradu modela koji u sebi sadrže dinamiku promena u prirodnim ekosistemima. U radu je analizirano brdsko-planinsko područje Rogozne. Primenjena je klasifikacija bazirana na EUNIS sistemu klasifikacije staništa. Korišćenjem satelitskih snimaka visoke rezolucije (veličina pixela 1m) za područje Rogozne definisan je prostorni raspored staništa. Periodičnim snimanjem karakterističnih područja na teritoriji Srbije pratiće se prostorna zastupljenost ekosistema, kao i promene u njihovom sastavu i strukturi.*

Ključne reči: ekosistem, biodiverzitet, klimatske promene, stanište, GIS

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Acknowledgement: The study was partly financed by the Minstry of Science and Technological Development of the Republic of Serbia, the Project – TR 20056 „High-resolution satellite images in the collection and processing of spatial information on forests and forest ecosystems“

1. INTRODUCTION

Climate is a natural condition that most directly affect forest ecosystems. On forest ecosystems affected by climate as:

- macroclimate (planetary)
- regional climate (regional impacts of climate) and
- microclimate (climate of small spatial units, and even point (eco climate - climate of flowers or plants, air tree crowns).

Effects of climate are more:

- indirectly, through climate factors (latitude and longitude, the layout of land and sea, altitude, etc.)
- directly, through the elements of climate (radiation, air temperature and soil, air pressure, wind, humidity, cloudiness, precipitation, etc.)

In its development of forest vegetation, provided that the ecosystem can not be seriously disturbed by a change in environmental factors, reaching its peak, represented a stable community, in conformity with the regional climatic conditions. As a result occur climatogene or climate zonal communities, which are tailored to regional climate conditions and the most complete reflection of the natural conditions of a region. Community-specific mountain belts are climate regional. All of these communities caused by the general climatic conditions are now simply called the zonal vegetation, including the same concept climate zonal (in plain) and climate regional (in the high mountain belts).

2. PROJECTIONS OF CLIMATE CHANGE IN THE 21ST CENTURY

Presented according to the latest estimates of regional climate change in Southern Europe Region which belongs to the Republic of Serbia, in addition to the trend of further increase in air temperature, in the coming period is expected to further decrease precipitation, followed by reducing the number of days with snow and snow cover, reducing runoff, soil moisture and availability water resources.

Climate change projections for Europe show a reduction of annual rainfall in South Eastern Europe by 1% per decade. This decrease of rainfall in South East Europe would be the most distinctive in the warm half of the year, and for a given scenario amounted to about 22% at the end of this century. Climate change in our cause of increased air temperature (evapotranspiration increased), reducing the amount of rainfall as well as the deterioration of physical properties of soil. Deterioration of water-air properties of soil will term deterioration of soil structure caused by the reduction of organic matter. Reduce the protective role of vegetation, soil erosion ability increase the number of forest fires, and will dramatically worsen living conditions for afforestation. A large part of the negative effects caused by climate change can be reduced by proper choice of ways to use the land, the replacement of cultures and species that are adapted to new conditions and other measures. Based on monitoring changes in temperature can be planned in future afforestation activities in terms of proper choice of species (species that are best submitted made changes), such as planting materials, choosing the appropriate method of soil preparation.

3. HABITAT CLASSIFICATION

The concept of protection of biodiversity habitat becomes a central unit of protection. Habitat is defined as a "community of plants and animals (and other members of biocoenosis), which together with abiotic factors (soil, climate, water quantity and quality, etc..) represents a unique functional unit" (Davies CE & Moss, D. 2002: EUNIS Habitat classification – European Habitats Classification System, European Environment Agency & European Topic Centre on Nature Protection and Biodiversity).

The main documents that define the initial elements in the protection of habitat for:

- Convention on Biological Diversity - CBD - UNCED, Rio de Janeiro, 1992
- Berne Convention - Council of Europe, Bern, 1972 and
- Habitat Directive - the EU Habitats Directive 92/43/EEC.

Serbia habitat classification system is based on the EUNIS classification system (Lakušić, D. 2005). Most, but not all EUNIS habitats are actually biotopes or areas with equal environmental conditions enough to support a distinctive combination of organisms that inhabit them. All EUNIS habitats (except the smallest) include at least 100 m2 surface, while the upper limit is determined. At the low scale can be described and called "microhabitats" (which generally take up less than 1 m2, and is significant for some small invertebrates and lower plants). Examples of this are dead trees from old forests, which are ideal habitats for many species decomposers. For larger scale habitat can be grouped in the so-called. "Habitat complexes", which often occur in a typical mosaic, or a combination of individual habitat types, which may be in mutual dependence. With the development of the classification itself, made the basis of parameters that includes the reference systems for climate, soil, water quality, vegetation, and typical physiographical elements, or the dominant plant and animal species. The aim of establishing this system is just creating a reference database on species, habitats and areas that forms the basis of the Directive on Birds and Habitats Directives of the NATURA 2000 network and its network of similar EMERALD Berne Convention, and is also used in the development of indicators (EEA Core Set and others) and create reports on the state of environment.

4. HABITAT TYPES OF ROGOZNA MOUNTAIN

In the area of Rogozna noted the following habitats:

C - LAND SURFACE WATER HABITATS
C2 - Surface running water
  C2.5 – Temporary running water (wet phase)

D – Moor, peat and jack habitats
  D5.3 – Dominated habitats (*Juncus effusus*) or other high site (*Juncus* spp.)

E – GRASS TURF HABITATS AND HABITATS OF HIGHER THE GREEN
E1 – Dry grass formation
  E1.2 – Perennial grass limestone formations and steppe in the bazal background
    E1.2B – Serpentine steppe
      E1.2B1 – Serpentine steppes of deeper soil
      E1.2B2 – Serpentine steppe on shallow rocky soil
      E1.2B3 – Formation of large blocks of rock Serpentine
  E1.7 – Non-Mediterranean dry acid and neutral closed grass formation
  E1.71 – (*Nardus stricta*) herbaceous community
      E1.71A – - moderately humid (*Nardus stricta*) herbaceous community
      E1.71B – Dry (*Nardus stricta*) herbaceous community
E2 – Moderately moist grass formation

- E2.1 – mesofhyle permanent pastures and meadows for grazing after mowing
  - E2.13 – abandoned pastures
- E2.3 – Mountain high meadow
  - E2.33 – Balkan high mountain meadows

E3 – Seasonal wet and wet grass formation

- E3.3 – Sub-Mediterranean wet meadows
- E3.4 – Wet and wet eutrophic and mesotrofic grass formation
  - E3.46 – Continental wet meadows
    - E3.465 – Continental with wet meadows dominated by *Deschampsia caepitosa*
    - E3.466 – Continental with wet meadows dominated by *Festuca pratensis*
    - E3.467 – Continental wet meadow with domination of *Alopecurus pratensis*
    - E3.4672 – Continental with wet meadows dominated by clover and species (*Alopecurus pratensis*)

E5 – Forest averages and habitat clearing and high green

- E5.2 – Thermophilic forest averages
  - E5.21 – Ksero-thermophilic forest averages
  - E5.22 – Mesophile forest averages
- E5.3 – Bracken (*Pteridium aquilinum*)
- E5.4 – Wet and moist habitats of high green meadows and marginal bracken habitats
  - E5.43 – Shadow forest edge averages

F – Peat, shrubby habitats and Tundra

F3 – Temperate and Mediterranean habitats mountain bushes

- F3.1 – Moderate thickets and bushy habitats
  - F3.16 – shrubby habitats common juniper (*Juniperus communis*)
  - F3.17 – Coppice hazel (*Corilus)*

F9 – River and jack thickets

- F9.1 – bushy willow (*Salix*) along streams and lakes

FA – hedge

- FA.3 – hedge rich indigenous species

G – forests and woodland habitats and sylvan OTHER AREAS

G1 – broadleaf deciduous forest

- G1.1 River Forest willow (*Salix*), alder (*Alnus*) and birch (*Betula*)
  - G1.12 – Bore-alpine river gallery
    - G1.121 – Mountain Galleries gray alder (*Alnus incana*)
      - G1.1211 – Mountain mono dominant gallery gray alder (*Alnus incana*)
- G1.6 – Beech (*Fagus*) forests
  - G1.69 – Moesian beech (*Fagus moesica*) forests
    - G1.691 – Moesian mountain beech (*Fagus moesica*) forests
      - G1.6914 – Moesian cascades of mountain forest with oak
    - G1.692 – Moesian acidofilne mountain beech (*Fagus*) forests
      - G1.6921 – Moesian mountain beech forest with Bekic (*Luzula* sp.)
- G1.7 - Thermophilic deciduous forests
  - G1.75 – Southeast subtermopfile oak (*Quercus*) forests
    - G1.751 - Moesian forest oak (*Quercus petrae*)

- G1.7513 – Moesian forest oak (*Quercus petrae*) on serpentine with black hornbeam (*Ostrya carpinifolia*)
- G1.753 – Moesian cerris forests (*Quercus cerris*)
  - G1.7532 – Moesian cerris forests (*Quercus cerris*) in the serpentine
- G1.8 – Acidophil forests dominated by oaks (Quercus)
  - G1.87 – Central European acidophil oak (Quercus) forests
    - G1.871 – Moesian acidophil forest oak (Quercus petrae)
      - G1.872 – Moesian acidophil cerris forests (Quercus cerris)
- G1.9 – Forests with birch (*Betula*), Aspen (*Populus trémula),* rowan (*Sorbus aucuparia*) and hazel (*Corylus avellana*) beyond the zone of rivers
  - G1.91- birch (Betula) forests on the dry ground
    - G1.91B - Balkan birch (*Betula*) forests on the dry ground
- G1.92 – Forest Aspen (*Populus trémula*)
    - G1.923 – Montana habitat Aspen (*Populus trémula*)

G3 – coniferous forests

- G3.5 – Austrian pine forest (*Populus nigra*)
  - G3.52 – Western Balkan Austrian pine (*Pinus nigra*)
    - G3.522 – Western Balkan Austrian pine forest (*Pinus nigra*) at the Serpentine
      - G3.5222 – Austrian pine (*Pinus nigra*) on serpentine with (*Potentilla alba*)
- G3.F – Very artificial coniferous plantations
  - G3.F1 – Plant native conifers
    - G3.F11 – Artificial built stands of spruce
    - G3.F14 – Built artificial Austrian pine stands
    - G3.F14 – Artificial built stands of Scotch pine

H – INTROCONTINENTAL hardly developed HABITATS WITH VEGETATION

H1 – Terrestrial underground caves, cave systems, and water mass passes

- H1.7 – Used underground mines and tunnels

H2 – Scree

- H2.6 – Calcitereus and ultra-basic rock creep hot exposure
  - H2.6E – Illyrian scree with (*Achnatherum calamagrostis*)

H5 – Different introcontinental habitats with poorly developed vegetation

- H5.5 – Burnt zone without or with very scattered vegetation
  - H5.51 – Recent burned land with no vegetation
  - H5.52 – Burned areas with scattered vegetation

H5.6 – Stamped area

- H5.61 – Naked area

I – REGULAR OR NEARLY CULTIVATED AGRICULTURE, HORTICULTURE OR DOMESTIC HABITATS

I1 – Arable land and gardens where crops are grown for cane field

- I1.1 – Intensive monoculture
  - I1.13 – Small intensive cropping (<1ha)
- I1.5 – Naked exemplary, or reaped almost abandoned arable land
  - I1.51 – Naked model surface
  - I1.52 – Reaped non flooded field weeds with one community
  - I1.53 – Reaped non flooded field with one perennial weeds and communities

I2 – Cultural garden areas and parks
    I2.3 – Weeds recently abandoned community garden

J – CONSTRUCTION, INDUSTRIAL AND OTHER ARTIFICIAL HABITATS
J2 – Rare housing units
    J2.1 – Rare housing
    J2.2 – Rural public buildings
J4 – Transport networks and other areas of surface structures
    J4.1 – weeds community transport networks and other zones of surface structures
    J4.2 – Road Network
J5 – Very artificial water made by man and the attached structure
    J5.3 – Very artificial unsalted standing water
    J5.33 – Water storage tanks
J6 – Waste Landfills
    J6.2 – Waste from households and waste places
    J6.4 – Agricultural and horticultural waste
        J6.42 – Liquid agricultural waste (manure)
        J6.5 – Industrial Waste
        J6.51 – Cinder hills

Using high-resolution satellite imagery (pixel size 1m) is defined by the spatial arrangement of habitats.

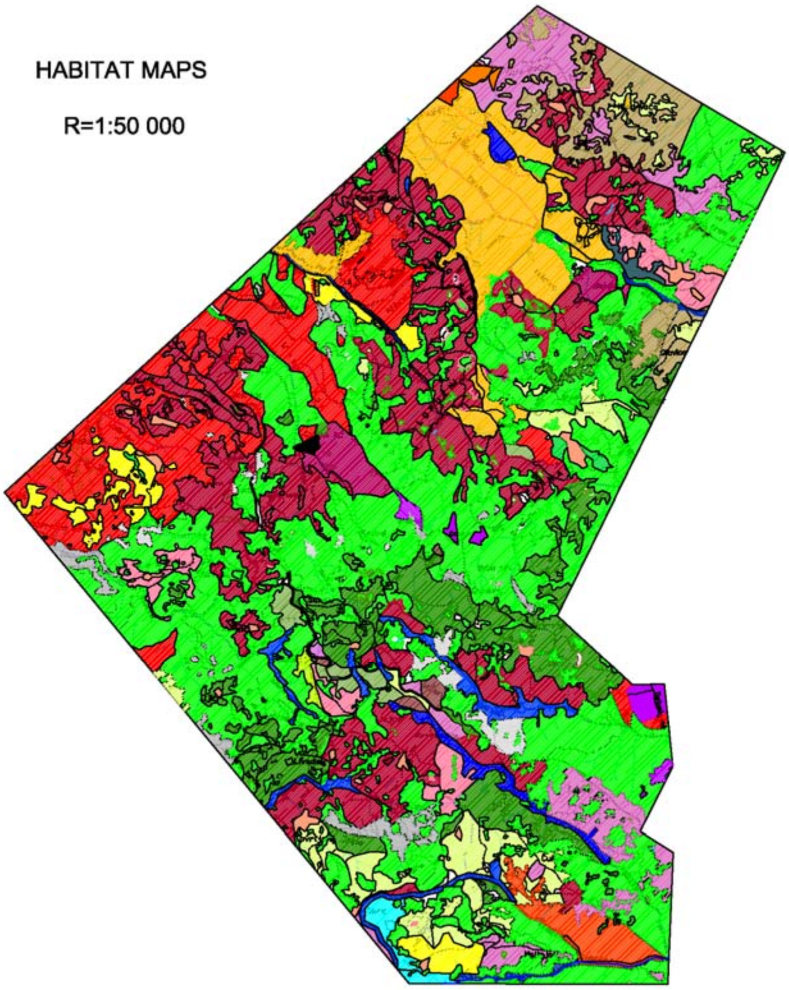

Figure 1: *Map of research habitat areas*

5. TYPES OF CHANGES HABITATS

The changes represent a translation of habitat area one category to another class of habitats. Conditions for the identification of categories of habitats using satellite imagery has changed the reflection spectrum. These changes recognize the changes in properties of elements are interpreted. On a methodological point of view it means that the pictures of two or more periods (time series) used to identify changes in land cover. They use two basic methods for the detection of changes in satellite images:

- Visual and computer-aided visual interpretation
- The method of digital identification changes

In order to monitor changes in habitat most used visual interpretation of satellite images. All necessary changes are performed at the initial (primary) layer of the data, that changes only locally in the areas where they identified changes in the habitats. All unchanged polygons (homogeneous) keep the border areas from the previous period. Do not create the new database but the data supplement. This will minimize the occurrence of errors in the database during the change, which is common when comparing independently established database. Significantly and reduced cost (drawing) polygons.

On the use of high resolution satellite imagery database to form a homogeneous whole of the minimum area of 1 m2. Changes in the habitats of the map if they reflect the actual evolution of changes in habitats (e.g. growth of settlements, clear cutting forests, etc..) Rather than its seasonal changes.

Typical types of changes are:

- Changes in habitat on the entire surface of the polygon: the diameter, reaped not flooded field with one perennial weeds and communities (and 1.53) was used as a continental wet meadows with dominance and clover species (*Alopecurus pratensis*) (E3.4672);
- Exchange of land between two polygons: for example, building settlements and expansion of peripheral zone urban regions (J1.2) on account of reduction in weed communities recently abandoned garden (I2.3);
- The appearance of the new polygons: for example the Balkan birch (*Betula* sp.) forests in dry field (G1.91B) within the burned areas with scattered vegetation (H5.52)
- The disappearance of a polygon: for example hazelnut shrubs (*Corilus* sp.) (F3.17) with artificially raised stands of white pine (G3.F14).

6. CONCLUSION

Global changes are reflected in the areas of smaller regions, so that their monitoring of great importance to changes in ecosystems. For this purpose we use high resolution satellite images, and using GIS technology developed is a method of monitoring the periodic changes in ecosystems. The collected data allow development of models that contain dynamic changes in natural ecosystems. Periodic recording of the characteristic areas in Serbia will be followed by a spatial representation of ecosystems, as well as changes in their composition and structure.

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SPECTRAL ENHANCEMENT OF THE SATELLITE IMAGES IN THE CLASSIFICATION OF FOREST VEGETATION IN THE REGION OF VRSAC HILL

Dragan STEVIĆ[1], Dragomir GRUJOVIĆ[2]

Abstract: *Forest vegetation is one of the important factors in determining the climate of the local and global character. The spectral Landsat7 satellite channels have a significant application in the vegetation classification. The channels of the visible and near infrared part of the EM specter have been used, the period of taking images was mid-summer, and these images cover the north-eastern part of Serbia (the area of Vrsac Hill). The multi-spectral processing of the satellite image has been carried out by means of unsupervised classification process (ISODATA method), and the spectral enhancement by means of: the vegetation index, normalized difference of vegetation index (NDVI), as well as the transformed NDVI (TNDVI).*

Key words: forest vegetation, climate, Landsat7, multispectral, ISODATA classification

1. INTRODUCTION

The total forest area and forest soil in Vojvodina is about 175 136 ha, out of which the forest vegetation covers 140 718 ha. The percentage of the forested areas is only 6.51%, and within this percentage 96.07% is state-owned, and in private ownership is 3.96%. The largest part of forests represents the separate entity: Vršački Breg, Narodni Park (People`s Park) Fruška Gora, Deliblatska peščara, Subotička peščara, valleys of the rivers Sava, Danube, Tisa and Tamiš (Fig. 1).

Vršački Breg is part of the Carpathian Mountain Range, in the close vicinity to the border of Serbia and Romania, of more than 600 m above sea level, covering the area of 4177 ha. The forest vegetation of Vršački Breg, as well as the plantations of vineyards on its southern slopes have impact on the mild climate of this region. This locale is especially suitable for biodiversity development, and in 2000 it became a significant area in Europe in terms of preservation of birds. The fauna of Vršački breg is very rich, there are several animal species, as well as around 130 species of birds, especially those belonging to the forest habitat and among them 90 are protected by law.

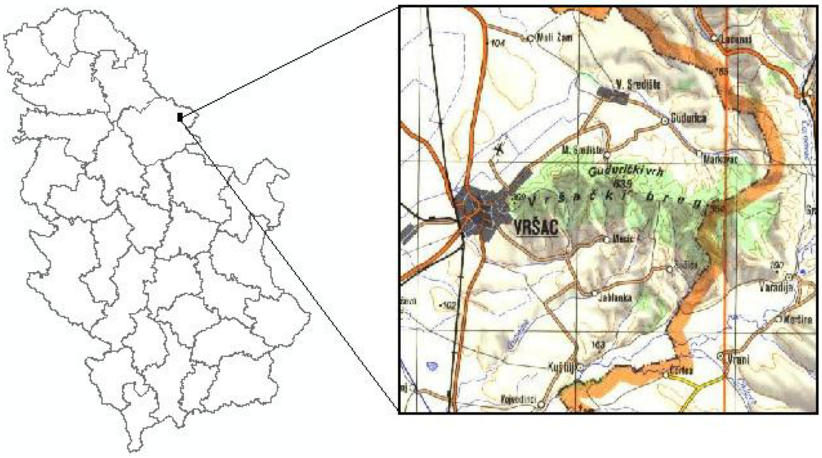

Fig. 1. *The geographical position of Vršački breg*

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The Vršački breg forests are the protected area of the Pannonian plain due to its specific position, diversity of its flora and vegetation, the rich forest eco-system with ideal possibilities for excursions and recreation in the beautiful scenery.

2. DIGITAL PROCESSING OF LANDSAT 7 IMAGERY

In this paper the Landsat 7 imagery processing and the analysis of the region of Vršački breg have been shown as well as presentation of the results of the research and methodology of separation of the forest vegetation by means of the program package ERMapper (1). Landsat 7 imagery represents very significant source of the data for presentation and monitoring of forest vegetation content on the surface of the Earth. Understanding of all links and relations among the digital values (DN) pixel recorded on the satellite Landsat 7 imagery and events on the terrain enable correct interpretation and imagery analysis in terms of content presentation of forest vegetation (2). In the process of research of Vršački breg the satellite imagery has been used, with the imagery recorded on June 16, 2002. Having in mind a more precise separation of the forest vegetation from other specific areas on the imagery, the operations of enhancing the spectral characteristics and imagery quality by application of the high frequency pixel (5x5 and 7x7) filters [3] have also been conducted.

The accentuation of the imagery special content has been achieved by application of the convulsion principle, the so-called “special filtering”, as well as the statistical methods (the error matrices… , classification dendograms and correlation analyses), by means of which the various contents of forest vegetation could be accentuated or removed, and consequently separated from other similar contents.

3. ISODATA CLASSIFICATION

In this paper the satellite channel Landsat 7 imagery 3 (the red one) has been processed and analyzed, from the visible part of EM specter and the channel 4 from the near IR part of the EM specter), the imagery being recorded on June 16, 2002, at the area of Vršački breg and also the overview has been given of the results of the research of forest vegetation by the program package ER Mapper [4].

The ISODATA classification method has been applied (the Unsupervised classification process), which yields good results of the forest vegetation classification, has the possibility of encompassing the procedures of separating, combining and grouping of the forest vegetation classes so that the optimal set of output classes could be obtained. The ISODATA method defines the initial set of the tested classification centers of forest vegetation and it also assigns pixels to the nearest classification center. At each consequent iteration the process initially changes the temporary set of the classes. The large forest vegetation classification may be divided on the basis of a large number of pixels, maximum standard deviation or the average distance of the classification sample from the classification center. The forest vegetation classification which turned out to be beyond the minimum of the initial values is thus rejected and its pixels assigned to other classes of the forest classification [5].

The pairs of classes are then combined in case the distance between their classification centers falls beyond the initial value. After the classes have been determined and the new centers have been calculated the whole process is being repeated [6]. The iteration processes are continued until there is the least number of changes in the position of the classification center or until the iteration limit has been achieved. In our case the number of iteration has been limited to 10, and the number of classes to 30, while the other parameters have been applied according to default. The ISODATA classification methods results have been shown in the Fig. 2.

It is evident that the forest vegetation is separated (accentuated) relatively well, but the clear boundary cannot be made since the class representing the forest vegetation is intermingled by other classes which do not represent the vegetation. The reason for this is that within the vegetation other soil covers can also be observed [7]. Having in mind that the classification process has been initiated with 30 classes, with the aim of obtaining as detailed raster as possible, the merging of the close classes of the forest vegetation has been carried out.

The result of separation of the forest vegetation from other ambiences has been shown in the Fig. 2. The dark green colour represents the deciduous forest lime-tree (Tilia), the bright green colour shows acacia (Robinia pseudoacacia) and yellou collour represents mixed forest [8].

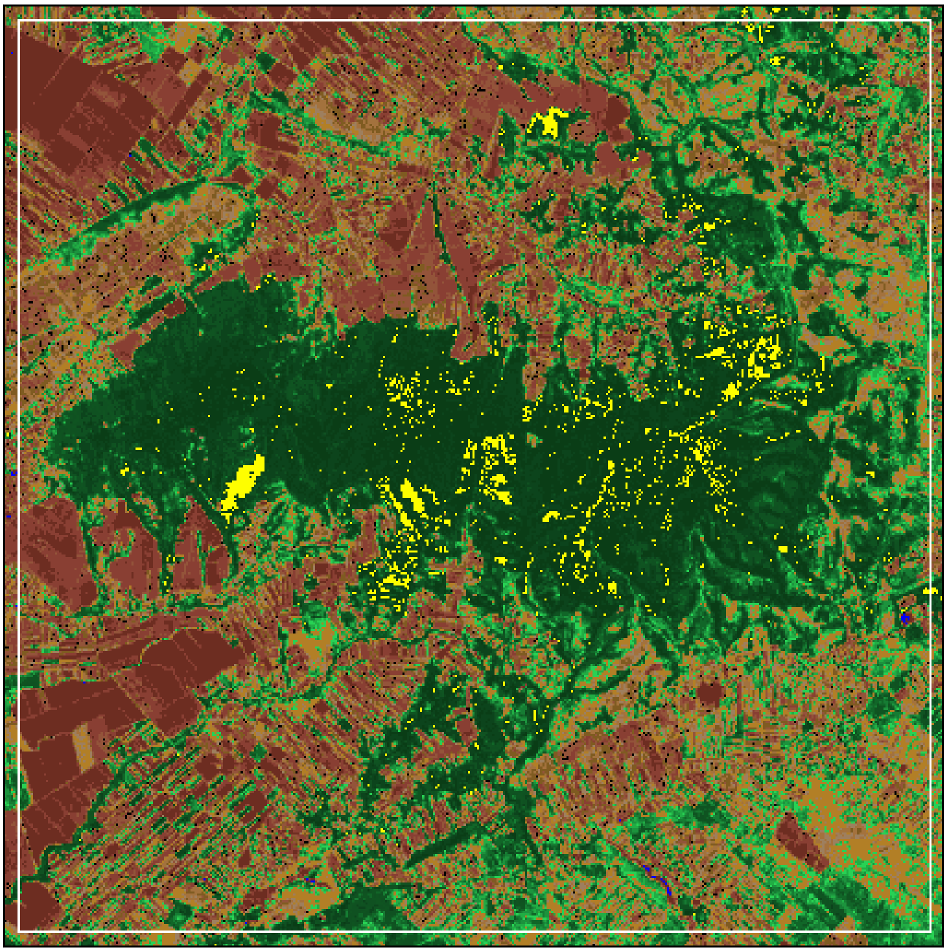

Fig. 2. *The clusters of the forest vegetation*

4. CONCLUSION

By application of the classification methods of remote detection the quality and up-to-date data have been obtained in terms of updating data basis of management units, which primarily contributes to separation of sections and determination of their square areas.

The support in the creation of the data basis of the forest vegetation, besides the classification methods of supervised and unsupervised procedure, constitute all data obtained by the digital processing of the terrestrial, aerial-photography, multi-spectral satellite, thermo-visual, radar and other imagery. The data basis provides the quality management of available forest area. At definite periods of time it is necessary to perform aerial-photogrammetrical and satellite imagery recordings by means of the high resolution sensors within the definite part of EM specter, with the aim of detection, identification and classification of the forest vegetation and its impact on the climate of a concrete area.

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THE APPLICATION OF FUZZY C MEANS CLASSIFICATION OF THE VEGETATION ON THE PHOTOGRAMMETRIC IMAGES

Dragan STEVIĆ[1], Dragomir GRUJOVIĆ[2]

Abstract: *The unsupervised Fuzzy C Means classification method, gives the representative data and wide range of applications in the vegetation classification. In the paper the photogrammetric color images covering the area of Kosmaj mountain in the visible part of EM specter (400-700nm) at the scale of 1:15000, in mid-summer period, have been used. The spectral analysis of the images, with the analytical approach and indicated classification enables an accurate isolation of the forest vegetation. The above-mentioned method enables a new approach in the isolation of the homogenous areas for the sustainable forest management requirements as an important factor in the formation of this area climate.*

Key words: Fuzzy C Means classification, vegetation classification, photogrammetric color images, spectral analysis, climate.

1. INTRODUCTION

The name Kosmaj originates from the Celtic word “cos (forest) and the pre-Indo-European word “maj (forest). According to the national legal regulations this area has the status of the Region of exceptional characteristics. Kosmaj is the largest and the highest mountain, as well as the most important geomorphological extraordinary scenic landmark in the range of the mountains of Šumadija near Belgrade, at the northern geographical latitude of 44°28’28” N, the eastern geographical longitude 20°34’48” E, covering the area of 1171 ha and at 626 m above sea level. The three peaks are of significance for Kosmaj: Mali, Goli and Rutavi vrh. In the Fig. 1 the geographical position has been shown, and in the Fig. 2 the panoramic view of Kosmaj. This mountain is rich in water, has exceptional continental Danube region climate, and as the result of crisscrossing of the air currents from the Carpathian Mountains and Mediterranean it has also impact on the microclimatic characteristics of the wider area of Belgrade. The geological basis mainly comprises fleches d’amour, serpentine and clay.

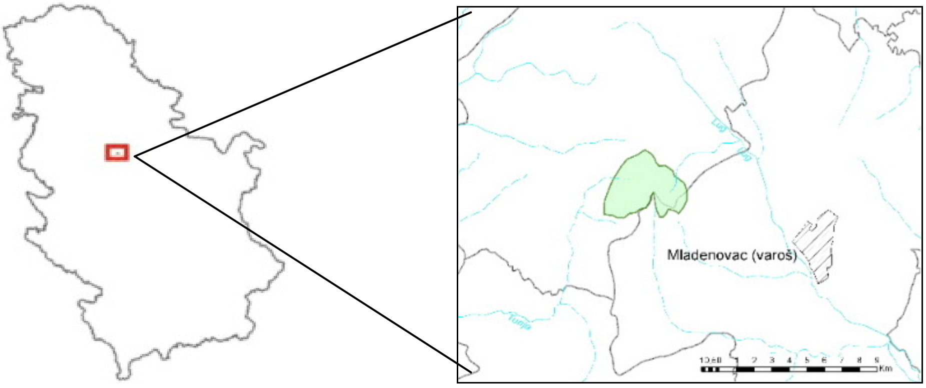

Fig. 1. *The geographical position of Mt Kosmaj*

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The area of Mt Kosmaj is a significant factor for the ventilation of the river valleys that run down along Topčider river and other streams around Belgrade and is also characteristic of specific biodiversity. The whole panoramic area of Kosmaj is under vegetation. The dominant types of forest vegetation are the forests of the oak, beech, hornbeam and in some parts there are coniferous forests as well as the mosaic consisting of barren ground and the grassland and shrubs. The mild slopes are covered with grass vegetation, and the foot of the mountain is under orchards and cultivated fields, while the level terrain mostly consists of clearings. The Kosmaj forests have quite a number of general beneficial functions, which many times surpass the economic functions (absorption of CO_2 from atmosphere, reducing of the greenhouse effects, easing of the climatic changes, protection of soil from water erosion, protection of cultivated fields from the excessive drying up, preservation of biodiversity in the forest and neighboring eco-systems, preservation of geo-fund of forest trees and others.

Fig. 2. *The panoramic view of Mt Kosmaj*

2. LANDSAT 7 SATELLITE SPECTRAL CHANNELS

As the main source of data the Landsat 7 satellite imagery has been used, which has 8 channels. The seven channels (1, 2, 3, 4, 5 and 7 are with resolutions of 30x30m, and channel 6 is IC, with resolution 60x60m), while one channel is a panchromatic with special resolution of 15x15m [1]. The presentation of the spectral range and applications of the channels have been given in the table 1.

Table 1. *The presentation of the spectral range and applications of LANDSAT 7 satellite channels*

Channel	Range [μm]	Application
1	0,45 – 0,52	Mapping of ocean shores, seas and lakes
2	0,52 – 0,60	Pointing out the health status of vegetation
3	0,63 – 0,69	Classification of a sort of the vegetation
4	0,76 – 0,90	Soil exploitation
5	1,55 – 1,75	Determining the water contents in plants
7	2,08 – 2,35	Mapping of the hydrothermal occurrences and surface minerals
6	10,40-12,50	Soil mapping (according to its moisture, temperature and similar)
PAN	0,52 - 0,90	Enhancing the channels resolution

The imagery has been delivered at the level 2A, which means that the previous processing has also been carried out implying the imagery radiometric correction, and the imagery has been geo-referentially introduced into the UTM 34 projection of WGS 84 coordination system. Firstly the geo-referential processing of the imagery has been done within the state coordination system (DTK) by choosing the orientation points, for which the coordinates have been read out from TK25. The graphical precision of these maps satisfies the needs of geo-referential processing of the satellite imagery with its special resolution of 30x30m. For the forest vegetation classification the 3 (red) and 4 (NIR) channels have been exploited, by using the program package ER Mapper [2].

3. FUZZY C MEANS CLASSIFICATION

While making the forest vegetation classification, a significant methodological support represent the unsupervised classification methods which the Landsat 7 satellite imagery statistically analyze and divide into several areas or homogenous groups on the basis of the spectral differences existing in the imagery digital data [3].

Fuzzy C Means classification method employs numerous processing iterations with the aim of forming the classes, exploiting in the process the rules of the fuzzy logics, which enables the possibility that the class boundaries may be fuzzy or gradational. The method creates the initial adaptation of the prototype of classes and only consequently defines the gradation representation for each pixel within each class separately. The gradation has been used for assigning and calculating of the class centers and the process is continued until it reaches the iteration limit (in this case this is 5 iteration processes). The number of initial classes in this classification process is 20, and 3 classes have been set aside representing the nuances of the colour shown in the Fig. 5.

For the forest vegetation classification of Mt Kosmaj the Fuzzy C Means classification method has been used, which classifies the raster objects based on the statistical groupings of the spectral characteristics with the numerous processing iterations with the aim of forming the forest vegetation classes [4].

At this type of classification it is necessary to introduce adequate parameters (entry channels – colours representing the satellite imagery components, the number of classes, the number of iterations, the required percentage of unchangeable patterns, the type of Fuzzy C-means classification), so that consequently the process has been automated by application of the required mathematical algorithms. The program groups pixels into the classes according the spectral characteristics of the pixels and the given parameters. After the process has been completed, the obtained rasters can be edited with the aim of obtaining as qualitative vector as possible [5].

The satellite imagery processing has been made by the program softver ER Mapper by initially presenting the Landsat imagery channels in *tif format, which have subsequently been translated into the working format, where each colour represents specific channel: 1 (blue), the channel 2 (green), the channel 3 (red), 4 (NIR) part of EM specter. In this classification 20 classes have been used, 5 iterations, 3 and 4 channel of Landsat7 satellite. The initial class centers have been formed with the assigned pixels. Each raster pixel has been assigned to the nearest class, and the pixel positioned too far from the existing class center becomes the center of a new class [6]. While analyzing the forest vegetation in the raster processing the linking of close classes have been made, that is, the classes within which there existed the probability of being in the category of the same forest vegetation, and the degree of the successfulness of the class which was set aside by means of application of modified Brovi transformation [7].

In the Fig. 3, the overlay orto-photo set onto the topographic map (TK25), in Fig. 3a forest type map, has been shown, in the Fig. 4 the orto-photo has been presented, and in the Fig. 5 the classified forest vegetation of the Mt Kosmaj area has also been given. The results of this classification method have been given in the Fig 5. The yellow colour represents a mixed forest - beech, (*Fagus*) chub (*Acer campestre*), hornbeam *(Carpinus betulus)*, oak (*Quercus robur*), bright green colour represents the coniferous forests - black pine, duglazija (*Pseudotsuga menziesii*), cedar (*Cedrus*), dark green colour denotes the deciduous forest - cerrus (*Quercus cerris)*, English oak (*Quercus robur*), pomegranate (*Quercus frainetto)* [8]. By further application of the classification statistics no major results have been obtained in the process of separating the forest vegetation, which can be seen in the Fig. 5, primarily on account of the Landsat7 channel low resolution being 30x30m.

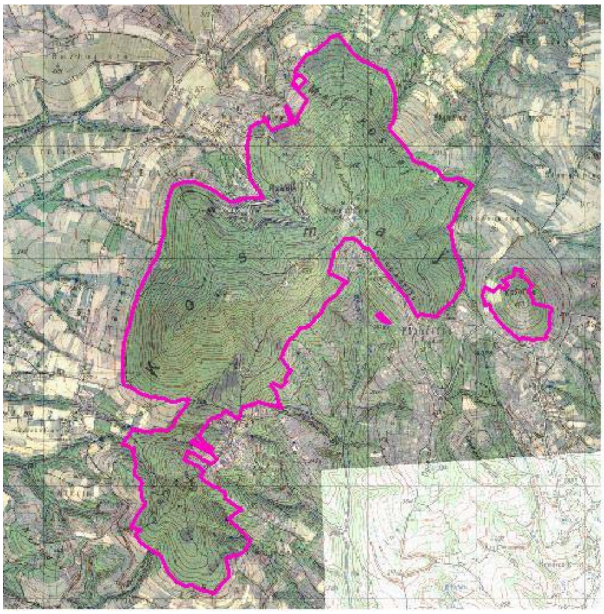

Fig.3. *Overlay ortophoto end the topographic map of Mt Kosmaj*

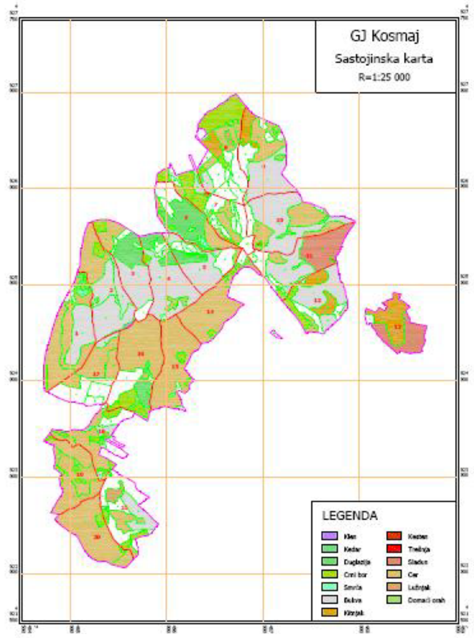

Fig. 3a. *Forest type map*

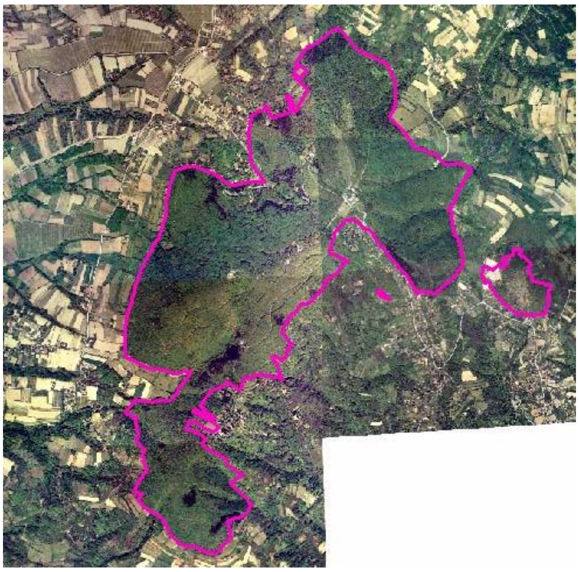

Fig.4. *The Ortophoto of Mt Kosmaj*

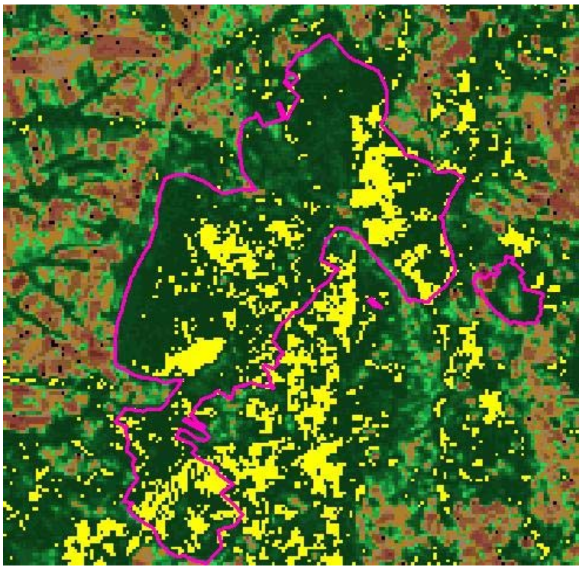

Fig. 5. *The classified forest vegetation*

4. CONCLUSION

In this paper the results of the Fuzzy C Means classification method have been presented, aimed at the classification of the forest vegetation, by digital processing of the satellite imagery, and by application of the program package ER Mapper.

The obtained results of the forest vegetation classification by means of the afore-mentioned method and the Landsat7 satellite channels can be exploited for the requirements of the sustainable forest management. On the basis of the said method and other methods of classification (ISODATA, C Means, Simple One-Pass Clustering and others), as well as the application of the multi-spectral satellite imagery of very high resolution (IKONOS, HELIOS, SPIN, EROS-A, SPOT, QuikBird) the relevant data can be obtained for the forest vegetation classification and other requirements for overall forest assessment.

The reliable methods of the satellite imagery classification, very high special resolution, the relation of price/area covered by the imagery, provide the application of methods of remote detection in the protection of the environment, survey of the climatic changes, the identification of diseased and healthy vegetation, monitoring in some accidental (emergency) situations, observing and controling the forest fires and damage from them, monitoring flooding, chemical pollutions of the soil, pedologic content of the soil, thermal changes of a terrain, movement of oil slicks, analyses and planning of space and transport.

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INVESTIGATION OF ARTIFICIALLY ESTABLISHED BROADLEAVED STANDS ON THE TERRITORY OF STEPIN LUG

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Abstract: *Introduction of autochthonous and allochthonous broadleaved species into oak habitats, categorized as special purpose forests, in different microclimatic conditions presents one of several reclamation operations in these specific forest complexes in central Serbia. The study comprises investigations of environmental conditions (particularly of climatic factors) and stand condition in artificially established stands of Norway maple (Acer platanoides L.), Narrow-leaved Ash (Fraxinus angustifolia Vahl.), Hazeltree (Corylus colurna L.), Plane (Platanus acerifolia Wild.) and White Linden (Tilia tomentosa Moench.) in the forest complex Stepin Lug on the territory of Belgrade. These valuable stands are 50-55 years old. The total number of individual trees and wood volume, for each tree species are as follows: Norway Maple 650 trees per hectare and 371,13 m^3/ha; Narrow-leaved Ash. 587 trees per hectare and 439,56 m^3/ha; Hazeltree 1559 trees per hectare and 598,24 m^3/ha; Plane 807 trees per hectare and 445,89 m^3/ha and White Linden 982 trees per hectare and 497,05 m^3/ha. The stands are even-aged with a sufficient number of good quality trees which can be selected as function bearing trees. On the basis of research results, bearing in mind climatic and microclimatic changes of particular habitat conditions, basic bioecological characteristics of the species and specific features of the functions which these stands have to perform, we have suggested tree species suitable for the introduction into investigated habitats. The selection of these species should ensure stability and durability of the investigated stands, as especially significant forests as well as fulfilment of all multiple benefit forest functions.*

Key words: Introduction of broadleaved trees, oak habitats, microclimatic conditions, especially significant forests.

ISTRAŽIVANjE VEŠTAČKI PODIGNUTIH SASTOJINA LIŠĆARA NA PODRUČJU STEPINOG LUGA

Izvod: *Unošenje autohtonih i alohtonih lišćarskih vrsta na hrastova staništa, kategorisana za šume posebne namene, u različitim mikroklimatskim uslovima, predstavlja jedan od meliorativnih zahvata u ovim specifičnim šumskim kompleksima centralne Srbije. U radu su izvršena istraživanja uslova sredine (posebno, klimatskog činioca) i sastojinskog stanja u veštački podignutim sastojinama mleča, poljskog jasena, mečje leske, platana i srebrne lipe u šumskom kompleksu Stepin Lug na području Beograda. Ove vredne sastojine su starosti 50-55 godina. Ukupan broj stabala i drvna masa, po vrstama drveća, iznose: mleč - 650 stabala po hektaru i 371,13 m^3/ha; poljski jasen – 587 stabala po hektaru i 439,56 m^3/ha; mečja leska – 1559 stabala po hektaru i 598,24 m^3/ha; platan – 807 stabala po hektaru i 445,89 m^3/ha; lipa – 982 stabala po hektaru i 497,05 m^3/ha. Sastojine karakteriše jednodobna struktura, sa dovoljno kvalitetnih stabala za izbor stabala nosilaca funkcije. Na osnovu rezultata istraživanja, uzimajući u obzir klimatske i mikroklimatske promene konkretnih stanišnih uslova, osnovne bioekološke karakteristike vrsta i specifičnost funkcija koje ove sastojine treba da vrše, dat je predlog odgovarajućih vrsta drveća za unošenje na proučavana staništa. Ovakvim izborom vrsta treba da se obezbedi stabilnost i trajnost istraživanih sastojina, kao šuma posebnog značaja i ispunjenje svih opštekorisnih funkcija.*

Ključne reči: unošenje lišćara, hrastova staništa, mikroklimatski uslovi, šume posebnog značaja

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1. INTRODUCTION, PROBLEM AND RESEARCH TASK

Silvicultural operations in special purpose forests which have distinguished recreational, healthcare, sanitary, hygienic and aesthetic functions involve the application of complex reclamation measures aimed at achieving primary functional effects. Introduction of autochthonous and allochthtonous broadleaves into forest complexes with primary social functions implies proper selection of suitable species of trees and shrubs which, in the first place, lead to the reconstruction of basic types of forest communities on these sites (Jovanović, B., Vukićević, E., 1977; Isajev, V. et al., 2006). On the other hand, varied selection of proper woody species in artificially established stands forms picturesque natural landscapes with a distinguished wide range of colours which intensifies their aesthetic value and many other so-called non-material benefits from forests (Medarević, M., 1983, 1991).

As a typical example of forests within urban areas, forest complex Stepin Lug, in the vicinity of Belgrade, falls into the subgroup of especially significant forests (Živadinović, B., Isajev, D., 2006; Krstić, M., 2008). These forests comprise a significant portion of artificially established stands of autochthonous and allochthtonous broadleaves.

The above mentioned led to the following problem and research task of this study:

- to study the site characteristics of the investigated stands;
- to determine the current condition of the investigated stands;
- to propose silvicultural aims for the improvement of the condition of specific stands as special purpose forests.

2. RESEARCH MATERIAL AND METHOD

The research was carried out in artificially established stands of broadleaves on the territory of FMU Stepin Lug, FE Beograd, departments 15a, 16b and 16s. The stands were 50-55 years old. The data were collected during 2008. Five constant experimental areas were selected in which stand conditions and stand state in stands of Plane (*Platanus acerifolia* Wild.), White Linden (*Tilia tomentosa* Moench.), Narrow-leaved Ash (*Fraxinus angustifolia* Vahl.), Norway Maple (*Acer platanoides* L.) and Hazeltree (*Corylus colurna* L.) were investigated. Data were processed using a common method used in this type of research. Data on climatic conditions were separately processed and the hydric balance for the investigated area in the period 1990-2008 was calculated using the *Thornthweit* method.

3. RESEARCH RESULTS AND DISCUSSION

3.1. Environmental conditions in the investigated stands

3.1.1. Orographic conditions

The investigated stands are at an altitude of 160-250 m, on a mild (5°) and moderate (20°) slope and exposition from a mild flat plain to northeast exposition.

3.1.2. Geological background and edaphic conditions

Geological background is composed of loam sediments. Ecological characteristics of the soil in this region were studied by Antić, M. et al. (1977), they found the presence of a large number of soil formations which are to a great extent typical of a wetter climate or areas of greater altitude. Taking into account the relief conditions in the investigated stands, organic matter constantly accumulates which provides favourable course of pedogenetic processes and forming of deep and fresh soil, rich in diluvial nutrients. The soil was characterized as deep, brown soil on loess.

3.1.3. Climatic conditions

The data of the ***Republic Hydrometeorological*** Service of Serbia for the meteorological station Košutnjak (203 m altitude) for the period from 1990-2008 were used for the study of climatic conditions in the investigated area. Due to the format limits of this paper only the results of the processing of the hydric balance and climate classification using Thornthweit method were shown into detail.

3.1.3.1. Air temperature

Mean annual air temperature for the observed period is 12.4°C, with great oscillations from 11.1°C to 14.0°C. Mean value of the temperature in the vegetative period is 19.0°C. On average, the coldest month is January with a monthly mean value of 1.6°C whereas the hottest month in a year is August with a monthly mean temperature of 20.8°C. In certain years winters can be very cold with air temperature which descends up to -26.2°C. In summer air temperature can reach the value of 43.6°C. According to average mean values of air temperatures in different seasons it can be concluded that winters are moderately cold, springs are cool, summers are relatively warm, and the autumn period is relatively pretty warm.

3.1.3.2. Precipitation regime

Average total annual precipitation quantity value is 710.5 mm. The precipitation quantity value is the lowest in winter (21% of the total annual value) and the highest in spring and summer (53%) when plants are in greatest need of moisture. It happens very often that during two consecutive years the precipitation quantity oscillates from the lowest to the highest in a certain period (or vice versa) which is one of the characteristics of the precipitation regime on the territory of Belgrade and its surrounding area.

3.1.3.3. Climatic index calculated using Thornthweit method and hydric balance

Table 1 shows hydric balance using Thornthweit method for the period 1990-2008. On the basis of these data the following values were calculated: Humidity index 13.25, aridity index 19.17 and climatic index 1.75. It should be pointed out that the climatic index shows great fluctuation; from 41.6 during 1999 (HUMID MODERATE CLIMATE TYPE B_2) to -49.76 during the following 2000 (ARID CLIMATE TYPE E). The calculated hydric balance elements indicate that the climate in the investigated area is **SUB-HUMID WETTER CLIMATE TYPE C_2**. By applying the same method, investigations of the same hydric balance for the territory of Belgrade (Stojanović, Lj., 1982) indicated approximately the same values of humidity and aridity indexes as well as the climatic index for the long period between (1888-1958), which implies slight oscillations of climatic conditions during many decades on the territory of Belgrade and the surrounding area.

Hydric balance for the investigated period shows that the average annual quantity of moisture lost from the soil by evapotranspiration is 610 mm, which means that the soil moisture surplus is only 100 mm. Moisture surplus occurs in the period from January to April and in the period from July to September there is a lack of moisture with a total average amount of 145 mm which is unfavourable for the vegetation.

Table 1. *Hydric balance calculated using the Thornthweit method for the area of Stepin Lug in the period from 1990-2008*

month	T (^oC)	i	(PE)	PE	P	R	RE	L	S
I	1.6	0.18	3	3	42	100	3	0	40
II	3.4	0.56	8	6	35	100	6	0	29
III	7.6	1.88	25	26	43	100	26	0	17
IV	12.3	3.91	48	54	56	100	54	0	2
V	17.7	6.78	78	103	51	48	103	0	0
VI	21.0	8.78	98	127	95	16	127	0	0
VII	22.7	9.88	109	148	67	0	83	65	0
VIII	22.8	9.95	110	137	66	0	66	71	0
IX	17.4	6.61	76	79	71	0	71	9	0
X	13.1	4.30	52	50	54	4	50	0	0
XI	7.3	1.77	24	19	58	43	19	0	0
XII	2.0	0.25	4	3	72	100	3	0	12
year	12.4	54.84		755	711		610	145	100
V.P.	19.0			648	406		503	145	2
	I_h = 13.2527			I_a = 19.1722			I_k = 1.74935		
Climate type:		SUB-HUMID WETTER - (C_2)							

PE – potential evapotranspiration
RE - real evapotranspiration
L – lack of moisture in the soil
S – surplus moisture in the soil

Conclusion on the climate

From the above listed data on the climatic conditions in the investigated area it can be seen that the climate of this region has translatory character, and that it is influenced by sub-Atlantic factors from the West and more severe continental factors from the East, as well as mild sub-Mediterranean factors from the South. On the basis of average values of thermic and precipitation regimes of many years it can be concluded that the climate of Belgrade approaches the climate of continental areas. Significant characteristics of the climate in this area are moderately cold winters, as well as moderately hot summers with relatively low quantities of atmosphere sediment, equally distributed in different seasons. The hydric balance confirms certain humidity of the climate so that forest communities have sufficient quantities of available moisture in the soil all year long. On the basis of the applied method the climate was determined as sub-humid wetter, type C_2. In the investigated period, variation of climate types from arid type E (year 2000) to temperate humid climate, type B_2 (1999) was observed.

Microclimatic characteristics

It should be pointed out that the microclimatic characteristics in the investigated area significantly differ not only from remote areas but also from the closer nearby regions which have a different relief and forest composition. Taking into account the orographic conditions it should be pointed out that the microclimate of Stepin Lug is modified by significant dissection of the terrain i.e. more influential is the highly developed microrelief. Besides that, the range of slopes (5-20°) of the terrain of the investigated stands contributes to the variety of microclimatic conditions of the specific sites. Considering the temperature and precipitation regimes as well as the altitude (the values of which are on average much higher than in the urban areas of Belgrade) and the presence of many valleys and alluvial planes the whole area is characterized by colder and wetter microclimatic conditions than the ones in the nearer and farther surrounding areas.

3.1.4. Phytocenological and typological condition

Under the direct and indirect influence of the above mentioned site conditions, particularly the highly developed relief and microclimatic conditions, complex Stepin Lug is characterized by the presence of a number of mesophilic micro-habitats predetermined by orographic conditions (according to Jovanović, B., Vukićević, E., 1977) with their mosaic-like presence in the prevailing community of Hungarian oak and Turkish oak (*Quercetum frainetto-cerris* Rud. 1949), as the typical climatogenous community of the areas of Belgrade and Šumadija. So the investigated stands were established on the site of the community of Hornbeam and Sessile oak (*Querco- Carpinetum*) and typologically defined as: **artificially established stands of Plane, White linden, Hazeltree, Norway Maple and Narrow-leaved Ash on the site of Sessile oak and Hornbeam** (*Querco- Carpinetum*) **on deep brown soil on leoss**.

3.2. Stand condition in the investigated stands

On the basis of the summary of the data presented in table 2 and graph 1 it can be perceived that the number of trees per ha (N) varies greatly among certain species in the first place as a result of thinning, due to various damages and the application of different planting density. The lowest number of trees was found in the Norway Maple stand, 650 trees, and the highest in the Hazeltree stand, 1559 trees. Mean stand diameter (d_g) ranges from 21.1 cm in Hazeltree to 26.8 cm in Narrow-leaved Ash and is directly correlated with the present density i.e. number of trees per ha. Wood volume (V) ranges from 371.1 m^3/ha for Norway Maple to 598.2 m^3/ha for Hazeltree which clearly shows the correlation of wood volume and tree number per ha. Further, Hazeltree reached by about 60% higher volumes than Norway maple; Linden by about 34%, Plane and Narrow-leaved Ash by about 20%. The data presented must be taken with reserve because of the experimental areas which were established in the most homogenous parts of the stands and the amounts obtained are by about 30% higher than the average amounts for the whole stand.

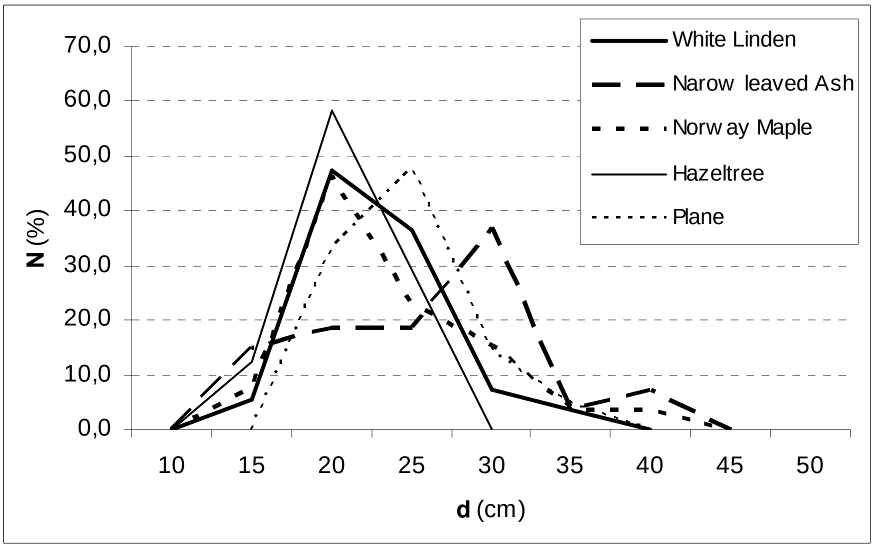
The structure of the distribution of tree numbers (graph 1) by diameter class reveals a typical distribution of even-aged stands. Only in the Narrow-leaved Ash stand appeared certain differentiation and there are two maximal percentages i.e. this stand is two layered. Based on the quality of trees in Norway Maple, Ash and Linden stands it can be concluded that there is a sufficient number of good quality trees for the selection of the so called "*function bearing trees*". Due to excessively large number of trees in the stands of Hazeltree and Plane these trees were not selected. In the past twenty years in these stands regular tending or thinnings were not carried out so the trees have a high degree of slenderness. Stands are on the whole pretty "unstable" for certain heavy operations so that great care must be taken while carrying out further thinnings. For that reason the proposed silvicultural measure is light thinning, 10- 15% by N and V, with thinning intensity of 5 years.

Compared to the researches of natural coppice forests of Hungarian oak and Turkish oak on the territory of Lipovica (Vukin, M., Bjelanovic, I, 2006) it can be concluded that artificially established stands in Stepin Lug reach significantly greater volumes, by about 10-60% (table 2). Further, the stands chosen for comparison were Turkish oak and Hungarian oak stands which were somewhat older (60-65 years) and with greater participation of Hungarian oak (60%) which are the best preserved stands and the stands of the highest quality within the climatogenous community of Hungarian oak and Turkish oak as the most significant forest complex on the territory of Belgrade.

Table 2. *Basic data on the investigated stands*

stand	**N (per ha)**	**d_g (cm)**	**h_g (m)**	**V (m^3/ha)**	**V (%)**	**Function bering tree number (per ha)**	**Marked trees (%)**	
							per N	**per V**
Norway Maple	650	24,4	24,1	371,1	100	225	7,7	6,5
Narrow –leaved Ash	587	26,8	26,0	439,6	118,5	217	11,1	9,6
Hazeltree	1559	21,1	21,1	598,2	161,2	-	-	-
Plane	807	24,9	23,0	445,9	120,2	-	-	-
Linden	982	23,2	23,7	497,0	133,9	268	18,2	13,8
Natural coppice stands of Turkish Oak and Hungarian Oak on the territory of FMU Lipovica	688	24,1	25,4	365,8	98,6	112	16,3	10,7

Graph 1. *Distribution of tree number by diameter class*



4. CONCLUSIONS

Based on the researches of artificially established stands of broadleaves on the territory of Stepin Lug, aged 50-55 years, the following conclusions were reached:

- stands were typologically defined as: **artificially established stands of Plane, White Linden, Hazeltree, Norway Maple, and Narrow-leaved Ash on the site of Sessile Oak and Hornbeam** (*Querco-Carpinetum*) **on deep brown soil on loess**;
- based on the analysis of the distribution of tree numbers by diameter class the largest number of trees per ha was found in the Hazeltree stand – 1559, and the lowest number of trees per ha was found in the Norway Maple stand - 650;
- the largest wood volume was found in the Hazeltree stand 598.2 m^3/ha, whereas volume lower by about 60% was found in the Norway Maple stand – 371.1 m^3/ha;
- the stands have even-age structure with a sufficient tree number for the selection of the „*function bearing trees*“;

- as a silvicultural operation the proposed measure is light thinning, 10-15% by N and V, with thinning intensity of 5 years. Considering specific functions which should be provided by these forests as especially significant forests further application of thinnings should be aimed at forming as varied and attractive habituses of the selected „*function bearing trees*" as possible;
- based on the bioecological characteristics of the investigated tree species, quality and vitality of the trees and the achieved volume the investigated stands are able to utilize the high production potentials of a specific site;
- all the investigated species have a high functional and aesthetic value and considering the above mentioned, they are recommended in the selection of species for the reconstruction of special purpose forests on the same or similar sites. The proposed species introduced in this way should occupy smaller areas, which forms well-balanced ecosystems and stable vegetation relationships. At the same time, the selection of these tree species creates the impression of a „natural landscape" with a distinguished wide range of colours which provides the primary functions of especially significant forests.

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MICROORGANISMS POPULATION SIZE OF THE SOIL ORGANIC LAYER AND CHARACTERISTICS OF THE BLACK LOCUST LITTERFALL (*ROBINIA PSEUDOACACIA* L.) ON THE RECLAIMED SOIL OF THE ENERGY-INDUSTRIAL COMPLEX KOLUBARA

Zoran MILETIĆ, Snežana STAJIĆ, Vesna GOLUBOVIĆ-ĆURGUZ[1]

Abstract: *The researches were conducted on the reclaimed mine soil formed by the deposition of the waste-rock from the open-pits of the lignite mines in three black locust monocultures. The total annual yield of the litterfall, organic carbon and nitrogen, as well as phosphorous and potassium, calcium and magnesium, was studied. The C/N ratio and hydrolized forms of nitrogen were determined. In the soil organic layer under the black locust culture the seasonal dynamics of the population size of the saprophytic mircroorganisms, which perfom the important function in the nitrogen cycle in the forest ecosystems, was studied. Along with the black locust litterfall in the monocultures of these species, the native species have an important role in the formation of the soil organic layer, which provides the various energy material for the saprophytic microorganisms and create favourable conditions for the humus synthesis. The extremely high quantities of nitrogen, which is basic missing nutrient in the studied reclaimed soil, are present in the black locust litter. The products of the decomposion of the black locust leaves are the important source of the nutrients for the native species. Because of the characheristics of the black locust litter and light regime in the black locust stands, this species is very favourable for the use in the thick mixed plantations of the short rotation intended for the production of timber for the energy purposes. The products of the decomposition of the black locust litter and humus in the mixed plantations can improve the nutrition of the other species.*

Key words: black locust, litterfall, soil organic layer, saprophytic microorganisms, nutrients.

BIOGENOST ORGANSKE PROSTIRKE I KARAKTERISTIKE LISNOG OPADA BAGREMA (*ROBINIA PSEUDOACACIA* L.) NA DEPOSOLIMA REIK "KOLUBARA"

Izvod: *Istraživanja su izvršena na rekultivisanim deposolima nastalim odlaganjem jalovine sa površinskih kopova rudnika lignita u tri monokulture bagrema. Ispitivan je ukupan godišnji priliv lisnog opada, organskog ugljenika i azota, fosfora i kalijuma, kalcijuma i magnezijuma. Određen je C/N odnos i hidrolizujući oblici azota. U organskoj prostirci pod kulturom bagrema ispitana je sezonska dinamika brojnosti saprofitnih mikroorganizama koji obavljaju važnu funkciju u kruženju azota u šumskim ekosistemima. Pored bagremovog opada u monokulturama ove vrste na formiranje horizonta organske prostirke značajnu ulogu imaju i samonikle vrste, što obezbeđuje raznovrstan energetski materijal za saprofitne mikroorganizme i povoljne uslove za sintezu humusa. U opadu bagrema prisutne su izuzetno velike količine azota, koji je osnovni nedostajući element ishrane u ispitivanim deposolima. Produkti razlaganja bagremovog lišća predstavljaju značajan izvor hranljivih materija za samonikle vrste. Karakteristike bagremovog opada i svetlosni uslovi u bagremovim sastojinama čine ovu vrstu izuzetno pogodnom za primenu u gustim mešovitim zasadima kratke ophodnje namenjenih proizvodnji drveta u energetske svrhe. Produkti razlaganja bagremovog opada i humusa u mešovitim zasadima mogu da poprave ishranu drugih vrsta.*

Ključne reči: bagrem, lisni opad, organska prostirka, saprofitni mikroorganizmi, biljni asimilativi.

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Acknowledgement: The study was partly financed by the Minstry of Science and Technological Development of the Republic of Serbia, the Project – TR 18201A.

1. INTRODUCTION

The production of timber for the energy purposes, in the intensive plantations does not require the obtaining of the valuable timber assortments. The production of the combustible biomass and wood volume, as the most valuable part of biomass in regard to the energy, is the main goal. The ideal sites for the establishment of these intensive plantations are the soils formed by the mining activities, made of unconsolidated and semi-consolidated sedimentary rocks (psammites, aleurites, pelites and clays). The reclaimed mine soil of lignite mine "Energy-Industrial Complex" Kolubara are such sites. The physical and chemical, as well as microbial characteristics of this reclaimed mine soil were researched by numerous authors (Stojanović et al 1977; Antonović et al 1978; Antonović et al 1984; Veselinović et al 1984; Rasulić 1997; Šmit, Veselinović 1997; Šmit, Miletić 1997, Dražić 1997; Miletić 2004, Miletić, Radulović 1995). The physical characteristics of this reclaimed mine soil are very favourable. They are characterized by the avaiable water capacity, by the almost complete lack of rock fragments, and by unlimited physiological depth of solum. The chemical characteristics are most frequently unfavourable for the intensive plant production. The plant nutrition, and thereby the biomass production, depends upon the chemical characteristics of the soil.

The quantities of the total potassium in the reclaimed soil of the Energy-Industrial Complex "Kolubara" under the different forest cultures range from 5.47–19.02 gK_2O/1, and the quantities of phosphorous 0.20 – 1.84 P_2O_5g/1 kg of the total P_2O_5 (Miletić 2004). This high variability of the total quantities of phosphorous and potassium in the reclaimed soil is the result of the different mineralogical composition of the deposited waste-rock, since there is no selective deposition in this area. At recently deposited waste-rock phosphorous and potassium are most frequently present in the forms which are not available to the plants, so the forest species are forced to use the forms which are less avaialable. The forest trees transport the plant assimilatives in the organic forms to the soil surface via the litterfall. By the mineralization of the soil organic layer the plant assimilatives are released in the forms which are available to the plants. The complete lack of the nutrients, and thereby of the nitrogen, in the recently deposited reclaimed mine soil poses a special problem (Stojanović et al 1977; Antonović et al 1978; Antonović et al 1984; Veselinović et al 1984; Šmit, Veselinović 1997; Šmit, Miletić 1997, Dražić 1997; Miletić 2004). The forest tree species which are able to use the athmospheric nitrogen by the symbiotic nitrogen fixation do not have any difficulty in using nitrogen in the nutrition. They transport the great quantities of nitrogen to the soil surface, where the organic nitrogen is subject to mineralization and transformed into the forms which can be used by other tree species. The black locust is the species which is able to use the atmospheric nitrogen by the symbiotic nitrogen fixation (Lindsay, Wayne 1984).

The black locust is the heliophilious species with an open and transluscent crown which casts a slight shade. In the black locust monocultures on the soil surface there are light spots and light breaks, so the full spectre of the wavelength of the solar radition is not transported to the ground. By contrast, the monocultures of sciophilic species (Douglas fir, lime, etc) do not transmit the phytosynthetically active wave lenghts to the soil surface and thereby hinder the development of the ground vegetation. The floristical composition of the black locust cultures on the observed sites is much more diverse, and the population size and of the native species and canopy closure are higher in comparison with the other monocultures on the reclaimed soil of Energy Mine Complex Kolubara (Miletić, 2004). It is partly the result of the favourable light conditions in the black locust monocultures, as well as of the favourable nutrition conditions which are created by the decomposition of the black locust litterfall.

This paper is aimed at the study of the possibilities of the use of black locust, as the species which can use the atmospheric nitrogen for its nutrition, in the aim of the improvement of the nutrition by nitrogen and other elements of the nutrition of other species in the intensive mixed forest plantations for the energy purposes.

2. METHODS

The characteristics of the black locust leaflitter were researched in the black locust monocultures 11, 29 and 30 years old, on the reclaimed soil of Energy Industrial Complex “Kolubara“. Only the recently deposited litterfall, which was transported to the soil surface in the same year when the research was conducted, was studied. In order to prevent mixing of the one-year-old litterfall with the soil organic layer, i.e. mixing with the older litterfall, the litterfall was collected in the wooden boxes which were set in the cultures prior to the phenophase of leaf formation.

In the litterfall collected in this way, by the analysis of the ash obtained by dry combustion the following macro elements of the nutrition were determined: the total phosphorous by using colorimetric method, whereas flame photometry was used for the determination of the total potassium, and the complexometry was used for the determination of the total calcium and magnesium (Džamić et al 1996). The content of total nutrogen was determined by using Ansttet's method, modifed by Ponomareva and Nikolajeva (Ponomareva, Plotnikova 1975). The following hydrolyzed forms of nitrogen were determined: total hydrolyzed, ammoniac, amino acid, and hexosamine nitrogen (Black et al 1965).

In the horizon of the soil organic layer the population size od the physiological groups of the soil microorganisms, which are important for the dynamics and the balance of the nitrogen cycle in the forest ecosystems, was determined. The number of the amonifiers on the mesopeptone agar, the total number of the microorganisms on the soil agar, as well as the number of oligonitrophilic bacteria on Krasiljnikov's agar were determined. The sowing on these media was performed by the soil suspension 0.1 ccm diluted to 10^{-3}. The data on the number of the microorganisms were determined per 1 g of the air dry soil.

3. THE RESEARCH RESULTS

The litterfall is the most important source of the organic carbon for the forest soil. Along with the litterfall, nitrogen and other nutrients are transported to the soil surface (Rodin, Bazilevič 1965; Nordén 1994). The production of the litterfall on the soil surface under the black locust cultures is high. The quantities of the litterfall under the black locust monocultures which were calculated for three sample plots averagely account for 1786,48 kg/ha of the absolutely dry matter. Along with the black locust, the high percentage of the total decomposed organic residues are produced by the native species.

The litterfall produced by the black locust is rich in ash. The average content of the ash in the black locust litterfall on the observed sites is 8.71% (Table 1). The most common macroelement of nutrition in the ash of the black locust litterfall is calcium (4.62 % of the completely dry litterfall), and via the litterfall it also transports CaO to the soil surface (averagely 82.63 kg CaO per hectare). The second most abundant element is potassium (2.16 % K_2O in the completely dry litterfall), and the annual yield of it on the soil surface is 38.45 kg/ha. Magnesium is also present in the litterfall (0.65 % of MgO), and the annual yield per hectare is 11.38 kg. The percentage of phosphorous in the black locust litterfall is low (0.05 %, i.e. 0.91 kg per hectare).

The black locust litterfall is also characterized by extremely low content of the organic carbon and high content of nitrogen. The black locust is the species which is able to use the atmospheric nitrogen by the symbiotic nitrogen fixation (Boring, Swank, 1984). The nitrogen accounts for 2.01 % of the black locust litterfall.

The mineralization of the organic nitrogen in the oxidation environment is the oxidation process, and in the anoxidation process it is the hydrolitic process (Tešić, Todorović 1997). The highest percentage of the total nitrogen in the black locust litterfall is subject to hydrolysis (1.2 %), which means that the oxidation environment is not necessary for the mineralization of it. The amino acid nitrogen is most common form of nitrogen in the hydrolizer of the black locust litterfall, whereas the ammoniac nitrogen is the second most common form of nitrogen, whereas the hexosamine nitrogen is significantly less present.

The ratio of carbon to nitrogen in the black locust litterfall is narrow (C/N =13.8). Such C/N is the precondition for the fast mineralization to the end products of the decomposition (Ohta, Kumada 1978, Zhang, D et al 2008).

Table 1. *Characteristics of the black locust litterfall*

	% in litterfall	kg/ha		% in litterfall	kg/ha
Nutrient	91.29	1,630.41	Ash	8.71	156.07
Total C	27.22	486.39	Total K_2O	2.16	38.45
Total N	2.01	35.80	Total P_2O_5	0.05	0.91
Hydrolyzed N	1.20	21,35	Total CaO	4.62	82.63
NH_4-N	0.20	3.48	Total MgO	0.65	11.38
Hexosamine -N	0.05	0.80	C/N = 13.8		
Amino acid -N	0.94	16.79			
Non-hydrolyzed-N	0.82	14.56			

The high quantity of the decomposed organic residues which is produced by the black locust, but also the other native species to a great extent, forms the horizon of the soil organic layer, which is most potent in autumn, after the phenophase of the leaf fall (01 sub-horizon). In the next spring some parts of the soil organic layer is subject to the fast mineralization. This part mainly consists of the black locust leaves with the narrow C/N ratio. In the autumn, at the beginning of phenophase of leaf fall soil organic layer is made of the residues produced by other, native species. The leaf petiols of the black locust leaves and pods, i.e. the fragments of soil organic layer made of mechanical and vascular tissues, are the residues of the black locust litterfall, owning to which they are characterized by the wider C/N ratio. In contrast to the black locust leaflets, which mainly decompose in the spring in the first year of their transport to the soil surface, but cannot be morfologically separated in the soil organic layer fragments as early as in the summer, the leaf petioles remain in the next year as well.

Under the black locust monocultures in the spring the number of the ammonifiers in the soil organic layer, significantly exceeds the number of the other physiological groups of saprophytic microorganisms (Table 2). The black locust litterfall, as well as the litterfall of other species from Leguminosa family, is rich in proteins. The basic energy material for ammonifiers are the proteins from the soil organic layer. As the product of their activity, the nitrogen in the ammoniac form is released. Owning to the low temperatures, in winter all decomposition processes are extremely decelerated or even completely stopped. As a result, in spring the soil organic layer is still rich in the protein nitrogen, which occurs in the autumn. It leads to the significant increase of the number of the ammonifiers in the soil organic layer and surface layer of the soil, in comparison with the number of the mineralogical and oligonitrophilic microorganisms.

In spring the mineralogical microorganisms on the soil agar are the second most common physiological group. These microorganisms use the mineral forms of plant assimilatives, and mainly nitrogen, for the synthesis of their own cell substances.

Table 2. *Seasonal dynamics of population size of the physiological groups of soil microorganisms in the soil under the black locust cultures (1000 mo/1g soil)*

Depth cm	Spring	Summer	Autumn	Average	σ	V
Ammonifiers on MPA agar						
Olfh	273,702.0	5,308.1	38,522.5	105,844.2	146,314.7	138.2
0–2	984.3	42.0	26.9	351.1	548.4	156.2
2–7	2,818.1	54.0	199.8	1,024.0	1,555.5	151.9
The total number of microorganisms on soil agar						
Olfh	810.7	79,146.9	74,149.7	51,369.1	43,856.1	85.4
0–2	123.4	469.5	24.3	205.7	233.7	113.6
2–7	93.2	648.5	253.4	331.7	285.8	86.2
Oligonitrophiles on Erzbi agar						
Olfh	23,292.5	12,322.3	15,589.1	17,068.0	5,632.6	33.0
0–2	325.5	203.0	10.9	179.8	158.6	88.2
2–7	689.1	235.0	168.9	364.3	283.2	77.7

The oligonitrophilic microorganisms are the third most common physiological group in spring. These microorganisms use the nutrients of the wide C/N ratio as the energy material. They require small quantities of the nitrogen from the nutrients which are decomposed by the biochemical processes, and are able to use the atmospheric nitrogen as well.

In summer the population size and the ratio of some physiological groups of the soil microorganisms change. The number of ammonifiers decreases significantly. It is partly the result of the low humidity of the soil and soil organic layer, as well as of the reduced quantities of the protein nitrogen, which is decomposed as early as in spring. The reduced number of the ammonifiers, which use the proteins as the energy material, leads to the decrease of the production of the mineral forms of nitrogen in the soil organic layer. As a result, the number of the mineralogical microorganisms which develop on the soil agar and use the mineral forms of nitrogen decreases. The decrease of the number of the mineralogical microorganisms is less expressed than the decrease of the number of the ammonifiers. Owning to the change of the content of the soil organic layer, the number of the oligonitrophilic microorganisms significantly increases, since in summer the soil organic layer is made of the nutrient of the wide C/N ratio, which is favourable energy material for the oligonitrophilic microorganisms. By the activity of oligonitrophiles, which use the atmospheric nitrogen for their own needs, the C/N ratio of the soil organic layer becomes narrower, because by the decomposition of them the nutrients rich in nitrogen is transported.

In autumn, due to the phenophase of the leaf fall the fresh energy material for the saprophytic microorganisms is obtained. Along with the black locust litterfall the undistrubed proteins are transported to the soil organic layer by the biochemical processes. The population size of the ammonifiers increases, as the proteins are their basic energy material. The increase of the ammonifiers results in the increased release of the ammoniac nitrogen from the soil organic layer, due to which the number of the mineralogical microorganisms increases. The oligonitrophilic microorganisms are still dominant physiological group, since at the beginning of the phenophase of leaf fall the fragments of the wide ratio C/N, such as leaf petioles, pods and woody fragments which can be older than one year, are still dominant in the total soil organic layer.

Over the year there is the uninterrupted horizon of soil organic layer under the black locust cultures. The peculiar structure of the black locust leaves, which is made of the leaflets susceptible to fast decomposition and leaf petioles which decompose at a slow pace, as well as the significant presence of the organic residues of the native species provide very diverse energy material for the saprophytic microorganisms. The intensive processes of the decomposition of the leaflets of the black locust leaves, which occur in spring, lead to the fast release of the mineral forms of nitrogen. Nitrogen is the most mobile and dynamic element of nutrition in the soil. The mineral forms of nitrogen are easily lost from the soil, since the ammonicial form is subject to volatility, and the nitrate form to the wash out from the soil (Savić, Jekić 1975). The loss of the mineral forms from the soil under the black locust mocultures is to some extent prevented by the mineralogenic microorganism, and to a greater extent by the native vegetation which more common under the black locust cultures than under other cultures on the observed area.

The biological accumulation of nitrogen in soil occurs in the humus compounds, in the phase prior to the muture humus, which is the result of the mutual synthesis of the amino acid and quinones (Kononova, 1963). Amino acids appear as the intermediate product of the protein decomposition, and quinones as the intermediate product of the decomposition of the organic compounds which do not contain nitrogen. They are the nitrogen and carbon components of humus. By the further polymerization of the stage prior to humus formation the humic acids are formed (Kononova 1963). By the decomposition of the soil organic layer, made of very different organic residues, under the black locust monocultures the sufficient quantities of both carbon and nitrogen components are formed, which is the precondition for the intensive processes of humus synthesis. The morphological indicators of the creation of the real humus-accumulative horizon, which is the base of the ameliorative impact of the black locust monocultures, are present at all three sample plots.

4. CONCLUSION

In the artificially established black locust sites at the reclaimed soil of Energy-Industrial Complex “Kolubara“ the high quantities of the nutrients circulate. The black locust litterfall contains high quantities of the nutrition macroelements, and particularly the high quantities of nitrogen. The leaflets of the black locust leaves are affected by the saprophytic microorganisms and decompose to the end products, since the leaf petioles and other fragments which are produced by other species decompose significantly slower. The release of the mineral forms of nitrogen from the soil organic layer is most intensive in spring, and it decreases significantly as early as in summer. It is proved by the decrease of the number of microorganisms which use the mineral forms of nitrogen (ammonifiers and mineralogical) and by the increase of the number of microorganisms which use the atmospheric nitrogen (oligonitrophiles). The loss of the mineral forms of nitrogen is partly prevented by the native species and mineralogic microorganisms. There are favourable conditions for the humus synthesis and biological accumulation of the nutrients under the black locust monocultures. Humus is the stable, long-lasting and well-balanced source of the nutritive forms which are available to plants, since the processes of the decomposition of the humus substances are decelerated. When it is applied in the mixed cultures on the reclaimed soil which do not contain nutrients, which also implies that they do not contain nitrogen, the black locust can also improve the nutrition of other tree species within the culture.

The open and transluscent crown of the black locust and the favourable light conditions in its cultures, make the black locust favourable for the thick mixed plantations which are established for the energy purposes.

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Sumarry

The researches were conducted on the reclaimed mine soil formed by the deposition of the waste-rock from the open-pits of the lignite mines in three black locust monocultures. This paper is aimed at the study of the possibilities of the use of black locust, as the species which can use the atmospheric nitrogen for its nutrition, in the aim of the improvement of the nutrition by nitrogen and other elements of the nutrition of other species in the intensive mixed forest plantations for the energy purposes. In the artificially established black locust sites at the reclaimed soil of Energy-Industrial Complex "Kolubara" the high quantities of the nutrients circulate. The black locust litterfall contains high quantities of the nutrition macroelements, and particularly the high quantities of nitrogen.

There are favourable conditions for the humus synthesis and biological accumulation of the nutrients under the black locust monocultures. Humus is the stable, long-lasting and well-balanced source of the nutritive forms

which are available to plants, since the processes of the decomposition of the humus substances are decelerated. When it is applied in the mixed cultures on the reclaimed soil which do not contain nutrients, which also implies that they do not contain nitrogen, the black locust can also improve the nutrition of other tree species within the culture. The products of the decomposition of the black locust litter and humus in the mixed plantations can improve the nutrition of the other species.

The open and transluscent crown of the black locust and the favourable light conditions in its cultures, make the black locust favourable for the thick mixed plantations which are established for the energy purposes.

BIOGENOST ORGANSKE PROSTIRKE I KARAKTERISTIKE LISNOG OPADA BAGREMA (*ROBINIA PSEUDOACACIA L.*) NA DEPOSOLIMA REIK "KOLUBARA"

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Rezime

Istraživanja su izvršena na rekultivisanim deposolima nastalim odlaganjem jalovine sa površinskih kopova rudnika lignita u tri monokulture bagrema. Cilj ovog rada je ispitivanje mogućnosti primene bagrema, kao vrste koja za potrebe svoje ishrane može da koristi atmosferski azot, u svrhe popravke ishrane azotom i drugim elementima ishrane ostalih vrsta u intenzivnim mešovitim šumskim zasadima za energetske potrebe. U veštački podignutim sastojinama bagrema na deposolima REIK "Kolubara" kruži velika količina hranljivih materija. Lisni opad bagrema sadrži velike količine makroelemenata ishrane, a prvenstveno velike količine azota.

Pod bagremovim monokulturama postoje povoljni uslovi za sintezu humusa i biološku akumulaciju hranljivih materija. Humus predstavlja stabilan, dugoročan i uravnotežen izvor biljkama lako pristupaćnih oblika elemenata ishrane, jer su procesi razlaganja humusnih materija usporeni. Primenjen u mešovitim kulturama na deposolima koji ne sadrže organsku materiju, a time ni azot, bagrem u značajnoj meri može da popravi ishranu drugih vrsta drveća u kulturi. Produkti razlaganja bagremovog opada i humusa u mešovitim zasadima mogu da poprave ishranu drugih vrsta.

Retka i prozračna krošnja bagrema i povoljni svetlosni uslovi njegovih kultura, čine bagrem posebno pogodnim za guste mešovite zasade koji se podižu u energetske svrhe.

THE IMPACT OF THE AUSTRIAN AND SCOTS PINE ON THE ORGANIC FORMS OF PHOSPHOROUS AND THE FORMS OF PHOSPHOROUS AVAILABLE TO THE PLANTS IN THE RECLAIMED MINE SOIL OF THE ENERGY-INDUSTRIAL COMPLEX KOLUBARA

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Abstract: *The impact of the monocultures of the acidifying species (Austrian and Scots pines) on the content of the organic forms of phosphorous and the forms of phosphorous which are available to the plants in the mine soil recultivated by the reforestation was studied. The researches were conducted in the Energy-Industrial Complex "Kolubara". The total annual yield of this element on the area of soil by the litterfall was determined. Under the influence of the cultures of the Austrian and Scots pines in the surface layers of the studied reclaimed soil the content of the organic forms of phosphorous increased in comparison with the deeper layers, whereas the content of the forms which are available to the plants decreased in comparison with the deeper layers.*

Key words: Reclaimed mine soils, Austrian pine, Scots pine, phosphorous.

UTICAJ MONOKULTURA CRNOG I BELOG BORA NA BILJKAMA PRISTUPAČNE I ORGANSKE OBLIKE FOSFORA U REKULTIVISANIM DEPOSOLIMA REIK "KOLUBARA"

Izvod: *Ispitivan je uticaj monokultura acidifikatorskih vrsta (crnog i belog bora) na sadržaj biljkama lako pristupačnih i organski vezanih oblika fosfora u deposolima rekultivisanih pošumljavanjem. Ispitivanja su obavljena na području REIK „Kolubara". Određen je ukupan godišnji priliv ovog elementa na površinu zemljišta preko lisnog opada. Pod uticajem kultura belog i crnog bora u površinskim slojevima ispitivanih deposola došlo je do povećanja organski vezanih oblika fosfora u odnosu na dublje slojeve, dok su količine biljkama lako pristupačnih oblika smanjene u odnosu na dublje slojeve.*

Ključne reči: Deposoli, crni bor, beli bor, fosfor.

1. INTRODUCTION

The reforestation of the reclaimed mine soil is the form of the protective reforestation, aimed at the protection of the areas from the water and wind erosion. On the reclaimed mine soil formed by the recently deposited waste-rock from the open pites of the lignite mines of the Energy-Industrial Complex "Kolubara" the conditions for the development of forest trees are unfavourable.

The physical and chemical, as well as the microbial characteristics of this reclaimed mine soil were studied by numerous authors (Stojanović et al 1977; Antonović et al 1978; Antonović et al 1984; Veselinović et al 1984; Rasulić 1997; Šmit, Veselinović 1997; Šmit, Miletić 1997, Dražić 1997; Miletić 2004, Miletić, Radulović 1995). According to the above authors, these reclaimed mine soils are characterized by the complete lack of the nutrients and nitrogen, as well

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Acknowledgement: The study was partly financed by the Minstry of Science and Technological Development of the Republic of Serbia, the Project – TR 20202A.

as the insuficient availability of the phosphorous and potassium forms, whereas the physical characteristics are mainly favourable for the oligotrophic forest tree species. The forest tree species of the oak altitudinal zone, which are floristic representatives of the natural potential vegetation of the observed reclaimed mine soil are more demanding in regard to the nutrition than it is enabled by the recently deposited waste rock. As a result, the forest cultures on the reclaimed mine soil of the first rotation should play the ameliorative role, i.e. initiate the pedogenetic processes, improve the soil characteristics and create conditions which are suitable for the development of the natural vegetation. Only the natural potential vegetation can to the greatest extent use the productive potential of sites and in the best way provide the hydrological and protective functions of forests.

Phosphorous is the important element of the nutrition of forest trees, the quantities of which in the available forms, on the recently deposited waste rock of Energy-Industrial Complex "Kolubara" are most frequently found below the limit of detection for AL method. The forms of phosphorous which are available to the plants in the soils are formed in two ways: by processes of phosphorylation, i.e. by the decomposition of the organic phosphorous organic compounds from the soil organic layer and by the processes of phosphorous mobilisation, i.e. by the conversion of the insoluble mineral phosphorous forms in the water-soluble forms which are available to the plants.

This paper is aimed at the study of the impact of the monocultures of the acidifying species of Austrian and Scots pines on the accumulation of the organically bound phosphorous in the soil, as well as on the content of the forms of this element which is available to plants.

2. METHODS

The researches were conducted on six sample plots, three under the Austrian pine and three under the Scots pine cultures, from 16 to 18 years old.

On all sample plots the wooden boxes for the collection of litterfall were set. The boxes were set in spring (April), and the quantities of litterfall which have been collected in them were determined in winter (January). In this way the quantity of the litterfall, which was transported to soil surface over the year, was determined. In the litterfall collected in this way the content of the total phosphorous by the analysis of the ash after the dry combustion was determined, and the phosphorous was determined by the colorimetric methods in the presence of tin choloride and ammonium molybdate. In the soil layers phosphorous was determined by the fixed depths 0-2 cm, 2-7 cm, 7-17 cm and 17-100 cm. The content of total phosphorous in the soil was determined by Ginzburg et al (Džamić et al 1966) method, and the content of organic phosphorous by Legg and Black method 1955 (Olsen, Dean 1965). The forms of phosphorous which are available to plants were determined by using Al-method.

3. RESEARCH RESULTS AND DISCUSSION

The quantities of the total phosphorous in the observed reclaimed mine soil are low in all profiles and ranged from 0.046 to 0.184% of total P_2O_5. Such a high spatial variability of the content of total phosphorous, both horizontal (between the sample plots), and vertical (by depth of soil solum), is the result of the unselective deposition of waste rock of the different mineralogical composition. Since the total quantities of phosphorous in natural soil in this country (Džamić 1996 et al) range from 0.25 – 0.5% of total P, i.e. from 0.57-1.15% P_2O_5, it can be concluded that the reclaimed mine soil of Energy-Mine Complex "Kolubara" are extremely poor in the the total quantity of this element.

Austrian and Scots pine are the pioneer oligotrophic tree species which do not have great requirements in the nutrition, and particularly do not require the high quantities of phosphorous. Therefore, the quantities of phosphorous in litterfall of both oligonitrophilic and pioneer species are extremely low (Table 1). The average yield of phosphorous which is transported by the litterfall to the soil surface under Austrian pine is 0.31 kg/ha, and under Scots pine 0.79 kg/ha. These low quantities of phosphorous point to the fact that the litterfall of neither Austrian pine nor Scots pine is the significant source of the organic phosphorous for the soil. Along with the extremely low content of phosphorous, the litterfall of Austrian pine and Scots pine is characterized by the extremely wide ratio of carbon to phosphorous. It is particularly well-expressed in the Austrian pine litterfall

Table 1. *Quantities of phosphorous in the Austrian pine and Scots pine litterfall*

Culture	Quantity of litterfall (kg/ha)	P in litterfall (%)	P_2O_5 in litterfall (%)	P_2O_5 in litterfall (kg/ha)	Organic C (%)	C/P
Austrian pine	1,368.75	0.010	0.023	0.31	35.760	3,576.0
Scots pine	2,138.75	0.016	0.037	0.79	30.970	1,935.6

The organic phosphorous in the soil forms the indivisible organic residues (nucleic acids, nucleoproteides, phosphides, phytate, etc), then the intermediate products of their decomposition, and is mainly incorporated into the humus compounds (Jakovljević, Pantović 1991.). The organic forms of phosphorous are very favourable source of soluble forms of phosphorous which are available to plants. The conversion of the organic phosphorous in the forms which are available to plants is much faster than the conversion of the insoluble phosphates from the mineral components to the soluble phosphates. The release of phosphates from the nutrients (phosphorylation) is the result of the activity of phosphorous dissolving bacteria which belong to the physiological group of ammonifiers (Menkina 1950). The chemical characteristics of the litterfall have an important role in the conversion of phosphorous from the organic to the mineral forms. The nutrients of the wide C/P ratio is not the good source of the available form of phosphorous, since the great percentage of phosphorous, which is released from the nutrients by the processes of phosphorylation, are used by the soil microorganims for the synthesis of their own cell substances.

The small quantity of phosphorous and the extremely wide C/P ratio in the litterfall of both pine species at the same time, points to the fact that the litterfall of these species is not the significant source of the organic phosphorous for the soil on the observed sites. However, there is the high quantity of organic forms of phosphorous on all observed sample plots (Table 2). The highest quantity is found in the surface soil 0-2 cm deep, and with the increase of depth it decreases in a similar way as the total humus. The exception to this rule is the profile 1 under the Scots pine culture, where the high quantity of the organic phosphorous was reported in the deeper layer as well. The reclaimed mine soil formed by the deposition of the waste rock from the open pit coal mines is frequently contaminated by the coal (Ussirs, Lal 2008). There is a similar situation in the profile 1 under the Scots pine culture. Therefore, it can be safely assumed that in this profile the increase of the content of the organic phosphorous is not the result of the recent chemical processes, but of the presence of coal.

In contrast to the organic form of phosphorous, the forms of phosphorous which are available to the plants react in a completely different way. In the surface layers of the reclaimed mine soil, in all observed profiles there is the lowest content of the forms of phosphorous which are available to the plants, and it increases with the increase of the depth The situation is different in the broadleaf cultures on the observed sites. Under the broadleaf cultures of lime, black locust and common alder (Miletić 2004) the change in the content of the available forms of phosphorous with the change of the depth of solum occurs in a same way as in the organic phosphorous. The highest quantity of the available forms is found in the soil surface, and it decreases with the increase of the depth.

Table 2. *The quantity of the total, organic phosphorous which is available to the plants in soil*

Culture	Sample plot	Depth	pH H_2O	Total P_2O_5	Available P_2O_5	% available P_2O_5 out of the total	Organic P_2O_5	% organic P_2O_5 out of the total
		cm		mg/100g	mg/100g		mg/100g	
Austrian pine	1	0–2	6.4	106.00	0.70	0.66	20.39	19.24
		2–7	6.7	100.00	3.80	3.80	4.35	4.35
		7–17	7.8	83.00	6.00	7.23	7.33	8.83
		17–100	8.0	88.00	5.20	5.91	0.00	0.00
	2	0–2	6.2	88.00	0.70	0.80	13.98	15.88
		2–7	6.4	55.00	0.40	0.73	2.98	5.42
		7–17	7.0	106.00	5.80	5.47	4.58	4.32
		17–100	7.9	100.00	15.10	15.10	3.21	3.21
	3	0–2	7.1	82.00	10.40	12.68	16.04	19.56
		2–7	7.4	94.00	9.30	9.89	11.46	12.19
		7–17	7.6	94.00	14.50	15.43	9.17	9.76
		17–100	7.7	82.00	13.20	16.10	2.75	3.35
Scots pine	1	0–2	6.4	121.00	3.30	2.73	11.00	9.09
		2–7	6.6	141.00	4.10	2.91	9.85	6.99
		7–17	6.7	163.00	7.70	4.72	14.44	8.86
		17–100	7.5	184.00	11.30	6.14	8.25	4.48
	2	0–2	6.0	70.00	0.70	1.00	8.48	12.11
		2–7	6.0	58.00	0.50	0.86	6.42	11.06
		7–17	6.0	70.00	0.30	0.43	6.19	8.84
		17–100	6.2	64.00	0.70	1.09	4.12	6.44
	3	0–2	3.8	46.00	0.70	1.52	4.58	9.96
		2–7	3.3	52.00	1.50	2.88	4.12	7.93
		7–17	3.5	58.00	3.20	5.52	4.58	7.90
		17–100	3.4	58.00	5.00	8.62	1.37	2.37

By the processes of the phosphorous mobilization the insoluble mineral phosphorous compounds are converted into the soluble forms which are available to the plants (Tešić, Todorović 1988). The direct phosphorous mobilization is the result of the activity of bacteria *Bacillus calcis,* which use calcium from tricalcium phosphates for their own needs and in this way convert it in the soluble secundary and primary phosphates, which are available to the plants. The indirect phosphorous mobilization implies the conversion of tricalcium phosphates in the secondary and primary phosphates which is the result of the chemical processes caused by the activities of mineral and organic acids, which bound calcium from tricalcium phosphates. These acids are the product of the decomposition of the nutrients and activities of other microorganisms. The phosphorous acid can react in a similar way with the magnesium minerals as with the calcium, but the magnesium salts which react with the phosphorous acid are hydrated to a greater extent, and thereby more easily soluble (Jakovljević, Pantović 1991). It implies that the increase of the acidification of soil solution, in the neutral soil, under the influence of the forest cultures, leads to the increase of the quantity of available forms of phosphorous, since the multibase forms of phosphates, which the phosphorous acid forms with alkaline earth elements, are less soluble or completely insoluble. Austrian and Scots pine are acidifying species (Knežević 1992), which acidify soil. By the decomposition of the soil organic layer under these cultures, the organic acids and agressive low-molecular fulvic acids, which has a destructive influence on the mineral component, are produced. As a result, the products of the decomposition of the litterfall in the neutral soil, as the observed reclaimed mine soil, should have initiated the processes of phosphorous mobilization. Nevertheless, the reported quantity of the forms which are available to the plants on the observed sites are lowest in the surface layers of the profiles, where the highest quantity of humus is found, and where the influence of the acid products of decomposition is strongest.

Phosphorous is characterized by the extremely low mobility and it hardly migrates through the soil solum, so the content of the available forms of phosphorous in the deeper parts of the observed soil cannot be the result of its transportion from the surface layers.

The positive reaction to the acidification to the solubility of phosphorous and its conversion into the forms which are available to the plants, can be expected only in alkaline and neutral sois, in which the highest percentage of phosphorous is found in the form of calcium phosphates. In the acidic environments, the phosphorous acid is to the greatest extent bound to the iron and alluminium (Jai Prakash, Bhasker 1974).

Iron and alluminium phosphates are also characterized by low solubility, and their solubility decreases with the increase of basicity (Jakovljević, Pantović, 1991). The most soluble iron phosphate is $Fe(H_2PO_4)_3$, which is followed by $Fe_2(HPO_4)_3$, $FePO_4$, $Fe_3(OH)_3(PO_4)_2$, $Fe_2(OH)_3PO_4$ and $Fe_3(OH)_6PO_4$.

By the acidification of the soil, which is already acidified, the basicity of the phosphoric acid increases, since the iron and aluminum become more active. The occluded (polybase) iron and aluminum phosphates are more often excluded from the nutrient cycle in the ecosystems since they are not available to the plants and are insoluble even in the presence of different exoferments, secreted by higher plants or microorganisms. They are soluble only in the royal water. By the increase of the acidification of soil solution the positively charged colloids (basoids), on which anions are absorbed, become more active, and the anion of the phosphoric acid is subject to the extremely strong absorption.

The acidifying activities of Austrian pine and Scots pine is visible on all observed sites. The highest acidity was reported in the surface layers of mine soil, which are most affected by the soil organic layer and the acid products of its decomposition (Table 2). However, the acidification of soil to such an extent which would lead to the processes of phosphorous occlusion was not reported on any sites. The surface layers in some profiles, regardless of the considerably lower pH values in comparison with the deeper layers, are neutral in regard to the reaction of the soil solution. As a result, the decrease of the quantities of the available phosphorous forms in the surface soil layers under the observed Austrian pine and Scots pine cultures is not the result of the phosphorous occlusion.

4. CONCLUSION

Under the cultures of Austrian pine and Scots pine via the litterfall the extremely low quantity of phosphorous is transported to the soil, since both species are oligotrophic and do not require high quantity of this element in nutrition. The litterfall of Austrian pine and Scots pine is characterized by extremely wide C/P ratio, which implies that by the processes of the decomposition of the soil organic layer the high quantity of the phosphorous forms which are available to the plants is not released, and that the highest percentage of phosphorous which is transported to the soil via the litterfall is used by the saprophytic microorganisms. In the cultures of these extremely acidifying species the intensive processes of phosphorous mobilization occur, as a result of the acidification of the soil.

The highest percentage of the available phosphorous, which is converted in the surface soil layers from the insoluble phosphates to the soluble forms, is used by the microorganisms, which convert it into the organic form. These processes lead to the increased content of the organic phosphorous in the soil surface layers, and to the decreased content of the available forms of phosphorous.

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THE IMPACT OF THE AUSTRIAN AND SCOTS PINE ON THE ORGANIC FORMS OF PHOSPHOROUS AND THE FORMS OF PHOSPHOROUS AVAILABLE TO THE PLANTS IN THE RECLAIMED MINE SOIL OF THE ENERGY-INDUSTRIAL COMPLEX KOLUBARA

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Summary

This paper is aimed at the study of the impact of the monocultures of the acidifying species of Austrian and Scots pines on the accumulation of the organically bound phosphorous in the soil, as well as on the content of the forms of this element which is available to plants.

Austrian and Scots pine are the pioneer oligotrophic tree species which do not have great requirements in the nutrition, and particularly do not require the high quantities of phosphorous. Therefore, the quantities of phosphorous in litterfall of both oligonitrophilic and pioneer species are extremely low. Along with the extremely low content of phosphorous, the litterfall of Austrian pine and Scots pine is characterized by the extremely wide ratio of carbon to phosphorous.

In the cultures of these extremely acidifying species the intensive processes of phosphorous mobilization occur, as a result of the acidification of the soil. The highest percentage of the available phosphorous, which is converted in the surface soil layers from the insoluble phosphates to the soluble forms, is used by the microorganisms, which convert it into the organic form. These processes lead to the increased content of the organic phosphorous in the soil surface layers, and to the decreased content of the available forms of phosphorous.

UTICAJ MONOKULTURA CRNOG I BELOG BORA NA BILJKAMA PRISTUPAČNE I ORGANSKE OBLIKE FOSFORA U REKULTIVISANIM DEPOSOLIMA REIK “KOLUBARA“

Zoran MILETIĆ, Snežana STAJIĆ, Zlatan RADULOVIĆ, Katarina MLADENOVIĆ

Rezime

Predmet ovog rada je ispitivanje uticaja monokultura acidifikatorskih vrsta crnog i belog bora na akumulaciju organski vezanog fosfora u zemljištu, kao i na sadržaj biljkama lako pristupačnih oblika ovog elementa.

Crni i beli bor su pionirske oligotrofne vrste drveća koje nemaju većih zahteva u ishrani, a naročito ne prema fosforu. Zbog toga su količine fosfora i u lisnom opadu ovih oligotrofnih i pionirskih vrsta izuzetno male. Pored izrazito niskog sadržaja fosfora lisni opad crnog i belog bora istovremeno karakteriše i izuzetno širok odnos ugljenika i fosfora.

U kulturama ovih izrazito acidifikatorskih vrsta odvijaju se intenzivni procesi fosfomobilizacije, jer dolazi do zakiseljavanja zemljišta. Veliki deo pristupačnog fosfora koji se u površinskim slojevima iz nerastvorljivih fosfata prevodi u rastvorljive, koriste mikroorganizmi i prevode ga u organski oblik. Ovakvi procesi dovode do povećanog sadržaja organskog fosfora u površinskim slojevima zemljišta, a smanjenog sadržaja pristupačnih oblika fosfora.

THE IMPACT OF THE AUSTRIAN AND SCOTS PINE MONOCULTURES ON THE FORMS OF POTASSIUM WHICH ARE AVAILABLE TO THE PLANTS IN THE RECLAIMED MINE SOIL OF THE ENERGY-INDUSTRIAL COMPLEX KOLUBARA

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Abstract: The impact of the monocultures of the acidifying species (Austrian and Scots pines) on the content of the forms of potassium which are available to the plants, absorbed and water-soluble, in the mine soils recultivated by the reforestation was studied. The researches were conducted in the Energy-Industrial Complex "Kolubara". The total annual yield of this element on the area of soil by the litterfall was determined. Under the influence of the cultures of the Austrian and Scots pines, as well as under the influence of the products of decomposition of their leaf litter, in the surface layers of the studied reclaimed mine soil, the content of the forms of potassium which are available to the plants increased in comparison with the deeper layers.

Key words: Reclaimed soils, Austrian pine, Scots pine, potassium.

UTICAJ MONOKULTURA CRNOG I BELOG BORA NA BILJKAMA PRISTUPAČNE OBLIKE KALIJUMA U REKULTIVISANIM DEPOSOLIMA REIK "KOLUBARA"

Izvod: *Ispitivan je uticaj monokultura acidifikatorskih vrsta (crnog i belog bora) na sadržaj biljkama lako pristupačnih adsorbovanih i vodno rastvorljivih oblika kalijuma u deposolima rekultivisanih pošumljavanjem. Ispitivanja su obavljena na području REIK „Kolubara". Određen je ukupan godišnji priliv ovog elementa na površinu zemljišta preko lisnog opada. Pod uticajem kultura belog i crnog bora, kao i pod uticajem produkata razlaganja njihovog lisnog opada, u površinskim slojevima ispitivanih deposola došlo je do povećanja biljkama lako pristupačnih oblika kalijuma u odnosu na dublje slojeve.*

Ključne reči: Deposoli, crni bor, beli bor, kalijum.

1. INTRODUCTION

The mine soil formed by the waste rock disposition from the open-pit lignite mines is characterized by the very unfavourable chemical characteristics (Stojanović et al 1977; Antonović et al 1978; Marković, Veselinović 1979; Antonović et al 1984; Šmit, Veselinović 1997; Šmit, Miletić 1997, Dražić 1997; Miletić 2004).In contrast to the chemical characteristics, physical characteristics of this anthropogenically-formed soil are mainly favourable, which implies that the oligotrophic tree species, which do not need high quantities of the nutrients from the soil, can successfully develop on this mine soil, and perform the productive function of forests. The established forest plantations should at the same time perform the reclamation function, i.e. improve the soil characteristic and provide the conditions for the development of the species which are more demanding in regard to the nutrition by the nutrients which they produce.

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Acknowledgement: The study was partly financed by the Minstry of Science and Technological Development of the Republic of Serbia, the Project – TR 20202A.

2. METHODS

In order to determine the impact of the Austrian and Scots pine on the content of the potassium forms, which are available to the plants, water-soluble and absorbed, in the mine soil of Energy-Industrial Complex "Kolubara", six sample plots, i.e. three under the monocultures of each species, were established.

On all sample plots the wooden boxes for the collection of the litterfall were set. The boxes were set in the spring (April), and the quantities of litterfall, which were collected in the boxes over the year, were determined the following winter (January). In this way the quantity of the litterfall, which was transported to the soil surface over this period, was determined.

On each sample plot one soil profile, from which the soil samples for the laboratory researches was taken, was opened. In order to compare the research results more easily, the horizon of the soil organic layer was not included in the solum depth, since it varies over the year, whereas the mineral, i.e. organic mineral layer immediately under the soil organic layer (0cm deep) was treated as the soil surface. As the first sample the soil layer 2 cm deep (0-2 cm deep), immediately under Olfh–horizon, was taken. As the second sample the soil layer 5 cm deep (2-7 cm deep) was taken, as the third sample the soil layer 10 cm deep (7-17 cm deep), and as the fourth sample the soil layer 17-100 cm deep.

In the collected nutrients the quantities of ash and nutrients were determined, and by analyzing the ash the content of the total potassium, by using the flame photometry method after the conversion into the chlorides was determined.

In the sampled soil layers the following elements were determined:

- the total content of potassium determined by using the flame photometry method after the destruction of the sample by the mixture of hydrofluoric and perchloric acid (Džamić et al 1996),
- exchangeable potassium forms (water-soluble and absorbed), as well as the cation exchange capacity, by using Bover et Atens method (Džamić et al 1996) and
- the available potassium forms by using Al-method.
- the texture of the fine soil was determined by the sedimentation method by using Na-pyrophosphate as the peptizing agent.

3. THE RESEARCH RESULTS

By the foliar analysis of the litterfall on the studied soils it was reported that the Austrian pine and Scots pine transported the small quantity of potassium to the soil surface. The total quantity of potassium in the Austrian pine litterfall is 1.4%, and the average yield to the surface on the studied soils is 19.20 kg K_2O/ha annually. The K_2O content in the litterfall of Scots pine is 1.3%, and the annual yield on the soil surface via the litterfall is 27.91 kg K_2O/ha. These very low potassium quantities in the Austrian pine and Scots pine litterfall are the result of the fact that both species are oligotrophic and not very demanding in regard to the nutrients from the soil, which implies that they do not absorb high quantities of potassium.

By the biochemical processes of the decomposition of the decomposed organic residues on the soil surface, the potassium from the litterfall is released and transformed into the mineral forms which are available to the plants. However, neither Austrian pine nor Scots pine transforms the significant quantity of this element to the soil surface. As a result, the soil organic layer, which is formed under these monocultures, is not the great source of the available forms of potassium.

The total potassium in the soil refers to: potassium of the primary minerals, less-exchangeable (fixed) potassium in the interlamellar space of the clay minerals, easily-exchangeable (absorbed) potassium on the surface of the clay minerals and water-soluble potassium soils (Popović, 1989). The quantities of some potassium forms in the soil are in the dynamic harmony. By the decrease of concentration of the water-soluble potassium, the part of the absorbed potassium is transformed into the water-soluble form, and the part of the fixed forms is partly transformed into the absorbed form.

Table 1. *Quantities of potassium in Austrian pine and Scots pine litterfall*

Culture	Quantity of litterfall (kg/ha)	Ash %	K_2O in litterfall (%)	K_2O in litterfall (kg/ha)
Austrian pine	1,368.75	2.31	1.40	19.20
Scots pine	2,138.75	4.46	1.30	27.91

In spite of the significant spatial variability of the quantities of the total potassium, i.e. there are significant differences between the sample plots, the concentrations of it are similar by the depth of solum at the same sample plots. In the analyzed profiles the quantity of the total potassium ranges from 746 to 1,213 mg K_2O/100g (Table 2).

Table 2. *The content of the total potassium and texture of the fine mine soil under the Austrian and Scots pine cultures*

OP		Depth	Total K_2O	Texture fractions						Texture class by using Ferre classification
				Coarse sand 0.2-2mm	Fine sand 0.02-0.2mm	Powder 0.002 -0.02 mm	Clay < 0.002 mm	Total sand	Total clay	
		cm	mg/100g	%	%	%	%	%	%	
Austrian pine	1	0–2	1,148	1.4	21.2	25.8	51.6	22.6	77.4	Clay
		2–7	1,097	1.0	22.9	23.8	52.3	23.9	76.1	Clay
		7–17	973	2.0	15.7	19.5	62.8	17.7	82.3	Clay
		17–100	1,099	2.8	20.9	21.0	55.3	23.7	76.3	Clay
	2	0–2	944	2.2	24.0	15.5	58.3	26.2	73.8	Clay
		2–7	1,035	2.3	31.3	17.3	49.1	33.6	66.4	Clay
		7–17	1,068	2.2	27.0	22.0	48.8	29.2	70.8	Clay
		17–100	1,135	0.7	33.5	20.7	45.1	34.2	65.8	Clay
	3	0–2	1,213	0.9	43.9	38.2	17.0	44.8	55.2	Loam
		2–7	1,153	0.8	47.5	34.4	17.3	48.3	51.7	Loam
		7–17	1,183	0.7	46.9	31.8	20.6	47.6	52.4	Loam
		17–100	1,150	0.6	42.8	28.5	28.1	43.4	56.6	Sandy Clay Loam
Scots pine	1	0–2	746	0.8	56.7	26.6	15.9	57.5	42.5	Sandy loam
		2–7	980	0.0	56.8	16.2	27.0	56.8	43.2	Sandy loam
		7–17	1,073	0.5	55.8	25.3	18.4	56.3	43.7	Sandy loam
		17–100	1,065	0.6	25.0	31.7	15.7	52.6	47.4	Sandy loam
	2	0–2	1,096	0.6	66.4	13.0	20.0	67.0	33.0	Sandy loam
		2–7	1,298	0.5	65.1	13.2	21.2	65.6	34.4	Sandy loam
		7–17	1,213	1.0	63.0	14.5	21.5	64.0	36.0	Sandy loam
		17–100	1,203	0.6	64.9	13.9	20.6	65.5	34.5	Sandy loam
	3	0–2	838	1.9	30.4	23.2	44.5	32.3	67.7	Clay
		2–7	928	1.7	30.0	22.2	46.1	31.7	68.3	Clay
		7–17	1,090	1.6	40.1	18.7	39.6	41.7	58.3	Clay loam
		17–100	1,078	2.8	35.6	21.5	40.1	38.4	61.6	Clay

The moving of the potassium from the crystal grid of the mineral and their transformation into the form which are available to the plants depend on the decomposition rate of minerals, i.e. on the intensity of decomposition agents and the resistance of minerals to decomposition. The surface layers of mine soils are most exposed to the decomposition agents, since the impact of the atmosphere is greatest in this part of the soil. The temperature amplitudes are greatest in the surface soil layers, and, at the same time, there are frequent variations of the humidity. Such conditions enable the more intensive physical decomposition of the primary minerals and the release of potassium from their crystal grid, whereas it implies the stronger swelling of the clay minerals, as well as the contraction of the interlamellar space. The expansion and contracting of the interlamellar space of the clay minerals, which is more frequent in the surface than in the deeper soils, enable the more easily transformation of potassium from one to another form (fixed ↔ adsorbed ↔water-soluble).

Along with the stronger impact of the physical agents of the mineral decomposition, in the surface layer of mine soil the impact of the chemical decomposition is also more intensive. The oxidation conditions are most intensive, as a result of the easier exchange of the gases between the atmosphere and soil. At the same time, the influence of the nutrients, is greatest in the surface layers of soil, since the products of its decomposition, depending of the chemical character, can be very potent agents of the mineral decomposition. Austrian pine and Scots pine are acidifying species (Knežević 1992). By the processes of decomposition of the soil organic layer the great quantity of fulvic acid of fraction 1 a, which is very aggressive to the mineral soil component, is produced.

In all analyzed profiles in the surface mine soils, 0-2 cm deep, the quantities of the available potassium forms greater than 20 mg K_2O/100 g soil were reported (Table 3), which is based on the limit values for AL method treated as the good soil supply with this available element of the tree nutrition. The content of the potassium which is available to the plants decreased owning to the increase of the solum depth in all studied profiles. In the deepest analyzed layers of mine soil under the studied plantations the content of the available potassium forms are within the limits of the average soil supply with this element, based on the limit values for AL-method.

The quantity of the absorbed potassium to a great extent depends on the soil texture, since potassium is absorbed on the surface of the clay minerals. The studied mine soil greatly differ in the texture. In regard to the texture, the analyzed samples belong to the classes which range from sandy loam to the clays (Table 2). It also implies that there are no regular changes of the texture which is the result of increase of the solum depth in the observed profiles. In the studied mine soil under the Austrian pine and Scots pine monocultures the greater quantities of the absorbed potassium in the mine soil with a higher percentage of clay were reported.

Table 3. *The content of potassium forms which are available to the plants in the mine soil under Austrian pine and Scots pine cultures*

Culture / Depth	Austrian pine			Scots pine		
	Sample plot 1	Sample plot 2	Sample plot 3	Sample plot 1	Sample plot 2	Sample plot 3
cm	mg K_2O/100g soil			mg K_2O/100g soil		
0-2	29.30	32.22	21.73	20.32	17.05	35.85
2-7	20.30	26.65	16.02	19.10	16.66	23.33
7-17	14.40	21.93	18.03	18.52	13.43	12.98
17-100	17.67	16.88	15.11	13.71	13.27	14.06

The exception to this rule are the surface layers 0-2 cm deep, in which the content of the absorbed potassium is more dependent on the cation exchange capacity than on the texture. The cation exchange capacity, besides the texture, depends on the humus content and in all profiles it is higher in the surface than in the deeper layers. The increased content of the absorbed potassium in the surface soils in comparison to the deeper soils is the result of the presence of the Austrian pine and Scots pine monocultures. Owning to the increase of the solum depth, the quantity of the absorbed potassium decreases in the similar way as the potassium forms which are available to the plants do. The exception to this rule is Profile 2 under the Austrian pine monoculture, the texture of which is very heterogeneous and in which the highest quantity of clay and absorbed potassium is found in the layer 7-17 cm deep.

Table 4. *The exchangeable potassium in mine soil under Austrian and Scots pine cultures*

		Sample plot 1				Sample plot 2				Sample plot 3			
	Depth	CEC	Absorbed	Water soluble	Exchangeable	CEC	Absorbed	Water soluble	Exchangeable	CEC	Absorbed	Water soluble	Exchangeable
	cm	ekv.milimol/100g				ekv.milimol/100g				ekv.milimol/100g			
Austrian pine	0-2	44.61	0.86	0.02	0.88	28.75	0.27	0.05	0.32	34.69	0.53	0.05	0.58
	2-7	41.47	0.61	0.02	0.63	25.01	0.31	0.03	0.34	32.11	0.48	0.03	0.51
	7-17	39.69	0.4	0.02	0.42	25.03	0.42	0.03	0.45	27.75	0.44	0.04	0.48
	17-100	26.78	0.17	0.03	0.2	22.1	0.13	0.02	0.15	23.96	0.39	0.03	0.42
Scots pine	0-2	24.85	0.48	0.01	0.49	19.69	0.43	0.02	0.45	47.36	0.88	0.06	0.94
	2-7	22.75	0.46	0.01	0.47	21.3	0.44	0.02	0.46	42.44	0.57	0.06	0.63
	7-17	25.9	0.40	0.03	0.43	20.65	0.41	0.01	0.42	37.84	0.42	0.02	0.44
	17-100	29.29	0.25	0.02	0.27	26.22	0.37	0.02	0.39	46.07	0.42	0.03	0.45

The water-soluble potassium is the most available potassium form in the soil. There are small quantities of this form of potassium in the mine soils under the studied Austrian and Scots pine monocultures. The regular changes of the water-soluble potassium owning to the increase of solum depth were not reported.

4. CONCLUSION

The certain quantities of the organically bound potassium, which are not as high as it can be expected under the broadleaf species, are transported via the litterfall on the surface of the reclaimed mine soils under the Austrian pine and Scots pine monocultures. The nutrients which are transported to the soil surface are subject to the decomposition processes, which enable the return of the potassium in the mineral form. The potassium which is released from the nutrients first occurs in the water-soluble form, and then, depending on the environmental conditions, can be absorbed, fixed, or it can associate to the humus and form potassium humates and fulvates, and transport in the deeper layer of solum in the form of the water-soluble salts. The permanent transport of the potassium to the soil surface via the litterfall is, besides the favourable physical and chemical conditions of the mineral decomposition, one of the causes of the increased content of the available forms of this element in the surface layers of the observed mine soil. Along with the biological accumulation via the litterfall, the increase of the potassium under the Austrian pine and Scots pine cultures also occurs as the result of the presence of nutrients and their products of decomposition, which are strong agents of the chemical decomposition of minerals and transformation of the potassium from the crystal grid of mineral in the forms which are available to the plants.

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THE IMPACT OF THE AUSTRIAN AND SCOTS PINE MONOCULTURES ON THE FORMS OF POTASSIUM WHICH ARE AVAILABLE TO THE PLANTS IN THE RECLAIMED MINE SOIL OF THE ENERGY-INDUSTRIAL COMPLEX KOLUBARA

Zoran MILETIĆ, Snezana STAJIĆ, Vlado COKEŠA

Sumarry

The impact of the monocultures of the acidifying species (Austrian and Scots pines) on the content of the forms of potassium which are available to the plants, absorbed and water-soluble, in the mine soils recultivated by the reforestation was studied. The researches were conducted in the Energy-Industrial Complex "Kolubara".

The certain quantities of the organically bound potassium, which are not as high as it can be expected under the broadleaf species, are transported via the litterfall on the surface of the reclaimed mine soils under the Austrian pine and Scots pine monocultures. The permanent transport of the potassium to the soil surface via the litterfall is, besides the favourable physical and chemical conditions of the mineral decomposition, one of the causes of the increased content of the available forms of this element in the surface layers of the observed mine soil. Along with the biological accumulation via the litterfall, the increase of the potassium under the Austrian pine and Scots pine cultures also occurs as the result of the presence of nutrients and their products of decomposition, which are strong agents of the chemical decomposition of minerals and transformation of the potassium from the crystal grid of mineral in the forms which are available to the plants.

UTICAJ MONOKULTURA CRNOG I BELOG BORA NA BILJKAMA PRISTUPAČNE OBLIKE KALIJUMA U REKULTIVISANIM DEPOSOLIMA REIK "KOLUBARA"

Zoran MILETIĆ, Snezana STAJIĆ, Vlado COKEŠA

Rezime

Ispitivan je uticaj monokultura acidifikatorskih vrsta (crnog i belog bora) na sadržaj biljkama lako pristupačnih adsorbovanih i vodno rastvorljivih oblika kalijuma u deposolima rekultivisanih pošumljavanjem. Ispitivanja su obavljena na području REIK „Kolubara".

Preko lisnog opada na površinu rekultivisanih deposola pod monokulturama crnog i belog bora dospevaju određene količine organski vezanog kalijuma, koje nisu toliko velike kakve bi se mogle očekivati pod lišćarskim vrstama. Stalno iznošenje kalijuma na površinu zemljišta preko lisnog opada je, pored povoljnih fizičkih i hemijskih uslova raspadanja minerala, jedan od uzroka povećanog sadržaja pristupačnih oblika ovog elementa u površinskim slojevima ispitivanih deposola. Pored biološke akumulacije preko lisnog opada, na povećanje kalijuma pod kulturama crnog i belog bora dolazi i pod dejstvom organske materije i njenih produkata razlaganja, koji su jak agens hemijskog raspadanja minerala i pokretanja kalijuma iz kristalne rešetke minerala u biljkama pristupačne oblike.

MONITORING THE IMPACTS OF SILVICULTURAL MEASURES IN THE PROCESS OF RESTORATION OF TREE DEVITALISATION IN COMMON OAK MIDDLE-AGED STAND

Martin BOBINAC[1], Siniša ANDRAŠEV[2]

Abstract: *The impacts of different silvicultural measures on the restoration of tree devitalisation consequences occurring at the stand age of 42 years, were analysed in two permanent sample plots (O.P.-1 and O.P.-2) in artificially established middle-aged stand of common oak, in the age period between 42 and 57 years.*

The stand was established on the noncalcareous chernozem soil type. The site is characterised by the plant community: Tilio-Carpino-Quercetum robori-cerris. During the study period, thinning and sanitation cutting were carried out in O.P.-1 at the ages of 42 and 48 years, and in O.P.-2 only the dead trees were removed.

At the age of 42, there were 832 trees per hectare and volume 194.2 m3•ha-1 in O.P.-1, and in O.P.-2 there were 804 trees per hectare and volume 220.8 m3•ha-1. Under the similar silvicultural treatment in the stand before the establishment of sample plots, till the age of 52 years, in O.P.-1 altogether 160.5 m3•ha-1were felled, and on O.P.-2 the felling amounted to 106.1 m3•ha-1. Over the period 43-52 in OP-2 current volume increment of 8.49 m3•ha-1•yr-1 was attained by 612 trees per hectare, and in OP-1 current volume increment of 8.06 m3•ha-1•yr-1 was attained by 404 trees per hectare. As the result of the applied silvicultural measures at the age of 52 years, the volume per hectare was greater in O.P.-2 (267.4 m3•ha-1) compared to O.P.-1 (181.9 m3•ha-1).

After the age of 52, the process of tree devitalisation continued in OP-2, which conditioned the change in silvicultural strategy. 33% of volume was removed by thinning and sanitation cutting at the age of 52 years in O.P.-2, and in O.P.-1 thinning was postponed till the age of 57. With approximately the same values of basal area and volume per hectare in both sample plots at the age of 57, during the period from 53 to 57 years, current volume increment of 7,56 m3•ha-1•yr-1 was attained by 380 trees per hectare in OP-2, and in OP-1 current volume increment of 7.17 m3•ha-1•yr-1 was attained by 404 trees per hectare.

The study results indicate that the character and intensity of silvicultural measures have a direct impact on common oak rehabilitation from unfavourable effects.

Key words: Q. robur L., permanent sample plots, devitalisation, monitoring, impacts of silvicultural measures

1. INTRODUCTION

The loss of tree vitality and tree dying in forest stands are caused by various factors. **Manion (1981)** classified, in the conceptual model, the tree dying factors into three categories: the initial or predispositional factors, causeing long-term environmental stresses on trees and making them susceptible to the effect of the second group of factors which cause the damage directly on weakened trees. The third group of factors affects in the final stage, and leads directly to tree dying. In the process of tree dying, each forest complex is subject to various combinations of adverse factors and, consequently, the monitoring of forest condition is a very complex process.

The extent of tree dying processes in common oak stands increased over the past decade and it had a significant impact on the realisation of forest management plans (**Dubravac, Dekanić 2009, Medarević et al. 2009**). From the silvicultural aspect, the complexity of management was especially great in inadequately tended middle-aged and maturing stands, because the reinstatement of consequences often requires the implementation of more complex silvicultural measures, compared to the measures designed for the expected stand development

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(**Bobinac, Andrašev. 2001a, 2001b, Bobinac. et al. 2003**). According to **Bobinac, Adrašev (2009),** the conditions for the sustainable development of the remaining trees in the stands will be satisfied only if the factors of tree decline and dying in forest complexes are identified in their genesis, and if in this framework an adequate silvicultural strategy is applied in addition to preventive and repressive protection measures. Conversely, if only the sanitation cutting is applied, the rehabilitation of the remaining trees in devitalised stands is merely prolonged**.**

The phyto-sociological weakening of common oak trees in the river Sava basin, thanks to the inadequate stand structure, was especially severe in middle-aged stands at the beginning of the 20th century, when the dying of common oak forests had an epidemic character (**Marković, Manojlović 1929)**. The inadequate silvicultural treatment in the then juvenile and middle-aged common oak stands resulted in the irregular development and periodically expressed decline of trees in the subsequent period (**Jodal 2008**). In the above trajectory, the dominant attitude is that, with the increasing age, the structure of irregularly formed juvenile common oak stands becomes more irregular and unfavourable for optimal yield and production of good-quality forest products **(Bobinac 2008)**. **Čater et al. (2008)** reported that the decrease in vigour in common oak stands over the period 1930-1965 resulted in mass dying during the eighties, and its consequences are visible even today. Over the past decades this was to some extent periodically demonstrated by the surveys of dead and dying trees in common oak forests on optimal sites in the river Sava basin (**Grbić et al. 1991, Medarević et al. 2009, Dubravac, Dekanić 2009**).

The objective of this study was to point out the effects of different silvicultural measures in the process of restoration of declining trees in common oak middle-aged stands. On the comparative permanent sample plots, the decline was identified at the stand age of 42 years, and the effects of silvicultural measures were monitored over the stand age between 43 and 57 years.

2. MATERIAL AND METHODS

The study area is an artificially established common oak monoculture in the area of Bački Monoštor in FMU "Kolut-Kozara", compartment 32 j (φ_n=45° 49', λ_e=18° 39'), altitude 88 m. The site is characterised by polydominant plant community *Tilio-Carpino-Quercetum robori-cerris* (Alliance *Aceri tatarici-Quercion* Zol. et Jak. 1957). The soil is chernozem non-calcareous, with the thickness of humus-accumulation horizon 40-50 cm. Based on climate data at the weather station Sombor (φ_n = 45°40', λ_e = 18°59', altitude 86 *m,*) in the period 1978-2004, mean annual air temperature was 10.9 °C, and mean annual precipitation was 585 mm.

Two permanent sample plots were established in the study stand at the age of 42 years, plot size 0.25 ha, with a 10 m wide protection belt. All trees on the sample plots were permanently enumerated and the points at breast height were marked for diameter measurement. At the ages of 42 years and 48 years, silvicultural-sanitation cutting of moderate to heavy thinning was performed on O.P.-1, and O.P.-2 was left to the natural process of tree removal till the age of 52 years. At the age of 52 years, the silvicultural strategies on sample plots were changed, thinning and sanitation cutting were carried out on O.P.-2, and on O.P.-1 thinning was prolonged to the age of 57 years.

The data were collected and processed using the commmon metod implemented on permanent sample plots. The stand state and the periodic effects of the application of various silvicultural treatments on sample plots at the stand ages between 42 and 52 years were reported by **Bobinac et al. (1997), Bobinac, Andrašev (2001a, 2009)**.

The data used in this study were surveyed on sample plots at the stand ages of 42, 48, 52, and 57 years. Stand volume was calculated using Schwappach's volume tables for oak, with height curves fitted by the function $h=ae^{-b/d}+1.30$. Data processing consisted of finding the basic numerical parameters of diameter increment. The mean values of diameter increment were compared using t-test, and the structures of diameter increment were compared using non-parametric Kolmogorov-Smirnov test (|D| statistics). The effects of different treatments on sample plots were analysed in the age periods 43 - 52 and 53 – 57, by comparing the structure of curent (average periodical) diameter increment (i_d), calculated using the control method.

3. RESULTS

3.1. Elements of stand growth at the age of 42 -57 years

Elements of growth in common oak monoculture aged 42, 48, 52, and 57 years are presented in Table 1.

Table 1. *Main data on growth elements of trees and stands on sample plots.*

Age	State	N *[trees·ha^{-1}]*		G *[m^2·ha^{-1}]*		V *[m^3·ha^{-1}]*		d_g *[cm]*		h_g *[m]*	
		OP-1	OP-2	OP-1	OP-2	OP-1	OP-2	OP-1	OP-2	OP-1	OP-2
42	Initial	832	804	22,44	24,72	194,17	220,81	18.5	19.8	17,24	17,65
	Thinning	216	148	4,75	3,56	39,11	29,96	16.7	17.5	16,60	16,90
	End	616	656	17,69	21,17	155,06	190,85	19.1	20.3	17,44	17,80
48	Initial	616	656	21,02	23,71	199,62	228,34	20.8	21.5	18,71	18,91
	Thinning	212	44	5,91	0,97	53,69	8,41	18.8	16.7	18,09	17,30
	End	404	612	15,10	22,74	145,93	219,93	21.8	21.7	18,99	18,96
52	Initial	404	612	17,77	26,23	181,92	267,37	23.7	23.4	19,96	19,88
	Thinning		236		8,91		88,60		21.9		19,45
	End	404	376	17,77	17,32	181,92	178,77	23.7	24.2	19,96	20,09
57	Initial	404	376	20,20	19,90	217,78	216,58	25.2	26.0	20,88	21,09

Legend: OP – sample plot; N – number of trees per hectare; G – basal area per hectare; V – volume per hectare..

Diagram 1. *Height curves in stands*

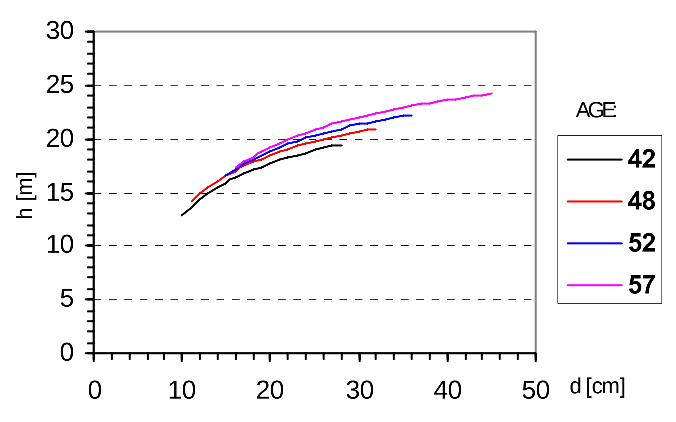


Table 2. *Parameters of height curve model and their elements of evaluation.*

Height curves				
Model: $h=a\cdot exp(-b/d_{1.3})+1.3$				
Parameters of models and their evaluation	*Age*			
	42 year	*48 year*	*52 year*	*57 year*
a	23,380	24,556	26,19	27,85
b	7,081	7,150	8,032	8,878
R^2	0,703	0,696	0,626	0,617
s_e	0,831	0,864	0,902	1,153
n	208	154	43	192

a, *b* – parameters of height curves;
R^2 – coefficient of determination; s_e – standard

At the age of 42, there were 832 trees per hectare on O.P.-1 and the volume was 194.2 m^3·ha^{-1}, and on O.P.-2 there were 804 trees per hectare and the volume was 220.8 m^3·ha^{-1}. At that age, the process of intensive biological differentiation and tree decline was evident. A high degree of dependence of the degree of crown decline on crown class and the degree of crown class indicated that the declining process was directly related to the stand structure, i.e. to the silvicultural treatment in the preceding period (**Bobinac, Andrašev 2009**).

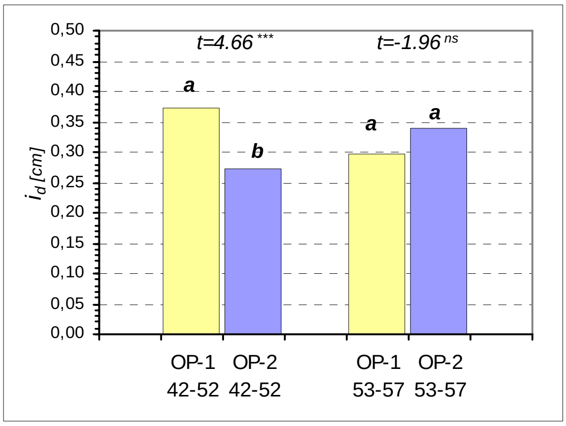
In the two silvicultural interventions, at the ages of 42 and 48 years, 404 trees per hectare with 92.8 $m^3 \cdot ha^{-1}$ were felled on O.P.-1, and on O.P.-2, 192 trees per hectare were felled with 38.4 $m^3 \cdot ha^{-1}$. As the result of different silvicultural measures on sample plots at the age of 52 years, the volume per hectare was greater on O.P.-2 (267.4 $m^3 \cdot ha^{-1}$) compared to O.P.-1 (181.9 $m^3 \cdot ha^{-1}$). By the removal of declined and non-prosperous trees at the age of 52 (236 trees.$\cdot ha^{-1}$), with the volume of 88.6 $m^3 \cdot ha^{-1}$, on O.P.-2 total felled volume was 127 $m^3 \cdot ha^{-1}$. Under a similar silvicultural treatment in the stand before the establishment of sample plots, before the stand age of 52 years, the total volume of felled trees was 160.50 $m^3 \cdot ha^{-1}$ on O.P.-1, and on O.P.-2 the total volume of felled trees was 194.66 $m^3 \cdot ha^{-1}$.

The height curves (Diagram 1, Table 2) are characterised by a mild increase in the heights depending on the stand age, and by the horizontal course, which indicates that the devitalisation process had an unfavourable effect on the stand height development. The height of the stand quadratic mean diameter (d_g) in the period between the ages of 43 years and 57 years increased by 3.4-3.6 m.

3.2. Effects of silvicultural measures in the stand at the age of 42-57 years

At the stand age of 43-52 years, on OP-1 current volume increment of 8.1 $m^3 \cdot ha^{-1} \cdot yr^{-1}$ was realised by 404 trees per hectare, and on OP-2 current volume increment of 8.5 $m^3 \cdot ha^{-1} \cdot yr^{-1}$ was realised by 612 trees per hectare. With the approximately identical sizes of basal area and volume per hectare on sample plots at the age of 53-57 years, on OP-2 current volume increment of 7.6 $m^3 \cdot ha^{-1} \cdot yr^{-1}$ was realised by 376 trees per hectare, and on OP-1 current volume increment of 7.2 $m^3 \cdot ha^{-1} \cdot yr^{-1}$ was realised by 404 trees per hectare.

Diagram 2. *Mean values of current diameter increment.*



Legend: OP – Sample plot; *t* -test.

Diagram 3. *Cumulative curves of current diameter increment structure between 43^nd^ and 52^nd^ and between 53^nd^ and 57^nd^ year on sample plots.*

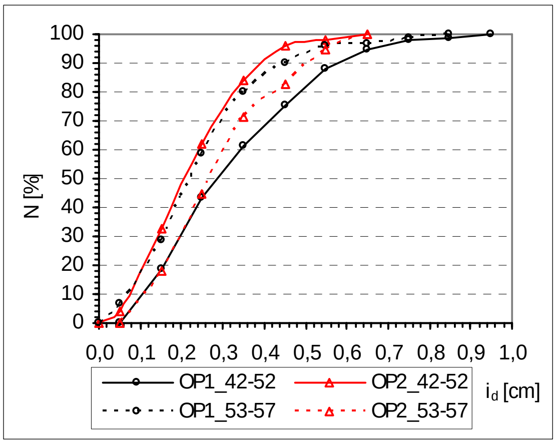


Table 3. *Numerical indicators of current diameter increment structure between 43nd and 52nd and between 53nd and 57nd year on sample plots.*

Numerical indicators	Period *[year]*			
	43-52		53-57	
	OP-1	OP-2	OP-1	OP-2
n	101	153	101	153
$\bar{i}_d$ *[cm]*	0,37	0,27	0,30	0,34
$i_{d\_20\%}$ *[cm]*	0,46	0,36	0,46	0,45
s_{id} *[cm]*	0,18	0,13	0,15	0,14
c_v *[%]*	49,4	46,3	51,1	42,2
i_{d_min} *[cm]*	0,10	0,05	0,01	0,12
i_{d_max} *[cm]*	0,99	0,68	0,84	0,67
v_w *[cm]*	0,89	0,63	0,83	0,55
α_3	0,760	0,729	1,091	0,541
α_4	3,094	3,328	4,762	2,444
$\|D\|$	0.265^{***}		0.163^{ns}	

Legend: *n* - number of trees on sample plot; i_d - arithmetic mean of diameter increment; $i_{d\_20\%}$ - diameter increment of dominant trees; s_{id} - standard deviation; c_v - coefficient of variation; v_w - variation width; i_{d_min} - minimal diameter increment; i_{d_max} - maximal diameter increment; α_3 – coefficient of skewness; α_4 - coefficient of kurtosis; $|D|$- statistics of Kolmogorov-Smirnov nonparametric test.

Mean values of diameter increment differed significantly between sample plots at the age of 42-52 years when diameter increment was greater by 37% on O.P.-1 than on O.P.-2. By the change in the silvicultural strategy in the age period 53-57, diameter increment on O.P.-2 was greater by 13% compared to O.P.-1, but it was not a significant difference (Diagram 2).

The summary curve of diameter increment at the ages of 43-52 years on O.P.-1 was moved to the right, towards the higher values of increment, compared to O.P.-2, and at the ages of 53-57 years, it was vice versa. The Kolmogorov-Smirnov test confirmed the significant differences in the structures of diameter increment on sample plots in the period 43-52 years, while in the period 53-27 years, the values of $|D|$ statistics were not significant. Also, there was a difference in the curve shape, which implies the differences in the variability of diameter increment (Diagram 2). The numerical parameters of diameter increment structure exhibit the increase in the right skewness, the leptocurtic distribution and the increase in variability on O.P.-1 in period 53-57 compared to O.P.-2 (Table 3).

4. DISCUSSION AND CONCLUSIONS

At the age (42 years), the common oak monoculture was subject to intensive tree differentiation, caused by the unfavourable environmental factors (supposed coincidence of defoliation and extreme climate conditions - arid periods) and by the absence of adequate tending It resulted in the decline of a great number of trees, which required the stand thinning in the subsequent period.

The implementation of silvicultural-sanitation cutting at the ages of 42 and 48 yeaes, on O.P.-1, resulted in the significantly higher current diameter increment in the remaining trees at the age of 43-52 years, compared to the sanitation cutting on O.P.-2, so from the aspect of the reinstatement of tree decline consequences, such treatment can be taken as more efficient compared to sanitation cutting. However, by the removal of the declined and silviculturally non-prosperous trees on O.P.-2 at the age of 52 years, in the period 53-57, there was an increase in diameter increment compared to the previous period, and a somewhat greater diameter increment compared to OP-1, on which the last thinning was performed at the age of 48 years.

The presented observations of the effects of different silvicultural measures in the analysed stage of stand development indicate that the common oak revitalisation capacity and the rehabilitation from environmental stresses depends on the intensity and character of silvicultural measures.

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POSSIBLE USE ALKALIZED SOIL TO INCREASE AFFORESTATION AREA IN BANAT REGION

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Abstract: *Chemical characteristics and granulometric composition of solonetz soils in the Banat area are presented in this paper. This study was concerned with the depth of pedological profile and the following were determined: carbonate leaching, increase in alkality, and total salt content, steady decline in organic matter, and increse in total clay share. The share of total salts, and content of total clay increased due to eluvial-illuvial migration in alluvial Bt horizon that had evident prismatic structure, which revealed poor chemical, and water-air characteristics of this horizon. Characteristics of alkalized soils proved that afforestation of such soil could be possible only with the tree species tolerant to such habitats.*

Key words: solonetz, afforestation, Banat

1. INTRODUCTION

In Vojvodina salt-affected soils occupy the area of 233.927 ha, from which 148.000 ha is occupied by „true saline soil", and 85,927 ha by saline soils. Formation of saline soils in this area is closely associated with geology and geomorphology of the terrain. *Miljkovic (1963)* according to Nejgebauer, mentioned that from the huge crown of the Carpathians, surrounding the Pannonian Basin some elements were released during natural processes of rock decomposition, which were transferred by water to the lower parts, and became easily soluble salts. In association with that, the largest area under saline soil is located in Banat, in the flood areas of the watercourses in the Carpathian basin. The same author also mentioned that water soluble salts were formed in the lowlands, from the loess and sand in eolithic sediments containing all minerals found in the rocks of the Carpathians crown.

During tectonic movement, and the emergence of cracks, salty neogen sediments got closer to the surface than in the central part of the lowlands, and communication passage between lower salty waters and upper waters was made, which in that way became strongly mineralized, and the soil salt content was increased by the ascedent rise.

Class of alkalized soils (class solonetzs, type solonetz) is the most widely spread (within the solonetz soils in Vojvodina) in our country, and it covers the area of 115.593 ha, from which the largest part of 89.249 ha (*Miljković, 2005)* is located in Banat. According to the same author it is most often found in complex with solonchaks and other saline soils of automorphic and hydromorphic origin, which are affected by the alkalization, salinization, and desalinization processes. Hence, the saline soils have different transitional forms depending on the relief, hydrology, and hydrochemistry of ground waters in a semi-arid and arid climate.

Morphological structure of this soil was A/E-Bt,na-C-CG, or A-E-Bt,na-C-CG, and depth of ground water rich in Na_2CO_3 ranged from 150 to 300 cm. The basic way in which this land was formed was transition to Na^+ ions from aqueous solution into soil adsorptive complex. According to *Miljković, (2005)* alkalization process with semiarid climate in Vojvodina region took place in two ways: when ground waters rich in Na_2CO_3 with their ascedent flows moistured

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the soil, and when it saturated the adsorptive complex with Na^+ ions, and solonchak desalinization. By inserting more than 15% of Na^+ ions, the process of eluvial-illuvial migration of soil colloids, which were transfered from humus A horizon into deeper layers was initiated, and illuvial Bt,na horizon was formed in that way. Due to migration of matters from humus A horizon and eluvial E horizon, these horizons were characterized by the low participation of $CaCO_3$, pH value was slighty acidic to neutral, so they were just slightly less salty, and had lower clay and colloid contents.

Illuvial Bt,na horizon presented the basic diagnostic indicator of solonetzs, it had prismatic structure, increased clay and colloid content, increased soil reaction, and salt content, and its thickness (35-55cm) reflected the degree of alkalization. Since the clay and colloid content in Bt,na horizon was increased, the pores were swollen and closed due to moisturizing, and this soil was characterized by very poor water-air characteristics with poor ecological and production characteristics. Due to their characteristics these soils are not used in intensive plant production. Use of production potential of these soils requires different melioration procedures, and due to their chemical and physical characteristics the solonetzs are used as natural, very poor pastures. According to their beneficial effects on plant production these soils belong to class VII bonitet (*Hadžić, et al. 2002*). Differential species found in holomorphic habitats is *Quercus robur*, which has specific habitat protective function, and high ecological values (*Galić et al. 2006)*. Habitats on alkalized soils were covered with oak and ash forests (*Querceto-Fraxinetum angustifoliae*) in the past, which are today, according to *Ivanisevic et al. (2006)* degraded, with the bushy remnants of blackthorn and hawthorn, or individual trees of wild pear, wild cherry, and wild rose. So, the choice of tree species for afforestation of the above mentioned habitats must be made among mentioned tree species of which the following are the most suitable: *Quercus robur, Fraxinus angustifolia, Fraxinus americana, Juglans nigra, Populus alba, Prunus sp., Pirus piraster i Eleagnus angustifolia*

2. MATERIALS AND METHOD

Four pedological profiles were opened in representative locations marked as solonetz for this investigation. The profiles were located in the Banat area, in the vicinity of Idvor and Crna Bara. Internal and external morphology of the profiles was described, and the following laboratory analyses of the soil samples from each genetic horizon were done:

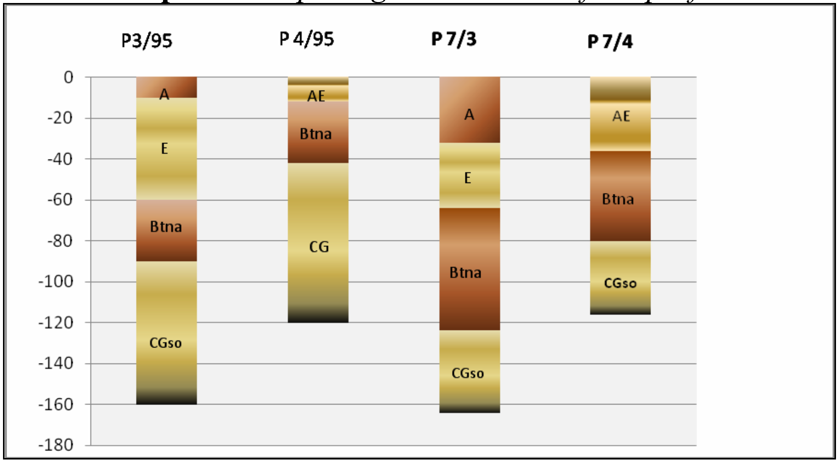
- determination of mechanical soil composition according to the International pipette method with preparation in Sodium pyrophosphate;
- determination of humus content in the soil using Tjurin method modifed by Simakov;
- determination of $CaCO_3$ content in the soil using volumetric method with »Scheibler calcimeter«;
- Determination of soil chemical reaction, pH in water using electrometric method with glass diode;
- Determination of nitrogen according to Kjeldahl method;
- determination of easily accessible phosphorous and potassium according to Al – method, Egner-Riehm –Dominigo;
- determination of total water soluble salts in the soil using method of measurement of the electrical conductivity of a saturated soil paste.

Species of trees tolerant to these habitats were proposed based on the morphology of pedological profiles and the obtained results of soil analysis.

3. RESULTS AND DISCUSSION

Morphological structure (Graph. 1) of the profile was analyzed and it was found to be A-E-Bt,na-CGso or AE-Bt,na-CGso. It was characterized by very shallow humus horizon. Its thickness ranged from 10 to 36 cm. Illuvial horizon Bt,na was found at the depth of 12-64 cm, it had extremely prismatic structure, and its thickness ranged from 30-60 cm. Depth of Bt,na horizon pointed out to moderately deep to deep physiologically active profile depth.

Graph. 1. *Morphological structure of the profile*



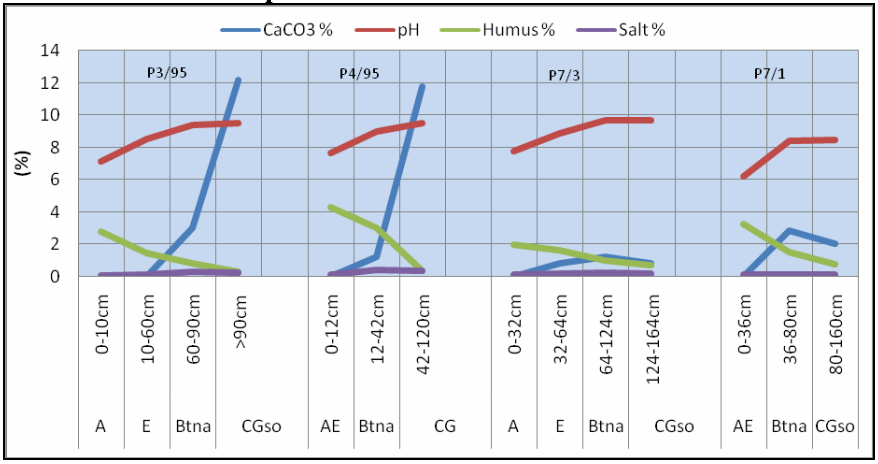
By analyzing chemical characteristics of these soils (Graph. 2) it could be seen that the $CaCO_3$ content in the humus horizon was totally absent due to leaching, and it had minimal values of 0,82% in the eluvial horizon, while it was accumulated in the illuvial Bt,na horizon and its values were increased and ranged from 1,20 to 3,0%, and it was particularly expressed in the lowest horizons, where it reached the value of up to 12,20%.

Soil reaction was also increased with the depth of pedological profiles, and in humus horizon it ranged from 6,2 – 7,8, while in illuvial Bt,na horizon it ranged from 8,4 – 9,7.

Content of organic matter in surface horizon had values ranging from 1,97 – 4,29%, and declined steadily with the profile depth, and according to *Nešić, (2006*) it also influenced the genesis, development and saline characteristics.

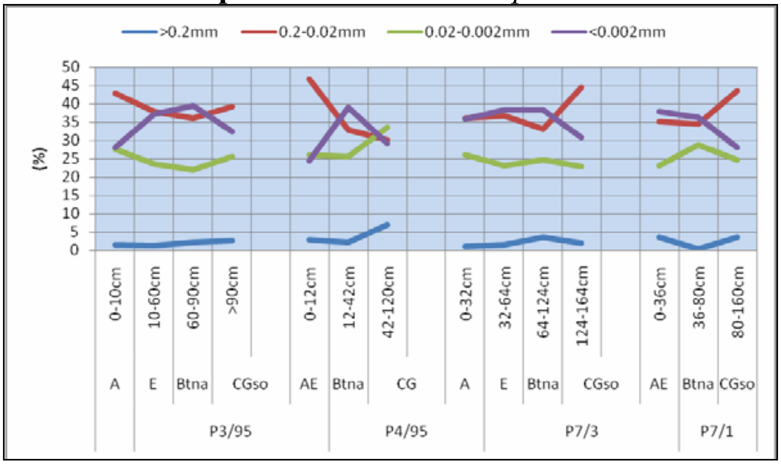
Analysis of the total salt content revealed accumulation in Bt,na horizon, where its values were increased and ranged from 0,12 – 0,43, while *Belić,et al. (2004)* mentioned the most frequent range of salts in the Bt horizon ranging from 15-25%.

Graph 2. *Chemical characteristics*



Mechanical composition of these soils (Graph. 3) had a typical schedule of analyzed soil fractions per profile depth, namely increased fraction values of total clay in illuvial horizon were observed, and they ranged from 61,6 – 65,2%, while in the surface horizon they ranged from 50,4 – 62,8%. Textural class of the total profile ranged from sandy-clay loam to clay-loam, and in illuvial Bt,na horizon it was only clay loam.

Graph. 3. *Mechanical composition*



Obtained results of studied solonetz characteristics pointed out to moderate deep to deep phisologically active profile depth (rhizosphere depth). Content of carbonates per profile depth pointed out to leaching of carbonates into deeper horizons. Distribution of organic matter content was of humus accumulative type. Reaction of soil solution in the humus accumulative type was slightly acidic to neutral and alkaline in deeper profile parts. Total salt content was the highest in Bt,na horizon. Texture of these soils ranged from sandy clay loam to clay loam. Illuvial horizon of these soils (Bt,na horizont) was according textural composition always clay loam, and it had total clay content exceeding 61%.

Due to heavy mechanical composition, which was the result of textural migration caused by eluvial – illuvial processes, this soil had unfavorable water-air characteristics. These unfavorable characteristics were pronounced in impenetrable Bt,na horizon, which had prismatic structure. Position of Bt,na horizon, which was at the depth of 12 to 64 cm in the studied profile, was conditioned by rhizosphere depth in these soils. Due to the above mentioned poor physical and chemical characteristics no trees, only pastures can be found on such soils.

Namely, a large space under these soils were covered with grassy vegetation, with no tree species, it was degraded, with the remnants of the shrubby formation of blackthorn and hawthorn, and individual trees of wild pear, wild apple and wild roses. Since habitats on alkalized soil were covered with oak and ash forests (*Querceto-Fraxinetum angustifoliae)* in the past, they should be reintroduced into areas where they had disappeared.

The selection of woody species for afforestation of the mentioned habitats should be chosen within species that are tolerant to the mentioned habitat conditions, and the most appropriate among them are: *Quercus robur, Fraxinus angustifolia, Fraxinus americana, Juglans nigra, Populus alba, Prunus sp., Pirus piraster and Eleagnus angustifolia.*

By establishing the forest vegetation in the areas under such soils, the afforested area in Banat would be increased, and ecosystem stability with many positive features of the forest would also be increased.

4. CONCLUSION

The morphological structures A/E-Bt,na-C-CG or A-E-Bt,na-C-CG of alkalized soils belonging to solonetzs class (solonetz type) were analyzed in this paper. Textural migration from the surface horizons into illuvial horizon caused by eluvial-illuvial processes was observed in these soils.

Illuvial Bt,na horizon was determined in these soils at a depth of 12-60cm, which was characterized by the high share of total clay (over 61%) and high total salt content (0,12-0,43%), and thickness ranging from 30 to- 60cm, prismatic structure, and adverse water-air properties. Characteristics of these alkalized soils showed that tree species tolerant to these habitats should be used to increase afforestation. As the most appropriate tree species for afforestation of these habitats the following were suggested: *Quercus robur, Fraxinus angustifolia, Fraxinus americana, Juglans nigra, Populus alba, Prunus sp., Pirus piraster and Eleagnus angustifolia.*

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PRODUCTION EFFECTS OF THE RECONSTRUCTION OF BEECH COPPICE FORESTS IN THE AREA OF BUKOVI

Ivan BJELANOVIĆ[1], Milun KRSTIĆ[1], Srđan KEREN[2]

Abstract: *This paper shows the research results which refer to the development of dominant trees in coppice beech stands, as well as man-made stands of Douglas fir, spruce and Austrian pine, artificially established in the process of reconstruction on the site of beech mountain forest. The comparative analysis between coppice beech trees alongside artificially grown Douglas fir, Norway spruce and Austrian pine trees was carried out by testing the significance of differences in development of diameters (dbh) and heights. In the oldest common age (40 years) dbh shows statistically significant differences among analyzed species. Beech reaches the lowest values (100%), than Austrian pine (123%), and the highest values have Norway spruce (150%) and Douglas fir (160%) among which there is no significant difference. All species have maximum increment values between 10 and 15 years of age. Culmination values for beech with 6,2 mm to 7,3 mm are significantly lesser, in statistical term, compared to conifer species. At time of culmination, Austrian pine has the highest increment with 14,1 mm, than Douglas fir with 13,1 mm and Norway spruce with 12,2 mm. Douglas fir has the greatest total height which makes it significantly different, in statistical sense, in relation to other species. The second total height has Norway spruce, than come Austrian pine and beech that do not differ significantly in total height. If beech height is marked as 100%, than Austrian pine achieves 96%, Norway spruce 141%, and Douglas fir 165%. Douglas fir and Austrian pine have maximum increment between 10 and 15 years of age, while Norway spruce is similar to beech reaching maximum increment between 15 and 20 years of age. Douglas fir has the biggest culmination value of 1,07 m, and is followed by Norway spruce (0,77 m), beech (0,62– 0,65 m) and Austrian pine (0,54 m). Research results were used to define silvicultural goals and to select the most suitable silvicultural measures with the aim of improving the present state of the sites and better use of their production capacities.*

Key words: beech coppice forests, artificially established conifer stands, reconstruction, tree development.

1. INTRODUCTION

According to the data released by the National Forest Inventory – NFI (2004 - 2007), coppice forests of Serbia account for approximately 1.455.050 ha or 64,6% of the total forest area. Since beech is the species with the highest share (29,6%), beech coppice forests are the most important objects of reclamation. The area of manmade conifer stands in Serbia amounts to 124.800 ha or 5,54% (Banković, S. *et al.*, 2008).

Reclamation of degraded forests can be carried out in accordance with different methods based on direct and indirect conversion and their combinations. Radical measures of reconstruction used to be the most commonly applied methods in the past, which implied substitution of degraded and coppice forests with artificially established conifer stands.

Studies of condition, eco-productive potential and proposals of silvicultural measures in order to meliorate degraded beech forests in Serbia were conducted by Krstić, M. (2004), Krstić, M. *et al.* (2004, 2004/a), Pantić, D. *et al.* (2003), Ćirković, T. (2006) and others.

In artificially established conifer stands in Serbia the researches encompassing architecture, site conditions and their comparative features, and tending measures were performed at different sites by many authors: Miščević, V. *et al.* (1981); Tomanić, L. *et al.* (1990, 1990/a, 1990/b); Stojanović, Lj. (1989-1990); Stojanović, Lj., Banković, S. (1981); Stojanović, Lj., Krstić, M. (1984, 1984/a, 1997); Jovanović, B., Stojanović, Lj. (1982);

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Stojanović, Lj. *et al.* (1993, 2002); Krstić, M. (1982, 1998); Dražić, M., Ratknić, M. (1990); Stamenković, V. *et al.* (1983, 1987,); Vučković, M. *et al.* (1990, 1990/a); Bobinac, M., Krstić, M. (1994); Cvjetićanin, R. *et al.* (1995); Koprivica, M., Ratknić, M. (1996); Koprivica, M. *et al.* (1998); Bobinac, M. (2004); Ćirković, T. (2006); Bjelanović, I. (2008), etc.

The importance of studies pertaining to the coppice and other degraded forest forms, as well as to conifer cultures grown in the process of reconstruction warrants the finding of optimal meliorating measures in order to improve the current state of forests.

2. MATERIALS AND METHOD

The study was carried out in the area of Bukovi in the mountain beech coppice forest (*Asperulo odoratae-Fagetum moesiacae* B. Jov. 1973) and forest cultures of Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco), Norway spruce (*Picea abies* Karst.) and Austrian pine (*Pinus nigra* Arn.) in management unit "Bukovi", compartments 21, 33 i 34 that belong to Forest Company Department „Kosjerić".

Data were collected in the field following standard procedure on permanent sample plots. Different sets of data were collected: inventory data along with data needed for examining of site conditions, typological denomination, stand condition and development of individual trees. Collected data were processed following standard methodology for this kind of research. The most becoming silvicultural treatments that have been proposed were based on the results of statistical data processing.

3. RESULTS AND DISCUSSION

3.1. Basic data about subject site and stand

Study of site conditions and phytocoenology was carried out in beech stands belonging to two defined ecological units of mountain beech forests (*Fagetum moesiacae montanum* B. Jov. 1953 fac. *rubosum*) on deep and medium deep typical eutric brown soil on diabase and artificially grown stands of Douglas fir, Norway spruce and Austrian pine on the same site and locality.

Basic architecture elements of studied stands are shown in Table 1.

Table 1. *Average values of site and stand basic data*

Vrsta	beech eco-unit 1	beech eco-unit 2	Douglas fir	Norway spruce	Austrian pine
altitude (m)	885-900	815-860	860	835-865	920-930
exposition	E-ESE	ENE-ESE	E-ENE	E-ENE	SE
inclination (°)	8-14	5-8	8-9	7-9	11-13
age (years)	75-80	65-70	41	41	43
N (tree/ha)	324	386	684	859	1431
BA (m^2/ha)	32,09	31,91	50,30	49,39	59,03
V (m^3/ha)	353	341	575	366	470
d_g (cm)	35,5	32,4	30,6	27,1	22,9
h_g (m)	25,6	24,1	27,2	22,9	16,4
D_g (cm)	43,7	40,7	39,4	35,0	30,9
H_g (m)	26,4	25,2	30,1	25,3	17,2

The stands of ecological unit 2 have higher total number of trees/ha in comparison to the stands of ecological unit 1 because they are younger (10-15 years old) and, consequently, have smaller dimensions, bigger participation of trees in smaller dbh classes and of trees that live in biological position III. Among artificially grown conifer cultures the stand of Austrian pine was singled out due to leaving out of tendering measures, which makes it have higher number of trees/ha in comparison to the monocultures of Douglas fir and Norway spruce.

The largest total volume has Douglas fir stand and is followed in successive order by the stands of Austrian pine, Norway spruce, beech from ecological unit 1 and the lowest total volume has beech from ecological unit 2 (Table 2). Provided that volume of beech from eco-unit 1 has value of 100%, than as a result Douglas fir reaches 163%, Austrian pine 133% and Norway spruce 104%. The volume of eco-unit 2, although it contains more trees, is of comparable amount to that of eco-unit 1, and a bit smaller dimensions of trees resulted in somewhat lower values of volume. Austrian pine monoculture has high value of volume that is, due to omission of nurture, distributed on numerous trees which therefore have smaller dimensions than trees of Douglas fir and Norway spruce.

Beech forests are characterized with very high productivity. In terms of accumulated volume and volume increment Douglas fir proved to be highly productive on inherent beech sites; Norway spruce can use these sites efficiently, and is especially dominant over sprouting beech and Austrian pine, while it lags behind Douglas fir.

3.2. Development of dominant trees

Development of dominant trees is the best indicator of site potential utilization because it is assumed that their development is influenced by site and their bioecological features, and it's actually independent from stand condition, that is, from effects of silvicultural measures. Standard dendrometric analysis was performed on three mean trees among 20% of the largest trees in each series of sample plots.

3.2.1. Diameter growth and development

Comparative display of trendlines of coppice beech diameter development and its increment for eco-units 1 and 2, along with the results for Douglas fir, Norway spruce and Austrian pine from respective monocultures is shown in figure 1. The results on diameter development and increment, and statistical significance at $p<0.05$ level determined by LSD test are shown in Tables 2 and 3.

Table 2. *Significance of differences in dbh development of analyzed species*

<table>
<tr><td colspan="2" rowspan="3">Tree species</td><td colspan="15">age (years)</td></tr>
<tr><td colspan="3">10</td><td colspan="3">15</td><td colspan="3">25</td><td colspan="3">30</td><td colspan="3">40</td></tr>
<tr><td colspan="15">dbh without bark (cm)</td></tr>
<tr><td colspan="2">beech eco-unit 1</td><td colspan="3">38</td><td colspan="3">69</td><td colspan="3">119</td><td colspan="3">147</td><td colspan="3">208</td></tr>
<tr><td colspan="2">beech eco-unit 2</td><td colspan="3">46</td><td colspan="3">83</td><td colspan="3">134</td><td colspan="3">160</td><td colspan="3">215</td></tr>
<tr><td colspan="2">Douglas fir</td><td colspan="3">28</td><td colspan="3">93</td><td colspan="3">190</td><td colspan="3">233</td><td colspan="3">332</td></tr>
<tr><td colspan="2">Norway spruce</td><td colspan="3">37</td><td colspan="3">98</td><td colspan="3">196</td><td colspan="3">233</td><td colspan="3">312</td></tr>
<tr><td colspan="2">Austrian pine</td><td colspan="3">63</td><td colspan="3">134</td><td colspan="3">197</td><td colspan="3">217</td><td colspan="3">256</td></tr>
<tr><td colspan="2">$F_{calculated}$</td><td colspan="3">4,99</td><td colspan="3">11,41</td><td colspan="3">14,94</td><td colspan="3">18,23</td><td colspan="3">59,36</td></tr>
<tr><td colspan="2">$F_{(0,05;\ k-1,\ N-k)}$</td><td colspan="15">3,48</td></tr>
<tr><td rowspan="5">NSD</td><td>beech e.u.1</td><td>*</td><td></td><td></td><td>*</td><td></td><td></td><td>*</td><td></td><td></td><td>*</td><td></td><td></td><td>*</td><td></td><td></td></tr>
<tr><td>beech e.u. 2</td><td>*</td><td></td><td>*</td><td>*</td><td>*</td><td></td><td>*</td><td></td><td></td><td>*</td><td></td><td></td><td>*</td><td></td><td></td></tr>
<tr><td>Douglas fir</td><td>*</td><td></td><td></td><td></td><td>*</td><td></td><td></td><td></td><td>*</td><td></td><td></td><td>*</td><td></td><td>*</td><td></td></tr>
<tr><td>Norway spruce</td><td>*</td><td></td><td></td><td></td><td>*</td><td></td><td></td><td></td><td>*</td><td></td><td></td><td>*</td><td></td><td>*</td><td></td></tr>
<tr><td>Austrian pine</td><td></td><td></td><td>*</td><td></td><td></td><td>*</td><td></td><td></td><td>*</td><td></td><td></td><td>*</td><td></td><td></td><td>*</td></tr>
</table>

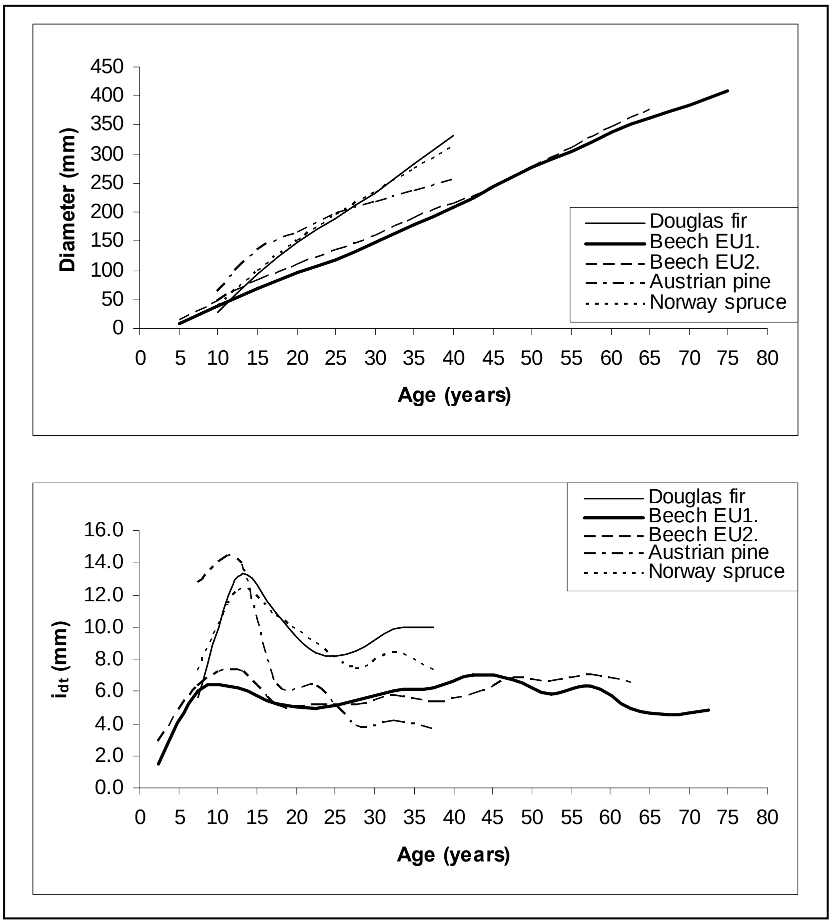

Figure 1. *Diameter development and current dbh increment of analyzed species*

In relation to conifers beech has more intensive development only in first few years owing to sprouting capacity of stools. Austrian pine singles itself out from other species (except from beech in eco-unit 2) by the largest dbh until the age of 10, which is conspicuous from testing of statistical significance differences for dbh at the age of 10. Douglas fir and Norway spruce overtakes beech sometime between the age 10 to 15. Faster growth of Austrian pine at this age can be explained by its higher demand for light compared to Douglas fir and Norway spruce. Beech trees from both eco-units have similar development that is until the end of analyzed period significantly of lower intensity than that of conifers. Austrian pine has more intensive growth than Douglas fir and Norway spruce until the age of 25, and than it becomes overtaken by these two species (for this point statistically important difference is determined). After this point diameter growth of Austrian pine significantly decreases and lags behind two above-mentioned species. There is no statistically important difference between Douglas fir and Norway spruce concerning their dbh values for the entire length of analyzed period of time.

At the highest age of 40 the largest dbh has Douglas fir that is followed by Norway spruce, Austrian pine, and beech after all. Provided that dbh of beech from eco-unit 1 has value of 100%, than as a result beech from eco-unit 2 reaches 163%, Austrian pine 123%, Norway spruce 150% and Douglas fir makes it up to 160%. Species differences in growth dynamics are also noticeable from the data about needed number of years for reaching dbh of 20 cm. In order to reach dbh of 20 cm Douglas fir needs 27 years, Norway spruce 26 years, Austrian pine 26 years, and beech needs 37-38 years.

Table 3. *Significance of differences in current dbh increment of analyzed species*

Tree species		age (years)				
		5-10	10-15	15-20	20-25	35-40
		current dbh increment (mm)				
beech eco-unit 1		6,0	6,2	5,2	4,9	6,2
beech eco-unit 2		6,3	7,3	5,1	5,1	5,3
Douglas fir		5,6	13,1	10,9	8,4	10,0
Norway spruce		7,3	12,2	10,7	9,0	7,3
Austrian pine		12,7	14,1	6,4	6,3	3,7
$F_{calculated}$		7,94	27,48	12,36	5,45	19,96
$F_{(0,05;\ k-1,\ N-k)}$		3,48				
NSD	beech e.u. 1	*	*	*	*	* *
	beech e.u. 2	*	*	*	*	* *
	Douglas fir	*	*	*	* *	*
	Norway spruce	*	*	*	*	*
	Austrian pine	*	*	*	* *	*

In the earliest stage all analyzed species exhibit swift growth and have early culmination of dbh increment because of sprouting vigor in beech and planting origin of conifers. Austrian pine has the most intensive growth in the earliest stage, which significantly differs from all other species as early as at the age of 5 to 10. Maximum current dbh increment appears sometime between the age of 10 to 15, which is in accordance with cited literature. Culmination values (6,2 mm and 7,3 mm) of beech trees from both eco-units are almost twice lesser than those of conifers. At the culmination point Austrian pine has the biggest increment with 14,1 mm, than come Douglas fir with 13,1 mm, and Norway spruce with 12,2. Such sequence of culmination values corresponds with species demand for light as it is known that light demanding species have more intensive growth than the shade tolerant in the earliest development stages. However, differences in culmination values among conifers are not statistically significant. After culmination increment lines of all species show abrupt drop, which is also consistent with cited literature. Austrian pine experiences the most noticeable decrease of increment between the age 15 to 20, o be conducted earlier and equals with increment values of coppice beech; after the age of 25 it has statistically important lesser value of dbh increment compared with beech from eco-unit 1. Until the age of 40 all species experience one more maximum that is smaller and appears as a result of thinning operation, which by the way ought to be conducted earlier so as to have full and expected effect. Ultimately, at the age between 35 and 40 dbh increment of Norway spruce falls down and doesn't differ significantly (in statistical term) from beech from eco-unit 1, while Douglas fir has significantly higher values than all other analyzed species. The biggest culmination values, as stated above, are reached by Austrian pine that is followed by Douglas fir, Norway spruce, beech from eco-unit 2, and beech from eco-unit 1. In relation to culmination value of beech from eco-unit 1, beech from eco-unit 2 makes 118% of the increment, Austrian pine 227%, Norway spruce 197% and Douglas fir makes it up to 211%.

3.2.2. Height development and increment

Comparative display of height development and increment of analyzed species is shown in Fig. 2. The results on tree height development and respective increment, and statistical significance at $p<0.05$ level determined by LSD test are shown in Tables 4 and 5.

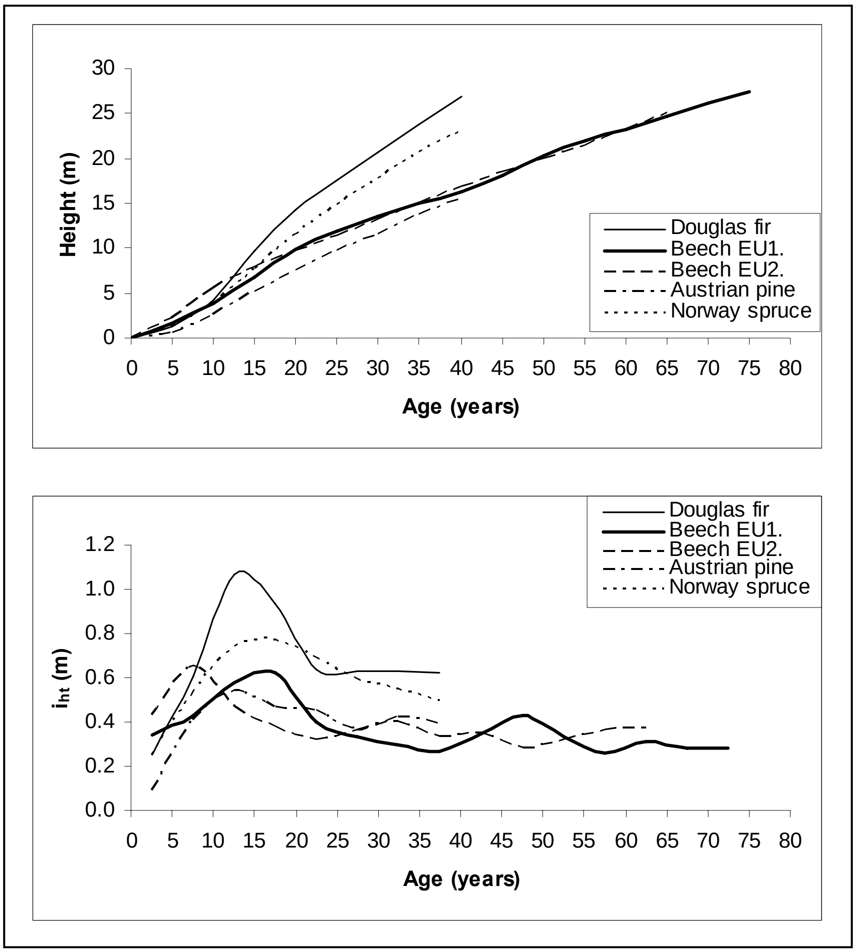

Figure 2. *Tree height development and current height increment of analyzed species*

Table 4. *Significance of differences in tree height development of analyzed species*

Tree species		age (years)				
		10	15	20	30	40
		tree height (m)				
beech eco-unit 1		3,86	6,76	9,84	13,49	16,33
beech eco-unit 2		5,44	7,80	9,70	13,08	16,75
Douglas fir		4,28	9,62	14,27	20,65	26,88
Norway spruce		3,93	7,63	11,47	17,83	23,10
Austrian pine		2,50	5,20	7,53	11,58	15,62
$F_{calculated}$		15,13	14,34	22,60	73,43	169,47
$F_{(0,05;\ k-1,\ N-k)}$		3,48				
NSD	beech e.u. 1	*	*	*	*	*
	beech e.u. 2	*	*	*	*	*
	Douglas fir	*	*	*	*	*
	Norway spruce	*	*	*	*	*
	Austrian pine	*	*	*	*	*

As a consequence of coppice origin beech from eco-unit 2 has the most vigorous height growth in first 10 years, while there is no significant difference at the age of 10 between beech from eco-unit 1, Douglas fir and Norway spruce. At the age of 15 Douglas fir, after culmination, overtakes other species, while there is no significant difference between beeches from both eco-units and Norway spruce. Beeches from both eco-units lag more and more so that they become overtaken by Norway spruce with statistical importance at the age of 20. However, there is no difference between these species in the life period from 20 to 65 years. There are significant differences in development between Douglas fir and Norway spruce as from the age of 15 to 65 whereby Douglas fir eventually has higher value for 16 %. Height development line of Austrian pine is under respective lines of other species, indicating the slowest development for the observed period, which is a consequence of inadequate use of site potential and biological behavior of the species (it is not a fast-growing one).

At the age of 40 Douglas fir has the biggest height and is followed by Norway spruce, beech from eco-unit 2, beech from eco-unit 1, and Austrian pine. Provided that tree height of beech from eco-unit 1 has value of 100%, than as a result beech from eco-unit 2 reaches 103%, Austrian pine 96%, Norway spruce 141% and Douglas fir makes it up to 165%. Differences among these species are noticeable from the data about needed number of years for species to reach 15 m in height. Douglas fir makes it at the age of 21, Norway spruce at 26, beech at 35, and Austrian pine at the age of 39.

Table 5. *Significance of differences in current height increment of analyzed species*

Tree species		age (years)				
		5-10	10-15	20-25	35-40	max
		current height increment (m)				
beech from eco-unit 1		0,43	0,58	0,40	0,27	0,62
beech from eco-unit 2		0,65	0,47	0,32	0,33	0,65
Douglas fir		0,61	1,07	0,64	0,62	1,07
Norway spruce		0,53	0,74	0,69	0,50	0,77
Austrian pine		0,41	0,54	0,45	0,39	0,54
$F_{calculated}$		2,17	23,37	52,18	26,62	5,91
$F_{(0,05;\ k-1,\ N-k)}$		3,48				
NSD	beech e.u. 1	*	*	*	*	*
	beech e.u. 2	*	*	*	* *	*
	Douglas fir	* *	*	*	*	*
	Norway spruce	* *	*	*	*	*
	Austrian pine	*	*	*	*	*

Regarding current height increment beech from eco-unit 2 has the earliest culmination at the age between 5 to 10 with 0,65 m, but the difference in relation to Douglas fir and Norway spruce at that period is not statistically confirmed. Douglas fir and Austrian pine reach maximum increment at the age between 10 and 15, while Norway spruce makes it later at the age between 15 and 20. In years 10 to 15 height increment of beeches and Austrian pine is similar, while Douglas fir and Norway spruce differ from each other significantly on behalf of Douglas fir. Beech from eco-unit 1 has lower growth rate in the earliest stages and therefore reaches culmination between 15 and 20 years of age having almost identical culmination values with beech from eco-unit 2. Douglas fir achieves the biggest culmination values with 1,07 m, and is followed by Norway spruce (0,77 m), beeches (0,62 – 0,65 m) and Austrian pine (0,54 m). In relation to culmination values of beech from eco-unit 1, beech from eco-unit 2 reaches 105%, Austrian pine 87%, Norway spruce 124% and Douglas fir makes it up to 173%. Culmination value of Douglas fir increment differs significantly from other species, and differences between other species are attributed to casual variations. Abrupt fall of increment values occurs after culmination, which further tends to keep constant level with minor oscillations.

Initiation period of thinning operations is linked with culmination of current height increment and they are supposed to be conducted at that point of time or just little before the culmination. Based on analysis of current dbh and height increment trendlines it is possible to conclude that it would have been more effective if thinning operations in the subject conifer - and beech stands had been performed when they reached 15 years of age.

4. CONCLUSIONS

This paper shows research results which refer to development of dominant trees in the coppice beech stands, as well as manmade stands of Douglas fir, spruce and Austrian pine, artificially established in the process of reconstruction on the site of beech mountain forest. The comparing analysis between coppice beech trees alongside artificially grown Douglas fir, Norway spruce and Austrian pine trees was carried out by testing the significance of differences in development of diameters (dbh) and heights.

Research results which refer to environment conditions, stand condition and development of dominant trees in the coppice beech stands, as well as manmade stands of Douglas fir, spruce and Austrian pine were used to define silvicultural goals and to select the most suitable silvicultural measures with the aim of improving the present state of the sites and better use of their production capacities. This study implies relevant selection of species for reconstruction along with choice of other appropriate silvicultural measures that should be prescribed for the subject stand and site conditions.

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PROPOSAL OF SILVICULTURAL OPERATIONS IN COPPICE SESSILE OAK AND BEECH FOREST OF THE MANAGE UNIT „TRSTENICKE SUME“

Ivan MILENKOVIĆ[1]

Abstract: *Influenced by many different factors, there was a creation of coppice forests in large areas, so that their current situation is not satisfactory in terms stand status, quality, stability, vitality and health. The paper points out the problem of large representation of coppice forests, unsatisfactory situation and the need to repair and improve the current situation. Adversely state is caught in studied manage unit "Trstenicke forests", the Trstenik area, whose covered surface is: 2018.58 ha. Of this number, 81.6% consists of coppice forest by area and by volume, of which 78.8% are preserved. The results of studying the situation and proposed of silvicultural interventions in coppice sessile oak and beech stands, which is located on the sessile and Turkey oak habitat (Querceto petreae-ceriss), aged about 50 years, have been presented. Taking into account the origin and that this forest is in the age when she needed care, according to study site conditions and stand state, corresponding cultivated procedures are proposed.*

Key words: Coppice sessile oak forests, stand state, silvicultural operations, conversion

1. THE PROBLEM AND THE TASK

Man has long thought that the forest are indestructible, and sources of goods from her inexhaustible, which contributed to the merciless destruction of forests and the occurrence of many, freely speaking, emergent forms of unnatural forest.

There is no naturally created coppice forests in large areas! This is a category that man has created, consciously or unconsciously acting.

The problem of Forestry Serbia, as well as many countries, is the great disparity that exists between the importance, potential and current state of forests. It is estimated that the current volume and productivity of our forests to only about 50% of the possible. This is characterized by inadequate dencity degree and forested area, unfavorable structure of the training system, the composition and mixture, adversely stand status, unfavorable health. *(Јовић Н., Банковић С., Медаревић М., 1992. г., Крстић М. 2006. г.).*

The total area of forests and forest land in Serbia is 2 634 800 ha, which is 29.6% of the territory of Serbia, or 0.3 hectares per capita. From this area, high forests occupy 27.6%, artificially erected stands 7.8% and 64.6% coppice, the remainder of 4.7% waste thickets, and other degradation forms. *(Банковић С., Медаревић М.., and others, 2009. g ;* Национална инвентура шума Републике Србије*).*

The value of volume in the high forests is approximately 254 m3/ha and ongoing volume growth is 5.5 m^3 / ha. The average volume in the coppice forests is 124.4 m^3 / ha, a gain of 3.1 m^3 / ha. From these differences we see that annually lose 3 500 000 m^3 of timber, not to mention the environmental effects in terms of bonding carbon and oxygen production.

Forests of oak, as one of the most important species of oak in Serbia, occupy 10.28% of forest fund. From that high waste 28.7%, the coppice even 60.51%, and shrubs and šibljaci take 10.79% *(Медаревић М., Банковић С., Пантић Д. 2006. g.).*

Over-exploitation in the past and the lack of funds for ameliorative works led to such a situation. These data indicate that it takes a lot of attention paid to the condition of existing forests and improving them.

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Forestry Serbian long-term goal is to establish the optimum condition Forest breeding ameliorative measures, and thus increase the production of timber volume, improving the composition and structure of forests, allowing fuller use production potential habitat and optimizing other functions of forests as ecosystems *(Крстић М. 2006. г.).*

It is envisaged that until 2050. the increased participation of high-forest to 90%, participation coppice and other degradation form reduced to about 10%. Also the participation of conifers should be 25%.

This current situation and a great representation of coppice and degraded forests indicates the need for their reclamation. Known way that this issue is resolved *(Крстић М. 2006. г.):*

- Conversion,
- Restitution,
- Substitution.

During the earlier Forest, coppice forests were sorted into three groups as follows: good in good habitat - conversion; bad to good habitat - for restitution, the poor to poor habitat - forest protection or substitution of characters.

Today, when editing determines stand state, within each type coppice forests, they are divided into three groups: well-preserved, diluted, demolished. According to this classification, and translation coppice forests in the high, according to *Стојановић et all* (2004), answer the following cultivated procedures:

- For preserved, conversion;
- Diluted for the combination of conversion and restitution;
- For demolished, restitution in combination with substitution.

Unsatisfactory condition is caught in studied mange unit „Trstenicke sume“ where the coppice forests represented about 81.6% by volume and surface. Of this percentage 78.8% coppice forests are preserved. In coppice sessile oak and beech forest in the department 20, division a, which is taken as representative of the manage unit, the following task are seted:

1. Study the environmental conditions
2. Undertake analysis of the state associations
3. Based on the environmental conditions studied and measured stand situation and knowing bioecological characteristics of species, we shell propose silvicultural operations in the studied stand.

2. PROPERTY AND METHOD OF STUDY

Research in this work is done in natural oak and beech stands in the area Trstenik. The study was selected in a coppice stand, manage unit „Trstenicke sume“. This forest is located at an altitude from 230 to 400 m. Exposure is a Western-Southwestern. Climatic features of this site are based on data obtained from measurements of the nearest meteorological station in Krusevac, and for a period of 10 years (1999-2009).

During the research were used taxation data collected in the usual way, for the purposes of making a special basis for forest management for this manage unit. Directly in the field was conducted detailed study of site conditions, typological affiliation and stand condition. Data processing is also performed by usual methodology, in research of this type. Used computer and statistical software in the usual way.

Volume was calculated by the method volume table for coppice forests in Serbia, and the current volume increment by diameter increment method.

3. RESULTS

3.1 Basic information on habitat and stand

Studied stands is in manage unit „Trstenicke sume “, department 20, division a, at an altitude between 230 and 400 m. Exposure is the Western-Southwestern, and slope is steep (16-20^0).

Climatic characteristics of this area are: mean annual temperature is 10, 8^0C, and mean annual maximum temperature is 16.7^0 C. The average annual amount of precipitation is 647.51 mm/m^2. Mean annual relative humidity is 77%.

Geological base consists of sandstone and slated structures, which are slightly disrupted. They were represented distric or eutric brown soil. Land is a medium deep, wet, and without skeletal. Still mat is abundantly represented.

Examined associations belonging to the group ceno-ecological types of sessile oak woods and Turkey oak (Quercion petreae ceriss) in different brown soils.

This stand is coppice origin, age about 50 years, which means that it is made clear cutting, shortly after the Second World War.

Circuit is preserved, thick (0,8-0,9). Foliage are short (1 / 4 to 1 / 3 height). Belongs to a group of complex associations in shape, or form.

3.2 Stand status and structure

Stand department 20, section A, makes coppice stands of beech and oak. These are mixed and preserved stands thick canopy. The stand is the most represented sessile, which in the total number of trees participating with 48.9% in volume with 62.33%. Then there is a beech with 14.5% in the number of trees and 22.7% in volume. Hornbeam participates with 17.9% in the number of trees and other species with 18.7%. These last two participate with 14.97% of the total volume

The distribution of trees by diameter degrees analyzed for associations is given in absolute and relative amount in the Table. 1 and the Figure. 1.

Table 1. *Basic information on studied stands*

Species	Sessile oak		Beech		Hornbeam		Other		Total	
Diameter degrees	Number of trees		Number of trees		Number of trees		Number of trees		Number of trees	
	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%
7,5	80	15,47	40	26,14	163	85,79	116	59,18	400	37,84
12,5	87	16,82	23	15,03	13	6,84	15	7,65	173	16,34
17,5	143	27,66	10	6,54	7	3,68	10	5,1	170	16,08
22,5	110	21,28	43	28,1	3	1,57	10	5,1	167	15,79
27,5	73	14,12	30	19,61	3	1,57	7	3,57	113	10,69
32,5	20	3,87	3	1,96	/	/	/	/	23	2,17
37,5	3	0,58	3	1,96	/	/	3	1,53	10	0,95
Total	517	100	153	100	190	100	196	100	1057	100
%	48,9		14,5		17,9		18,7		100	

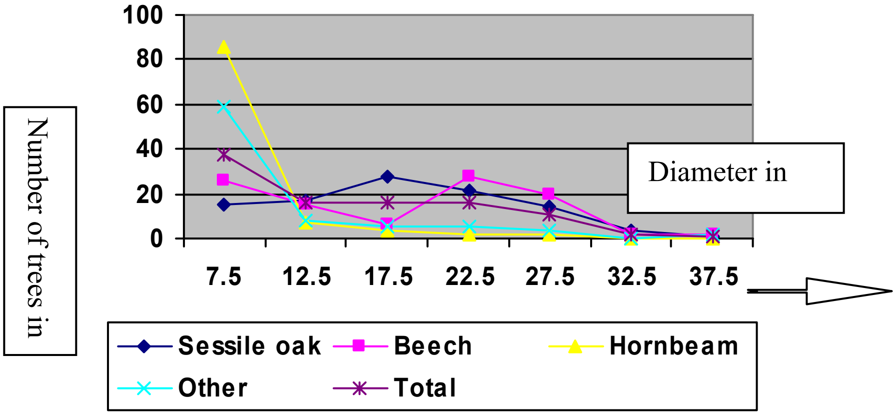

Chart 1. *Distribution of trees by diameter degrees*

The total number of studied stand is 1057 trees per ha., sessile oak has 517 or 48.9%. Beech has 153 or 14.5%. Hornbeam occurs with 190 trees per ha, or 17.9%. Other species have 196 trees per ha, or 18.7%. Figure 1 shows that the observed associations is about same aged.

The distribution of volume is shown in the following tables and charts:

Table 2. *Distribution of volume by diameter degrees*

Species	Sessile oak		Beech		Hornbeam		Other		Total	
Diameter degrees	V in m^3		V in m^3		V in m^3		V in m^3		V in m^3	
	Per ha	%	Per ha	%	Per ha	%	Per ha	%	Per ha	%
7,5	0,037	0,029	1,71	3,69	7,056	53,46	4,27	24,53	14,76	7,21
12,5	9,22	7,03	2,76	5,94	1,57	11,86	1,55	8.90	17,85	8,72
17,5	29,08	22,62	2,34	5,04	1,65	12,52	2,01	11,54	34,22	16,72
22,5	36,89	28,73	16,65	35,82	1,17	8,87	3,32	19,09	55,62	27,17
27,5	35,58	28,46	17,37	37,35	1,75	13,27	3,48	20,01	56,29	27,50
32,5	13,99	10,93	2,41	5,20	/	/	/	/	15,98	7,81
37,5	2,82	2,17	3,23	6,94	/	/	2,77	15,92	9,25	4,52
Total	128,4	100	46,5	100	13,20	100	17,44	100	204,7	100
%	62,33		22,7		6,45		8,52		100	

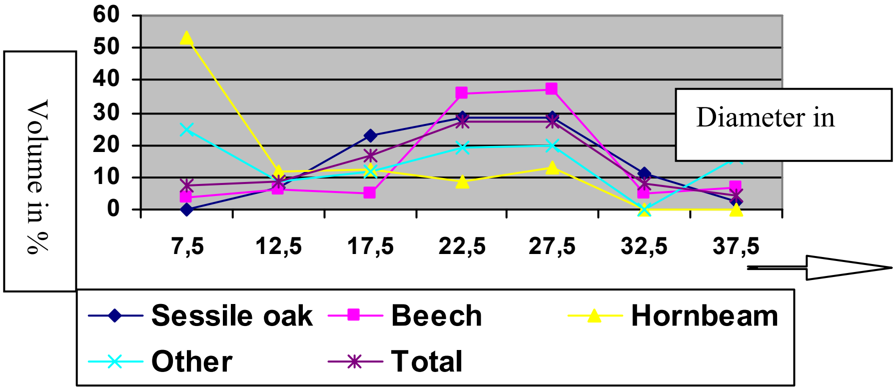

Chart 2. *Distribution of volume by diameter degrees*

Total volume in the department a is 8 475 m3. Of this waste of sessile 62.33% or 128.4 m^3/ha. Beech takes up 22.7% or 46.5 m^3 / ha. Other consume 14.97% of the volume.

The total volume takes the proper line, the bell distribution, which confirms same aged character of these associations (Graph. 2).

The observed current stand volume growth is 6.9 m^3 per ha. Of this number sessile oak has 4.3 m^3 and 2.6 m^3 of beech. The total value of cross section for the whole stand is 24.4 m^2.

3.2 The proposal silvicultural measures

Based on the environmental conditions studied and analysis stand state, for the studied stands is proposed to perform thinning cuts. Volume silvicultural interventions can be determined based on multiple criteria *(Стојановић Љ., Крстић М. 2000. г.)*:

1. Hart-Beckingov Factor spaces of trees in this stand is 14.65%, and during the performance of space needed to be careful, because the stand thick and stable enough,
2. Slenderness ratio of trees in this stand is 98, and shows us that stands sufficiently stable, so caution is required when performing spacing,
3. Intensity thinning procedures by volume, according to Matić formula is 20%. On the basis of all may be proposed high selective thinning of moderate intensity interventions to 20%.

Before the performance space must be based on the presented stand state and habitat conditions, set short and long term goals, that these measures should be achieved.

As a short-term goal, it is necessary to extract the tree of the future, as holders of production.

Long-term goals would be in the stands were as follows:

1. Increase participation of oak and beech in the mixture;
2. Remove hornbeam, and oak restoration of natural disturbances;
3. Preparation stands for natural restoration and translation in higher silvicultural form.

4. DISCUSSION

A detailed study was done in coppice sessile oak and beech forest in the manage unit “Trstenicke sume”, the area of Trstenik. Based on the studied environmental conditions, stand state and health, given the proposed silvicultural interventions.

Number of trees per ha in 1057 is relatively high for the specified age of 50 years, and as one of the main goals of imposing a gradual reduction of the number of anticipated future number of trees.

Given the origin of, the volume of 204.7 m^3 / ha of this forest is satisfactory and higher than average, which amounts to 124.4 m^3/ha for coppice forests in Serbia *(Банковић С., Медаревић М. and others, 2009. g.; Национална инвентура шума Републике Србије)*. Increment of 6.9 m3/ha also higher than the average of 3.1 m3/ha.

Effect on such high values certainly have a high number of trees per ha, caught in the stands.

All of the above tells us that this stand has the potential to successfully translate into higher training system, and using known conversion method *(Крстић М. 2006. г.)*.

In proposing silvicultural procedures and measures in the coppice forests should not be a problem of access “stereotype”, but each stand must be treated individually depending on its condition, and environmental conditions in which it is located.

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RESEARCH RESULTS OF THE EFFECT OF CLIMATIC FACTORS ON THE DIAMETER INCREMENT OF TREES IN SLOVAKIA

Rudolf PETRÁŠ, Julián MECKO[1]

Abstract: *Correlation dependence of increment indexes on climactic factors was studied on annual rings orders of 455 trees of spruce, oak and beech. Average monthly temperatures are presented for the years 1931-2005, and total monthly precipitation for the years 1901-2005. Estimated correlation coefficients with values 0.2-0.5 are statistically significant. Examined trees react positively, in particular to precipitation in June and July. Reaction of spruce is strongest. Precipitation from second half of vegetation period of previous year has important influence too. Influence of higher temperatures during vegetation period on increment changes is mostly negative and statistically insignificant.*

Keywords: climatic effects, annual rings, spruce, oak, beech

1. INTRODUCTION

Diameter increments are typical growth parameters of trees, and in our moderate climatic zone they have seasonal character. Site, individual tree dispositions as well as climatic conditions under which each tree is growing contribute to their formation. These facts were confirmed by many research results published recently in connection with a possible effect of climatic changes on forests. OTS, RAUK (1999), VITA, BITVINSKAS (1998), MÄKINEN (1998), FELIKSIK, WILCZYŃSKI (1999, 2004), ROLLAND et al. (1998), ANFODILLO ET AL. (1998), OBERHUBER, KOFLER (2000, 2003), VEJPUSTKOVÁ et al. (2004) studied coniferous trees and KNOTT (2004), GRUBER (2001), ŠMELKO, MIKOVÁ (1999), PAJTÍK, IŠTOŇA (2003), PETRÁŠ et al. (2006, 2007) studied broadleaved trees. All mentioned authors studied mainly the effect of monthly temperatures and precipitation on radial increments of trees. They state in their works that in cold regions monthly temperatures are more significant and in warmer regions precipitation. KAHLE et al. (2008) reached little different results when he studied in several locations of Scandinavia, western and Central Europe the effect of precipitation on radial increment of spruce, beech and pine. He states that it is not probable that higher increment of forests in Europe is the result of greater amount of atmospheric precipitation. MELLERT et al. (2008) has not confirmed in the same study unanimous effect of precipitation also on height growth of trees. He has not confirmed nor the effect of precipitation in the combination with increased amount of atmospheric nitrogen.

The aim of our work is to present the results of research on the effect of basic climatic factors on radial increments of spruce, oak and beech trees in Slovakia.

2. MATERIALS AND METHODS

Empirical material was gathered in central part of Slovakia. Annual rings were sampled on dominant and co-dominant trees in homogenous stands of spruce, beech and oak growing in the circle of about 20-25 km from meteorological station at Sliač (Fig. 1). Only one annual ring sample

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was taken at the breast height of each tree. Sampling was conducted in the period 2004-2006 on 455 trees in 18 stands with following characteristics according to respective tree species:

		Number of			
Tree species	*Stands*	*Trees*	*Age*	*Site class*	*Altitude (m)*
Oak	8	190	70-170	22-30	400-650
Spruce	5	145	85-120	32-40	350-480
Beech	5	120	105-160	18-30	500-700

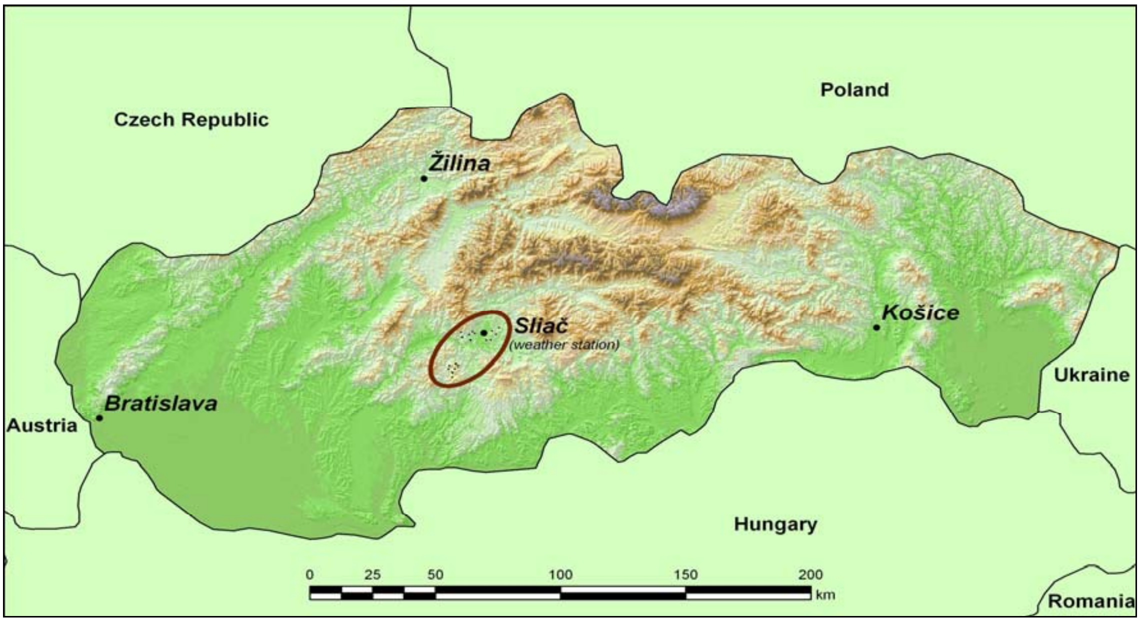

Fig. 1. *Location of meteorological station Sliač and of experimental stands in central part of Slovakia*

Annual rings orders were synchronized, dated and standardized. Method of graphical comparison of the greatest increment minima and statistical testing of parallelism of increment trends by Schweingruber (1983) was used. Percent of parallelism of annual rings orders is relatively high. The value for spruce is 61-98%, oak 65-96% and beech 55-90%. Regarding high percent of parallelism we may state for all tree species that their increment curves are very similar and individual trees react very similarly to growth factors of concrete stand with relatively high probability. In most of cases trees have also increments minima in the same calendar years. In most of stands the minima were recorded in the year 1905, 1923, 1947, 1962, 1974, 1993 and 2000. Annual rings orders were standardized by means of increment indexes Ii, which represent proportions of actual increments ia and their model values im

$$I_i = \frac{i_s}{i_m} \qquad (1)$$

Model increments represent moving averages of radial increments. PETRÁŠ et al. (2007) consider this procedure more objective than smoothing of age increment trends. Increment indexes were analysed and their correlation dependence on average monthly temperatures and monthly precipitation was examined. Data were obtained from meteorological station Sliač (Fig. 2). Values for temperature were come from the years 1931-2005 and precipitations in the years 1901-2005. Totals of annual precipitation in this region reach 500-1,000 m but for the months May – August only 100-500 mm. It is similar also for the values of air temperature. Average annual temperature is about 6–10° C and in vegetation period 15–19° C. Regarding long-term trend of temperatures it is obvious that they have relatively high variability and provide good possibilities for studying their effect on trees increments.

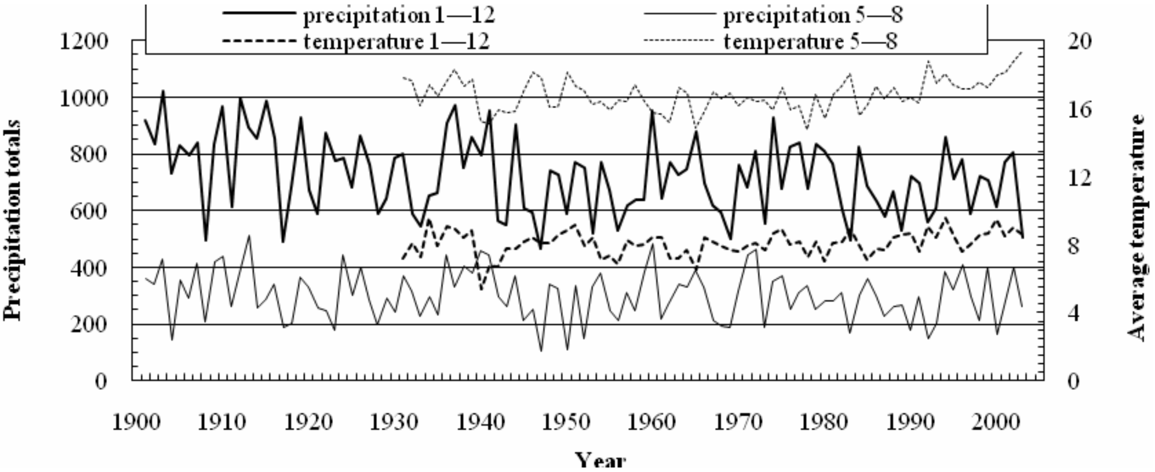

Fig. 2. *Precipitation total and average temperatures at meteorological station Sliač*

3. RESULTS

Effect of monthly precipitation and temperature on diameter increment of trees

This effect was examined by correlation analysis on standardized increment curves. For each tree pair correlation coefficients were calculated to measure the intensity of linear dependence only of a couple of variables, in our case particularly dependencies of annual increment indexes on monthly precipitation totals and average monthly temperatures according to all months (Jan – Aug) of current year (i.e. year when studied increment was formed) as well as for last 8 months (May – Dec) of previous year. Significance of correlation coefficient was tested at the level of significance $\alpha = 0.05$ with the number of openness degrees n-2.

Correlations significance for spruce

According to the proportion of trees with significant correlation coefficient (Fig. 3) of all 145 trees we may state with 95% probability that:

- About 85-90% of trees react positively to precipitation in June and July,
- Only 10% of trees react positively to precipitation in April, May or August,
- About 20% of trees react positively to precipitation in August and September of previous year,
- Effect of monthly temperatures on diameter increment of spruce trees is mostly negative,
- About 30% of trees react negatively to higher temperatures in August of current year,
- About 40% of trees react negatively to high temperatures in June and almost 65% of trees to high temperatures in September of previous year,
- Only 30% of trees react positively to higher monthly temperatures, but only in March of current year.

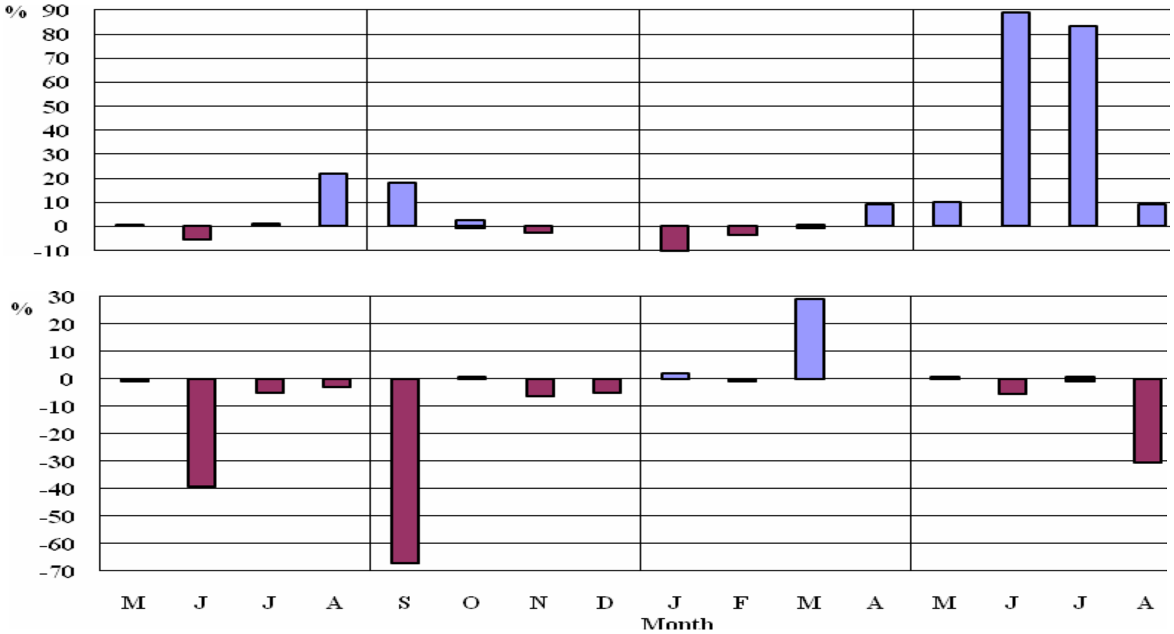

Fig. 3. *Proportion of spruce trees with significant effect of precipitation (upper graph) and temperature (lower graph) on increment on all plots*

Significance of correlations for oak

After assessment of correlation coefficients in all 190 trees we may state that precipitation in spring and summer of current year influence annual trees increments (Fig. 4) statistically significantly and positively. Proportion of those trees grows by about 10-45% in the months April – July. Another important period what concerns precipitation is August – October of previous year. Proportion of trees that are influenced significantly by precipitation is about 10-25%. Temperature influences radial increment mostly negatively. About 10-25% of trees react negatively to average temperature in July – September of previous year and in April of current year. Only about 20% of trees are influenced positively by temperature in March.

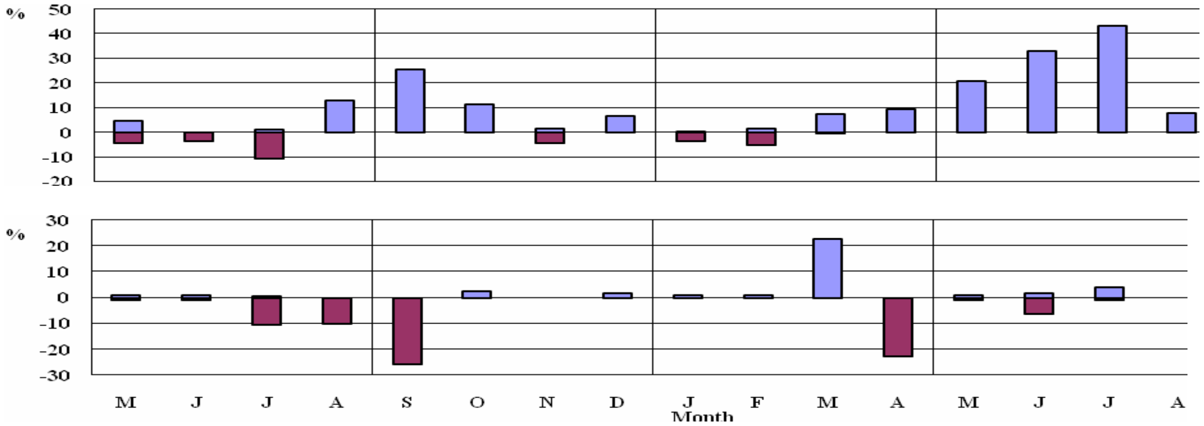

Fig. 4. *Proportion of oak trees with significant effect of precipitation (upper graph) and temperature (lower graph) on the increment on all plots*

Significance of correlations for beech

According to the number of trees with statistically significant correlation coefficient of all 120 trees (Fig. 5) with may state with 95% probability that:

- About 40-50% of trees react positively to precipitation in June and July,

- About 20-70% of trees react positively to July and August precipitation of previous year,
- Effect of monthly temperatures on diameter increment of beech trees is mostly negative,
- Only 10-15% of trees react negatively to higher temperatures in July – September of previous year.

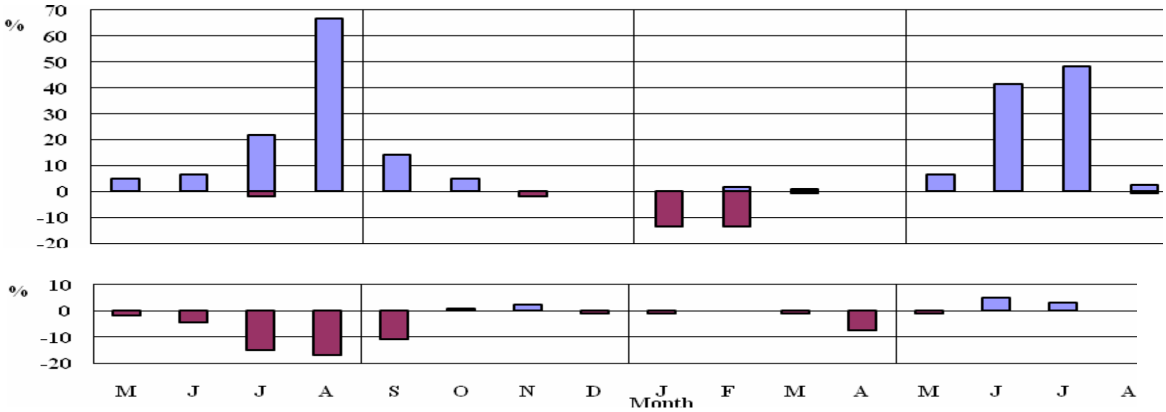

Fig. 5. *Proportion of beech trees with significant effect of precipitation (upper graph) and temperature (lower graph) on increment on all plots*

4. DISCUSSION AND CONCLUSIONS

After generalization of the obtained data we may state that statistically significant dependencies were confirmed between basic climatic factors and changes in increments. Their correlation coefficients range from about 0.2 to 0.5. Also the intensity of their effect on increment is not high. All tree species react positively mainly to precipitation during vegetation period. For increment changes mainly June and July precipitations, known in Central Europe as summer monsoons, are significant. Precipitations from the second half of vegetation period of previous year are significant as well. The effect of higher temperatures during vegetation period on increment is mostly negative. Only in spruce and oak higher March temperatures influence increments positively.

Our findings are not surprising as many authors assign in our climatic conditions greater significance to higher precipitations than to air temperature. Higher precipitations are very important mainly in lower and middle locations where a high consumption of soil moisture arises during vegetation period for evapotranspiration. Even very high supplies of water in the soil from winter or spring precipitation are insufficient to cover high water consumption during summer months. Though the reaction of studied tree species to climatic factors is diverse we may state that spruce react to them the best, and is followed by beech and oak. Main reason for spruce reaction may be its anatomic dispositions, mainly its shallow root system that is capable of absorbing also smaller amount of precipitation that reaches only soil surface. Similarly assimilatory apparatus that produces also in early spring or late autumn when broadleaved tree species only form their leaves or already fall. Beech and particularly oak have deeper root systems and only water from heavy atmospheric precipitation can reach them. Also a finding that mainly broadleaved tree species react positively also to precipitation in August and September of previous year is noteworthy. This reaction of broadleaved tree species is connected with higher production of reserve substances for more intensive formation of the assimilatory organs in following year.

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ECOLOGICAL ASPECT OF WOOD PRODUCTION AND CO_2 ABSORPTION IN AUSTRAN PINE PLANTATIONS IN SERBIA

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Abstract: The main aim of this study was to investigate characteristics and the ecological aspect of wood production and CO2 absorption in Austrian Pine plantations in Serbia. Material for analysis contains 34 sample plots on characteristic geological substrates (limestone, serpentine and granite). In the paper we also present main growth characteristics of Austrian Pine plantations.

Key words: Austrian pine, plantations, wood production, CO_2 absorption

INTRODUCTION

Generally it could be said that the role of artificially established stands is derived from their area, composition regarding flora and fauna, self-regulation capability and efficacy in fulfilling the basic forest functions, but also from the local and general, temporary and permanent needs of the society. Further, the effects of the economic forest function can oscillate considerably especially in countries with underdeveloped and unstable economy. On the other hand, the need for ecological and protective forest functions is becoming the necessary requirement of the modern world. It is often the case that love of nature and amateur approaches develop certain illusions about forests and in a way impose a disturbance to the realization of expert programs for wood production and utilization. For that reason, it is always up-to-date to point to the various aspects of the productive forest function which does not affect the economic function only and is, as it may seem without deeper introspection, opposed to the ecological, protective and other forest functions.

RESEARCH OBJECT AND METHOD

Research material was collected at ecologically distinctive and economically significant sites where the plantations of Austrian pine were established. Further, the plantations involved were established on different evolutionary genetic soil phases on:

A. limestone
B. granite rocks
C. serpentine

The research to a great extent relies on the investigations of development and production characteristics of Austrian pine of the specific sites (*Vučković M.*, 1979, 1989, 1982) as well as other numerous researches. The best-preserved parts of plantation stocking were chosen as the experimental areas.

Data on stand condition and the main elements of tree and stand growth and production characteristics were obtained through surveys in experimental areas (12 areas object A, 10 areas in object B and 12 areas in object C) and the analysis of 150 felled dominant trees.

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For quality determination stand indexes were construed on the basis of upper heights (mean height of the 20% of the highest trees in the stand). For that purpose *Chapman-Richards* function was used:

$$H = A \cdot (1 - e^{-a_1 \cdot t})^p$$

H = upper height, t= age, A, a_1, p = parameters of the function A, a_1, p = parameters of the function.

AUSTRIAN PINE PLANTATIONS IN SERBIA

Austrian pine is one of the significant forest tree species. High quality, wide range of utility values, the capability to adapt to nutritive conditions of unfavourable substrates, resistance to harmful chemical agents ($S0_2$ etc.) and the capability to grow and produce wood in fairly modest site conditions make this species appropriate for fulfilling of complex forest functions starting from the economic function to ecological, protective and aesthetic ones. The capability to grow in conditions of air pollution as well as favourable aesthetic qualities contributed to the choice of this species for afforestation in the vicinity of towns, spa and touristic facilities where its significant function is to improve the quality of the environment.

Plantations of coniferous trees in Serbia were established on the territory of 124.800 ha (*Banković et al. 2008*). Pine plantations (mainly Austrian pine) account for as much as 70% or 86.000 ha of that territory. Spread of pine dissemination was supported by afforestation so that nowadays artificially established stands cover the area twice as big as the area of Austrian pine and Scotch pine stands of natural origin. Average wood volume per 1 ha is 130 m^3.

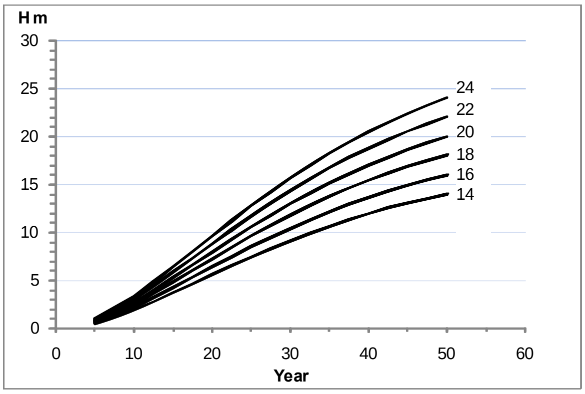
Due to the fact that as the consequence of specific historical development the inherited forest fund contained 50% of devastated and degraded forests, scrub and brushland, intensive establishment of artificially established stands was started in the previous century. Afforestation was the most intense in the middle of the last century which can be seen by the age-classes of the areas (table 1).

Table 1. *Age-class structure of the plantations*

Total area [ha]	Age- class area [%]							
	I	II	III	IV	V	VI	VII	VIII
86 000,00	3,3	18,1	40,9	22,8	9,8	2,3	1,9	0,9

Production characteristics of the plantations of Austrian pine

Production characteristics of the artificially established stands of Austrian pine mainly depend on the site quality and stand density. The variety of sites afforestated with Austrian pine is represented by site indexes (graph 1).



Graph 1. *S ite indexes*

Production parameters (volume and the current volume increment) of the fully stocked stands in the 50th year point to significant differences in the production potential of the sites in which the plantations of Austrian pine were established (table 2).

Table 2. *Volume and the current volume increment in the 50th year for different stand qualities*

Site index	SI 22	SI 20	SI 17	SI 14
Volume [$m^3 \cdot ha^{-1}$]	530	500	360	250
Current volume increment [$m^3 \cdot ha^{-1}$]	18,0	16,0	10,0	5,9

On the best quality sites (most often beech sites) Austrian pine has at least twice as big volume and even three times bigger current volume increment than in sites of the poorest quality. The above mentioned data point to the need to investigate the assumption that Austrian pine does not use the production potential of highly productive sites to the fullest degree. This should especially be done because even more productive tree species (such as fir, spruce or beech) rarely reach greater volumes at the age of 50 years. So, for example spruce volume exceeds pine volume only after the age of 40-50 years (Stojanović and Banković 1981, Solymos 1983).

Through analysis of growth characteristics and productivity of Austrian pine in artificially established stands at different quality sites Vučković (1989) found that from the aspect of maximum wood volume production in a certain period lower rotation limits should range from 65 years in the best quality sites to 80 years in sites of the poorest quality. Only in case of rotations with periods longer than these it would be reasonable to argue that Austrian pine, especially in good quality sites does not utilize site productivity, and besides that in certain circumstances even first signs of stem devitalisation and stand degradation may appear. Solymos (1983) found that from the aspect of maximum production for the Austrian pine stands in Hungary the most favourable are 40-50 year rotations.

ECOLOGICAL ASPECT OF DENDROMASS PRODUCTION AND CO_2 ABSORPTION

The awareness of the significance of forests is as old as the forestry of the contemporary era. Numerous written documents even in this region speak in favour of that. Hence, Todorović (1900) more than a century ago pointed to the fact that *" ...our forests are considerable capital and that is why when issues of economic improvement of the country are concerned they must be among the most important ones, particularly because the benefits from our forests are both great and various..."*.

Basic functions of forest ecosystems are derived from the process of assimilation in which organic matter (biomass) is formed from the environment, CO_2 is absorbed and the oxygen is released. Efficiency of assimilation can be measured by the biomass increment. The fact that plant biomass accounts for 97% of the total biomass on Earth of which 84% account for forest biomass (Vyskot, 1982) tells of the significance of forests for the survival of living organisms on the planet. The fact that 1 gram of dry wood contains almost 0.5 grams of carbon implies that forests are enormous carbon storages.

Wood is an important raw material, fuel, and construction material. About 3.5 billion m^3 of wood is felled in the world every year. About half of that wood is used as fuel, one fourth is used for paper and cardboard production, and one fourth for construction, furniture and packaging industries. The use of wood is significantly larger than the use of some other materials such as cement, iron,

Table 3. *Annual production of wood, cement, steel, plastics and aluminium in the world.*

	Billions of tonnes	Billions m^3
Wood	2,10	3,50
Cement	1.10	1,00
Steel	0,80	0,10
Plastics	0,09	0,08
Aluminium	0,02	0,007

Source: http://www.dainet.de/dain/foren/forstwirtschaft / literatur_ index.htm (1999) plastics and aluminium (table 3). That shows that wood as a renewable resource has been accepted worldwide as an irreplaceable substance which has no alternative from an ecological point of view. Substitution of wood with other materials and fuels would contribute to great violation of the environment. So, by burning 1 tonne of wood 15 times less carbon is emitted than by burning the same quantity of fuel-oil and the energy required for felling, transport and sawing of wood is 32 times smaller than the energy needed for extraction, transport and processing of oil in a refinery (Burschel,1994).

Also, the effects of other numerous forest functions, such as protection from soil erosion, accumulation and water refining, mitigation of extreme climatic conditions, easing of strong air streams etc. are directly proportional to the produced biomass, both on the surface and beneath the surface of the soil. For that reason the main aspiration of forestry, which is permanent and ever greater production of dendromass and sustainable utilization, is consonant with ecological and social priorities. It should be understood as a direct and necessary reaction to the growth in population and the needs of the population and the "greatest geophysical experiment ever" as it was named by the American geophysicists Revelle and Suess (Lenhard, 1990) in 1957- the use of fossil organic matter, consequences of which are globally reflected in the rise of CO_2 in the atmosphere, blurring of the atmosphere with industrial gases and mineral particles, change in ecosystems due to the imission of pollutants and imminent climatic changes. Hence, it can be concluded that wood production as well as wood utilization are ecological and economic priority of the contemporary civilisation (Vučković *et al.* 1997).

Ecological effect of plantations of Austrian pine in characteristic sites in Serbia can be observed through the dendromass increment and the absorbed CO_2. Table 4 shows the ratio of the current volume increment of large wood, current increment of the total dendromass which involves the root system, pruning-wood and the other components of dendromass and the absorbed CO_2.

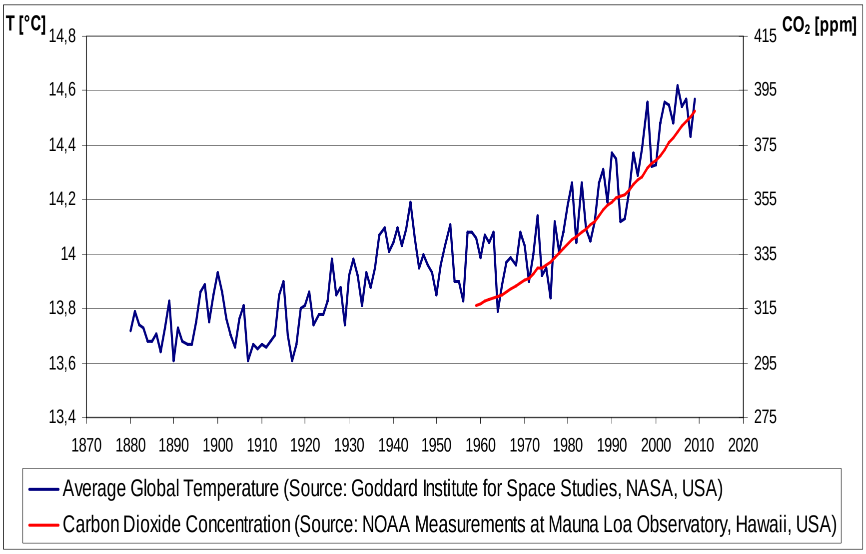
Table 4. *Current volume increment of large wood (m^3), current volume increment of the total dendromass in dry state (tonnes) and the absorbed CO_2 in different site qualities*

Site index	SI 22	SI 20	SI 17	SI 14
Current volume increment of large wood [$m^3 \cdot ha^{-1}$]	18,0	16,0	10	5,9
Current volume increment of total dendromass in dry state [$t \cdot ha^{-1}$]	10,5	9,4	5,8	3,4
Absorbed CO2 [$t \cdot ha^{-1}$]	19, 2	17,2	10,6	6,2

The data in the table show that the dendromass increment is not only the economic indicator but also a bioindicator of the fulfilment of multiple forest functions. Forests with small dendromass increment and present decomposition instead of being CO_2 absorbers become CO_2 emitters and in that way become the so called "green lies" which do not fulfil their basic functions many decades before symptoms of collapse become noticeable. That is why the production time-span of stands (rotation) should be adjusted to the movements in their production and ecological efficacy. The use of elements of tree and stand growth as arguments for determination of objective criteria can contribute to the avoidance of numerous unnecessary misunderstandings in the relationship economy-environment.

A significant part of the artificially established stands in Serbia, primarily in the best sites due to the unplanned afforestation density and lack of timely silvicultural measures develop characteristics of degraded and insufficiently stocked stands after only several decades which drastically decreases their production potential (Vučković 1989), and also the effects of their ecological and protective impact. Deviation of the effects of specific stands from the possible effects on a specific site in the first place because the inappropriate stand density causes ecological and economic losses proportional to the decrease in the current volume increment. If we observe the forest as an ecosystem its optimum functioning is ensured only when stands utilize the production potential of the site to the fullest degree. Hence, the „functioning“of an ecosystem can be tested through the degree of utilization of the production potential of a site (Kotar 1996).

The significance of artificially established stands of Austrian pine should be observed in the light of significant climatic changes and other factors which are limiting for forest growth. In the past 100 years the climate of the Earth has been characterized by the rise in air temperature and a decrease in precipitation quantity. In the past 120 years in the Northern hemisphere the air temperature above the land rose by 0.7 °C, and above the sea by about 0,3°C (Röhle 1995). The changes in the atmosphere which are reflected in the constant rise of CO_2 concentration and the rise of air temperature (graph 2), weakening of the ozone layer and the rise in the greenhouse effect point to the future changes of the conditions for the growth and survival of forest tree species. On the basis of level of increase in the concentration of CO_2 so far it can be assumed that the concentration of CO_2 will amount to 0.055% in the middle of this century. It is believed that for keeping the CO_2 concentration at this level it would be necessary to immediately reduce the antropogenously influenced emission by about 60-80%. The continuation of the present tendencies would cause great climatic changes with immense consequences for forest ecosystems. The assumed growth in CO_2 concentration in the period of next 100 years could contribute to the movement of isotherms for up to 500 km.



Graph 2. *Trend of growth in the concentration of CO_2 in the atmosphere and air temperature (T) in the second half of the 20th century. The correlation coefficient between these two (in the zone of mutual observation) is 0.89 which shows that in the 20th century the air temperature and CO_2 concentration in the atmosphere grew at the same pace. (http://www.scienceinschool.org)*

Spontaneous adaptation of forests to such abrupt climatic changes is difficult to achieve. It is believed that changes in natural conditions can take place far more quickly than the possible spontaneous migration of forest tree species (100 to 300 m annually) which would prevent natural succession in favour of more thermophilic species and imperil the survival of forests. The capability of different trees to adapt to certain aridity is not the same. Austrian pine is a species whose artificially established stands could contribute to the mitigation of the consequences of abrupt changes of the conditions for growth and survival of the existing forests due to its ability to grow in extremely unfavourable conditions.

Particularly important quality of artificially established stands of Austrian pine on quality sites is the ability to form mixed stands especially with atochthonous tree species such as Sessile oak, beech, fir etc. In this way the production can be raised to a certain higher level and the effects in the utilization of other (primarily ecological and protective) forest functions.

Vučković (1979) gave an example of the mixed Austrian pine and Sessile oak stand on a Sessile oak stand aged between 45 and 50 years which enables the utilization of Austrian pine to the fullest degree amounting to cca100 m^3 per ha. The production process is undisturbed and continues by the conversion of this stand into a pure Sessile oak stand.

DISCUSSION AND CONCLUSIONS

Globally, forest plantations are becoming ever more significant due to the growing need for wood and other forest functions. In spite of the widespread belief that there is a need for afforestation there are often contestations of the true potential of afforestation which are to a great extent based on the fact that utter effects of afforestation can be compromised due to the extensive approach to afforestation and subsequent treatment of the stands established in that way.

Nowadays we can say that decades ago in this country opinions on the following issues were adopted:

- the need for the increase in forest covered area and establishment of artificially established stands, objects with distinguished productive function but also ecological and protective forest functions.
- the need for the achievement of the optimal structure of forest stands and in order to utilize the potential of their site to the fullest degree.
- multiple functionality of forests and the principle of continuity (sustainable development)

If we were supposed to assess the realization of these a long while ago proclaimed and adopted opinions, among numerous positive impressions we would have to point out the following:

- still unresolved issue of planting density, and the neglected fact that there are various sites which are being afforested with a suitable specific aim of production, different infrastructure (communications, orography the need for thinning material etc.),
- since Zamminer (Zamminer 1828, in Wenk et al. 1990) until today the issue of optimal stand density as the basic issue regarding productivity has not been resolved.
- we still speak of different forest functions as separate and often opposed categories and insufficiently about the ecological aspect of wood production and utilization.
- there is still enormous disproportion between potential and true dendromass production
- we still transfer the knowledges based on global averages and often problematic assessments on specific objects

Therefore, we can conclude that there are significant problems in understanding and realization of opinions which were proclaimed and accepted a long while ago. The objective assessment of the ecological aspect of wood production and CO_2 absorption in Austrian pine plantations in Serbia can be carried out by observing the basic production parameters for precisely defined sites with appropriate rotation and stand density. Instead, production, ecological and other effects of the plantations of Austrian pine are most often spoken of in terms of averages, which is reasonable when the issues on the whole are concerned. However, such an approach does not allow enough opportunities for the analysis which can point to the solutions for forest functionality improvement. This happens because in that way certain productive and ecological characteristics which can hardly be applicable to a specific object are obtained. Such an approach led to underestimate of ecological and production potentials of the plantations of that species.

Taking into account the distinguished indications of climatic changes it is necessary to provide conditions for more extensive research of Austrian pine plantations, because the possible response of forestry to the changes in environmental conditions is proportional to the quantity and quality of information on ecological factors and the course of growth and productivity of forest stands.

In the past 20 years the economic crisis in Serbia contributed to the decrease in economic activity in all fields which considerably reduced both the demand for wood and its price. Rough and insufficiently grounded estimate that artificially established stands of Austrian pine in good sites inadequately utilize their production potential also fairly contributed to the development of a negative opinion regarding afforestation with Austrian pine.

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HUNTING ROLE: DOES TRADITION FIT THE SUSTAINABLE DEVELOPMENT?

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Abstract: *Trough the history of mankind, the role of hunters was to provide security for their community. The hunting enabled the development of civilization, transforming the humans from collectors to the hunters, from a pray to the predators. Therefore the Hunting was the corner stone for establishing the human society. Nevertheless, during the XX century, especially during the last quarter, the pressure of environmental non-governmental organizations (eNGOs) increased against hunting. At a present time the public concern about the Climate changes, the losses of biodiversity and habitat fragmentation raised the question if the hunting is needed any more. Except the pressure of variety eNGOs, the Hunting is in a collision with the traditional forestry. The traditional role of mono-functional forestry is productivity, which can be affected with tree damages caused by large ungulates. From its perspective, the presence of wild ungulates is negative for a forest utilization. The sustainable development, based on economical, ecological, social and cultural components is the right solution to solve this conflict. The balance between the traditional forestry, biodiversity conservation and wildlife management, is necessary for establishing multifunctional forestry. Therefore, the role of hunting in modern forestry is a complex issue which needs carefully to be evaluated.*

Key words: hunting, traditional role, sustainable development, modern forestry

ДА ЛИ ЈЕ ЛОВСТВО У СКЛАДУ СА ОДРЖИВИМ ГАЗДОВАЊЕМ?

Извод: *Кроз историју човенчанства улога ловаца је била да прехрани првобитну заједницу. Лов је омогућио развој људске цивилизације, мењајући људе од сакупљача до ловаца, од плена до предатора. Због тога се Лов може сматрати темељом настанка савременог друштва. Ипак, током XX века, посебно током последњих 25 година, многобројне еколошке не-владине организације (еНВО) су усмериле своје активности против Ловства. У данашње време јавно мњење, услед забринутости о Климатским променама, губитку биодиверзитета и фрагментацији станишта, све више поставља питање да ли је Ловство потребно савременом друштву. Осим притиска еНВО, Ловство је у традиционалном сукобу са шумарством. Традиционална улога шумарства је било усмерена ка производњи дрвне масе, коју дивљач умањује својом исхраном. Са таквог становишта присуство дивљих папкара негативно утиче на коришћење шума. Одрживо газдовање, засновано на еколошкој, економској, социјалној и културолошкој компоненти је право решење овог сукоба. Равнотежа између традиционалног шумарства, очувања биодиверзитета и газдовања дивљачи је неопходно за успостављање вишенаменског шумарства. Због тога, улога Ловства у савременом шумарству је комплексно питање које мора бити пажљиво анализирано.*

Кључне речи: ловство, традиционална улога, одрживо газдовање, савремено шумарство

Trough the history of mankind, the role of hunters was to provide security for their community. The hunting enabled the development of civilization, transforming the humans from collectors to the hunters, from a pray to the predators. Therefore the hunting was the corner stone for establishing the human society (Leopold, 1949). In such a society the first hierarchy was based on hunting skills of individuals. Until the beginning of the XX century, in most countries of the world, the hunting was considered as a normal human activity. Nevertheless during the XX century, especially during the last quarter, public concern about the environment was raised due to the Climate changes, the ozone holes, the losses of biodiversity and a habitat

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fragmentation. With the public concern for the environmental issues, the pressure of environmental non-governmental organizations (eNGOs) was increased against the Hunting (Causey, 1989). At present time the question is raised, if the hunting is needed any more. Except the pressure of variety eNGOs, the hunting is in collision with the traditional forestry. The traditional role of mono-functional forestry is productivity. According to the traditional view, the forest productivity can be affected with tree damages caused by large ungulates. From its perspective, the presence of wild ungulates is negative for forest utilization (Motta, 1996).

The first step in better understanding of the Hunting should be to define what does it present. Is it an industry, a sport or a state of mind? From the perspective of wildlife managers it is an industry branch which brings incomes and employments, either directly or indirectly. The hunting directly brings incomes to the hunting grounds trough the hunting permits, trophies, meat, accommodation, daily money for gamekeepers and other offers of the hunting ground (Lindsey et al. 2007). Indirectly it supports rifle, ammunition, outdoor gear and equipment industry. It also provides incomes for shooting grounds, taxes and toll costs for the State. Therefore the Hunting has the same role to the State as any other industry branch. Another argument for a necessity of the Hunting is a balance regulation in ecosystems, especially in those ones where predators have been extinct. In such circumstances the hunters are taking the role of the predators, trough trophy, selective, management or health hunt. However, non-hunters are arguing that the Nature would retrieve the balance without the hunters involvement. This discussion rise a lot of opposite opinions and arguments, where the hunters support the theory, which stress out that, if the Hunting is conducted on a sustainable way it can not disturb the Nature, since it is a part of the Nature (Swan, 1995).

The critics on the Hunting are mainly focus on the hunters behavior and their attitudes, identifying them as violent people who enjoy killing. However, the Hunting provided the survival of humanity, and as such it became the basic instinct of humans (Swan, 1995). During the hunt, a hunter has a specific relation with the Nature. He develops a intense personal relationship with his surrounding, while he takes again the role of his ancestors in search for a prey. According to Kellert's study from 1978, all hunters can be grouped in three categories – Meat hunters, Nature hunters and Sport hunters, where the first group has direct benefits of a hunt, while the second group has more knowledge about the environment and their primarily motivation is to be close to the Nature. Only the third group defines the Hunting as a sport activity. From this research it can be concluded that the Hunting for the hunters is something more than the sport activity, especially since majority of them is interested in a game meat.

Therefore it can be concluded that the Hunting is an industry which brings incomes and welfare to the society, while the minority also takes active part in it, trough the hunting. However in most of cases these hunters have benefits from its hunting (meat) or their stay in the Nature has non market value.

Mono-functional forestry is timber orientated, where all factors which are decreasing its production and timber quality are defined as treats. According to traditional view of mono-functional forestry, game is sufficient in forest ecosystems with intense management, since it brings restrictions and tree damages. The game can affect timber production on several ways, either with bark peeling, fraying antlers (wild ungulates such as red deer, fallow deer and roe deer), grazing seedlings or browsing (Motta, 1996). This timber damages are more common for herbivores – large ungulates and brown hares, despite carnivores can also make sometimes tree damages, when they are marking territory. Beside tree damages, the harmonization of forest utilization with the wildlife management brings restrictions which are also affecting productivity. However, the mono-functional forestry is nowadays overcome, since forest has more functions than the timber production. The balance between ecological, economical, sociological and cultural components of the forests is the core of the sustainable forest management.

The game is part of the forest ecosystems and as such it can not be excluded from the forest management. Nevertheless, the tree damages can be caused by the game. It can be reduced on a minimal level trough harmonization of forest and wildlife management practices. Despite it is traditionally assumed that the ungulate abundance is the most important factor which cause tree damages, the forest structure is also important factor. If the forest stand has several under layers, mixture of dominant tree species, enough meadows and pastures, the percentage of damaged tree will be much lower than in even aged mono-cultural stand. However the lack of predators in forest ecosystems can result with high density of large ungulates, and in such a case the Hunting is needed to reduce its abundance.

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CLIMATE CHANGE AND FOREST DISEASES

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Abstract: *The analyses of relationships between climate and forest fungal diseases and the potential effects of predicted climate change on forest pathogens, hosts and their interaction will be presented. The effects of climate change could have positive, negative or no impact on individual pathogens and the diseases they cause. Climate change could alter patterns of disturbance from pathogens through: direct effects of the development and survival of pathogens, physiological changes in tree defences, and indirect effects from changes in the abundance of insect vectors of tree pathogens, superparasites and antagonists. Multiple effects on the epidemiology of forest diseases are expected, including the survival of primary inoculum, the rate of disease progress during a growing season, disease transmission and the duration of epidemics. Because of their short life cycles, mobility, reproductive potential and physiological sensitivity to temperature and moisture, even modest climate change could have rapid impacts on the distribution and abundance of many forest pathogens (Armillaria spp., Heterobasidion spp., Sphaeropsis sapinea, Phytophthora spp., etc). Climate change could alter stages and rates of the development of the pathogen, its reproduction rates, modify host defences and susceptibility, and result in changes in the physiology of host-pathogen interactions.*

Key words: Climate change, forest pathogens, fungi, host-pathogen interaction, scenario

1. INTRODUCTION

During the past 100 years, average global temperature has risen by about 0.74°C and is projected to increase from 1.8 to 4°C until the next century (IPCC, 2007). Althought global climate change does occur naturally, the rate and magnitude of change humans are seeing today is beleived to be both faster and larger than has ever occurred before. A broad spectrum of scientist believe that this unprecedented change in the Earth's climate is due largely to human activities, such as burning of fossil fuels, deforestation and animal production which increases the concentration of greenhouse gases in the atmosphere, particularly carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). These gases, which may remain in the atmosphere from a decade to centuries, act to heat the planet because of absorption and re-radiation of infrared radiation (IR). Even if human-caused greenhouse gas concentrations were to be stabilized, warming due to greenhouse gases and aerosols would continue for centuries due to the time scales associated with climate processes and feedbacks (IPCC, 2007).

Aim of this paper was to present possible changes and interactions between forest pathogenic fungi and their hosts in a changing climate.

2. METHODOLOGY

The purpose of this work is to provide usable information on the potential effects of predicted climate change on forest pathogens, hosts and their interactions just as to identify diseases that threaten forest ecosystems undergoing rapid climate change. Information gathered is intended for predicting and understanding how climate change can influence forest diseases (distribution, severity, etc.) and how those changes can influence forests. Recent reviews on the

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subject have served as a useful input. All information gathered from literature are compared and combined with the results of authors to predict possible scenarios for host- pathogen interactions of studied pathogenic fungi.

3. RESULTS AND DISCUSSION

Because plant disease involves the interaction of a susceptible host, a favorable environment, and a virulent pathogen, climate change may influence forest diseases and the damage they cause by:

1. **Directly** – impacting stages and rates of the development of the pathogen, its reproduction, survival and spread, altering host's distribution and physiological changes in tree defenses or
2. **Indirectly –** impacting ecological relationships between pathogens, their environment and other species, such as insect vectors of tree pathogens, superparasites and antagonists that regulate the abundance of pathogens

Direct effects on pathogens are likely to be strongest, although different pathogen life stages may be affected by climatic variables with opposite effects on parasite fitness. For example, the latent period i.e. the time between inoculation and sporulation is being extended under high CO_2 levels. In spite of a delay in the initial establishment of a pathogen increased CO_2 concentrations may accelerate pathogen development and increase its fecundity (Coakley et al., 1999). Accelerated pathogen development and a longer growing season may result in an increased number of disease cycles and thus inoculum for polycyclic pathogens, such as *Phytophthora* spp. Moreover, greater biomass and slower decomposition of forest litter due to increases in CO_2 along with increased pathogen survival due to milder winters may result in higher levels of initial inoculum in the spring (Coakley et al., 1999). Higher winter temperatures may also allow greater host tissue colonization for perennial stem canker fungi whose growth is temperature-limited (e.g. *Cryptodiaporthe populea* (Sacc.) Butin) (Keča, 2007). Changes in climate may result in host resistance to pathogens being overcome more rapidly, owing to accelerated evolution of pathogen populations due to increased fecundity (Coakley et al., 1999). Resistance mechanisms of host trees may be altered by changes in the host physiology and anatomy due to increased CO_2 concentrations. Those alterations will likely enhance plant resistance and may appear as lowered nutrient concentration, greater accumulation of carbohydrates in leaves, more waxes, extra layers of epidermal cells and increased fiber content (Chakraborty et al., 1998).

Changes in CO_2 levels, temperature, moisture and other climatic factors may affect host susceptibility and pathogen aggressiveness. Warmer and drier summers would make trees more vulnerable to attack by weak pathogens, whose activity is dependent on host stress, particularly root pathogens and secondary canker-causing fungi (Broadmeadow 2002; Lonsdale and Gibbs, 2002), such as *Armillaria* spp. (Keča et al., 2009; Keča & Solheim, 2010), *Heterobasidion annosum* (Fr.) Bref. (Keča, 2008), *Botryosphaeria dothidea* (Moug.:Fr.) Ces. & ***De*** Not. (Karadžić et al., 2000), *Sphaeropsis sapinea* (***Fr.***) ***Dyko & Sutton, etc (Table 1). However, the incidence of frost damage may be expected to decrease along with the canker fungi that invade damaged tissues after injury from frost (Londsale and Gibbs, 1996).***

In addition, dry conditions may be unfavorable for many root and most foliar pathogens. Moisture, from the sources including rainfall, dew deposition and irrigation, is the main environmental control on population size of *Phytophthora* spp. Therefore, climate change effects like hotter summers and wetter springs may result in increased mortality from *Phytophthora ramorum* ***Werres*** et al. 2001, for example. *P. ramorum* was recently imported into Europe and represents a serious threat to many different native hosts. Climate change may lead to increases in inoculum production by the pathogen (Frankel, 2007; Rizzo et al., 2005). An increase in CO_2 may increase tree canopy size and density, resulting in a higher microclimate relative humidity, and a subsequent increase in foliar and rust diseases that require moist surfaces to infect their hosts (Manning and Tiedmann, 1995).

Reduced precipitation in terms of snowfall and shorter periods of snow cover may lower the risk of damage by pathogens such are *Phacidium infestans* Karst. and *Herpotrichia juniperi* (Duby) Petrak. Those fungi attack the needles and shoots of various conifers while they are covered by snow because they require persistently high atmospheric humidity that occurs beneath snow cover, as well as insulation from extreme cold. The longer the snow cover, the longer the fungi are able for development and infection.

Global climate change could also make trees more vulnerable to damage from pathogens that have existed at law levels and been considered insignificant, because of unfavorable climate. Since climate change is likely to alter disease severity, new forest diseases may arise in certain regions while some other diseases may cease to be economically important. For example, *Dothistroma pini* Hulbary is a native pathogen in British Columbia which was causing relatively minor damage in the past. But due to increased frequency of warm and moist conditions which favor infections of this foliar pathogen, it suddenly began causing widespread damage in northeastern part of the state (Woods et al., 2005). *Phaeocryptopus gaumanii* (T. ***Rohde***) Petr. is an endemic, foliar pathogen of Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) in western Oregon where it has long been considered an insignificant treat to forest health. A recently increasing in disease severity has been correlated with higher winter temperatures and increases in leaf wetness duration in spring (Manter et al., 2005).

Table 1. Effects of climate changes to several forest pathogenic fungi.

Pathogen	Temperature increases	Precipitation			Less frost injuries	Potential outcomes
		Increases		Decreases		
		In spring	In summer	In terms of snowfall		
Armillaria spp.	+	n/a	+	n/a	n/a	++
Heterobasidion annosum s.l. (Fr.) Bref.	+	n/a	+	n/a	/	++
Phytophthora spp.	+	+	+	n/a	/	++
Botryosphaeria dothidea (Moug.:Fr.) Ces. & De Not	+	+	+	/	–	++
Sphaeropsis sapinea Dyko & Sutton	+	+	+	/	–	++
Phacidium infestans P.Karst.	n/a	n/a	n/a	–	/	--
Herpotrichia juniperi (Duby) Petr.	n/a	n/a	n/a	–	/	--
Mycosphaerella pini E. Rostrup apud Munk	+	+	–	/	/	++
Phaeocryptopus gaeumannii (T. Rohde) Petr.	+	+	–	/	/	++

Legend: Positive effects (+), negative effects (-), no effects (/) on individual pathogen. Potential outcomes of climate change: increase in disease intensity (++), reduced disease intensity (--)

Because climate limits the ranges of many pathogens climate change likely will result in expanding of geographical distribution into higher latitudes and altitudes of those pathogens requiring warm temperatures. At the same time, pathogens may disappear from areas that have become climatically unsuitable. The southern boundary of the present geographical distribution of the pathogen may become too warm, which might result in a northward shift or even range contraction. For example, the thermophilic European rust pathogen *Melampsora allii-populina* Kleb. which appears only sporadically in northern Europe is likely to spread northwards with increased summer temperatures. That may have serious implications for the large areas in northern countries where susceptible poplar clones are grown (Chacraborty, 2002). The strong correlation between the presence of a leaf parasite *Melampsora* and *Marssonina* species and the climate was also observed in forest plantations along rivers in Serbia (Keča, 2003). With climate change scenarios of increased average temperatures the root rot pathogen *Phytophthora cinnamomi* Rands for which winter survival is a limiting factor linked to low temperatures is predicted to spread northward and increase in severity in continental Europe (Brasier, 1996). *P. cinnamomi* was recently discovered in oak forests in Serbia too (N. Keča, unpublished).

The distribution and occurrence of any forest pathogen is closely associated with the host tree species. Thus, if host species migrate to new areas in response to climate change pathogens would likely fallow the migrating hosts in their geographical distribution. Shifts in climatic suitability in previously unsuitable regions of the world provide opportunities for forest pathogens to establish in new locations. But the rate at which pathogens become established in the new environment is a function of the mechanism of pathogen dispersal, suitability of the environment for dispersal, survival between seasons and physiological and ecological changes in the host plant (Coakley et al., 1999). There are some predictions that *Cronartium ribicola* J.C.Fisch. might change the distribution of *Pinus strobus* L., because species won't be able to colonize some area where it was present in the past (Kim et al. 2003).

An increase in global trade adds another level of complexity to the host-pathogen interactions (Figure 1). The accidental transfer of plant pathogens to new regions of the world together with pathogens expanding into new territories may create new host-pathogen systems. Once one pathogen has been introduced/has expanded its range to forest that has not been previously exposed to a given disease, it will likely have the capacity to jump to new hosts that might have no co-evolved resistance mechanisms against it, potentially causing serious damage. (i.e. *Phytophthora ramorum*). Furthermore, natural enemies of the pathogen may be absent which may also alter ecological balance between the forest host and the pathogen. Introduced pathogens undergoing sustained population growth while encountering novel hosts should exhibit greater potential for rapid evolutionary response to changing abiotic conditions than native pathogens (Brasier et al., 1995).

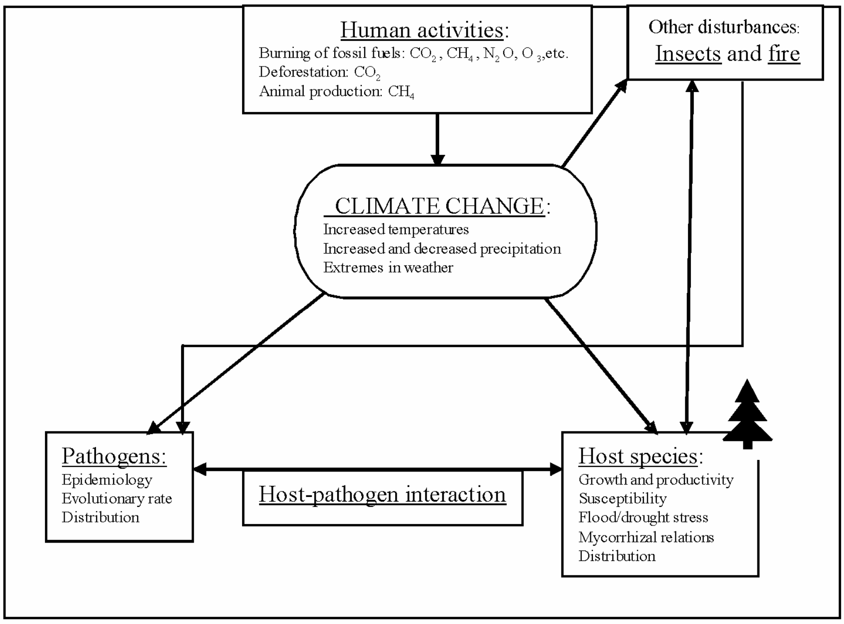

Figure 1. *Possible interactions between biotic (hosts, pathogens, human activities) and abiotic (climate changes and fires) factors.*

An introduction/expansion of pathogens into new areas may result in genetic hybridization and hence the production of new, potentially destructive pathogen species. For example, invasive alder Phytophthora is considered likely to be a hybrid between Phytophthora cambivora (Petri) Buisman, forest pathogen that causes Ink disease in European Chestnut trees (Castanea sativa Miller) and a fungus close to Phytophthora fragariae Hickman, a pathogen of strawberry (Brasier et al., 1999). This spreading Phytophthora can be very damaging and poses a serious threat to alder and the stability of riparian ecosystems. Many different Phytophthora hybrids have recently been discovered in Europe and scientists still have no idea how they might influence biodiversity in natural forests.

As the geographic distribution of many forest pathogens is more limited than their host distribution, new territories may also provide a large expanse of pathogen's natural host species. Host-pathogen systems involving native/introduced forest host and invasive pathogen are the most likely to create opportunities for new epidemics to occur, resulting in reductions in forest growth and tree mortality, especially when it comes to introduced host species. Interactions between two major environmental issues-climate change and invasive pathogens could have strong influence on the state of health of the world's forests and other natural ecosystems.

Not only warmer temperatures at northern latitudes and higher elevations may favor pathogens, but may also favor insect vectors, extending their geographic ranges and hence the ranges of disease incidence, which may result in increased damage to hosts and to forest ecosystems (Figure 1). Indirect consequences from climate change impacts on forest pathogens also include elimination of nesting trees for birds and negative effects of mycorrhizal fungi (Gehring et al., 1997; Ayres and Lombardero, 2000). Through its influences on forest diseases climate change may influence overall biodiversity.

4. CONCLUSIONS

- The effects of climate change could have positive, negative or no impact on individual forest pathogens and the diseases they cause;
- Climate change could favour some highly damaging pathogens and have considerable and widespread impact on forest health and the losses forest diseases cause;
- In a changing environment the rate at which pathogens evolve and overcome host resistance may increase. Resistance mechanisms of host trees may be altered by changes in the host physiology and anatomy due to increased CO2 concentrations;
- Warmer summers and drought stress may facilitate the impacts of many root and canker pathogens, and in a case of perennial stem cankers fungi also milder winters. But canker pathogens may be unfavored by reduced incidence of winter frost damage;
- The incidence of damage from pathogens benefiting from insulation by snow is likely to decrees because of the expected changes in the amount and persistence of snowfall;
- With warming, some forest diseases may be able to occur further north or at higher elevations than under current conditions (e.g. Dothistroma pini, Sphaeropsis sapinea, etc.);
- If migrations of tree species in new environments happens, then new diseases should be expected;
- Climate change may facilitate invasions by nonnative pathogens which may lead to new epidemics.

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FOREST FIRES AND CLIMATE CHANGES

Predrag ALEKSIĆ, Gordana JANČIĆ[1]

Abstract: *Forest fires are a global problem and require the engagement of all the institutions and subjects of the society in the prevention and suppression of forest fires and in the reclamation of burnt areas, both at the local and at the international levels.*

Forest fires are a great ecological and economic problem, because they destroy large areas of forests. Worldwide, more than 50,000 forest fires are registered on average annually and they destroy about 400,000 hectares of forests.

In the forest area managed by the State Enterprise for Forest Management "Srbijašume", over the period 1999 – 2008 there were 853 forest fires with the burned area amounting to 16,537.13 hectares.

Human activities, first of all the combustion of fossil fuels, have affected and still affect the climate changes.

Climate changes are classified as the greatest global ecological problem of the modern civilisation which, unless the appropriate and urgent measures are undertaken, can result in the further increase of air temperature between 1.40C and 5.8 0C till the end of the 21st century, compared to 1990.

Forest ecosystems are exposed to unfavourable influences of climate changes, they are a significant reservoir of carbon and a significant potential for the mitigation of the global warming, because of which they require a special method of management which includes the protection, the improvement of the existing state and the establishment of new forests.

Forest protection against forest fires, especially in the extreme climate conditions, is one of the most important goals not only of SE "Srbijašume", but also of the entire society, taking into account the forest significance and the functions.

Key words: forest fires, climate changes, forest protection

1. INTRODUCTION

Forest fires are the most extreme aspect of forest devastation or complete destruction. Forest fires depend on climate conditions, fuel moisture and quantity and human activities. Over the past decades, the dominant trend in Serbia has been the rise of air temperature and the decrease in precipitation. Climate changes increase the hazard of forest fire occurrence and spreading.

2. METHOD

This study is based on the following sources: database on forest fires in SE "Srbijašume", data on air temperature and precipitation at the main weather stations in central Serbia, and professional literature. The presented data include the number of forest fires in state forests managed by SE "Srbijašume" over the time period 1999-2008 and the analysis of the effect of climate on forest fire occurrence and behaviour.

3. FOREST FIRE INCIDENCE AND BEHAVIOUR

The investigation of the causes of forest fire incidence and behaviour is extremely important for the organisation of the preventive activities, timely and effective forest fire suppression actions.

Forest fire appears as the result of physical-chemical processes when the fuel, heat and air occur in the critical combination to sustain the process of combustion, the so-called "fire triangle"

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(Vasić, “Forest fires“, 1992). Factors which have a decisive effect on the behaviour and development of forest fires are: fuel, climate and topography (relief, aspect, altitude and slope gradient). The fuel type and state affect the behaviour forest fires. Fuel type defines the forest fire intensity and behaviour. Fuel condition, moisture content in the fuel, has a decisive significance in the forest fire appearance and spreading.

Precipitation, relative air humidity, air temperature and wind define the behaviour of forest fires. Longer rain periods contribute to the increase in fuel moisture content. Relative air humidity, prolonged periods of high or low humidity, affect all fuel types. Air temperature with relative humidity, causes the fuel desiccation. Wind also affects the behaviour of forest fires (stimulates and increases the burning process and causes the spreading of forest fire over the area).

Slope gradient influences the creation of local climate, the soil and plant cover, the direction and velocity of forest fire spreading. The terrains exposed to the sun are naturally the most endangered by forest fire (fires occur more frequently, spread more quickly, and have a greater destructive power). In the lower regions of submontane belts, altitude does not have a crucial effect on the changes in ecological conditions, but in the higher and high upland areas, altitude is a decisive factor which determines the change in macro and microclimate, soil properties and the composition of vegetation.

The most frequent agent of forest fires is the human factor and fires mainly start on private holdings and forests.

3.1. Climate characteristics in Serbia and the expected effects on forest fires

Climate is the basic natural resource and it has a decisive effect on ecosystems. Global warming prevails on the entire planet, but it is more expressed above the land areas. The increasing trend in air temperature is also dominant in Serbia (1951-2007). The most intensive positive trend of air temperature was recorded in the North part of the country, in the areas of Loznica, Belgrade and Negotinska Krajina. The positive trend was also recorded in summer air temperature. At Smederevska Palanka weather station air temperature measured on July 24th 2007 was 44.90C, which was the new absolute record of maximal air temperature in Serbia (Popović, et al. “Climate changes in Serbia and the expected effects“, 2009). The average value of air temperature at weather stations in central Serbia over the period 1999-2008 was 10.8 degrees. The years with precipitation deficit have been dominant since the eighties of the past century (drought intensity increased). After 1984, the prevailing summers were characterised by a deficit of precipitation of different intensities. Especially intensive summer droughts occurred in 2000 and 2003. The period of air temperature increase was followed by a period of decrease in annual precipitation. Average annual value of precipitation at weather stations in central Serbia, in the period 1999-2008 was 736.2 mm/m2.

The forecasts of future climate point out that in Serbia we can expect a significantly warmer climate, especially over summer months and the decrease in the quantity of precipitation, especially during summer. Temperature extremes will be more and more frequent. It is expected that the frequency, intensity and duration of heat waves will increase, while the number of frost and icy days will decrease. This type of climate is especially expected in the Southeastern and Eastern Serbia. Climate changes increase the hazard of forest fire occurrence and spreading. Still, it should be taken into account that global warming is negated by a certain minor part of scientists.

4. FOREST FIRES AND CLIMATE CHANGES

Forest fires can occur throughout the year, but there are three critical periods: March – April, July – August and September - October. In the area of state forests managed by SE “Srbijašume“, over the period 1999-2008, forest fires were registered in all months (Table 1). The greatest number of forest fires was registered in July and March. In the first critical period –

31.07%, in the second– 48.88% and in the third – 2.70%. A great number of fires was also registered in November (4.34%), so the third critical period of forest fire occurrence, in the last years also includes the period September-November. The greatest number of fires in July (35.05 %) is the consequence of air temperature which has the highest average values in this month (21.30C), regardless of the fact that the average precipitation in July is relatively high 73.8 mm/m2 (the average precipitation is higher only in June – 77.2 mm/m2). The high number of forest fires in August (13.83%) is caused by similar climate conditions as in July. A high number of forest fires in March (17.82%) is the consequence of the low average quantity of precipitation (46.74 mm/m2) and the burning of fuel on agricultural lands (when fire often spreads to private and state-owned forests).

Table 1: *Number of forest fires over the period 1999 - 2008 in SE “Srbijašume“*

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I-XII
Number of fires	2	18	152	113	39	49	299	118	11	12	37	2	853
%	0.23	2.11	17.82	13.25	4.57	5.74	35.05	13.83	1.29	1.41	4.34	0.35	100.00
Period			I				II		III				
%			31.07				48.88		2.70				
Tempera-ture	-0.3	1.3	6.2	10.8	16.1	19.4	21.3	20.9	15.4	11.3	5.7	0.9	10.8
Precipitation	47.5	44.1	46.7	64.0	66.3	77.2	73.9	64.3	75.1	58.0	60.1	59.1	736.2

Of the total burnt area of 16.357,12 ha over the period 1999-2008 (Table 2.), the largest burnt areas were recorded in 2000 (3,569.86 ha – 21.8%), 2002 (1,290.85 ha, of which 1,066.11 ha in FE Boljevac because of extremely low values of precipitation, in February only 1.8 mm/m2, weather station – Negotin) and in 2007 (9,710.20 ha, 59.4%). In 2000 and 2007, forest fires devastated 13,280.06 ha or 81.2% of the forests in the study period. In 2000 and 2007 forest fires destroyed some areas in all forest estates (there were conditions for the ignition of forest fires over the entire area of central Serbia). Average annual temperature in 2000 and 2007 was 11.60C, which is a considerably higher value than the average temperature (10.80C) over the period 1999-2008 (2000 and 2007 were the warmest years in the study period). Average precipitation in central Serbia in 2000 was 471.6 mm/m2, which was much less than the average (736.2 mm/m2). The average precipitation in 2007 was 760.3 mm/m2, which was higher than the average in the study region over the period 1999-2008. In July 2007, rainfall was only 16.4 mm/m2, which was 2.2% of the total precipitation during 2007. In July 2007 forest fires destroyed the area of 7,658.68 ha or 78.9% of the total burnt area in that year.

The analysis of forest fire occurrence per forest areas over the period 1999-2008 shows that the largest areas destroyed by fire were in Eastern and Southeastern Serbia (Timočko forest area - Boljevac – 26.4%; Moravsko forest area - Niš 12.3%; Južnomoravsko forest area - Vranje -11.3%; Nišavsko forest area – Pirot -10.6% and Severno Kučajsko – Kučevo – 8.8%). Total burnt area in the above forest areas was 11,365.76 ha or 69.5% (Table 2). All the above forest areas have a significantly greater average ten-year air temperature than the average for central Serbia (Table 3). Exception is the average ten-year temperature in Dimitrovgrad, which, by its climate characteristics, does not represent fully the Nišavsko forest area (Pirot). Average annual precipitation over the period 1999-2008 was significantly lower in the above forest areas than the ten-year average for central Serbia (736.2 mm/m2). This statement is especially valid for the areas of Vranje (581.5 mm/m2) and Zaječar (591.7 mm/m2).

Table 2: *Burnt area over the period 1999-2008 per Forest Estatesin hectares*

Forest Estate	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**Total**	**%**
Beograd	85.00	7.30	0.00	0.00	0.00	0.00	0.00	0.00	3.25	0.36	95.91	**0.6**
Boljevac	0.00	304.00	102.55	1.066.11	0.00	0.00	0.00	633.03	2.093.58	122.70	4.321.97	**26.4**
Vranje	0.00	480.36	11.00	15.33	8.50	0.00	1.00	5.00	1.317.65	4.50	1.843.34	**11.3**
Despotovac	0.00	374.88	1.00	0.000	0.00	0.00	0.00	6.92	491.21	69.78	970.79	**5.9**
Ivanjica	0.00	206.41	2.60	0.00	79.48	0.00	0.00	0.60	64.79	4.50	358.38	**2.2**
Kragujevac	0.00	56.12	2.00	0.00	13.37	0.00	0.00	8.50	23.31	0.00	103.30	**0.6**
Kraljevo	2.80	347.70	5.30	0.60	31.34	0.00	2.50	0.00	67.01	2.53	459.78	**2.8**
Kruševac	7.50	160.60	15.30	3.25	45.75	8.25	3.90	2.00	128.87	0.00	375.42	**2.2**
Kučevo	0.00	576.06	16.34	51.49	61.85	0.00	0.00	43.00	672.18	26.53	1.447.45	**8.8**
Kuršumlija	0.00	61.60	0.00	0.00	32.00	0.00	0.00	1.05	891.62	5.00	991.27	**6.1**
Leskovac	3.30	177.42	47.00	27.80	2.50	0.00	0.00	6.50	54.46	0.10	319.08	**2.0**
Loznica	0.00	96.60	0.00	0.05	0.00	5.00	0.69	0.00	7.37	0.00	109.71	**0.7**
Niš	0.00	146.23	0.00	0.00	0.00	0.00	0.00	1.70	1.866.67	1.95	2.016.55	**12.3**
Pirot	0.00	195.60	148.00	0.00	0.00	0.00	1.00	0.00	1.389.85	2.00	1.736.45	**10.6**
Prijepolje	10.40	214.23	4.90	0.00	17.80	0.00	0.50	1.50	602.72	0.00	852.05	**5.2**
Raška	0.00	154.73	0.00	105.92	0.00	0.00	1.00	8.00	18.31	0.00	287.96	**1.8**
Užice	0.00	10.02	0.00	20.30	18.55	0.00	0.50	1.00	17.35	0.00	67.72	**0.4**
“Srbijašume“	**109.00**	**3.569.86**	**355.99**	**1.290.85**	**311.14**	**13.25**	**11.09**	**718.80**	**9.710.20**	**266.95**	**16.357.13**	**100.0**
%	**0.7**	**21.8**	**2.2**	**7.9**	**1.9**	**0.1**	**0.1**	**4.4**	**59.4**	**1.6**	**100.00**	
Number of forest fires	**9**	**233**	**33**	**85**	**57**	**6**	**8**	**33**	**358**	**31**	**853**	
Average burnt area per fire	**12.11**	**15.32**	**10.79**	**15.19**	**5.46**	**2.21**	**1.39**	**21.78**	**27.12**	**8.61**	**19.18**	

Average burnt area per forest fire over the period 1999-2008 was 19.18 ha. In extremely droughty years, average burnt area was: 15.32 ha – 2000 and 27.12 ha - 2007. In 2006, average burnt area (21.78 ha) was the consequence of a large-scale forest fire in FE Boljevac.

Table 3: *Burnt area (ha) over the period 1999-2008 per Forest Estates and climate elements at weather stations*

ŠG	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total	%
I	Burnt area in Timočko forest area – Forest Estate Boljevac											
Boljevac	0.00	304.00	102.55	1.066.11	0.00	0.00	0.00	633.03	2.093.58	122.70	4.321.97	26.4
Climate elements at weather stations in Zaječar												
air temperature	11.7	12.4	11.6	11.8	11.0	11.0	10.4	11.1	12.3	11.0	11.1	average
precipitation	629.5	302.9	538.8	627.3	610.7	650.8	783.0	565.2	628.3	580.7	591.7	average
Climate elements at weather stations in Negotin												
air temperature	12.4	13.1	12.3	12.9	12.1	12.2	11.5	12.2	13.6	12.9	12.5	average
precipitation	658.9	350.6	502.8	751.8	665.8	641.2	867.3	657.4	610.4	637.0	634.3	average
II	Burnt area in Moravsko forest area – Forest Estate Niš											
Niš	0.00	146.23	0.00	0.00	0.00	0.00	0.00	1.70	1.866.67	1.95	2.016.55	12.3
Climate elements at weather stations in Niš												
air temperature	12.1	13.1	12.4	12.6	12.4	12.0	11.2	11.9	13.5	13.2	12.4	average
precipitation	617.8	385.6	662.3	662.4	547.4	756.3	731.0	620.4	600.2	619.2	620.3	average
III	Burnt area in Južnomoravsko forest area – Forest Estate Vranje											
Vranje	0.00	480.36	11.00	15.33	8.50	0.00	1.00	5.00	1.317.65	4.50	1.843.34	11.3
Climate elements at weather stations in Vranje												
air temperature	11.5	12.3	11.6	11.6	11.5	11.0	10.7	10.8	12.4	12.3	11.6	average
precipitation	544.8	314.8	551.2	710.2	540.1	757.3	616.4	591.2	596.1	593.3	581.5	average
IV	Burnt area in Nišavsko forest area – Forest Estate Pirot											
Pirot	0.00	195.60	148.00	0.00	0.00	0.00	1.00	0.00	1.389.85	2.00	1.736.45	10.6
Climate elements at weather stations in Dimitrovgrad												
air temperature	10.3	11.0	10.3	10.5	10.3	10.1	9.5	9.8	11.1	11.0	10.4	average
precipitation	727.6	311.5	714.8	742.9	665.3	689.0	868.9	673.9	740.6	546.2	668.1	average
V	Burnt area in Severno-Kučajsko forest area – Forest Estate Kučevo											
Kučevo	0.00	576.06	16.34	51.49	61.85	0.00	0.00	43.00	672.18	26.53	1.447.45	8.8
Climate elements at weather stations in Veliko Gradište												
air temperature	11.4	12.7	11.8	12.4	11.8	11.4	10.7	11.4	12.6	12.5	11.9	average
precipitation	795.6	390.9	881.2	613.3	558.7	691.8	822.9	687.7	699.0	545.9	668.7	average

* average values of air temperature (^{0}C) and precipitation (mm/m^2)

5. CONCLUSION

Forest fires are the most extreme aspect of forest devastation or complete destruction. Forest fires depend on climate conditions, fuel moisture and quantity and human activities. Over the period 1999-2008 forest fires (853) destroyed 16,357.13 ha

In Serbia, a period of air temperature increase followed by a period of annual precipitation decrease started in 1984. Average annual value of precipitation at weather stations in central Serbia, over the period 1999-2008, was 736.2mm/m2, and average air temperature was 10.80C. Of the total burnt area of 16,357.12 ha, the largest areas were in 2000 (3,569.86 ha - 21.8%) and in 2007 (9,710.20 ha - 59.4%), i.e. forest fires destroyed 13,280.06 ha or 81.2%, which was the consequence of high air temperatures and low precipitation. The largest areas destroyed by forest fires were in the forest areas of Eastern and South-eastern Serbia (69.5%),because of considerably higher average air temperatures and lower average precipitation than the average in Central Serbia. Forest protection against fires is one of the most important goals in SE "Srbijašume".

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FOREST FIRES AND CLIMATE CHANGES

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Summary

Forest fires are a great ecological and economic problem and they are the most extreme aspect of devastation and complete forest destruction. The incidence of forest fires depends on weather conditions, moisture content and quantity of plant fuel and human activities. Over the period 1999-2008 forest fires (853) burned over 16,357.13ha. The most endangered areas were Eastern and Southeastern Serbia.

In Serbia, a period of air temperature increase followed by a period of annual precipitation decrease started in 1984. Average annual value of precipitation at weather stations in central Serbia, over the period 1999-2008, was 736.2 mm/m2, and average air temperature was 10.80C. Of the total burnt area of 16,357.12 ha, the largest areas were in 2000 (3,569.86 ha - 21.8%) and in 2007 (9,710.20 ha - 59.4%), i.e. forest fires destroyed 13,280.06 ha or 81.2%, which was the consequence of high air temperatures and low precipitation. The largest areas destroyed by forest fires were in the forest areas of Eastern and South-eastern Serbia (69.5%), because of considerably higher average air temperatures (area of Negotin 12.50C and Niš 12.40C) and lower average precipitation (area of Vranje 581.5 mm/m2 and Zaječar 591.7 mm/m2).

Forest protection against forest fires ids one of the most important goals of SE "Srbijašume" and the society in general.

COMPARATIVE ANALYSIS OF FOREST VITALITY IN THE REPUBLIC OF SERBIA IN THE PERIOD 2004-2009

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Abstract: *An insight into the health state of forests for making conclusions about the necessary improvement measures, it is possible to determine through monitoring of condition of forests. Subject of ICP Forests is monitoring of anthropogenic (primarily air pollution) and biotic factors harmful to the state and development of European forest ecosystems. Determining the status of forest ecosystems requires detailed ecological, socio-economic research to explain consequences of forest deterioration and analysis of the impact of global climate change on forest communities. The paper gives a comparative overview of monitoring forest condition on sample plots the Republic of Serbia. International Cooperating Program for the monitoring of forests is carried out continuously since 2003, and was done at Level I of this program. In the period 2004 - 2009 the observation were performed on 130 sample plots and collected the data necessary for further analysis. Plots are systematically located in network of 16x16 km, and the 4x 4 km. On experimental fields was done evaluation of degree for defoliation, discolouration and recorded damages by class. Comparative analysis of the data in this period will be provided access to the previous situation of forests in Serbia as well as some trends defoliation and discolouration of broadleaf and coniferous species.*

Key words: biomonitoring, ICP Forests, climate change, Serbia

УПОРЕДНА АНАЛИЗА ПРАЋЕЊА ВИТАЛНОСТИ ШУМА У РЕПУБЛИЦИ СРБИЈИ У ПЕРИОДУ 2004-2009. ГОДИНЕ

Извод: *Увид у стање шума ради доношења закључака о потребним мерама унапређења, могуће је установити кроз праћење кондиционог стања шума. Предмет рада ICP-а за шуме су праћње антропогеног (превасходно ваздушно загађење) утицаја и биотичких штетних фактора на стање и развој шумских екосистема Европе. Утврђивање стања шумских екосистемима захтева детаљна истраживања еколошких, друштвено-економских последица пропадања шума и анализу утицаја глобалних промена климе на шумске заједнице. У раду је дат упоредни преглед мониторинга стања шума на биоиндикацијским тачкама у Републици Србији. Међународни кооперациони програм за праћење стања шума одвија се континуирано од 2003. године, и вршено је на Нивоу 1 овог програма. У периоду од 2004. године до 2009. године обављена су осматрања на 130 тачака и прикупљени су подаци неопходни за даљу анализу. Тачке су систематски распоређене у мрежи од 16 x16 км, и 4x4 км. На огледним пољима урађена је процена степена дефолијације, деколоризације и евидентирана су оштећења по класама. Упоредном анализом података у овом периоду пружиће се увид у досадашње стање шума у Србији као и у последице трендова дефолијације и деколоризације на лишћарским и четинарским врстама.*

Кључне речи: биомониторинг, ICP за шуме, биоиндикацијске тачке, климатске промене, Србија

1. INTRODUCTION

Programme ICP Forests (International Cooperative Programme on Forest Condition Monitoring) has been performed continuosly since 2002 in Republic of Serbia. The forest condition monitoring Level 1 of this programme mainly refers to the observation and defoliation and discolouration assessment of the tree crowns on the certain parcels of the sample plots in

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Republic of Serbia, along with the other observation according to the ICP Forests Manual. Since the system of the forest condition monitoring has been integrated in the state forestry environment, several institutions with their associates take part in the programme, under the coordination of the Forest Directorate and National Focal Centre (NFC) for the forest condition monitoring in Institute of Forestry. The example of such structure is CLRTAP programme (Convention on Long-Range Transboundary Air Pollution), which was established 25 years ago with the aim of reduction of air pollution in Europe.

2. MONITORING ACTIVITIES AT LEVEL I

The Level 1 network is established for the monitoring of the forest health condition and for their large-scale spatial and temporal changes and during the necessary time period. The system of this level of the monitoring adequately covers the most important forests in Europe. The Level 1 network contains approximately 6,000 parcels of the monitoring (sample plots) systemically arranged in the 16 x 16 km grid across Europe. In some countries there is denser national network with the aim of the more elaborate assessment of the condition at the national and regional levels. Within the Level 1 the following parameters are monitored: crown condition, chemical characteristics of the soil and nutrition of the forest trees.

3. METHODS AND CRITERIA

Forests monitoring is one of the largest forest biomonitoring system that is implemented in order to evidence the change in the forests with the key environmental parameters. Based on the data it is possible to determine the spatial and time trends on the state of forests and tree species and the status of their crown in the regions. In addition, in the broader context of correlation can be made of data on the state crown with the corresponding experimental data, surface and external data on the natural and anthropogenic stress factors, which gives some indication of the vitality of relations between noise and stress.

In period 2003-2009, it was found and placed 130 sample plots in the Republic of Serbia, the network 16 x 16 km and 4 x 4 km. (Nevenić et al., 2006). Number of trees per species varies slightly from year to year because some trees cut and replaced with new (Table 1.), and at some points was made clear cut the number of points in year 2009. was the 122. Finally, the last year of research, the assessment of defoliation and discolouration was done as well as damage monitoring caused by the biotic and abiotic factors on the total 2,765 trees. The number of trees insignificantly varies in comparison with the previous year of the forest condition monitoring.

Table 1. *Percentage of trees on sample plot in 2009*

	Species	Number	%
Conifer	*Abies alba*	63	19
	Picea abies	143	43
	Pinus nigra	69	21
	Pinus silvestris	56	17
Total Conifer		331	100
Broadleaves	*Carpinus betulus*	112	5
	Fagus moesiaca	841	34
	Quercus cerris	505	21
	Quercus frainetto	362	15
	Quercus petraea	168	7
	Other species	446	18
Total Broadleaves		2434	100
Total		2765	100

The researchers of the NFC Serbia - Institute of Forestry with collaborators from other institutions in Serbia, have worked all sampling points and made visual assessment of the crown condition (the assessed parameters are defoliation and discolouration) and collected the other necessary field data.

3.1. Crown condition

Within the national and transnational research (Level 1) the crown condition is expressed by the classes of the foliage loss, changes of color, and combined classes of the damages. Defoliation is estimated by the intervals of 5% and grouped into 5 classes of the unequal scope (Table 2).

Table 2. *Classes of defoliation according to UN/ECE and EU classification*

Class	Degree of defoliation	Needle / leaf loss %
0	none	0–10
1	slight (warning)	>10–25
2	moderate	>25–60
3	severe	>60–100
4	dead	100

Discolouration is an important diagnostic indicator of the crown condition and can be estimated according to the classes stated in the Table 3.

Table 3. *Classes of discolouration according to UN/ECE and EU classification*

Class	Degree of discolouration	Needle / leaf loss %
0	none	0–10
1	slight (warning)	>10–25
2	moderate	>25–60
3	severe	>60–100
4	dead	100

The combined assessment of the defoliation and discolouration of the leaves/ needles is shown in the Table 4.

Table 4. *Combined assessment of damage*

<table>
<tr><td>Defoliation class</td><td colspan="4">Discoloration class</td></tr>
<tr><td rowspan="3">0</td><td>0</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td colspan="4">Resulting class of damage</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>2</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>2</td><td>2</td></tr>
<tr><td>2</td><td>1</td><td>2</td><td>3</td><td>3</td></tr>
<tr><td>3</td><td>2</td><td>3</td><td>3</td><td>3</td></tr>
</table>

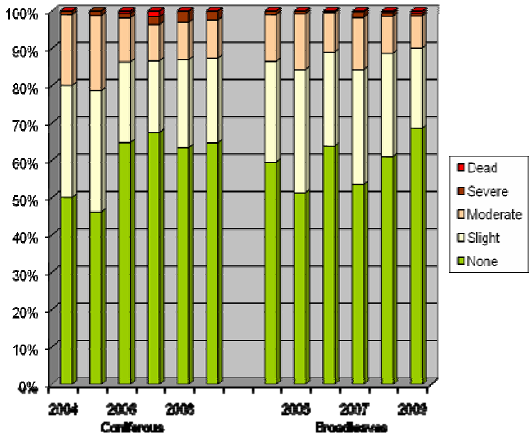
4. COMPARATIVE ANALYSIS RESULTS OF MONITORING IN THE REPUBLIC OF SERBIA IN PERIOD 2004-2009

Although six years is relatively short period of meticulously statistical processing in terms of comparative analysis, by examining the collected data values for defoliation and discolouration, some conclusions could yet be to come. Certainly, primarily because of the short time period analyzed, any conclusions reached should be conditionally interpreted as a trend.

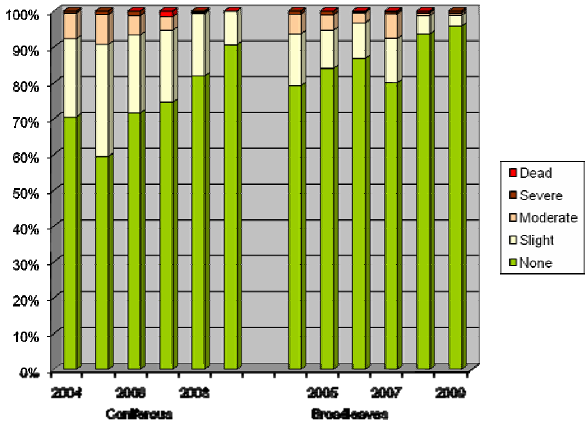
Oscillations of annual values for three elements processed represent state of health of forests (defoliation, discolouration, damages) in all categories of vulnerability, for the conifers are more pronounced than in deciduous trees case.

Looking at the past years, it can be concluded that the data for defoliation with conifers and deciduous trees at a fairly balanced. With coniferous and deciduous trees at 2005th years set aside as the most unfavorable, as manifested by fewer defoliation on unaffected trees. In conifers, the situation was slightly better in 2004th, while for the deciduous 2007th years was similar to the 2005th. As defoliation is concerned, the only real legitimacy is evident in the strong defoliation of conifers, however, and it is difficult to talk about the trend because of the very small number of trees affected by this category of damage (total number is 10 trees). Compared with other years in 2009 with was marked discolouration which can be explained by favorable seasonal hydro-meteorological characteristics. Country about affected trees with defoliation for the past six years are shown, on Graph 1.

Graph 1. *Evaluation of defoliation in period 2004-2009*



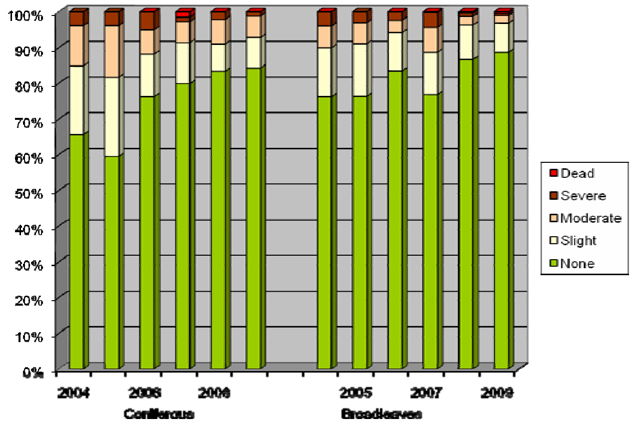
Graph 2. *Evaluation of discolouration in period 2004-2009*



As with defoliation, the period of monitoring and evaluation of discolouration of five years is too short to be reliable trend about this phenomenon with those deciduous and coniferous species, which are most common sample plots. Still can conclude that it in the processed period, the percentage of discolouration for not affected trees (category with no discolouration), consistently with the deciduous trees is greater than for conifers. In deciduous trees any kind of discolouration was not registered at 80 percent and more trees. This can be explained by the annual rejection leaves and the formation of new leaves at broadleaves species, while coniferous species because of keeping the needles for many years, their damages spread and in the next year. In conifers, the 2005th years set aside as extremely unfavorable, as manifested by a small number of by discolouration unaffected trees.

Data which represent damages are, in function of the first two elements of health (defoliation and discolouration). They are dependent, and the perceived regularity, more or less, and relate to them. Damages trend, during these years was closer to real meaning of trend than, it is in a case for defoliation and discolouration. The frequency of damages in conifers is greater than on deciduous trees, which is a continuation of trends in defoliation and discolouration. Because retention of dried needles on the branches of evergreens, the intensity of discolouration is approached with defoliation intensity, and total damages were higher. In deciduous trees, the frequency of damage in the observed period decrease. The values are between defoliation and discolouration, which is understandable, because a deciduous tree annually aborts leaves.

Graph 3. *Evaluation of damages in period 2004-2009*



5. GENERAL FINDINGS AND DISCUSSION

As a result, the condition assessment of trees on sample plots (drying and chlorosis), the next step will be integrated with the monitoring system of determining changes in soil, analysis of leaves, estimate deposition pollutants and additional, similar to the cartwheel, research and study.

Collecting these data during a long period and their connection with phytocoenological characteristics and environmental aspects, will allow more specific information about dyeing of forests in space and time. In the final, 2009. year experimental trees were the most vital and this is also the defoliation and discolouration can be explained by favorable hydro-meteorological conditions.

5. 1. Defoliation

Looking at the previous period of six years, it can be concluded that the data with conifers and deciduous trees at a fairly consistent. And the conifer and deciduous trees at 2005th year set aside as the lowest, which is manifested by a small number of unaffected trees. The cause of the extremely dry period, reflecting the state of vegetation with phenological aspects. In conifers, the situation was slightly better in 2004, while with broadleaves 2007 was similar to 2005 (dry period during summer).

5. 2. Discoloration

The percentage of discolouration unaffected trees (category without discolouration), the broadleaves is constantly higher than that of conifers in the research period. I deciduous species discolouration is not registered at 80 percent and more trees. This may explain the rejection of the annual formation of new leaves and leaves with deciduous species, while coniferous species, for many years to keep the needles, damage to their transfer and the next year. At sawmills in 2005 set aside as an extremely unfavorable, primarily due to climatic conditions.

5. 3. Damages

In broadleaves, the frequency of damage in the period reduced, and the values are between defoliation and discolouration, which is understandable, because the annual broadleaved reject assimilation organs. When the frequency of damage in the deciduous processed period was quite uniform, while the state of coniferous species in 2004 and 2005 there were some worse than others (needle damages passed in the following year).

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COMPARATIVE ANALYSIS OF FOREST VITALITY IN THE REPUBLIC OF SERBIA IN THE PERIOD 2004 – 2009

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Summary

National Focal Center at the Institute of Forestry in Republic of Serbia continuously participate in an international program of ICP Forest since 2003 with a tendency of further development work and harmonization with other approaches to work on monitoring of forests and forest ecosystems. The estimation of the forests crown, through discolouration and defoliation, and the establishment of damages to trees from disease and pests, on BIT in period 2004-2009, contributing to the performance of definitive conclusions about the vitality of forests. It occurs as a result of adverse effects of the complex factors abiotic and biotic origin of trees as living organisms and complex natural processes within the forest biocoenosis. Influence of pollutants and climate change factors on the vitality of forests is evident as a phenomenon in Serbia, the region and throughout Europe. These topics are very actual and will be object of research with us and the world, in further.

THE STUDY OF SOME PHYSIOLOGICAL CHARACTERISTICS OF FUNGUS *CRYPHONECTRIA PARASITICA* (MURR.) BARR

Zlatan RADULOVIĆ[1], Zoran MILETIĆ, Katarina MLADENOVIĆ

Abstract. *One of the preconditions for the effective fight against the plant diseases is the knowledge on the bioecology of pathogens. This paper presents the results of the research of the influences of temperature, light and different media on the growth and characteristics of mycelia of fungus C. parasitica. The influence of temperature was studied on two isolates, at the temperatures ranging from 4 and 39^0 C. The optimal temperature for its growth, as well as the interval in which the fungus is physically active, was determined. The influence of light was studied by using 16-hour photoperiod, whereas the growth and characteristics of mycelium were studied on three different media. The results point out to the fact that the optimal temperature for the mycelial growth is 25^0 C, that mycelium grows more slowly by daylight, and that the most favourable medium for the mycelial growth is PDA.*

Key words: *C. parasitica*, mycelial growth, temperature, nutritive media, light.

ИСПИТИВАЊЕ НЕКИХ ФИЗИОЛОШКИХ КАРАКТЕРИСТИКА ГЉИВЕ *CRYPHONECTRIA PARASITICA* (MURR.) BARR

Извод. *Један од предуслова за успешну борбу против биљних болести је познавање биоекологије патогена. У раду су представљени резултати испитивања утицаја температуре, светлости и различитих подлога на пораст и карактеристике мицелије гљиве C. parasitica. Утицај температуре је испитиван на два изолата у интервалу од 4-39^0 C. Утврђена је оптимална температура за њен пораст, као и интервал у којем је гљива физиолошки активна. Утицај светлости је испитиван са фотопериодом од 16 сати, а пораст и карактеристике мицелије испитиване су на три различите подлоге. Добијени резултати указују да је оптимална температура за пораст мицелије 25^0 C, да мицелија спорије расте при дневној светлости и да је најповољнија подлога за пораст мицелије ПДА.*

Кључне речи: *C. parasitica*, пораст мицелије, температура, хранљиве подлоге, светлост

1. INTRODUCTION

There are about one thousand species which belong to the family *Fagaceae* worldwide. According to GOVAERTS and FRODIN (1998), this family refers to seven genera which growth in the Northern Hemisphere, and the number of species varies to a great extent within the genera. Genus *Chrysolepis* contains two species, whereas genus *Quercus* contains between 450 and 600 species. Within genus *Castanea* 13 species have been described so far. Alongside the European species (*Castanea sativa* Mill.), the important species in America are the following: *Castanea dentata* (Marsh.) Borkh., in Japan: *Castanea crenata* Siebold & Zucc.and in China: *Castanea mollissima* Blume. (LANG et al. 2007).

The decay of chestnut is mainly caused by fungus *Cryphonectria parasitica* (Murrill) Barr, which causes chestnut blight. Over the period 1940-1950 this fungus destroyed more than

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Acknowledgement: The study was partly financed by the Minstry of Science and Technological Development of the Republic of Serbia, the Project TR20052 „Changes in forest ecosystems affected by global warming“

3.5 thrillion American chestnut trees (RITTENOUR, 2005). This species was first described by Murrill in 1906, under the name *Diaporthe parasitica*. As this name was not accepted by the majority of mycologists, Anderson and Anderson changed it into *Endothia parasitica* in 1912. The genus was re-named again in 1978, when the species was given the name which is still used (*Cryphonectria parasitica*).

In Europe *C. parasitica* was recorded for the first time in Italy in 1938, whence it spread to the majority of the European countries. In the beginning the pathogenicity of this fungus was intensive almost to the same degree as in America. In the middle of the 20th century it was reported that the trees infected by this fungus do not decissate. By the subsequent researches GRENTE (1965) isolated atypical isolates from the canker wounds of such trees, which were white-coloured and displayed decreased virulence. He called this phenomenon hypovirulence and today it is the most important method in the fight against this disease. *C. parasitica* is the wound parasite, but it can also attack the most vital trees. For the effective struggle against *C. parasitica* it is necessary to gain better knowledge on its physiology. Since the temperature, light and nutrients important factors during the whole process of pathogenesis, they were the subject of the laboratory studies.

2. MATERIAL AND METHOD

For the study of the influence of temperature on the growth of mycelium of fungus *C. parasitica* the experiment was set in the polythermostat at 4, 5, 9, 15, 22, 25, 28, 33 and 39°C. The researches were done on PDA medium with two isolates of *C. parasitica* (CS3 и SG1). The mycelial growth was monitored every 24 hours. The average daily growth was determined as the mean value obtained by measuring two cross-sectional diameters, which meet at 90° angle. The experiment was repeated twice.

For the study of the influence of the different media on the mycelial growth, the media which consisted of malt extract (5 Bé sugar) and agar (2 %), and the combined Lutz medium, in which the pieces of chestnut or oak bark were extracted instead of the beech wood sawdust, were used. In these researches the isolate marked with CS3 was used. The combined Lutz agar was prepared in the following way:

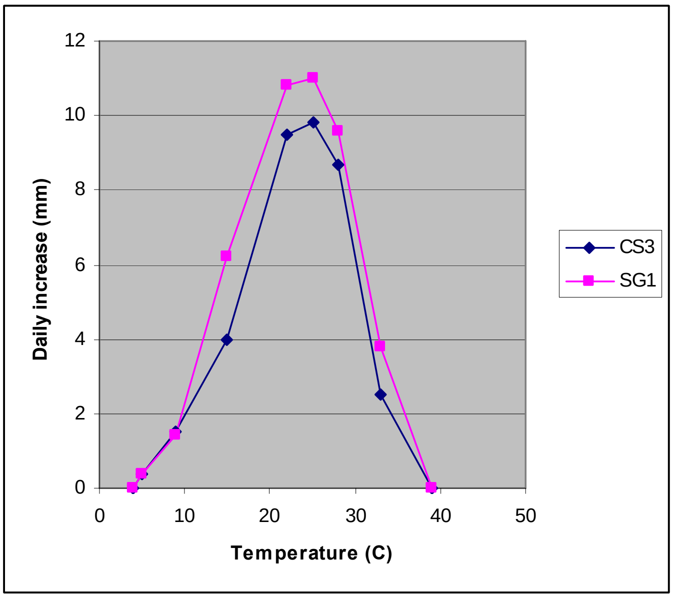
In Erlenmeyer 147099 Pa of chopped chestnut or oak bark was poured and 750 ml of distilled water was added. The Erlenmeyer was closed and put in the autoclave. In the next two hours the extraction was performed at 121°C and 2 atmospheres pressure. The filtrate obtained in this way was filtrated, and then 2.5 g of maltose, 2.5 g of xylose, 0.5 g of ammonium sulfate, 0.5 g of amonium-nitrate, and 15 g of agar was added to 500 cm^3 of filtrate. After the agar melted, the medium was sterilized by the standard method. The researches were done at 20, 25 and 30 °C.

For the study of the influence of light on the growth and look of mycelium the isolate CS3 was used. The researches were done on PDA medium at 21 °C. The Petri dishes were incubated in the total darkness and during the alternate cycle day/night (16-hour photoperiod).

3. RESEARCH RESULTS

The influence of temperature on the mycelial growth of fungus *C. parasitica* is presented on the Graph1.

Graph 1. *Influence of temperature on the mycelial growth C. parasitica*

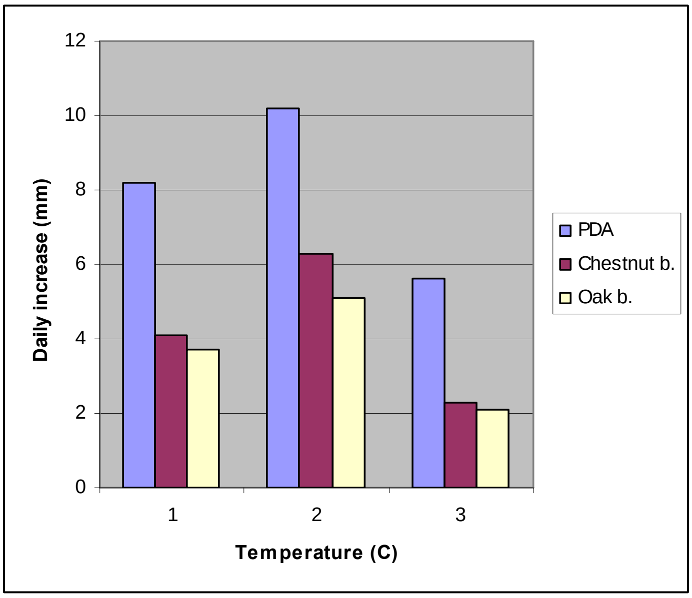


Based on the research results, it can be concluded that the mycelial growth of both isolates does not start at 4 °C. Both isolates are physiologically active at 5°C and their growth is the same at this temperature. At all other temperatures at which their physiological active was studied (9,15, 22, 25 28 и 33°C) the mycelial growth of isolate SG1 was greater. Since the greatest daily growth of both isolates was determined at 25°C , it can be considered to be optimal. Somewhat smaller growth of both isolates is observed at 22°C . At 39°C neither isolate grows. After seven days both isolates are exposed to 25°C (optimal) temperature, but their growth did not begin.

The growth of mycelium of isolate SG1 at all observed temperature ranging from 9 to 33°C is greater, based on which can be concluded that for the development of it somewhat higher temperature than for the isolate CS3 is needed.

The influence of different media on the mycelial growth of *C. parasitica* is presented on the Graph 2.

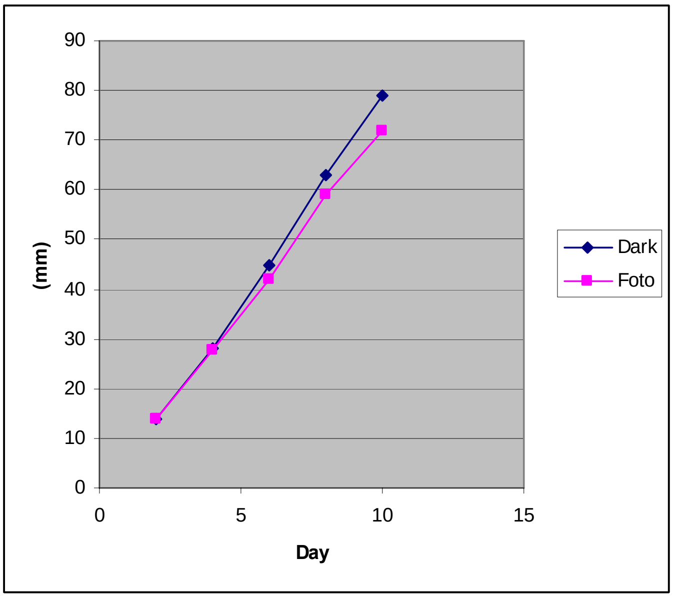
Graph 2. *Influence of different media on the mycelial growth C. parasitica*



Out of all three observed media, the greatest mycelial growth of *C. parasitica* was reported on PDA medium. The significantly smaller growth of it was reported on the combined Lutz medium, to which chestnut bark was added, and the smallest growth was reported on the combined Lutz medium to which oak bark was added. The differences between the media to which chestnut or oak are added are very small at all three observed temperatures. With regard to the temperatures, the difference (between PDA and combined Lutz media) is the greatest at 30°C, somewhat smaller at 20°C, and it is the smallest at 25°C.

The influence of light on the mycelial growth of fungus *C. parasitica* is presented on the Graph 3.

Graph 3. *Influence of light on the mycelial growth C. parasitica*



The mycelial growth of isolate CS3 is greater when it is incubated in the complete darkness than during the alternate cycle day/night (16-hour photoperiod). The differences are very small and after 10 days equal to 6mm. Light affects the look of the colony of fungus to much greater extent. If it grows in the darkness the colony is of the lighter colour and forms less pycnidia. During the change of the light regime the colony is of the darker colour and it has more pycnidia which are arranged in the concentric circles (correspond to the daily light periods).

4. DISCUSSION

For the successful fight against *C. parasitica* it is necessary to gain as much knowledge as possible on its bioecology. Its bioecology to a great extent depends on the environmental factors, and some of these factors also influence the sensitivity of the host to this fungus.

In these researches HEALD AND WALTON (1914) state the temperature ranging from 18-28°C as the optimal for the development of *E. parasitica.* The minimal temperature at which this fungus starts to grow is 8-9°C, and the maximal is 35°C. In these reseaches the greatest daily growth of both isolates was determined at 25°C Somewhat lower growth of both isolates was reported at the temperatures ranging from 22°C to 28°C. For both observed isolates it can be concluded that the optimal temperature ranges between 22 and 28°C.

Based on reseaches done by GUÉRIN and ROBIN (2003) the infections of the trees by the conidia are the most frequent in spring and summer (about 63% of the visible lesions), whereas they are the least frequent in winter (no visible lesions). However, although there were no visible lesions from this material *C. parasitica* was isolated after 3-7 months. These results point out that the latent infections which occur in autumn and winter activate in spring.

The spread of the cankers varies during the season and it is most intense over the growing season, whereas in winter is very small, or not present at all. The chestnut is most sensitive to the infection during the period of the greatest dispersal of ascospores. Based on the researches done by GUÉRIN et al. (2001), the dispersal of ascospores begins seven days after the incubation at the temperatures ranging from 15 to 25°C. The majority of the ascospores disperse at 20 and 25 °C temperatures. Over the year the ascospores disperse to the greatest extent in the period from March to October, and the maximum disperse occurs in May. This period coincides with the growing season of the host and this period BAZZIGHER (1981) states as the most sensitive to the infection by *C. parasitica*. The similar results were obtained in the reseaches done by HEALD and WALTON (1914). They determined that the optimal temperatures for the dispersal of ascospores ranging from 20 to 27°C. In the field conditions WALTON (1914) determined that the ascospores start to release when then temperature is higher than 11°C for at least three days in the sequence.

In their reseaches PUHALLA and ANAGNOSTAKIS (1971) state that for the growth and production of conidia *C. parasitica* the inorganic salts, glucose, and thiamine are necessary, but for the germination of the conidia, biotin is necessary as well. The optimal pH value of the subsoils is 4, and the fungus does not grow at the pH higher than 5.5. Studing the concentrations of some elements in the phloem of the trees from the vital and infected stands, Portela (2001) noticed the important differences. The concentrations of N, K and Fe are significantly higher in the trees from the infected stand, whereas Ca and ratio Ca/N is significantly higher in the trees of the vital stand. The highest concentrations of the nitrogen occurred twice, first in the time of the bud openings, and the second in autumn, whereas the ratio Ca/N is the opposite. Also, this scientist determined that the exchangeable forms of Ca, Mg and K in the soil are significantly higher in the unaffected stand.

In these researches done on all three observed media the greatest mycelial growth *C. parasitica* at all three studied temperatures was reported on the PDA medium. The significantly smaller growth of it was reported on Lutz medium, to which the chestnut bark was added, whereas the smallest growth was reported on the combined Lutz medium, to which oak bark was added.

Studying the influence of the light intensity on the look of the colony, the production of conidia, and on the production of the oxalic acid, HILLMAN et al. (1990) determined that the growth of this fungus and the production of mass was greatest in the darkness, and that it was smallest when it is exposed to the light of the highest intensity. The production of conidia and oxalic acid increased with the increase of the light intensity. The increased light intensity led to the increased pigmentation of the colony *C. parasitica.* In their researches PUHALLA and ANAGNOSTAKIS (1971) did not determine the relation between the growth of mycelium and light, but the presence of light is necessary for the formation of conidia. In these reseaches the growth of the isolate CS3 was greater when it was incubated in the complate darkness than during the alternate day-night cycle (16-hour photoperiod). The differences are very small and after ten days equal to 6mm. The light has much greater influence on the look of the colony of fungus. During the growth in the darkness the colony is of the lighter colour and less pycnidia is formed.

In order to mitigate the risk from the spread of *C. parasitica* it is necessary to perform all the activities aimed at the feeling and branch pruning at the time of the lowest sensitivity of the host and of the lowest infection potential of the fungus (when the production of ascospores is minimal). These two conditions occur during the winter. The development of the cankers over the season is the result of the seasonal changes of the sensitivity of the chestnut and the influence of the meteorological factors on the development of *C. parasitica*. The chestnut bark is more sensitive over the growing season than during the dormancy in vegetation. The sensivity of the bark increases with the increase of the relative humidity of the bark and it depends on the quantity of the nutrients in the bark. According to ANAGNOSTAKIS and AYLOR (1984), there is the positive correlation between the development of the cankers and the change of temperature, and it directly depends on the influence of the temperature on the development of *C. parasitica*. The temperature and drought have the synergetic effect on the development of the cankers, which is reflected in their most intensive decissation in summer.

5. CONCLUSION

Based on the reseaches of the bioecology of fungus *C. parasitica,* the following conclusions can be made:

► The mycelial growth of both isolates (CS3 and SG1) does not start at 4 °C. The physiological activity of both observed isolates starts at 5°C and at this temperature their growth is the same. At all other temperatures at which their physiological activities was studied (9,15, 22, 25 28 и 33°C) the mycelial growth of the isolate SG1 is greater.

The greatest daily growth of both isolates was determined at 25°C Somewhat smaller growth of both isolates were reported at 22°C and 28°C. For both studied isolates it can be concluded that the optimal temperatures range from 22 to 28°C.

Neither isolate grows at 39°C. After seven days both isolates were transported to 25°C (optimal) temperature, but their growth did not begin.

► Out of three observed media, the greatest mycelial growth of isolate CS3 at all three observed temperatures, was reported on PDA medium. Significantly smaller growth of it was reported on the combined Lutz medium. During the growth on the combined Lutz medium, somewhat greater growth of it was reported in the variance when the chestnut bark was added to this medium, and the smallest growth was reported when the oak bark was added.

► The greater mycelial growth of the isolate CS3 was reported when it was incubated in the complete darkness than during the alternate day-night cycle (16-hour photoperiod). The differences are very small and after ten days equal to 6mm. The light has much greater influence on the look of the colony of fungus and the formation of pycnidia.

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THE STUDY OF SOME PHYSIOLOGICAL CHARACTERISTICS OF FUNGUS *CRYPHONECTRIA PARASITICA* (MURR.) BARR

Zlatan RADULOVIĆ, Zoran Miletic, MILETIĆ, Katarina MLADENOVIĆ

Summary

For the successfull fight against *C. parasitica* it is necessary to gain as much knowledge as possible on its bioecology. Its bioecology to a great extent depends on the environmental factors, and some of these factors also influence the sensitivity of the host to this fungus.

In these reseaches the physiological activity of both observed isolates (CS3 and SG1) starts at 5°C, and at this temperature their growth is the same. At all other temperatures at which their physiological activities was studied (9,15, 22, 25 28 и 33°C) the mycelial growth of the isolate SG1 is greater. The greatest daily growth of both isolates was determined at 25°C. Somewhat smaller growth of both isolates were reported at 22°C and 28°C. For both studied isolates it can be concluded that the optimal temperatures range from 22 to 28°C. Neither isolate grows at 39°C. After seven days both isolates were transported to 25°C (optimal) temperature, but their growth did not begin. Out of three observed media, the greatest mycelial growth of isolate CS3 at all three observed temperatures, was reported on PDA medium. Significantly smaller growth of it was reported on the combined Lutz medium. During the growth on the combined Lutz medium, somewhat greater growth of it was reported in the variance when the chestnut bark was added to this medium, and the smallest growth was reported when the oak bark was added. The greater mycelial growth of the isolate CS3 was reported when it was incubated in the complete darkness than during the alternate day-night cycle (16-hour photoperiod). The differences are very small and after ten days equal to 6mm. The light has much greater influence on the look of the colony of fungus and the formation of pycnidia. In order to mitigate the risk from the spread of *C. parasitica* it is necessary to perform all the activities aimed at the feeling and branch pruning at the time of the lowest sensitivity of the host and of the lowest infection potential of the fungus (when the production of ascospores is minimal). These two conditions occur in winter.

ИСПИТИВАЊЕ НЕКИХ ФИЗИОЛОШКИХ КАРАКТЕРИСТИКА ГЉИВЕ *CRYPHONECTRIA PARASITICA* (MURR.) BARR

Златан РАДУЛОВИЋ, Зоран МИЛЕТИЋ, Катарина МЛАДЕНОВИЋ

Резиме

За успешну борбу против *C. parasitica* неопходно је што боље познавање њене биоекологије. Њена биоекологија у великој мери зависи од фактора спољашње средине, а неки од ових фактора утичу и на осетљивост домаћина према овој гљиви.

У нашим истраживањима физиолошка активност оба испитивана изолата (CS3 и SG1) почиње на температури од 5°C и на овој температури имају исти пораст. При свим осталим температурама на којима је испитивана њихова физиолошка активност (9,15, 22, 25 28 и 33°C) изолат SG1 има већи пораст мицелије. Највећи дневни пораст код оба изолата утврђен је на температури од 25°C. Нешто слабији пораст оба изолата имају на температурама од 22°C и 28°C. За оба испитивана изолата може се констатовати да се температурни оптимум креће у границама између 22 и 28°C. На температури од 39°C оба изолата не расту. После седам дана оба изолата су премештена на температуру од 25°C (оптималну) али нису почела са

растом. Од три испитиване подлоге највећи пораст мицелије изолат CS3 на све три испитиване температуре има на ПДА подлози. Много мањи пораст има на комбинованој подлози Лутз-а. При расту на комбинованој подлози Лутз-а нешто већи пораст има у варијанти када је овој подлози додавана кора кестена, а најмањи када је додавана кора храста. Изолат CS3 има већи пораст мицелије када је инкубиран у потпуном мраку него при наизменичном смењивању светлости и мрака (16 сати фотопериод). Много већи утицај светлост има на изглед колоније гљиве и формирање пикнида.

За смањење ризика од ширења *C. parasitica* неопходно је све радове око сече и орезивања грана изводити у време најмање осетљивости домаћина и најмањег инфекционог потенцијала гљиве (када је продукција аскоспора минимална). Ова два услова се јављају током зиме.

INTERACTIONS BETWEEN SOME ANTAGONISTS AND FUNGUS *CRYPHONECTRIA PARASITICA* (MURR.) BARR

Zlatan RADULOVIĆ[1], Dragan KARADŽIĆ[2]

Abstract: *The fungus Cryphonectria parasitica (Murrill) Barr, which cause "chestnut bark disease", has the greatest influence on the decay of sweet chestnut. Alongside the use of its hypovirulent strains, the possibilies of the use of some antagonists to a greater extent, are researched. This paper presents the results of the laboratory studies of the interactions between fungus C. parasitica and antagonistic fungi Trichoderma harzianum, Trichotechium roseum, Penicillium sp., Alternaria alternata and Aspergillus sp. The interactions were studied at two different temperatures. The sensitivity indexes were determined for each fungus, and based on them the types of reaction of the antagonist fungi in the mixed cultures were determined.*

Key words: *Cryphonectria parasitica*, mixed cultures, type of reaction, index of sensitivity

МЕЂУСОБНИ ОДНОСИ НЕКИХ АНТАГОНИСТА И ГЉИВЕ *CRYPHONECTRIA PARASITICA* (MURR.) BARR

Извод: На пропадање питомог кестена највећи утицај има гљива *Cryphonectria parasitica* (Murrill) Barr која изазива "рак коре кестена". У борби против ове гљиве поред коришћења њених хиповирулентних сојеви, истражују се и могућности масовније примене неких антагониста. У раду су представљени резултати лабораторијских испитивања међусобних односа гљиве *C. parasitica* и анатагонистичких гљива *Trichoderma harzianum*, *Trichotechium roseum*, *Penicillium* sp., *Alternaria alternata* и *Aspergillus* sp. Међусобни односи су испитивани на две различите температуре. За сваку гљиву су утврђени индекси сензитивности, а на основу њих и реакциони типови супростављених гљива у смешаним културама.

Кључне речи: *Cryphonectria parasitica*, смешане културе, реакциони тип, индекс сензитивности

1. INTRODUCTION

Sweet chestnut (*Castanea sativa* Mill.) is the European species from the family *Fagaceae* and genus *Castanea*. Within this genus 13 species have been described so far. Alongside sweet chestnut, the important species in America are: *Castanea dentata* (Marsh.) Borkh., in Japan: *Castanea crenata* Siebold & Zucc. in China : *Castanea mollissima* Blume.

Based on the reseaches by GLISHIC (1975), Serbia is relatively poor in sweet chestnut. Great complexes of sweet chestnut forests are situated between Pec and Djakovica, where they form one vegetation complex. Concerning the other sites, it is most frequent in the vicinity of Vranje. Small, isolated sites are found in Vrshacki Breg and Mt.Frushka Gora, on the northern slopes of Mt. Guchevo near Loznica, in Kostajnik near Krupanj, near Prijepolje (Hisardzik Village), near Prokuplje (Chukovac Village), and in the vicinity of Chachak (Trnava Village).

The fungus *Cryphonectria parasitica* (Murrill) Barr, which cause "chestnut bark disease", has the greatest influence on the decay of sweet chestnut. The desiccation of American

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Acknowledgement: The study was partly financed by the Minstry of Science and Technological Development of the Republic of Serbia, the Project TR-20202 „Development of biotechnological methods in establishing and improving of forest ecosystems"

chestnut (*Castanea dentata* (Marsh.) Borkh.), caused by this fungus, is one of the greatest botanical catastrophies in the human history. The first trees infected by *C. parasitica* (earlier name *Endohtia parasitica* (Murr.) And.& And.) were registered in New York Zoo in 1904. By 1950 more than 3.5 thrillion of American chestnut trees were destroyed, which endangered the survival of this species (RITTENOUR, 2005). In Europe *C. parasitica* was recorded for the first time in Italy in 1938, whence it spread to the most European countries. Based on the claims by ROBIN and HEINIGER (2001) its presence was not determined only in Holland and Great Britain. In the beginning the pathogenicity of this species was expressed almost to the same level as in America. However, in 1951 BIRAGHI discovered that 85% of the infected trees seemed "suprisingly healthy". By the subsequent reseaches, GRENTE (1965) obtained the atypical, white-coloured isolates of the decreased virulence from the cankers of such trees. He named this phenomen hypovirulence. The introduction of hypovirulent forms of the fungus in the infected chestnut stands is used as the biological method of fight.

In addition, the attempts were made to use some antagonists as the biologival method of fight against *C. parasitica.* In the most researches the species from the gena *Trichoderma* and *Penicillium* were used. The laboratory results showed the satisfactory results, but in the practical application the significant progress was not made. This paper presents the results of the laboratory studies of the interactions between *C. parasitica* and antagonistic fungi *Trichoderma harzianum*, *Trichotechium roseum*, *Penicillium* sp., *Alternaria alternata* and *Aspergillus* sp.

2. MATERIAL AND METHOD

The fungal cultures used in these researches were isolated from the chestnut samples collected at Sobina site. The isolate *T. harzianum* was obtained from mycota collection of the Institute of Pesticides and Environmental Protection.

During the studies of the interactions between the above fungi and fungus *C. parasitica*, the mycelial fragments 5x5 mm were simultaneously set at the opposite sides of Petri dishes. The same principle was also used for the control Petri dishes with the individual isolates of the observed fungi.

The interactions were monitored in the laboratory on the artificial nutrient PDA medium, at 21^0 C and 30^0 C. After the period of the adaptation of fungi, the rate of mycelial growth was measured on a daily basis. It was measured (in mm) on three diameters, set at a 22.5^0 angle. Alongside the rate of mycelial growth, the interactions in the contact zone of the simultaneously planted mycelia were studied. Also, the width of the zone in the cases when one fungus overgrew the another one was measured. The width of the zone by which one fungus overgrew the another one was measured only at the mean diameter. When the fungi did not made contact, the width of the zone of inhibition was measured. The obtained results were presented by using the method suggested by Ekstein and Liese, (1970., quoted by Miric and Popovic,2003).

Based on the obtained data, the mean diameters of the colony of fungus which grew independently were determined (control Petri dishes), and the mean diameters of the colony of the same fungus grew in Petri dish with the antagonistic fungus. For each fungus the parameters when the fungus grew independently and the parameters when it grew with the antagonistic fungus were presented.

By rotating the graph with the data on one fungus around x-axis by 180° and overlapping with the graph of the antagonistic fungus, the new graph was obtained, on which all parameters of the simultaneous growth of the antagonistic fungi can be observed (contact, width of the zone of inhibition, width of the zone by which one fungus overgrows the another one...).

Based on these data the index of sensitivity and type of reaction of each fungus were determined. The explanation of the sensitivity index and types of reaction are presented in the reseach results. The experiments were repeated three times.

3. RESEARCH RESULTS

The results of the research of the interactions of the above fungi and fungus *C. parasitica* are presented on the Graphs 1-5 and on the Figures 1-5.

Figure 1. Type of reaction VI: ***Cp*** i ***T_h***

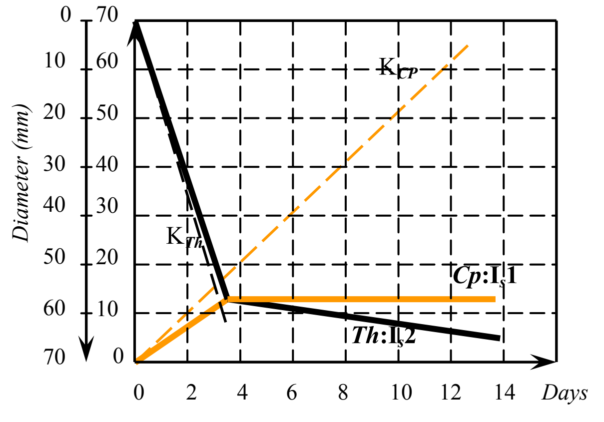

Figure 1

Figure 2. Type of reaction VI: ***Cp*** i ***Psp.***

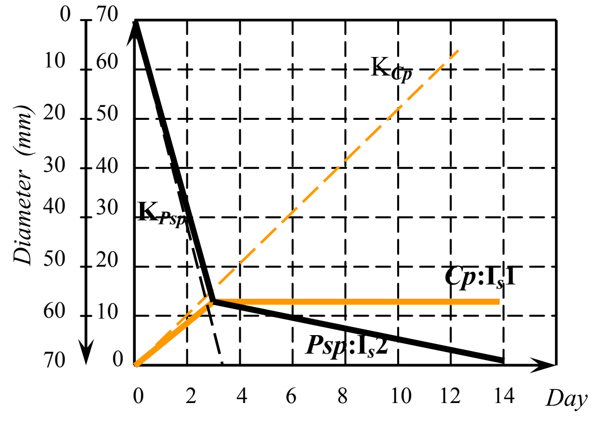

Figure 2

Figure 3. Type of reaction VI: ***Cp*** i ***Asp***

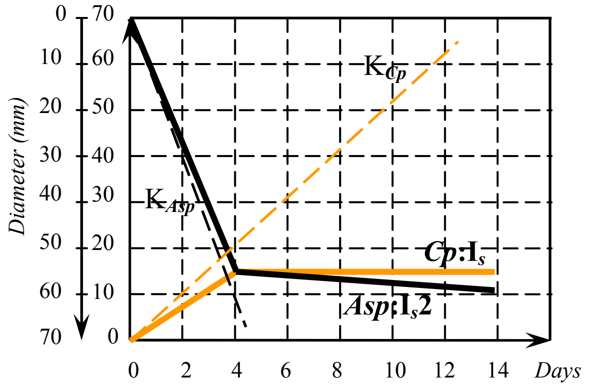

Figure 3

Figure 4. Type of reaction I: ***Cp*** i ***Alt***

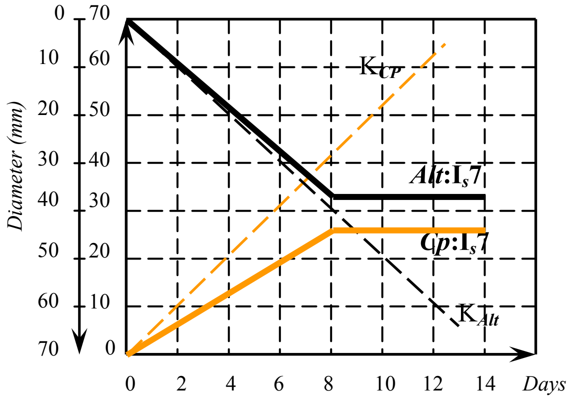

Figure 4

Figure 5. Type of reaction VI: ***Cp*** i ***Tr***

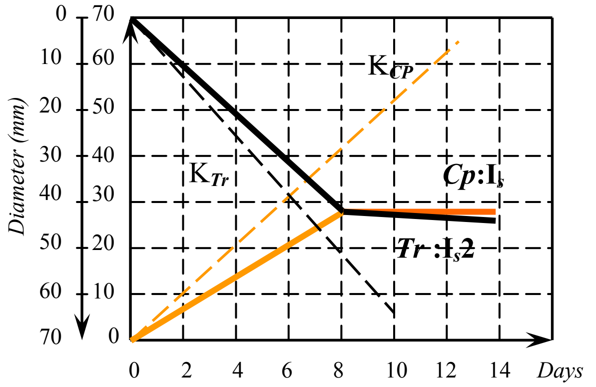

Figure 5

When it grew in the same Petri dishes with fungus *T. harzianum* at both observed temperatures, the fungus *C. parasitica* grew at slower rate than the control series, and after the contact was made it stopped growing (Index of Sensitivity 1). The growth of the fungus *T. harzianum* also decelerated, but after the contact was made it overgrew the fungus *C. parasitica* (Index of Sensitivity 2).

When they grew together, the type of reaction of these two fungi is IV (Graph 1, Figure 1). They only differed in the interval when the contact was made. At 21^0 C the contact was made between third and fourth day, and at 30^0 C after five days.

After the contact was made, the fungus *T. harzianum* overgrew the fungus *C. parasitica* on the fourteenth day, by the zone which was 7 mm wide.

When it grew in the same Petri dish with *Penicillium* sp. at both observed temperatures, the fungus *C. parasitica* grew at slower rate than the control series, and after the contact was made it stopped growing (Index of Sensitivity 1). *Penicillium* sp. also grew at a slower rate, but after the contact was made it overgrew the fungus *C. parasitica* (Index of Sensitivity 2). When they grew together, the type of reaction of these two fungi was VI (Graph 2, Figure 2). At 21^0 C the contact was made after three, and at 30^0 C after four days.

When it grew in the same Petri dish with *Aspergillus* sp. at both observed temperatures, *C. parasitica* grew at slower rate than the control series, and after the contact was made it stopped growing (Index of Sensitivity 1). At 21^0 C *Aspergillus* sp. also grew at slower rate, but after the contact was made it overgrew the fungus *C. parasitica* (Index of Sensitivity 2). When they grew together at 21^0 the type of reaction of these two fungi was VI (Graph 3, Figure 3). At 30^0 *C. parasitica* grew at slower rate than the control series, and after the contact was made it stopped growing (Index of Sensitivity1). The growth of *Aspergillus* sp. was the same as in the control series, and after the contact was made it overgrew the fungus *C. parasitica* (Index of Sensitivity 4). When they grew together at this temperature, the type of reaction of these two fungi was VIII (Graph).

At 21^0 C the contact was made after four days, and at 30^0 C after five days.

When it grew in the same Petri dishes with *A. alternata* at both observed temperatures, the fungus *C. parasitica* grew at slower rate in comparison with the control series, and it stopped growing before the contact was made (Index of Sensitivity 7). *A. alternata* also grew at slower rate, and before the contact was made it stopped growing (Index of Sensitivity 7). It stopped growing eight days after the contact was made, and the zone of inhibition was about 5 mm wide. When they grew together at both temperatures, the type of reaction of these two fungi was 1 (Graph 4, Figure 4).

When it grew in the same Petri dish with *T. roseum* at both observed temperatures, the fungus *C. parasitica* grew at slower rate in comparison with the control series, and after the contact was made it stopped growing (Index of Sensitivity 1). *T. roseum* also grew at slower rate and after the contact was made it overgrew the fungus *C. parasitica* by the zone which was 1 to 2 mm wide (Index of Sensitivity 2). When they grew together, the type of reaction of both fungi was VI (Graph 5, Figure 5). At 21^0 C the contact was made after eight days, and at 30^0 C between ninth and tenth day.

The results of the interactions between the observed fungi are presented in the Table.

Table 1. *The indexes of sensitivity and types of reaction of the observed fungi*

21^0 C			**30^0 C**		
Combination	**Index of sensitivity**	**Type of reaction**	**Combination**	**Index of sensitivity**	**Type of reaction**
C. parasitica	Is1	**VI**	*C. parasitica*	Is1	**VI**
T. harzianum	Is2		*T. harzianum*	Is2	
C. parasitica	Is1	**VI**	*C. parasitica*	Is1	**VI**
Penicillium sp.	Is2		*Penicillium* sp.	Is2	
C. parasitica	Is1	**VI**	*C. parasitica*	Is1	**VIII**
Aspergillus sp.	Is2		*Aspergillus* sp.	Is4	
C. parasitica	Is7	**I**	*C. parasitica*	Is7	**I**
A. alternata	Is7		*A. alternata*	Is7	
C. parasitica	Is1	**VI**	*C. parasitica*	Is1	**VI**
T. roseum	Is2		*T. roseum*	Is2	

The data presented in the Table 1 point out to the fact that during the research of the interactions between the observed fungi the following indexes of sensitivity and type of reactions were determined:

Indexes of Sensitivity:

Index of Sensitivity 1 – The fungus grows at slower rate and it stops growing in the contact zone;
Index of Sensitivity 2 – The fungus grows at slower rate and after the contact is made it overgrows the antagonist;
Index of Sensitivity 4 – The fungus grows at the same rate as the control series, and after the contact is made it overgrows the antagonist;
Index of Sensitivity 7 – The fungus grows at slower rate and it stops growing before the contact is made.

Types of reaction:

I – Both fungi grow at slower rate and they stop growing before the contact is made by forming the zone of inhibition in between;
VI – Both fungi grow at slower rate before the contact is made, and in the contact zone one of them stops growing, and the another one overgrows it;
VIII – One fungi grows at slower rate until the contact is made and after the contact is made it stops growing. The another one grows at the same rate as in the control series and after the contact is made it overgrows the first one;

4. DISCUSSION

The different methods were used in the fight against *C. parasitica.* One of the ways implied the introduction of the resistant Asian species of the chestnut and their crossing with sweet chestnut in the aim of the obtaining the resistant forms. In addition, the attempts were made to apply the direct mechanical methods (felling of the infected trees or their parts, debarking), as well as to apply the chemical methods (applying oil antiseptics or other fungicides to the stumps). Alongside, some other antagonistic and competative microorganisms were used for the biological control of this fungus (*Trichoderma* sp., *Penicillium rubrum*, *Bacillus suptilis*). Nowadays the hypovirulent strains of the fungus *C. parasitica,* which enable the healing and the stop the spreading of the cankers, are most frequently used. These strains cause the cankers after the infection, but these cankers are shortly callused and closed up (“benign cankers“) and the desiccation does not occur. The use of hypovirulent strains is the most effective way of the biological control of *C. parasitica*.

The majority of the previous researches have pointed to the possibility of the use of *Trichoderma* species and *Penicillium rubrum* in the fight against the chestnut blight. In their researches KRSTIC and HOCEVAR (1959) studied the influence of *Penicillium rubrum* and *Bacillus suptilis* on the infections of the sweet chestnut caused by *Endothie parasitice*. The results of their experiments showed the undoutful influence of microflora on the preventing or the deceleration of the infection of the sweet chestnut by *E. parasitice*. The high efficiency of *Penicillium rubrum* was particularly visible. In the similar researches USCUPLIC and LAZAREV (1972) used four *Penicillium* species, one species from the genus *Trichoderma* and one bacterium which was not determined. Three isolates of *Penicillium* species and the bacterium were very antagonistic to *E. parasitica* in the laboratory conditions. One isolate of *Penicilliuma* and *Trichoderma* did not inhibit the growth of *E. parasitica,* but owning to the fast growth the growth of it was blocked. The results of their field researches showed that these antagonists were not able to prevent the germination of the reproductive organs of *E. parasitica* and it is way in which the biological fight did not give positive results.

The possibility of the use of some antagonists in the biocontrol of some pathogens of the forest trees in the laboratory conditions was also studied by KARADZIC (1992). He used *Penicillium rubrum*, *Trichotecium roseum* and *Trichoderma viride* as the biological agents in the fight against two *Nectria* and *Ophiostoma* species, and against *Sphaeropsis sapinea* species. *Penicillium rubrum* forms the zone of inhibition with the greatest number of the pathogenic fungi, which is particularly expressed on the potato-dextrose agar. *T. viride* proved to be a weak parasite, whereas *T. roseum* showed particularly strong parasitism towards *S. sapinea.*

In these reseaches instead of *T. viride* species *T. harzianum*, which was also used for the biological control of many plant pathogens, was applied. Weindling was the first to point out to the use of *Trichoderma* species for the biological control in 1932, by using *T. lignorum* in the fight against *Rhizoctonia solani,* which was quoted by HOWELL (2003). The species from this genus were also used in the fight against the most important pathogens of the root of the forest trees (*Heterobasidion annosum* and *Armillaria* sp.). Alongside the control of the chestnut blight, *T. viride* is used in the fight against *Chondrostereum purpureum* on the branches of the fruit trees GROSCLAUD et al. 1973).

Nowadays numerous biological preparations based on *T. harzianum* are used. In Belgium Bio-Fungus was registered, in Israel Trichodex and Trichoderma 2000, in the USA SoilGard, in Spain Tusal, and in India Trieco. The most significant of them in the domain of forestry is Binab-T (Sweden), which is used in the fight against the agents of the trees rot and the root pathogens, as well as Trichoject, Trichopel, Trichodowels and Trichoseal (New Zeland), which are used against the species from the gena *Armillaria*, *Botryosphaeria*, *Chondrostereum*, *Fusarium*, *Nectria*, *Phytophthora*, *Pythium* and *Rhizoctonia* (MONTE 2001).

The species from the gena *Trichoderma* are antagonistic in several ways. These mechanisms involve the competition for the space and the nutrients, mycoparasitism, production of the inhibitory substances, inactivation of the enzymes of the pathogens, and the induced resistance (MONTE 2001, HARMAN 2006,).

In these reseaches *T. harzianum* stopped the growth of *C. parasitica* after the contact was made. At 21^0C the contact was made between third and fourth day, and at 30^0 C the day later. At the place where the contact was made *T. harzianum* formed a concentric zone which was 2 cm wide in the subsequent days, and slowly began to overgrow *C. parasitica*. *Penicillium* sp. behaved similarly. The species *A. alternata* and *C. parasitica* stopped growing after eight days and between them the zone of inhibition was formed. When it grew in the same Petri dish with *T. roseum* at 21^0C, the contact was made after eight days, and at 30^0C between the ninth and tenth day. *C. parasitica* stopped growing, and *T. roseum* overgrew it by the zone which was between 1 and 2 mm wide. After the contact was made, *Aspergillus* sp. insignificantly overgrew *C. parasitica*.

Out of the observed species, the strong parasitism towards *C. parasitica* were exhibited by *T. harzianum* and *Penicillium* sp., whereas the significant antagonism towards it was exhibited by *A. alternata*. *Aspergillus* sp. and *T. roseum* behaved as the weak parasites. The parasitism of *T. roseum* was well-expressed only in the contact zone, which was 1 to 2 mm wide.

By applying the antagonists in the fight against the sweet chestnut blight, the satisfactory results were achieved in the laboratory and at the sample plots, but the mass production and the application of the antagonists in great areas poses a problem. SCHUBERT et al. (2008) state the formulations of the conidia and abiotic factors, particularly humidity, as the limiting factors for the mass application of *T. harzianum.*

5. CONCLUSION

Based on the laboratory studies of the interactions between some antagonists and *C. parasitica,* the following conclusions can be made:

- At both observed temperatures the species *T. harzianum* and *Penicillium* sp. show strong parasitism towards *C. parasitica*. The type of reaction of both species in the mixed culture with *C. parasitica* is VI.

- At both observed temperatures *A. alternata* shows the strong antagonism towards *C. parasitica* by forming the zone of inhibition. The type of reaction in the mixed culture with *C. parasitica* is I.

- *Aspergillus* sp. show weak parasitism towards *C. parasitica*. At 21^0 C in the mixed culture with *C. parasitica* the type of reaction is VI, and at 30^0 C the type of reaction is VIII.

- *T. roseum* show weak parasitism towards *C. parasitica*. In the mixed culture with *C. parasitica* the type of reaction is VI.

The obtained results point out to the fact that by the use of *T. harzianum* and *Penicillium* sp. the satisfactory results can be achived in the control of *C. parasitica*. It is necessary to check the obtained results in the field experiments, particularly since there are numerous registered biological preparations based on *T. harzianum*.

Acknowledgments
We are grateful to Ivana Potocnik on *T harzianum* isolate which was used in this study

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INTERACTIONS BETWEEN SOME ANTAGONISTS AND FUNGUS *CRYPHONECTRIA PARASITICA* (MURR.) BARR

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Summary

The fungus *Cryphonectria parasitica* (Murrill) Barr, which cause “chestnut bark disease“, has the greatest influence on the decay of sweet chestnut. The different methods were used in the fight against *C. parasitica.* One of the ways implied the introduction of the resistant Asian species of the chestnut and their crossing with sweet chestnut in the aim of obtaining the resistant forms. The attempts were made to apply the direct mechanical methods (felling of the infected trees or their parts, debarking), as well as to apply the chemical methods (applying oil antiseptics or other fungicides to the stumps). Nowadays the hypovirulent strains of the fungus *C. parasitica,* which enable the healing and the stop the spreading of the cankers, are most widely used.

Alongside, some other antagonistic and competative microorganisms were used for the biological control of this fungus (*Trichoderma* sp., *Penicillium rubrum*, *Bacillus suptilis*). These laboratory studies show that by the use of . *T. harzianum* and *Penicillium* sp. the satisfactory results in the control of *C. parasitica* can be achieved. These species in the mixed culture with *C. parasitica* show the strong parasitism towards *C. parasitica* at both observed temperatures. At both observed temperatures *A. alternata* shows the strong antagonism towards *C. parasitica* by forming the zone of inhibition (The type of reaction I). *Aspergillus* sp. and *T. roseum* show the weak parasitism towards *C. parasitica.* It is necessary to check the obtained results in the field experiments, particularly since there are numerous registered biological preparations based on *T. harzianum*.

МЕЂУСОБНИ ОДНОСИ НЕКИХ АНТАГОНИСТА И ГЉИВЕ *CRYPHONECTRIA PARASITICA* (MURR.) BARR

Златан РАДУЛОВИЋ, Драган КАРАЏИЋ

Резиме

На пропадање кестена највећи утицај има гљива *Cryphonectria parasitica* (Murrill) Barr која изазива "рак коре кестена". У борби против *C. parasitica* коришћене су различите методе борбе. Један од начина је уношење отпорних азијских врста кестена и њихово укрштање са питомим кестеном у циљу добијања отпорних форми. Покушано је и са применом директних механичких мера (сеча заражених стабала или њихових делова, гуљење коре) као и хемијских мера (премазивање пањева уљаним антисептицима или другим фунгицидима). Данас се највише користе хиповирулентни сојеви гљиве *C. parasitica* који омогућују зарастање и заустављање ширења рак-рана.

Поред ових, за биоконтролу ове гљиве коришћени су и неки антагонистички и конкурентски микроорганизми (*Trichoderma* sp., *Penicillium rubrum*, *Bacillus suptilis*). Наша лабораторијска истраживања указују да се коришћењем *T. harzianum* и *Penicillium* sp. могу постићи добри резултати у контроли *C. parasitica*. Ове врсте у смешаној култури са *C. parasitica* показују на обе испитиване температуре јак паразитизам према *C. parasitica*. *A. alternata* на обе испитиване температуре показује антагонизам према *C. parasitica* формирањем инхибиционе зоне (реакциони тип I). *Aspergillus* sp. и *T. roseum* показују слаб паразитизам према *C. parasitica*. Добијене резултате неопходно је проверити у огледима на терену, тим пре што већ постоји велики број регистрованих биопрепарата на бази *T. harzianum*.

SEEDLINGS MYCORRHIZATION UNDER THE TREAT OF CLIMATE CHANGES

Jelena LAZAREVIĆ[1]

Abstract: *Under the treat of climate changes, question of seedling production, as a one of the most important areas concerning forestry techniques in a whole, became more important, since both the successful forestation and quick development have been highly depending on the seedling quality.*

Mycorrhiza provides many benefits to both the seedlings and the adult trees. Ectomycorhhiza, formed with important coniferous species of Pinaceae and hardwood species of Fagaceae and Betulaceae, are prevailing inside forest ecosystems. Several thousand fungal species are thought to form ectomycorrhizas on the global scale, and more than 250 have been recorded in Montenegro until now.

Differences, expressed on ecological and functional significance of such diversity, are evident. Hence the value of individual species in seedling mycorrization is different.

In 2005-2009, collection containing 45 isolates of ectomycorrhizal fungi from Montenegro territory was formed. Based on literature data, and on hither experience in manipulation with these fungi, preliminary evaluations of individual fungi isolates for seedling mycorrization during nursery plant production were made.

The aim of the paper is not only to emphasize the importance of seedling mycorrhization in forthcoming period, through the explanation of benefits which those treatments are enabling, but also to signify the necessity of examination of features of ectomicorrhizal fungi isolates from autochthonous populations.

Key words: ectomycorrhiza, seedling production, isolates of ectomzcorrhizal fungi, autochthonous

INTRODUCTION

Under the treat of climate changes, question of seedling production, as a one of the most important areas concerning forestry techniques in a whole, became more important, since both the successful forestation and quick development have been highly depending on the seedling quality. Environment provides a continuous treat to initial plant establishment, especially in some areas of Southeastern Europe, due to the prevalence of high soil and air temperature, low relative humidity and low rainfall. In such situation careful selection and planting of high quality stock is crucial to ensure high survival rate in the field (Radoglou et al, 2009.) The seedling quality is being assessed by the evaluation of both morphological and physiological parameters which allow an anticipation of the success of the field installation. This also depends on the seed genetic information, production conditions, handling of the seedling and the plantation site. (Claro et al. 1998, cit. Lazarević, 2009)

Controlled inoculation techniques using mycorrhizal fungi, are useful as an additional nursery culture method to increase field performance of out-planting seedlings (Rincon et al, 2001). Mycorrhiza provides many benefits to both the seedlings and adult tree. Ectomycorhhiza (ECM), formed with important coniferous species of *Pinaceae* and hardwood species of *Fagaceae, Salicaceae* and *Betulaceae*, are prevailing among trees in forest ecosystems (Buscot et al. 2000).

Studies related on enhancement of resistance to environmental extremes have confirmed that ECM fungi not only enhance the growth, but also improve the survivorship of young trees. It is frequently observed that the more severe the environmental conditions are, the greater is the requirement for mycorrhizal colonization if survival is to be assured. As an illustration, data from investigations found 45% survival of nonmycorrhizal *Pinus taeda* seedlings at 40˚ C root

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temperatures, but 70 and 95% survival of plants inoculated with *Telephora teresstis* and *Pisolithus tinctorius*, unrelated to growth response.(Marx et al, 1982).

Mycorrhiza ameliorates the physiological status on seedlings mainly by improving water and nutrient uptake from the soil, carbohydrate distribution and growth substance production, so can play an important role in the protection of plants against environmental stress factors such as drought, pathogenic agents or heavy metal pollutions.

Morphological features of the mycorrhizal root system are particularly relevant to the physical base for the mycorrhizal response. Hatch (1937, cit Bowen 1970) proposed that nutritional response was due to increase in absorbing surface of the roots caused by increased diameter and branching of mycorrhizae, to the growth of hyphae into soil, and to the greater longevity of mycorrhizae. The distribution of absorbing power along roots is affected markedly by soil conditions, e.g., soil temperature, but one of the striking features of mycorrhiza is their sustained absorbing power in one place in soil. Mycorrhiza is functioning for a long period, and can feed from a much larger volume of soil than the elongating portions of uninfected root which are with a short functional life. (Bowen, 1970)

Presence of ectomycorrhizae enhanced pathogen resistance. Marx (1973, cit Read, 1999.) suggested that thick fungal mantle surrounding ECM roots would present an effective physical barrier to penetration by pathogens, but recent works is indicative of additional antibiotic properties of ECM fungi. Antifungal compounds have been isolated from pure culture of *Pisolithus tinctorius* and other ectomycorrhizal fungi. (Read, 1999).

Besides, mycorrizal colonisation enables significant increase in the rate of photosynthesis (Read, 1999). Perhaps one of the most important and very interesting questions is interplant transfer of resources (carbon transfer) trough mycorrhizal mycelia, in ectomycorrhizal system. While some specificity occurs in ECM partnerships, majority of these fungal associations of temperate and boreal forest tree species show little selectivity when colonizing roots (Molina et al, 1982). As a result, the mycelia of these fungi form extensive physical interconnections between individual trees and between tree species. Research using microcosms has enabled visualization of mycelial networks forming interspecific linkage and demonstrated, using ^{14} CO_2, that carbon can flow from plant to plant trough mycelial system (Finlay and Read, 1986 cit Read 1999).

Several thousand fungi are thought to form ectomycorrhizas on global scale (Buscot et al. 2000), and more than 250 putative ectomycorrhizal species are recorded in Montenegro until now (Lazarević et al, 2007). Differences which are expressed in their ecological rules and also on functional significance of such diversity are evident. Hence, the value of individual species in seedling mycorrization is different. Numerous investigations conducted all over the world in last 40 years, emphasize the importance of selecting compatible fungal-host species combinations for nursery inoculation and source of inoculum adapted to the environmental conditions of the transplantation site (Rincon et al, 2001_Parlade et all, 1996).

It is also clear that ectomycorrhizal fungi display extensive intraspecific variations in a range of physiological and other life-history parameters, depending not only on geographical or host plant origin. It seems likely that some of the observed intraspecific variations in ectomycorrhizal fungi represent ecotypic adaptations according to environmental pressures in different geographical regions or, on a smaller scale, to localized heterogenecity in edaphic conditions (Cairney, 1999). Understanding of intraspecific variation of ECM fungi is still rising, even the much more isolates from wider populations could be examined. In recent studies, it has been shown that intraspecific variations exist according following fungal features: mycelial growth, host fungus interactions, nitrogen utilization, enzyme activities, metal sensitivity (Cu, Al, Zn, Cd, etc.), temporal (meaning during meinaining in culture) variation of growth, etc. That's why it is necessary to examine characteristics of isolate from autochthonous and geographically close populations of ectomycorrhizal fungi, and estimate their real potential for seedling mycorrhization in process of nursery production.

In 2005-2009, collection containing 45 isolates of ectomycorrhizal fungi from Montenegro territory was formed. As a fundament for future works, preliminary evaluation of value of single fungus isolates for seedling mycorrization during nursery plant production was made.

MATHERIAL AND METHOD

Sporocarps of putative ectomycorrhizal fungi were collected thought 2006-2009 in different forest ecosystems and in park areas in Montenegro. Data about associated tree species and locality are noted for each of investigated species (Table 1). Isolation and taxonomic identification were carried out on the collected sporocarps. The names and taxonomic position of the species are given according Index fungorum. To obtain pure culture isolates, the sporocarps were externally brushed and the pieces of inner tissue were taken and placed in Petri dishes filled with modified Melin-Norkrans agar medium (MMN). Cultures were incubated 7-30 days on 22˚C depending on the species. The isolates obtained were transferred to MMN-filed tubes and maintained by transfer on MMN every 3 months. (Rincon et al, 1999)

Mycelium obtained in pure culture were later used for investigation of their growth on different culture media: solid, liquid and vermiculite- based (vermiculite-peat 10:1 moistured with liquid medium), and for inoculation of pine seedlings (*P. heldreichii* Christ and *P. nigra* Arnold) through vermiculite-base inoculums.

Sporocarps of *Pisolithus arhizus*, *Suillus granulatus and S. collinitus* were collected and used to obtain the spore inoculums. Final contrecation or spores was calculated by haemocytometer.

Based on literature data, and on hither experience in manipulation with them, there was made a preliminary evaluation of value of single fungus isolates for seedling mycorrization during nursery plant production.

RESULS AND DISSCUSION

In 2005-2009, collection containing 45 isolates of ectomycorrhizal fungi from Montenegro territory was formed.

Table 1. *Ectomycorhhiyal fungi isolates in collection, formed in period 2005-2009 from Montenegro territory.*

AGARICOMYCETES, ***AGARICOMYCETIDAE,*** *AGARICALES Amanitaceae*: ***Amanita caesarea*** (Scop.)Pers (**Cs,** Livari), ***A. citrina*** (Pers.)Pers (**Cs,** Livari), ***A. crocea*** (Quel)Singer (**Fm,** Biogradska Gora), ***A. muscaria*** (L.)Lam (**Pa,** Durmitor), ***A. pantherina*** (De)Crombh (**Qc,** Kržanja, Kuči), ***A. vaginata*** (Bull) Lam (**Pha** Gorica, Pg); *Cortinariaceae:* ***Cortinarius anomalus*** (Pers)Fr. (**Fm,** Građen, Kuči), ***Cortinarius 1.*** (**Cs,** Livari), ***Cortinarius 2.*** (**Ph,** Kastrat, Kuči); *Hydnangiaceae*: ***Laccaria ametystina*** Cooke (**Qc,** Građen, Kuči), ***Hygrophorus eburneus*** (Bull)Fr. (**Fm,** Građen, Kuči), *Inocybaceae*: ***Inocybe sp***.(Fr.)Fr. (**Pha,** Gorica, Pg); *Strophariaceae*: ***Hebeloma sinapizans*** (Fr.)Sacc (**Ph,** Građen, Kuči); *Tricholomataceae*: ***Tricholoma albobruneum*** (Pers)Kumm (**Pha,** Gorica Pg), ***T. batchii*** Guldern (**Ph,** Korita, Kuči), ***T. imbricatum*** (Fr.)Kumm (**Ph,** Korita, Kuči), ***T. stans*** (Fr). Sacc (**Ph,** Bindža, Kuči), ***T. sulphureum*** Kumm (**Cs,** Livari);
BOLETALES, Boletaceae: ***Boletus luridus*** var ***luridus*** Schaeff (**Qc,** Kržanja, Kuči), ***B. reticulates*** Schaeff (**Fm, Račama, Kuči**), ***B. fechtneri*** Velen (**Qc,** Kržanja, Kuči), ***B. radicans***

Pers (**Qc,** Građen, Kuči), ***B. legaliae*** Pilat (**Qc,** Građen, Kuči), ***Chalciporus piperitus*** (Mc Nabb)Pegler&Young (**Ph,** Bindža, Kuči), ***Chalciporus amarellus*** (Quel) Bataile (**Ph, Korita, Kastrat; Kuči**), ***Leccinum scabrum*** (Bull) Gray, (**Co,** Građen, Kuči), ***Xerocomus sp.1*** (***S,*** Pg**),** ***Xerocomus 2*** (***Fm+Ph,*** Račama, Kuči), ***Xerocomus 3*** (**Qc,** Kržanja, Kuči); *Sclerodermataceae:* ***Pisolithus arhizus*** (Scop.)Rauschert (**Ca,** Podgorica)**,** ***Scleroderma sp*** (**P,** Tivat); *Suillaceae:* ***Suillus granulatus*** (L.)Rousell (**Ph,** Građen, Korita, Kastrat, Račama; Kuči), ***S. collinitus*** (Fr) Kuntze (**Ph,** Građen, Korita; Kuči), ***S. mediteraneus*** (Jack&Bloom) Red**.** (**Pha,** Crvena Glavica, Bečići**),** ***S. lakei*** Murill (**Qi,** Podgorica).
INCERTAE SEDIS, CANTHARELLALES ***Hydnum sp***. (**Fm,** Lovćen), *RUSSULALES* ***Lactarius semisanguifluus*** Heim&Leclair (**Ph,** Korita, Kuči), ***L. volemus*** (Fr.)Fr.(**Pha,** Crvena Glavica, Bečići) ***Russula solaris*** (**Fm**, Biogradska Gora), ***Russula sp 1.*** (Pers)Fr (**Ph,** Korita, Kuči).

Associated host tree: **Cs**-*Castanea sativa* Mill, **Fm** –*Fagus moesiaca* (Maly) Czeczott, **Pa** –*Picea abies* (L.)Karst, **Qc**-*Quercus cerris* L., **Qi**-*Quercus ilex* L., **Ph**-*Pinus heldreichii* Christ, **Pha**-*Pinus halepensis* Mill, Ca- *Cedrus atlantica* (Endl.)Manetti ex Carriere, **Co**-*Corylus avellana* L., **S**-*Simphorycarpus orbiculatus* Moench, **P**-*Prunus* L. .

The success of mycorrhizal inoculation lies in the correct selection of mycorrhizal fungi. The preselection of ectomycorrhizal fungi is a critical step for establishing nursery inoculation programs. The selection criteria are based on physiological and ecological differences between different fungi, and even fungal strains, the symbiotic compatibility of fungus and host, the ecological adaptability of the mycorrhizal fungus to the site of transplantation, the ability of the fungus to compete against native fungi and the ease of inoculums production (Rincon et al, 2001, Parlade et all, 1996).

As potentially very important-valuable, following species were recognized: *Pisolithus arhizus (*syn. *P. tinctorius), Scleroderma sp., Suillus granulatus*, *S. collinitus.*

Experience in using *P. arhizus* in coniferous mycorization was excellent, all over the world. It has a proven host range of over 50 tree species. Sporophores of *P. arhizus* are readily identified because brown-yellow spores produced in peridioles are a unique characteristic. It forms large sporocarps containing many basidiospores, and sporocarps are usually formed in groups. In our collection, 1 g of spore containing 14,3 x 10^8 spore. (Material collected in Podgorica, 3.09.2009.) It means that about 2g of spore are enough for inoculation of about 300 seedlings in concentration 10^7 spore/plant). Mycelium of investigated isolate is brownie-reddish, dense and wooly. It intensively colored a growing medium, soon after inoculation. This fungus isolate can easy be propagated in laboratory on a solid, liquid or vermiculite-based media. According to literature, the fungus was capable of growing at 40˚ to 42˚ C and grew most rapidly at 28-30˚ C. Thermal death point of its hyphae was 45˚C (Marx et al, 1982). Tolerance of the fungus to high temperatures of growing substrata could be a key advantage for successful inoculation of seedlings in process of nursery production in Podgorica, and also for use in reforestation.

Scleroderma sp. has been found to be commonly associated with various tree species in nurseries as well in plantations and forests, and thought to be promising inoculants. These fungi are early root colonizers producing large quantities of rhizomorphs that enhance water uptake. They have been successfully used in warm and semi arid climates of Mediterranean to increase *P. radiata* and *P. pinaster* outplanting success (Parlade et al, 1996, Dunabeitia et al. 2004). and also are the component of some commercial products for seedlings mycorrhization. Mycelium of investigated isolate is white, dense and wooly; slow do mediate fast growing. The isolate can easy be propagated in laboratory on a solid, liquid or vermiculite-based media. Good results in mycorrhization by vegetative (vermiculite-base) inoculums we achieved on *P. nigra* seedlings 3 months after inoculation.

Suillus granulatus is common in natural forests of P. *heldreichii* producing abundant sporocarps, which makes it easy to obtain spore inoculums for large scale application in nursery. We calculated that one average sporocarp of *S. granulatus*, about 6 cm in diameter, contains about 10^9 spore. (Material collected on Račama (Kučka planina) 11.07. 2009). Isolates from *S. granulatus* from different localities trough *P. heldreichii* areal in Kučka planina in Montenegro all have white to yellow brownie colors, not equally colored on surface view, mostly laying trough the substrata, and are middle fast growing with optimum on 22-24° C. The isolates can easy be propagated in laboratory on a solid, liquid or vermiculite-based media. *S. granulatus* isolates originates from high mountain *P. heldreichii* forests, so the mycelium have a temperature optimum on lower temperatures, but it also could be presumed that it is well adapted for hard and extremely dry habitats. This species seems to be appropriate both for spore and mycelium inoculations, although according to Riffle and Tinus, (1982), inoculation with *S. granulatus* in USA generally shows low percent of seedling root colonization.

S. collinitus is the most frequent fungus of choice in European Meditteranean countries, where it is native and abundant, and was used for the production of *P. halepensis* in nurseries in Spain and France, where it improved the settlement and performance of *P. halepensis* plantations (Torres et al, 1994.). We calculated that one average sporocarp of *S. collinitus*, about 15 cm in diameter, containing about 2,4 x 10^9 spore. (Material collected on Gradjen (Kučka planina) 13.06. 2009)

As a valuable, but still under the examinations are: *Amanita caesarea*, *Cortinarius vulpinus, Tricholoma. Imbricatum, T. sulphureum*, *Melanogaster odoratisimus.*

Because of many favorable, but different among each other characteristics, following species are also under the detailed examinations: *Boletus luridus, B. reticulates, Chalciporus amarellus, Suillus mediteraneus, S. lakei, Lactarius semisanguifluus, Russula sp.*

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HETEROBASIDION ANNOSUM (FR.) BREF. AND THE CONDITION OF SCOTS PINE PLANTATIONS IN WEST BULGARIA

Boyan ROSSNEV, Peter PETKOV[1]

Abstract: *Studies on the health condition of Scots pine plantations have been performed in the period 1994-2008. The findings demonstrate a chronic process of defoliation and drying, including trees dying by groups. The action of Heterobasidion annosum in this process has been closely followed and observed. The dynamics of foci of infection increase has been established, as in some plantations it has them to become more dispersed caused.*

Key words: *Scots pine, Heterobasidion annosum, drying*

INTRODUCTION

Over the past 20 years, the research performed on how the major ecological factors influence the forest ecosystems has shown evidence that the disease on Scots pine, caused by the fungus *Heterobasidion annosum* (Fr.) Bref. is indeed very important but yet still underestimated. More and more plantations get a disease and dry out. Major contributors to this situation in most of the cases are the climate anomalies, as these plantations are intended for shallow (primitive) soils, in the oak tree forests, with serious disruptions in the water supplies.

West Bulgaria is a very typical region where after the 1950s hundreds of hectares pine forests have been created over bare areas, cultivated lands, pastures with disturbed microflora. They are situated in the pre-mountainous and mountainous parts, from 300-400 to 1400 m altitude, at the water reservoirs of the rivers Struma and Mesta (at the slopes of West Rila, West and East Pirin, Osogovo, Maleshevska and Konyavska mountains, and the West slopes of Vitosha mountain). Climatically all those regions are influenced by the Mediterranean draught – stronger in the areas of Gotse Delchev, Sandanski and Kyustendil, and weaker in Sofia region. However, all of the regions are beneficial for the growth and development of the Scots pine. Brown forest soils prevail (CM(dy), CM(eu)) but shallow (primitive) soils are not rare either – like those belonging to the Regosols and Leptosols types, which are a predisposition for a strong influence of drying-outs on the Scots pine growth and condition in the last few years.

The current research aims at tracing the dynamics of the changes that happen in the condition of the Scots pine cultures in West Bulgaria, and attempts to emphasize *H. annosum*'s role in the trees' drying process, in dispersing of some of the forest plantations, and undertaking adequate measures for improving this situation.

RESEARCH AREAS AND METHODICS

The evaluations on the trees and plantations condition have been performed by the ICP 'Forests' program methodics (1985-2005), in 8 Scots pine cultures, aged from 41 to 68 years (in 2008), growing at altitudes of 450 to 1385 m, at various exposures and in different soils (Table 1). All cultures have been parts of logging in the past.

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Table 1. *Ecological/Forest characteristics of the plantations investigated*

№	State forestry	Locality	Compo-sition	Age (2008)	Altitude (m)	Exposi tion	Soils	Precipi-tations mm/m^2
1	Botevgrad	Bebresh	Ps 9,Qp 1	43	450	S	CM(dy)	830
2	Breznik	Zavala	Ps 10	41	1092	NE	(um)LP	560
3	Gotse Delchev	Papaz chair	Ps 10	45	1205	SE	RG(dy)	696
4	Radomir	Dren	Ps 9,Pn 1	41	838	N	CM(cr)	606
5	Radomir	Galabnik	Ps 10	47	751	N	RG(eu)	606
6	Rila Monastery	Rila Monastery	Ps 10	55	1177	S	CM(eu)	594
7	Sandanski	Popina laka	Ps 10	56	1385	NW	RG(dy)	533
8	Radomir	Selimitsa	Ps 10	68	1300	W	CM(dy)	1060

In order to establish the condition of the trees from 1994 to 2008, visual evaluations of crown defoliation, colouration of needles, abiotic and biotic harmful influences have been performed. A complex evaluation has been carried out, based on all the research performed, and it reflects rates (from 0 to 4) and percents in the damage spread and health status.

H. annosum has been identified through fruiting bodies in the ground parts of tree trunks, as well as through other additional symptoms (needle shortening, decreased growth of the top and side shoots), and the rottenness in the roots of the trees becoming or already dry. The disease intensity is identified (every 4-5 years) by the quantity of drying up and already dry trees, and the size of the formed outbreaks.

RESULTS AND DISCUSSION

Fig. 1 shows the complex evaluation of the condition of all observed trees in the researched plots of land. Gradual deterioration in their condition took place in the period 1994-2008, as the defoliation increased and the needles colouration changed. The largest number of trees with rates 2-4 was observed in 2004, especially in the researched plots of land in Breznik, Galabnik, Dren and Selimitsa. A slight improvement has been noted afterwards. The findings demonstrate that the trees keep their one year old, two years old and partially the three-year old needles. Shrinking of the needles has also been observed. The number of trees with rates 3 and 4 - getting dried out and already dry - grows rapidly larger. The observed trend during the whole observational period is that the number of such trees increases. This process develops most slowly in the researched plots of land in Dren and Galabnik (from 0 up to 25%), while it does evolve much more swiftly in the other researched areas. It is very common that the drying out and already dry trees form outbreaks (boilers) with diameters ranging from 10 to 50 m, encompassing parts of the researched areas and stretching even beyond them. Some of the researched plots of land – Papaz chair, Celimitsa and Popina laka – have two formed outbreaks each, a fact that demonstrates clearly the range of the damage.

A more elaborated phytopathological study that has been performed shows that defoliation could result not only from the serious dry periods that have taken place in the last years, experienced in a most violent way in 2001-2004 but also from influence of the pathogens from the species *Lophodermium, Naemacyclus*, *Dothistroma* and *H. annosum.* Leaf-pathogens show varying magnitude, and affect mainly the lower and middle parts of the crowns.

The dry periods, along with the biological influences coming from pathogens, have lead to a decrease in the trees' vitality. In many of the cases of accidental attacks from stem insect pests from the species *Ipidae* and other, still before the complete drying out of the trees, the process of drying out is speeded up, and the famous pine bark beetle spots are formed.

*H. annosum'*s influence in this process is very strong. It has been found out that almost all drying out or dry trees in the researched plots have a roots fungus, whose rotting has spread to the roots and the ground trunk parts. The fungus' settling in the roots has most probably taken place after the selection cuts, which have been performed in all of the researched plantations but the fungus growth intensity varies. The intensity is defined by the size of the formed outbreaks along with the number of dried and drying out trees (Fig. 2). Weaker drying intensity, caused by *H. annosum*, clearly demonstrate the cultures growing in the drier lands of growth, situated at 700-800 m altitude (Zavala, Galabnik and Dren). On the contrary, a very intensive process of pathogen development and trees drying out are visible in the researched plots situated at 800 to 1300 m altitude – Rila Monastery, Popina laka, Papaz chair and Selimitsa. The plantations in those research plots have almost lost their quantity in the period from 1994 to 2008.

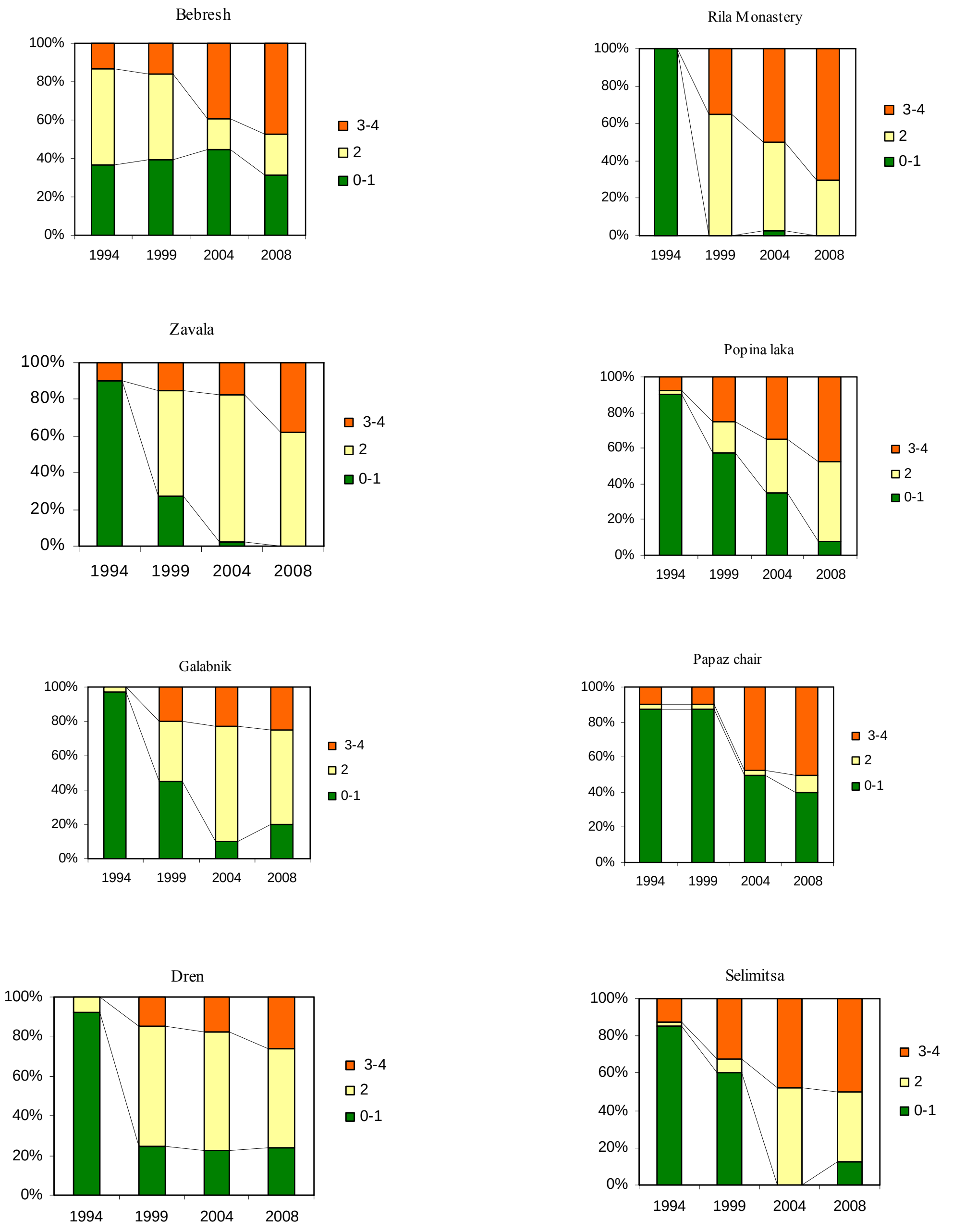

Fig. 1. *Health condition dynamics observed in the trees in the researched plots*

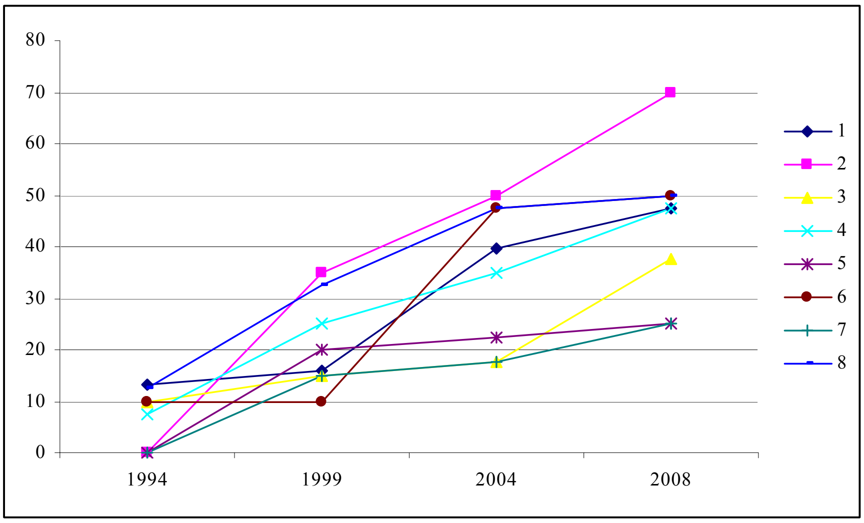

Fig. 2. *Development of H. annosum in the sample plots*

1 – Bebresh, 2 – Rila Monastery, 3 – Zavala, 4 – Popina laka,
5 – Galabnik, 6 – Papaz chair, 7 – Dren, 8 - Selimitsa

The plantation's age and health condition pose the question of what their future is. Wherever possible, it will be necessary that the Scots pine plantations get gradually replaced by deciduous root trees for the regions in the lower zone of growth, which is resistant to the fungus *H. annosum*. As for the plantations in the higher areas, a natural revival of the Scots pine will be necessary, when the new crops get planted, it is recommended that biological means for limiting the pathogen contamination and spread are used. Such products have been manufactured with fungi-antagonists as a base, and have proven effective. In such a manner we could create and sustain highly productive and long-lived new forests.

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CELLULOLITIC AND XYLANOLITIC ACTIVITY OF SOME WOOD – DECAYING FUNGI OF OAK WOOD *IN VITRO*

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Abstract: *It has been investigated cellulolitic as well as xylanolitic activity of four wood decaying fungi of Oak wood: Stereum hirsutum, Chondrostereum purpureum, Stereum rugosum and Xylobolus frustulatus in vitro. Wood decaying fungi with its' enzymatic complex decompose basic constituants of wooden cell wals – cellulose, chemicelluloses and lignin, in different ammount. As a consequence, it appears a few types of decay, so that mechanical properties depending of certain constituants are beeing lost. Cellulose in the wood use to build an scelet – substance and is being responsible for bending strength, while its' decomposition cause decrease or loss of this mechanical propertie of the wood. Decomposition of cellulose is forced if the chemicelluloses are previously removed from the wood. Only wood decaying fungi are capable to deteriorate chemicelluloses inside wooden cell wals. As a group of polysacharides built from great number of molecules of different sugars (50 – 200) they represent the main constituants of primary and seccundary walls. Cellulolitic activity has been investigated by "Clearing" and "Remazol – Avicel" method, while xylanolitic activity according to method of "Reduced Xylan". Result showed that the highest cellulolitic activity had Ch. purpureum. All tested fungi have had simmilar xylanolitic activity. Results gained in laboratorial conditions in vitro does not quite represent situation in nature where it happens that on enzymatic activity of fungi a numerous of factors have an simultanuous effect, so they should represent just an orientation.*

Key words: *Stereum hirsutum; Chondrostereum purpureum; Stereum rugosum; Xylobolus frustulatus*; enzymatic activity

CELULOLITIČKA I KSILANOLITIČKA AKTIVNOST NEKIH GLJIVA TRULEŽNICA HRASTOVOG DRVETA *IN VITRO*

Izvod: *Ispitana je celulolitička i ksilanolitička aktivnost četiri gljive truležnice hrastovog drveta: Stereum hirsutum, Chondrostereum purpureum, Stereum rugosum i Xylobolus frustulatus in vitro. Gljive truležnice svojim enzimskim kompleksom dekomponuju u manjoj ili većoj meri osnovne konstituante zidova drvnih ćelija – celulozu, hemiceluloze i lignin. Kao posledica toga javlja se više tipova truleži i gube se mehanička svojstva za koja su odgovorni pojedini konstituanti drveta. Celuloza u drvetu gradi skeletnu supstancu i odgovorna je za savojnu čvrstoću, a njena razgradnja izaziva smanjenje ili gubitak ovog mehaničkog svojstva drveta. Razlaganje celuloze ubrzano je ukoliko su iz njega prethodno uklonjene hemiceluloze. Samo su gljive truležnice sposobne da razaraju hemiceluloze unutar ćelijskih zidova drveta. One su grupa polisaharida izgrađenih od velikog broja molekula različitih šećera (50 – 200) i predstavljaju glavne sastojke primarnog i sekundarnog zida. Celulolitička aktivnost je ispitana "Clearing" i "Remazol – Avicel" metodom, a ksilanolitička- po metodu redukovanog ksilana. Rezulati su pokazali da najveću celulolitičku aktivnost ima Ch. purpureum. Sve ispitivane gljive generalno su imale sličnu ksilanolitičku aktivnost. Rezultati dobijeni u laboratorijskim uslovima in vitro, ne reprezentuju u potpunosti situaciju u prirodi gde na enzimatsku aktivnost gljiva istovremeno utiče veći broj faktora, pa kao takvi treba da predstavljaju samo orjentaciju.*

Ključne reči: *Stereum hirsutum*, *Chondrostereum purpureum*; *Stereum rugosum*; *Xylobolus frustulatus*; Enzimatska aktivnost

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1. INTRODUCTION

Phenomena of wood decay is directly connected with fungal enzymatic systems (Schmidt, O.; Kerner - Gang, N., 1986). While white rot fungi decompose lignin, cellulose and hemicelluloses, brown- and soft rot fungi decompose carbo - hydrates without- or with slight impact on lignin (Montgomery, R. .A. P., 1982). In hydrolysis of 4 – 0 - metilglucuronoxylan, four groups of xylanolitic enzymes take place: 1. extra cellular endo-beta-1,4-xylanases; 2. Intracellular and/or membranous exo-beta-1,4-xylozidases; 3. Alfa - glucuromidases and 4. acetilxylanesterases (Fengel, D.; Wegener, G., 1984). In this way a total hydrolysis happens. Glico - and galactoglucomannans use to be degradable on the simmilar way by beta - 1,4 - mananasas and beta - 1,4 manozidasas. Decomposition of cellulose can be provoked by different bacteria, imperfect fungi (*Fungi imperfecti*) and higher fungi (*Ascomycetes* and *Basidiomycetes*) consuming derivates of cellulose. Decomposition of the wood is also faster if the hemicelluloses are previously removed from wooden cell walls. Because of importance of hemicelluloses and cellulose, which quantity and organization define wood properties in the widest sense, it has been investigated cellulolitic as well as xylanolitic activities of 4 stereoide fungi.

2. MATERIJAL AND METHOD

Cellulolitic activity of tested fungi has been tested on two different ways using "Clearing" and "Ramazol-Avicel" method (Schmidt, O.; Kebernik, U., 1988). "Clearing" method is based on increased solubility of products of cellulose decom- position due to enzymatic activity, what in the presence of microorganisms which exude cellulolitic enzymes, causes clearing of agar containing “Whatman” cellulose prepared according to Walseth -u C. S. (1952). Aseptic inoculation has been done on free surfaces of agar media containing Whatman cellulose in tubes and incubation under standard climate conditions has been provided in period of 12 weeks. Two times a week it has been measured and marked the length of cleared zones, while average depth of clearing has been estimated based on three replicates. "Remazol - Avicel" method is based on using of reactive Remazol – brilliant blau which chemically reacts with cellulose (Avicel PH 105) according to procedure recommended by Ng, T. K. and Zeikus, J. G. (1980.). During decomposition of macromolecule of cellulose due to activity of cellulasas exudated by fungi, colored products of macromolecules of cellulose splitting, sett free. After that, depending on absorption (i. e. extinction) of light threw medium, cellulolitic fungal activity has been estimated by pho-tometry. Tubes (16 x 160 mm) containing two-parted agar, have been prepared according to prescription of Smith, R. E. (1977) and Collet, O. (1984). Inoculation has been done with round inoculums (7 mm) on the upper surface of blue part of medium, and incubation was 6 weeks at 24°C except for *X. frustulatus* and *Ph. chrysosporium*, which have been incubated at 28°C. Values on photometer have been notified as absorp- tion light coefficient (Hegarty, B. et al.,1987.). In the both cases, as control fungi it has been used *Phanerochaete chrysosporium* Karst. (P 65). (Perfect form: *Phanerochaete chrysosporium* Karst.- Fam. Corticiaceae; Imperfect form: *Sporotrichum pulverulenthum* Link, - Hyphomycetes).

The activity of endo – beta - 1,4 - xylanasas has been estimated according to method of “Reduced sugar” in filtrate of tested fungi by photometry. Fungus *Schizophyllum commune* (strain P 55), has been used as control due to its` strong xylanolitic activity. Based on difference in extinction of the light between control and test samples, i. e. coefficient of light – absorption, it has been estimated the content of xylose (mg/ml) in tested solutions by using of calibration curve, and out there also enzymatic activity in nanocathals. One nanochatal here is defined as delivering of 1 – nMol of xylosas for 1 second in 1 ml of filtrate at temperature of 30°C. Obviously, estimation of xylanolitic activity of tested fungi is based on estimation (by using photometry) of intensity of reducing of content of xylose due to enzymes, in filtrate of fungal cultures, during 15 min. at temperature of 30°C.

3. RESULTS AND DISCUSSION

According to "Clearing" method (Table 1.) all tested fungi provoked clearing of substrate, but the fastest was control fungi *Ph. chrysosporium* and the slowest *X. frustulatus*. Till the fifth week of incubation all tested fungi have had equal capability of clearing of substrate.

According to "Remazol - Avicel" method (Table 2.) the best cellulolitic activity has had the fungus *Ch. purpureum*, All other tested fungi have had more lower activity like as control species *Ph. chrysosporium* (253 till 270 nm).

All tested fungi (except control species *Sch. commune*) have had similar xylanolitic activity in the first three weeks (between 0,15 - 0,89 nKat), what means that they use to be orientated in similar level in consumption of xylan from nutritive substrate.

Table 1. *Speed of clearing of substrate with Walseth - cellulose (mm) due to 5 stereoide fungi and Ph. chrysosporium in dependence of time of incubation*

Fungus	**Depth of cleared part of substrate (mm) after…weeks**						
	2	**4**	**6**	**8**	**10**	**12**	**14**
Control	0	0	0	0	0	0	0
***Stereum hirsutum* (German strain)**	18	28	35 *	41	46	51	55
***Stereum hirsutum* (Domestic strain)**	15	22	24 *	26 *	29	31 *	38
Chondrostereum purpureum	16	27	41	55	63	71	74
Stereum rugosum	17	28	37	50	65	71	76
Xylobolus frustulatus	8	18	24	31	35	38	43
Phanerochaete chrysosporium	23	32	38	44	48	53	57

***** *: values from calibration curve*

The fungus *Ch. purpureum* after two weeks have had the strongest xylanolytic activity (0,74 nKat), and *S. rugosum* the lowest (0,15 nKat). Xylanolytic activity, as a part of metabolic process depends on the presence of alternative sources of certain nutrients, so that if in the wood fungus could find some alternative nutrients, its` xylanolytic activity could be lower or stronger in comparison to results gained by tests *in vitro*. Stronger xylanolytic activity of the fungus *Sch. commune* indicates its` higher requirements towards hemicelluloses as a carbon sources and energy, what could be one of reasons of its` pioneer appearance on the freshly felled timber or physiologically weakened trees.

Cellulolitic activity of fungi is different depending on test conditions (content of nutritive media, alternative sources of nutrients,temperature, pH etc.). The intensity of fungal attack on fibres of cellulose containing lignin and chemicelluloses, use to be much stronger than in the case of pure (native) cellulose or delignified wooden fibres.

Mandels, M. and Reese, E. T. (1960.) obtained that cellulolitic activity of fungi on cellulose substrate decreases fast in presence of 0,5% cellobiose, while after consuming of cellobiose, cellulasas itself activate again. This prove that many factors affect cellulolitic activity of fungi, although it is well known that removed mycelia from filtrate of culture does not inhibite activity of cellulasas that remain in substrate (Johansson, M., 1966.).

Table 2. *Absorption of light (at 578 nm) threw medium colored due to cellulolitic activity of 5 stereoide fungi and Ph. chrysosporium in dependence on time of incubation*

Fungus	**Absorption of light after ... weeks**				
	2	**3**	**4**	**5**	**6**
Control	0.248	0.252	0.265	0.245	0.250
Stereum hirsutum **(German strain)**	0.245	0.280	0.260	0.255	0.258
Stereum hirsutum **(Domestic strain)**	0.245	0.273	0.290	0.268	0.275
Chondrostereum purpureum	0.320	0.503	0.655	0.820	0.920
Stereum rugosum	0.260	0.278	0.325	0.300	0.298
Xylobolus frustulatus	0.258	0.280	0.300	0.270	0.270
Phanerochaete chrysosporium	0.260	0.268	0.270	0.253	0.260

Control fungi *Sch. commune* have had significantly stronger xylanolitic activity then other tested fungi - 7,85 nKat after two, and 8,07 nKat after 3 weeks of incubation. According to Dittberner, D. (1988), after 3 weeks this fungi have had activity of 6,96 nKat.

Based on gained results it should not be considered with secureabout intensity of xylanolytic activity of stereoide fungi (*in vivo*) inside the wood as a substrate since it also depends on presence of alternative sources of certain nutrient, previously of carbon. Regarding to chemical content of wood, intensity of xylanolytic activity could be less or higher comparing with one notified by our tests *in vitro*.

Table 3. *Xylanolytic activity (nKat) of 5 stereoide fungi depending on time of incubation*

Fungus	**Incubating period … weeks**	
	2	**3**
Stereum hirsutum **(German strain)**	0.52	0.89
Stereum hirsutum **(Domestic strain)**	0.37	0.22
Chondrostereum purpureum	0.74	0.82
Stereum rugosum	0.15	0.15
Xylobolus frustulatus	0.22	0.89
Schizophyllum commune	7.85	8.07

**** In tables are shown the highest values for appropriate serie***

4. CONCLUSION

The fastest clearing of substrate was in the case of control fungus *Ph. chrysosporium*, and slowest was *X. frustulatus*. According to "Remazol - Avicel" method, the strongest cellulolitic activity have had *Ch. purpureum*, The results of tests *in vitro* does not represent events in nature for shore. Xylanolitic activity for stereoide fungi was relatively low - between 0,15 do 0,89 nKat and all of them have had similar requirements towards xylan, while control fungi *Sch. commune* have had much stronger xylanolitic activity. All tested fungi increased xylanolitic activity with the time of incubation. Fungus *Ch. purpureum* after two weeks of incubation have had the strongest xylanolitic activity than all other tested fungi. Xylanolitic activity depends on the presence of alternative sources of certain nutrients in the wood, so if fungus could find some alternative nutrients, its` xylanolitic activity could be different than we concluded from results gained by tests *in vitro*.

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CELLULOLITIC AND XYLANOLITIC ACTIVITY OF SOME WOOD – DECAYING FUNGI OF OAK WOOD *in vitro*

Milenko MIRIĆ, Snežana IVKOVIĆ, Miroslava MARKOVIĆ

Summary

Cellulolitic as well as xylanolitic activity of four wood decaying fungi of Oak wood: *Stereum hirsutum, Chondrostereum purpureum, Stereum rugosum* and *Xylobolus frustulatus* have been investigated *in vitro*. Cellulolitic activity has been investigated by “Clearing” and “Remazol – Avicel” method, while xylanolitic activity according to method of “Reduced Xylan”. Result showed that the highest cellulolitic activity had Ch. purpureum. All tested fungi have had simmilar xylanolitic activity. Results gained in laboratorial conditions *in vitro* does not quite represent situation in nature where it happens that on enzymatic activity of fungi a numerous of factors have an simultanuous effect, so they should represent just an orientation.

CELULOLITIČKA I KSILANOLITIČKA AKTIVNOST NEKIH GLJIVA TRULEŽNICA HRASTOVOG DRVETA *IN VITRO*

Milenko MIRIĆ, Snežana IVKOVIĆ, Miroslava MARKOVIĆ

Rezime

Celulolitička i ksilanolitička aktivnost četirti gljive truležnice: *Stereum hirsutum, Chondrostereum purpureum, Stereum rugosum* i *Xylobolus frustulatus* ispitane su *in vitro.* Celulolitička aktivnost ispitana je “Clearing” i “Remazol – Avicel” metodom, dok je ksilanolitička aktivnost ispitana metodom “Redukovanog ksilana”. Rezultati su pokazali da je najveću celulolitičku aktivnost imala gljiva *Ch. purpureum*. Sve ispitivane gljive imale su sličnu ksilanolitičku aktivnost. Rezultati dobijeni u laboratorijskim uslovima *in vitro* ne reprezentuju u potpunosti situaciju u prirodi, gde na enzimatsku aktivnost gljiva mnogi faktori imaju istovremeni uticaj, pa kao takvi oni bi mogli predstavljati samo orjentaciju.

Investigations have been financially supported by project: MNTRS No:TR 2010536

SPEED OF PENETRATION OF WOOD – DECAYING FUNGI THREW MECHANICAL INJURIES ON STEMS OF SESSILE OAK *(QUERCUS PETRAEA AGG.) IN VIVO*

Milenko MIRIĆ[1], Snežana IVKOVIĆ[1], Miroslava MARKOVIĆ[2]

Abstract: *Speed of penetration of four wood - decaying fungi of Oak threw mechanical injuries on sound healthy trees have been investigated as follows: Stereum hirsutum (two geographicaly different strains), Chondrostereum purpureum, Stereum rugosum and Xylobolus frustulatus. Artificial inoculations with mycelia have been provoked in vital standing trees of Sessile oak (Quercus petraea agg.) in stands (in vivo) and appearance of dying - back symptoms, the rate of mycelia spread through the stem, speed of wound callusing and appearance of fruit bodies or decay symptoms, have been observed. The results of investigation show that decaying fungi spread faster in axial than in tangential direction, what is probably in dependence with anatomical structure of wood and direction of spreading of vessel elements inside the wood. During experiment all tested fungi have been reisolated from the sapwood zone except X. frustulatus which have been detected in the zone of heartwood. On the major number of stems the appearance of callusing in zone near by places of mechanical injury, i.e. inoculations, has been detected. Indexes of dieback of inoculated stems on Goč showed more changes than it was the case on the location of Slačina, but the changes on leafs haven't been detected neither here. Appearance of dried branches and leaf chlorozis have been detected just on a few stems at the end of the test, but it couldn't be directly connected with presence of tested fungi inside the wood, regarding that they have had an saprophytic way of nutrition, or appeared as weakened parasites, while for this test we had chosen sound healthy trees of Sessile Oak. Among five control stems which haven't been artificially inoculated, two stems changed indexes of dieback, what use to prove the state that artificial inoculation is not the causer of chlorozis. Indexes of dieback of inoculated stems on Goč showed more changes than it was the case on the location of Slačina, but the changes on leafs haven't been detected neither here. In this test, as like in major experiments in vivo, much more factors use to have impact on results than during the tests in vitro, what is often not possible to notify or to have under control.*

Key words: *Stereum hirsutum; Chondrostereum purpureum; Stereum rugosum; Xylobolus frustulatus*; *Quercus petraea*; wood biodeterioration;

BRZINA PRODIRANJA GLJIVA TRULEŽNICA KROZ MEHANIČKE OZLEDE NA STABLIMA HRASTA KITNJAKA *(QUERCUS PETRAEA AGG.) IN VIVO*

Izvod: *Ispitana je brzina prodiranja četiri gljive truležnice hrastovog drveta kroz mehaničke ozlede na zdravim stablima i to: Stereum hirsutum (dva geografski različita izolata), Chondrostereum purpureum, Stereum rugosum i Xylobolus frustulatus. Veštačke infekcije micelijom izvršene su na zdravim dubećim stablima kitnjaka (Quercus petraea agg.) u sastojinama (in vivo), a praćene su pojave simptoma sušenja, brzina širenja micelije kroz stablo, vreme kalusiranja rana, pojava plodonosnih tela gljiva i simptoma truleži. Rezultati istraživanja pokazuju da gljive truležnice brže prodiru u aksijalnom nego u bočnom pravcu, što verovatno ima veze sa anatomskom građom drveta i pravcem prostiranja sudovnih elemenata unutar drveta. Tokom ispitivanja sve testirane gljive su reizolovane iz zone beljike sem X. frustulatus koja je konstatovana u zoni srčike. Na većini stabala konstatovana je pojava kalusa u zoni mehaničkih ozleda, odnosno inokulacije. Pojava suvih grana i hloroze lišća konstatovana je na svega nekoliko stabala na kraju ogleda, ali se ne može dovesti u direktnu vezu sa prisustvom test gljiva u stablima, s obzirom da se radi o vrstama koje imaju saprofitski nacin ishrane ili se ponašaju kao paraziti slabosti, a za test su odabrana potpuno zdrava stabla kitnjaka. Od pet kontrolnih stabala, koja nisu veštački inokulisana, dva stabla su promenila indekse sušenja što takođe potvrđuje stav da veštačka inokulacija nije uzrok pojavi hloroze. Indeksi sušenja inokulisanih stabala na Goču pokazali su veće promene nego što je to bio slučaj na lokalitetu Slačina, ali ni ovde nisu konstatovane promene na lišću. U ovom, kao i u većini ogleda in vivo, na rezultate utiče mnogo veći broj faktora nego pri ogledima in vitro, a koje često nije moguće pratiti ili držati pod kontrolom.*

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Ključne reči: *Stereum hirsutum*, *Chondrostereum purpureum*; *Stereum rugosum*; *Xylobolus frustulatus*; *Quercus petraea*; biodegradacija drveta

1. INTRODUCTION

In process of dieback of Oak forests, fungi have the most emphasized role. Parasitic fungi attacking sound healthy trees have extraordinary importance but emphasized role in that process have also those species that behave as weakened-trees parasites and after felling of trees as a saprophytes. This species use to colonize wood threw different injuries on the surface on bark and to continue their destructive activity after felling of trees causing appearance of decay (Franckland, J. C.; Hedger, J. N.; Swift, M. J., 1982). Among such fungi in Oak stands there also almost always exist: *Stereum hirsutum and Chondrostereum purpureum (white rot), Stereum rugosum (cancer wounds) and Xylobolus frustulatu (heartwood white pocket rot – partridge wood).*

According to its` importance as well as the area of distribution in Serbia among the Oaks, the most important is Sessile Oak (*Q. petraea agg.)* and as like it is endangered from above mentioned decaying fungi.

2. MATERIJAL AND METHOD

Field tests have been performed on localities Slačina (Majdanpek domain, dep. 60) and Krčanik (Goč – dep. 89). Each two sound upstanding trees of Sessile Oak (*Quercus petraea agg*) have been artificially inoculated with 5 stereoide fungi in breast height (130 cm) till the depth of cca 50 mm. After 20, 22, 62, 122, 152 and 163 weeks of inoculation, it have been taken control plugs from the distance of 7,5 cm left and above of the point of inoculation. Health condition of tested trees has also been observing according to criteria for intensity of dying - back in class A, and changing of leafs color in class B, marked by indexes:

A_0 – health sound trees (no dried branches);
A_1 – initial phase of dying back (few dried branches);
A_2 – drying from the top (2 - 5 m);
A_3 - crown heavy thinned (over 50% dried branches) – final phase of disease;
A_4 – dried, dead trees;
B_0 – green color of leafs (no symptoms of chlorosis);
B_1 – slight chlorose (the first changes on leafs);
B_2 – strong chlorosis (covered over 50%);
B_3 - dried leafs;

Reactions of trees in the zones of mechanical injuries (wounds of inoculations) were observing on the appearance of callusing, deformation of cortical and sub cortical tissue, splitting in wound zones, ecsudation etc. Untreated sound trees in class A_0B_0, have been treated as like control.

3. RESULTS AND DISCUSSION

At locality of Slačina on the Sessile Oak stems, tangential spreading of mycelia of almost all tested fungi (except domestic strain of *S. hirsutum*), even after 163 weeks haven't reached distance of 7, 5 cm (Tab. 1). In the case of longitudinal spreading, mycelia has been detected at distance of 7,5 cm over the place of inoculation after 22 weeks for all tested fungi except *Ch. purpureum*, which also reached distance of 15 cm after 152 weeks on 50% of inoculated stems. In wound zones of inoculation, after 163 weeks plants formed vertically orientated callus in length ranging from 5 till 30 cm. Faster spreading in longitudinal direction use to be consequence of specific order of anatomical wood elements. Spreading of mycelia depends of fungal species, time of inoculation, part of stem, place of inoculation etc. (Boddy, L., Rayner, A. D. M., 1984). Laboratorial analysis proved that mycelia of all tested species could be reisolated from sapwood zone except *X. frustulatus* which has been reisolated from heartwood. This is in accordance with knowledge that all fungi we tested use to attack sapwood, except *X. frustulatus* which use to be taninophylic one and very tolerant against oxygen deficiency in the death zone of stem, i.e. heartwood. The question of changing of indexes of dieback should not be considered since control trees showed some changes as well. The changes on trees are probably consequence of acute phenomena of dieback in whole Europe and all over the world in last several decades, but not exclusively because of artificial inoculations of stems.

At locality of Krčanik on the Sessile Oak stems, results of tangential spreading of mycelia of all tested fungi have been identical as like for locality of Slačina (Tab. 2). In the case of longitudinal spreading, mycelia of German strain of *S. hirsutum* after 62 weeks has been detected at distance of 7, 5 cm, but only in one case. Mycelia of domestic strain has been detected on this height after 22 weeks (stem 2) and after 62 weeks (stem 1), and on distance of 15 cm after 156 weeks of inoculation. In wounds zones of inoculation, after 163 weeks plants formed vertically orientated callus in length ranging from 5 till 30 cm. Faster spreading in longitudinal direction use to be consequence of specific order of anatomical wood elements. Spreading of mycelia depends of fungal species, time of inoculation, part of stem, place of inoculation etc. Pearce, D. B.; Ruthrford, J. (1981). Fungus *Ch. purpureum* even after 163 weeks hasn't reached distance of 7, 5 cm neither in tangential, nor in longitudinal direction. Indexes of dieback of stems on Goč have more changes than in the case of locality Slačina, but even here it hasn't been detected the changes on leafs. Changes of dieback - indexes of control stems express the phenomena of acute dieback, which causer has not been detected by these investigations.

According to some authors, the depth of penetration of fungi depends on wound – diameter and concentration of inoculums, but not on tree age (Spiers, A.G., Hopcroft, D.H., 1988). Fresh wounds are the most endangered for infection, wounds old one month – hardly and after three months almost impossible to be infected by *Ch. purpureum*. The main reason should be in competition of other microorganisms that in the meantime already colonize the wound surface (Brooks, F. T., Storey, H. H., 1923; Brooks, F. T., Moore, W. C., 1926; Subramanin, C. V., 1983; Mercer, C. P., Kirk S. A., 1984).

Table 1. *Speed of mycelia penetration of 5 stereoide fungi and reaction of inoculated stems of Sessile Oak (Q. petraea) after 3 years at locality of Slačina*

Fungus	**Stem No:**	**h (m)**	**Direction of fungal spreading**	**Time (weeks) of fungal spread till distance of ...cm**			**State and look of stems 3 years after inoculation**	
		$D_{1,30}$		**<7,5**	**7,5**	**15**	**wounds**	**index of dieback**
***Stereum hirsutum* - German strain**	1	18	longitudinal		22	152	vc l=30cm	A_0B_0
		43	tangential	163	/	/		
	2	16	longitudinal		22	/	vc l=20cm	A_0B_0
		36	tangential	163	/	/		
***Stereum hirsutum* - domestic strain**	1	17	longitudinal		22	/	vc l=20cm	A_2B_0
		42	tangential		22	/		
	2	19	longitudinal		22	152	vc l=30cm	A_2B_0
		44	tangential	163	/	/		
Chondrostereum purpureum	1	16	longitudinal	163	/	/	vc l=10cm	A_1B_0
		39	tangential	163	/	/		
	2	16	longitudinal		22	/	vc l=5-7cm	A_0B_0
		45	tangential	163	/	/		

Stereum rugosum	1	18	longitudinal		22	/	wdct 30x10cm	A_2B_0
		41	tangential	163	/	/		
	2	17	longitudinal		22	152	cs l=10cm	A_1B_0
		40	tangential	163	/	/		
Xylobolus frustulatus	1	17	longitudinal		22	152	vc l=5cm	A_2B_0
		45	tangential	163	/	/		
	2	18	longitudinal		22	/	vc l=5cm	A_1B_0
		46	tangential	163	/	/		

vc: vertical callus; wdct: wave – like deformation of cortical tissue; cs: callused split;

The results of tests at locality Krčanik are shown in the table 2.

We do think that presence of microorganisms has influence on the speed of reaction of host-plant, but also that it could not be exclusive reason for wound callusing. Reactions in traumatic – zones are also the consequences of normal natural lignifications and diameter income of stems, as well as chemical reactions of wooden tissue – constituents and sap with atmosphere air.

Table 2. *Speed of mycelia penetration of 5 stereoide fungi and reaction of inoculated stems of Sessile Oak (Q. petraea) after 3 years at locality Krčanik (Goč)*

Fungus	**Stem No:**	**h (m)**	**Direction of fungal spreading**	**Time (weeks) of fungal spread till distance of ...cm**			**State and look of stems 3 years after inoculation**	
		$D_{1,30}$		**<7,5**	**7,5**	**15**	**wounds**	**index of dieback**
***Stereum hirsutum* - German strain**	1	15	longitudinal	163	/	/	nr	A_3B_0
		40	tangential	163	/	/		
	2	15	longitudinal		62	/	vc l=10cm	$A_{2-3}B_0$
		40	tangential	163	/	/		
***Stereum hirsutum* - domestic strain**	1	17	longitudinal		62	156	vc l=25cm	$A_{1-2}B_0$
		35	tangential		22	/		
	2	18	longitudinal		22	156	vc l=25cm	$A_{2-3}B_0$
		40	tangential	163	/	/		
Chondrostereum purpureum	1	17	longitudinal	163	/	/	vc l=11cm	A_1B_0
		25	tangential	163	/	/		
	2	18	longitudinal	163	/	/	vc l=11cm	A_1B_0
		40	tangential	163	/	/		
Stereum rugosum	1	17	longitudinal		22	/	wdct 20x10cm	A_1B_0
		45	tangential	163	/	/		
	2	17	longitudinal		22	/	ncs 25x10cm	$A_{1-2}B_0$
		35	tangential	163	/	/		
Xylobolus frustulatus	1	12	longitudinal		62	156	vc l=4cm	$A_{0-1}B_0$
		30	tangential	163	/	/		
	2	14	longitudinal		62	156	vc l=4cm	$A_{0-1}B_0$
		35	tangential	163	/	/		

vc: vertical callus; wdct: wave – like deformation of cortical tissue; ncs: non callused split; nr: no reaction;

3. CONCLUSION

Tested decaying fungi penetrate faster in longitudinal than in tangential direction, due to anatomical structure and direction of tracheas inside the wooden tissue. During investigation all tested fungi have been reisolated from the zone of sapwood, except *X. frustulatus* which has been detected in heartwood. On the most of inoculated stems it has been detected the appearance of callus in the zones of mechanical injuries, i.e. places of inoculation. Appearance of dried branches and leaf chlorosis have been notified on only few stems at the end of the test, but it could not be considered in direct connection with the presence of test fungi in stems. Among control stems which haven't been artificially inoculated, two trees changed their indexes of dieback, what use to be proof that artificial inoculation was not the causer of chlorosis appearance. Indexes of dieback of inoculated stems on Goč have had much more changes than in the case of locality of Slačina, but also without changes on leafs. In tests *in vivo* there are many affecting factors which have certain important impact on results of experiments.

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Summary

Speed of penetration of four wood - decaying fungi of Oak threw mechanical injuries on sound healthy trees have been investigated as follows: *Stereum hirsutum*, *Chondrostereum purpureum, Stereum rugosum* and *Xylobolus frustulatus*. Artificial inoculations with mycelia have been provoked in vital standing trees of Sessile oak (*Quercus petraea agg.*) in stands *(in vivo)* and appearance of dying - back symptoms, the rate of mycelia spread through the stem, speed of wound callusing and appearance of fruit bodies or decay symptoms, have been observed. The results show that decaying fungi spread faster in longitudinal than in tangential direction, what is in dependence with anatomical structure of wood. During test all used fungi have been reisolated from the sapwood zone, except *X. frustulatus* which have been detected in heartwood. Appearances of dried branches and leaf chlorosis have been detected just on a few stems at the end of the test, but it couldn't be directly connected with presence of tested fungi inside the wood, regarding that they have had a saprophytic way of nutrition. Two control stems changed their indexes of dieback, so that artificial inoculation was not the causer of chlorosis appearance.

BRZINA PRODIRANJA GLJIVA TRULEŽNICA KROZ MEHANIČKE OZLEDE NA STABLIMA HRASTA KITNJAKA *(QUERCUS PETRAEA AGG.) IN VIVO*

Milenko MIRIĆ, Snežana IVKOVIĆ, Miroslava MARKOVIĆ

Rezime

Ispitana je brzina prodiranja četiri gljive truležnice hrasta kroz mehaničke ozlede na potpuno zdravim stablima i to: *Stereum hirsutum*, *Chondrostereum purpureum, Stereum rugosum* i *Xylobolus frustulatus*. Veštačke inokulacije su izvršene na zdravim dubećim stablima kitnjaka (*Quercus petraea agg.*) u sastojinama *(in vivo)* i praćene su pojave simptoma sušenja, brzina širenja micelije kroz stablo, brzina kalusiranja rana, pojava plodonosnih tela ili simptoma truleži. Rezultati pokazuju da se gljive truležnice brže šire u aksijalnom nego u tangencijalnom pravcu, što zavisi od

anatomske građe drveta. U toku testa sve ispitivane gljive su reizolovane iz zone beljike osim *X. frustulatus* koji je konstatovan u srčici. Pojava suvih grana i hloroze lišća je zabeležena na samo nekoliko stabala na kraju ogleda, ali to ne može biti u vezi sa prisustvom ispitivanih gljiva unutar drveta, s obzirom da one ispoljavaju saprofitski način ishrane. Dva kontrolna stabla promenila su svoj indeks sušenja, tako da veštačka inokulacija nije bila uzročnik pojave hloroze.

Investigations have been financially supported by project: MNTRS No:TR 2010

RESISTANCE OF THERMALLY MODIFIED BEECH WOOD - *FAGUS MOESIACA* (DOMIN, MALLY/ CZECZOTT.) AGAINST SOME WOOD DECAYING FUNGI

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Abstract: *Resistance of the beech wood - Fagus moesiaca (Domin, Mally, Czeczott.) exposed to different temperature treatments, against wood decaying fungi, has been investigated using samples dim. 25 x 15 x 5 mm³. Thermally treatment has been performed according to method reccomended by Welbacher (2007.). Samples have been exposed to the temperatures of 100, 140, 170 and 200 ºC , during 5 hours. After thermal treatment samples have been exposed to the impact of wood decaying fungi: Coniophora puteana (Schum.:Fr.) Karst. and Trametes versicolor (Fr.) Pil. in Petri dishes (D = 90 mm) in duration of 8, 12 and 16 weeks. Mass loss of beech wood due to impact of decaying fungi has been estimated as a difference of masses of samples in absolutely dried condition before and after exposition to fungal attack and calculated in percentage. By this investigation it has been confirmed that thermally modified wood (TMW) use to be more resistant against impact of fungi causing brown- and white rot in comparison to untreated- or treated wood at lower temperatures. Nevertheless, gained results are obtaining that thermally modified wood as material is not resistant against impact of decaying fungi, especially against the causers of white rot.*

Key words: Thermally modified wood, *Fagus moesiaca,* mass loss, *Coniophora puteana, Trametes versicolor.*

OTPORNOST TERMIČKI MODIFIKOVANOG DRVETA BUKVE PREMA NEKIM GLJIVAMA TRULEŽNICAMA

Izvod: *Otpornosti drveta mezijske bukve (Fagus moesiaca (Domin, Mally, Czeczott.)) izlaganog različitim termičkim tretmanima prema nekom gljivama truležnicama ispitan je na uzorcima dimenzija 25 x 15 x 5 mm³. Termički tretman je izvršen po metodu koji je predložio Welbacher, C.R. (pers.com., 2007.). Uzorci su izloženi temperaturama od 100, 140, 170 i 200ºC u trajanju od 5h. Nakon termičkog tretmana, uzorci su izloženi dejstvu lignikolnih gljiva: Coniophora puteana (Schum.:Fr.) Karst i Trametes versicolor (Fr.) Pil. u Petri posudama (D = 90 mm) u toku 8, 12 i 16 nedelja.. Gubitak mase bukovog drveta pod uticajem gljiva truležnica određen je na osnovu razlike u masi uzoraka u apsolutno suvom stanju pre i posle izlaganju napadu gljiva i izražen u procentima. Ovim istraživanjima je potvrđeno da je termički modifikovano drvo otpornije na uticaj gljiva izazivača mrke i bele truleži od drveta koje nije tretirano ili je tretirano na nižim temperaturama. Međutim, dobijeni rezultati ukazuju da je termički modifikovano drvo material koji nije otporan na uticaj epiksilnih gljiva, naročito onih koje izazivaju belu trulež.*

Ključne reči: termički modifikovano drvo, *Fagus moesiaca*, gubitak mase, *Coniophora puteana, Trametes versicolor.*

1. INTRODUCTION

Thermal modification of wood in Europe has been tested in the last decade as a non toxic and ecologically acceptable method in the aim of increasing wood durability against pest organisms. This physical method causes chemical degradation of some constituents of wooden cell walls making it inconvenient as a appropriate substrate for developing of pest microorganisms, stabilizing in the same time its` dimensions, but also decreasing some

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mechanical properties (Mayes, Oksanen, 2002). Impact of thermal modification has been investigated on some conifers (Pinus sylvestris L., Picea abies Karst., Abies alba Mill., Pseudotsuga menziesii Franco etc.), and on some broad leaf wood (Quercus petraea Liebl. and Fagus silvatica L.) so far. As in Serbia beech forests are presented in pure and mixed stands with other broad leaved trees and conifers up to 50% in area and volume (Medarević et all., 2005), it is one of the most important domestic wood species. It has to be emphasized that beech wood use to be extremely sensitive against different microorganisms, especially against wood decaying fungi. By certain investigations and monitoring it has been obtained some 18 wood decaying fungi occurring on the beech wood on storages (Petrović, Mirić, 1987). Thermal modification should provide better dimensional stability, as well as increasing of durability of beech wood against wood decaying fungi in certain condition of exploitation.

2. MATERIAL AND METHOD

Impact of thermal modification on resistance of beech wood (*Fagus moesiaca* /Domin, Mally/Czeczott.) has been estimated based on mass loss of samples exposed to mycelia of brown- and white rot fungi: *Coniophora puteana* (Schum.:Fr.) Karst and *Trametes versicolor* (Fr.) Pil..

Wood samples originated from mountain Goč dim. 25 x 15 x 5 mm^3 have been exposed to thermal treathment of 100, 140, 170 and 200 ºC during 5h. After measuring of wood in absolute dried conditions and sterilisation by UV light, samples have been exposed to dicariotic mycellia of test fungi during 8, 12 and 16 weeks at temperature of 25 ± 2 ºC.

Based on difference in masses of samples before and after fungal attack, the mass loss has been calculated using formula: $G_m = (m_1 - m_2) / m_1 \times 100$ (%), where is: G_m = Mass loss (%);m_1 = Mass of absolutely dried wood before fungal attack (g); m_2 = Mass of absolutely dried wood after fungal attack (g);

3. RESULTS AND DISCUSSION

Maximal mass loss of beech wood due to thermal treathment appeared at temperature of 200ºC and it reached 6,14%, while at 170ºC it was just 0,24% and at 140ºC of about 0,13% (figure 1). All wooden samples darkened due to exposure at high temperatures. Treatments at 100 till 170ºC have no significant impact on resistance of wood against wood decaying fungi *Coniophora puteana* and *Trametes versicolor*, but treatment at 200 ºC increased resistance significantly.

Mass loss due to impact of *Coniophora puteana* (table 1.) after 8 weeks at 200 ºC, decreased on just 3,93%, what is 6 times less in comparison with control (24,48%), while after 12 weeks mass has been decreased for 5,82% (control 31,71%), and after 16 weeks for 9,65% (control 37,93%) (photo 1,2,3), what means that thermal modification of beech wood at 200 ºC during 5 hours does not protect the wood against brown rot fungi, but just decreases their impact. Mass loss of wood due to *Trametes versicolor* (table 2.) after 8 weeks treated at 200 ºC decreased from 33.27% to 13,36%, and after 12 weeks from 34.78% to 19.42%, while after 16 weeks mass loss reached 19.46%, and in the same time control was 45.25% (photo 1,2,3). That proved that thermal modification does not make beech wood resistant against white rot fungi.

Photo 1. *Samples of TMW after 8 weeks of impact of T. versicolor (up) and C. puteana (down). From left to right: Control; 100 ºC; 140 ºC ; 170 ºC ; 200 ºC;*

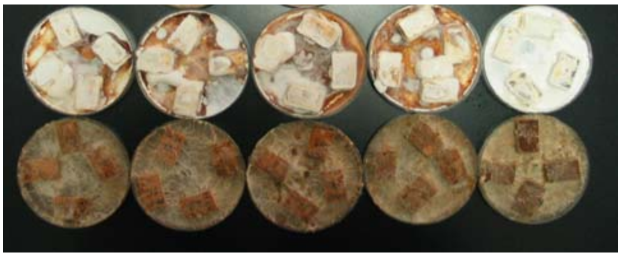
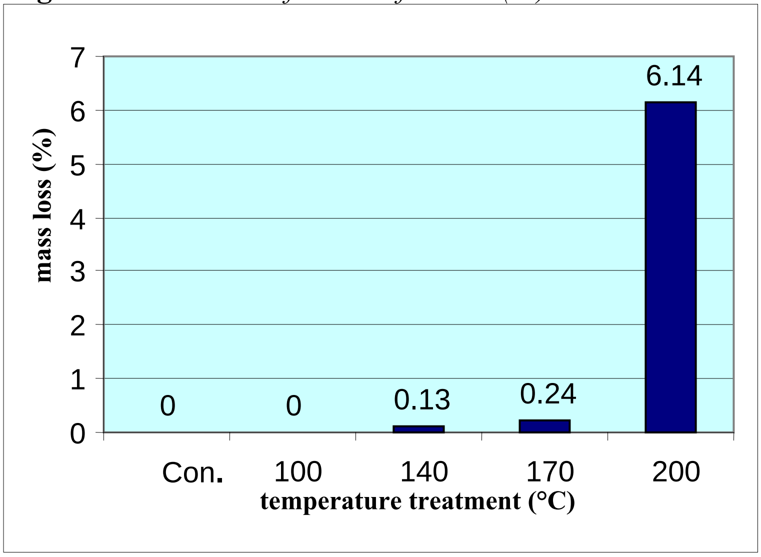


Photo 2. *Samples of TMW after 12 weeks of impact of T. versicolor (up) and C. puteana (down). From left to right: Control; 100 ºC; 140 ºC ; 170 ºC ; 200 ºC;*

Photo 3. *Samples of TMW after 16 weeks of impact of T. versicolor (up) and C. puteana (down); From left to right: Control; 100 ºC; 140 ºC ; 170 ºC ; 200 ºC;*

Figure 1. *Mass loss of TMW of beach (%) due to treatment*



Difference in mass loss between wood treated at 200 ºC and control group of samples exposed to impact of fungus *Coniophora puteana* use to be significantly bigger than the difference in mass loss of the same groups of samples exposed to fungus *Trametes versicolor*.

That phenomena should be explained with fact that during thermal modification cellulose and hemicelluloses change itself much more than lignin (Weiland, Guyonnet, 2003). Mass loss of samples due to impact of decaying fungi under all temperature treatments and in all three incubation period is significantly less in the case of samples exposed to attack of fungus *Coniophora puteana* than *Trametes versicolor* (figure 2,3,4).

Table 1. *Mass loss of TMW of beech (%) due to impact of Coniophora puteana*

Temperature treatment	**Mass loss (%) after... weeks due to impact of C. puteana**		
	8	**12**	**16**
Control	24.48	31.71	37.93
100°C	25.05	31.44	38.20
140°C	24.71	30.86	37.26
170°C	24.55	30.12	35.27
200°C	3.93	5.82	9.65

Table 2. *Mass loss of TMW of beech (%) due to impact of Trametes versicolor*

Temperature treatment	**Mass loss (%) after... weeks due to impact of T. versicolor**		
	8	**12**	**16**
Control	33.27	34.78	45.25
100°C	32.88	33.22	45.52
140°C	32.10	33.05	46.91
170°C	30.87	36.88	44.37
200°C	13.36	19.42	19.46

Figure 2. *Mass loss of TMW of beach (%) due to impact of C. puteana and T. versicolor after 8 weeks*

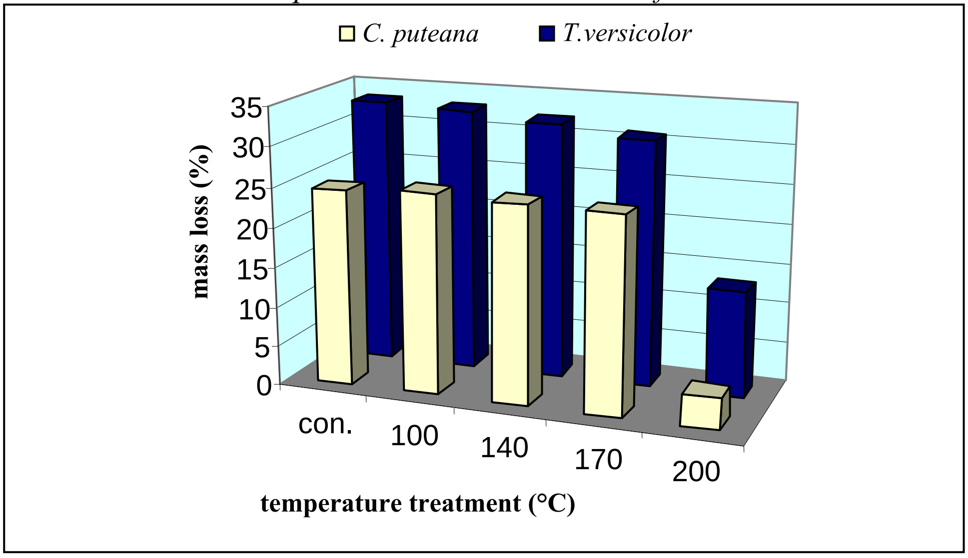


Figure 3. *Mass loss of TMW of beach (%) due to impact of C. puteana and T. versicolor after 12 weeks*

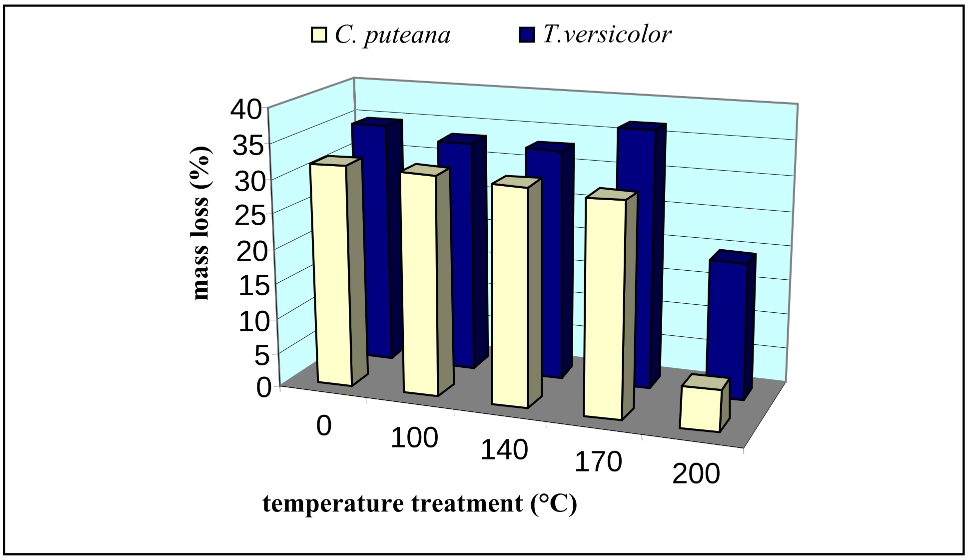
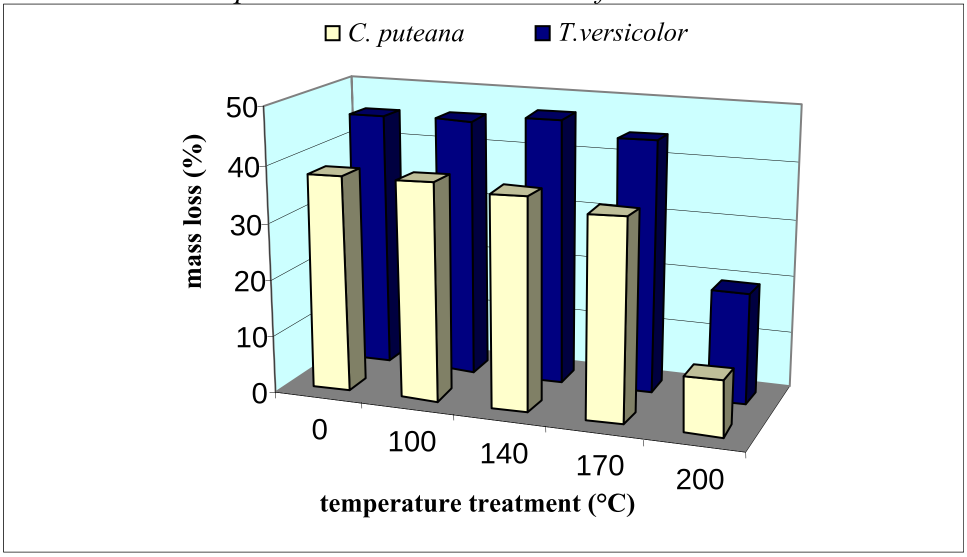


Figure 4. *Mass loss of TMW of beach (%) due to impact of C. puteana and T. versicolor after 16 weeks*



4. CONCLUSION

It is confirmed by this tests that beech wood after thermal treatment become darker and that the mass loss is the most emphasized at treatment by 200 ºC and reaches 6,14%, while at 170 ºC was just 0,24%.

Wood treated 5 hours at 200 ºC and exposed to fungus *C. puteana* after 16 weeks incubation lost in average 9,65% of its` mass, while the fungus *Trametes versicolor* caused mass loss of 19,46%. Based on reached results one could conclude that used thermal treatments does not protect the beech wood against fungal attack, but just increase its` resistance.

Difference in mass loss between wood treated at 200 ºC and control group of samples exposed to brown rot fungus *Coniophora puteana* is less than the difference in mass losses of the same groups of samples exposed to fungus *Trametes versicolor*. This phenomena could be explained by facts that during treatment of wood by high temperature the cellulose changed much more than other wood constituents.

This tests show that thermal modification of wood is not the method which could protect it against impact of harmful microorganisms, but just decrease their influence.

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RESISTANCE OF THERMICALLY MODIFIED BEECH WOOD – *FAGUS MOESIACA* (DOMIN, MALLY/ CZECZOTT.) AGAINST SOME WOOD DECAYING FUNGI

Snežana IVKOVIĆ, Milenko MIRIĆ, Vladan JELKIĆ, Miroslava MARKOVIĆ

Summary

Resistance of beech wood - *Fagus moesiaca* (Domin, Mally, Czeczott.) exposed to different temperature treatment during 5 hours, against impact of decaying fungi: *Coniophora puteana* (Schum.:Fr.) Karst and *Trametes versicolor* (Fr.) Pil., has been tested after 8, 12 and 16 weeks of incubation. Based on gained results one can conclude that thermal treatment described in this article does not protect the wood against decaying fungi, but just increase its` resistance. Significant difference in mass loss between the wood treated by 200 ºC and control group, appeared in the case of *Trametes versicolor* what can be explained by the fact that during heat treatment with high temperature, cellulose use to be changed much more. These investigations show that thermal modification is not the method that could protect the wood against the impact of pest microorganisms, but only that their impact could be decreased.

OTPORNOST TERMIČKI MODIFIKOVANOG DRVETA BUKVE PREMA NEKIM GLJIVAMA TRULEŽNICAMA

Snežana IVKOVIĆ, Milenko MIRIĆ, Vladan JELKIĆ, Miroslava MARKOVIĆ

Rezime

Otpornost drveta bukve - *Fagus moesiaca* (Domin, Mally, Czeczott.) izloženog različitim temperaturnim tretmanima u trajanju od 5h prema dejstvu lignikolnih gljiva: *Coniophora puteana* (Schum.:Fr.) Karst i *Trametes*

versicolor (Fr.) Pil. ispitana je nakon 8, 12 i 16 nedelja inkubacije. Na osnovu rezultata sprovedenih istraživanja, može se zaključiti da termički tretmani opisani u radu ne štite drvo od gljiva truležnica, već samo povećavaju njegovu otpornost. Značajna razlika u gubitku mase između drveta tretiranog na 200 ºC i kontrolne grupe, javila se kod *Trametes versicolor*, što se može objasniti činjenicom da se pri tretmanu drveta visokom temperaturom, u većoj meri menja celuloza. Ova istraživanja pokazuju da termička modifikacija nije metod kojim se drvo može zaštiti od uticaja štetnih mikroorganizama, već da se njihov uticaj samo može umanjiti.

Investigations have been financially supported by project MNTRS No:TR 20105

THE ROLE OF FOREST POLICY IN FIGHTING CLIMATE CHANGE IN R. MACEDONIA

Makedonka STOJANOVSKA[1], Marina MIOVSKA[2], Vladimir STOJANOVSKI[3]

Abstract: *This paper analyzes existing forest policy with concern to fighting climate change in R. Macedonia.*

Forestry in general has not been adequately incorporated into the current mitigation efforts – neither in terms of fossil fuel substitution nor in terms of the carbon sequestration potential for forests. Moreover, the adaptation of forestry to climate change has been almost entirely neglected in Macedonia. There are many benefits that society and environment can gain from the forests, like wood from one side but what is more non-wood forest products, soil protection, water regulation, conservation of natural habitats and biodiversity, recreational functions and many others. From other perspective all might be seriously jeopardized. That is the main purpose to analyze the untaken activities towards mitigation climate change with connection to forestry and in addition to produce recommendations for further development.

The method used is qualitative analysis of secondary data related to forestry and climate change.

The results have shown that there are number of law regulations and measures taken by the appropriate institutions concerning climate changes. It has to be stressed that MOEPP is more active in this area and the most of activities and measures that were undertaken during last decade are initiated by environmentalists. Moreover, forestry has introduced international policy related to the mitigation of climate change later. Still, it is very important that first steps are made and forest policy is going into right direction.

This paper has huge importance and should be a basis for further analyses regarding policy development processes concerning climate changes in Macedonia.

Key words: Law on Forest, Law on Nature, legislation collision, forests, environment.

INTRODUCTION

Climate change has emerged as one of the most important issues facing the global community in the 21st century. The primary cause of climate change is increased concentrations of greenhouse gas (GHG) due to the human activities, such as combustion of fossil fuels, deforestation and increased methane emissions. In response to emerging of these impacts, the international community negotiated the United Nations Framework Convention on Climate Change (UNFCCC), which was signed at the Rio Earth Summit in June 1992 and came into force in March 1994. To reinforce the goals of Convention, Kyoto Protocol was adopted in 1997.

Acknowledging the significance of the climate change problem and the necessity to take effective actions for its mitigation, on December 4, 1997, Macedonia ratified the UNFCCC and became a party to the Convention on April 28, 1998. In January 2000, the Climate Change Project Office was set up within the MOEPP to support the development of the First National Communication on Climate Change. Afterwards, Macedonia harmonized its existing legislation with the European one.

The forestry in general has not been adequately incorporated into current mitigation efforts – neither in terms of fossil fuel substitution nor in terms of the carbon sequestration

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potential for forests. Moreover, the adaptation of forestry to climate change in Republic of Macedonia has been almost entirely neglected.

In Macedonia, the forests cover more than one third of the total territory, or about one million ha. Forests, forest crops and intensive plantations occupies an area of 934.128 ha[1] or 36,7% of the total area of the country. Net absorption of CO_2 by Macedonian forests is estimated to be in the range of 2.2 $MtCO_2eq/yr$. However, the level of CO_2 absorption can be significantly ameliorated: almost 71% of the total area under forest in Macedonia is currently occupied by low dendriform and degraded forests. Activities leading to reforestation of degraded forest areas are technically eligible to be registered under CDM mechanisms and generate CERs in the amount corresponding to the increase in sinks of GHG in re-forested area.

Therefore, the main goal of this paper is to inquire the involvement of the forestry sector and sector for environment towards climate changes issues and regarding Macedonian' legislation framework. The objectives set are determining if the forestry legislation documents addressed climate changes issues within and what is the amount and type of activities undertaken from the forestry sector side regarding the mitigation of climate changes effects in Macedonia.

METHODOLOGY AND METHODS

The method used for the needs of this research was summative content analyzes. It involved counting and comparison of the keyword for this paper "climate change", found in the text or in the chosen and reviewed related documents of the Macedonian regulation in the forestry sector and the sector of environment. The examined documents for this paper are taken from the available existing sources mainly from written documents and as well as from the internet sources.

DATA ANALYSIS

Within the data collection phase for this research, the regulations that are in connection with the climate change issues are analyzed. Therefore, the Law regulations in Macedonia, that concern this topic are divided into two groups and therefore carried out and ratified by following institutions: Ministry of agriculture, forestry and water economy – **FORESTRY REGULATION**; and by the Ministry of environment and physical planning – **ENVIRONMENTAL REGULATION**.

The analyses here are presented through related parts of analyzed laws and strategies concerned to this topic and all divided into the forestry and environmental regulation groups.

Forestry regulation of Macedonia entails the Law on forests and Strategy for Sustainable Development of Forestry of the Republic of Macedonia (2006), together with Action Plan for the period of 2007-2009. The Macedonian Law on forests has few versions with modifications and amendments of which the last version dates from May 2009.

Forest law as a regulatory framework for mitigation of climate changes - Within this law, climate change is tackled within the general provisions of the forests functions article. Here, the multifunctional beneficiaries of the forests, addressing the sustainable development and improvement of environment, are presented. Among other forest`s functions, the Macedonian law on forests emphasizes the influence of forests to climate change also. The forests positive effects connected to CO_2 sequestration and other aspects of oxygen production and purification of atmosphere as well the forests influence on the whole biodiversity are stressed.

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[1] Physical Plan of Macedonia, 2004

Strategy for sustainable development of forestry in the Republic of Macedonia - The preparatory of the Strategy for sustainable development of forestry in Macedonia, introduced the importance of climate changes on forests and forestry and gave the issue appropriate place in the Strategy. This is second document related to forestry and involving the climate changes within the goals and visions set for the forestry in future. There are defined some of the main threats and problems in forest management and governance: illegal logging that takes huge proportions, other illegal activities, forest fires which have affected nearly 100 000 ha for the last 10 years, climate changes trough the process of drying of the forests, insect calamities and diseases, which lead to enormous economic and environmental losses to the sector.

From other side, the strategy within the forestry research part prescribes strengthening capacities in forestry research institutions to obtain new knowledge and development of technologies. This means that the forest sector entails the scientific researcher of climate changes too and for reaching the goal set strategy with the concerned measures, among which as well:

- support research/analysis on CO_2 sequestration in forests and carbon storing in forest products;
- support research and monitoring activities to better understand the possible impact of climate change on forests and their ability to reduce the impact of disasters as extreme weather events;
- undertake research on appropriate forest management in conditions of global climate change.

Within *the role of the state in the development of the forestry sector part the inter - sectoral and international cooperation is set.* It determines establishment of appropriate cross-sectoral cooperation that will enable unlimited flow of information and joint activities at all levels. Moreover, aims towards secured participation and linkage to all international institutions and associations in the field of forestry. In this direction, measures to promote and mannerly facilitate external donor funding of forestry projects, especially in the fields of forest governance, climate changes, forest protection, and small and medium size enterprises are prescribed. This implies towards enhancing cross-sectoral cooperation oriented on organization level of forestry and environmental sectors as well.

The last is Forestry and the Environment chapter, where the forest protective function is emphasized. Here the forests are presented as the most valuable part of the ecosystem and taking into account their capability of improving general life conditions, they should occupy a special position in the global concept of environmental protection in the Republic. Beside this, the document prescribes that the role of forests in carbon sequestration from atmosphere should be taken into account related to the Kyoto Protocol. Therefore, forests deserve a special treatment by an appropriate system of protection, care and usage in function of sustainable development.

The goals are to ensure maintenance of protective forest functions and to increase positive contribution of forest sector to environmental protection, water and soil protection, protection of people, natural hazards, local and global greenhouse gas emission reduction etc.

Therefore, the following measures are prescribed:

1. *Assess the effects on the environment of the potentially harmful activities in forest regions;*
2. *Maintain, encourage and support ecologically friendly activities and practices in forests;*
3. *Stimulation of the maintenance of forest protection functions - sanation of eroded and degraded lands and forests and protection of headwater areas;*
4. *To improve technology and utilization methods of the forest resources in order to minimize damages to the environment;*
5. *To increase the area under forest and undertake appropriate sylviculture that increases the CO_2 sequestration;*
6. *Encourage sustainable forest management practices, taking into account the possible implementation of forestry activities under UNFCCC and Kyoto Protocol.*

Action plan 2007-2009 – The Action Plan as a follow up document addresses the climate change issues and contains activities among which are as well actions concerning forestry and forests in the Republic of Macedonia. Therefore the actions and carry out criteria for managing with forests in correlation with global climate changes and all relevant regulation in this area, as well as at the same time to take care about quantity and quality of forest as a renewable resource are taken from the document and presented within the text below.

1. Here within *the forestry sector, resources and economic issues*, actions prescribed are:

- 2,500 ha barelands afforestation, 3 years time period from 2007, budget-175,000 000 MKD;

Forestry is the only sector that acts like a carbon sink and therefore, the afforestation is one of the measures for GHG emission reduction in this sector. According to the second National Ecological Action Plan (2006), the MAFWE approved a budget of 160,000,000 MKD (€260,000) for 2008 to finance: afforestation of bare lands, coppicing, erosive soils and melioration of degraded forests and coppice; sanitation of burned forest areas; care; preventive protection from insect calamities and diseases and providing seedlings for reforestation.

- start of the first stage of a melioration process of the 450 ha degraded oak forests, for 3 years period time, counted from 2007 and with Indicative Bugget of 40,500 000 MKD;
- study for prevention and protection of forest fires. The forest fires appear as one of the most negative factors reducing forest areas and their health condition. Motivated by catastrophic national forest fires in 2007, several mass forestation national events have been organized and on 12 March 2008, more than two million seedlings, equaling the number of citizens in the R. Macedonia, were planted in one day.

Regarding the development of the Program for adapting the forestry to the global climate change, there is planned an action for establishing Consultative units (Boards) on forestry at national and regional level as well, action planned for the time period of one year (during 2007).

In the Action plan is predicted action for development a study on the impact of the forest activities onto forest ecosystems. Its duration is aimed to last 3 years and starting year is 2007.

The Action plan document shows lots of predicted actions and forestry regulations, which can significantly improve the situation of the climate change issue. But the main problem here is that until now there were few actions that were fulfilled. Actually, the action plan in general has failed at its last stage, in implementation phase.

The climate changes are entailed also within the documents of environmental sector legislation framework of Macedonia and the results from the analysis of the documents from this sector are the following:

Regarding the **Environmental Law,** there are concreate climate issue parts: concerning *the contents of the National Environmental Action Plan, Environmental impact assessment of certain projects, Basis for financing the activities in the area of environment, Sustainable development and global issues concerning environment with the* National plan for mitigation of climate**.** Climate change issues are incorporated in the Law on Environment, including details on preparation of inventories of GHG emissions and removals by sinks as well as action plan on measures and activities to abate increase of GHG emissions and to mitigate adverse impacts of climate change. In the changes and amendments of the Law on Environment it is planned to introduce articles on CDM.

The Second National Environmental Action Plan (2006) - The MOEPP is the national focal point for climate change issues and is responsible for policy making with regard to the implementation of the UN Framework Convention on Climate Change. The Government adopted the First National Communication on Climate Change in 2003 incorporating the Action Plan for GHG abatement, as well as measures for adaptation to future climate changes in the most sensitive sectors. The plan however lacks precise specifications of the obligations as well as a time frame and cost estimations for the implementation of the proposed activities. The measures to implement towards the reduction of GHG emissions include also increased use of biomass and renewable energy sources together with the introduction of cleaner production.

-State of environment - The first GHG inventory has been prepared under the First National Communication on Climate Change in 2003. In total, GHG emissions in 1998 amounted to some 15 MtCO2-eq. According to baseline scenario, emissions are projected to increase by 17% in 2012, where energy sector provides the highest GHG abatement potential.

National Strategy for Clean Development Mechanism (CDM) - The document comprises the Action Plan with recommended measures for GHG mitigation and adaptation to the impact of climate change in the most vulnerable sectors. In 2005, preparation of Macedonia's Second National Communication on Climate Change was initiated with financial support from UNDP and from GEF. The Ministry of Environment and Physical Planning has coordinated all activities related to ratification of the Protocol and raising public awareness.

Respectable climate change addressing requires engagement of additional financial resources. In general, the available *financial support* (particularly the national one) of climate change activities in the country is scarce and limited, so there is recognized an urgent need for fund raising, involvement of private sector, and awareness rising of policy-makers. The budgets of the relevant ministries (MOEPP, Ministry of Education and Science, MOAFWE) do not contain direct allocations for climate change issues, so these projects are mainly financed/co-financed by international institutions (UNDP, GEF, GEF Small Grant Programme). In the future, financing provided by international finance institutions (World Bank), UNFCCC adaptation fund and bilateral assistance through use of climate change initiatives will remains the main source of funding. Active involvement in EU Framework Research Programs, as well as allocation of additional funds in the state budget of relevant governmental institutions is necessary.

DISCUSSION AND CONCLUSIONS

The fact that climate change has serious consequences is revealed through the growing number of world catastrophes which are happening nowadays. It is a significant to be recognized the need to introduce and implement all regulative framework documents related to this serious issue. The relevant ministries in R. Macedonia have taken some actions introducing and harmonizing the regulative framework related to this very important issue or they have already recognized the role of the forests on climate changes. Although some of the forestry actions and documents have failed in their implementation phase, the more frequent problems and world catastrophes should serves as an example that all stakeholders should try a little bit harder and put more efforts with the future regarding this issue.

The most important forest adaptation measures fighting climate changes issues predicted in our country involve:

- adjust forest management to climate change, through forest species and planning measures introduction;
- improvement of the species composition of forests (natural and afforested) with endemic tree species, resistant to climate change;
- strengthen preventive measures that improve and minimize the risks of fires;
- increase monitoring and observation pilots in most vulnerable and economically valued forests.

Forests have a significant impact on the global warming. Therefore, the policy makers, climate negotiators and participants in the carbon market should recognise the essential role of forests to effectively and equitably combat climate change issues in our country and wider.

Climate protection provides a new way for forest protection to contribute and to succeed if we learn lessons from the past and we need to link these two issues.

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NATURE PROTECTION AND FORESTRY LEGISLATIVE CONFLICTS – NP FRUŠKA GORA STATEMENT

Radovan NEVENIĆ, Zoran PODUŠKA, Renata GAGIĆ, Ilija ĐORĐEVIĆ[1]

Abstract: *There are 3 institutions at same area who are involved in conflict and not able to find out solution for managing the meadow, which is under jurisdiciton and use of all involved in conflict.*

The difference attitudes of conflict actors who has to be in charge for meadow maintanace, different attitudes regarding nature protection legislative and rules, leads, independent parties identified overlapping and unclear legislation as a main cause of conflict.

It is evident that there is a great number of laws and regulations which are related with same area. Investigation and research action was leading in direction to find out what are the main collision between two legislation and what will be the conflict management strategies, fosused on improvement of communication and collaboration as prewweniton of conflict.

Case Study performed in frame of national and regioanl research by FOPER project – Forest Policy ans Economnics Eduation Research, a project for strengthening the capacities of education in South-Eastern Europe region.

Key words: forest policy, conflict, legislative, nature, protection, management

1. INTRODUCTION

The role of forests as a source of a multitude of locally available and renewable resources has long been underestimated. Accordingly, their potential contribution to local, regional, and national development has been under-utilized. Today, a consensus is gaining ground that forestry practices have to be incorporated more consistently into national environmental and development legislation and policies. Integrating the forest sector into a multi-sector network creates synergistic effects, provided that the interrelationships between different sectors are correctly identified and analyzed. These relations often are recognized as conflicts. Relevant criteria for an evaluation of forest law provisions are the objectives and functions of forestry, forest sector development planning, and the definition and designation of forests and forest land. These criteria are also used in evaluating of influence of environmental legislative to maintained conflicts. Attributes of it are more complexity in afforested protected areas, in Case Study examined in this paper.

The complexity of public policy networks leads to an increasing interdependence between forest laws, economic development laws and natural resources and environmental legislation. It requires a thorough analysis of the compatibility of laws and regulations. The following aspects need attention. The first are implications of the expanding system of environmental and nature protection legislation on forests management, and the second the scope for inserting in environmental protection laws specific provisions related to forest conservation and management.

The role of governments in direct interventions in society but also increasingly as mediators between societal actors is discussed, including network management and the appropriate choice of policy instruments to exercise the desired influence on landowners and users, and ultimately on the state of forests. Case Study approach was first scientific step, in investigation of forestry vs. nature protection conflict phenomena in Serbia.

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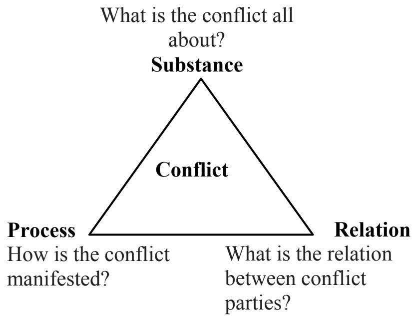
The area of investigation focused, in the part of the research, which is dealing with concrete and practical implications of the overlapping and conflicting forest and environmental policies and on the field, is National Park “Fruska Gora”, which are the good example to show the real situation concerning environmental and forestry law, and also, considering the fact that it is a high conservation area, but also with some private owned land and forests. The Case will be compared with similar approaches in the SEE region (Nevenić et al. 2008).

Theory definies the conflict in the different ways, using the different terms to explain the word “conflict“. The terms such as: struggle, pressure, opposition, aspirations, convictions, interaction, cooperation, rivalry, competition, are frequently used in the defining of the conflict situation.

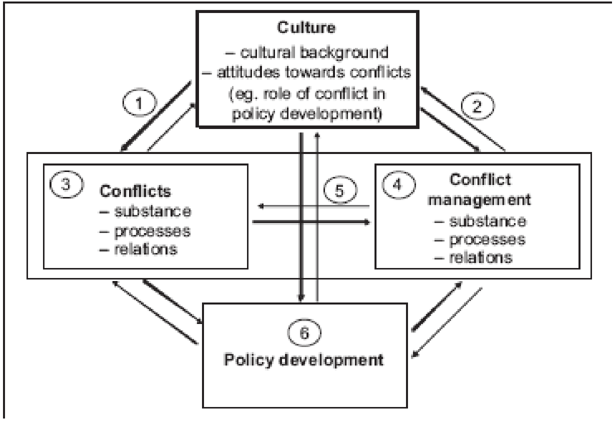
The theory of Walker and Daniels (1997) states that each conflict is the combination of three main elements: substance of conflict, process of conflict, and the relation between the participants.

Figure 1 *Progressive triangle*



source: Walker, Daniels 1997

Figure 2 *Theoretical framework*



The conflict situation has three elements: substance, process, and the relations, based on which the cause of the conflict, the participants in the conflicts, and the relation between them can be analyzed. The different aspects of the conflict influence the approach to the conflict management. The complex relations are often the obstacle to the solution of the problem, but at the same time serve as a base for the establishment of the mediation, by preventing the further escalation.

The conflicts in the domain of forestry were researched within the FOPER project (Forest Policy and Economical Education and Research, project for strengthening capacity within the forestry policy and economy in the countries of the Balkans), by using the qualitative methodological approach. The qualitative approach was used during the study of the conflict situations in the National Park “Fruska gora“.

2. METHODOLOGY

The conflicts in the domain of forestry were researched within the FOPER project, by using the qualitative methodological approach. The qualitative approach was usedduring the study of the conflict situations in the National Park “Fruska gora“. This national park was selected due to the numerous legal and sublegal acts, which directly refer to the management to the national park, as well as the property relations. The Law on Restitution (Official Gazette of the Republic of Serbia, 46/06), which guaranteed the restitution of the forest to the Serbian

Ortodox Church and monasteries, was adopted in 2006. There are 17 monasteries in Mt. Fruska Gora which claim the forests occuping an area of tens of thousands hectares.

The professional and scientific literature, as well as the sources obtained from the Internet, were used as the source of the data. The literature and data are mainly analyzed by the use of the following special scientific methods (Mihajlovic D., 2004): analytical-syntethic method, the method of abstraction and concretization, the method of generalisation and specialisation, the method of classification, and the methods of induction.

The qualitative research has the clearly defined phrases and corresponding results.

The privately-owned forests and forest land occupy an area of 291 hectares of the National Park "Fruska gora" (Special Management Plan, 2006). Seventy-seven members of the Forrest Association "Beocin" from Beocin village, are the owners of these forests and forest land. During the qualitative reseach the problem was analysed subjectivelly, based on the individual interviews and available literature.

The reseach refers to the analyses of the type and intensity of conflict, as well as the precondition for the conflict situation settlement. Along with the characteristics and elements of conflict, it is needed to define the participants in conflict and their mutual relations. The participants in conflict are characterized by the attitude towards problem, authority, power, and status in the decision-making process. The research is focused on the study of the connections and relations between the participants in conflict. Therefore, all processes are inter-related and dynamic. Based on these requirements, the questions are formulated. The questions are classified as main and auxiliary. The main questions should raise the answers on the essence, processes and relations in the conflict situation. If the examinee does not provide the sufficient scope of information to the questions, the attititudes on the missing information about conflict are initiated by the secondary questions.

The interview should be planned so that the three surveys of the basic data, based on the answers of the examinee, are formed:

1) The chronology of events;
2) The survey of the most important actors;
3) The survey of the possible and available sources of data, particularly written ones, out of which some are also collected (Nevenić et al.2009).

3. RESULTS

In forestry, as mainly nature scientific discipline, there is the increasing need for the socio-economic researches, which is the result of the fact that man is inextricably bound to nature. The increasing impact of the society and economy on the environment promotes the socio-economic researches. The socio-economic researches are the set of methods which the research scientists systematically apply in order to gain knowledge on the society based on the scientific facts. These researches are aimed at the creation of the study of men, their needs, behaviour, beliefs, interactions and institutions. Given the fact that many decisions made by the political leaders are not followed by the adequate social researches, it is needed to point to the researches by the qualitative methodological approach (Nauman W.L., 2004). Each research should be followed by the research project. By meeting the requirements of all phases of the research process and monitoring of it, the expected results are obtained.

All participants of conflicts were identified. The direct participants in the conflict are:

- National Park "Fruška Gora", as the State Enterprise, which manages the protected nature reserve based on the Law on National Parks (Official Gazette of the Republic of Serbia 39/93), i.e. Nature on Nature Protection (Official Gazette of the Republic of Serbia, 36/09);

- The Forest Association ”Beocin“, as the specific form of the cooperation between the owners of the privately-owned forests. The members of the Forest Association are the allied owners of the forests covering an area of the National Park “Fruska Gora“ (The Special Forest Management Plan, 2006).
- The Institute for Nature Conservation of Serbia, as the unique institution in the Republic, the main task of which is to preserve and improve the condition of the national nature reserves. The indirect participants in the conflict are:
- The Ministry of Forestry, Agriculture, and Water Management and the Ministry of Environment and Spatial Planning, as the executive authority which creates and implements the laws and strategies.

The elements which define the conflict among the participants are the essence of it. The disagreement about the manner in which the meadow, covering an area of 17 hectares, is managed. The meadow is privately-owned by the Forest Association “Beocin“. It is located in the protected zone of the National Park “Fruska gora“, in the vicinity of the regional “Partisan Road“. The owners are required to manage the meadow in a sustainable manner. This obligation is imposed on them by the Institute for Nature Conservation, as the answer to the appeal which the Forest Association made to the Institute for Nature Conservation and the management of the National park and which refers to the ability to manage the meadow in this way, so that both owners and visitors can benefit from it. The meadow is a favourite picnic area of the citizens of Novi Sad. On the other hand, it is the site of numerous protected and rare herbaceous species. It can be noticed that in this instance the requirements for the economic benefit clashes with the requirement for the complete conservation of the private ownership within the National Park. The management of the National Park offered the service of the maintenance of the meadow. The price of the service was much higher than the financial solvency of the Forest Association. Therefore, the limit of the right to use the private ownership was imposed, and in turn the expensive service of the maintenance was offered.

The process of the conflict: The process domain of the conflict is characterized by the activities which enable the refoms in the legislation. The creation of the Law on Forests, which takes into account the private ownership, is under way. The Law on Nature Conservation, by the positive intepretation of which the “compensation for the deprivation or the limiting of the right of the usage“ of the private ownership in the protected zones is enabled, is adopted. There are the clearly visible changes in the manner in which the private ownership in the National Park “Fruska gora“ is managed, and the plan for the management of the Forest Management Unit “Forest Association“ – Beočin, owned by the Forest Association from Beocin village, is made in 2007.

Relations among the participants: The Ministry of Agriculture, Forestry and Water Management, the Ministry of Environment and Spatial Planning, the Institute for Nature Conservation of the Republic of Serbia, Regional Department for Environment Protection and Sustainable Development, Forest Association „Beocin“, local governments, and academic and scientific-research organisations, are involved in the management and use of the National Park “Fruska Gora“.

It was concluded that the participants slowly and safely project an image of their communication as advanced. The conflict is in the latent phase, hidden from public view. The participation of the political parties in the management of the natural resources is clearly visible. The relation element of the conflict is the integral part of the conflict management, and it is expressed by: mediation, dialogue, cooperation, and education.

There are following aspects of conflict: institutionally-political aspect, economic, social, and culturological aspect. In addition, the conflict can be viewed in regard to the natural resources. The natural resource can be under the protection regime, or under the regular management regime.

In regard to policy making, the conflict is observed as the disagreement over the determinants (criteria and priorities) of the political decisions (Walker Daniels 1997). The conflict is associated with the lack of information, disinformation, and the different interpretations of the available data. It was reported that the sides in the conflict had the different rating scale of the information and attitudes. For instance, some phenomena are considered to be rational by some people, but they are considered to be irrational by others.

Many conflicts between the forestry and nature protection are caused by the economy. The owners or users of the natural resources claim that they are entitled to offer their ownership to the market, regardless of the category of protection.

The categorization and structure of the protected areas are the frequent topics of the debates, but at same time the sources of the numerous conflicts.

It is hard to estimate and compare the social and culturological benefits of forests with the economic benefit. The forest is traditionally of great importance to the owner or community. The forest is inherited, but rarely sold. The issues of the ownership and the right of usage is the frequent cause of the conflict. The tradition, as the part of the sociological and culturological aspects of the natural resources management, is clearly visible in the behaviour of all acters.

After the recognition of the relevant situation and defining the elements and participants in the conflict, based on the principles of the qualitative methodological approach, the study case was selected as the technique for the data collection. The case study method implies the use of the scientifically formulated occurrence model as a starting point and leads to the reconstruction of the current or to the construction of the new model (Miljevic M., 2004). The study case is the concrete, descriptive method, and analyzes the problem in depth.

The specification of case study is also called “case study protocol“ (Miljevic M., 2004). The integral part of the protocol is also the form with the questions which the examiner will put to the examinee.

The questions are focused on the previously defined topic, and the participants in the interview are informed in advance about the topic of the interview, and the agreements about the time, place and duration of the interview are made.

The interview plan resulted in the creation of the forms with questions. The examinees are selected by the principle of general knowledge, i.e. by the method of “snowball“ sampling .

The participants in the interview, i.e. the examinee first answer to the common questions. The aim of the interview is the identification and definition of the opinions and views of the topic, as well as the determination of the level of connection based on research sample.

The quality of answers and results directly depends on the skill and experience of the examiner. Along with the common questions, the auxiliary questions, aimed at finding the data which were omitted by the examiner.

The answers to the questions which were put are obtained as a result of interview.

4. DISCUSION AND CONFLICT MANAGEMENT- FURTHER DIRECTIVE

4.1. General findings

Authorities of tree institutions who are involved in conflict are not able to find out solution for managing the meadow, which is under jurisdiction and use of all involved in conflict. Private forest owners association have obligation to maintenance the meadow, but they do not have financials to do it.

4. 2. Substance

By interpreting and judging several laws and regulations which are related with the same area as such, each of the sectors can in theory justify its activity. In practice, it causes misunderstanding, disagreements and even the open conflict between interests of the Association of Private Forest Owners and nature protection requirements. Institutions for Nature Protection with their rigid attitude insist on application of Laws without any review of economic situation of PFOA. PFOA are without any extension, training and financial support but with willingness and tradition in managing on nature goods with big value. A willingness to discuss matters clearly exists among the associations.

Cause of conflict is issue of the benefits from forests and from the forestry sector have been, and generally still are, considerably undervalued. This is true both for marketed products and for environmental and ecological services which result as positive external effects from protecting forest vegetation and managing the resource as a multifunctional system. The concept of sustainable development places new demands on the regulatory framework for the utilization and management of forests in order to increase the economic and social values generated by the sector for public and private forest owners, and for society as a whole. Important legal issues in this context are the scope of management plans, the framework for forest utilization, and rules concerning the commerce of forest products.

4. 3. Process

Conflict who will pay meadow maintenance is forwarding from one year to another. PF Owners have not direct profit and on the other side National Park and Institute for nature protection have harm when meadows are not maintenance due to rare meadow plant species. Institute of Nature Protection demands (according the legislation) that meadow has to be well managed, but without significance - how the PF Owners association will pay managing, obvious without financials for that action

4. 4. Relations

The common goals of the three organizations (Institutions for Nature Protection, Association of Private Forest Owners and National Park Fruska Gora) open up the chance for mutual support. On the other hand, they also have the option of opposing each other which results in conflicts, particularly concerning the unclear weighting of ecological and economical objectives in the protected area. The analysis of laws included in the present survey is based on an evaluation framework which has been developed with the participants in the survey. The assessment of further important forest law developments in the Serbia it is going to be under review is presented according to the following themes:

- Integration of forestry into development and environment polices (Authority, jurisdiction of Ministries);
- Participation and new role of stakeholders (Association of Private Forest Owners)
- Diversification of management systems (National Park Fruska Gora)
- Forest conservation (Institutions for Nature Protection)
- Measures for an appropriate institutional framework for the forestry sector (cross-sectoral cooperation).

4. 5. Conflict management - Participation and new role of stakeholders

Forest Administration: It would be useful to distinguish between general tasks of state administration (i.e. superintendence of the sector and law enforcement; provision of advisory and technical services for private and public stakeholders) and entrepreneurial management tasks in state-owned forest areas (National Park "Fruška Gora", Institutions for Nature Protection).

Cross-sectoral Advisory Bodies: It follows that most laws contain no rules, or only rudimentary rules, which enable the establishment, and putting into function, of cross-sectoral advisory bodies and commissions, in order to ensure the participation of local community authorities in the process of designating forest areas and approving the conversion of forest land(Forestry Scientific institutions).

Participation of Forest Owners: Forest owners should participate in the development of the forestry sector by managing private forests within the framework of the applicable rules. In terms of access to forest resources and management rights, the forest sector in the conflict which was under review was and still is dominated by state competencies and public interventions.

Rules concerning the management of state-owned forests lay down that the forestry administration is either in charge of managing state-owned forests, or that it may transfer utilization and management rights to a third party (Forestry Scientific institutions) by granting forest concessions, licenses and permits.

The owners have to respect certain restrictions in order to ensure protective forest functions, but have considerable liberty in decision-making, e.g. the case of natural areas, (meadow in our Case study). Where private forest tenure exists in natural forests, the ownership rights are usually even more restricted by law, in that any utilization of natural forests must be declared to relations and processes in conflict.

Transfer of Management Rights to Local Groups: The transfer of management and utilization rights to local groups has the potential to bring about considerable changes with regard to a more active involvement of different stakeholders in forest management. The main differences between stakeholders concern the degree of intervention by forest administrations, the importance of supervision functions, and the level of advisory services and technical assistance (National Park Fruška Gora).

***Traditional Use Rights*:** Customary rights are generally acknowledged in the mentioned laws. They are limited to subsistence needs and exclude the commercial use of forest products. While these rights are severely restricted inside forest reserves, they are less restrictive on other forest lands. Traditional use rights can be limited or even abolished in forests for which management plans have been adopted(Association of Private Forest Owners - The Private Forest Community "Beočin" was established 1903 in the Beočin).

Distribution of Benefits Derived from Forests: The laws acknowledge the principle that forest owners should receive the revenues derived from the utilization of their forest. This also applies in the case of transfer of management rights to local groups. However, special provisions may be made to regulate benefit sharing between the local groups and the forest administration.

Education, Training and Research: Forest sector development and sustainable forest management require appropriate training, and technical and professional education of staff for all categories of forest ownership and at all functional levels. The forest laws of other countries under review only give general indications without specific provisions concerning scope, addressees, contents, organization, or financing. There are also provisions for support of the National park in organizing training activities and in promoting general education programmes related to environment issues (Forestry Scientific Institutions).

Forest Development Funds: In view of the multiple roles of forests in providing private and public benefits, their sustainable management requires public stewardship and investment in developing the productive potential of the sector. Precise descriptions of the organization of such funds, the composition of decision.

5. CONCLUSIONS

Clear move to promote local and private forestry practices can be recognized in the forest and environmental laws, as collision between them that have been examined. This is evident from provisions relating to the acknowledgement of local use and management practices, the gradual transfer of management responsibilities to local entities and co-operatives and from efforts to support such developments by the forest administration. With regard to environmental aspects, the major contribution of forest legislation remains its regulatory function in protecting forest cover, classifying forest areas according to major uses, and providing for preservation of nature reserves, protected areas and national parks.

Demographic pressure on forest land (especially in protected areas), migration and urbanization trends, and the availability and effectiveness of education and research facilities determine to a large extent the road towards sustainable land management. Many sectors have forward and backward linkages to forest land use, and many public policies have impacts that are to be considered as part of the institutional framework that shapes forest sector development.

Prime examples are the actual and potential conflicts between sustainable utilization for the economic production of goods, on the one hand, and the need to protect and conserve forest lands for environmental and ecological reasons, on the other hand. There is an increasing specialization of land use norms and planning activities, often based on parallel, or in part divergent, organizational and resources allocation structures.

The laws put considerable emphasis on forest management plans, and regulate the content and procedural aspects of the preparation and implementation of such plans with considerable detail. However, they contain little to strengthen the entrepreneurial forces of the sector by providing an appropriate supporting environment. Instruments and measures to this end include transparent allocation of exploitation rights, clear directives for sustainable use, deregulation of markets, and development of self-regulating mechanisms such as the certification of forest products.

Altogether the findings show that the present forest legislation does not address environmental aspects at a significant level. However, some legal provisions are based on a cross-sectoral ecosystem approach and identify the preservation of biological diversity as consistent with international conventions. A general draw-back is the absence of rules regarding sovereignty over and access to genetic resources as well as the transfer, handling and use of organisms that may have adverse effects on biological diversity. Further amendments will be required to address these issues in order to combine forest sector development with ecological sustainability.

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NATURE PROTECTION AND FORESTRY LEGISLATIVE CONFLICTS – NP FRUŠKA GORA STATEMENT

Radovan NEVENIĆ, Zoran PODUŠKA, Renata GAGIĆ, Ilija ĐORĐEVIĆ

Summary

The paper summarizes results of Case study evaluating national forest laws currently in effect in National Park, Fruška Gora, Serbia. Several major themes are examined: integration of forestry into development and environment policies; roles for stakeholders; diversification of management systems; valuing entity of private forest owners; forest conservation; and measures to promote an appropriate framework for the forestry sector. The results show that most recognizable collisions are between the forest and environmental laws, so they are the research topic which was investigated. However, conflicts are recognized and regulated with varying intensity. They, as legislative gaps result differ to some extent from standards and guiding principles established by the national, from one and local community, from the other side. Conflict are dominant consequences of different numerous legal and sublegal acts, which directly refer to the management to the national park, as well as the property relations. Shortcomings relate mainly to: co-ordination of forest sector development with economic and social development objectives; adequate participation of all stakeholders; assistance to forest owners and local communities (PFOA Beocin); and compensation for social and environmental services of forests(National park-Fruška Gora and Institute for Nature Protection).

BARRIERS AND OPPORTUNITIES FOR CONSERVATION AND MANAGEMENT OF DEHESAS

Pablo GONZÁLEZ-MORENO[1]

Abstract: *Dehesa is an agroforestry system of the western part of the Iberian Peninsula where an open oak forest is combined with livestock raising in order to provide a wide range of functions. Dehesa system is nowadays subject of an intense debate regarding its actual situation and sustainability. The lack of regeneration, out-aged stands and pest outbreaks are considered to be symptoms of a holistic process where social and environmental factors take part. This paper reviews the main aspects of traditional dehesas concerning EU policy and climate change. The analysis has revealed that dehesas have suffered important changes due to socioeconomic and political factors. Moreover, these factors can become both barriers and opportunities for future development depending on the management decisions. Contrarily, climate change seems to be a barrier for management as only negative impacts are predicted.*

Keywords: agroforestry, climate change, policy, montados, Mediterranean

INTRODUCTION

The dehesa (Spanish) or montado (Portuguese) is a traditional Mediterranean agroforestry system that covers 3 to 3.5 millions ha in the western part of the Iberian Peninsula (San Miguel-Ayanz, 1994). It is characterized by scattered holm oak (*Quercus ilex*) and cork oak (*Quercus suber*) woodlands combined with extensive livestock ranging and intercropping (Plieninger et al., 2003). It is considered an ecosystem of high biodiversity due to the combination of different vegetation types and management practices (Plieninger and Wilbrand, 2001). This has placed dehesas among the priority habitats within the Habitat Directive 92/43.

There are five main aspects in the dehesa namely oaks trees, livestock, pastures, crops (Olea and San Miguel-Ayanz, 2006) and humans. Oak tree is considered the keystone of the system (Plieninger and Wilbrand, 2001). It provides the structure of the system linking species necessities and enabling ecosystem functioning. One of the major aims of oak tree is to limit erosion, an aspect of high relevance in Mediterranean ecosystems. It also works as refuge for wild animals and fulfils special necessities of rare species such as Iberian eagle, *Aquila adalverti* (Gonzalez et al., 2008). The acorn production and browsing or pruned trees are very important as a food source for farm and wild animals (Joffre et al., 1988). This is enhanced by the fact that the low density of trees, less than 40 trees/ha, increases acorn production comparing to natural conditions (Pulido, 1999). Oak tree also provides direct products such as timber, cork, tannin and charcoal that help to maintain the profitability of these diverse semi natural systems.

The livestock management in the dehesas is flexible and includes the use of cattle, sheep, goat and pigs. The different species cover the spatio-temporal diversity in the dehesas providing fertilization (Joffre et al., 1988; Olea and San Miguel-Ayanz, 2006) and seed dispersal services (Malo et al., 2000). Livestock are at the same time an important source of income for farmers and the engineers of the open areas. For instance, an extensive Iberian pig raising is, in many cases, the only profitable way to sustain the dehesas system thanks to its high value products while other uses have been extremely reduced (Lopez-Bote, 1998). Livestock limit shrub encroachment and help maintaining and improving pasture (Olea and San Miguel-Ayanz, 2006).

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Together with livestock, wild animals also function the same and constitute an important factor and dynamic agent of the dehesas.

Natural pastures are characterized by the temporal variability caused by Mediterranean climate. Pastures are mainly based on annual grass species whose yield change seasonally and yearly (Olea et al., 2005). Perennial species can also be found in special locations such as the bottom of the valleys and intensive grazed areas (Olea et al., 2005). Natural pastures are an important food source for livestock and wild animals. However, due to this production variability animals cannot depend on this source continuously. In this case, perennial species and external food supply play a major role on the stability of the system.

In better soils, crops are established to provide fodder for livestock. The main crops used are cereals (oat, wheat and barley) and fodder legumes (Joffre et al., 1988; Joffre et al., 1999). The harvest is not the main objective of the crops, thus grain, fodder or straw might be collected or left for feeding (Olea and San Miguel-Ayanz, 2006). The relation between trees and crops has proven to be efficient in increasing fertility of soils and yield (Moreno et al., 2007; Moreno, 2008) allowing a low input intercropping system. Crops also limit the development of shrubs. It is a common practice to clear shrub areas and to establish crops (Joffre et al., 1999; Olea and San Miguel-Ayanz, 2006).

Dehesas are a man made ecosystem. Over centuries, humans have simplified the Mediterranean oak forest building a savanna-like landscape unique in Europe (Joffre et al., 1999). The soil poor conditions and the characteristics of the Mediterranean climate (San Miguel-Ayanz, 1994) make difficult to use the land for only one purpose such as extensive monoculture agriculture. Instead, dehesas have been developed as a holistic system where there is not a unique product or service but a wide range of them structurally and temporally diversified (Joffre et al., 1988; San Miguel-Ayanz, 1994). Management is an intrinsic part of the system needed to assure the sustainability of the processes. However management practices might change due to factors such as demographic processes, policy and regulations, economic changes or global warming. Several signs of these changes have already being pointed out such as the lack of regeneration (Pulido et al., 2001; Plieninger et al., 2003), out aged oak stands or pest outbreaks (Plieninger et al., 2003). This paper aims to review these factors in order to understand their role in the development of dehesas and their future implications. The dehesa system in Spain is analyzed according to the historical perspective, EU policy and future changes due to global warming. I hypothesize that the three factors condition in a high extent the management and conservation of the dehesa.

POLICY POINT OF VIEW

Different policy strategies has influenced the traditional dehesa system in Spain from the mid of the 20th century until our days (Joffre et al., 1999; Muñoz Igualada et al., 2006; Vicente and Alés, 2006). During the 60s and 70s, the Ministry of Agriculture supported livestock intensification in order to deal with the socioeconomic problems of the rural areas. This incipient involvement had important effect in the proliferation of different practices. For instance, the use of cattle decreased the livestock diversity that was characteristic of the traditional dehesa (Joffre et al., 1988). However, the strongest political impact was observed when Spain became member of EU in 1986. The EU policies considered in this review that affected dehesas are the Common Agrarian Policy (CAP) and the Rural Development policy.

Common Agrarian Policy

The Common Agrarian Policy (CAP) with its huge monetary budget is supposed to be an important factor of the agricultural dynamics. The first approach of this policy was coupled to production. Incentives were given to maximize production and varied from livestock. For instance pig raising was not subsidized while cattle was the most favoured one. Therefore, subsidies contribute in a high percentage to the profitability of the farms conditioning the stocking rate and the proportion between different animals (Gaspar et al., 2007). It was not until the third modification of the CAP when incentives were partly decoupled of production. This change towards management oriented incentives might have important consequences for dehesas (Muñoz Igualada et al., 2006; Gaspar et al. 2007).

The new CAP in Spain (Council Regulation 187/2003) was incorporated into national law by the Royal Decree 2352/2004 and 2353/2004. According to Muñoz Igualada et al., (2006), the implementation of the new CAP continues promoting cattle as the incentives are higher than for other livestock. Beef production is still coupled to production while the sheep sector has been decoupled to 50 % (Gaspar et al., 2007). It also incentives extensive grazing but at densities higher that the needed for the sustainability of the system (1.4 LU/ha) (Muñoz Igualada et al., 2006). This issue has been updated by the Royal Decree 1470/2007 until 1.5 LU/ha and restricting the incentive only for beef cattle.

Rural Development Policy

The CAP has been accompanied by a set of norms to promote environmental friendly agricultural practices and sustainable rural development. The first EU regulations that affected dehesas in Spain in this sense were the Council Regulation 2078/92 (Agricultural production methods compatible with protection of the environment and maintenance of the countryside) and the Council Regulation 2080/92 (Community aid scheme for forestry measures in agriculture) incorporated into national law by the Royal Decree 51/1995 and Royal Decree 152/1996 respectively. Dehesas were the most favoured systems to get incentives from the latter regulation (Plieninger et al., 2003). The regulation included incentives for plantation during a maximum of 5 years and compensation for 20 years. During the whole period agriculture practices were not allowed while grazing was prohibited in the period when the animals could threat the survival of trees.

A more solid rural development policy was established in 1999 through the Council Regulation CE 1257/1999 and applied by the CE 817/2004. This new scheme included compensatory allowances for less-favoured areas and with environmental restrictions (transposed by the Royal Decree 3842/2000), agrienvironmental practices (Royal Decree 4/2001 modified in 2002 and 2004) and afforestation incentives (Royal Decree 6/2001).Dehesas should be a target of the compensatory allowances according to the characteristics of less favoured areas and because they belong in most of the cases to Natura 2000 network (Muñoz Igualada et al., 2006). However, two main restrictions have limited its inclusion. The first constraint is the limit of 100 ha per estate (Muñoz Igualada et al., 2006) when the legal definition of dehesas in Extremadura refers to estates bigger than 100 ha (Gaspar et al., 2007). The second limit is imposed by the regional normative that reduce or restrict the susceptible area (Muñoz Igualada et al., 2006). The latter limit is also observed in the agrienvironmental scheme (Muñoz Igualada et al., 2006). The actual afforestation incentives scheme follows the approximately the same scheme of 1996 with minor changes.

Policy implications

EU policy in agriculture and rural development plays a major role in the dehesas. Different incentives schemes might shift economical activities and encourage specific practices that might not be sustainable in the future. As a clear example, EU policy has continuously encouraged cattle production. Farmers might see the subsidies as an opportunity to run their dehesas with less labour input as cattle is less labour demanding than pig or sheep (Gaspar et al., 2007). The slightly higher profitability and the low economical diversity of the dehesas make them very vulnerable to policy changes (Gaspar et al., 2007). Other dehesa systems less dependant on policy should be more sustainable. Highly diverse dehesas with different livestock might be more adaptable to market and policy fluctuations as they can relatively easily change their stocking rates. Nevertheless, these special dehesas must have a big size in order be able to hold different livestock without high input and maintaining the low stocking ration characteristic of the dehesas systems (Gaspar et al., 2007). Dehesas with pig breeding are also independent from policy changes as Iberian pig breeding is an economical activity with high profitability and without EU subsidies (Lopez-Bote, 1998; Gaspar et al., 2007).

Low profitability and labour intensiveness of dehesas have convinced the owners to accept afforestation subsidies. Considering the general lack of regeneration and the problem of out-aged oaks in actual dehesas (Pulido et al., 2001; Plieninger et al., 2003) afforestation schemes might be suitable solution for the sustainability of the system if planned carefully (Plieninger et al., 2003). Recent studies have shown that recovery periods of dehesas should be between 20 to 30 years (Plieninger et al., 2003). This period fits with the compensatory period of 20 years considered by the subsidized scheme. However, the land use change towards forest in a big scale might bring undesirable consequences such as reduction of biodiversity or cultural landscape lost (Joffre et al., 1999; Plieninger et al., 2003; Ramírez and Díaz, 2008). Therefore, total abandonment of the activities and afforestation of the whole state might not be correct if the objective is to assure the long-term sustainability of the dehesas.

CLIMATE CHANGE

Dehesas as a Mediterranean ecosystem are likely to be affected by climate change (IPCC, 2007). The most probable changes in climate in the Mediterranean basin would be related to reduction of rainfall, longer drought periods and increase of temperature (IPCC, 2007). These climate changes might have an important impact on vegetation dynamics mainly due to changes in wildfire regime and the higher recurrence of extreme events.

Wildfire is an intrinsic factor of Mediterranean forest. However, if the recurrence of the disturbance or the intensity is high, this natural process might lead to shifts of vegetation (Pausas, 2004). For instance, Mouillot (2002) projected an increase of fire frequency that might shift the dominance of landscape to shrubland. The predicted drier and warmer conditions (IPCC, 2007) and extreme hot summer days (Kjellström, 2004), might increase flammability of forest fuels and therefore increase the risk of ignition (Moreno, 2005). Longer drought periods might also increase the length of fire season exhausting the vegetation and increasing the fire risk (Moriondo et al., 2006).

Due to climate change dehesa vegetation is likely to afford more extreme conditions that might affect the normal response against pests. For instance, soil water content is likely to be reduced to 25 % by 2040 (Gracia et al. 2002) producing stress impacts on the ecosystems with water limitation. Furthermore, longer drought periods might reduce carbohydrates reserve, making difficult the survival of individuals on extreme events and weaken the barrier mechanisms against infections (Gracia et al. 2005). Although pests are a normal element of forest ecosystems and contributes to its dynamic, it is important to consider that changes in vegetation will be pointed out by the proliferation of diseases and pests (Gracia et. al 2005).

Climate change implications

In dehesas, wildfire does not play a major role under active management. The scattered tree distribution and low undercover vegetation prevent the easy fire propagation. Furthermore, wildfires are also controlled by human as it might cause economic losses in the agriculture activity. However, nowadays it can threat the sustainability of the system if the dehesas follow the tendency of abandonment or afforestation. In the first situation, complete land abandonment might imply the development of shrubs under the tree cover. This situation will lead to a continuous horizontal and vertical biomass cover that consequently will facilitate fire propagation. Furthermore, the lack of conservation of rural infrastructures will constitute a serious problem for fire extinction as roads and/or water supplies will not be maintained. In the afforestation, the vegetation dynamics is human controlled. Owners might prevent wildfire as afforestation incentives might be cancelled if wildfire occurs (Royal Decree 6/2001). Therefore, planned afforestations are likely to have less importance in increasing wildfire occurrence than dehesas abandonment.

Under more extreme conditions, dehesas might develop towards a different ecological equilibrium. Based on the hypothesis that under water limit, canopy density is developed to fit both the minimum water stress and maximum biomass requirements (Eagleson and Tellers, 1982), Joffre et al. (1999) suggests that in dehesas under 650-700 mm rainfall, tree density seems to be related to rainfall while in higher precipitation regimes other factors must be more influencing such as human management or livestock pressure. According to this theory, if a reduction in rainfall is expected due to climate change, dehesas with already water limitation might show weakening signals in the form of diseases or pests that will facilitate the change of vegetation to lower tree density. In this context, (Joffre et al., 1999) advices a management focused on weak trees in order to reduce tree density and adapt the system to the new water limitations.

Nevertheless, in a hypothetical case that climate change might not exist or that projections do not agree with real future climate development, climate change efforts for adaptation, such as the one suggested by (Joffre et al., 1999), could be completely inefficient or even catastrophic. Measures that imply high intensity intervention and that try to force shifts in vegetation considering predicted climate might bring undesirable consequences. History of human intervention on ecosystems has taught us that what we think is better for nature sometime is not true. For instance, the historical high wildfire suppression has proven to increase large fires causing enormous impacts on ecosystems instead of solving the problem (Arno and Brown, 1991). Therefore, adaptive measurements for climate change must be developed carefully, considering not only the estimated positive impacts but also the negative ones.

CONCLUSION

Dehesas are traditional agroforestry systems shaped by a long human involvement and a diversified uses of the resources. This review has shown that socioeconomic changes and changing policies are factors that determine the dynamics of the system. Researchers have tried to characterize and support a traditional landscape image that has changed during the history according to human needs. Socioeconomic and political changes have led to new management practices that in principle might be against the sustainability of the dehesas (Joffre et al., 1988; Joffre et al., 1999). However in practice they are the result of a new equilibrium between nature and humanity.

Policy is also playing an important role in the dynamics promoting specific practices that encourage the shift of economical activities in the dehesas (Joffre et al., 1988; Gaspar et al., 2007). The EU policy in agriculture and rural development is developed in a global context that affects in a great extent the local conditions. The fluctuations in the approach of the policy and the way the norms are transposed into national and regional normative explain the economic activities pattern and might constrain the future development of the dehesas into not sustainable directions. The actual focus on cattle ranging, undermining the benefits or other livestock, is an example of this barrier for management.

Climate change is also likely to negatively affect the conservation and management of dehesas. Two projected aspects have been considered in the analysis, the reduction of rainfall and the increase of wildfire risk. The first one should be considered in the management of dehesas with water limitation and the latter one might be more important in the case of abandoned dehesas. However, the uncertainty of the future predictions adds difficulty to assess future impacts of climate change.

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GEOMATICS IN FORESTRY. SOME ASPECTS OF THE LITERATURE ANALYSIS

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Abstract: *The development of every field of knowledge is related to the appearance of bibliographical sources registering the literature of a given field. Thanks to them it is possible to research the development of interests of professional groups and of the researchers related to a specific field, the directions of its development and diversification of subject matters of their works. Base on the characteristic of the profile of a magazine and its impact factor three foreign magazines from the scope of geomatics (International Journal of Geographical Information Science, GeoInformatica, Photogrammetric Engineering & Remote Sensing) were selected. Next, the articles included in them were analysed in relation to the application of geomatics in the forestry, and especially using the geoinformation technology in exploring forest ecosystems. Analysis comprises the period of 3 years (2007-2009).*

Key words: geomatics, forestry, literature analysis

1. INTRODUCTION

The concept of geoinformation science was introduced in 1992 by Michael Goodchild. To describe this science other terms also appeared, such as geomathematics, spatial information science as well as geoinformation engineering [5]. In the world's literature exist the terms geomatics and geoinformatics. The term geomatics appears more often in the areas of English language influence, and geoinformatics in German-speaking countries. Both these names are synonyms. In Poland, as well as the terms geomatics and geoinformatics, a concept of geoinformation science and technology is used, where the word technology is used in the sense of the entirety of individual technologies concerning geoinformation [2]. The lexicon of geomatics [1] defines geomatics (geoinformatics) as a scientific-technological discipline dealing with assembling, analyzing, interpreting, popularizing and practical application of geoinformation. Geomatics containing and integrating several fields, among others: geodesy, cartography, remote sensing, photogrammetry, GIS (geographical information systems) and GPS (global positioning systems). Informatics tools using in these fields are applied in various fields, also in forestry.

In this paper articles included in three geomatics magazines were analysed in relation to the application of geomatics in the forestry, and especially in forest ecosystems and climate changes. Analysis comprises the period of 3 years (2007-2009).

2. ANALYSIS OF GEOMATICS JOURNALS IN ASPECTS OF FORESTRY

In the subject of geomatics several international journals are published. Base on the characteristic of the profile of a journal and its impact factor three foreign journals were selected for research - International Journal of Geographical Information Science (IJGIS) [4], GeoInformatica (GI) [3], Photogrammetric Engineering & Remote Sensing (PE&RS) [6]. The table 1 presents number of articles related to the forestry and founded in these journals.

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Table 1. *Number of articles in geomatics journals related to the forestry*

Name of journal	IJGIS			GI			PE&RS		
Years	2007	2008	2009	2007	2008	2009	2007	2008	2009
Number of articles in year	0	0	1	0	0	0	6	13	14
Number of articles in journal	1			0			33		
Total number of articles	34								

Characteristic of selected articles is presenting below:

1. Evaluating the effects of land-use development policies on ex-urban forest cover: An integrated agent-based GIS approach; *D. T. Robinson, D. G. Brown.* Authors use a GIS-based agent-based model (ABM), named dynamic ecological exurban development (DEED), with spatial data in hypothetical scenarios to evaluate the individual and interacting effects of lot-size zoning and municipal land-acquisition strategies on possible forest-cover outcomes in Scio Township, a municipality in Southeastern Michigan. The results using an integrated GIS and ABM framework for evaluating land-use development policies on forest cover provide additional insight into how these types of policies may act out over time and what aspects of the policies were more influential towards the goal of maximising forest cover. (IJGIS 2009, vol. 23, no 9, p. 1211).
2. Use of Landsat ETM and Topographic Data to Characterize Evergreen Understory Communities in Appalachian Deciduous Forests; *Robert A. Chastain, Jr. and Philip A. Townsend*. Evergreen understory vegetation was classified using Landsat ETM imagery and ancillary data in two physiographic provinces in the central Appalachian highlands; the Ridge and Valley and the Allegheny Plateau. DEM-derived topographic information was integrated with Landsat data to assess its potential to improve classification accuracy, maximum likelihood, and minimum distance, and decision tree classification approaches were tested with these data in a factorial manner. (PE&RS 2007, vol. 73, no 5, p. 563).
3. An Object-oriented Approach to Urban Forest Mapping in Phoenix; *Jason S. Walker and John M. Briggs*. Authors present a classification procedure in order to delineate woody vegetation in an arid urban ecosystem using high-resolution, true-colour aerial photography. The segmentation process was parameterized to isolate vegetation patches from shrubs to large trees. (PE&RS 2007, vol. 73, no 5, p. 577).
4. Patterns in Forest Clearing Along the Appalachian Trail Corridor; *David Potere, Curtis E. Woodcock, Annemarie Schneider, Mutlu Ozdogan, and Alessandro Baccini*. Forest clearing in the vicinity of the Appalachian Trail National Park undermines the Trail's value as a wilderness retreat for millions of annual hikers. A combination of boosted decision tree classifiers, multitemporal Kauth-Thomas transforms and the GeoCover Landsat dataset enabled a single, un-funded analyst to rapidly map land-cover change at 28.5- meter resolution within a 3.8 million hectare study area that spanned 16 Landsat scenes. (PE&RS 2007, vol. 73, no 7, p. 783).
5. Estimating Species Abundance in a Northern Temperate Forest Using Spectral Mixture Analysis; *Lucie C. Plourde, Scott V. Ollinger, Marie-Louise Smith, and Mary E. Martin*. Effective, reliable methods for characterizing the spatial distribution of tree species through remote sensing would represent an important step toward better understanding changes in biodiversity, habitat quality, climate, and nutrient cycling. *(PE&RS 2007, vol. 73, no 7, p. 829).*
6. Forest and Land Cover Mapping in a Tropical Highland Region; *Christian Tottrup.* Linear mixture modeling, in combination with a set of decision rules, is used to map tropical forest and land-cover classes within a highland region in north central Vietnam. In conclusion, the presented classification approach is believed to advance the use of satellite remote sensing in support for land-use planning and natural resource management in areas of complex terrain. (PE&RS 2007, vol. 73, no 9, p. 1057).

7. Estimating Basal Area and Stem Volume for Individual Trees from Lidar Data. *Qi Chen, Peng Gong, Dennis Baldocchi, and Yong Q. Tian*. This study proposes a new metric called canopy geometric volume G, which is derived from small-footprint lidar data, for estimating individual-tree basal area and stem volume. (PE&RS 2007, vol. 73, no 12, p. 1355).
8. The Fragmentation of Space in the Amazon Basin: Emergent Road Networks. *Eugenio Y. Arima, Robert T. Walker, Marcio Sales, Carlos Souza, Jr., and Stephen G. Perz. A*uthors simulate forest fragmentation patterns by reference to the actual decision-making of the agents engaged in the fragmentation process itself. They took as empirical case fragmentation in the Brazilian Amazon basin associated with road-building by loggers. They combine geostatistical methods with GIS to replicate a common fragmentation pattern found in tropical forests known as dendritic. (PE&RS 2008, vol. 74, no 6, p. 699).
9. Integration of Hyperion Satellite Data and A Household Social Survey to Characterize the Causes and Consequences of Reforestation Patterns in the Northern Ecuadorian Amazon; *Stephen J. Walsh, Yang Shao, Carlos F. Mena, and Amy L. McCleary.* The integration of Hyperion and Ikonos imagery are used to differentiate the subtle spectral differences of landuse/ land-cover types on household farms in the Northern Ecuadorian Amazon (NEA) with an emphasis on secondary and successional forests. (PE&RS 2008, vol. 74, no 6, p. 725).
10. Changing Regimes: Forested Land Cover Dynamics in Central Siberia 1974-2001; *Kathleen M. Bergen, Tingting Zhao, V. Kharuk, Y. Blam, Daniel G. Brown, L.K. Peterson, and N. Miller.* Authors used the 1972 to 2001 Landsat archive bracketing this transition to observe change trends in southern central Siberian Russia in primarily forested study sites. Landsat resolved conifer, mixed, deciduous and young forest; cuts, burns, and insect disturbance; and wetland, agriculture, bare, urban, and water land covers. (PE&RS 2008, vol. 74, no 6, p. 787).
11. Data Combination and Feature Selection for Multisource Forest Inventory; *Reija Haapanen and Sakari Tuominen*. Both satellite images and aerial photographs are now used operationally in Finland’s forestry for different tasks; satellite images are used for national forest inventory purposes and aerial images for forest management planning. Due to the double coverage, it could be advantageous to utilize the strengths of both image types. The aim of this study was to evaluate the potential of the combination of Landsat ETM+ spectral and aerial photograph spectral and textural features for forest variable estimation. (PE&RS 2008, vol. 74, no 7, p. 869).
12. Change Detection Techniques for Use in a Statewide Forest Inventory Program; *D.W. Wilkinson, R.C. Parker, and D.L. Evans.* Eight change detection procedures and a hybrid forest type classification procedure were tested for their ability to detect forest land-cover change in east-central Mississippi. The results of this study were compared to a prior pilot inventory study for the same study area in east-central Mississippi. (PE&RS 2008, vol. 74, no 7, p. 893).
13. Neural Network Classification of Mangrove Species from Multi-seasonal Ikonos Imagery; *Le Wang, José L. Silván-Cárdenas, and Wayne P. Sousa.* Tropical forests Central and South America experience strong seasonality in climatic variables such as rainfall, solar radiation, wind speed, and relative humidity. Authors compared the efficacy of three different classification methods for discriminating mangrove canopies. Second aim was to compare the absolute and relative discrimination abilities of these methods when applied to images of the same forest acquired in different seasons. Two sets of Ikonos images acquired in February (dry season) and May (early wet season) 2004 were analyzed in this study. (PE&RS 2008, vol. 74, no 7, p. 921).
14. MODIS-based Change Detection for Grizzly Bear Habitat Mapping in Alberta; *Alysha D. Pape and Steven E. Franklin.* Coarse resolution data from the Moderate Resolution Imaging

Spectroradiometer (MODIS) was used to test the effectiveness of 250 m data to detect forest disturbances and update an existing, large-area (150,000 km^2), 30 m Landsat ETM+ and TM land-cover map product used in Grizzly Bear habitat analysis. (PE&RS 2008, vol. 74, no 8, p. 973).

15. Lidar-based Mapping of Forest Volume and Biomass by Taxonomic Group Using Structurally Homogenous Segments; *Jan A.N. van Aardt, Randolph H. Wynne, and John A. Scrivani*. This study evaluated the potential of an object-oriented approach to forest type classification as well as volume and biomass estimation using small-footprint, multiple return lidar data. The approach was applied to coniferous, deciduous, and mixed forest stands in the Virginia Piedmont, U.S.A. Results lead to the conclusion that a lidar-based approach to forest type classification and volume/biomass assessment has the potential to serve as a single-source inventory tool. (PE&RS 2008, vol. 74, no 8, p. 1033).
16. Mapping Selective Logging in Mixed Deciduous Forest: A Comparison of Machine Learning Algorithms; *Christopher D. Lippitt, John Rogan, Zhe Li, J. Ronald Eastman, and Trevor G. Jones*. Study assesses the performance of five Machine Learning Algorithms (MLAs) in a chronically modified mixed deciduous forest in Massachusetts (USA) in terms of their ability to detect selective timber logging and to cope with deficient reference datasets. (PE&RS 2008, vol. 74, no 10, p. 1201).
17. Subpixel Urban Land Cover Estimation: Comparing Cubist, Random Forests, and Support Vector Regression; *Jeffrey T. Walton*. Three machine learning subpixel estimation methods (Cubist, Random Forests, and support vector regression) were applied to estimate urban cover. (PE&RS 2008, vol. 74, no 10, p. 1213).
18. Estimation of Forest Stand Characteristics Using Spectral Histograms Derived from an Ikonos Satellite Image; *Jussi Peuhkurinen, Matti Maltamo, Lauri Vesa, and Petteri Packalén*. The aim of this paper was to examine the potential of Ikonos satellite images for estimating boreal forest stand characteristics using frequency distributions of radiometric values. (PE&RS 2008, vol. 74, no 11, p. 1335).
19. Conterminous U.S. and Alaska Forest Type Mapping Using Forest Inventory and Analysis Data; *B. Ruefenacht, M.V. Finco, M.D. Nelson, R. Czaplewski, E.H. Helmer, J.A. Blackard, G.R. Holden, A.J. Lister, D. Salajanu, D. Weyermann, and K. Winterberger*. Classification-trees were used to model forest type groups and forest types for the conterminous United States and Alaska. The predictor data were a geospatial data set with a spatial resolution of 250 m developed by the U.S. Department of Agriculture Forest Service (USFS). The response data were plot data from the USFS Forest Inventory and Analysis program. This is the first forest type map produced for the U.S. (PE&RS 2008, vol. 74, no 11, p. 1379).
20. Leaf Area Index (LAI) Change Detection Analysis on Loblolly Pine (Pinus taeda) Following Complete Understory Removal; *J.S. Iiames, R.G. Congalton, A.N. Pilant, and T.E. Lewis*. The confounding effect of understory vegetation contributions to satellite-derived estimates of leaf area index (LAI) was investigated on two loblolly pine (Pinus taeda) forest stands located in Virginia and North Carolina. Total vegetative biomass removed under the canopies was estimated using the Tracing Radiation and Architecture of Canopies (TRAC) instrument combined with digital hemispherical photography (DHP). (PE&RS 2008, vol. 74, no 11, p. 1389).
21. Automated 3D Forest Surface Model Extraction from Balloon Stereo Photographs; *Keiji Kushida, Kunihiko Yoshino, Toshihide Nagano, and Tomoyasu Ishida*. Authors upgraded an automated forest digital surface model (DSM) extraction method from balloon stereo photographs of a tropical peat swamp forest in Narathiwat, Thailand by evaluating the image matching accuracy and forest surface height (FSH) estimation. They modified an image correlation matching method based on the characteristics of the tree crown shapes. (PE&RS 2009, vol. 75, no 1, p. 25).

22. Understory Bamboo Discrimination Using a Winter Image; *Tiejun Wang, Andrew K. Skidmore, Albertus G. Toxopeus, and Xuehua Liu*. In this study, a new approach is presented that combines forest phenology and Landsat vegetation indices to estimate evergreen understory bamboo coverage in a mixed temperate forest. The results suggest that winter is the optimal season for quantifying the coverage of evergreen understory bamboos in a mixed forest area, regardless of the classification methods use. (PE&RS 2009, vol. 75, no 1, p. 37).
23. A Comparison of Individual Tree and Forest Plot Height Derived from LiDAR and InSAR; *Shengli Huang, Stacey A. Hager, Kerry Q. Halligan, Ian S. Fairweather, Alan K. Swanson, and Robert L. Crabtree*. To compare the capability and the accuracy of Light Detection And Ranging (lidar) and Interferometric Synthetic Aperture Radar (INSAR) for the detection and measurement of individual tree heights and forest plot heights, one lidar dataset with nominal spacing of 3 m and one short-wavelength Ku-band INSAR with comparable ground resolution of 3 m were studied. These results indicate that lidar is much better than INSAR for the detection and estimation of tree and forest plot height. (PE&RS 2009, vol. 75, no 2, p. 159).
24. Effects of Mismatches of Scale and Location between Predictor and Response Variables on Forest Structure Mapping; *Yaguang Xu, Brett G. Dickson, Haydee M. Hampton, Thomas D. Sisk, Jean A. Palumbo, and John W. Prather*. Measurement error introduced by mismatches of scale and location between response and predictor variables is one of the major sources of error in forest structure mapping. Using forest structure attributes measured in a specifically-designed ground plot system, authors isolated the measurement error from the total mapping errors that are related to multiple factors, and examined the distribution and magnitude of this error caused by a scale mismatch between a relatively larger forest unit and a relatively smaller forest unit, as well as location mismatch of a specific distance between two forest units of the same size. (PE&RS 2009, vol. 75, no 3, p. 313).
25. Canopy Reflectance Model Inversion in Multiple Forward Mode: Forest Structural Information Retrieval from Solution Set Distributions; *S. A. Soenen, D. R. Peddle, C. A. Coburn, R. J. Hall, and F.G. Hall*. Remote estimation of canopy structure is important in forestry and a variety of environmental applications. Three approaches are presented for deriving BSI from MFMLUT multiple solution sets: reflectance equality (REQ), nearest spectral distance (NSD), and spectral range domain (SRD). These approaches were validated at a Rocky Mountain test site, for which SRD corresponded best with field data, with RMSE 0.4 m and 0.8 m obtained for horizontal and vertical crown radius, respectively. (PE&RS 2009, vol. 75, no 4, p. 361).
26. Hemispheric Image Modeling and Analysis Techniques for Solar Radiation Determination in Forest Ecosystems; *Ellen Schwalbe, Hans-Gerd Maas, Manuela Kenter, and Sven Wagner*. Hemispheric image processing with the goal of solar radiation determination from ground-based fisheye images is a valuable tool for silvicultural analysis in forest ecosystems. The basic idea of the technique is taking a hemispheric crown image with a camera equipped with a 180° fisheye lens, segmenting the image in order to identify solar radiation relevant open sky areas, and then merging the open sky area with a radiation and sun-path model in order to compute the total annual or seasonal solar radiation for a plant. The results of hemispheric image processing can be used to quantitatively evaluate the growth chances of ground vegetation (e.g., tree regeneration) in forest ecosystems. Paper shows steps towards the operationalization and optimization of the method. (PE&RS 2009, vol. 75, no 4, p. 375).
27. GeoSAR and DBInSAR: Combining “X” With “P” for Tropical Forest “C”; *Mark L. Williams and L.G. Jenkins*. Recent and anticipated policy changes in the U.S. and abroad are moving the world closer to a new global currency: carbon. As an increasingly valuable commodity, governments around the world are promoting carbon-trading programs to help curb greenhouse gas emissions. Protection of tropical forests is key to this concept. The

Reduced Emissions from Deforestation and Degradation (REDD) initiative of the United Nations Framework Convention on Climate Change proposes performance-based incentives to reverse these high rates of emission through large-scale tropical forest conservation. (PE&RS 2009, vol. 75, no 7, p. 738).

28. Forest Type Mapping using Object-specific Texture Measures from Multispectral Ikonos Imagery: Segmentation Quality and Image Classification Issues; *Minho Kim, Marguerite Madden, and Timothy A. Warner*. This study investigated the use of a geographic object-based image analysis (GEOBIA) approach with the incorporation of object-specific grey-level co-occurrence matrix (GLCM) texture measures from a multispectral Ikonos image for delineation of deciduous, evergreen, and mixed forest types in Guilford Courthouse National Military Park, North Carolina. The results demonstrated that the scale of segmentation directly influenced the object-based forest type classification results. (PE&RS 2009, vol. 75, no 7, p. 819).
29. Quantifying Impacts of Land Ownership on Regional Forest NDVI Dynamics: A Case Study at Bankhead National Forest in Alabama, USA; *Xiongwen Chen and Rory Fraser*. In this study, the spatial and temporal dynamics of Normalized Difference Vegetation Index (NDVI) at three adjacent areas with different proportions of private land (6 percent, 20 percent and 55 percent) in the Bankhead National Forest in Alabama, USA from 1998 to 2004 were examined. (PE&RS 2009, vol. 75, no 8, p. 997).
30. Individual Object Change Detection for Monitoring the Impact of a Forest Pathogen on a Hardwood Forest; *Tim De Chant and Maggi Kelly*. To quantify changes in horizontal canopy structure to the oak woodlands in China Camp State Park, California, USA, a heavily hit area, authors developed a novel change detection technique that tracks changes to individual objects. (PE&RS 2009, vol. 75, no 8, p. 1005).
31. Toward a National Early Warning System for Forest DisturbancesUsing Remotely Sensed Canopy Phenology; *William W. Hargrove, Joseph P. Spruce, Gerald E. Gasser, and Forrest M. Hoffman.* (PE&RS 2009, vol. 75, no 10, p. 1150).
32. Synchronicity between Satellite-Measured Leaf Phenology and Rainfall Regimes in Tropical Forests; *Sunyurp Park.* The seasonal and interannual cycles of the canopy phenology of Hawaiian tropical ecosystems were extracted from seven year MODIS VI data. NDVI responded sensitively to surface greenness of dry-to-mesic ecosystems, but it showed little change as mean annual precipitation (MAP) surpassed 2,000 mm. Study results report that the photosynthetic activity of dry biomes responded synchronously to annual rainfall patterns. (PE&RS 2009, vol. 75, no 10, p. 1231).
33. Assessment of 2001 NLCD Percent Tree and Impervious Cover Estimates, *Eric J. Greenfield, David J. Nowak, and Jeffrey T. Walton.* The 2001 National Land Cover Database (NLCD) tree and impervious cover maps provide an opportunity to extract basic land-cover information helpful for natural resource assessments. To determine the potential utility and limitations of the 2001 NLCD data, this exploratory study compared 2001 NLCD-derived values of overall percent tree and impervious cover within geopolitical boundaries with aerial photo interpretation-derived values for the same areas. (PE&RS 2009, vol. 75, no 11, p. 1279).
34. A Two Stage Method to Estimate Species-specific Growing Stock; *Petteri Packalén, Aki Suvanto, and Matti Maltamo.* Information about tree species-specific forest characteristics is often a compulsory requirement of the forest inventory system. In Finland, the use of a combination of ALS data and orthorectified aerial photographs has been studied previously, but there are some weaknesses in this approach. The results show the benefits of using aerial photographs together with ALS data in order to estimate tree species-specific characteristics. Compared to earlier studies, the new two-stage method shows a considerable improvement in applicability in operational use. (PE&RS 2009, vol. 75, no 11, p. 1451).

3. CONCLUSIONS

Analysis of 3 geomatics journals in the 3 years in aspects of forestry selected 34 articles, but most of them, 33 articles, were published in Photogrammetric Engineering & Remote Sensing, and only 1 in International Journal of Geographical Information Science.

Most of articles are related to application of geomatics technology in researches of forest-cover and tree classification, but also such problems as: changes of biodiversity (5), climate changes (5, 13, 27), forest management (6, 11), environmental protection (13), forest ecosystems (26, 32), silviculture (26), forest protection (27), biomass (15, 20) are presented.

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CLIMATE CHANGES IMPACTS ON FORESTS IN MONTENEGRO – MITIGATION AND ADAPTATION

Milić ČUROVIĆ[1], Velibor SPALEVIĆ[2]

Abstract: *On the basis of available data on Montenegrin forests, as well as undertaken silviculture activities, the possible impacts of climate change on forests in Montenegro are considered as well as measures to minimize these impacts and measures for better adaptability of these ecosystems.*

In addition the paper are presented the data from base inventory of gases with greenhouse efects for Montenegrin forests by the IPCC methodology prescribed in the revised manual from 1996.

UTICAJ KLIMATSKIH PROMJENA NA ŠUME CRNE GORE – UBLAŽAVANJE I PRILAGODLJIVOST

Izvod: *Na osnovu dostupnih podataka o stanju šuma, kao i o šumsko-uzgojnim aktivnostima koje se preduzimaju, sagledane su mogući uticaji klimatskih promjena na šume Crne Gore. Razmotrene su i mjere za smanjivanje ovih uticaja kao imjere za bolju adaptibilnost ovih ekosistema.*

Osim ovoga u radu su prezentovani i podaci osnovne inventarizacije gasova sa efektom staklene bašte za šume Crne Gore po IPCC metodologiji koja je propisana revidiranim manualom iz 1996.godine(IPCC 1996).

METHOD OF WORK

Possible impacts of climate change on forests in Montenegro as well as measures to minimize these impacts and measures for better adaptability of these ecosystems are considered on the basis of available data on Montenegrin forests, as well as undertaken silviculture activities.

Basic inventory of gases with the main greenhouse effects is done for Montenegrin forests by the IPCC methodology which is prescribed in the revised manual 1996 (IPCC 1996). Only "Tier 1" methods were used for the Sector of Land use change and forestry (LUCF) because available data only allow the application of these methods.

Based on growing stock increment and calculated timber biomass in submodel "Changes in forests" were calculated annual absorption of carbon in Montenegrin forests. Total harvested wood biomass expressed in kt of dry matter data is based on data on annual cut, or the amount of technical, firewood and waste. Based on these data were calculated the annual amount of absorpted CO_2 in Gg.

STATE OF MONTENEGRIN FORESTS

Forests and woodlands cover an area of 743 609ha, or 53.85% of the land surface of Montenegro. Out of the total area under forests (620 872ha) forests in state ownership affect 500,041 hectares or 67.25% while the privately owned forests takes 243,568 hectares or 32.75%. State forests have much better structure in relation to private forests, which best reflects the amount of wood mass that private forests is only 17.2% of the total growing stock.

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In Montenegro, we can find domination of mixed forests with 59.8% and pure forests are 40.2% of the total area under forests.

Total timber stock in the forests of Montenegro are estimated at about 72,056.699 m^3, of which 29,527.555 m^3 of coniferous and 40.98% 42,529.144 m^3 or 59.02% of broadleaved trees.

Timber stock in Montenegrin forests	Coniferous (m^3)	Broadleaved (m^3)
State forests	28,355,635	31,275,245
Private forests	1,171,920	11,253,899
Total	29,527,555	42,529,144

Overall increment of the Montenegrin forests is estimated at 1,489.189 m^3

Structure of increment	Coniferous (m^3)	Broadleaved (m^3)	Total	%
State forests	664,792	575,589	1,240,381	83.29
Private forests	30,144	218,664	248,808	16.71
Total	694,936	794,253	1,489,189	100.00

Planned yield is 815.000 m^3, Current harvest levels are unclear but estimates vary from 550 000m^3 to 650. 000m^3.

IMPACT OF THE CLIMATE CHANGE ON FOREST ECOSYSTEMS

Climate change on forest ecosystems affected primarily moving of the vegetation vertical layout belts. When it comes to warming is done moving up. Climate change has the greatest impact on the species with narrow ecological valence, such as spruce, fir and oak, and some endemic species such as some pines (*Pinus peuce* and *Pinus heldreichii)*

Resistance of the forests to climate change depends on their surface, the degree of naturalness, of biodiversity and structure. To enable easier and better adaptation of forests to climate change, management should be directed to save natural composition of the given stands and to save diversity. Stands that are closest to natural stands (according to types of trees, composition, structure etc.) are optimal for the habitat and the most resistant to various abiotic and biotic adverse impacts. Forest ecosystems of Biogradska gora, Durmitor, Lovcen, Prokletije etc. are among the most important forest facilities in the Region, due to its exceptional diversity and high degree of preservation. These ecosystems are due to the lack of influence of human factors, professionaly and scientific very interesting, and especially grateful as research facilities. It is necessary to meet the developmental process in intact forests to learn how to manage forests in a sufficiently high level of biodiversity (Medarević, M.et al 2004).

Also, occurrences of forest fires are increasingly common. The fact that in the last 15 years in Montenegro, recorded more than 1,500 major forest fires, with fire surface over 15,000 hectares and damaged or destroyed about 1,300,000 m3 of timber volume (only in 2003 was more than 350 fires on 2500 ha), shows a specific risk for the disappearance of large areas of forests and forest land.

MITIGATION MEASURES

In forestry sector often are mentioned two types of measures: to increase carbon stocks in biomass as Holes emissions and use of biomass for energy purposes as the substitution of fossil fuels.

Annual afforestation in Montenegro be made on about 620 hectares. Afforestation of clear land is done on more than 200ha. In addition the Action Plan of the National sustainable development strategy envisages afforestation around the 100ha/ year. Small area on which to execute afforestation reflects the economic situation and not needs. Therefore, it should be observed in future the possibility of implementation of afforestation as CDM (clean development mechanism) project.

Forest conservation is ecluded from the Clean Development Mechanism, which is limited to afforestation and reforestation (Gullison et al.2007). Although the saving of forests as a global warming countermeasure was initially controversially discussed (Fearnside 2001), the awareness has grown that reduction targets for CO2 emissions will hardly be achievable without solving the deforestation problem. Since Stern (2006) identified that curbing deforestation is a highly cost-effective way of reducing GHG emissions, climate policy makers have confirmed the need for action to reduce emissions

from deforestation and forest degradation, named REDD, at the UNFCCC (United Nations Framework Convention on Climate Change) meeting in Bali 2007 (UNFCCC 2008).

Forests which are managed to be structurally closest to natural stands are characterized by greater stability and greater supplies of biomass and therefore greater accumulation of CO_2 (Knoke et al 2006). Management and silviculture measures should be directed to:

- Preserve and improve the forest habitat and biodiversity;
- Increase the share of high forest in relation to low forests;
- Make sanation and reconstruction of devastated forests;
- Use the seedlings of indigenous species;

In assessing the possible use of complete biomass of trees - from waste (sawdust, large and small branches picks, etc.) there are great uncertainties in determining the theoretical potential of accounting, technical and economic potential of justifiable use. Use complete biomass has significant socio-economic and environmental consequences, as in the assessment of potential should be taken into account.

To complete biomass could be used should be previously made preparation for the exploitation of energy, including biomass collection, transport, its further processing and use. In Montenegro, there have been only isolated attempts to exploiting the existing quantity of wood waste, mostly using dry sawdust and industry wood waste. Production of fuel briquettes and pellets for now is only in their infancy.

Potential could be expressed following calculation. If we use the standard % of waste and yield that was in the previous period approximately 660.000m^3 of roud wood, trash in forestry (with wood processing) reaches over 160,000 m^3 of raw materials that can be directed to industrial briquettes, wood pellets or tablets.

The effects of this production, through increased energy efficiency of the country, would not be small. However, it is necessary before that to be done a more detailed study with costs projections of collecting and transport raw materials and processing. It should be noted also additional effects, such as:

- Cleaning the forest waste,
- Reduce the possibility of infection of insects,
- Reduce the possibility of phytopathological infection,
- Improving fire safety,
- Environmental benefits of forests and factories (this industry called facilities cleaner),
- Reduce firewood logging,
- New jobs etc.

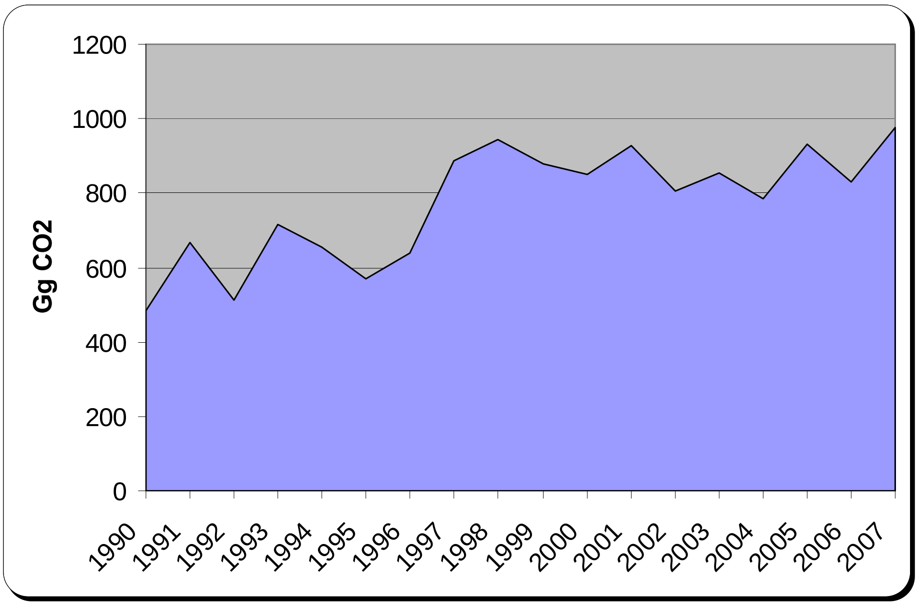
INVENTURE OF GASES WITH GREENHOUSE EFFECTS

Basic inventory of gases with the main greenhouse effects is done for Montenegrin forests by the IPCC methodology which is prescribed in the revised manual 1996 (IPCC 1996).Input data for estimation of total carbon content for each type of forest, annual growth, logged and planted forests are in tonnes of dry matter (t dm). Carbon fraction of dry matter is 0.5 of biomass.

Commercial harvest statistics are often provided for the commercial portion of the biomass in cubic metres (m^3) of roundwood. The volume of biomass expressed as m^3 must be converted to mass of dry matter expressed as tonnes (t dm). The conversion ratio (t dm total biomass : m3) for commercial roundwood of logged forests is 0.95.

It should be noted that the model made an inventory of CO_2 for this sector does not include lack of biomass destroyed in the fires. Error is greater if one bears in mind that the area of fire long lead in official statistics as the area under forest

Year	CO_2 (Gg)
1990	485
1991	668.39
1992	513.36
1993	717.38
1994	655.06
1995	568.17
1996	638.32
1997	886.42
1998	944.68
1999	878.3
2000	849.17
2001	926
2002	805.54
2003	853.26
2004	783.85
2005	930.2
2006	831.11
2007	975.86



The trend of increasing amounts of CO_2 that is compromised for the period 1997-2007 almost doubled over the period 1990-1995 is the result of the fall of wood processing industry and a minimum current capacity utilization and it is not result of any of mitigation measures.

CONCLUSION

Based on the above mentioned it can be concluded the following:

- Land under forests in Montenegro is in the last 20 years at the level of about 620 000ha. Annual afforestation as one of mitigation measures is made on 620 hectares. Afforestation of clear land is done on more than 200ha. Small area on which to execute afforestation reflects the economic situation and not needs. Therefore, it should be observed in future the possibility of implementation of afforestation as CDM (clean development mechanism) project.

- Forests which are managed to be structurally closest to natural stands are characterized by greater stability and greater supplies of biomass and therefore greater accumulation of CO_2. To enable easier and better adaptation of forests to climate change, management should be directed to save natural composition of the given stands and to save diversity.
- amount of harvested timber is twice less in last 5 years then in 1990 but use of complete biomass of trees is only in their infancy. Use complete biomass has significant socio-economic and environmental consequences, as in the assessment of potential should be taken into account. However, it is necessary before that to be done a more detailed study with costs projections of collecting and transport raw materials and processing.
- The trend of increasing amounts of CO_2 that is compromised for the period 1997-2007 almost doubled over the period 1990-1995 is the result of the fall of wood processing industry and a minimum current capacity utilization and it is not result of any of mitigation measures.

Problems against climate change and the role of forestry should be approached more seriously and thus spread the range of potential measures.

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THE MIGRATION TRENDS AND SOIL PROTECTION FROM THE EROSION IN GRDELIČKA GORGE AND VRANJSKA VALLEY

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Abstract: *This paper presents the results of the researches and analysis of the trends of the population, the number of households, and residential density according to the censuses from 1948, 1953, 1961, 1971, 1981, 1991 and 2002, based on the data for the municipalities (parts of municipalities) which belong to the researched area: Leskovac, Vladicin Han, Crna Trava, Surdulica, Vranje, and Bujanovac. The data were collected and analyzed for the total of 221 inhabited places.*

The decrease in the population of the rural inhabited places is the result of the decrease of the total population growth rate and migrations. The increase in the population of the Grdelicka gorge and Vranjska valley was typical for all the inter-census intervals until 1991, since the decline of the population in all parts of the area was typical for the latest inter-census period 1991-2002. The decrease in the population in the latest census-interval was reported in Bujanovac, Surdulica, as well as in the areas which belongs to Leskovac and Crna Trava. The decline was also reported in Vladičin Han, whereas the increase in the population was reported only in Vranje. In this area, as well as in the greatest part of Serbia, the population migrated from the mountain to the lowland areas, and from the rural to the urban centers. The analyzed demographic and socio-economic changes in the researched area affected the decrease of the intensity of the erosion processes.

Key words: population, migrations, number of households, residential density, erosion

MIGRACIONA KRETANJA I ZAŠTITA ZEMLJIŠTA OD EROZIJE NA PODRUČJU GRDELIČKE KLISURE I VRANJSKE KOTLINE

Izvod: *U radu su prikazani rezultati istraživanja i analize kretanja stanovništva, prema broju domaćinstava, i gustine naseljeneosti prema popisima stanovništva od 1948, 1953, 1961, 1971, 1981, 1991 i 2002, a na osnovu podataka za opštine (delovi opštine) koji pripadaju istraživanom području: Leskovac, Vladičin Han, Crna Trava, Surdulica, Vranja i Bujanovca. Podaci su prikupljeni i analizirani za ukupno 221 naseljenih mesta.*

Smanjenje stanovništva u seoskim naseljenim mestima je rezultat smanjenja ukupne stope rasta populacije i migracije. Porast stanovništva u Grdelickoj klisuri i Vranjskoj kotlini bio je tipičan za sve periode između popisa stanovništva sve do 1991, a pad broja stanovnika u svim delovima ovog dela zemlje tipičan je za razdoblje 1991-2002. Smanjenje poulacije u posljednjem popisu stanovništva zabeleženo je u Bujanovcu, Surdulici, kao i u područjima koja pripada Leskovcu i Crnoj Travi. Pad je zabeležen i u Vladičinom Hanu, dok je porast stanovništva bio prijavljen samo u Vranju. U ovom području, kao i najvećem delu Srbije, stanovništvo migrira iz planinskih u nizinska područja, a iz ruralnih u urbane sredine. Analizirane demografske i društveno-ekonomske promene u istraživanom području odrazile su se i na smanjenje intenziteta erozioskih procesa.

Ključne reči: populacija, migracije, roj domaćinstava, gustina naseljenosti, erozija

1. INTRODUCTION

The pace of movement of population, households and population density areas Grdelička gorge and Vranjska valley influenced geographical and traffic location, natural conditions and

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Acknowledgement: The study was partly financed by the Minstry of Science and Technological Development of the Republic of Serbia, the Project – TR 20056 „High-resolution satellite images in the collection and processing of spatial information on forests and forest ecosystems“

historical, cultural and political factors. Expanse of forest and meadow, abundant sources of water and were suitable for settlement since the Neolithic period.

2. RESEARCH AREA AND METHODS

Grdelička gorges area and Vranje valley is located in southeast Serbia. Direction of providing the area is generally southwest-northeast, the length is about 60 km, an area of 173,261 ha and is located in the altitude zone of 252 to 1874 meters above sea level. In 1953rd singled out as one of the biggest erosion hot spots and began antierosion works trough torrent basins and rivers. Main roads in the area has a north-south direction in which they form a much larger settlements (Grdelica, Vladičin Han, Vranje, Bujanovac, Preševo, etc.). In the north the south the area is related to Skoplje and the Vardar valley remains with Greece, while the north is connected via Leskovac and Niš and further via Belgrade with the European Union. According to the East region, through Vlasina plateau is associated with Bulgaria. The process of population redistribution caused a visible increase in urban and rural population decline. It is caused by creating areas of demographic growth (cities) and the area decline (most villages) with a completely different general characteristics. Towns reported a steady increase in the population to which they are represented components increase (natural and migration).

The state of erosion in the area of study was determined based on existing maps of erosion. Their digitalization and measuring the area under a particular category of erosion of the middle coefficients were calculated for both erosion Zsr reference period. (Gavrilović, 1972). Analysis of movement of population, number of households and population density by census of 1948, 1953, 1961, 1971, 1981, 1991 and 2002 was done on the basis of data for the following municipalities (municipality parts) that are in the area of research: Leskovac 25 - settlements, Crna Trava - 7 settlements, Vladicin Han - 51 settlement, Surdulica - 25 villages, 80 towns of Vranje and Bujanovac - 33 settlements. Data were collected and analyzed for the 221 settlements.

3. RESEARCH RESULTS

It was found that there was a significant decrease in the intensity of erosion processes. Surface processes that affect the processes of medium and excessive erosion in the period of 1953 decreased by 2,5 times. Area under the weak processes of erosion was increased by 7,34 times, and the process of very weak erosion is 2,09 times.

The cause of this reduction, in addition to derivative antierosion works bed and a large number of basins torrent watercourses, should be sought in the influence of anthropogenic factors, because in parallel with the decrease of the intensity of erosion took place and the process of changing of land use.

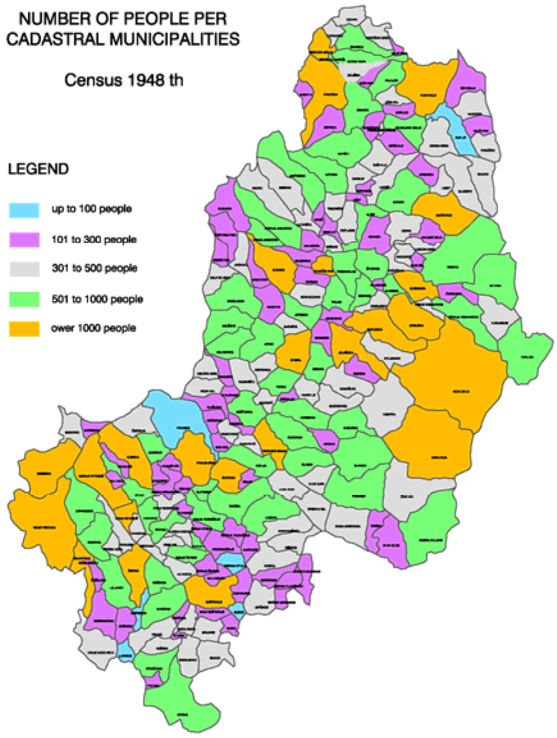
Table 1. *Population by municipalities and census years*

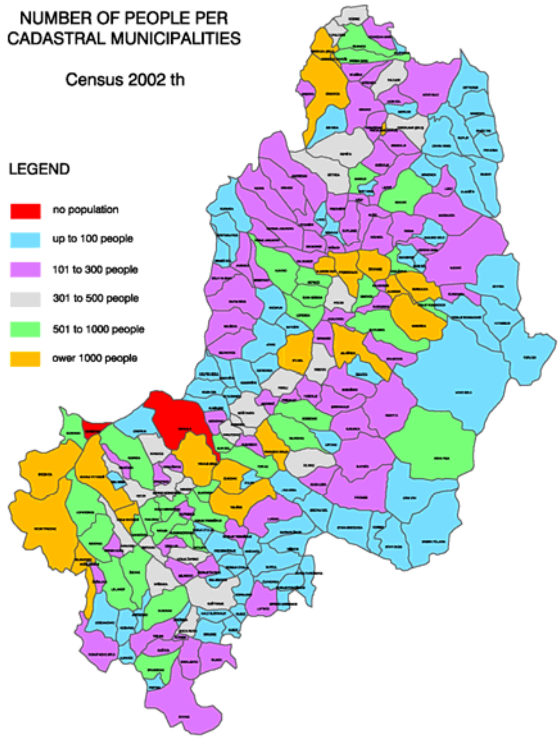
Municipality	1948	1953	1961	1971	1981	1991	2002
Leskovac	12776	13070	14063	14242	14055	13229	12366
Crna Trava	2352	2297	2069	1292	727	359	199
V. Han	24946	25927	26074	25231	25441	25253	23710
Surdulica	17305	20057	19467	19662	21098	21260	19738
Vranje	48388	51173	54841	63160	75571	80778	84004
Bujanovac	20841	22185	23630	26915	29929	33137	29324
Total	126608	134709	140144	150502	166821	174016	169341

As in most parts of Serbia and the region of movement of the population were directed from the mountains to the plains areas, ie. from rural to urban centers. The increase in population of Grdelica gorge and Vranjska valleys characteristic for all inter-census period to 1991. year, while the last inter-census period 1991-2002., is characterized with population stagnation of the whole area. Decline in population in the last Census period were noted in Bujanovac, Surdulica and observed areas that belong to Leskovac and Crna Trava. Stagnation is registered in Vladičin Han, while only recorded population growth was in Vranje.

Table 2. *Altitude zone distribution of settlements and population*

Altitude zone	Number of settlements	%	Population in census years						Projection for 2021.	%
			1948	%	1971	%	2002	%		
do 300	1	0,45	11252	8,89	28613	19,01	55052	32,51	61800	37,79
300-500	84	38,01	54699	43,20	64296	42,72	76611	45,24	72313	44,21
500-700	58	26,24	26335	20,80	28289	18,80	25532	15,08	22107	13,52
700-1000	50	22,62	22119	17,47	19177	12,74	9933	5,87	6962	4,26
>1000	28	12,67	12203	9,64	10127	6,73	2213	1,31	373	0,23
Total	221	100	126608	100,00	150502	100,00	169341	100,00	163555	100,00





Most of the villages are located in altitude zone of 300-500 m, than in high altitude areas of 500-700 m, and those numbers are followed by altitude zone of 700-1000 m. In altitude zone over 1000 m there is 28 settlements, and in the zone to 300 m only one settlement is located. Intensive processes of depopulation caused the biggest changes in high altitude areas up to 300 m and over 1000 m. In the altitude zone to 300 m of the population was increased 4.9 times since 1948, while in altitude zone above 1000 m decreased by 5.51 times. In altitude zone of 700-1000 m the population decreased by 2.22 times, in the zone 500-700 m 0,96 times, and in the zone of 300-500 m the population increased by 1,32 times compared to the 1948th year census. Reducing the number of inhabitants of rural settlements is a consequence of reduced population growth and migration.

Table 3. *Altitude zone distribution of settlements and population in municipality of Surdulica*

Altitude zone	Surdulica	Population							Projection for 2021.
		1948	1953	1961	1971	1981	1991	2002	
300-500	6	3584	3736	3796	3863	4134	4472	4496	4618
500-700	5	4982	6190	6755	8291	11202	12791	12120	11284
700-1000	9	5487	6324	5560	4955	4521	3471	2859	2160
>1000	5	3252	3807	3356	2553	1241	526	263	0
Total	25	17305	20057	19467	19662	21098	21260	19738	18062

In Surdulica in 1948 the 49% of the population lived in high altitude areas: 300-500 m (19%), 500-700 m (30%), and 51% in areas of 700-1000 m (32%) and over 1000 m (19%).

Table 4. *Altitude zone distribution of settlements and population in municipality of Vranje*

Altitude zone	Vranje	Population							Projection for 2021
		1948	1953	1961	1971	1981	1991	2002	
To 300	1	11252	13465	17999	28613	44094	51215	55052	61800
300-500	29	17521	17999	18049	17959	18629	20283	21499	22109
500-700	17	5752	5817,00	5537,00	4773	4029	3403	3095	2418
700-1000	20	8030	7928	7282	6368	4848	3360	2737	1795
>1000	13	5833	5964	5974	5447	3971	2517	1621	313
Total	80	48388	51173	54841	63160	75571	80778	84004	88435

Population in 1971 and further increased in the areas of 300-700 m, and decreased in areas above 700 meters. According to the 2002 census the largest population growth in 1948 was recorded in the zone of 500-700 m, (2,43 times) and the biggest decrease of population in the area over 1000 m, as much as 12,4 times. According to population projections for 2021 area over 1000 meters will be without inhabitants.

In the municipality of Vranje biggest population changes were in the area up to 300 m, where in relation to the 1948th year an increase of 4,89 times, as a result of migration of the population in the city. Increase in population recorded in the area of 300-500 m (1,22 times), and for the other high mountain areas the population decreased. The largest decrease was in the zone of over 1000 meters (3,60 times).

Table 5. *Altitude zone distribution of settlements and population in municipality of Vladičin Han*

Altitude zone	Vladičin Han	Population							Projection for 2021
		1948	1953	1961	1971	1981	1991	2002	
300-500	25	13462	14132	14318	14653	16928	18746	18720	19094
500-700	13	6077	6263	6016	5290	4209	2981	2131	825
700-1000	11	5002	5104	5308	4875	4061	3349	2737	1796
>1000	2	405	428	432	413	243	177	122	45
Total	51	24946	25927	26074	25231	25441	25253	23710	21760

In the municipality of Han Vladičin 79% of the population live in the zone of 300-500 m. The number in 2002nd was increased by 1,39 times compared to the 1948th year. In other areas, as well as at the municipal level, there was a decrease of population. Discharge process is most intense in areas over 1000 meters (3,31 times).

Table 6. *Altitude zone distribution of settlements and population in municipality of Crna Trava*

Altitude zone	Crna Trava	Population							Projection for 2021
		1948	1953	1961	1971	1981	1991	2002	
700-1000	1	75	51	26	21	21	7	6	4
>1000	6	2277	2246	2043	1271	706	352	193	15
Total	7	2352	2297	2069	1292	727	359	199	19

In the Municipality of Crna Trava population in 2002nd was decreased by as much as 11.8 times compared to the 1948th year; in the altitude zone of 700-1000 m 2002nd was 12,5 times, and in altitude zone over 1000 m of 11,8 times compared to the 1948th.

Table 7. *Altitude zone distribution of settlements and population in municipality of Bujanovac*

Altitude zone	Bujanovac	Population							Projection for 2021
		1948	1953	1961	1971	1981	1991	2002	
300-500	17	15215	16362	17755	21194	24832	28756	25181	19746
500-700	12	4774	4922	4953	4755	4192	3583	3469	3489
700-1000	3	693	743	776	780	824	733	674	594
>1000	1	159	158	146	186	81	65	0	0
Total	33	20841	22185	23630	26915	29929	33137	29324	26724

In Bujanovac reported an increase in the number of inhabitants in 2002 to 1,41 times compared to the 1948 census, due to the increase of population in altitude zone 300-500 m, which houses the largest number of settlements. In other areas there has been a reduction in the population and to fully discharge of Đorđevac village at an altitude of 1088 m.

Table 8. *Altitude zone distribution of settlements and population in municipality of Leskovac*

Altitude zone	Leskovac	Population							Projection for 2021
		1948	1953	1961	1971	1981	1991	2002	
300-500	7	4917	5286	6134	6627	7004	6852	6715	6746
500-700	11	4750	4937	5201	5180	5226	5154	4717	4091
700-1000	6	2832	2597	2463	2178	1748	1196	920	613
>1000	1	277	250	265	257	77	27	14	0
Ukupno	25	12776	13070	14063	14242	14055	13229	12366	11450

In municipality of Leskovac were recorded constant increase from 1948 to 1971 , and then to 2002. The decrease of population. As in other municipalities in research area increasing of 1.37 times was recorded in altitude zone 300-500 m, and drastic drop in population in the area over 1000 m, even 19,7 times. The number of residents in the area of 700-1000 m was reduced by 2,6 times.

According to population projections for the 2021st year is expected to further reduce the number of residents in all municipalities analyzed, unless the municipality of Vranje, and completely empty of settlements located over 1000 meters in the municipalities of Bujanovac, Surdulica and Leskovac.

The following review is an important indicator of population size of settlements in high-altitude schedule. The above classification of the settlement indicates the spatial-temporal expression of demographic depletion and fragmentation of the settlement.

Table 9. *Population size distribution of settlements to altitude zones*

	to 100			101-300			301-500			501-1000			over 1000		
	1948	1971	2002	1948	1971	2002	1948	1971	2002	1948	1971	2002	1948	1971	2002
< 300	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
300-500	0	0	6	21	26	25	22	19	17	24	22	18	14	14	15
500-700	1	1	10	21	28	28	22	15	11	19	20	15	9	6	8
700-1000	3	3	10	14	19	13	20	36	2	10	10	4	3	2	1
> 1000	1	3	13	8	11	3	12	10	0	5	3	1	2	1	0
Total	5	4	26	56	73	66	64	70	30	53	52	37	27	23	25

It is evident that the reduction of population size of village with 301-500 residents, which in 1948 comprising 29%, in 1971 - 32%, and in 2002 - 13.5% of their total number (Table 9). By reducing the number comes in all the high altitude zones, but is most prominent in areas above 1000 meters, 500-700 meters, 700-1000. Then, reduction of population size of settlements with 501-1000 inhabitants, who in 1948 comprising - 24%, 1971 - 23%, in 2002 the 12% of their total number, and in this case to reduce the number comes in all high altitude areas (except 300-500 m), but is most prominent in areas above 1000 meters, 500-700 meters, 700-1000 m. Reducing the population size of settlements over 1,000 people is something minor, except in the area over 1000 m, where in 1948 there were two settlements, in 2002 no one in the area 700-1000m, where the in 1948 just 3 registered settlements of this size, and in 2002 there was only one. On the other hand, noted a significant increase in the number of small settlements with fewer than 300 inhabitants, who in 1948 it was represented by 27.6%; in 1971 to 34.8%; in 2002 with 41.6% of the total settlement. The most important is to increase the number of settlements to 100 people, which in 1948 were 5 of them, 1971 year 4 of it, even the 26 in 2002.

4. CONCLUSION

Analyzed demographic changes in the area of research have influenced the significant reduction of erosion process intensity. Surface processes that affect the processes of medium and excessive erosion in the period since 1953 decreased by 2,5 times.

Analysis of population size of the settlement by the schedule indicated altitude is expressed depopulation and breaking settlements. Constant reduction of the rural population, especially at higher altitudes, has led to changes in the way of land use. Many abandoned agricultural land and there was a renewal of their degradation in a way of spreading aggressive weed vegetation.

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THE POSSIBILITY OF *PAULOWNIA SP.* UTILIZATION IN THE RECLAMATION OF DEGRADED LAND

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Abstract: *At present stage of technological development fossil fuels still have the dominant role. Open pit exploitation of coal and its use for the purpose of production of heat and electricity are drastically disturbs the environment.*

The obligation of the human collectivity, as well as a condition of his continued survival is to mitigate the negative effects caused by these activities. Reclamation of the mechanically damaged soil as a consequence of exploitation of opencast mining and ash of thermal power plants are the challenges which require urgent resolution.

The paper presents the potential of Paulownia sp. in the process of biological recultivation. The species is tolerant to the environmental conditions. Produce a large amount of leaf biomass each year. It is rapidly growing species with high quality wood. Paulownia tree is the species which is devoted great attention in the world. Results of previous research indicate that this species is suitable for use in reclamation by afforestation.

Keywords: Biological recultivation, deposol, afforestation

MOGUĆNOST KORIŠĆENJA *PAULOWNIA SP.* U REKULTIVACIJI DEGRADIRANIH ZEMLJIŠTA

Izvod: *Razvojem civilizacije potreba za energijom sve je izraženija. Na današnjem stupnju tehnološkog razvoja kao energent dominantnu ulogu i dalje imaju fosilna goriva. Eksploatacijom uglja i njegovim korišćenjem u svrhu proizvodnje toplotne i električne energije se drastično narušava životna sredina.*

Obaveza je društva, ali i uslov njegovog daljeg opstanka da ublaži negativne efekte koje izaziva ovim aktivnostima. Rekultivacija odlagališta otkrivke kao posledice površinske eksploatacije i deponija pepela termoelektrana su izazovi koji traže hitno rešavanje.

U radu su prikazani potencijali vrste Paulownia sp. u procesu biološke rekultivacije. Vrsta je tolerantna na ekološke uslove. Produkuje veliku količinu biomase lista svake godine. Brzorastuća je vrsta sa kvalitetnim drvetom. U svetu je Paulovnija drvo kome se posvećuje velika pažnja. Rezultati dosadašnjih istraživanja ukazuju da je ova vrsta pogodna za korišćenje u rekultivaciji i na našim prostorima.

Ključne reči: biološka rekultivacija, deposol, pošumljavanje

1. INTRODUCTION

Consumption of wood in the world is growing continuously. Bearing in mind the importance of forest ecosystems in the survival of life on the planet with excessive cutting of forest we run the risk of experiencing self-destruction. Due to the expressed needs for wood mass is growing interest in the cultivation of fast growing species in short rotation plantations.(Bergman *et al*., 1997) This is particularly topical in the regions that have available land that do not meet the quality of agricultural land (Vilotić *et al*., 2005) and in areas where a surface exploitation of mineral resources is dominantIn (Veselinović, Golubović, 2001).

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Paulownia is by far the fastest growing hard wood tree in the world (Vilotic *et al*., 2005). Under good growing conditions these trees will reach 15m to 20m in height in 5□7years. (Jiménez *et al*., 2005, Popović & Radošeić 2008) They will produce commercially harvestable timber in 12 –15 years. (Šoškic *et al*.,2003). For making Bio Fuel the full growth circle can be five years with thinning starting at three years. Paulownia species can provide the same amount of cubic meters in a butt log at year 10 as most fast growing softwoods can provide at year 25. The root system is unique, it grows deep in the land and its development is dependent on soil structure (Ayan *et al*., 2003).

2. DEGRADED LAND IN KOLUBARA AS LIMITING FACTOR FOR BIOLOGICAL RECULTIVATION

Mining-energetic industrial combine PK ″Kolubara″ started open-cut coal mining in 1957. The region of the Kolubara Basin covers the area of 600 km^2. Open-cast coal mining has changed completely the topography of this area. The hilly terrain in the East part of the Basin is leveled because of coal mining, and flattened landforms are formed by the deposited material, whereas previously flat areas of Tamnava are raised, acquiring the form of elevated plateau. The microclimate has also changed because of destroyed forest areas, whereas due to the modified microtopography, aerodynamic regime of ground atmosphere has also changed. According to Šmit *et al*. (1997) climate in the Kolubara Basin is rather dry, with continental and steppe characteristics. Winter months are with low precipitation and soil is not provided with moisture in the initial stage of vegetation. In the second half of spring, the quantity of rainfall is sufficient. Besides, in June, July and August, although the quantity of rainfall is high, it is still insufficient because of high temperatures. In autumn, rainfall is sufficient but not well-timed, because it is distributed at the end of the vegetation period. Human interference has created a completely new topography in this region. Natural soil is completely disturbed by overburden removal in strip mining and the newly formed soil – deposol is created by inverting, loosening, mixing and re-depositing of overburden constituents.

Physical characteristic of disturbed soil. Substrates are mostly light mechanical composition. Due to the lack of tiny particles and organic matter, constitution of stable aggregates is not possible (Table 1).

Table 1. *Physical properties of deposols*

Substratum type	Deep in cm	Granular composition						Texture class
		Coarse sand	Fine sand	Dust	Clay	Total sand	Total clay	
White send	0-30	0,50	86,90	7,50	5,10	87,40	12,60	Loamy sand
	30-130	0,50	86,60	6,90	6,00	87,10	12,90	Loamy sand
Drab Clay	0-41	12,00	52,50	23,10	12,40	64,50	35,50	Sandy loam
	41-100	7,00	58,00	26,80	8,20	65,00	35,00	Sandy loam
Yellow send	0-30	4,50	71,20	16,80	7,50	75,70	24,30	Sandy loam
	30-100	0,50	78,30	15,90	5,30	78,80	21,20	Sandy loam
Red send	0-30	1,00	71,60	18,40	9,00	72,60	27,40	Sandy loam
	30-140	0,50	41,50	24,10	3,90	72,00	28,00	Sandy loam

Chemical characteristic of disturbed soil (Table 2). The data show very pronounced deficiencies of organic matter, as well as total nitrogen. Values for easily accessible potassium are very variable, while of accessible phosphorus exist only in traces. pH values are between 6,6 and 7,3 which is favorable for the normal development of forest vegetation.

Table 2. *Chemical properties of deposols*

Substratum type	Deep in cm	pH		$CaCO_3$	Humus	N	Total Accessible P_2O_5 u mg	K_2O/100g soil
		H_2O	KCl	%	%	%		
White send	0-30	6,7	5,6	-	0,55	-	< 1	3,4
	30-130	6,8	5,7	-	0,36	-	-	-
Drab clay	0-41	7,0	5,4	-	0,53	0,08	< 1	9,7
	41-100	6,9	5,5	-	0,43	-	< 1	9,7
Yellow send	0-30	6,6	5,9	-	0,44	0,08	< 1	9,3
	30-100	7,3	6,1	-	0,36	-	1,0	6,2
Red send	0-30	7,4	6,4	-	0,32	-	< 1	3,0
	30-140	7,5	6,3	-	0,04	-	-	-

The concentration of heavy metals in the examined soil (Table 3) is normal for the analyzed elements (Veselinovic, 2005) and there is no toxic concentration of heavy metals for plants (Vanmechelen, 1997).

Table 3. *Content of heavy metals (ppm) in samples of deposols of PK Kolubara*

Sample	**Elements**			
	Pb	**Cd**	**Cu**	**Zn**
1	0.4	2.56	0.26	0.28
2	0.27	7.94	0.26	0.24
3	0.0	081	0.18	0.23
Average	0.22	3.77	0.23	0.25

Microbiological activity of soil. Total number of microorganisms on soil agar and the number of ammonification microorganisms in deposol is very small (Table 4).

Table 4. *Population of soil microflora*

Substratum type	Profile number	Total microorganisms	Ammonificators.	Oligonitrophils	Actinomycetes		Fungi	
		Soil agar	MPK	Erzbi's agar	Synthetic agar	Chapek's agar	Chap.	Sintet.
White send	3	586	200	333	33	13	146	6
	5	17	11	-	-	28	11	-
Drab clay	7	39	17	28	11	-	56	-
	11	410	119	770	23	-	11	35
	13	300	73	621	5	26	-	5
Yellow send	2	27	10	-	-	-	-	-
	4	553	145	526	5	5	-	-
	6	70	11	162	5	-	98	29
	8	800	400	129	70	-	77	17
Red send	1	10	5	16	26	-	5	-
	1		187	212	81	-	2	18

3. POTENTIALS OF PAULOWNIA SP. TO MEET LIMITING FACTORS

The Paulownia sp. tree can withstand temperatures between □20^0C and + 40^0C, optimal conditions for growth are between 24^0C and 29^0C. Paulownia is sensitive to water logging. Sandy soils work well; clay and rocky soils do not. Paulownia will also grow on soils that have naturally low humus content and with low fertility. Loose, well□drained soils with a pH between

5 and 8 are ideal. Paulownia can grow well even in highly saline soils, where its ability to selectively absorb Ca++ and Mg++ ions gives it an advantage (Lyons, 1993). Paulownia is a pioneer plant which rapidly removes minerals from soil and has a high tolerance for adverse conditions. This rare combination of characteristics makes it ideally suited for projects such as mine reclamation and waste management projects. These deciduous hardwood species are easy to propagate, grow very quickly, and require little care. Paulownia wood has many favorable characteristics. It is lightweight, yet strong, and is very easy to work with. It dries easily and does not crack, warp, or suffer other effects of high humidity (El-Showk and El-Showk, 2003). Paulownia trees need to be coppiced, pruned and thinned after first year growth to encourage sprouting. The trees are pruned in the second and third year to height of 4-6 m to provide a butt log without knots. On that way five or more stems are allowed to develop and if they harvested annually tree is allowed to grow anew each year. The branches and leaves of paulownia are also valuable. A 10-year-old tree can produce 350-400 kilograms of branches for fuel wood in a year, as well as 100 kilograms of fresh leaves which, because they are rich in protein and carbohydrates, make fine animal fodder as well as natural fertilizer (Zhao *et al*., 1986). Green leaves have a high food value, and can be a valuable source of organic matter and nutrients for the soil (Wang and Shogen, 1992) or used for compost (Lyons, 1993). Owing to the large surface of leaf, *Paulownia* is able in the course of one year to absorb significant amounts of sulfur dioxide from the air (Šijačić-Nikolić *et al*, 2008). For soil erosion we achieved to binds soil by planting Paulownia with its wide root system. How she manages and the very poor substrates it is possible to used for the revitalization of both natural and artificially created erosive soil (open pit, ash disposal etc.). The deep rooting system of *Paulownia* in combination with the rapid rate of growth enables it to take up more nutrients than other species and may therefore offer potential for bioremediation purposes. Previous research has demonstrated that Paulownia trees that were 8 years old had the ability to remove N at a rate of 930 kg/ha/year, based on an average N foliar content of 2.6% (Zhu, 1991). Recent work by Zhang *et al.* (2007) in China, where land near a Pb/Zn smelter that was contaminated with heavy metals was revegetated with *P. fortunei* demonstrated that the use of *P. fortunei* for revegetation greatly improved structural and functional characteristics of the soil microorganisms.

Features of *Paulownia* species allow us to start with experimental afforestation of deposols of PK Kolubara. According to current research in the world can be expected that Paulownia submit an limiting environmental factors that are present in the area of PK Kolubara. In order to mitigate the harmful effects of the development of open pit mining, it is necessary to monitor biological reclamation works and arranging disposal of degraded landscapes. It is a way to re-establish the different vegetal and other ecosystems on deposols.

4. CONCLUSION

Open pit exploitation of coal are drastically disturbs the environment. Surface that remains behind is burdened with many limitations. One of the best solutions for the resolve of degraded area is a biological reclamation by afforestation. Limiting factors for the selection of species for afforestation are numerous. This narrows the number of species that may in such circumstances to achieve good results. According to previous experiences in the world Paulownia is one of them. Paulownia is far the fastest growing hard wood tree in the world, with unique root system, produce a large amount of leaf biomass each year. The deep rooting system of Paulownia in combination with the rapid rate of growth enables it to take up more nutrients than other species and may therefore offer potential for bioremediation purposes. Features of Paulownia species allow us to start with experimental afforestation of deposols of PK Kolubara.

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FOREST LANDS VALORIZATION POSSIBILITY THROUGH FAST GROWING ENERGY CROP *MISCANTHUS X GIGANTEUS* CULTIVATION

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Abstract: *Status of fuel and energy base in the world requires a radical intervention in the energy sector, notably by changing the fuel base and the use of additional resources in the form of renewable energy. Renewable energy sources are based on sophisticated and environmentally friendly technologies and contribute to strengthening and diversifying the structure of industry, agriculture and forestry. Biomass energy use has a multifaceted meaning. When the energy biomass is grown specifically on the agro - forest land, it contributes to maintaining the landscape, its biodiversity, to the economy of enterprises, which produce this biomass, especially in areas less suitable for intensive agricultural and forestry production. Energy crops are often grown in marginal areas, respectively in soils contaminated with heavy metals or organic pollutants. It would be optimal for these soils cultivated species, which would also apply its eco-renovation capability and consequently their use of biomass for energy purposes. From this point of view, plants of the genus Miscanthus are extremely promising. Miscanthus x giganteus high level biomass production, noticed in previous researches in the field sample plot established in Serbia, and possibility of cultivation on less quality soil make this crop very suitable as annual renewable raw material for bio-fuel production on uncovered, low quality or withdrawn forest lands for other purposes (power level lines, telecommunications etc.). Possibility of this energy crop cultivation on forest lands and production of pellets and briquettes in Serbia is considered in this paper as a way of economic valorization of uncovered, withdrawn or low quality forest lands.*

Key words: energy crop, forest lands, economic valorization

INTRODUCTION

Status of fuel and energy base in the world requires a radical intervention in the energy sector, notably by changing the fuel base and the use of additional resources in the form of renewable energy. Renewable energy sources are based on sophisticated and environmentally friendly technologies and contribute to strengthening and diversifying the structure of industry, agriculture and forestry. Biomass energy use has a multifaceted meaning.

Energy crops offer clear ecological advantages over fossil fuels, such as a positive carbon balance (due to the photosynthesis of the biomass used as raw material) which contributes to the reduction of greenhouse gases emissions and the low sulphur content, which contributes to the reduction of acidifying gases emissions (GOSSE, 1995). Among the biomass crops, *Miscanthus* is one of the most interesting, since it can transform solar energy into electricity, and due to its high content in cellulose it can also be used for paper pulp production (EL-BASSAM, 1996). In previous researches, several aspects of the sustainability of *Miscanthus x giganteus* biomass production in Serbia have been evaluated (DŽELETOVIĆ *et al.*, 2007; 2009; DRAŽIĆ *et al.*, 2009). Obtained results are in accordance with literature data for long term investigations in Europe and USA (MIGUEZ *et al.*, 2008) and suggest that production of *Miscanthus* biomass in the Republic of Serbia is possible at the level of about 10-20 t/DM/year, depending of agro-ecological conditions. *Miscanthus giganteus* high level biomass production and possibility of cultivation on less quality soil (HEATON *et al.*, 2004) make this crop very suitable as annual

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renewable raw material for bio-fuel production on uncovered, low quality or withdrawn forest lands for other purposes (power level lines, telecommunications etc.).

Literature data show that cultivation of miscanthus is characterized with the highest energy efficiency comparing to other producers of biomass as bio fuel raw material (LEWANDOWSKI *et al.*, 2008). This industrial crop has very important storage potential and carbon exclusion potential, which make it very important in battle against global climate changes (CLIFTON-BROWN *et al.*, 2007). Miscanthus, sterile hybrid, has specificities related to heavy metals and other stressors besides high productivity, and that is probably consequence of *Miscanhtus sinensis* as a parent, which has higher resistance comparing with other parent species *M. sachariferus* (characterized with high productivity). All these traits provide miscanthus with ability for development on low quality land (EZAKI *et al.*, 2008, SCEBBA *et al.*, 2006).

According to existing research results on *Miscanthus x giganteus* biomass productivity in Europe and in Serbia (DRAŽIĆ *et al.*, 2008a, b; DRAŽIĆ *et al.*, 2009 a, b; DŽELETOVIĆ *et al.*, 2007, 2009), possibility of this energy crop cultivation on forest lands and production of briquettes in Serbia is considered in this paper as a way of economic valorization of uncovered, withdrawn or low quality forest lands.

MATERIALS AND METHODS

Plant material

Miscanthus rhizomes were planted in previously analyzed soil in the spring 2007. The examination of biomass quantity was performed in field experiment at six locations in Republic of Serbia. Rhizomes (100) were palanted in plots of 10 x 10 m each in 3 repetitions. The yield was measured by harvesting all abowerground plant material per 1 m^2 in 3 repetitions in same experimental plot. Results are shown as aritmetic mean ±standard error.

Soil properties

Soil properties were determined before planting. pH in H_2O was determined for the ratio soil: solvent ratio 1:2,5. We determined the total amount of organic C using the procedure described by NIKITIN (1972): heating soil samples with a chromium-sulphuric mixture, followed by spectrophotometrical measurement of optical densities in Visible spectrophotometer Ultro Spec 2000 (Pharmacia Biotech, UK). Total N content was determined by semi-micro Kjeldahl digestion with Se, $CuSO_4$ and K_2SO_4 as the catalysts (BREMNER, 1996). Available phosphorus was measured colorimetrically by ultraviolet/visible light spectrophotometer using the method of OLSEN and SOMMERS (1982). Available K was determined by flame photometry after extraction with mixture of 0.1N ammonium lactate on 0,4N acetic acid solutions.

Economic parameters

Economic parameters evaluation for miscanthus orchard establishment is conducted for the area of 10 ha with available capacities for briquette production.

RESULTS AND DISSCUSION

According to experimental data presented in Table 1, it can be assumed that real possibilities in miscanthus technological dry biomass yield achieving in the Republic of Serbia are 10-30 t per year, which depends on soil characteristics and quality.

Table 1. *Soil properties and miscanthus yield (early spring harvest) after 1 and 2 years of cultivation*

Sample plot	pH	N %	P_2O_5 mg/100 g	K_2O mg/100 g	organic C %	Max yield (kg/ha) 1st year	Max yield (kg/ha) 2nd year
Kozjak 1	5,04	0,05	1,78	7,59	0,66	145±62	5±4
Kozjak 2	5,97	0,14	50,31	112,65	2,23	1327±68	3582±360
Ribari	6,43	0,15	37,96	50,40	2,71	806±236	3004±280
Platicevo	6,37	0,06	13,39	20,52	1,12	984±260	508±106
Zemun	6,63	0,09	17,89	27,75	2,86	1930±310	3450±137
Ralja	5,3	0,11	5,0	11,8	1,38	3140±125	7260±158

Techno-economic analyze is conducted according to real yields for the orchard on 10 ha, with assumption that there is no cost for fertilizing, irrigation, application of agricultural machines for soil cultivation, harvesting and transport to the briquette capacities location. Established orchard will be in usage for 20 years period. Real prices of material and energy, as well as briquettes were used for calculation. The price of briquettes at the exit of the processing capacities is 130 €/t (1€=97 RSD).

Production price (Table 2) is relevant for the first production year and it amounts <3000 EUR/ha, while direct costs of briquetting process are around 64 EUR/t (Table 3).

Table 2. *Miscanthus biomass production price (EUR/ha)*

		EUR/ha
1.	Import of rhizomes 0,18 eurcent/ha 10.000 com per 1 ha + costs	1.930
2.	Custom costs	16
3.	Transport costs	500
4.	Phyto-sanitary assessment = 1.000 RSD	10
5.	Expedition costs	50
6.	Other administrative costs, taxes	24
7.	Soil preparation costs, seedling, tractor, fuel, seedling machine	400
8.	Workers	50
	Ukupno:	2.980

Table 3. *Direct costs of briquetting process*

		RSD/t	Comments
1	Dry mass from the orchard 56 EUR/t	5.432,00	
2	Transport 0,5 RSD/kg	500,00	
3	Electrisity	171,50	For 1t: electrisity 45 kwh + 4 kwh for light = 49 kwh x 3,5 RSD = 171,50
4	Plastic packaging	100,00	
Total		6.203,50	or 64 EUR

Table 4. *Total income table*

Production year	Costs in EURs per 10 ha per year	Yield t/ha	Income in EURs per 10 ha
1.	29.800	0	0
2.	22.500	5 – 7	6.500 - 9.100
3.	2.500	10 - 15	13.000 – 19.500
4.	2.500	15 - 25	19.500 – 32.500
5.	2.500	15 - 25	19.500 – 32.500
6.	2.500	30	39.000

Production year	Costs in EURs per 10 ha per year	Yield t/ha	Income in EURs per 10 ha
7.	2.500	30	39.000
8.	2.500	30	39.000
...	2.500	15 - 25	19.500 – 32.500
20	2.500	15 - 25	19.500 – 32.500
Total for 20 years	97.300		409.500 – 600.600

According to data presented in Tables 2, 3 and 4, static assessment of investment economic parameters is developed:

- Return on Capital Employed –ROCE in EUR= 447,07 %
- Working capital turnover = 9,82
- Economy = 6,53 > 1
- Accumulation = 0,61.
- Which means:
- Total invested capital of the orchard owner will increase 4,4 times for 20 years,
- Start up capital will be increased for 10 times until the end of rotation in 2030,
- Incomes are significantly higher than costs, which imply sustainable production process.

The best experimental results on biomass yield are used for economic parameters analyze, but there is always a dilemma, from bio-rationale soil usage point of view, related to high quality soil resources used for biomass production in renewable energy source purposes. Also, there is a realistic risk of yield sustainability during the whole exploitation period. That is the reason for assessment of possibilities of miscanthus biomass production on degraded areas, brown fields, abandoned forest lands or similar localities. These plots could also be used for biomass production of forest tree species with fast rotation, which implies necessity of comparative studies on ecological and economic parameters for different species (herbaceous and wooden).

Country-specific information on current prices to construct life-cycle cost assessments for production of Miscanthus and short rotation coppice willow (SRCW) is available for Ireland (STILESA *et al.* 2008). Gross margins for different harvest and supply strategies (e.g. chopped or baled harvest for miscanthus; stick or chipped harvest for SRCW) are calculated based on farm-gate biomass prices equivalent to 70, 100 and 130 h t^{-1} dry matter (DM) at maximum 20% moisture content—reduced for some SRCW supply strategies to reflect additional chipping and transport costs, and lower heating values.

These are compared with gross margin projections for conventional agricultural systems (dairy, cattle rearing, ‘cattle and other’, sugar beet, winter wheat, spring barley and set aside) using a net present value approach. Production costs expressed per t DM were similar for Miscanthus (h37–48) and SRCW (h31–46). Mid-estimate discounted, annualized gross margins ranging between 326 and 383 h ha^{-1} for Miscanthus, and between 211 and 270 h ha^{-1} for SRCW, compared favourably with all conventional agricultural systems considered except dairy. These gross margins were based on peak-productivity combustible yields of 14 and 10 t DM ha^{-1} for Miscanthus and SRCW. Yield variation will affect gross margins, but low yields were still calculated to realize positive returns. However, the application of high-activity cost estimates for all energy-crop cultivation activities resulted in negative returns for some supply strategies. Recently announced government support for SRCW and Miscanthus in EU countries considerably reduces investment risk for farmers, whilst utilisation of SRCW to treat waste water could substantially increase revenues. It is, also, a great challenge to examine possibilities of miscanthus usage for water and soil eco-remediation purposes. Energy crop cultivation has the potential to offer farmers a modestly profitable alternative to declining returns from conventional land uses.

CONCLUSION REMARKS

1. Experimental research results on miscanthus production in Serbia show that this kind of production is possible in our conditions;
2. Yield strongly depends on agroecologycal conditions;
3. Processing capacities (briquettes production) near to the orchard are necessary for economically sustainable production of miscanthus, and existence of energetic capacities is also recommended (for heating and electricity);
4. According to previous, strong functional linkage between scientific-research and biotechnological sectors is necessary through project activities and applications for investment funds.

Acknowledgements

The present work was supported by the project "Biorational usage and ecoremediation of land by growing plants for industrial processing", No. TR20208, funded by the Ministry of Science and Technological Development of the Republic of Serbia.

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NEW TECHNOLOGIES IN THE FORESTRY SECTOR IN SERBIA
– CASE STUDY HARVESTER –

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Abstract: *Improvement of forest ecosystems involves the use of new technologies. If we look at cutting trees as a way of use, protection and improvement of forest ecosystems, applying harvester is a new method in the contemporary forest use. In Serbia harvester is used to cut the poplar plantation. Cutting is performed on large areas afterwards the conditions for the establishment of new poplar plantations is about to be set. Intensive cultivation of poplar contributes to recultivation of degraded soils, Carbon sequestration, giving a great contribution to the mitigation of climate change. Uses of harvester in poplar plantations provide a strong backbone of forest enterprise to economically and environmentally sustainable managed forests.*

In this paper identify the fostering and impending factors for the introduction and application of new technologies in the process of utilisation of poplar plantations in JP "Vojvodinašume". Modern methodological approach applied based on qualitative research methods.

Keywords: new technologies, harvester, forest ecosystems, case study

NOVE TEHNOLOGIJE U ŠUMARSTVU U SRBIJU
- STUDIJA SLUČAJA HARVESTER -

Izvod: *Unapređenje šumskih ekosistema podrazumeva upotrebu novih tehnologija. Ako seču stabala posmatramo kao način korišćenja, zaštite i unapređenja šumskih ekosistema, primena harvestera predstavlja novu metodu u savremenom korišćenja šuma. U Srbiji harvester se koristi u seči topolovih plantaža. Seča se obavlja na velikim površinama nakon čega nastaju uslovi za osnivanje novih topolovih plantaža. Intenzivno gajenje topola doprinosi obnavljanju degradiranih zemljišta, ubrzava vezivanje atmosferskog ugljen-dioksida za drvnu masu pružajući veliki doprinos ublažavanju klimatskih promena. Upotreba harvestera u topolovim plantažama daje snažan oslonac šumarskim preduzećima da ekonomski i ekološki održivo gazduju šumom.*

U ovom radu identifikuju se podsticajni i ograničavajući faktori za uvođenje i primenu novih tehnologija u procesu seče i korišćenja topolovih plantaža u J.P. „Vojvodinašume". Primenjen je savremeni metodološki pristup, baziran na kvalitativnim naučnoistraživačkim metodama.

Ključne reči: Nove tehnologije, harvester, šumski ekosistemi, studija slučaja

INTRODUCTION

The use of new technologies in the forestry sector, which represents a significant improvement of products and production processes as well as a significant modification of existing technology is innovation. Diffusion of innovation per forest company make contribution to forest sector. The use of innovation in the forestry sector in Serbia has a long tradition. Thanks to the enthusiasm and foresight of individuals as well as market and economic situation of state forest companies use of new technologies are increasingly represented in foresty. Introduction of new technology can be traced from the end of World War I. Notes on the first mechanization (Obućina, Z., Jezdić, D., sn). present the use of wagons for timber transport by rail. Wagons

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were donations of France, and were used in two forest railway in the territory of present Forest Management Unit "Sremska Mitrovica". The first major improvement of forest machinery took place after the World War II, through technical assistance from the U.S. when they received two frontal log. Planned procurement of machinery in F.M.U. "Sremska Mitrovica" link for the 1956th and the beginning poplar plantations. Procurement was done for Ferguson tractors, Belarus, Zetor, Zadrugar and others, as well catepilars Fiat and Ansaldo. The first machine designed for combined transport and loading timber tractors equipage was composed of tractor, trailer and hydraulic crane. It was introduced in Srem region in the year 1969th. The particular forest tractor purchased in the year 1970th, and shortly thereafter moved to the implementation forwarders. Together with forwarders in the year1977th first Harvester Timberjack brand IE-30 were obtained (Nikolic, S., Jezdić, D., 1980). The harvester applied in the forestry sector in Serbia had a hydraulic plier for cutting thin diameter trees in the poplar plantations. The use of new technologies in the exploitation of forests in Serbia chronologicaly is shown in a number of technical and scientific papers (Obućina, Z., Jezdić, D., sn, Bajic, V., 1995., Bajic, V., Danilovic, M., Cupric , N., 2005). Recent research deal with aspects of economic and technological effects of the use of modern multifunctional machinery (Danilovic, M., Tomasevic, I., 2000). Progress in the field of economy, humanization of work and environmental acceptability of multifunction machines placed in the ranking of high technology to exploit the forest (Danilovic, M., 2005).

This paper presents the results of socio-economic research on the diffusion of new technologies in the forestry sector in Serbia with special osvtom the state of the Š.G. "Sremska Mitrovica".

1.1. The introduction of new technologies from a theoretical point of view

The introduction of new technologies in forestry sector is a phased process on company level. Innovation in a broader sense indicate the successful introduction of innovations. On the basis of modern theories differ in at least two major categories of innovation, product innovation and process innovation.

Figure 1. *Categories of innovation*

Product Innovation	**Process Innovation**
material goods | intangible services	technological | organisational

source: (Rametsteiner, E., 2005)

Product innovation is defined as changes in outputs of companies in which can either be goods or services. Processes innovation can either be technological innovations or innovations in the organisation of the company. Innovation can happen by introducing novelities in the existing products or processes. The term innovation is necessary to vary the terms of the invention. The invention is to generate new ideas through research and creativity. Research creative inventiveness, which culminated in the new ideas, sketches, models for new products or processes. Invention is often licensed regardless of the actual possibility of their practical use. Innovation differs from invention in the successful use or placement on the market. Applied idea or discovery made by the profit is called innovation. Many of invention never become innovations. To make something any innovation should suffer a degree of change. There are three levels of change that determine whether something is innovation. The first level is the degree of change determining how much is something new. The second level determines which something is new. The third level determines how creation newspaper.

How much is a new:

1. Category of radical innovation, which includes creative destruction and the introduction of new technology replacing the old one.

2. Category incremental innovation involves the development of the current technological trends.

Who's new set of three categories?

1. New on the company level, which is a minimum requirement that to qualify as an innovation;
2. New on the market or new to the sector;
3. New in the world.

In what way is something innovated determine two categories:

1. A continual innovation - improvement of the current producing or processes;
2. Discontinues innovations - basic innovations which affect the implementation of changes in one or more industrial sectors.

Improvement and modernization is not the same as creating entirely new products and services. Distinguish the degree of change which characterizes the novelty and it can be minor, incremental improvement or radical change that completely changes the way we use the product. These radical changes are sometimes important for the sector or a particular activity, however, sometimes make a change with far-reaching consequences for the entire company. The degree of novelty depends on the environment or sector in which the newspaper created. The degree of novelty may be subjective categories. Technologically advanced societies develop and implement an entirely new products and processes. Less advanced companies, sectors and organizations gradually improving existing products and processes. Innovation is the successful introduction of new ideas and the process or converting new ideas into commercial success in the market. In the relevant literature, we find the following definition of innovation:

Rogers (1983) defines an innovation as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption.

Innovations are non-linear planned changes in processes or products of a company (Rametsteiner E., Weiss G., Kubetzsko K., 2005)

Shumpeter (1934) identifies five types of innovation: 1 introduction of new products or qualitative changes in existing products, 2 innovation of production process; third opening access to new markets; 4th development of new raw materials; 5th changes in the organization of production.

There are 10 basic reasons why innovation is necessary:

1. Improving the quality of products;
2. Conquer new markets;
3. Reduce the labor costs;
4. Increase the volume of products;
5. Increase the flexibility of production;
6. Faster adjusment with standards and regulations;
7. Reduce the impact on the environment;
8. Reduced energy consumption;
9. Reducing the consumption of materials;
10. Accelerating the replacement of existing products;

The most common factors that hinder innovation are:

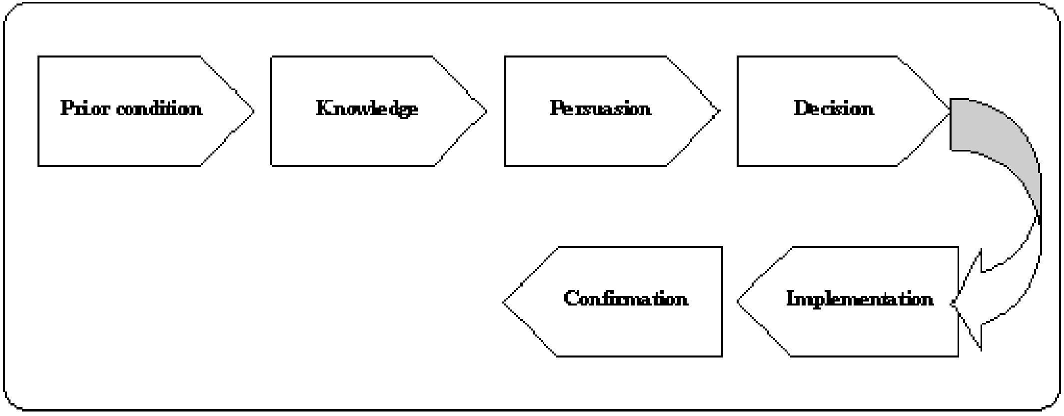
1. Too high prices;
2. Too high risk;
3. Lack of funds;
4. Lack of information on markets;
5. Lack of skilled labor;
6. Organizational rigidity of the company;

7. Non-compliance with standards and regulations;
8. Lack of interest from clients;
9. Lack of information on technologies and so on.

Integration of innovation is based on the national innovation system, which includes managing the process of innovation, incentives, monitoring, implementation and use of innovation. If we look at innovation as a process it is necessary to identify the phases. The stages of innovation are:

- Prior condition;
- Knowledge;
- Persuasion;
- Decision;
- Implementation;
- Confirmation.

Figure 2. *The phase of introducing innovation in the enterprise.*



source: Roger, M.E., 1983.

Knowledge

In this stage the decision makers is first exposed to an innovation but lacks information about the innovation. During this stage of the process the individual has not been inspired to find more information about the innovation.

Persuasion

In this stage the decision makers is interested in the innovation and actively seeks detail about the innovation.

Decision

In this stage the individual takes the concept of the innovation and weighs the advantages/disadvantages of using the innovation and decides whether to adopt or reject the innovation.

Implementation

In this stage the decision makers employs the innovation to a varying degree depending on the situation. During this stage the individual determines the usefulness of the innovation and may search for further information about it.

Confirmation

In this stage the decision makers finalizes their decision to continue using the innovation and may use the innovation to its fullest potential.

2. METHOD

During the research it was necessary to analyze the available literature on new technologies in forestry. As a secondary data used a professional and scientific literature as relevant web pages. On the basis of secondary data for selected case study F.M.U. "Sremska Mitrovica". The reason is a long tradition of using new technologies as well as economic power and position on the market. So, as a method of research (D. Mihajlovic, 2004) applied the method of content analysis and case study methods (Miljević, M., 2007).

A case study is a concrete, descriptive, goes into depth problems. This method of scientific research provides a subjective view of the problem on the basis of collected information and individual interviews. The collection, processing and interpretation of data consisted of the following phases:

- Identification of the material, which consisted of finding the literature related to innovation;
- Analysis of the material based on criteria relevant to the research and
- Interpretation of data.

The collected material was the basis for the formulation of research questions. Analysis of innovation include: innovation process, institutions, national strategy and policies, instruments and mechanisms for introducing innovations. Therefore, it is necessary to obtain answers to questions and gather information about the following aspects:

- Innovation process (idea, development, implementation);
- Participants and their roles;
- Impact of innovation on the organization of production;
- The role and strategy of the state;
- How innovative system works?;
- Fostering and impending factors;
- Expected and unexpected results.

This method requires conducting in-depth interviews (Neuman, WL, 2006). The questions were focused on pre-defined theme, and participants informed in advance of interviews on the subject of interviews with the agreement of the time, place and duration of the interview. Questions are intended to more effectively discover the facts and personal views of respondents about the anticipated subject.

3. RESULTS AND DISCUSSION

The new technology - multifunction machine harvester was introduced in the process of felling in S.E. “Vojvodinašume”. The process of introducing innovation in F.M.U.”Sremska Mitrovica” has a long and successful tradition of introducing new technology. The company has the John Deere Harvester Series D-1710. In the given case harvester performs cutting of trees. Logs draw two forwarders Timberjack 1210 B. The main objectives of the use of new technology are as follows: increase productivity, reduce the number of injuries, reducing damage to the trees, the less damage to roads. The company has financed the purchase of harvester from its own sources, using bank loans. During the process of introducing harvester appeared limited to the following factors: high cost harvester, the high cost of maintenance and service, the lack of an authorized service provider in Serbia. Lack of skilled operators was solved by additional training after two harvester operators trained to operate the machine. For efficient use these machines requires the continuity cutting, which allowed large areas of plantation grown poplar. The machine provides better ergonomics for the operator has a soundproof air conditioned cabin to enable a good overview of the field on which the cutting is done. Powerful hydraulics with proper handling provides felling trees with minimal damage to neighboring trees. Felling of trees and proper use of harvester reduce environmental pollution, land damage and negative impact on flora and fauna.

4. CONCLUSION

Sustainability of business operations in the felling in an environmentally, ergonomically and economically justifiable way of using modern technology almost as significant as its own sustainability of forest ecosystems. The introduction of new technologies in forestry is inevitable because it provides better working conditions and puts forestry in an advanced discipline. A good example is the acquisition and application of one of the latest John Deere Harvester D-1710 in S.E. "Vojvodinašume”. Important sector for the progress of the role of state institutions and national systems for encouraging innovation. Companies and entrepreneurs need to rely on incentives and appropriate funds to encourage the introduction of new technologies. Public companies need to use their maximum potential. Gutter decision on the introduction and application of new technologies, which are often very expensive, should be adequately planned technological advancement. The basis for planning and collaboration with state institutions that encourage innovation and scientific research institutions to explore the process of innovation.

Recommendations for encouraging innovation in the forestry sector:

- Needs to use the existing potential of knowledge and experience of employees;
- Train and educate workers for operating and maintenance of modern machinery;
- Encourage the private sector in using the innovation;
- Create and encourage competition in the market;
- Innovation should be understood not only as economically justifiable investment but as a value-added natural resources;
- Needs to improve the incentive national innovation system.

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USING FOREST RESIDUES FOR CLEAN UP METAL POLLUTED WATER

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Abstract: *The increased amount of heavy metal in various forms, in the environment, causes a severe threat to the ecological system due its negative impact on most life forms. In contrast to organic pollutants, that can be metabolically degraded or transformed, the remediation of heavy metals needs their total removal or conversion into biologically less active or inactive species. The conventional methods for the removal of heavy metals from aqueous solution are very expensive and in some cases left new, undesired waste. There is a need to develop rapid, economical and environmentally friendly technology for the removal of these pollutants from different liquid effluents. It is known that different bio materials passively absorb heavy metals and this process called biosorption could be a potential alternative to the existing physicochemical technologies to clean up wastewaters. Many biomaterials are used for this purpose such as algae, ferns, moss, fungi and different residues from agriculture and forestry industries. This biomass is available in large quantities and can form a good basis for the development of bio sorbent materials. Moreover, the use of dead biomass has the some advantages as follow: it is abundant and very cheap; the process does not require a continuous nutrient supply for maintaining the cells in good physiological conditions etc. This paper presents a review of the data on potential cheap cellulose-containing natural materials such as wood sawdust, bark and other forest resides for adsorption of ions of heavy metals and dye from wastewaters.*

Key words: Heavy metal, dead biomass, forest residues, sawdust, bio sorbents

INTRODUCTION

In recent years, metal pollution has become one of the most important environmental problems. Increased concentrations of various forms of heavy metals in the environment represent a major threat to ecological ecosystems because of their negative impact on flora and fauna. Due to their toxicity to many life forms the presence of heavy metals ions such as Cu, Fe, Ni, Pb, etc. in the environment poses a major concern [1]. At high concentrations, heavy metal ions reach all cells and forming different toxic compounds in it [81]. Also, metals are very stable in nature; they accumulate and are carried over the food chain in the process of biomagnifications. From contaminated surface waters and soil, metals are leaching to groundwater, posing a great threat to human health.

Conventional methods for removing heavy metals from aqueous solutions such as oxidation and reduction, precipitation, filtration, electrochemical treatment, etc. are very expensive and in some cases leave the new waste, which also represents a potential polluting material.

In recent years, researches have focused more on new technologies rather than traditional methods, which are expensive and often inefficient. The need for economical, effective, and safe methods of removal of heavy metal ions from water has resulted in use of the many unconventional materials that might be useful for that purpose [2].

Recent research showed that the use of biomaterials containing compounds for binding of heavy metals does not require special maintenance and is suitable for remediation of very contaminated areas where living organisms cannot survive.

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In recent years, considerable attention has been devoted to the study of removal of heavy metal ions from solution by adsorption using agricultural materials such as waste wool, nut wastes, tree barks and sawdust. Sawdust from timber industry is often considered as waste material and widely available [3].

1. WATER POLLUTION BY HEAVY METALS

Heavy metal pollution occurs in many industrial wastewaters such as those produced by metal planting facilities, mining operations, battery manufacturing processes, the production of paints and pigments, and the glass production industry. This wastewater commonly includes Cu, Ni, Cr, Cd, and Pb. These heavy metals are not biodegradable and their presence in water leads to bioaccumulation in living organisms, causing health problems in animals, and human beings [4]. Increasing concentrations of these metals in water constitute a severe health hazard mainly due to their non-degradability and toxicity. Numerous metals such as chromium Cr(III) and Cr(VI), copper (Cu), lead (Pb), manganese (Mn), mercury (Hg), cadmium (Cd), etc. are known to be significantly toxic [5]. Therefore, the removal of excess heavy metal ions from wastewater is essential to protect human and environmental health [4].

We know that copper is a widely-used material, where an intake of excessively large doses by man may lead, for example, to severe mucosal irritations, a central nervous system irritation, possible necrotic changes in the liver and kidney, etc. [5]. Copper and its compounds are ubiquitous in the environment and are thus found frequently in surface waters. Copper bearing mining wastes and acid mine drainage discharge significant quantities of dissolved copper in wastewaters. The most widely used method for removing copper (II) is precipitation, and then ion exchange treatment [6].

The effects of Ni exposure vary from skin irritation to damage to the lungs, nervous system and mucous membranes [7].

Chromium occurs most frequently as Cr (VI) or Cr (III) in aqueous solutions [8]. The two oxidation states have different chemical, biological and environmental properties [9]. Cr (III) is relatively insoluble, and an essential micronutrient [10], while Cr (VI) is a primary contaminant because of its toxicity to humans, animals, plants and microorganisms [11, 12]. Cr (VI) is known to be a strong oxidant and to be highly toxic [13]. Chromium has widespread industrial application; hence, large quantities of chromium are discharged into the environment. The major industries that contribute to water pollution by chromium are mining, leather tanning, textile dyeing, electroplating, aluminum conversion coating operations, plants production industrial inorganic chemicals and pigments, and wood preservatives [14].

Cadmium is considered as non-essential and highly toxic element [15, 16] possibly because it forms a strong bond with sulfur and hence can displace essential metals, i.e. Zn^{2+} and Ca^{2+} from the binding sites of certain enzymes [17]. A provisional maximum tolerable daily intake of cadmium from all sources is 1–1.2 $\mu g\ kg^{-1}$ body mass [18] is recommended by FAO-WHO jointly. Cadmium may occur in substantial concentrations in hydrosphere due to the discharge of wastewaters, especially of plating wastes [19]. It is therefore important to develop efficient, fast, precise and accurate methods for recognizing/removing of cadmium from biological and environmental materials.

Among many industries making use of metals or their salts, the dyestuff industry and the textile process houses also make use of these metal ions in different forms such as catalysts, treatment chemicals, etc. The elimination of heavy metals in an effective manner from water and wastewater is, thus, ecologically very important. There are many reported and established technologies for the recovery of metals from wastewaters, which include chemical precipitations

[20], flotation [21], biosorption [22], electrolytic recovery, membrane separation [23], removal by adsorption on minerals [24], activated carbon adsorption [25,26], etc.

2. MECHANISM OF BIOFILTRATION

The underlying mechanisms, which allow biofilters to work and which must be controlled to ensure success, are complex. The biofilter contains a porous medium whose surface is covered withwater and microorganisms. The contaminant may form complexes with organic compounds in the water and may be adsorbed by the support medium. Ultimately, biotransformation converts the contaminant to biomass, metabolic by-products or carbon dioxide and water. The biodegradation is carried out by a complex ecosystem of degraders, competitors and predators that are at least partially organized into a biofilm [82]. There are three main biological processes that can occur in a biofilter:

- Attachment of microorganisms.
- Growth of microorganisms.
- Decay and detachment of microorganisms.

The mechanisms by which microorganisms can attach and colonize on the surface of the filter media of a biofilter are transportation of microorganisms, initial adhesion, firm attachment and colonization [83]. The transportation of microorganisms to the surface of the filter media is further controlled by four main processes [84]:

- Diffusion (Brownian motion),
- convection,
- sedimentation due to gravity, and
- active mobility of the microorganisms.

As soon as the microorganisms reach the surface, initial adhesion occurs which may be reversible or irreversible depending upon the total interaction energy, which is the sum of van der Waal's force and electrostatic force. The processes of film attachment and colonization of microorganisms depend on influent characteristics (such as organic type and concentration) and surface properties of the filter media. The following parameters are taken into consideration to estimate the attachment of microorganisms on the surface of the filter media:

- The steric effect,
- hydrophobicity of the microorganisms,
- contact angle, and
- electrophoretic mobility values.

The factors that influence the rate of substrate utilization within a biofilm are substrate mass transport to the biofilm, diffusion of the substrate into the biofilm, and utilization kinetics within the biofilm. Adsorption and biodegradation performs simultaneously in biofilters to remove biodegradable and water soluble hazardous organic molecules, which results in simultaneous adsorption and biodegradation [85,86]. Though the mechanism of heavy metals removal by biofilter differs from that of the organic chemicals removal, but all the above conditions regarding growth of biomass in the biofilm are the same. Only exception in this case is that there is no biodegradation in case of heavy metals removal. The mechanism of heavy metals removal from contaminated water in biofilter is as follows. The non-biodegradable water soluble heavy metals are either oxidized or reduced by the microorganisms and produce less soluble species. The less soluble form of these metals which are formed due to microbial reactions are adsorbed or precipitated/co-precipitated on the surface of the adsorbent and the extra cellular protein of the microorganisms in the biolayer [87]. The methylation of metals is also another important route for bioremediation of heavy metals in water [88]. Though the microbial action on metal ion transformation is still a matter of research, it is assumed that there are two paths. In one path oxidation or reduction of heavy metal ions takes place by extra cellular enzymes where the metal ions do not enter into the bacterial cell. In the other path the metal ions are transported into the microbial cells by trans-membrane proteins and are converted to other less soluble forms by metabolic actions of enzymes in the cells followed by subsequent excretion from the cells, yet both the paths are plasmid mediated [87]. Whether the microbial action on a metal ion is performed by only one path or by both the paths is a matter of research.

3. RESIDUES FROM FORESTRY PRODUCTION FOR WATER REMEDIATION PURPOSES

Due to the growing water pollution, the testing and use of natural materials as adsorbents for removal of various pollutants such as heavy metals from industrial wastewaters is becoming more frequent. Wood sawdust is a solid waste product obtained from mechanical wood processing that can be used as a low-cost adsorbent of heavy metals, largely due to lignocellulosic composition [27]. It is mainly composed of cellulose (45-50%) and lignin (23-30%), both with a capacity for binding metal cations due to hydroxyl, carboxylic and phenolic groups present in their structure [27]. Cellulose is a natural polymer made of β-D-glucose repeating units and contains abundant primary and secondary hydroxyl groups [28]. Lignin contains a network type of structure with majority of methoxy and free hydroxyl groups. Both these chemical entities are, therefore, capable of adsorbing various metal ions [29]. By-products of agricultural and forestry production are suitable because they are cheap, require little processing and they are abundant in nature.

3.1. Sawdust as adsorbent of heavy metals

Based on previous findings, maple sawdust is a promising adsorbent for removal of chromium [3] and nickel [30] from untreated industrial wastewaters.

In addition, it was proved that the sawdust can be used as an efficient adsorbent for removing copper Cu (II) from wastewaters. This adsorption process is also dependent on numerous factors such as the solution pH, temperature, the agitation speed, the initial concentration, the contact time, the liquid to solid ratio, the ionic strength, etc [4]. The maximum percentage removal occurs between the pH ranges 2.0-8.0 [4].

With oak (*Quercus coccifera*) sawdust which has been modified by means of hydrochloric acid treatment, it is possible to remove ions such as Cu (II), Ni (II) and Cr (VI) from aqueous solutions through absorption [5]. Acid-modified sawdust is suitable for the removal of heavy metals from wastewater. Although the adsorption capacity per unit mass is lower than that of competing substances as ion-exchange resins and activated carbon, its high adsorption capacity per unit cost makes this material a promising and economical alternative [5].

Moreover, sawdust and modified peanut husk were used as adsorbents to remove Pb (II), Cr (III) and Cu (II) from aqueous solution [31].

Previous researches show that the sawdust of oak and black locust is suitable for adsorption of copper and zinc ions from water [2].

Sawdust of deciduous soft wood-poplar and coniferous soft wood-fir, are capable for adsorption of copper and zinc ions from water. The adsorption capacities of this wood sawdust are almost the same for both metal ions, although this sawdust is different in chemical composition and anatomical structure [2].

Sawdust of *Pinus sylvestris* contains various organic compounds (lignin, cellulose and hemicelluloses) with polyphenolic groups that might be useful for binding heavy metal ions [32]. It was found that sawdust *Pinus sylvestris* is an effective adsorbent for Pb (II) and Cd (II) from aqueous solutions. Past studies indicate that the sorption of lead is higher than that of cadmium. Moreover, both sorption capacity and sorption rate are strongly dependent on the initial concentration in heavy metals, initial pH of solution, and sawdust concentration [32]. It can be concluded that the use of *Pinus sylvestris* sawdust as an adsorbent may be an alternative to more costly materials such as activated carbon for the treatment of liquid wastes containing metal ions [32].

Poplar sawdust has the ability to bind heavy metal ions from electroplating wastewater. The selectivity of the sawdust for metal ion adsorption was as follows: Cu (II) > Zn (II) > Cd (II) [27].

Generally it has been proved that the wood sawdust is an excellent adsorbent for copper removal from aqueous solution [6].

The present observations record that successful use of sawdust from cedar and pine in Ni sorption attribute mainly to the presence of oil or resins to a considerable extent [33, 34].

p-Nitrophenol is a common pollutant found particularly in the effluents from pesticides, pharmaceuticals, petrochemicals and other industries [35]. Adsorption is a well-known removal technique for organic compounds from water. The use of activated carbon as adsorbents for the removal phenol compounds [36-38] is very common in practice. The major disadvantages of using these carbons are the high capital and regeneration cost of these activated carbons. The adsorbent prepared from sawdust may be used for the removal of p-nitrophenol and needs further studies to increase its industrial importance [35].

3.2. Sawdust as adsorbent of dyes from wastewaters

Among various industries, textile industry ranks first in usage of dyes. The effluents of the textile industry are highly colored and the disposal of these water into natural water resources causes damage to the environment as they may significantly affect living organisms in water because of reduced light penetration and may also be toxic to some aquatic life because of the presence of metals, chloride and others components in them. Therefore, environmental research has paid special attention to dye compounds because of the extensive environmental contamination arising from dyeing operations. Textile effluents are usually treated by physical or chemical processes. Among several chemical and physical methods, an adsorption process is often one of the effective methods to remove dyes from wastewater [39].

Dyes are widely used in industries such as dyestuff, textiles, rubber, leather, paper, plastics, cosmetics, etc., to color their products; these dyes are invariably left in the industrial waste. Today more than 9000 types of dyes have been incorporated in the color index [40].

Dyes even in very low concentrations affect the aquatic life and food chain. Hence, the removal of dye from process or waste effluents becomes environmentally important. Because of the high degree of organic present in these molecules and the stability of modern dyes, conventional physicochemical and biological treatment methods are ineffective for their removal from wastewater [40].

Due to low biodegradability of dyes, a conventional biological treatment process is not very effective in treating a dye wastewater [41]. It is usually treated by physical or chemical processes. However these processes are costly and cannot effectively be used to treat the wide range of dye wastewater. It is known that activated carbon adsorption (ACR) is a very efficient procedure for dye removal, but it is too expensive. Consequently, numerous low-cost alternatives have been proposed including wood [42] and sawdust [43]. New economical, easily available and highly effective adsorbents are still needed [41]. Sawdust is a waste byproduct of the timber industry that is either as cooking fuel or packaging material.

3.3. Using bark as residue from the forestry production

In has been reported that certain lignocellulosic waste such as nut wastes [44-46], tree leaves [47-50], barks [51-55] and barley straw [56] effectively adsorb heavy metal ions from aqueous solutions, indicating the potential utility of these materials to remove heavy metal ions from industrial effluents. Among these, barks are especially promising because of being available in large quantities. For example, several coniferous barks effectively remove heavy metal ions from aqueous solution. It has been proved that *Picea jezoensis* bark can adsorb Cd^{2+} from wastewaters [57]. Therefore, the coniferous bark, which is inexpensive and locally available, shows the potential utility to remove heavy metal ions from waste waters and could be applied to a pollution control system [57].

3.4. Using residues from forestry production to produce active carbon

Disposal of biomass waste, produced in different agricultural activities, is frequently an environmental problem. A solution for such situations is the recycling of these residues for the production of activated carbon, an adsorbent which has several applications, for instance in the elimination of contaminants [58]. Activated carbon has a large volume fraction of very small pores, which results in a large specific surface area [59].

Activated carbon has a practical advantage over other adsorbents because it may be obtained from a variety of carbonaceous raw materials, including byproducts or wastes from industrial processes [60-62]. The reuse of solid wastes, as rice husk or wood sawdust, could be important for the regional economics. The preparation of activated carbon from wastes is an example of that, because high-value products are obtained from low-cost materials, and simultaneously, solutions to the problems of disposal of wastes are a natural consequence [58].

Activated carbon can be prepared as a powder or granular [63], or shaped as briquettes [64], fibers [65], depending on its specific applications [66].

4. CONCLUSION

Among the many methods available to reduce heavy metals concentrations from wastewaters, the most common are chemical precipitation, ion-exchange, and reverse osmosis [32]. Precipitation methods are particularly reliable but require large settlings tanks for the precipitation of voluminous alkaline sludge and a subsequent treatment is needed. Ion-exchange has the advantage of allowing the recovery of metallic ions, but it is expensive and sophisticated [32].

In previous research, it was found that the adsorption of metal ions is cheaper when performed with natural products/biological waste [67-69]. However, all these technologies have their own advantages and limitations.

Biopolymers are of special interest and promising for a number of reasons [28]. Biopolymers are capable of removing metal ions to ppb levels, are cheap, abundant and themselves environmentally safe [28]. The cellulose biomaterials when loaded covalently by specific dyestuffs give an enhancement in their adsorptive capacity for metal ions [70]. This ability is used for purified biopolymeric materials like sawdust for adsorption of heavy metal ions namely, Cu (II), Ni (II) and Zn (II) from their aqueous solution [28].

Flame atomic absorption spectrometry is largely used for the determination of metals, showing good selectivity but low detectability, which may be improved by a preconcentration step [71]. Several methods for the preconcentration have been developed, enhancing the detectability of the instrumental analytical techniques [71]. For example, in the past 15 years, extensive research has been carried out of to identify new and economically priced adsorbent for cadmium ions removal/preconcentration such as seaweed [72], algae [73], rice husk [74], brown marine macro algae [75], rice polish [76] and sawdust [77,78]. Among these, agricultural waste material, especially sawdust, which in most cases represents waste material, has attracted particular attention as adsorbent.

Previous researches showed that sawdust is a cheap waste material obtained through mechanical processing of wood and can be used as an economically acceptable adsorbent of heavy metals because it consists mainly from cellulose (45-50%) and lignin (23-30 %) which has the capacity for binding metal cations by hydroxide, carboxylic and other groups.

During numerous investigations it has been proved and suggested that chemically modified materials should be used to improve the ability to adsorb heavy metals [79]. This is supported by the fact that the sawdust treated by sulphuric acid shows greater adsorptive capacity than the untreated sawdust when adsorbing dyes from aqueous solutions [41].

Based on previous researches on residues from forestry production, we can conclude that the use of sawdust as adsorbent of heavy metals in water remediation, has given positive results. However, the sawdust as adsorbent of heavy metals, unlike wood bark [80] which is commonly used, has not been sufficiently explored, and it is therefore necessary to direct further research toward developing rapid, economical and environmentally friendly technologies for removing heavy metals from wastewaters.

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THE IMPORTANCE OF ECOLOGICAL FOOTPRINT ESTIMATION FOR SERBIA

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Abstract: *The ecological footprint measures the environmental sustainability, showing the reality of living in a world with limited resources. It provides a visual representation of the Earth carrying capacity. In today's world, where humanity has already exceeded the limit of use of natural resources, many countries are faced with ecological deficit, and have the ecological footprint that exceeds their biocapacity. Some countries, due to the absence or insufficient resources within their boundaries, are heavily dependent on other countries. The aim of this paper is to point out the importance of applying method of ecological footprint in Serbia and to signify the possibility of achieving the objectives set out with National Sustainable Development Strategy with the help of this method.*

Key words: ecological footprint, indicators of sustainable development, use of natural resources, Serbia

ZNAČAJ PROCENE EKOLOŠKOG OTISKA ZA SRBIJU

Apstrakt: *Ekološki otisak meri ekološku održivost, prikazujući realnost života u svetu sa ograničenim resursima. On obezbeđuje vizuelni prikaz Zemljinog nosećeg kapaciteta. U današnjem svetu u kome je čovečanstvo već prevazišlo dozvoljeni limit korišćenja prirodnih resursa, mnoge zemlje se suočavaju sa ekološkim deficitom i imaju ekološki otisak koji prevazilazi njihov biokapacitet. Neke zemlje, zbog nepostojanja ili nedovoljno resursa u okviru svojih granica, u potpunosti zavise od drugih država. Cilj ovog rada je da ukaže na značaj primene metode ekološkog otiska u Srbiji i na mogućnost ostvarivanja ciljeva postavljenih Strategijom održivog razvoja Srbije uz pomoć ove metode.*

Ključne reči: ekološki otisak, indikatori održivog razvoja, upotreba resursa, Srbija

1. INTRODUCTION

The development of society and the industrial revolution had a major impact on the environment. Deterioration of ecological conditions encouraged researchers in attends to determine the relationship between man and nature. Many researchers have tried to devise and develop techniques for establishing and analyzing the link between nature and people. Some of these techniques focused on energy flows needed to support human activities while others started to look more explicitly at the human carrying capacity concept.

The global carrying capacity concept started to be at the top of the agenda in the '60s and '70s of the last century, with the publication of 'Limits to Growth' by the Club of Rome. At that time, Rees developed a method 'regional capsule', from which ecological footprint originated. (Lyndhurst, 2003).

The ecological footprint concept and calculation method was developed as the PhD dissertation of Mathis Wackernagel, under Rees supervision at the University of British Columbia in Vancouver, Canada, from 1990-1994 (Wikipedia, 2010). In 1996, Wackernagel and Ress published book Our Ecological Footprint: Reducing Human Impact on the Earth.

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Additional impetus for the development of these methods was the United Nations Conference on Environment and Development, held in Rio de Janeiro, 1992. An action plan for sustainable development for the 21st century, called Agenda 21, was adopted at the conference. The declaration, which obliged to sustainable development in the 21st century, emphasized the importance of measuring sustainable development at the global, national, regional and local levels and concurrent development of methods that will enable continuous monitoring and evaluation of sustainable development.

2. THE INFLUENCE OF ECOLOGICAL FOOTPRINT ON SUSTAINABLE DEVELOPMENT

In order to preserve the planet for future generations, humankind is faced with the need for common responsibility in accordance with the principles of sustainable development. Sustainable development is based on the fact that the right of the present generation to use resources and to enjoy a healthy environment must not compromise the same rights of future generations.

The United Nations created the Human Development Index (HDI), a formula that measures poverty, literacy, education, life expectancy and other factors for countries worldwide. According to this formula, countries fall into four broad categories based on their HDI: very high, high, medium and low human development. Countries with human development index higher than 0.8 are considered to be high-developed countries.

The ecological footprint quantifies humanity's demand on nature. It measures how much land and water area a human population requires to produce the resource it consumes and to absorb its wastes, using prevailing technology.

Countries with Human Development Index higher than 0.8 and ecological footprint smaller than 1.8 per person are considered to be the country that have sustainable development. However, the highly developed countries usually have a high ecological footprint.

3. ECOLOGICAL FOOTPTINT METHOD

Ecological Footprint accounting is based on six fundamental assumptions (Wackernagel *et al*. 2002):

- The majority of the resources people consume and the wastes they generate can be tracked
- Most of these resource and waste flows can be measured in terms of the biologically productive area necessary to maintain flows. Resource and waste flows that cannot be measured are excluded from the assessment, leading to a systematic underestimate of humanity's true Ecological Footprint.
- By weighting each area in proportion to its bioproductivity, different types of areas can be converted into the common unit of global hectares, hectares with world average bioproductivity.
- Because a single global hectare represents a single use, and all global hectares in any single year represent the same amount of bioproductivity, they can be added up to obtain an aggregate indicator of Ecological footprint or biocapacity.
- Human demand, expressed as the ecological footprint, can be directly compared to nature's supply, biocapacity, when both are expressed in global hectares.
- Area demanded can exceed area supplied if demand on an ecosystem exceeds that ecosystems regenerative capacity. This situation, where ecological footprint exceeds available biocapacity, is known as overshoot.

3.1. Advantages and limits of ecological footprint

Like any other method, ecological footprint has some advantages and limits.

Some of its advantages are:

- The ability to pass easily understandable message about the interaction of urban systems and the environment (Luck *et al.*, 2001). This feature can be used in the implementation of Local Agenda 21 as a tool for motivating and informing people.
- As an indicator, ecological footprint points to the existence of biophysical limitations and that the current pattern of consumption is not sustainable in the long run (Lyndhurst, 2003). The report of the World Wide Fund for Nature for 2008 has shown that at the global level, ecological footprint exceeded biocapacity of the planet and that humanity had been exhausting its natural capital at high speed (WWF, 2008).
- While the accuracy of the numbers that represent the ecological footprint can be questioned, there is no doubt that the final result shows which consumption sector has the greatest negative impact on the environment (Lyndhurst, 2003).
  For example, if the ecological footprint of transport has the highest number, that is the segment of society that most contributes to the deterioration of living conditions, and uses the most of natural resources.

The limits of ecological footprint are:

- Data for calculation of ecological footprint are not always available and their reliability may be questionable. Same information derived from multiple sources often has different values (Simmons, 2000). This problem often occurs while calculating the ecological footprint of cities. Frequently, large financial investments are required in order to get certain data at the local level.
- Ecological footprint focuses on renewable resources, and does not take account of the use and consumption of nonrenewable resources such as gas, oil, coal and metal deposits. These are only addressed by the ecological footprint where their extraction, refinement, distribution, use, or disposal imposes a demand on the biosphere's regenerative capacity (Wackernagel *et al.*, 2002).
- This method does not take into account the waste that cannot be assimilated by the biosphere. Therefore, discharges of heavy metals, radioactive and synthetic compounds are not included in the ecological footprint analysis (Bond, 2002).
- Ecological footprint is not a dynamic indicator (Lyndhurst, 2003). It shows the current consumption and biocapacity. However, the indicator can be used as a tool to devise scenarios by making assumptions about future consumption and biocapacity.
- Ecological footprint assumes that carbon dioxide can only be sequestered by forests even though agricultural crops and oceans also play an important role in carbon dioxide absorption (Lyndhurst, 2003).

4. NATIONAL FOOTPRINT ACCOUNTS AND SERBIA

Mathis Wackernagel, founder and president of Global Footprint Network, an association for the protection of environment, has initiated development of National Footprint Accounts, the report that deals with the calculation of ecological footprint of the planet for a given year. Calculation of ecological footprint is done with three-year delay due to the time required for data collection. The issue in 2009 has shown how great pressure humankind poses on the resources of the planet, how much of resources every county use and what consequences those actions have on the planet biocapasity. This edition of the report, shown the ecological footprint and biocapasity of 241 countries for 2006.

The ecological footprint and biocapacity accounts are comprised of six land use types: cropland, grazing land, forest land, fishing grounds, carbon uptake land, and built-up land. The ecological footprint represents demand for ecosystem products and services in terms of these land use types, while biocapacity is the supply of land available to serve each use (Ewing *et al.*, 2008).

The results showed that humanity as a whole is not living within the means of the planet. In 2006, humanity's total ecological footprint worldwide was 17.1 billion global hectares. However, there were only 11.9 billion global hectares of biocapacity available that year. This overshoot of approximately 40 percent means that in 2006 humanity used the equivalent of 1.4 Earths to support its consumption. If humanity continues to live like this people would need two planets to meet their own needs by 2040.

In National Footprint Accounts for 2009, Serbia is not mentioned. Data for ecological footprint of Serbia does not exist. All countries from Serbia's surrounding, with the exception of Macedonia, are included in this report. The only available data are for State Union of Serbia and Montenegro for 2005, from the National Footprint Accounts 2008. The state union effectively came to an end mid 2006. Since calculation of ecological footprint in this report is done with three-year delay, this may be the reason why Serbia has not been added to this report.

State Union of Serbia and Montenegro occupied 102 350 km^2 and had 10 million inhabitants in 2005. Total biocapacity of Serbia and Montenegro was 17.18 million global hectares or 1.64 global hectares per capita. Ecological footprint in the same year was 27.43 million global hectares or 2.61 global hectares per capita. Habits of the population have led to ecological deficit of 10.25 million global hectares or 0.98 global hectares per capita. Overshoot of 60% shows that Serbia and Montenegro were using more natural resources than the ecosystem could renew for one year (WWF, 2008).

However, Serbia and Montenegro had an ecological footprint below the World and European average. Ecological footprint of the planet in 2005 amounted to 2.7 global hectares per person. Ecological footprint of EU countries was 4.7 global hectares per person, and for European countries outside the EU ecological footprint was 3.5 global hectares per person (WWF, 2008). Consumption pattern of inhabitants of Serbia and Montenegro was not sustainable and led to a permanent degradation of the environment and to depletion of natural recourses.

5. APPLICATION OF ECOLOGICAL FOOTPRINT IN SERBIA

Serbian government adopted The National Sustainable Development Strategy on May 9th 2008. This strategy is based on globally adopted principles identified in the Sustainable Development Declaration from Johannesburg, the UN Millennium Development Goals and the EU Sustainable Development Strategy.

Ecological footprint is a measure of environmental sustainability and illustrates the reality of living in a world with limited resources. As an indicator of sustainable development, it supports the adopted strategy, contributing to a clear perception of disturbed ecological balance and leads to taking action in accordance with the strategy of sustainable development.

Ecological footprint of Serbia, would pave the way for the tracking and analyzing the degree of fulfillment of the objectives set by the Strategy, and it would be possible to select the best scenario that could lead to the best methods to achieve these goals. Analysis of the Ecological footprint, could show which component contributes to the overuse of natural resources and have major impact on the environment.

As a visual tool, ecological footprint can be used to facilitate involvement of citizens in decision-making process, because it easily explains the consequences of a particular model of consumption on the environment and environmental resources.

Ecological footprint is an important tool, which helps countries to understand the current state of the environment in their country and to plan use of resources and thus ensure its future.

By the application of ecological footprint Serbia will able to:

- Assess the value of country's ecological assets
- Monitor and manage assets
- Identify the risks associated with ecological deficits
- Set policy that is informed by ecological reality and makes safeguarding resources a top priority
- Measure progress toward goals set by the Strategy

6. CONCLUSION

Continuing deterioration of the environment has imposed the need for sustainable development. Sustainable development is development of society in economic and social terms with protection of the environment. These three factors must be adjusted so that the development of one factor does not have a negative impact on the other two factors.

Management of sustainable development is possible with the help of indicators of sustainable development. One of them is the ecological footprint. The importance of this indicator is reflected in the fact that it shows which consumer sector of society has the strongest effect on the deterioration of the environment and points out the steps that should be taken in order to improve current situation.

Ecological footprint of humanity points to the unsustainable development of modern civilization. Excessive use of natural resources cause overshoot and leads to the destruction of ecosystems, species extinction, depletion of fresh water systems, and the buildup of pollution and waste, which creates problems like global climate change.

Serbia is one of the few countries in Europe without information of ecological footprint for 2009.

The population growth in cities in Serbia is continuing. Therefore, need for space for the construction and disposal of waste is increasing. Cities are constantly spreading, forest cover has been diminishing steadily, and the need for natural resources increases. This fact indicates that the sustainable development of Serbia is possible only if the cities are developing in accordance with the principles of sustainable development. 'Green cities' are a difficult task that is in front of decision makers, especially if the goal is to reduce the ecological footprint, which is necessary in order to city become sustainable.

With further improvement of the methodology of calculation of the ecological footprint, this method could play a leading role in planning the strategy of using resources in the future, and thus in sustainable development.

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FOREST ECOSYSTEM PROTECTION PLANNING IN THE REPUBLIC OF SERBIA

Milijana CVEJIĆ[1]

Abstract: *Endangerment of forest ecosystems due to climate changes is up – to – date problem. We are witnesses of influence of climate changes on environment and forest ecosystem as a part of it.*

Climate changes threatening forest health and stability. Increasement of air pollution and nuber of periods of extremely high temperatures resulting in depredating phenomena such as acid rains, drought and storm. Result of such a phenomena that influence forest is land erosion, increasement of land acidity as well as degeneration of forest ecosystems (severe wood regeneration, increasement in damage of forest fire, foul weather, pest and plant disease). Those phenomena restraining natural regeneration growth and biological diversity of forest.

One of the available instruments to protect forest ecosystem within process of protection of environment is production and application of legal act, planning documents and incorporation in international conventions.

Objective of the text will be research of strategic and plan aspects of forest ecosystem protection through the current plans documentation. Methodical concept of environment protection by means of predicted factors and terms define sustainable conduction of natural values and anticipate arrestment, control, decrease and recovery of all aspects of degradation.

By analyzing current plan documentation understanding of plan concept of forest ecosystem protection will be developed.

Intention of text is to propose effort on base of researched documentation for plan and strategic protection and improvement of forest ecosystems in condition of global climate change.

Key word: Environment, Forest ecosystem, Climate changes, Protection

PLANIRANJE ZAŠTITE ŠUMSKIH EKOSISTEMA U REPUBLICI SRBIJI

Izvod: *Ugrožavanje šumskih ekosistema usled nastalih klimatskih promena je aktuelna problematika. Danas smo svesni uticaja promene klime na životnu sredinu i šumske ekosisteme kao njenog dela.*

Klimatske promene ugrožavaju zdravstveno stanje i stabilnost šuma. Zbog povećane zagađenosti vazduha i povećanja učestalosti ekstremno visokih temperatura, javljaju se degradirajuće pojave kao što su kisele kiše, suša i olujne nepogode. Posledice navedni nepovoljnih zbivanja na šumu manifestuju se u vidu učestale zemljišne erozije, pevećanja kiselosti zemljišta i pogoršanja stanja šumskih ekosistema (otežana regeneracija drveća, povećanje šteta od šumskih požara i atmosferskih nepogoda, povećanje napada štetočina i biljnih bolesti). Ove pojave sprečavaju prirodno obnavljanje, rast i biološki diverzitet šuma.

Jedan od instrumenata za zaštitu šumskih ekosistema u okviru zaštite životne sredine je izrada i primena Zakona, strateških i planskih dokumenta i uklapanje u međunarodne konvencije.

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Analizom aktuelne planske dokumentacije dobiće se uvid u planski koncept zaštite šumskih ekosistema .

Cilj rada je da se na osnovu istražene dokumentacije da predlog mera za plansku i stratešku zaštitu i unapređenje šumskih ekosistema u uslovima globalne promene klime.

Ključne reči: Životna sredina, Šumski ekosistem, Klimatske promene, Planiranje zaštite

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1. INTRODUCTION

Endangerment of forest ecosystems due to climate changes is up-to-date problem. We are witnesses of influence of climate changes on environment and forest ecosystem as a part of it.

One of the available instruments to protect forest ecosystem within process of protection of environment is production and application of legal act, planning documents and incorporation in international conventions.

2. OBJECTIVE

Objective of the text will be research of strategic and plan aspects of forest ecosystem protection through the current plans documentation. Methodical concept of environment protection by means of predicted factors and terms define sustainable conduction of natural values and anticipate arrestment, control, decrease and recovery of all aspect of degradation.

Intention of text is to propose effort on base of researched documentationfor plan and strategic protection and improvement of forest ecosystems in conditions of global climate change.

3. METHOD

By analyzing current plan documentation understanding of plan concept of forest ecosystem protection will be developed.

4. PROBLEM DEFINITION

4.1 Climate changes and there influence on forest ecosystem

Climate changes threatening forest health and stability. Increasement of air pollution and number of periods of extremely high temperatures resulting in depredating phenomena such as acid rains, drught and strom.

Result of such a phenomena that influence forest is:

- land erosion,
- increasement of land acidity as well as
- degeneration of forest ecosystems (severe wood regeneration, increasement in damage of forest fire, foul weather, pest and plant disease).

Those phenomena restraining natural regeneration growth and biological diversity of forest.

5. RESULTS OF WORK

Documents whose main goal is to protect forest ecosystem planning that are degraded due to climate change are:

- Spatial plan of the Republic of Serbia
- General Spatial Plan of Belgrade 2021
- Regional spatial plan of the administrative territory of Belgrade
- Law on forests
- Forestry development strategy of the Republic of Serbia

- Law on Environment
- Law on Planning and Construction.

This work was carried out selection of need documents for the analysis of performance conclusions.

5.1 General Spatial Plan of Belgrade 2021.

In order to reduce emissions General Spatial Plan includes the following proposed measures:

measures to reduce environmental pollution:

- through integrated land use planning, enforcement of legislation for environmental protection to implement cleaner production technologies and waste reduction;
- improving the efficiency of quality control factors of the environment through the public involvement in decision making on issues of environmental protection.

measures to reduce air pollution are:

- implementation of district heating and gasification, in that way will be ensure emission reduction furnaces from the individual fireboxes;
- harmonization of standards for air quality whith European standards;
- they require measures to ensure conditions for methodological and technical improvement of systems for monitoring environmental quality in accordance with European practice and standards;
- stimulate use of renewable energy sources (wind energy).

measures for water protection:

- to reduce the emission of pollutants into them in the following ways,

in accordance to Article 45 of the water, land and water areas must be protected against intentional or accidental pollution,

due to the presence of numerous pollutants, cut a separate program to determine the environmental problems in this area,

- to suggest establishing a new zone of protection and establishing of monitoring the quality of soil and ground water, direct source zone protection extracting the appropriate type of fence placed next to the table with text alert.

special measures for the protection of wather sources:

- protection against chemical accidents and generation ionizing radiation, transmission and storage of hazardous materials in existing and new facility and installations carried out preventive measures include the following, selection of appropriate sites, improving the technological reliability of safety systems, using the standard JUS ISO 14000,

5.2 Regional spatial plan of the administrative territory of Belgrade (2004)

This plan regulates issues - harmful gases, protection of forest land, afforestation, protection of water, control of industrial accidents cut control of hazardous substances.

5.3 Forestry development strategy of the Republic of Serbia

Document that gives the proposed solutions to problems in forestry, it provides a solution to the degradation of forests due to conflict with other sectors by applying impact assessment \ environment and improving inter-sectoral cooperation.

By basic provisions of the law regulates the organization, care, planning, farming, use and provided forests and forest land as natural resource, Supervision of implementation of the law, and other issues of importance for forest and forestry land.

5.4 Draft Law on Forests

In Article 6. on this document is emphasized the beneficial functions of forests;
his goal is solving the accumulated problems in the area of conservation, protection, use and disposal of forest and forest land, prohibition, guidelines, suggestions

6. DISCUSSION AND CONCLUSIONS

Documents on the basis are analyzed, concluded that most of the law, fhe draft law, planning documents, comprehensive, less or more detailed seen the problem and resolve issues protection of nature and forest ecosystems especially.

The main question is which continuing influence go to the negative trend to total forest degradation.

Reply required to new research that would contain next question:

- What is the degree of education of entire population of our country on nature changes and its impact on forests;
- what is the cultural level of nations and ethics on the preservation of nature
- is there a proposed control enforcement measures
- whether there are penalties if the proposed law is not implemented.

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FOREST ECOSYSTEM PROTECTION PLANNING IN THE REPUBLIC OF SERBIA

Milijana CVEJIĆ

Summary

Endangerment of forest ecosystems due to climate changes is up – to – date problem. We are witnesses of influence of climate changes on environment and forest ecosystem as a part of it.

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By analyzing current plan documentation understanding of plan concept of forest ecosystem protection will be developed.

Intention of text is to propose effort on base of researched documentation for plan and strategic protection and improvement of forest ecosystems in condition of global climate change.

PLANIRANJE ZAŠTITE ŠUMSKIH EKOSISTEMA U REPUBLICI SRBIJI

Milijana CVEJIĆ

Rezime

Ugrožavanje šumskih ekosistema usled nastalih klimatskih promena je aktuelna problematika. Danas smo svesni uticaja promene klime na životnu sredinu i šumske ekosisteme kao njenog dela.

Klimatske promene ugrožavaju zdravstveno stanje i stabilnost šuma. Zbog povećane zagađenosti vazduha i povećanja učestalosti ekstremno visokih temperatura, javljaju se degradirajuće pojave kao što su kisele kiše, suša i olujne nepogode. Posledice navedni nepovoljnih zbivanja na šumu manifestuju se u vidu učestale zemljišne erozije, pevećanja kiselosti zemljišta i pogoršanja stanja šumskih ekosistema (otežana regeneracija drveća, povećanje šteta od šumskih požara i atmosferskih nepogoda, povećanje napada štetočina i biljnih bolesti). Ove pojave sprečavaju prirodno obnavljanje, rast i biološki diverzitet šuma.

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CONTRIBUTION FOR RESEARCH ON CYTOSPORA FUNGI ON WILLOWS (*SALIX* SP.)

Miroslav P. MARKOVIĆ, Predrag PAP, Saša ORLOVIĆ, Petar IVANIŠEVIĆ,
Saša PEKEČ, Srđan STOJNIĆ [1]

Abstract: *This paper presents results of 3 year mycology research on species of genus Cytospora that causes necrosis and bark cancer on willows Salix sp. at the area of Srednje Podunavlje (situated between 45008¢18¢¢ and 45042¢50¢¢ N, and between 17010¢10¢¢ and 17058¢50¢¢ E). During the research, at the field was collected dendro-material with symptoms of illness and damage, same material was stored in herbarium and brought to the laboratory for further identification with standard methodology.*

During research on willows was noted 6 fungi form genus Cytospora (C. ambiens Sacc., C. chrysosperma (Pers.)Fr., C. fertilis Sacc., C. nivea Sacc., C. salicis Rab. and C. translucens Sacc.) causes necrosis and bark cancer on willows Salix sp. On collected samples was also determined presence of Leucostoma nivea (Pers. ex Fr.) Hoh. and Valsa salicina Fr. (telemorph stage C. nivea and C. salicis).

Key words: willow , Salix sp., bark , fungus , Srednje Podunavlje

INTRODUCTION

Due to the energy crisis which has been present for many years in the world, use of wood as energy carrier has increased. Limited natural production of wood (as raw material) and rapid development of wood industry has resulted in a reduction of wood funds and a growing deficit for wood.

It can be said that wood is one of the most important products of nature and a permanently renewable natural resource, as opposed to certain other raw materials where the funds are limited (e.g. mining, petroleum, coal etc) Even if the possibilities for growing production volume in natural forest is limited, limited production of crops and timber plantations is gaining greater importance.

If we keep in mind that the forest in Vojvodina mainly is located along the rivers and has a substantial area of land that is not suitable for agricultural production, raising plantations of poplar, willow, then, as a pioneer species and species that inhabit the plains of the lowest part of micro relief, have all greater importance.

Willow trees are forest which is not given no greater importance although they have a number of positive characteristics (they have great diffusion, with the only exception of Australia and New Zealand).

Willow is pioneer species and they have relatively fast growth, providing good production of wood useful in woodworking and chemical industry. Creating favorable conditions for the development of other species - valuable species of trees, to achieve good results to treatment (phytoremediation) of contaminated soil and ground water, and also are important medicinal plants because of the sap.

The research of problems related to willows diseases is limited, and also access to professional literature about illnesses is limited. People who has done research on willow diseases are: Vujic, P. (1963) and has registered 3 species of bacteria's and 23 types of fungus; the other, Gojkovic, N. (1974) has confirmed the results of Vujic, and concluded on one more type of fungus.

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MATERIAL AND METHOD

Field research and collection of materials was carried out in the middle of the river Danube and the area from Bacha to Beshka (between $45^{0}08'18''$ and $45^{0}42'50''$ north latitude and $17^{0}10'10''$ and $17^{0}58'50''$ East longitude), in nurseries, plantations and natural forests of willow in flooded areas of Danube and from flat ground to the altitude difference of 1 to 6 meters (at an altitude of 73 to 79 meters).

A variety of bays, marshland and wetlands, which are often under water, makes a favorable habitat for the growth of willow, which therefore was chosen to study mikroflore on this part of the Danube river- “Podunavlje”.

The climate in this area belongs to the temperate continental climate with characteristics stable continental Pannonia -steppe climate. During these surveys dendromaterial with symptoms of disease is collected to herbarium and then identification and isolation of fungi has been performed in the laboratory.

Based on the determination of established types of fungus (parasitic and saprophytic) temporary microscopic preparations were made, and then, in order to define the fungus species that apply, and based on the look of the fruiting body, spurs as organs and organs for reproduction were used.

In cases where it is not stated fruiting bodies from fungus (as cause of disease), but only the general symptoms of illness, approached the isolation of the nutrient medium. Isolation was performed on the standard nutrient medium PDA (potato-dextrose-agar) and MEA (Malco extract agar), prepared in the recipe Booth's (1971).

RESULTS OF RESEARCH

On the willow branches there was recorded 6 fungi of the genus of Cytospora. Of this genus a fungus called Cytospora chrysosperma (Pers.) Fr. can lead to considerable economic damage and to deterioration of willow.

Cytospora chrysosperma (Pers.) Fr.

(= Cytospora pulcherrima Dearn.& Hansbrough)
Deuteromycotina, Coelomycetes, Sphaeropsidales, Sphaeropsidaceae
(teleomorph = Valsa sordida Nitschke)
Ascomycotina, Diaporthales, Valsaceae

The disease occurs in the stalk, branches and twigs to form elongated, often embedded in the periderm of necrosis with clearly defined borders occurred due to the creation of callus.

Necrosis surface appears with the color reddish-brown to brown.

On necrotizing bark occurs gray-black pycnidia stroma the size 0.5- 1 μм in diameter (Figure No.1.). Favorable conditions (high humidity and moderate temperatures) leads to the distribution of spurs appearing as long “maggots” adhesive and with the color orange-red (Figure No. 2.).

Due too many years of presence of fungi on dead bark, necrotizing bark create cancer with “open wounds”. The perfect stage is rarely appearing

Pycnidium is created in the stroma, immersed in the bark, emerge to the surface through a common eruptive ostiole.Konidiofor is usually branched, hyaline, 10-40 μм long. Hyalinic konidiofor, alantoid, unicellular 3-5 h 1-1.5 microns, emerge the surface in the form of long, thin, twisted (almost curly) orange maggots. Periteci occurs in the stroma, immersed in the bark (ektostroma), 6-12 in the group, spherical to oval, dark-colored with a diameter of 300-500 microns. (Common Tree Diseases of British Columbia; www.forestry-dev.org (03/03/2010).They emerge to the surface through a joint ostiole. Accuse with 8 unicellular, hylian, alantoid, spurs rounded at both ends, 7-12 x 1.5-2.5 μм. Damages are low in natural areas but may be significant in young plantations, nursery gardens and horticulture.

This fungus is present almost all over the world. In Serbia it was first recorded by Krstic (1958), on the one-and two-year old branches of poplar trees

***Cytospora salicis* (Sda.) Rabenh.**

Deuteromycotina, Coelomycetes, Sphaeropsidales, Sphaeropsidaceae

(teleomorph = *Valsa salicina* Fr.)

Ascomycotina, Diaporthales, Valsaceae

The fignus show up very offen on part or completly at dry branch diffrent sort of willow since february tll autman. On brown necroted surface was showen large eruptiv embryo (piknids) with sharp point and white ostriols.(Figure No. 3 and 4).Conidias are smoll, eliptic size 4-6 x 1-1,5 μм, at surface show up like short,fat,orange worms.

Barnett, H. L. и Hunter, B. B. (1977) says that picnids are eruptive, about 0, 5 mm at diameter, with gray disks.Condias allantoids, size 4-7x1-1, 5 μм.It is very offen on dead smoll branch who is sill at the trees *S. alba, S. caprea, S. cinerea, S. viminalis* and *S. vitellina.*It is show up since January tll avgust.

At serbian area,first time was noted by Vujic (1963) at bark of willow who dont have good whater suplay.

Perticias are balack and its grown up at storms (Figure No. 5).Width storms is 835 μм, size perticians 258-280 x 236-258 μм.Askus are 4 and 8-slow with very thin walls. Sporas are large,wht no colors , single-cells, size 18,1-21.5 x 4,3-6,45 μм when akus 4-slow (Figure No. 6) or 15-18,5 x 4,3-6,5 μм when akus is 8-slow. Parasite is week but it can at some condition to make a lot of damage.

According to Butin (1960) those fungus do have from outside visible, white round ring size 0,2 mm, which is at ekstorm, through those ring embryo come to through. Embryo is like ball standing in circles.Aknus is tide, long, with 4-8 spors, dimensions 45-65 x 7,3 μм.Spors are like cylinder, little twisted, with no colors, in akcus with 4-8 spors size 20-30 x 5-7 μм and in acus with 8 spors 12-18 x 4-6 μм.

According to Ellis (1985) fungus is show at dead branches. Perticians are deep down, diameter is 0, 3-0, 4 mm, 2-8 at one storm. Disc is small and grey. Ackus is with 5-spors. Ascospors hialinks, size 16-22(30) x 5-8 μм.

***Cytospora nivea* Sacc.**

Deuteromycotina, Coelomycetes, Sphaeropsidales, Sphaeropsidaceae

(teleomorph = *Leucostoma nivea* (Persoon ex Fries) van Höhner
= *Valsa nivea* (Pers.) Fr. ;
= *Leukostoma niveum* (Hoff. ex Fr.) Höhn ;
= *Sphaeria nivea* Fr.
Ascomycotina, Diaporthales, Valsaceae

Symptoms of attack is characteristics by necrosis on core, which is late, because of made eruptive embryo (picnid), raise, which came to blow periderms and show white discs through ostiolas release spors. (Figure No. 7). Picknids are shows at storm. Storm is in groups, around form, black-gray color, size 485-750 x 1000-1336 μм.Boring of a periderm show up surface of ostiol which is like disks, white color. In center is one por. Picinospors are small, one cell, hijanic, elliptic- small, dimension 6-8,6 x 2,1-2,2 μм, and on surface show up in form of dark-red worm.

It is very often at willows, attack thin material, physiologically week plants and according pathogenically is week than fungus *Cytospora chrysosperma.*

Perfeck stadium is show uo like white raund ring size 0.2 mm (Figure No. 8), through those ring, in ectostorm, whit short and thin throat, embrio came through (6-12 bodys). Perticias are black with long black nick, deep in storm, dimensions 501-585 x 385-450 μм. In storm are in circle or whit no orders. Ackus are 8-sporas or 4-sporas, dimensions 51,6-60,2 x 5,2-6,5 μм.Ackosporas are with no colors , like cylinders, and twisted. According Butin (1957), when they are 8, then the size is 10-14 x 2, 5 μм and then they are 4 then size is 14-18 x 2-3 μм.

Perfect stadium is showed almost everywhere there is imperfect which is probably resulting of genetic characteristic of fungus. On willow is showed like saprofit or parasite of weakness.

Butin said that from family *Valsaceae*, from gender who is showed on willows, the most important *Valsa, Valsella* и *Leucostoma.* Common for all three gender is no color,cylindric light twisted one cell sporas. On willows is showed very offen *Valsa salicina* (Pers.) Fr. Perfec and unperfec stadium are grown up thogeder. Storms offen stand thogeder, at large number,crowded or in wide line sometime separatly.

Species from gender *Valsa* и *Leucostoma* are very offen on willow,but they dont have large significance and it is mark like parasites. (Butin, H. 1960).

On the willow are register also ***Cytospora ambiens* Sacc.**, (Figure No. 9), ***Cytospora fertilis* Sacc.** (Figure No. 10) and ***Cytospora translucens* Sacc.** (Figure No. 11. And 12.) They are showed on willow very offen but like parasites of weaknes, and dont have practikal significance.

DISCUSSION AND CONCLUSION

Cytospora species are causing necrosis and cancer on bark on poplar. The condition for the occurrence of this disease on the host plant is that the host is predisposed for attack, e.g. that the host is physiologically weakened in order to establish infection. This disease often occurs in the willows, and in particular, adverse conditions in the plant, may cause considerable damage.

An investigation proved that the fungus *Cytospora chrysosperma* (Pers.) Fr. (Perfect stage of *Valsa sordida* Nit.), are the most common parasitic fungi, both on seedlings and the old indigenous willows. Of the factors that appear conducive to infection may be pointed out: unfavorable habitat, primarily hydrological conditions, improper handling of planting material, adverse soil properties, and many other factors that weaken the plant physiological?

The greatest damage to seedlings occur in the first years after planting, especially if the spring is dry, and if absent flooding forested terrain. Physiologically weakened trees are attacked from the top; the fungus spreads to the thicker end of the seedlings. If the weather conditions are optimal, the fungus may fully colonize the seedlings.

Plants that survive an attack often appears with dry and reduced crown, weakened and vulnerable to attack from others (next) pests in the chain. On older trees often branches that are already physiologically weakened are attacked and that they began to die. This attack does not create damage to old trees, but is a source of infection for the surrounding trees and branches in and near the bottom of trees.

To protect willow in nursery gardens and young plantations from cancer causing necrosis and cortical tissue injury is required the use of chemical protection, i.e. use of fungicides in the critical period for infection.

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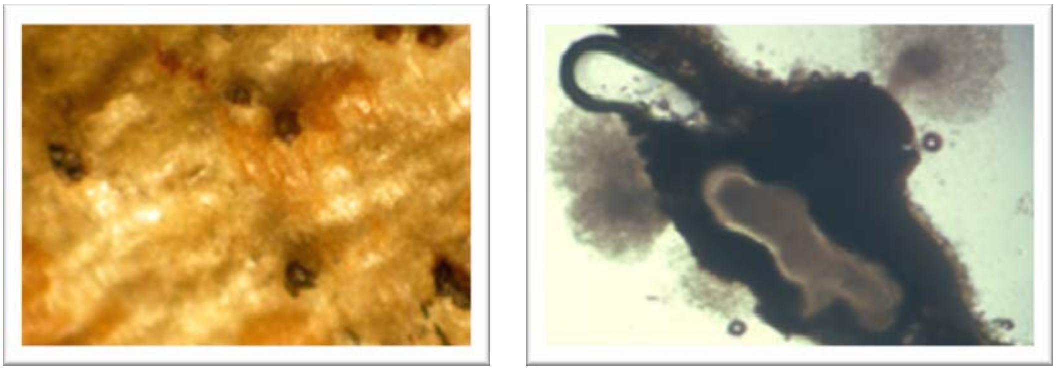
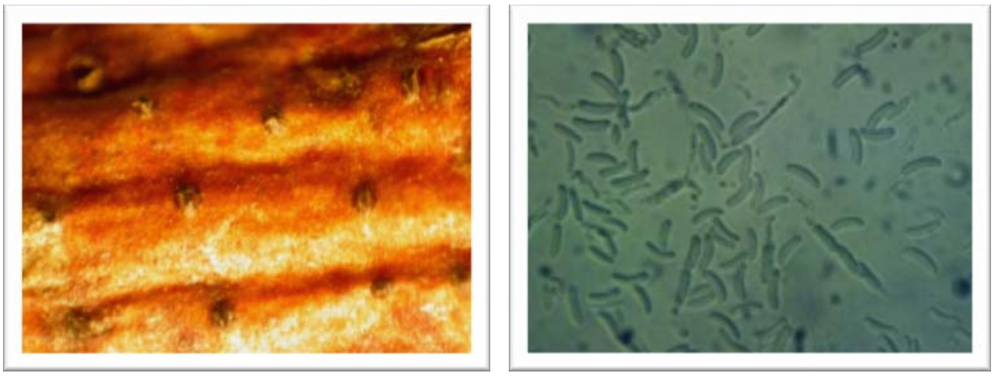
Cytospora chrysosperma : Figure No.1. necrosis; Figure No.2. distribution of spurs



Cytospora salicis: Figure No.3. piknids; Figure No.4. cross section of piknids



Valsa salicina: Figure No.5. Perticias; Figure No.6. Ascosporas

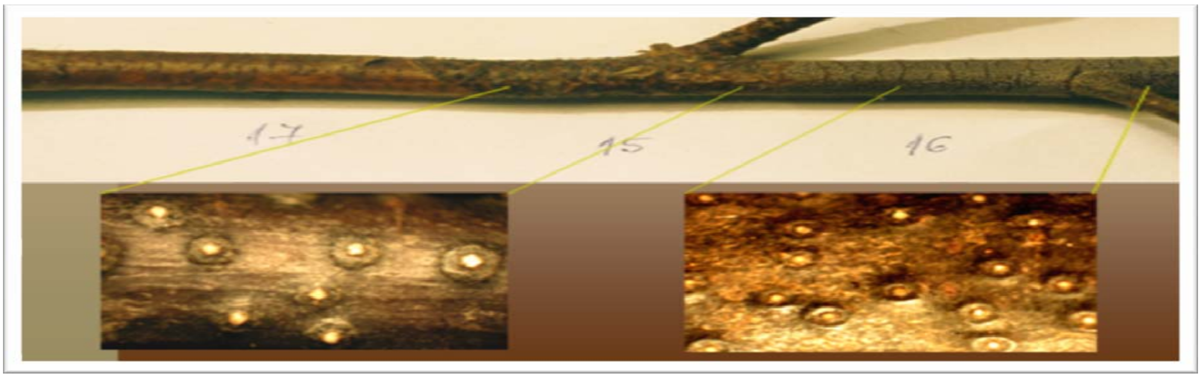


Figure No.7. Cytospora nivea - piknids;   Figure No.8. Leucostoma nivea - Perticias

Figure No.9. Cytospora ambiens ; Figure No.10. Cytospora fertilis

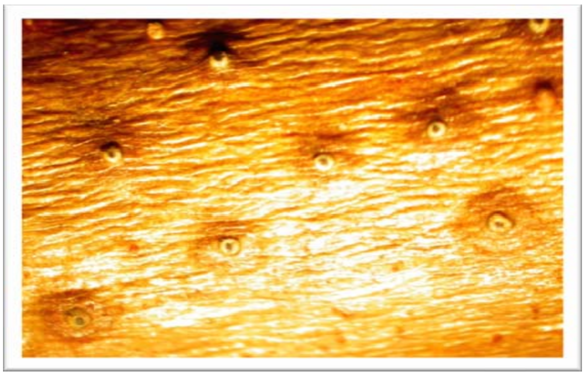


Figure No.11. and 12. Cytospora translucens