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PHYTOCENOLOGICAL CHARACTERISTICS OF SESSILE OAK AND TURKEY OAK ASSOCIATION (Ass. Quercetum petraeae-cerris Jovanović (1960) 1979) IN PEŠTER PLATEAU

Ljubinko Rakonjac, Mihailo Ratknić, Milorad Veselinović, Suzana Mitrović[1]

Abstract: Phytocenological characteristics of Sessile oak and Turkey oak association (Ass. Quercetum petraeae-cerris Jovanović (1960) 1979) in Pešterska Plateau are presented in this paper. Their percentage in the observed area, habitat properties, floristical composition and strutructure - biological specter, specter of floristic elements, layers, etc. are presented.

In this area Sessile oak and Turkey oak forests are located at the upper limit of altitudinal distribution, at two localities. Geological base are made of neogenic sediments, and the soil types are dystric cambisol and pseudogley. The plants adapted to the more extreme life conditions, i.e. plants which are low-temperature resistant and can survive high temperature amplitudes in a short vegetation period, i.e. xero-mesophilic plants are dominant in this association, since the area is located between Ilyrian and Mesian Provinces.

Key words: Sessile oak, Turkey oak, phytocenological characteristics, Pešterska Plateau, habitat.

FITOCENOLOŠKE KARAKTERISTIKE ZAJEDNICE KITNJAKA I CERA (Ass. Quercetum petraeae-cerris Jovanović (1960) 1979) NA PEŠTERSKOJ VISORAVNI

Izvod: U radu su prikazane fitocenološke karakteristike zajednice kitnjaka i cera (Ass. Quercetum petraeae-cerris Jovanović (1960) 1979) na području Pešterske visoravni. Prikazana je rasprostranjenost na području istraživanja, karakteristike staništa, floristički sastav i struktura - biološki spektar, spektar flonih elementa, spratovnost i dr. Na ovom području šume kitnjaka i cera nalaze se na gornjoj granici visinskog rasprostra-

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njenja, na dva nalazišta. Geološku podlogu čini neogeni sedimenti, a zemljišta su distrični kambisol i pseudoglej. U zajednici preovlađuju biljke prilagođene ne ekstremnije uslove života, tj. biljke koje podnose niske temperature i velike temperaturne amplitude i u kratkom vegetacionom periodu, odnosno biljke ksero-mezofilnog karaktera, pošto se nalazi na prelaznoj zoni između ilirske i mezijske provincije.

Ključne reči: kitnjak, cer, fitocenološke karakteristike, Pešterska visoravan, stanište.

1 INTRODUCTION

Sessile oak and Turkey oak associations in Serbia, Bosnia and Hercegovina, Montenegro and Macedonia are mainly described as *Quercetum montanum* subass. *cerretosum*, which implies the affiliation to the alliance *Quercion robori-petraeae* Br-Bl. 31. However, since there is a great number of xerotherm species (most usually from the order *Quercetalia pubescentis*), it was necessary to find some other solution (Tomić, 1988). Some authors (Horvat, Glavač, Ellemberg, 1974) tried to classify Mesian Sessile oak forests, as well as Sessile oak forests with Turkey oak as higher mountainous range climate-zonal Sessile oak and Turkey oak forest in the alliance *Quercion frainetto* Horv. 59. In accord with these notions, the Turkey oak forests with Sessile oak were classified as *Quercetum cerris moesiacum* Vuk. 66 *Quercetosum petraeae* Vuk. 76 in Serbia, but at a very wide interval of geological base and soil. The question of Sessile oak and Turkey oak forests was solved only by the formation of the new alliance of the continental Sessile oak and Turkey oak forests *Quercion petraeae-cerris* (Lakuš. 76) Lakuš. et. Jov. 80. V. Stefanović (1984) was the first to describe the association *Quercetum petraeae-cerris* Stef. 83, which contain several xero-mesophilic elements, since it is located in the transitional zone between Iliric and Mesian Provinces, as the dominant association in Eastern Bosnia (by Tomić, 1988).

2 WORK METHOD

The data by Federal Hydrometerological Institute were used for the description of the climate properties. The general climate characteristics, air temperature, relative air humidity, cloudiness, the duration of sun-light, wind, precipitation, hydric sum, are presented. The sufficient number of the pedological profiles was taken for the determination of the soil properties in forest associations, in the places where phytocenological recods were taken. The soil types were determined by the soil classification (Škorić et all, 1985). The standard laboratory methods were used for the determination of the soil samples.

The recent forest vegetation was studied by the principles and methods of the French-Swiss school Braun-Blanquet (Braun-Blanquet, 1928, 1921), typical and widely accepted in phytocenological research in our country. The floristically structural phytocenological tables were made by the phytocenological records. The specters of floristic elements (percentage of the groups of floristic elements and individual floristic elements) by the associations were made in accord with the systematisation of plant-geographic elements of Gajić (Gajić, 1989). The biological specters (percentage of some life forms) of plants were done by Kojić, M. et al., 1994), by the division in the types of life forms (Raunkiaer).

3 SUBJECT AND OBJECTIVE OF THE STUDY

The Sessile oak and Turkey oak stands in Pešter Plateu are the subject of the study. Since these stands are located in the upper limit of the altitudinal distribution, it was needed to study other habitat conditions, in order to determine the way in which they can be preserved, despite of numerous negative zoo-anthropogenic influences.

The objective of this study was to define habitat and phytocenological characteristics of these forests in a great detail, in order to determine all the peculiarities in which they develop, as well as the future directions of succession. Owning to their peculiarity, it is needed to emphasize the possibilities of the use of seedling material which is favourable to these conditions in the future reforestation of the deforested terrains with the similar habitat characteristics.

4 RESEARCH RESULTS

Sessile oak and Turkey oak forests *Quercetum petraeae-cerris* Jovanović, 1960, 1979 (synonym *Quercetum cerris quecetosum petraeae* Vukićević 1976) are transitional forms between monodominant Sessile oak forests of the mountainous regions and zonal vegetation, most often Hungarian oak and Turkey oak forests in Serbia. Actually, they occupy the lower belt of Sessile oak forests – up to 600 m above sea level, in the greatest part of their area. Expositions are usually warm, and soils are brown and lessivied on very different bases. These forests are more mesophilic than monodominant Turkey oak forests – alongside xerophilic species of the order *Quercetalia pubescentis* there are also some more mesophilic elements of Sessile oak and even Turkey oak forests (Tomić, 1992). This association is more frequent and more extensive than the monodominant Turkey oak forests. In particular, it occupies great areas in Northwestern and Western Serbia, in Gučevo, Maljen, Cer, branches of Tara and Zlatibor (Vukićević), as well as in Eastern and Northeastern Bosnia. This association also occurs in Fruška gora, at somewhat lower altitudes, up to 400 meters above the sea level (Janković et Mišić; Jović et al.), whereas there are only fregments of it in Eastern Serbia (papers quoted by Tomić, 1992).

4.1 Range and position in the observed area

In Peštersko-Sjenička Plateau and its lateral slopes, the Sessile and Turkey oak forests are situated in the upper limit of their altitudinal distribution. There are two localities. The first one is located in the open Sjenička plateau, in Babinjača, northwest of Sjenica. It spreads up to 1,200 meters above the sea level, up to karst Gradac. It covers a wide crest, flattened slopes Rašće and Plandište, from Tubića kuće in Donje Lopiže on the north exposition to Krmske valleys, west of Uvac Village. From Babinjača this association descends in the Uvac valley, and then it spreads upstream to Sumarača, to Mašovići Village, at 1,200 meters above the sea level. Uvac Village is located in the zone of the distribution of the former oak forests. In this area the oaks are localized in Uvac Gorge, from Čedovo to Lupoglav, where a few enclosed Sessile oak and Turkey oak forests of a high quality are located. In all parts of the area the Sessile oak and Turkey oak associations are frequently interspersed with hazel groves. Poplars and birches are frequent in them. In the lateral valleys of Peštersko-Sjenička Plateau Sessile oak and Turkey oak association is located at the other, important locality of Ljutska River

basin, on the south slopes of Golija, in direction of Novi Pazar. In this part of the plateau, alongside the degraded shrubs below Šarski karst, there are several private estates of a better quality. The Sessile oak and Turkey oak forests are renewable, below Duga Poljana. Sessile oak and Turkey oak forests are also located in Vrhovina, in piedmont mountain of Javor.

4.2 Properties of habitat

The main relief forms in which the association is located are long crests, but the gentle plateaus and long flattened ridges are present as well.

The altitudes in which the association is located in this area range from 800 and 1,200 meters above the sea level, but the forests are best preserved and developed at about 1,100 meters above the sea level. It is located at eastern, southeastern, southwestern and northwestern expositions. In regard with the inclination, the terrains range from the forms of plateaus to the greater inclinations, more than 20°.

The geological base in all parts of the area of this association is made of neogenic sediments; sandstones, gravels and clays, and only in the smaller area phillites are present. The soil area is void of the huge stones and rocks or is rocky to a small degree, since bedrock is prone to the process of physical decay. In the soil profile, the percentage of skeleton is not greatly expressed up to the level of geological base, where the transition is not abrupt, but gradual.

The most frequent soils which developed on such bedrocks and in this association are dystric cambisols, pseudogleys, as well as luvisol in the majority of the studied stands. The pedological studies which were conducted showed that the depth of the soil is over 70 cm. The thickness of forest floor ranges from 2 to 3 cm, and thickness of humus accumulative horizon ranges between 7 to 12 cm. The thickness of E horizon in luvisol ranges between 7 and 38 cm, and thickness (B) or g/Bt is from 29 to 62 cm. The other physical and chemical properties of soil are presented in the tables of the properties of soil by types of soil. Their texture classes range from the loams in the upper parts of the profile, to the clays in the lower parts of the profile. In regard to the acidity the majority of the soils are mainly acid at all depths of the profiles and pH value in the water ranges from 4.1 to 5.3, and in KCl from 3.3 to 4.6. The soil is rich in the total content of humus and nitrogen (nitrogen 0.35 %; humus 6.0–9.75%). In regard to the easily accessible phosphorous forms, the soil is poor (2.0 mg per 100g of soil), and it avaragely to well-supplied with kalium (15-34.28 mg per 100g of soil).

4.3 Floristic composition and structure

Floristic composition and structure are presented in phytocenological table 1 in 7 records. The phytocenological table contains 159 taxa: 7 tree species, 11 bush species and 141 species which are found in low-level flora layer. Among the low-level flora species are 3 fernery species and 138 flowering plant species. Certain phytocenological records contain from 41 to 63 plant species, 52 species in average. The Sessile oak and Turkey oak stands in Pešter are considerably degraded, somewhere the whole canopy is broken, so the plants from neighboring forest and meadow phytocenosis and cultures found favorable living conditions in the phyto-climate of the phytocenosis. The largest number of the records contains over 50 species, which is much more than in some other associations,

e.g. beech, which are also degraded and poorly preserved. Based on these data it can be concluded that Sessile oak and Turkey oak in Pešter belongs to the group of rich forest phytocenosis in the observed area. The floristic wealth is the consequence of the community itself and a property of stands where the studies were conducted.

Life-form spectrum – biologic spectrum

The association **biologic spectrum** is presented in Table 1. The high presence of hemicryptophytes is recorded (58%), which is the consequence of plant life condition aggravation, mainly climatic in this altitude level. Plants accustomed to extremer life conditions dominate the association, i.e. plants surviving low temperatures and high temperature amplitudes during short vegetation period. The greatest percentage of hemicryptophytes shows, inter alia, that the grasses from *Poaceae* families dominate, which is understandable taking into consideration the stand state viewed as a whole. The relatively favorable geophytes (14%) percentage points to the appropriate soil conditions (humidity, structure and soil depth). The hemicryptophytes and chamaephytes percentages are increased (58% and 7%), pointing to the extreme habitat conditions, severe stand degradation and lower temperatures. The small number of terophytes adjusted to a longer vegetation period in some thermophilic associations, as well as adjustment to habitats with scorching summers, points to climate transition toward mountain climate.

Table 1 - Plant life-form spectrum in association Quercetum petraeae-cerris Jovanović (1960) 1979

Life forms							
p	np	wc	hc	h	g	t	th
9%	5%	3%	4%	58%	14%	4%	2%
14%		7%					

Legend: *p - Phanerophytes; np - Nanophanerophytes; wc - Woody chamaephytes; hc - Herbaceous chamaephytes; h - Hemicryptophytes; g - Geophytes; t - terrophytes; th - Terophytes/chamaephytes*

Floral element spectrum

The association floral element spectrum is presented in table 2.

Table 2 - The spectrum of floral elements in association Quercetum petraeae-cerris Jovanović (1960) 1979

Floral element group	Plant number	Participation		Floral element	Plant number
NORTHERN REGION FLORAL ELEMENTS	2	2%	2%	Sub-boreal	2
MIDDLE EUROPEAN	31	33%	33%	Middle-European	10
				Sub Middle-European	21
SUB–ATLANTIC	3	4%	4%	Sub-Atlantic - sub-Mediterranean	3

Floral element group	Plant number	Participation		Floral element	Plant number
SUB-MEDITERRANEAN	3	3%	9%	Sub-Mediterranean	3
East sub-Mediterranean	4	4%		Eastern Sub-Mediterranean	4
Balkan and Balkan-Apennine	2	2%		Mesian	1
				Middle Balkan	1
PONTIC – CENTRAL ASIAN	3	3%	13%	Subpontic - sub-Central Asian - sub-Mediterranean	1
				Subpontic - sub-Central Asian	2
Pontic	9	10%		Pontic	2
				Sub-pontic	4
				Pontic - sub-Mediterranean	1
				Sub-Pontic - sub-Mediterranean	2
DESERT REGION FLORAL ELEMENTS	1	1%	1%	Iran - euxinian	1
EURO–ASIAN FLORAL ELEMENTS	30	33%	33%	Sub - south Siberian	4
				Euro-Asian	15
				Sub Euro-Asian	11
CIRCUMPOLAR AND COSMOPOLITE	5	5%	5%	Circumpolar	3
				Sub-circumpolar	1
				Cosmopolite	1
TOTAL:	93	100%	100%	TOTAL:	93

The spectrum of the floral elements of association can provide us with a good picture on structure, character and origin. The Euro- Asian floral elements are mostly found in this type of floral element spectrum 33%, as well as middle- European floral elements 33% forming the most of the spectrum pointing to middle- European and Euro-Asian influences. The sub-Mediterranean floral elements comprise 9% of the total, sub-Mediterranean (in a narrowed sense) 3%, east sub- Mediterranean 4% and 2% of Balkan and Balkan-Apennine elements. There is a considerable 5% percentage of circumpolar and cosmopolite, due to higher altitudes in which this community is found on Pester. The smaller part is comprised of sub-Atlantic floral elements 4%, northern region floral elements 2% and desert region floral elements 1%. The mesophilic plants (middle-European and sub-Atlantic floral elements) participate with 37%, and xerophilic type plants (pontic, sub-Mediterranean, Balkan, and desert region floral elements) account for 23%, while the wide ecologic amplitude plants (Euro- Asian and cosmopolite floral element) account for 34%. Frigoripyiric plants account for 6%

The sub-middle-European (21), Euro-Asian (15), sub Euro-Asian (11) and middle-European (10) are the most frequent individual floral elements. Less frequent are subpontic (4), eastern sub-Mediterranean (4), sub-south Siberian (4) and with three species each sub-Mediterranean, sub Atlantic - sub-Mediterranean and circumpolar.

The Sessile oak and Turkey oak association (*Quercetum petraeae-cerris*) is dominated by xerophilic character plants, since the association is located in the border zone

between Illyrian and Mesian Provinces. This Sessile and Turkey oak association is almost identical to the one in Voloder (Tomić, 1988) and with the community of Eastern and Southeastern Bosnia described and recorded in vegetation charts.

4.4 Layers

The vertical structure of this association is differentiated by layers of: trees, bushes and low-level flora. This is a bi-dominant community as the most Sessile oak and Turkey oak associations in Serbia are; the tree layer is dominated by Sessile oak and Turkey oak. The canopy cover in the first layer varies ranging from 0.3-0.8, the average being 0.6. The tree height differs depending on stand preservation degree ranging from 9-25m, mostly around 15m. The average diameter of the first layer trees in the observed stands is 25cm, ranging from 8cm on Strmac slopes to 30cm in Babinjača. The Sessile oak and Turkey oak stands are less preserved in lower altitude belt, with smaller trees than these in upper altitude zone, which are also better preserved. The least preserved stands are near village meadows and pastures, because they are exposed to the influence of villagers. The middle parts between villages contain slightly more preserved stands, where Turkey oak is more exploited and there is less of it now. Going up toward the ridges and saddles, stands have lower values of average tree height and thickness which are 9m high and 15cm thick. The upper border of these stands is not gradual, which might have been expected in the form of bush forest, but it directly passes into pasture, which is the consequence of the mass felling, since these forests have been easily available for exploiting. The stands of this association are almost destroyed on lateral slopes around rivers and brooks where forest has not managed to significantly regenerate, due to erosion. The two records show that there is no Sessile oak in the first layer, only stunted and old Turkey oak trees have remained, which often do not reach the tree layer height, although they are very old. The stands commonly found in forest enclosures and on remote parts of country roads are dominated by Sessile oak and Sessile oak achieves considerable dimensions despite the habitat conditions. Alongside the *Quercus petraea*, *Quercus cerris*, in tree layer *Populus tremula* are also found, whereas *Fagus moesiaca*, *Prunus avium*, *Pyrus pyraster*, *Tilia parvifolia* are rarely found.

Sessile oak and Turkey oak are less found in the **shrub layer** in comparison with hazel tree (*Corylus avellana*) and wild pear (*Pyrus pyraster*) which is found in almost all records. *Crataegus monogyna* and *Juniperus communis* are more frequently found having the III presence degree, which points to stand devastation. *Betula pendula*, *Carpinus betulus*, *Evonymus latifolius*, *Populus tremula*, *Prunus avium*, *Prunus spinosa* and *Salix capreae* are found in smaller numbers. *Crataegus calycina*, *Evonymus europaeus*, *Rosa agrestis* and *Viburnum lantana* are found individually.

The low-level flora layer is significantly lush and the soil cover ranges from 40 to 90 percent. The highest canopy cover is found in stand records in which devastation is expressed on steep slopes toward Uvac where it is 0.9. It is understandable that the lowest canopy cover is found in densely connected stands on northern slopes and gentle plains, which are less subjected to light where canopy is mostly 0.4. In the third layer the most dominant species are: *Campanula persicifolia*, *Prunela vulgaris. Ajuga reptans*, *Dactylis glomerata*, *Trifolium montanum* are also frequently present, but in a lower number and lower canopy cover, and with reduced sociability. *Viola silvestris*, *Aegopodium podagraria*, *Anemone nemorosa*, *Aremonia agrimonioides*, *Brachypodium silvaticum*,

Cirsium acaule, *Danaa cornubiensis*, *Euphorbia amygdaloides*, *Festuca heterophylla*, *Galium cruciata*, *Galium silvaticum*, *Genista ovata*, *Geranium sanguineum*, *Helleborus odorus*, *Helianthemum nummularium*, *Hieracium bauhinia*, etc. are also found but there is a lower percentage of them.

5 CONCLUSION

1) The altitudes in which the association is located in this area range from 800 and 1,200 meters above the sea level, but the forests are best preserved and developed at about 1,100 meters above the sea level. It is located at eastern, southeastern, southwestern and northwestern expositions. In regard with the inclination, the terrains range from the forms of plateaus to the greater inclinations, more than 20°.

2) The geological base in all parts of the area of this association is made of neogenic sediments; sandstones, gravels and clays, and only on the smaller area phillites are present. The soil area is void of the huge stones and rocks or is rocky to a small degree, since bedrock is prone to the process of physical decay. In the soil profile, the percentage of skeleton is not greatly expressed up to the level of geological base, where the transition is not abrupt, but gradual.

3) The most frequent soils which developed on such bedrocks and in this association are dystric cambisols, pseudogleys, as well as luvisol in the majority of the studied stands. The pedological studies which were conducted showed that the depth of the soil is over 70 cm.

4) The sub-middle-European (21), Euro-Asian (15), sub Euro-Asian (11) and middle- European (10) are the most frequent individual floral elements. Less frequent are subpontic (4), eastern sub-Mediterranean (4), sub-south Siberian (4) and with three species each sub-Mediterranean, sub Atlantic - sub Mediterranean and circumpolar. The Sessile oak and Turkey oak association (*Quercetum petraeae-cerris*) is dominated by xerophilic plants, since the community is located in the border zone between Illyrian and Mesian Provinces.

5) Floristic composition and structure are presented in phytocenological table 1 in 7 records. The community contains 159 taxa: 7 tree species, 11 bush species and 141 species which are found in low-level flora layer. Among the low-level flora species are 3 fernery species and 138 flowering plant species.

6) The Sessile oak and Turkey oak stands in Pešter are considerably degraded, somewhere the whole canopy is broken, so the plants from neighboring forest and meadow phytocenosis and cultures found favorable living conditions in the phyto-climate of the phytocenosis. According to these data it can be concluded that Sessile oak and Turkey oak association in Pešter belongs to the group of rich forest phytocenosis in the observed area. The floristic wealth is the consequence of the community itself and a characteristic of stands where the studies were conducted.

LITERATURE

Gajić, M. (1989): Flora and vegetation of Golija and Javor ŠPIK Ivanjica, 1-592, Ivanjica, Belgrade.

Horvat, I., Glavač, V., Elemberg, H. (1974): Vegetation Sudosteuropas.Geob. selecta, Band IV, pp. 1-768, Stuttgart.

Kojić, M., Popović. R., Karadžić, D. (1994): Phyto indicators and their significance in evaluating habitat ecologic conditions. IP Nauka, the Institute for Research in Agriculture "Serbia", pp. 45-129, Belgrade.
Škorić, A., Filipovski, G., Ćirić, M. (1985): Classification of soils of Yugoslavia. Sarajevo 1985. *(Original- Klasifikacija zemljišta Jugoslavije. Sarajevo 1985)*
Stefanović, V. (1984): Forest vegetation on verfenic sandstones and clays of Eastern and Southeastern Bosnia. Papers of Faculty of Forestry and Institute of Forestry and Wood Industry, IX, volume 9, book 3, pp. 1-116, Sarajevo.
Tomić, Z. (1988): Sessile oak and Turkey oak forest (Qurcetum petraeae-cerris Stef. 1983) in Voloder, Agriculture and Forestry, XXXIV, number 1, pp. 51-61, Titograd.
Tomić, Z. (1992): Serbia forest phytocenosis University textbook, Faculty of Forestry, pp. 1-131, Belgrade.

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Summary

The altitudes in which the association is located in this area range from 800 and 1,200 meters above the sea level, but the forests are best preserved and developed at about 1,100 meters above the sea level. It is located at eastern, southeastern, southwestern and northwestern expositions. In regard with the inclination, the terrains range from the forms of plateaus to the greater inclinations, more than 20°.

The geological base in all parts of the area of this association is made of neogenic sediments; sandstones, gravels and clays, and only on the smaller area phillites are present. The soil area is void of the huge stones and rocks or is rocky to a small degree, since bedrock is prone to the process of physical decay. In the soil profile, the percentage of skeleton is not greatly expressed up to the level of geological base, where the transition is not abrupt, but gradual.

The most frequent soils which developed on such bedrocks and in this association are dystric cambisols, pseudogleys, as well as luvisol in the majority of the studied stands. The pedological studies which were conducted showed that the depth of the soil is over 70 cm.

The sub-middle-European (21), Euro-Asian (15), sub Euro-Asian (11) and middle-European (10) are found as the most frequent individual floral elements. Less frequent are subpontic (4), eastern sub-Mediterranean (4), sub- south Siberian (4) and with three species each sub-Mediterranean, sub Atlantic- sub Mediterranean and circumpolar. The Sessile oak and Turkey oak association (*Quercetum petraeae-cerris*) is dominated by xerophilic plants, since the community is located in the border zone between Illyrian and Mesian Provinces.

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Ljubinko Rakonjac, Mihailo Ratknić, Milorad Veselinović, Suzana Mitrović

Rezime

Nadmorska visina na kojima se javlja zajednica na ovom području je od 900–1200 mnv, ali su šume najbolje očuvane i razvijene na terenima od oko 1100 mnv. Ekspozicije na kojima se ona javlja su istočne, jugoistočne, jugozapadne, severozapadne i dr. U pogledu nagiba, to su tereni od oblika zaravni do većih nagiba od preko 20°.

Geološku podlogu u čitavom arealu ove zajednice čine neogeni sedimenti; peščari, šljunkovi i gline, a samo na manjoj površini prisutni su filiti. Površina zemljišta je bez krupnog kamenja i stena ili je neznatno kamenita, jer je matični supstrat podložan procesu fizičkog raspadanja. U profilu zemljišta skeletnost nije mnogo izražena sve do nivoa geološke podloge, gde taj prelaz nije nagao nego postepen.

Najčešća zemljišta koja su se razvila na ovakvim matičnim supstratima i u ovoj zajednici su distrični kambisoli, psudoglejevi, na većini istraživanih sastojina i luvisol. Prema izvršenim pedološkim istraživanjima zemljišta su dubine preko 70 cm.

Kao pojedinačni florni elementi najzastupljeniji su subsrednjeevropski (21), evroazijski (15), subevroazijski (11) i srednjeevropski (10). Manje su zastupljeni subpontski (4), istočno-submediteranski (4), subjužnosibirski (4) i sa po 3 vrste submediteranski, subatlantsko-submediteranski i cirkumpolarni.

U zajednici kitnjaka i cera (*Quercetum petraeae-cerris)* preovlađuju biljke kseromezofilnog karaktera, pošto se nalazi na prelaznoj zoni između ilirske i mezijske provincije.

Floristički sastav i struktura predstavljen je fitocenološkom tabelom 1 sa 7 snimaka. Zajednica sadrži 159 taksona: 7 vrsta drveća, 11 vrsta grmova i 141 vrsta koje se javljaju u sloju prizemne flore. Među vrstama u spratu prizemne flore su 3 paprati i 138 cvetnica.

Sastojine kitnjaka i cera su na Pešteru dosta degradirane, negde i potpuno raskinutog sklopa, tako da su biljke iz susednih šumskih i livadskih fitocenoza i kultura našle povoljne uslove za život u fitoklimatu ove fitocenoze. Na osnovu ovih podataka može se konstatovati da zajednica kitnjaka i cera na Pešteru spada u red bogatih šumskih fitocenoza za područje istraživanja. Florističko bogatstvo je posledica osobina same zajednice i karakteristika sastojina u kojima su vršena istraživanja.

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Phytocenological table - *Association QUERCETUM PETRAEAE-CERRIS Jovanović (1960)1979*

The ordinal number of the record	1	2	3	4	5	6	7	The degree of the presence
Number of the record (field mark)	sVIII	s37	136	s36	s38	s38a	s39	
Date of the record	21.07.96	23.06.96	07.07.97	23.06.96	27.06.96	28.06.96	28.06.96	
Locality	Strmac	Babinjača	Uvac	Babinjača				
Size p. p. (m2)	900							
Altitude (m)		1,140	1,180	1,140	1,180	1,190	1,160	
Exposition (°)	I	J-JI	J-JZ	JZ		S-SZ	I-JI	
Inclination	15	20	15	20	0	18	15	
Geological base	Phillites	Sandstones, clays, hornstones and marls						
Soil	Dystric cambisol			luvisol			pseudogley	
I LAYER								
Canopy	0.8	0.5	0.7	0.3	0.6	0.6	0.7	
Height –mean (m)	11	10	14	9	20	25	22	
Diameter - (cm)	8-20	20	16	20	30	25	25	
Distance (m)	1-3	5	0.5-4	11	1-4	2-4	2-5	
Quercus petraea	4.5		1.1		4.4	4.4	4.4	V
Quercus cerris		3.3	3.3	2.3				III
Populus tremula					+.1	+.1		III
Betula pendula					+.1			I
Fagus moesiaca	+.1							I
Prunus avium					+.1			I
Pyrus pyraster		1.1						I
Tilia parvifolia							+.1	I
II LAYER								
Canopy	0.3	0.3	0.3	0.2	0.2	0.3	0.2	
Height (m)	2	3	2.5	2.5	1.5	1.5	2	
Corylus avellana	+.1	2.2	+.1	2.3		1.1	1.1	V
Pyrus piraster	+.1	1.1	+.1	+.1	+.1		+.1	V

The ordinal number of the record	1	2	3	4	5	6	7	The degree of the presence
Quercus petraea	2.2		1.1	+.1	+.1	1.1	1.1	V
Crataegus monogyna	+.1		+.1	1.1			2.2	III
Juniperus communis	+.1	1.1		1.1				III
Quercus cerris		2.3	2.2	+.1				III
Betula pendula						+.1	+.1	II
Carpinus betulus		1.1				+.1		II
Evonymus latifolius					+.1		+.1	II
Populus tremula			+.1			1.1		II
Prunus avium						+.1	+.1	II
Prunus spinosa			2.1	1.1				II
Salix capreae		+.1					+.1	II
Crataegus calycina					+.1			I
Evonymus europaeus								I
Rosa agrestis				1.1				I
Tilia parvifolia							+.1	I
Viburnum lantana							+.1	I
III LAYER								
Canopy	0.4	0.6	0.4	0.4	0.4	0.4	0.4	
Campanula persicifolia	+.1	+.1	+.1	+.1	+.1	+.1	+.1	V
Fragaria vesca	+.1	+.1	1.1	+.1		+.1	1.1	V
Prunella vulgaris		+.1	1.1	+.1	+.1	+.1	+.1	V
Ajuga reptans	+.1	+.1		+.1	+.1		+.1	IV
Dactylis glomerata	+.1		1.1		1.1	1.1	1.1	IV
Trifolium montanum	+.1	1.1		2.2	1.1		+.1	IV
Viola silvestris	+.1	+.1	+.1		+.1		+.1	IV
Aegopodium podagraria	+.1				+.1		+.1	III
Anemone nemorosa	1.1				2.2	1.2	2.2	III
Aremonia agrimonioides	1.1		+.1				1.1	III
Brachypodium silvaticum		1.1	1.2	+.1	+.1			III

The ordinal number of the record	1	2	3	4	5	6	7	The degree of the presence
Carex praecox					+.1	1.1	1.1	III
Cirsium acaule		+.1	+.1	1.2				III
Danaa cornubiensis	+.1	+.1	+.1					III
Euphorbia amygdaloides	+.1					+.1	+.1	III
Festuca heterophylla			1.2			1.2	1.2	III
Filipendula hexapetala			+.1			+.1	+.1	III
Galium cruciata		+.1		1.1			1.1	III
Galium silvaticum	+.1			1.1			1.2	III
Genista ovata	+.1			1.1			+.1	III
Geranium sanguineum			+.1			+.1	+.1	III
Helleborus odorus					+.1	+.1	+.1	III
Helianthemum nummularium		+.1		1.1	+.1			III
Hieracium bauhini		1.1		1.1	+.1		1.1	III
Hieracium pilosella		+.1		1.1	+.1	+.1		III
Hypericum perforatum	+.1		+.1				+.1	III
Inula hirta		1.1		1.1			+.1	III
Polygonatum odoratum	+.1					+.1	1.2	III
Primula veris	+.1			+.1			+.1	III
Silene nutans		+.1		1.1	+.1		1.1	III
Stachys officinalis		1.1	+.1	1.1				III
Stelaria holostea	1.1				1.1	1.1	1.1	III
Teucrium chamaedrys		1.1	+.1	1.2				III
Trifolium alpestre		1.1		1.1			1.1	III
Veronica officinalis		+.1		+.1	+.1	+.1		III
Asarum europaeum					+.1		1.1	II
Astrantia major					1.1	+.1		II
Briza media		1.1		1.1				II
Campanula patula		+.1		+.1				II
Carex montana	+.1		+.1					II

The ordinal number of the record	1	2	3	4	5	6	7	The degree of the presence
Cerastium brachypetalum		+.1		+.1				II
Chamaecytisus rochelii					+.1		1.1	II
Cytisus scoparius		2.3		+.1				II
Dactylorhiza incarnata					+.1	+.1		II
Dianthus armeria					+.1	+.1		II
Digitalis ambigua					+.1	+.1		II
Dorycnium herbaceum		1.1		1.1				II
Festuca vallesiaca	1.2						2.1	II
Filipendula hexapetala			+.1	1.1				II
Galium vernum		+.1	+.1					II
Galium verum						1.1	1.1	II
Hypericum montanum					+.1	+.1		II
Koeleria pyramidata		+.1						II
Lathyrus niger				1.1	+.1			II
Leontodon hispidus				+.1				II
Leucanthemum vulgare		1.1		1.1				II
Lilium martagon	+.1					+.1		II
Lolium perenne		1.1		1.1				II
Luzula campestris				+.1				II
Luzula luzuloides						2.2	1.1	II
Melampyrum pratense						1.2	1.1	II
Melampyrum sylvatucum					+.1	+.1		II
Melittis melissophyllum	1.1				+.1			II
Phleum montanum					+.1	+.1		II
Plantago altissima		+.1		1.1				II
Poa nemoralis		1.1	+.1					II
Polygala comosa				1.1	+.1			II
Potentilla erecta						1.1	+.1	II
Ranunculus steveni				+.1			+.1	II

The ordinal number of the record	1	2	3	4	5	6	7	The degree of the presence
Rumex acetosa		+.1		1.1				II
Serratula tinctoria					+.1		+.1	II
Silene vulgaris					+.1	+.1		II
Tanacetum corymbosum		+.1		1.2				II
Woody species in III layer								
Pyrus pyraster		+.1	+.1	+.1	+.1			IV
Quercus petraea		+.1	+.1					II
Prunus spinosa			1.1					I
Quercus cerris			1.1					I
Rubus canescens			+.1					I

In the individual phytocenological records the following species are reported:

Alchemilla vulgaris 1.1 (s38), Anthriscus sylvestris +.1 (s38), Avena pubescens 1.1 (136), Calamagrostis epigeios 1.2 (s38a), Campanula patula (+.1), Carex hordeistichos +.1 (s38a), Centaurea nyssana +.1 (s38a), Cephalantera longifolia +.1 (sVIII), Cephalantera rubra +.1 (sVIII), Cerastium brachypetalum +.1 (s38) Chamaecytisus supinus 1.1 (s39), Cynosurus cristatus +.1 (s37), Coronilla varia +.1 (sVIII), Crepis viscidula +.1 (s38a), Cytisus scoparius +.1 (136), Danthonia provincialis 1.2 (s37), Deschampsia flexuosa 1.2 (s38a), Digitalis ferruginea +.1 (s39), Dorycnium herbaceum +.2 (s39), Festuca amethystina 1.1 (s37), Galium aparine +.1 (sVIII), Galium kitaibelianum +.1 (sVIII), Galium rubioides +.1 (s38a), Geum rivale +.1 (s38a), Hieracium cymosum +.1 (s38a), Hieracium murorum +.1 (s39), Hieracium panosum +.1 (s38), Hieracium transsilvanicum +.1 (sVIII), Hipericum maculatum +.1 (s37), Inula salicina +.1 (s38a), Knautia arvensis +.1 (s36), Koeleria gracilis +.1 (s38a), Koeleria pyramidata +.1 (s37), Lamium galeobdolon +.1 (s39), Lathyrus hallersteinii +.1 (sVIII), Lathyrus venetus +.1 (sVIII), Latirus transilvanicus +.1 (s38), Leontodon hispidus +.1 (s38), Leucanthemum vulgare +.1 (s38), Linum hirsutum +.1 (s38), Luzula campestris +.1 (s36), Luzula pilosa 1.1 (s38), Lysimachia vulgaris +.1 (s39), Melica nutans 1.1 (s39), Mercurialis perennis +.1 (136), Myosotis arvensis +.1 (s37), Myosotis versicolor +.1 (s37), Ononis spinosa 1.1 (s36), Peucedanum palustre +.1 (s38a), Phyteuma spicatum +.1 (s38), Plantago argentea +.1 (s38), Plantago major +.1 (s39), Poa pratensis 1.1 (s37), Polystichum lobatum +.1 (s37), Potentilla australis +.2 (s38), Potentilla heptaphylla +.1 (s39), Primula acaulis +.1 (s39), Primula vulgaris +.1 (sVIII), Pteridium aquilinum +.1 (136), Pulmonaria officinalis +.1 (sVIII), Scabiosa triniaefolia +.1 (136), Selinum carvifolia +.1 (s37), Silene italica +.1 (sVIII), Silene roemeri subsp. sendtneri +.1 (s38a), Solidago virga-aurea +.1 (sVIII), Stelaria graminea +.1 (s38), Telekia speciosa +.1 (136), Thalictrum minus +.1 (s38a), Thymus longicaulis +.1 (136), Thymus serpyllum +.2 (s39), Torilis arvensis +.1 (s38), Trifolium hybridum 1.1 (s39), Trifolium medium 1.1 (sVIII), Trifolium pratense 1.1 (s38), Trifolium rubens 1.1 (s37), Verbascum lanatum +.1 (s39), Veronica chamaedrys +.1 (s38a), Veronica paecox +.1 (s37), Veronica teucrium +.1 (s38), Vicia cassubica +.1 (136) i Vicia cracca 1.1 (s39). Chamaespartium sagyttale +.2 (136).

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BIRCH FORESTS IN PEŠTER PLATEAU

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Abstract: Roughly 10 million acres of forest disappears each year pointing to the gravity of the problem and calling for urgent tackling measures for stopping degradation and devastation of the existing forest ecosystems. According to the concept of ecocentric (biocentric) resource use the ecosystem represents the complexity of living organisms and has value in itself because it views differently the needs of people and their relationship toward Nature. The work is based on the Sustainable Development Concept and its focus on smaller territorial wholes (areas). The research was conducted in birch forest on Pešter Plateau (Southwestern Serbia). Bearing in mind the fact that destruction of plant resources over the centuries has brought them into jeopardy; thus having the direct consequence on the socio – demographic status of the people inhabiting the Pešter Plateau area. The aim of these researches is to define the condition of the natural resources, give priority to the activities for stopping the negative influences and set measures for improving the state of things.[1]

Key words: birch forest, G191B, sustainable use, natural resources

ŠUME BREZE NA PEŠTERSKOJ VISORAVNI

Apstrakt: Nestajanja šuma od oko 10 miliona hektara godišnje ukazuje na ozbiljnost problema i zahteva hitno preduzimanje mera na zaustavljanju degradacije i devastacije postojećih šumskih ekosistema. U konceptu ekocentičnog (ili biocentrično) korišćenja resursa ekosistem predstavlja kompleksnost živih organizama i ima svoju vrednost sam po sebi zato što razmatra na drugi način potrebe ljudi i njihov odnos prema prirodi. Rad bazira na Konceptu održivog razvoja i usredsređena je na manje teritorijalne celine (područja). Istraživanje je obavljeno u šumi breze Pešterskoj visoravni (jugozapadna Srbija). S obzirom da je vekovnim uništavanjem biljnih resursa na području Pešterske visoravni njihovo stanje ugroženo i to se direktno odnosi i na sociodemografski status stanovni-

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štva. Cilj ovih istraživanja je da se definiše stanje prirodnih resursa, odrede prioriteti aktivnosti za zaustavljanje nepovoljnih uticaja i zatim odrede mere za unapređenje stanja.

Ključne reči: šume breza, G191B, održivo korišćenje, prirodna bogatstva

1 INTRODUCTION

Roughly 10 million acres of forest disappears each year pointing to the gravity of the problem and calling for urgent tackling measures for stopping degradation and devastation of the existing forest ecosystems. According to the concept of ecocentric (biocentric) resource use the ecosystem represents the complexity of living organisms and has value in itself because it views differently the needs of people and their relationship toward Nature. The way Nature creates and maintains ecosystems is respected. The ecocentric concept protects, maintains and regenerates the functioning of natural ecosystems, while at the same time using all resources and services to provide for the needs of people on permanent and stable bases. The advantage is given to ecological processes in ecosystems, in order to provide for society's economic needs, but not in the way of industrial use. The integral part is the care for soil, water, biodiversity and biomass. The realization of these aims is based on ecologic, socio-demographic and economic criteria. The work is based on the Sustainable Development Concept and its focus on smaller territorial wholes (areas).

2 MATERIAL AND METHOD

The research was conducted in birch forest on Pešter Plateau (Southwestern Serbia). The pedologic characteristics were tested on the basis of pedologic profiles, and type determination was conducted according to the soil classification (Škorić, Filipovski, Ćirić, 1985) as well as on the basis of FAO classification. The habitat classification was performed according to the EUNIS classification. "Flora of Republic of Serbia" (1970-1986), "Ikonographie der flora des südöstlichen Mitteleuropa "("Iconography of flora for southeast Middle-Europe") (Jávorka, Csapody, 1979), "Flora and Vegetation of Golija and Javor" (Gajić, 1990), "Flora of the National park Tara" are used for determination of specie types. The floral element spectrum was analyzed in accordance with Kojic and others (1997). The division on basic types of life forms was conducted according to Raunkiaer (Raunkiaer, 1934). The area under forests and forest stands, the area division based on the stand types, wood volume and volume accretion were analyzed. The representation of trees with diameter under 30cm was analyzed separately.

3 RESEARCH RESULTS

The birch forests in EUNIS classification belong to:

G1 – BROADLEAVED DECIDOUS FORESTS

G1.9 – Birch forest<*Betula*>, common aspen<*Populus tremula*>, European rowan<*Sorbus aucuparia*> or hazel tree<*Corylus avelana*> outside the waterway zones

G1.91 – Birch<*Betula*> forests in not swamped terrain

G1.91B – Balkan birch <*Betula*> forest in not swamped terrain

Equivalent community: *Betuleum verrucosae* Glisic, 1950

The birch (*Betula pendula*) is found on Pester plateau on acidic and very acidic soils (e.g. on Javor mountain under Suvi Rt in pasture terrain of high acidity (pH 3.5 – 4.5). The pure stands were noted in Ursule, in Kamena Glava (1265) and between Tosic and Papic, as well as between hamlets Brezdje and Nesovine. The tallest trees are found on Ursule meadows. It is also found in progressive succession on deserted meadows and pastures on acidic brown soil in the areas of villages Uvac and Lopize, as well as in felled beech forests on higher altitudes and in recently founded cultures. The birch is not capable of withstanding a longer fight with other species in recently founded cultures, especially spruce which places birch in subordinate position. The birch overpowers hazel and creates the upper layer in hazel bushes. The community is especially spread in form of young stands formed over the last twenty years (with the decrease of the cattle fond and abandoning of nomadic cattle breeding), in former pastures and meadows not mowed now. The community is expanding and densely populating these areas.

The pioneer birch community is found in the altitude range from 1110 to 1300 m, on inclines from 7° to 30°. The geologic foundation is sandstone. The soils belong to district cambisols; and according to the mechanic structure soils are mostly clays and sandy clays, from 65 to 90 cm depth.

The floristic structure of birch forests – 105 plants are found in birch forests, nine tree species, seven bush species and 89 species of low-level flora (table 1).

Table 1- Birch forest floristic structure

Acer pseudoplatanus L.
Ajuga reptans L.
Alchemila vulgaris L.
Allium pulchellum Don.
Anemone nemorosa L.
Angelica palustris (Bess.) Hoff.
Antennaria dioica (L.) Gaertn.
Aremonia agrimonoides (L.) DC
Asarum europaeum L.
Astrantia major L.
Betula pendula Roth.
Brachypodium silvaticum (Huds.) P.B.
Briza media L.
Bupleurum praealtum L.
Campanula patula L.
Campanula trachelium L.
Carex limosa L.
Carex pilosa Scop.
Carex pseudocyperus L.
Centaruea jacea L.
Centaurea montana L.
Cerastium brachypetalum Desp.
Chamaecytisus ciliatus (Wahlenb.) Rothm.
Chamaecytisus hirsutus (L.) Link
Chamaespartium sagittale (L.) P.Gibbs.
Cirsium acaule (L.) Scop.
Cirsium candelabrum Gris.
Juniperus communis L.
Knautia arvensis (L.) Coult.
Knautia dinarica (Murb.) Borb.
Knautia drymeia Hauff.
Koeleria gracilis Pers.
Lathyrus niger (L.) Bernh.
Leontodon crispus Vill.
Leontodon vulgaris Kitt.
Lilium martagon L.
Luzula campestris (L.) Lam.et DC
Luzula luzulina (Vill.) Tore et Sar.
Luzula luzuloides (Lam.) Dan.
Melampyrum pratense L.
Melampyrum silvaticum L.
Melica uniflora Retz.
Molinia coerulea (L.) Mnch.
Myrrhis odorata (L.) Scop.
Nardus stricta L.
Pedicularis comosa L.
Peucedanum officinale L.
Phyteuma spicatum L.
Picea abies Kars.
Pirus piraster Burg.
Poa trivialis L.
Polygala major Jacq.
Populus tremula L.
Potentila erecta (L.) Raucsh.

Corylus avelanna L.
Crataegus monogyna Jacq.
Danthonia provincialis Lam.et DC
Deschampsia flexuosa (L.) Tr.
Dorycnium herbaceum Vill.
Echium vulgare L.
Euphorbia amygdaloides L.
Evonymus europaeus L.
Fagus silvatica L.
Festuca amethystina L.
Festuca valesiaca Schl.
Filipendula hexapetala L.
Fragaria vesca L.
Frangula alnus Mill.
Galium boreale L.
Galium cruciata (L.) Scop.
Galium mollugo L.
Galium verum L.
Genista ovata W.etK.
Geranium sanguineum L.
Hieracium bauhini Schult.
Hieracium cymosum L.
Hieracium pilosella L.
Hieracium sparsum Friv.
Hypericum elegans Steph.
Hypericum perforatum L.
Potentilla chrysantha Tievir.
Potentilla heptaphylla Jusl.
Potentilla recta L.
Potentilla taurica Willd.
Primula veris Huds.
Prunela vulgaris L.
Prunus spinosa L.
Pteridium aquilinum (L.) Kuhn.
Ranunculus polyanthemus L.
Ranunculus repens L.
Rhamnus falax Boiss.
Rosa arvensis Huds.
Sanguisorba minor Scop.
Silene vulgaris (Mnch.) Gar.
Solidago virga-aurea L.
Stachys officinalis (L.) Trev.
Stellaria graminea L.
Stellaria holostea L.
Teucrium chamaedrys L.
Tragopogon dubius Scop.
Trifolium alpestre L.
Trifolium repens L.
Vaccinium myrtillis L.
Veratrum album L.
Veronica officinalis L.

Typical species are: *Betula pendula, Chamaespartium sagittale, Crataegus monogyna, Euphorbia amygdaloides, Genista ovata, Hypericum perforatum, Juniperus communis, Poa trivialis, Prunella vulgaris, Pteridium aquilinum, Trifolium arvense, Veronica officinalis, Fragaria vesca*.

The high presence of hemicryptophytes (58. 25%) pointing to colder climate conditions is noted in the **life-form spectrum** (table 2). The participation of geophytes (11. 65%) points to favorable soil conditions (humidity, structure and soil depth). The participation of phanerophytes and nanophanerophytes is 15. 54%. Chamaephytes participate with 7. 76% (wood and herbaceous 3. 88% each), therophytes 3. 88% and therophyte/chamaephyte participate with 2. 91%.

Table 2- Plant life-form spectrum in birch forests

Life-forms (%)							
p	np	wc	**hc**	**h**	**g**	**t**	**th**
8.74	6.80	3.88	3.88	58.25	11.65	3.88	2.91
15.54		7.76					

Legend: *p - Phanerophytes; np - Nanophanerophytes; wc - Woody chamaephytes; hc - Herbaceous chamaephytes; h - Hemicryptophytes; g - Geophytes; t - Terrophytes; th - Terophytes/Chamaephytes*

The largest community group is formed by middle – European floral elements (26. 92%); the individual area types of the said group are sub middle – European (15. 38%)

and middle – European floral elements (9.62%) (table 3). There is also high participation of euro-Asian floral elements (25.00%), with the highest participation of euro- Asian and sub euro – Asian elements as individual area types. There are only 8. 65% of sub–Mediterranean floral elements, and more specifically sub- Mediterranean and east Mediterranean participate with 2. 88%. The low participation of Balkans floral elements (1.92%), as well as Mediterranean and sub- Mediterranean elements, points to the low influence of sub- Mediterranean area over this community. Pontic – central Asian elements make up 15.38%. Circum – polar and cosmopolite elements participate with 11. 58% and floral elements of northern regions with 6.73%, giving a grand total of 18.31% pointing to colder habitats. Sub- Atlantic floral elements comprise 4.81%.

Table 3- Spectrum of floral elements in birch forests

Name of floral elemet group	Floral element	Participation %	
1. FLORAL ELEMENTS – NORTHERN REGION			
African floral elements			
Boreal floral elements	Subboreal –European-Westsiberian	0.96	
	Subboreal –Circum-polar	2.88	
	Boreal-Euroasian	2.88	6.73
2. MIDDLE-EUROPEAN FLORAL ELEMENTS			
Middle-European	Middleeuropean	9.62	
And European	Submiddleeuropean	15.38	
	Submiddle rusian	0.96	
	Alpe-Carpatian	0.96	26.92
3. SUBATLANTIC FLORAL ELEMENTS			
Sub-atlantic and atlantic	Sub-atlantic –sub-mediterraneian	4.81	4.81
4. SUBMEDITERANIEN FLORAL ELEMENTS			
Sub-mediterraneian	Sub-mediterraneian	2.88	
East- Sub-mediterraneian	East- Sub-mediterraneian	2.88	
Balkcan and	Subiliric	0.96	
Balkan-apeninian	Balkanic	1.92	8.65
5. PONTIC and CENTRAL-ASIAN FLORAL ELEMENTS			
	Pontic- Central-Asian	0.96	
	Sub-pontic-Central-Asian	3.85	
Pontic	Pontic	0.96	
	Sub-pontic	4.81	
	Pontic- Sub-mediterraneian	2.88	
	Sub-pontic-East- Sub-mediterraneian	0.96	
Pannonian	Sub-pannonian	0.96	15.38
6. FLORAL ELEMENTS of DESERT REGION			
	Sub_taurinsc	0.96	0.96
7. EURO-ASIAN FLORAL ELEMENTS			
	Sub-South-Siberian	3.85	
	Euro-Asian	11.54	
	Sub-Euro-Asian	9.62	25.00
8. CIRCUM-POLAR and COSMOPOLITE FLORAL ELEMENTS			
	Circum-polar	8.65	
	Sub-circum-polar	0.96	
	Cosmopolite	1.92	11.54

The birch community is mono-dominant; birch dominates in all trees and bush layers. The tree top coverage degree in the first layer ranges from 0.4 – 0.8. The tree height depends on the stand age and goes from 3.5 – 25 m. The first layer tree diameter is 20 cm depending on the stand age (from 4 cm on Lopiz slopes in young stands, to 30 cm in adult stands in Lemica gaj). The bush layer is built from a large number of species, and regarding the degree of presence besides birch there are: hazel bush (*Corylus avellana*), common juniper (*Juniperus communis*), *Populus tremula*, *Crataegus monogyna*, *Frangula alnus*, *Prunus avium, Rosa canina*, *Acer pseudoplatanus*, *Evonymus europaeus*, *Prunus spinosa*, *Rhamnus fallax,* etc. The low-level flora layer is very lush and the soil coverage ranges from 0.3 to 0.7. The highest coverage degree is found in stable, old stands where the airy birch tree tops enable the plant growth in low-level flora layer. The lowest coverage (0.4) is in densely connected stands on northern slopes where the light is reduced.

Ecological birch forest indexes

The ecological humidity index average value is 2.73 (depending on the recording value ranging from 2.57 to 2.93). Sub- mesophyll plants, which are best suited by mesophyll habitats, could be found here, as well as in xerophyll conditions.

The average value of ecological soil chemical reaction is 3.06 (from 2.87 to 3.35) pointing to neutrophillic plants found on neutral low-acidic soil.

The ecological nutrient indexes (the amount of nitrogen in the soil) are 2.41 (from 2.31 to 2.64) specifying that plants somewhere between oligotrophic and mesotrophic are found there.

The ecological light indexes are 3.31 (3.02 to 3.36) meaning that semi-sciophytes are found in birch forests.

The ecological temperature indexes are 3.07 (ranging from 2.97 to 3.22) pointing to the presence of mesothermal species found in mountain conditions.

Medicinal herbs in birch forests - The existence of 105 plant species has been recorded in birch forests. The 40 of the said number are medicinal herbs i.e. 38.1%.

Seven species belong to the first category i.e. 6.7%: *Betula pendula*, *Crataegus monogyna*, *Hypericum perforatum*, *Juniperus communis*, *Primula veris*, *Vaccinium myrtillis* and *Veratrum album*. *Veratrum album* is found in the Red Book and according to the UNCN category this taxon is extremely endangered and vulnerable so its collecting is prohibited. Other species from this group are under collecting and selling control.

The second category contains three species *Sanguisorba minor, Solidago virga-aurea* and *Veronica officinalis*. All species noted are on the market. Species *Solidago virga-aurea* is under collecting and selling control.

The third category numbers eight species i.e. 7.6% (*Ajuga reptans*, *Antennaria dioica*, *Asarum europaeum*, *Evonymus europaeus*, *Fagus silvatica*, *Populus tremula*, *Potentilla erecta* and *Prunus spinosa*). Species *Ajuga reptans*, *Antennaria dioica* and *Populus tremula* are not on the market and only have significance in traditional folk medicine. Species *Evonymus europaeus*, *Fagus silvatica*, *Prunus spinosa* are not on the market. Species *Potentila erecta* and *Asarum europaeum* from this group are characterized by unequal and irregular collecting, and because of that they are placed under the collecting control.

The forth category includes 10 plant species i.e. 9.5% (*Acer pseudoplatanus*, *Campanula trachelium*, *Corylus avellanna*, *Euphorbia amygdaloides*, *Filipendula*

hexapetala, *Fragaria vesca*, *Galium verum*, *Ranunculus repens*, *Stachys officinalis* and *Teucrium chamaedrys*). Species *Acer pseudoplatanus*, *Filipendula hexapetala* and *Ranunculus repens* are under no legal boundaries concerning the amounts collected in natural habitats. Species *Corylus avelanna*, *Fragaria vesca*, *Galium verum* and *Teucrium chamaedrys* are under controlled collecting and selling. Species *Campanula trachelium*, *Euphorbia amygdaloides* and *Stachys officinalis* are significant in traditional folk medicine.

The fifth category has 12 species i.e.11.4% (*Alchemila vulgaris*, *Anemone nemorosa*, *Centaruea jacea*, *Frangula alnus*, *Galium boreale*, *Hieracium pilosella*, *Lilium martagon*, *Picea abies*, *Potentilla recta*, *Prunela vulgaris*, *Pteridium aquilinum* and *Trifolium repens*). Species *Picea abies* and *Potentilla recta* are on the market without restrictions, *Alhemila vulgaris* is under controlled collecting and selling, while the rest of the species have little economic significance.

Fruit trees in birch forests - Taking into consideration the pioneer character of birch forest the community is poor in forest fruit trees, especially woody forest fruit trees. The presence of bushy species *Crataegus monogyna, Juniperus communis, Vaccinium myrtillis, Frangula alnus, Rhamnus falaxi and Rosa arvensis* has been noted, as well as the presence of specie *Fragaria vesca*.

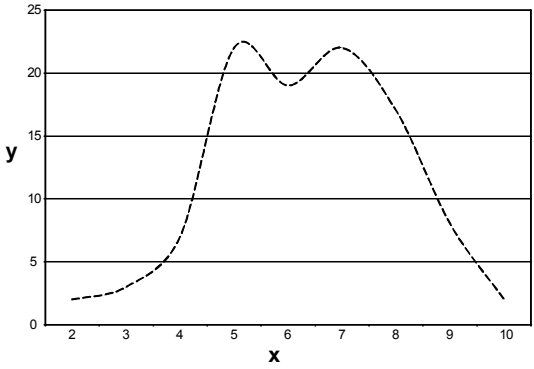
Melliferous plant species in birch forests - Based on the analysis conducted in birch forests are found 38 melliferous plant species, out of which five are woody plants, eight are bushy and 25 herbaceous (table 4, chart 1). The community average honey yield is 2.28. The number of bee plants in bloom is the highest in May, June, and July, thus providing the long term bee nourishment during summer months.

Table 4 - Melliferous plant species and blossoming time in birch forests

Species	Melliferous	Month								
		2.	3.	4.	5.	6.	7.	8.	9.	10.
Trees										
Populus tremula L.	D3	+	+							
Picea abies Kars.	D3			+	+	+				
Betula pendula Roth.	D2			+	+					
Fagus silvatica L.	D2				+					
Acer pseudoplatanus L.	D2			+	+					
Shrubs										
Corylus avelanna L.	Ž4	+								
Crataegus monogyna Jacq.	Ž3				+	+				
Evonymus europaeus L.	Ž3		+	+	+					
Prunus spinosa L.	Ž3		+	+	+					
Teucrium chamaedrys L.	Ž3					+	+	+		
Frangula alnus Mill.	Ž3				+	+	+	+		
Genista ovata W.etK.	Ž3				+	+				
Vaccinium myrtillis L.	Ž2				+	+				
Herbaceous plants										
Campanula trachelium L.	Z4						+	+	+	
Stachys officinalis (L.)Trev.	Z4						+	+		
Anemone nemorosa L.	Z4			+	+					

Species	Melliferous	Month								
		2.	3.	4.	5.	6.	7.	8.	9.	10.
Centaruea jacea L.	Z4					+	+	+	+	+
Centaurea montana L.	Z4							+	+	+
Echium vulgare (L.)	Z4									
Geranium sanguineum L.	Z4				+	+	+			
Trifolium alpestre L.	Z4				+	+	+			
Veratrum album L.	Z3						+	+		
Solidago virga-aurea L.	Z3						+	+	+	
Ajuga reptans L.	Z3				+	+	+			
Filipendula hexapetala L.	Z3				+	+	+			
Galium boreale L.	Z3					+	+	+		
Galium mollugo L.	Z3				+	+	+	+	+	
Potentilla recta L.	Z3				+	+	+			
Prunela vulgaris L.	Z3						+	+		
Astrantia major L.	Z3				+	+	+	+		
Phyteuma spicatum L.	Z3					+	+			
Polygala major Jacq.	Z3						+	+		
Hypericum perforatum L.	Z2						+	+	+	
Primula veris Huds.	Z2			+	+					
Fragaria vesca L.	Z2				+	+				
Lilium martagon L.	Z2						+	+		
Trifolium repens L.	Z2				+	+	+	+	+	
Knautia arvensis (L.) Coult.	Z2				+	+	+	+	+	

Chart 1- The number of melliferous plants in bloom in birch forest over the year (x- months, y- number of plants)



The wood resources of birch forests - The birch forest is found on 169.14 ha (table 5). The tall forest occupies 1.3% of the total number and the others are shoot stands. The devastated shoot stands cover 27.5%. The total wood volume is 15,238 m^3; the tall forest volume is 394 m^3, and the shoot stand volume is 14,844 m^3. The trees with the diameter under 30cm cover 87.7%.

Table 5 - Wood resources of birch forests

Area (ha)	Total volume (m^3)	Volume in thickness degrees										Volume accretion (m^3)
		< 10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	>90	
High birch forest												
2.20	394		123	153		48						11.3
Coppice birch forest												
120.40	14238	1578	5495	5339	1580	245						407
Devastated coppice birch forest												
46.54	606	605										5.7

4 DISCUSSION

Bearing in mind the fact that destruction of plant resources over the centuries has brought them into jeopardy; thus having the direct consequence on the socio – demographic status of the people inhabiting the Pešter Plateau area. The aim of these researches is to define the condition of the natural resources, give priority to the activities for stopping the negative influences and set measures for improving the state of things. Carrying into effect the research aims on the sustainable use of plant resources in Pester plateau sets the foundation for:

- Implementing of European standards, models, creating methodology for registering restorable plant resources;
- creating strategic span for sustainable management of restorable resources according to the sustainable development principles and the current exploration degree of the existing natural resources;
- maintaining and raising ecological, biological, climate, socio – cultural and economic contribution to plant resources use;
- protecting the environment, the social and spiritual function, natural ecosystem values achieved through establishment, expansion and adequate management of protected areas and communities, forest preservation in characteristic ecological systems and regions, wild life preservation and management, genofond preservation, setting up support and security measures for sustainable use of biological resources and biodiversity preservation;
- supporting and improving national afforestation programs and re – cultivation of degraded habitats, setting up new and improving the existing forests for various uses, in order to relieve the pressure on current forest ecosystems;
- founding the planning concept for permanent management of restorable plant resources on the criterion preserving the quality of environment, meaning that the economical use of restorable plant resources must not reduce numerous ecological functions, accompanied by sustaining and enhancing habitat biodiversity;
- creating conditions for ascertaining sustainable agricultural production;
- Preserving and improving biodiversity.

The data assembled enabled the multilayer comparative analysis of the area by GIS technology, as well as the establishment of the natural ecosystems endangerment degree and spatial suitability for certain activities. It enables forecasting direst and indirect consequences of aimless use of the area, permitting prevention

of higher level mistakes before reaching the final decision. The array of subprogram activities interacting can be formulated as a few general program tasks: environment protection, optimum natural resource use, strengthening of the secondary activities, market analyses and analyses of commercialization offers on this area, strictly in the function of preserving natural resources and environment protection (by applying the principle on sustainable development of restorable plant resources).

5 CONCLUSIONS

The birch forests appear as a stage of progressive succession on former pastures and meadows after ceasing of zoo – anthropogenic influences.

According to EUNIS classification they belong to the broadleaved deciduous forests (**G1.91 – Balkan birch < *Betula*> forests on non-swampy soil**).

The soil types are district cambisols, pseudogley, and luvisols.

A total of 105 plant species is recorded, nine of which are tree species, seven bush species and 89 species of low-level flora.

Ecological indexes have the following average values for: humidity 2.73, soil chemical reaction 3.06, nutrients 2.41, light 3.31 and temperature 3.07.

Out of the total number of registered plants 40 are medicinal herbs i.e. 38.1% and seven belong to the first, three to the second, eight to the third, ten to the forth and twelve species to the fifth healing property category.

Owing to the pioneer character of the birch forests the community is poor in fruit trees, especially in woody fruit trees. The bushy species *Crataegus monogyna, Juniperus communis, Vaccinium myrtillis, Frangula alnus, Rhamus falax and Rosa arvenis* have been recorded, as well as *Fragaria fresca*.

A total of 38 bee plant trees have been recorded in birch forests, five are woody, eight bushy and 25 herbaceous plants. The average honey yield is 2.82. The number of bee plants in bloom is at its highest in May, June and July providing the long term beenourishment during summer months.

The birch forest is recorded on 169.14ha; the tall birch forest occupies 1.3%, while the rest are shoot stands. Devastated shoot stands cover 27.5%. The total volume is 15,238 m^3, 394 m^3 is found in tall forest and 14,844 m^3 in shoot stands. Trees with the diameter under 30cm cover 87.7%.

LITERATURE

Gajić, M. (1984): Floristic elements of The Federal Republic of Serbia. The Serbian Academy of Sciencies and Art, Vegetation of Serbia I. Belgrade. *(Original- Florni elementi SR Srbije. SANU, Vegetacija Srbije I. Beograd)*

Gajić, M. (1989): Flora and vegetation of Golija and Javor ŠPIK Ivanjica, 1-592, Ivanjica, Belgrade. *(Original- Flora i vegetacija Golije i Javora. ŠPIK Ivanjica, Ivanjica, Beograd)*

Horvat, I., Glavač, V., Elemberg, H. (1974): Vegetation Sudosteuropas. Geob. selecta, Band IV, Stuttgart.

Jávorka, S., Csapody, V. (1979): Ikonographie der flora des südöstlichen Mitteleuropa. Akadémiai kiadó, Budapest.

Jovanović, B., Mišić, V., Dinić, A., Diklić, N., Vukićević, E. (1997): Vegetation of Serbia II forest communities 1, The Serbian Academy of Sciencies and Arts, Belgrade. *(Original- Vegetacija Srbije II šumske zajednice 1, Srpska akademija nauke i umetnosti, Beograd)*

Kojić, M., Popović. R., Karadžić, D. (1994): Phyto indicators and their significance in evaluating habitat ecologic conditions. IP Nauka, the Institute for Research in Agriculture "Serbia", pp. 45-129, Belgrade. *(Original- Fitoindikatori i njihov značaj u proceni ekoloških uslova staništa. IP Nauka, Institut za istraživanje u poljoprivredi "Srbija", Beograd)*

Lakušić, D. (2001): Diversity of ecosystems of Yugoslavia, The Accociation of Ecologists of Serbia, Belgrade. *(Original- Diverzitet ekosistema Jugoslavije, Društvo ekologa Srbije, Beograd)*

Mišić, V. (1961): Origin, succession and degradation of forest vegetation of Serbia (I). The Institute of Biology of People's Republic of Serbia, Collection of Papers, book 5. Belgrade. *(Original- Poreklo, sukcesija i degradacija šumske vegetacije Srbije (I). Biološki institut N.R. Srbije, Zbornik radova, knj. 5. Beograd)*

Mišić, V. (1964): Origin, succession and degradation of forest vegetation of Serbia (I). The Institute of Biology of People's Republic of Serbia, Collection of Papers, book 7. Belgrade. *(Original- Poreklo, sukcesija i degradacija šumske vegetacije Srbije (II). Biološki institut N.R. Srbije, Zbornik radova, knj. 7, Beograd)*

Mišić, V. (1983): Forest vegetation of Jadovnik, Zlatar and Mileshevka valley. The Arhives of Biological Sciencies, Belgrade. *(Original- Šumska vegetacija Jadovnika, Zlatara i doline Mileševke. Arhiv bioloških nauka, Beograd)*

Obratov, D. (1992): Flora and vegetation of Zlatar mountain. Doctoral thesis, The Faculty of Biology, The Faculty of Sciences and Mathemathics, Belgrade. *(Original- Flora i vegetacija planine Zlatar. Doktorska disertacija, Biološki fakultet PMF, Beograd)*

Rakonjac, LJ. (2002): Forest vegetation and its sites in Peshter plateau as the base for successful reforestation, Doctoral thesis, The Faculty of Forestry, Belgrade. *(Original- Šumska vegetacija i njena staništa na Pešteskoj visoravni kao osnova za uspešno pošumljavanje, Doktorska disertacija, Šumarski fakultet, Beograd)*

Ratknić, M. (2006): Sustainable use of the renewable plant resources of Peshter plateau, Doctoral thesis, The Faculty of Sciences and Mathematics, Kragujevac. *(Original- Održivo korišćenje obnovljivih biljnih resursa Pešterske visoravni, Doktorska disertacija, PMF, Kragujevac)*

Škorić, A., Filipovski, G., Ćirić, M. (1985): Classification of soils of Yugoslavia. Sarajevo 1985. *(Original- Klasifikacija zemljišta Jugoslavije. Sarajevo 1985)*

Stevanović, V. (2001): On biodiversity, Biodiversity and new Millennium, The Association of Ecologists of Serbia, Belgrade. *(Original- O biodiverzitetu, Biodiverzitet i novi milenijum, Društvo ekologa Srbije, Beograd)*

Stevanović, V. (2001): Diversity of flora of Yugoslavia, The Association of Ecologists of Serbia, Belgrade. *(Original- Diverzitet flore Jugoslavije, Društvo ekologa Srbije, Beograd)*

Stevanović, V. et all (1999): Red book of flora of Serbia, The Ministry of Environment of Republic of Serbia, Belgrade. *(Original- Crvena knjiga flore Srbije, Ministarstvo za životnu sredinu Republike Srbije, Beograd)*

Stevanović, V., Vasić, V. et all (1995): Biodiversity of Yugoslavia with the review of the species of the international significance, The Faculty of Biology of the University in Belgrade, Belgrade. *(Original- Biodiverzitet Jugoslavije sa pregledom vrsta od međunarodnog značaja, Biološki fakultet Univerziteta u Beogradu, Beograd)*

BIRCH FORESTS IN PEŠTER PLATEAU

Mihailo Ratknić, Ljubinko Rakonjac, Milorad Veselinović, Biljana Nikolić

Summary

The birch forests appear as a stage of progressive succession on former pastures and meadows after ceasing of zoo – anthropogenic influences. According to EUNIS classification they belong to the broadleaved deciduous forests (G1.91 – Balkan birch < Betula> forests on non-swampy soil). The soil types are district cambisols, pseudogley, and luvisols. A total of 105 plant species is recorded, nine of which are tree species, seven bush species and 89 species of low-level flora. Ecological indexes have the following average values for: humidity 2.73, soil chemical reaction 3.06, nutrients 2.41, light 3.31 and temperature 3.07. Out of the total number of registered plants 40 are medicinal herbs i.e. 38.1% and seven belong to the first, three to the second, eight to the third, ten to the forth and twelve species to the fifth healing property category. Owing to the pioneer character of the birch forests the community is poor in fruit trees, especially in woody fruit trees. The bushy species *Crataegus monogyna*, *Juniperus communis*, *Vaccinium myrtillis*, *Frangula alnus*, *Rhamus falax* and *Rosa arvenis* have been recorded, as well as *Fragaria fresca*. A total of 38 bee plant trees have been recorded in birch forests, five are woody, eight bushy and 25 herbaceous plants. The average honey yield is 2.82. The number of bee plants in bloom is at its highest in May, June and July providing the long term bee-nourishment during summer months. The birch forest is recorded on 169.14ha; the tall birch forest occupies 1.3%, while the rest are shoot stands. Devastated shoot stands cover 27.5%. The total volume is 15,238 m^3, 394 m^3 is found in tall forest and 14,844 m^3 in shoot stands. Trees with the diameter under 30 cm cover 87.7%.

ŠUME BREZE NA PEŠTERSKOJ VISORAVNI

Mihailo Ratknić, Ljubinko Rakonjac, Milorad Veselinović, Biljana Nikolić

Rezime

Šuma breze se javlja kao stadijum progresivne sukcesije, na nekadašnjim pašnjacima i livadama posle prestanka zooantropogenih uticaja. Po EUNIS klasifikaciji pripadaju širokolisnim listopadnim šumama (G1.91B - Balkanske brezove <Betula> šume na nezamočvarenom terenu). Zemljišta su distrični kambisoli, ređe pseudoglejevi i luvisoli. Konstatovano je 105 biljaka, od čega 9 vrsta drveća, 7 vrsta žbunova i 89 vrsta prizemne flore. Ekološki indesi za vlažnost imaju prosečnu vrednost 2.73, za hemijsku reakciju zemljišta 3.06, za hranljive materije 2.41, za svetlost 3.31 i za temperaturu 3.07. Od ukupno registrovanih biljaka 40 je lekovito, odnosno 38.1% i to: 7 pripadaju prvoj, 3 drugoj, 8

trećoj, 10 četvrtoj i 12 vrsta petoj kategoriji lekovitosti. Kako su šume breze pionirskog karaktera zajednica nije bogata šumskim voćkaricama, naročito drvenastim vrstama voćkarica. Konstatovano je prisustvo žbunastih vrsta *Crataegus monogyna*, *Juniperus communis*, *Vaccinium myrtillis*, *Frangula alnus*, *Rhamnus falax* i *Rosa arvensis*, kao i prisustvo vrste *Fragaria vesca*. u šumama breze konstatovano je 38 medonosnih vrsta, od čega 5 drvenastih, 8 žbunastih i 25 zeljastih. Srednja mednost zajednice iznosi 2.82. Broj medonosnih biljaka u cvetu je najveći tokom maja, juna i jula, što obezbeđuje dugotrajnu pčelinju pašu tokom letnjih meseci. Šuma breze konstatovana je na 169.14 hektara. Na ovoj površini visokih šuma ima svega 1.3%, dok su ostale izdanačke sastojine. Devastirane izdanačke sastojine breze učestvuju sa 27.5%. Ukupna zapremina je 15238 m^3 od čega je, u visokim šumama 394 m^3, a izdanačkim 14844 m^3. Stabla sa tanjim prečnikom od 30 cm učestvuju sa 87.7%.

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Original scientific paper

THE POSSIBILITY OF THE OCCURENCE OF ARID PERIODS OF THE ALTITUDINAL REGION OF SOUTHWEST SERBIA USING THE PEŠTER PLATEAU AS AN EXAMPLE

Ljubinko Rakonjac[1], Mihailo Ratknić[1], Milutin Dražić[2], Milorad Veselinović[1]

Abstract: Whether the unusually frequent turbulence of the climate events with the unpredicted occurrence of arid periods is the result of the global warming of the Planet, or they are the usual cycles of the arid and rainy years which, amongs other things, occur in the Middle European region, the science has not provided the accurate answer yet. Nevertheless, it is a fact that during 1985/86 year there was the partial dry of the forest cultures aged between one and six years on some sites, as the consequence of the long absence of the atmospheric precipitation in the summer period. Provided that the arid period is the period with the days devoid of precipitation, we analysed this phenomenon according to the data obtained by the meteorological station Sjenica.

Key words: climate changes, global warming, dry of the forest cultures

MOGUĆNOST POJAVE SUŠNIH PERIODA VISINSKOG REGIONA JUGOZAPADNE SRBIJE NA PRIMERU PEŠTERSKE VISORAVNI

Izvod: Da li je neuobičajena češća turbulentnost klimatskih manifestacija sa nepredviđenim pojavama sušnih perioda rezultat globalnog otopljavanja Planete ili su to uobičajeni ciklusi sušnih i kišnih godina koji se, između ostalog, javljaju u srednjeevropskom području, nauka još uvek nije dala egzaktan odgovor.

No, činjenica je da je tokom 1985/86. godine došlo do parcijalnog sušenja šumskih kultura starih od 1 do 6 godina na određenim staništima, kao posledica dužeg otsustva atmosferskih padavina u letnjem periodu. Ako prihvatimo da je sušni period vreme sa

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danima bez padavina, analizirali smo tu pojavu na osnovu podataka meteorološke stanice Sjenica.

Ključne reči: klimatske promene, globalno otopljavanje, sušenje kultura

1 INTRODUCTION

The great areas of the eroded skeleton barrens which are the result of the uncontrolled frequent fellings and burning of the forests in the previous historic period are exposed to the destructive erosional processes and torrents with the immesurable ecological and economically harmful effects.

The only way to stop the above destructive process is the re-establishment of the forest ecosystems by reforestation of the eroded skeleton barrens in the hilly-mountainous regions. These reforestations were started in Serbia in the late 19th and in the early 20th centuries, and were intensified after the Second World War.

There was an uneven trend in the average annual scope of the reforestation of barrens, since it varied from 6,562 ha in the period 1945-1954, to 19,560 from 1980 to 1985, i.e. over 20,000 ha annually for the period 1978-1986, during the reforestation by the voluntarily actions of the young forest campaigners of the settlement type.

From 1945 to 1990 the total of 483,880 ha was reforested, i.e. averagely 10,512 ha annually.

It should be emhasized that the "gold period of reforestation" was the period when the regional associations for forestry were established in 1977 according to the Forest Law, and the financial means for the infrastructural investement in the improvement of foresty was obtained by the nonbudget contributions of the all direct and indirect beneficiaries of the forest functions, i.e. all the work organisations and the citizens of Serbia.

By managing nonbudget means without the interference of the state, these associations were able to devise long-term plans for the infrastructural works in forestry, to finance the completion of the performative projects of reforestation, construction of the forest communiciations, non-commercial care and thinning of the forest cultures, safer planning of the production of seedling material by the application of the new technologies in the production of the seedlings with the protected root system, which enable the reforestation in vegetation season as well, by the application of certain methods and technology of reforestation.

The Institute of Forestry, with the financial support of the infrastructurial means intended for foresty, carried out a great number of the performative projects of reforestation by the use of team multidiclipine activities of the researchers of the different profiles, in the aim of the ecological determination of the site conditions necessary for the selection of trees for reforestation, selection of the optimal methods and reforestation technologies adapted to the constitutional skills of the youth – reforestation contractor.

The first performative project with the participation of team work of the researchers of the suitable specialties led by the main project-maker (M. D r a ž i ć), by the application of the new reforestation method "on cells" and planting of the seedlings with the root protected by the peat cork produced in the appropriate containers, was made in 1977 and carried out in the area of 1,000 ha in the Pešter Plateau during the vegetation season in 1978 by the voluntarily action of the young forest campaigners of the settlement type, with the participation of the young forest campaigners brigades from all the republics

of the Former Yugoslavia. The Institute of Forestry also made the performative projects of the same methodology for the barrens of Ibarska Gorge, Vlasina Region, Zlatibor, the barrens of Southeast Serbia and other areas.

Beside project-making activities, the Instite took an active role in the production of the quality seedlings with the protected root. The experts from the Institute were also engaged in the professional training of the brigadiers, operative instruction, and monitoring during the actions of reforestation.

The voluntarily actions of the young forest campaigners of the settlement type with the brigades of the young pupils, students and workers from all the republics of the Former Yugoslavia were organized until 1988. During this time by their activities an area of over 120,000 ha was reforested. Nowadays in these regions instead of the past greyness of the eroded stone barrens of Pešter, Ibarska Gorge, Vlasina Region and other localities, the majestic anthropogenic forests are present. In the area of Southwest Serbia, around 50,000 ha of the forest cultures, which are in the phase of the intensive development andneed care, were established in the previous decades.

Beside the previous successful reforestation in the region of Southwest Serbia, there are still the great areas of the unreforested eroded skeleton barrens, particularly in the domain of the private estates. These areas and the other barrens are part of the long-term strategy which includes the reforestation of over million of hectares of the current eroded barrens in Serbia by the end of this century, in order to increase the area covered by forests in Serbia to around 41%, by which the relatively harmonious ratio of the forest, agricultural and other ecosystems will be established, and the ecological balance in nature will be achieved.

2 THE IMPORTANCE OF RESEARCH

Man by his activities influenced the vast increase of carbon-dioxide in the air and the increase of the other gases which cause the occurrence of the phenomenon of "glass house", the cause of the accelerated global warming of the Planet, as well as the gases which cause the decay of the ozone layer and occurrence of the so-called "ozone holes", which have an adverse effect on man and the other living world. Since the above phenomena, reflected in the climate change, can endander life on the Earth, the international community led by the United Nations by the numerous resolutions, declarations and other international acts made it obligatory for the singatories of these documents to significantly reduce the emission of carbon-dioxide and other gases of "glass house", as well as the gases which destroy the ozone layer.

At the same time, the effort was made to stop the unreasonable destruction of the tropic rain forests in regions which are of the vital ecosystemic importance to the preservation of the balance between oxygen and carbon-dioxide in the atmposhere. Therefore, these forests are deservedly called "The Lungs of the Planet".

Whether the catastrophic floods on one hand and the occurrence of the long-lasting droughts in the vast areas on the other hand, as well as the other meteorologically unusual turbulences, which occurred in the last few decades, are caused by the global increase of warming of the atmosphere, it has not been accurately detemined by the scientists yet, owning to the fact that the scientists from this domain are not united. However, it is a fact that relatively numerous plant species, as well as some zoo species disappear from their former sites. There are still no visible practical signs whether the nature forest

and other ecosystems under the influence of climate change move from their sites to the boreal geographical regions or from the low orographic area to the high altitudes.

The scientific researches should timely point out whether it is possible by the measures taken by the international community to permanently establish the balance between the oxygen and carbon-dioxide in the atmosphere and thereby stop the accelerated warming of the Planet and reduce it to the scope of the geological-historical trend of the mild moving under the influence of nature forces.

In the light of the possible macro-climate events, influenced by the further increase of the global warming of the Earth, amongst other things, the forestry science also faces up with the problem whether in the long-term projections and reforestation strategies, which will last at least by the end of this century, until the achievement of the projected percentage of the area covered by forests from 41 to 42 %, it should rely on the current climate-edaph site conditions during the long-term projection of the selection of the forest tree species, or the introduction of the species which now thrive in the arid parts of the continents should be investigated and taken into consideration? The vast macroecological problems would influence the survival of the living world on our Planet if the drastical ecological changes occurred faster then the living world would be able by a long process to genetically and in other ways adapt and preserve the survival under the newly-formed global ecological conditions.

3 THE AIM OF RESEACH

The aim of reseach is to analyse the atmospheric precitation, the number of the days devoid of rain and other meteorological parameters which can influence the dryness of the plants in the forest cultures established by the reforestation in the vegetation season from 1978 to 1986, according to the data obtained by the meterological station in Sjenica, which is situated at 1,030 meters above the sea level.

4 WORK METHOD

Since no uniform, general method for the definition of drought has been accepted so far, we decided to analyse the application of two methods of research.

By the first method, it is considered that the arid period occurred if at least 20 days in a row were devoid of atmospheric precipitation, observing by the season (spring, summer, autum and winter), with the rule that if the arid period from one season extended to another, it is attributed to the season with more arid days, and if the number of the arid days was identical in two neighbouring seasons, it is attributed to the previous season. The arid periods are divided by classes (days of duration) in 6 classes - timestamps, i.e.the periods of the average duration between 20 and 30 days, 31-40, 41-50, 51-60, 61-70 and over 70 days in a season, with the condition that the total sum of the daily precipitation in a class is up to 0.5 mm, i.e. the total in the class of ten days is up to 5mm.

By this method, the number of the possible frequences of the arid periods by the classes and seasons according to the multi-annual observation was analysed (Table 1), the mean duration of the arid periods by the seasons for each class (Table 2), as well as the probability of the occurence of the arid period by the seasons expressed in percentages (Table 3).

In the aim of the determination of the type of meso-climate according to the long-term observation the mean ombro-hysto-thermal constellation (hydric balance) by the method of Thornthweit, according to the data of the meteorological station Sjenica, were analysed.

Another research method is based on the analysis of the climate indexes (abstracts of Thorthweit) in the aim of the determination of the dominant climate in the years of reforestation of the Pešter Plateau, according to the excerpts of Thornthweit's analyses of the determination of the water surplus and deficit by the months and years of reforestation from 1978 to 1986, as well as on the survey of the series of at least 10 days without precipitation, i.e. with the precipitation less than 1 mm, by the years 1978-1986 in the vegetation season, and at the end on the survey of the influence of arid year 1985/86 on the dry of the forest cultures in the Pešter Plateau.

5 RESEARCH RESULTS

The frequency of arid periods is defined by seasons (winter, spring, summer, autumn; since these period lasts for 10 days at least, the monthly frequencies would not provide a clear picture as seasonal. The frequency of the arid period by seasons is calculated in the following way: if the arid period extended from one to another season it is attributed to the season in which the period lasted longer. If the number of days was equal in both seasons, the period is attributed to the previous season. Since the arid periods are divided in six groups (classes), the possible arid period frequencies are represented in the following Table:

Table 1 - The frequency of the arid period

Classes	Spring	Summer	Autumn	Winter
20–30 days	28	18	25	25
31–40 days	12	5	10	10
41–50 days	3	1	1	1
51–60 days	1	1	1	2
61–70 days	1	1	1	3
>70 days	–	–	1	1
Total	45	26	39	42

The arid periods which last from 20 to 30 days are the most frequent, which is logical. They occur mostly in spring, autumn and winter, whereas they are rarer in summer. However, periods without precipitation lasting for more than 70 days occur only once in autumn and winter. Although winter droughts do not have any direct influence on the dryness of the cultures, they are of a great indirect significance, since they may cause humidity deficit in soil at the beginning of the spring.

Duration of the arid periods

Beside the frequency, the average duration was determined by the seasons for every above group: 20-30, 31-40, 41-50, 51-60, 61-70, and over 71 days. The mean durations of the arid periods for each group were derived from their frequency in the observed period. The values are shown in the Table 2:

Table 2- The mean duration of the arid periods

Classes	Spring	Summer	Autumn	Winter
20–30 days	24.3	23.3	23.7	24.1
31–40 days	34.8	35.2	35.9	33.2
41–50 days	43.6	41.0	48.0	46.0
51–60 days	52.0	55.0	60.0	55.5
61–70 days	62.0	61.0	69.0	67.3
>70 days	–	–	69.0	73.0

The data show that the mean duration of the arid periods by the classes is approximately at the level of the arithmetic mean of the range of the days in the class.

Probability of the occurrence of the arid periods

In order to represent the drought conditions in a clear way, the probability of the occurrence of the arid period was calculated for the analyzed intervals, as well as the frequencies and durations.

Table 3- The probability of the occurrence of the arid periods (%)

Classes	Spring	Summer	Autumn	Winter
20–30 days	75	48	67	67
31–40 days	32	13	27	27
41–50 days	8	2	2	2
51–60 days	2	2	2	5
61–70 days	2	2	2	8
>70 days	–	–	2	2

It can be seen from the Table that the highest probabilities of the occurrence are found in the intervals from 20-30 days, and from 31-40 days, which is logical, since in these intervals the largest frequencies occur as well. Nevertheless, it can be noted that values considering the number of the arid days are very high as well, particularly in spring, the period which is very important to the growth and development of forest cultures.

The hydrological balance according to Thornthweit

The Table of the hydrological balance shows that if the above mean monthly air temperature and precipitation amounts are present, not a month during the vegetation season has water deficit in active absorption layer, and that there are water reserves in the months when the mean monthly temperature is the highest. In the first six months, as well as in the last three months, the active absorption layer is saturated with water, and the surplus drains freely. The water surplus value is approximately 300 mm. The mean ombro-hygro-hysto thermal constellation of meso-climate of the Pešter Plateau is characterized by the moderate humidity, by the winter period with snow which lasts for five months, and by the possibility of the occurrence of frost in all months of the vegetation season (except July).

The analysis of Tables 1, 2, and 3 by the application of the first method of the possibility of the drought occurrences based on the multi-annual observation, points to the

fact that the frequency of the drought occurrences lasting from 20 to 30 days is possible in most cases, but the occurrence of it is lowest in the summer period when the unfavourable influence is the greatest. The possible mean duration of the arid period is within the limits of the logical arithmetic mean values, and it is logical that the possibility of the occurrence expressed in the percentages is the greatest in the class the duration of 20-30 days, and it is significant that there is the lowest probability during summer season.

The analyses only point to the possibility of occurrence of arid periods, but the applied method does not provide the answer when and under which concrete climate conditions we might expect arid periods with the negative ecologic consequences to vegetation i.e. dryness of the forest cultures.

The hydrological balance according to Thornthweit, based on the analysis of mean values of the multi-annual observation, shows that meso-climate based on the data from meteorological station Sjenica, showed the deficit in the soil humidity in no month.

Only in VII, VIII and IX months it did not show either deficit or surplus of humidity in soil, while in the all other months it showed the surplus of water, with the total surplus of 300 mm during the year, which is the characteristic of the moderate humid climate (Table 4).

The presented data of the hydrological balance according Thornthwet, which are based on the multi-annual mean values, do not provide us with the satisfying results in relation to the possibilities of the determination of the climate, as the ecological factor in certain years.

Therefore, we decided to analyze the climate phenomena by the years and months for a period from 1978 to 1985. The arid period is defined by the continuous rows of at least ten days with precipitation less than 1mm a day during the vegetation season. In order to get the insight into the changeability of the climate of the Pešter Plateau, the hydrological balance according to Thornthweit by the years from 1978 to 1985 was analyzed, which was followed by the analysis of the excerpt from the analysis of the water surplus and shortage by the months and years according to Thornthweit, which indicates the occurrence and duration of arid period influencing the dryness of the forest cultures.

Table 5- The hydrological balance according to Thornthweit

Year	Climate indexes			Definicija klime
	ih	in	Im	
1978	60.4	3.5	56.9	(B2) mild humid
1979	74.5	0.0	74.5	(B3) increased humid
1980	64.0	11.2	57.3	(B2) mild humid
1981	25.7	1.7	24.7	(B1) mild humid
1982	8.1	22.1	-5.1	(C1) sub-humid drier
1983	15.8	6.9	11.5	(C1) sub-humid moister
1984	21.9	12.8	14.2	(C2) sub-humid moister
1985	54.5	26.2	38.8	(B1) mild humid
1986	29.9	10.1	23.8	(B1) mild humid

The analyzed climate indexes show that the climate in the Pešter Plateau is rather changeable from year to year. It ranges from increased humid (B3) to sub-humid drier variant (C1), but in no year it was of the arid-xerotherm character. On the contrary, in

Table 4- Hydrological balance (Thornthweit)

Characteristic	MONTH												Year
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
T	-5.4	-2.5	0.8	6.2	11.2	13.8	15.3	14.6	11.7	7.2	3.3	-2.5	6.1
I	0.0	0.0	0.06	1.39	3.39	4.65	5.44	5.07	3.62	1.74	0.53	0.0	25.89
(PE)	0.0	0.0	1.7	2.20	46.6	62.0	68.0	65.0	50.0	27.5	10.6	0.0	343.3
PE	0.0	0.0	1.73	25.65	58.72	79.36	87.72	78.00	52.00	26.12	8.58	0.0	427.88
P	48	36	41	49	80	81	72	61	62	62	71	55	712
R	100	100	100	100	100	100	84.28	67.28	77.28	100	100	100	1118.84
SE	0.0	0.0	17.3	25.65	58.72	79.36	87.72	78.00	52.00	26.12	8.58	0.0	427.88
M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
V	48	36	39.27	23.35	21.28	1.54	0.0	0.0	0.0	13.6	62.42	55	300.46

the years when the plants dried (1985/86), climate indexes show that a variant of the mild humid climate was diagnosed. By the analysis and calculation of the other parameters of hydrological balance, we approached to determination of the surplus and deficit of water by the months and years, as it is represented in the excerpt of the analysis by Thornthweit in the survey of the Table 6.

From the review of humidity deficit and surplus according to Thornthweit, it can be seen that the deficit of humidity frequently occurs in the summer months in all analyzed years, except in 1979, which is climatically defined as humid increased.

From the Table 6 it is seen that the row of arid years with the humidity deficit during the summer period started in 1982 and with smaller oscillations, lasted to 1986, and the greatest deficit was reported in 1985.

The humidity deficit in 1981 was reported only in August, 10.1 mm. However, during the whole vegetation season the humidity surplus was not determined, but the characteristic of the climate index, as the mild humid climate, is mostly the consequence of humidity surplus of 149.7 mm in the period from January to March, and from November and December i.e. in the non-vegetation season.

The following year (1982) is marked as sub- humid drier (C1) and has soil humid deficit of 128.4mm in VII, VIII, IX and X months, while humidity surplus during vegetation season was not determined.

In 1985, when the dry of the cultures was the most intensive on the soils of II and III categories in south exposures and ridge parts subjected to insolation and wind, the humidity deficit of 153.6 mm was continuously registered from July to October, when the plants needed it most.

The analysis by the application of Thornthweit's hydrological balance is only relatively suitable method for the interpretation of the climate phenomena, as it was devised for relatively deep, structured climatogenic soils, and in this case reforested areas are of significantly more unfavourable pedo-climate, dominantly represented in the areas of II and III category i.e. skeleton eroded shallow soils. Although the pedo-climate is significantly more unfavourable than the analysis of the hydrological balance shows, it points to the causes of the influence of the arid period on the dryness of the plants from the certain sites.

Beside the analysis of the humidity deficit presented in the Table 6 and influence on the dry of forest cultures in certain micro-site conditions, since the reforestations were conducted on skeleton eroded soils of rather unfavourable hydrological capacity, the crucial influence on the dry of the plants is the continuous number of days devoid of precipitation by the months during vegetation. These continuous periods with precipitation less than 1mm within 24 hours are presented in the following review:

Table 7 - Rows of at least 10 days with precipitation less than 1 mm daily

Year	Time intervals with the number of days in a row devoid of precipitation, i.e. with the precipitation less than 1mm	The total number of days without the precipitation
1978	2/06-11/06(10); 29/06-15/07(17); 23/07-4/08(13); 7/10-20/10(14)	54
1979	30/7-8/08(10); 8/10-18/10(11)	21
1980	12/09-24/09(13); 27/09-9/10(14)	27
1981	16/09-30/09(13)	13

Table 6- Excerpt from the Thornthweit's analysis of the water surplus and deficit by the years and month

	Years (D =humidity deficit ; S =humidity surplus)																	
Month	1978		1979		1980		1981		1982		1983		1984		1985		1986	
	D	S	**D**	S	**D**	S	**D**	S	**D**	S	**D**	S	**D**	S	**D**	S	**M**	S
I	**0.0**	53.2	**0.0**	94.3	**0.0**	53.0	**0.0**	31.4	**0.0**	0.0	**0.0**	8.6	**0.0**	39.3	**0.0**	65.2	**0.0**	47.9
II	**0.0**	70.3	**0.0**	23.9	**0.0**	29.3	**0.0**	15.3	**0.0**	0.0	**0.0**	68.0	**0.0**	35.4	**0.0**	66.2	**0.0**	118.6
III	**0.0**	53.4	**0.0**	0.0	**0.0**	37.3	**0.0**	14.9	**0.0**	27.7	**0.0**	12.0	**0.0**	34.5	**0.0**	27.9	**0.0**	9.2
IV	**0.0**	7.3	**0.0**	2.7	**0.0**	27.9	**0.0**	0.0	**0.0**	19.7	**0.0**	0.0	**0.0**	13.5	**0.0**	17.6	**0.0**	0.0
V	**0.0**	70.7	**0.0**	2.7	**0.0**	19.6	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0
VI	**0.0**	0.0	**0.0**	41.5	**0.0**	0.0	**0.0**	0.0	**3.1**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0
VII	**1.7**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**70.9**	0.0	**0.0**	0.0	**71.6**	0.0	**77.4**	0.0	**0.0**	0.0
VIII	**17.7**	0.0	**0.0**	8.5	**21.2**	0.0	**10.1**	0.0	**0.0**	0.0	**35.6**	0.0	**0.0**	0.0	**27.3**	0.0	**4.2**	0.0
IX	**0.0**	13.2	**0.0**	0.0	**41.3**	0.0	**0.0**	0.0	**46.7**	0.0	**0.0**	0.0	**0.0**	0.0	**45.5**	0.0	**54.6**	0.0
X	**0.0**	0.0	**0.0**	49.7	**0.0**	4.8	**0.0**	0.0	**7.7**	0.0	**3.7**	0.0	**0.0**	0.0	**3.4**	0.0	**0.0**	0.0
XI	**0.0**	0.6	**0.0**	155.9	**0.0**	92.6	**0.0**	10.9	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	113.3	**0.0**	0.0
XII	**0.0**	63.2	**0.0**	51.3	**0.0**	93.3	**0.0**	77.2	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	28.9	**0.0**	0.0
Annual	**19.4**	331.9	**0.0**	430.5	**62.5**	357.8	**10.1**	149.7	**128.4**	47.4	**39.3**	88.6	**71.6**	122.7	**153.6**	319.1	**58.8**	175.7
Annual sum of precipitation	861.9		1.008.3		841.1		722.2		501.4		618.1		595.5		551.1		704.3	
The sum of precipitation in the vegetation season (IV-X)	542.6		591.3		465.2		476.6		377.0		315.2		359.2		262.4		432.4	

From the Table 7, it can be seen that in each analyzed year there were 10 or more days in a row without the rain during the vegetation season, which is qualified as arid period, which is accompanied with relatively high maximum temperatures during VI-IX months in south exposures, relatively low air humidity in the midday hours, and warm wind, which accelerated the evaporation, and had negative ecological influence on the vitality of forest cultures established on skeleton eroded shallow soils of II and III categories.

The most intensive dry of the forest cultures occurred during 1985, when in the period from July to the beginning of October the total of 70 rainless days were registered in three periods in the rows lasting from 18 to 30 days, and in 1986 when the total of 74 rainless days were registered in three periods from July to the beginning of October in the row lasting from 11 to 41 rainless days.

The negative ecological consequences during two successive years, i.e. 1985/86, were reflected in the dry of the of forest cultures established in south exposures and ridge parts exposed to insolation and dry summer winds.

The high temperature on the surface of the ground in the midday hours, which even exceeded 50°C, the warm wind and shallow unstructured skeleton soil, frequently only up to 20 cm deep with compact rock in the "C" horizon, without the possibility of gravity water retention during atmospheric precipitation, and the absence the of ascendant capillary rising, contributed to the drop of the humidity in the rhyzospheric zone below the point of dryness. Therefore, under such circumstances the dryness of the certain percentage of the sown plants in the forest cultures up to five-year old occurred.

Out of the total reforested area of 9,025 ha in the vegetation season, on 3,837 ha (42.5%) the optimum canopy was preserved, as the above arid period did not damage the cultures, since the plant survival rate was over 90%.

On the remaining 5,188.5 ha (57.5%) the 1985/86 drought caused the dry of 12% of 82% planted plants, 54% in average. The project aimed at the supplement established the reduced area of 2,789 ha or 31% of the total reforested area.

It is important to mention that on the all 5,188 ha of forest cultures established from 1980 to 1985, and damaged by the 1986 drought, after the first vegetation upon the planting during colaudation, the established survival rate was over 89%.

This fact serves as the proof of the fact that the applied method and the technology of the reforestation by the voluntarily actions of the young forest campaigners, as well as the planting in the vegetation season are not the causes of the dry of the forest cultures, since the first vegetation after planting is the most critical for the survival of the plants, and in the Pešter Plateau the mean level of the thriving of the planted seedlings after the first vegetation upon the planting was 89.9%.

The above arid years did not only caused damage to forestry, but the enormous damages were also recorded in agriculture, particularly in cattle breeding, the dominant agricultural activity of the region, since the production of the grass was decimated on the pastures, as well as hay production on meadows, which has considerably endangered cattle stock.

6 CONCLUSIONS

The climate characteristics of an area are beside edaph conditions, the most significant environmental factors for successful survival and development of forest cultures upon the reforestation of the eroded skeleton area of hill-mountainous region in Serbia.

In the period 1978-1988, in the area of Southwest Serbia, 120,000 ha were reforested, and only in the Pešter Plateau over 9, 000 ha were reforested in the vegetation season in the period 1978-1986 by planting the seedlings produced in containers with the protected root.

The arid period which occurred in 1985/86 influenced the partial dry of the plants in forest cultures on shallow skeleton barrens of south exposures, subject to insolation and the warm winds.

In the area of the Pešter Plateau, as the representative of altitudinal region of Southwest Serbia, by the use of the data from the meteorological station located in Sjenica, the researches of the possibilities of the occurrences of the arid periods and the influence of them on the dryness of the plants in the forest cultures were conducted.

The analysis based on the multi-annual processes of the climate phenomena, point to the real possible occurrence of arid periods, but not to the determination of arid period in time and space.

Thus, it necessary to analyze the climate parameters by the years and months, since it enables the accurate determination of the frequency and periodicity of the occurrence of the arid period in a row by the years, as well as the value of the certain climate parameters, during which it is most important to determine the intensity of the precipitation in the vegetation season less than 1 mm, as well as to analyze the water surplus and deficit in the soil by the years and months of the analysis according to Thornthweit.

Forest cultures established in the south-exposed areas of steep inclinations and ridges with the eroded skeleton shallow poorly-structured soils with the "C" horizon of the compact rock, owning to the inability to retain gravity water and due to the absence of capillary rising, when there is the increased evaporation on exposed micro-localities, the humidity in the rhysosphere zone drops below the point of dryness, causing the dry of the sowing plants.

Since the long-term strategy envisages reforestation of over a million of hectares of eroded skeleton barrens of hilly-mountainous region by the end of the century, it is necessary to find by the researches the technical-technological solutions to deepening of the pedologic profile, by the penetration to the rocky "C" horizon, which would enable the penetration of root system to deeper skeleton layers with incrusted smaller particles of soil.

The success of the reforestation in the vegetation season by planting the seedlings with roots protected by moist peat corks produced in containers, performed in the most unfavourable stone-skeleton and eroded areas on lime and serpentine mountain massifs of the barrens in Southwestern Serbia and other regions, ensures the successful reforestation of vast areas of barrens in Serbia.

LITERATURE

Gajić, M. (1987): Floristic Elements of Republic of Serbia. Forest botany with anatomy of trees, Faculty of Forestry, 287-345. Article 378-445, Belgrade. *(Original- Florni elementi SR Srbije. Šumska botanika sa anatomijom drveta, Šumarski fakultet, 287-345. Prilog 378-445, Beograd)*

Dražić, M. (1990): Particularities of projection and selection of technology of reforestation for successful organization of voluntarily work actions of the young forest campaigners. Special edition: Reforestation of barrens and improvement of forest-

ry of Serbia in the period 1972-1989. The Institute of Forestry and The Republican Federal Executive Institute (FEI) of Forestry. *(Original- Specifičnosti projektovanja i izbora tehnologije pošumljavanja za uspešno organizovanje omladinskih radnih akcija. Posebno izdanje: Pošumljavanje goleti i unapređenje šumarstva Srbije u periodu 1972-1989. Institut za šumarstvo i Republički SIZ šumarstva)*

Dražić, M. (1990): Mass reforestation and problem of desiccation of forest cultures. Special edition: Reforestation of barrens and improvement of forestry of Serbia in the period 1972-1989. The Institute of Forestry and The Republican Federal Executive Institute (FEI) of Forestry. *(Original- Masovna pošumljavanja i problem sušenja šumskih kultura. Posebno izdanje: Pošumljavanje goleti i unapređenje šumarstva Srbije u periodu 1972-1989. Institut za šumarstvo i Republički SIZ šumarstva)*

Dražić, M. (1997): The origin of barrens and reforestation in Serbia. Foresty number 6. *(Original- Postanak goleti i pošumljavanja u Srbiji. Šumarstvo br.6)*

Dražić, M. et all. (1981): The problem of reforestation of barrens of sand of Ram-Golubac sand by the seedlings with balled and bare roots. The Collection of Papers of The Institute of Forestry, volume XVI-XVIII, pp. 17-28. *(Original- Problem pošumljavanja peskova Ramsko-Golubačke pešćare sadnicama sa baliranim i golim korenom. Zbornik radova Instituta za šumarstvo, tom XVI-XVIII, str. 17-28)*

Dražić, M. et all. (1988): Performative project of reforestation of barrens and supplement of the cultures by Youth Work Action "Peshter". The Institute of Forestry. Belgrade. *(Original- Izvođački projekat pošumljavanja goleti i popunjavanja kultura ORA „Pešter". Institut za šumarstvo. Beograd)*

Kolić, B. (1978): Forestry ecoclimatology - micro climate of forest sites. University in Belgrade - Scientific book, Belgrade. *(Original- Šumarska ekoklimatologija – mikroklima šumskih staništa. Univerzitet u Beogradu – Naučna knjiga. Beograd)*

Milosavljević, M. (1963): Climatology, Scientific book, 1-258, Belgrade. *(Original- Klimatologija, Naučna knjiga, 1-258, Beograd)*

Ratknić, M., Dražić, M. (1989): Analysis of the climate conditions as the ecological factor which influence the survival of plants in the cultures of Peshter plateau. The Institute of Forestry and Wood Industry. The Collection of Papers, number 32-33. 59-70, Belgrade. *(Original- Analiza klimatskih prilika kao ekološkog faktora od uticaja na preživljavanje biljaka u kulturama Pešterske visoravni. Institut za šumarstvo i drvnu inustriju. Zbornik radova, br. 32-33, 59-70, Beograd)*

Ratknić, M., Šmit, S. (1999): Demarcation of agricultural and forest land and optimal use of the areas in forestry using Peshter plateau as the example. The Institute of Forestry, Special edition, Belgrade. *(Original- Razgraničenje poljoprivrednog i šumskog zemljišta kao i optimalno korišćenje površina u šumarstvu na primeru Pešterske visoravni. Institut za šumarstvo, Posebno izdanje, Beograd)*

Rakonjac, LJ. (1995): Thriving of forest cultures of black pine in Peshter plateau depending on the technological methods of reforestation and site conditions. The Institute of Forestry, Collection of Papers, numbers 36-37, 29-41, Belgrade. *(Original- Prijem šumskih kultura crnog bora na Pešterskoj visoravni u zavisnosti od tehnoloških postupaka pošumljavanja i stanišnih uslova. Institut za šumarstvo, Zbornik radova, br. 36-37, 29-41, Beograd)*

THE POSSIBILITY OF THE OCCURENCE OF ARID PERIODS OF THE ALTITUDINAL REGION OF SOUTHWEST SERBIA USING THE PEŠTER PLATEAU AS AN EXAMPLE

Ljubinko Rakonjac, Mihailo Ratknić, Milutin Dražić, Milorad Veselinović

Summary

From the end of the Second World War to 1990 over 400,000 ha of the eroded skeleton barrens of the hilly-mountainous region in Serbia were reforested.

By the long-term reforestation strategy, by the end of the century the area of around 1.3 million hectares should be reforested, in order to increase the percentage of the area covered by forests in Serbia from the current 27.5 % to around 41% and thereby the approximate ecological ratio in nature would be established and the quality of the environment would be improved.

Man by his activities influenced the vast increase of carbon-dioxide in the air and other the increase of the other gas pollutants, which cause the occurrence of the phenomenon of "glass house", the accelerated global warming of the Planet, which have an adverse effect on the changes of the macro-climate events and the living world.

The science warned the world about the necessity of the reduction of the carbon-dioxide emission in the atmosphere, of limiting of the destruction of the forest ecosystems, particularly "rain forests" in the tropic regions and of the reforestation of the areas in which the forest used to exist and thereby, by the increase of oxygen emission, the balance with carbon-dioxide should be established, in order to decelerate, if not to stop the fatal warming of the Earth and destruction of the living world.

Forestry science has the task to study whether the changes occur in the sites of the current forest ecosystems owning to the possible advance of the arid-xerotherm climate on boreal regions, which would cause the move of the numerous tree species and other plants from the current sites to the boreal areas and high altitudes.

The researches and practice show that in the area of Serbia as well the climate is changeable and that the arid periods occur in cycles, which should be taken into account during the planning of the reforestation of the barrens of the hilly-mountainous region.

Reforestation projection should be preeceded by the researches and analyses of the climate characteristics of the region which is being reforested – edaph environmental conditions, and according to these data the selection of the species for reforestation and optimal selection of the methods and technologies of soil preparation for the planting of the seedlings should be performed.

The degree of success of the reforestation in the vegetation cycle by the plantation of the seedlings with the root protected by the moist peat cork produced in containers, performed in the most unfavourable stone-skeleton and eroded areas in the limestone and serpentine mountain massifs of the barrens of Southwest Serbia and other areas, ensures the successful reforestation of the vast areas of barrens in Serbia.

MOGUĆNOST POJAVE SUŠNIH PERIODA VISINSKOG REGIONA JUGOZAPADNE SRBIJE NA PRIMERU PEŠTERSKE VISORAVNI

Ljubinko Rakonjac, Mihailo Ratknić, Milutin Dražić, Milorad Veselinović

R e z i m e

Od završetka II svetskog rata do 1990. godine, u Srbiji je pošumljeno preko 400.000 hektara erodiranih skeletnih goleti brdsko-planinske regije.

Dugoročnom strategijom pošumljavanja, do kraja ovog veka treba pošumiti još oko 1,3 miliona hektara kako bi se stepen šumovitosti Srbije sa sadašnjih 27,5% povećao na oko 41% i time uspostavila približna ekološka ravnoteža u prirodi i povećao kvalitet životne sredine.

S obzirom da je čovek svojim aktivnostima doprineo enormnom povećanju ugljendioksida i drugih gasovitih polutanata, uzročnika pojave fenomena "staklene baste" i ubrzanog zagrevanja naše Planete sa negativnim uticajem na promene makroklimatskih manifestacija i živi svet.

Nauka je upozorila svet o neophodnosti smanjenja emisije ugljendioksida u atmosferu, ograničenje uništavanja šumskih ekosistema, posebno „kišnih šuma" u tropskim predelima i reforestaciju prostora na kojima su šume postojale i na taj način, povećanjem emisije kiseonika u atmosferu uspostaviti balans sa ugljendioksidom, kako bi se usporilo ako ne i zaustavilo fatalno zagrevanje Zemlje i uništavanje živog sveta.

Šumarska nauka bi imala zadatak da istražuje da li nastupaju promene u staništima sadašnjih šumskih ekosistema zbog eventualnog nadiranja aridno-kserotermne klime na borealnim predelima, što bi dovelo do pomeranja brojnih vrsta drveća i drugih biljaka sa sadašnjih prostora njihovih staništa ka borealnim predelima i većim nadmorskim visinama.

Istraživanja i praksa pokazuju da je i na području Srbije klima promenljiva i da se ciklično pojavljuju sušni periodi o čemu treba voditi računa kod planiranja pošumljavanja goleti brdsko-planinske regije.

Projektovanju pošumljavanja treba da prethode istraživanja i analiza klimatskih karakteristika regije koja se pošumljava – edafskih uslova sredine i na osnovu tih saznanja vršiti izbor vrsta za pošumljavanje i optimalan izbor metoda i tehnologija pripreme zemljišta za sadnju sadnica.

Uspešnost pošumljavanja u vegetacionom periodu sadnjom sadnica sa korenom zaštićenim vlažnim tresetnim čepom proizvedenim u kontejnerima, izvršenih na najnepovoljnijim kamenito-skeletnim i erodiranim površinama na krečnjačkim i serpentinskim planinskim masivima goleti jugozapadne Srbije i drugih predela, obezbeđuje uspešnu reforestaciju ogromnih površina goleti na području Srbije.

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THE CHANGES IN THE INTERNAL STRUCTURE OF *Pseudotsuga menziesii* (Mirb.) Franco NEEDLES UNDER THE INFLUENCE OF AIR-POLLUTION

Milorad Veselinović, Dragana Dražić, Mihailo Ratknić, Ljubinko Rakonjac, Vesna Golubović-Ćurguz, Nevena Čule, Suzana Mitrović[1]

Abstract: The deposits of Kolubara open-pit mining fields are under the direct influence of the largest power plants of this type in our country. This area is under the influence of air pollution due to the lignite mine exploitation, combustion and transport.

The scope of our research has been aimed at the *Pseudotsuga menziesii* (Mirb.) Franco resistance to air-pollution; taking into consideration the fact that the foliage represents the primary zone under the negative effect of air-pollutants on plant species, the tests have been conducted in order to establish how pollution affects the internal structure of Douglas fir needles.

The paper presents the results obtained by stereologic analyses of volume-density of mesophyllic cells, intercellular spaces, central cylinder, resin channels and vascular bundles through the cross-section of Douglas fir needles subjected to the direct influence of air- pollution in the area of Kolubara open-pit mine, as well as those from control localities on Jelova Gora and Juhor Mountain.

Based on the research results, the decrease in volume density of chlorenchyma and the increase of intercellular spaces are reported in Douglas fir needles in polluted area as opposed to those in control locality, and the differences are statistically justifiable.

Key words: air-pollution, biological recultivation by afforestation, needle anatomy

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PROMENE U UNUTRAŠNJOJ STRUKTURI ČETINA *Pseudotsuga menziesii* (Mirb.) Franco POD UTICAJEM AEROZAGAĐENJA

Izvod: Odlagališta površinskih kopova na području PK Kolubarai se nalaze pod neposrednim uticajem najvećih energetskih postrojenja ovog tipa u našoj zemlji. Kao posledica eksploatacije, transporta i sagorevanja lignita ovo područje je pod svakodnevnim uticajem aerozagađenja

U okviru naših istraživanja koja su usmerena na istraživanja otpornosti vrste *Pseudotsuga menziesii* (Mirb.) Franco na aerozagađenja, a obzirom da je za delovanje vazdušnih polutanata lisna površina primarna zona negativnog uticaja na biljne vrste, vršena su i ispitivanja kako zagađenje utiče na unutrašnju strukturu četina.

U radu su prikazani rezultati stereoloških ispitivanja volumenskih gustina mezofila ćelija, intercelularnih prostora, centralnog cilindra, smonih kanala i provodnih snopića na preseku četina sa područja PK Kolubara koji su pod direktnim uticajem aerozagađenja i sa kontrolnih površina na Jelovoj gori i planini Juhor.

Na osnovu rezultata istraživanja utvrđeno je smanjenje volumenske gustine hlorenhima i povećanje intercelularnih prostora kod četina duglazije u zagađenoj sredini u odnosu na kontrolne i te razlike su statistički opravdane.

Ključne reči: aerozagađenje, biološka rekultivacija pošumljavanjem, anatomija četina.

1 INTRODUCTION

Douglas fir susceptibility to anthropogenic factors is the subject of the studies of numerous authors. Hermann and Lavander (1999) in their extensive paper on Douglas fir on authochtonous habitat, report that it is often the subject of very grave damages by various agents, stating only fungi and rodents, but not other anthropogenic factors, particularly air-pollutants. Nevertheless, there are some data that Dassler (1981b), speaking about susceptibility of individual important tree species to air-pollutants, classified Douglas fir as the species susceptible to SO_2. Studying the problems of species which are used in the urban environments and industrial zones Appelton et al. (2000) classified Douglas fir as the species tolerant to O_3, wheras Shreuder and Brewer (2001) came to the conclusion that the influence of the short exposure to a high chlorine concentration had an adverse physiological effect on the growth of *Pinus ponderosa* Dougl. Et Laws. needles and *Pseudotsuga menziensii* (Mirb.) Franco. The same gas increases the susceptibility of these species on other stressors, such as drought, reducing the photosynthetic foliage biomass.

Authors emphasize that *Pseudotsuga menziensii* is more susceptible to defoliation, and conclude that early defoliation in Douglas fir is a good indicator of the adverse effect of this gas after the first year.

Pseudotsuga menziesii (Mirb.) Franco has been used in REIK Kolubara for the first time for the recultivation by reforestation of the mechanically damaged soil (Šmit and Veselinović, 1996). The great adaptibility of this species has conditioned it to be among the conifer trees used for reforestation terrains antropogenically damaged in this way.

In mining-energy complex of Kolubara Basin, alongside with the soil degraded by surface lignite exploitation, energy and industrial facilities, such as thermal power plant in Crljeni, coal dryer, thermal power plants TENT A and TENT B in Obrenovac are lo-

cated, and one more thermal power plant in excavation site "Tamnava" Istočno polje is under construction. All these facts point out that this area is under the influence of air pollution as the consequence of combustion of great quantities of lignite which are used as the energy material for the work of the all aforesaid industrial facilites.

As a part of our investigations which are aimed at the studies of susceptibililty of *Pseudotsuga menziesii* (Mirb.) Franco species to air pollution, and regarding the fact that the foliage is the primary zone of the negative influence of the plant species for the activity of the air pollutants, the studies on the influence of pollution on the inner needle structure were done.

2 MATERIAL AND WORKING METHOD

For the analysis of influence of the air pollutants on the inner structure of needles the cultures established on the deposol of coal basin REIK Kolubara – strongly polluted Zs area with the greater number of pollutants in the air (SO_2, NO_3, CO); in Jelova gora – weakly polluted K1 area with the permitted SO_2 in the air; as well as Douglas fir culture established on the acid brown soil in Juhor – non-polluted K2 area.

For the studies in each experimental area with three dominant trees one-year-old and two-year-old needles in the autumn (October-November) and spring (April) were taken. The needle samples were taken from the middle of the crown from the side of the crown exposed to the source of pollution. The needle samples from the middle of the crown were also taken in the control areas. Only the green needles from the main axis of the branches were taken for the analysis. Upon taking in the field the needles were put into fixative. After fixation and dehydration in the laboratory conditions the tissue was impregnated with the araldite resin of low viscosity, and then the material was molded by putting the needles segments in the moulds in which the pure resin was previosly poured.

The material for histological studies was cut by LKB III ultramicrotom. For the experiments under the light microcope the sections 1 m thick, which were applied on the aforesaid tiles and dyed toluidin blue were used. The semi-thick sections were analysed in the laboratory of the Institute of Forestry in Belgrade under the microscope Laica Galen III by lens magnification 40×. The sections were recorded by mycroscopic CCCD camera (Topica TP-5001) in the appropriate formats (tif, bmp, cew, dwg), in the aim of the computer procession in Corel Draw, Photoshop CS (preparation) and AutoCad (measurements) environment.

The obtained and processed photos of sections were analysed by stereological methods. These methods enabled the quantitive appraisal of the dynamics of the alternation in the inner Douglas fir needles occured under the influence of the air pollution, long-term exposure to the effect or seasonal variations. By stereological study the following parameters were determined: volume density of the total needle mesophyll, healthy and injured mesophyll cells, intercellular space of the central cylinder, resin channels, and vascular bundles. Volume density of the studied needle parameter was determined by 30 photos obtained from the section of the one-year-old and two-year-old needles from the polluted and non-polluted zone by lens magnification 40 ×. The results of the measurements are synthesized in the appropriate formats of Excel software environment, and their statistics procession was done in the software package Statgraf. The average levels and average errors were determined, and the statistical significance of variant difference was determined by variance analysis (ANOVA – Duncan method).

3 RESULTS AND DISCUSSION

Volume density is the ratio between the area of the studied tissue and total area of the cross-section, i.e. percentage of this tissue in the total area of the cross-section of the needles. The volume density of chlorenchyma, intercellular space, vacular bundles, resin channels and epidermis was studied.

The volume density of chlorenchyma (Table 1) in autumn one-year-old needles is balanced between the experimental fields in polluted (Zs) and non-polluted areas (control K1 and K2 areas) and ranges between 58 and 59 percentages. The differences are minimal and insignificant per variances. In two-year-old needles the volume density of chlorenchyma is significantly less in the polluted area (Zs) – 55%, whereas in the control experimental areas (K1and K2) it is 61–63%, and the difference is statistically significant. In needles which lasted through the winter (the samples were taken in the spring), volume density of chlorenchyma of one-year-old needles is the smallest in the less polluted area (K1) – 50 %, wheras in the polluted area (Zs) it is 55%, but this difference is not significant. The differences between the one-year-old needles from the non-polluted area (K2), the volume density of which is 60%, is significant in the comparison with the needles from the less polluted area (K1). In two-year-old needles the difference in the volume density of chlorenchyma between the needles from the non-polluted area (K2) is also significant in the comparison with the needles from the polluted (Zs) and less polluted areas (K1).

By analysing the data one can see that in the winter time air pollution influenced the reduction of the volume density of chlorenchyma in the one-year-old and two-year-old needles from the polluted (Zs) and less polluted area (K1). It points to the fact that assimilative organs of the cultures in the polluted area (Zs) have sustained the same changes under the environmental influence, as well as the assimilative organs of the older cultures from the less polluted area (K1).

Table 1 - Volume density of chlorenchyma in one-year-old and two-year-old needles in the polluted area (Zs) and control areas (K1 and K2).

Experimental field	Needle age	Autumn	Spring
		Average value ± standard error	Average value ± standard error
Zs	one-year-old	0,5818 ± 0,0096[a]	0,5512 ± 0,0121[ab]
K 1	one-year-old	0,5921 ± 0,0025[a]	0,5073 ± 0,0471[a]
K 2	one-year-old	0,5850 ± 0,0031[a]	0,6077 ± 0,0071[b]
Zs	two-year-old	0,5532 ± 0,0277[a]	0,5258 ± 0,0203[a]
K1	two-year-old	0,6172 ± 0,0030[b]	0,5583 ± 0,0024[a]
K2	two-year-old	0,6333 ± 0,0079[b]	0,5948 ± 0,0061[b]

Multiple test of interval - values marked with the same letter in the column, do not show the difference at the level of importance $p<0,05$

Volume density of intercellular (Table 2) of the one-year-old needles collected in the autumn is the greatest in the polluted area (Zs) - 20 %, whereas in the non-polluted area (K2) it is 18%. In one-year-old needles which last through the winter (samples taken in the spring) volume density in the polluted area (Zs) is 24%, whereas in the less polluted area (K1) and in the non-polluted area (K2) it is significantly lower and the difference in the comparison with the polluted area (Zs) is significant. The results show that in the needles from the polluted area (Zs) volume density of

chlorenchyma was reduced and volume density of intercellular increased under the influence of air pollution.

Table 2 - Volume density of intercellular in needles the age of which ranges from one to two years from the polluted areas (Zs) and control areas (K1 and K2).

Experimental field	Needle age	Autumn	Spring
		Average value ± standard error	Average value ± standard error
Zs	one-year-old	0,2104 ± 0,0062b	0,2405 ± 0,0099c
K1	one-year-old	0,1923 ±0,0060a	0,1887 ± 0,0041b
K2	one-year-old	0,1964 ±0,0051ab	0,1666 ± 0,0079a
Zs	two-year-old	0,2052 ± 0,0115b	0,2403 ± 0,0089c
K1	two-year-old	0,1551 ± 0,0068a	0,2115 ± 0,0007b
K2	two-year-old	0,1848 ± 0,0028b	0,1728 ± 0,0066a

Multiple test of interval - values marked with the same letter in the column, do not show the difference at the level of importance p<0,05

Data in the Table 3 show that in the needles taken in the autumn volume density of the vascular bundles was greatest in the one-year-old needles of the older culture from the less polluted area (K1) and that the difference was statistically significant in comparison with the needles from polluted area (Zs) and non-polluted area (experimental field K2). In one-year-old needles in the polluted area (Zs) under the influence of air pollution the difference between the volume density of vascular bundles in comparison with both control areas (K1 and K2) was smaller, and the difference is statistically significant. However, in these needles collected after the period of reduced metabolycal activity the volume density of the vascular bundles in the needles from the polluted area (Zs) and both control ones (K1 and K2) were balanced. Therefore, the differences are not significant. In two-year-old needles (autumn samples) from the polluted area (Zs) the volume density of vascular bundles increased and it approached the volume density of the vascular bundles of the older culture. The difference between the volume density of the vascular bundles of the needles from the polluted area (Zs) and non-polluted area (K2) is statistically significant. It points to the fact that the independent influence of air pollution on the reduction of the volume density of the vascular bundles in these needles is significant. At the same time the obtained results point to the fact that two-year-old needles from the polluted area gain the features of old age due to air pollution.

Table 3- Volume density of vascular bundles in the needles the age of which ranges from one to two years from the polluted area (Zs) and control areas (K1 and K2)

Experimental field	Needle age	Autumn	Spring
		Average value ± standard error	Average value ± standard error
Zs	one-year-old	0,0648 ± 0,0020^{a}	0,0862 ± 0,0177^{a}
K1	one-year-old	0,0855 ± 0,0011^{c}	0,0797 ± 0,0008^{a}
K2	one-year-old	0,0776 ± 0,0009^{b}	0,0935 ± 0,0005^{a}
Zs	two-year-old	0,0747 ± 0,0016^{b}	0,0695 ± 0,0017^{a}
K1	two-year-old	0,0825 ± 0,0017^{b}	0,0911 ± 0,0001^{b}
K2	two-year-old	0,0738 ± 0,0014^{a}	0,1005 ± 0,0025^{c}

Multiple test of interval - values marked with the same letter in the column, do not show the difference at the level of importance p<0,05

The differences of the volume density of the resin channels (Table 4) in autumn samples of the one-year-old needles is not significant in the experimental samples, which means that the pollution did not affect the volume density of the resin channels in one-year-old needles. In two-year-old needles (autumn samples) the volume density of the resin channels is the smallest in the comparison with the other samples (Zs and K1). It points to the fact that air pollution influenced the increase of the volume density of the resin channels in the autumn samples.

In the needles sampled in the spring the volume density of the resin channels underwent significant changes. In one-year-old and two-year-old needles the volume density of the resin channels is smallest in the needles from the less polluted area (experimental field K1), whereas the difference in comparison with the ones from the polluted area (Zs) and non-polluted area (experimental field K2) is significant. In the one-year-old needles the difference in the volume density between the needles from the polluted area (Zs) and non-polluted area (experimental field K2) is also statistically significant. Air polluted also affected the reduction of the volume density of the resin channels.

Table 4 - Volume density of resin channels the age of which range from one to two years from the polluted area (Zs) and control areas (K1 and K2)

Experimental field	Needle age	Autumn	Spring
		Average value ± standard error	Average value ± standard error
Zs	one-year-old	0,0304 ± 0,0028[a]	0,0313 ± 0,0018[b]
K1	one-year-old	0,0273 ± 0,0039[a]	0,0244 ± 0,0002[a]
K2	one-year-old	0,0337 ± 0,0008[a]	0,0435 ± 0,0030[c]
Zs	two-year-old	0,0316 ± 0,0024[b]	0,0305 ± 0,0015[b]
K1	two-year-old	0,0261 ± 0,0027[b]	0,0186 ± 0,0001[a]
K2	two-year-old	0,0191 ± 0,0002[a]	0,0348 ± 0,0023[b]

Multiple test of interval - values marked with the same letter in the column, do not show the difference at the level of importance $p<0,05$

Volume density of the epidermis in the autumn samples (Table 5) in one-year-old and two-year-old needles from the polluted area (Zs) and less polluted area (K1) is equal and statistically significanly greater than the volume density of the epidermis of needles from the non-polluted area (K2). The volume density of the epidremis in needles which lasted through the winter (spring samples) did not undergo any changes in comparison with the autumn samples. Volume density of epidermis is the smallest in needles from the non-polluted area (K2). In the both cases air pollution affected the increase of the volume density of epidermis. Apple et al. (2002) showed that the Douglas fir needles of the older crowns are prone to lignification and the increase of the percentage of the epidermis. Therefore, it can be concluded that our results of the volume density of epidermis point to the fact that the needles from the polluted area (Zs) show the properties characteristic for the needles of the older trunks.

Table 5- Volume density of epidermis of needles the age of which ranges from one to two years from the polluted area (Zs) and control areas (K1 and K2)

Experimental field	Needle age	Autumn	Spring
		Average value ± standard error	Average value ± standard error
Zs	one-year-old	0,1195 ± 0,0041[b]	0,1101 ± 0,0033[b]
K1	one-year-old	0,1204± 0,0008[b]	0,1125 ± 0,0017[b]
K2	one-year-old	0,1080 ± 0,0016[a]	0,0887 ± 0,0005[a]
Zs	two-year-old	0,1200 ± 0,0048[b]	0,1161 ± 0,0024[b]
K1	two-year-old	0,1194 ± 0,0039[b]	0,1207 ± 0,0019[b]
K2	two-year-old	0,0891 ± 0,0003[a]	0,0971 ± 0,0012[a]

Multiple test of interval – values marked with the same letter in the column do not show the difference at the level of significance p<0,05

Air pollution influenced the decrease of the volume density of chholrenchyma and increase of the intercellular spaces in the needles in the polluted area (Zs), if they are compared with the volume density in the samples from the non-polluted area (K2) and the difference is statistically significant. This conclusion is in the accord with the results obtained by Ilijin (1995) for the species Picea omorica in the polluted area of Azotara in Pančevo. Volume density of some tissues, particularly of chlorenchyma, in the samples of less polluted area (K1) – older culture is similar with the volume density of tissues of the samples from the polluted area (Zs), which is in the accord with the results obtained by Apple et al. (2000, 2002) that the changes occur in the older cultures of Douglas fir in the structure of tissue of assimilating organs, particularly in chlorenchyma. In the same way, volume density of epidermis is significantly greater in the needles from the polluted area (Zs) and ones from the less polluted area (K1) than the volume density in the needles from the non-polluted area (K2). All these facts point to the conclusions that the changes of the percentage of some tissues in comparison with the total cross section of the needles in the trunks under the influence of air pollution give the picture of aging, which is reflected in the increase of the volume density of the vascular bundles and resin channels in two-year-old needles in the autumn samples both from the polluted area (Zs) and less polluted area (K1). Winner (1994) pointed to the fact that plants corresponded to the air pollution by leaf aging, which was reflected in the decrease of the mobility of stomata and photosythesis. According to the same author, it leads to the reduction of the distribution of nutritive matter from the crown, and thereby to the decrease of increment.

4 CONCLUSIONS

The results of the studies point to the following conclusions:

- For the effect of gas pollutants foliage is the primary zone of influence on the plant species.
- Air pollution influenced the decrease of the volume density of cholrenchyma and increase of the intercellular spaces, both in the needles in the more polluted area REIK Kolubara Zs and in the needles in the less polluted area of control areas K1 and Jelova gora.

- Under the influence of air pollutation volume density of epidermis is significanly greater in the needles from the area with the polluted environment (Zs) and control from the weakly polluted area (K1) in comparison with the control area (K2) from the non-polluted environment.
- The changes of volume density of some tissues under the influence of air pollutation give the picture of needle aging which is reflected in the increase of the volume density of vascular bundles, epidermis and resin channels in the two-year-old needles in the autumn samples from the both polluted (Zs) and less polluted area (K1).

LITERATURE

Apple, M., Bind, B., Young, J., McCready, D. (2000): Element analysis of old-growth Douglas-fir trees. Interfacial Chemistry and Engineering, Annual Report.

Apple, M., Tiekotter, K., Snow, M., Young, J., Soeldner, A., Phillips, D., Tingey, D., Bond B.J. (2002): Needle anatomy changes with increasing tree age in Douglas-fir. Tree Physiology 22, p 129-136.

Appleton, B., Koci, J., Harris, R., Sevebeck, K., Dawn, A., Swanson, L. (2000): Trees for problem landscape sites – air pollution. Virginia Science University, Publication No 430-022.

Dassler, H.G. (1981b): Reaktionen von Geholzen auf Immissionen und Schlussfolgerungen fur den Anbau. Bergruning in Industriegebiten, Ref. d. VII. Dendrol. Kongr. Soz. Lander 29. Jun ibis 3. Juli 1979 in Dresden, KB d. DDR, Graph. Werkst. Zittau, 31-36.

Hermann, R., Lavender, D. (1999): *Pseudotsuga menziesii* (Mirb.) Franco – Douglas-Fir. Silvics manual, Volume 1.

Ilijin – Jug, M. (1995): Histological- cytological and morphological changes in species *Picea omorika* (Panchic) Purkyne in the area of Panchevo in horticulture, caused by air-pollution. Doctoral thesis, Belgrade, pp.1-153. *(Original- Histološko-citološke i morfološke promene kod vrste Picea omorika (Pančić) Purkyne na području Pančeva u hortikulturi, izazavane aerozagađenjem. Doktorska disertacija, Beograd, str. 1-153)*

Shreuder, M.D.J., Brewer, C. (2001): Effects of short-term, high exposure to chlorine gas on morphology and physiology of Pinus ponderosa and *Pseudotsuga menyiesii*. Annals of botany 88: 187-195.

Šmit, S., Veselinović, N. (1996): Recultivation by reforestation of waste sites of open-pit lignite mines "Kolubara". Monograph. Belgrade. 111 p. (*Original- Rekultivacija pošumljavanjem odlagališta površinskih kopova rudnika lignita "Kolubara". Monografija. Beograd, 111 p.)*

Winner, W. (1994): Mechanistic anlzsis of plant responses to air pollution. Ecological applications, Vol 4(4), Ecologicl Society of America, p. 651-661.

THE CHANGES IN THE INTERNAL STRUCTURE OF Pseudotsuga menziesii (Mirb.) Franco NEEDLES UNDER THE INFLUENCE OF AIR-POLLUTION

Milorad Veselinović, Dragana Dražić, Mihailo Ratknić, Ljubinko Rakonjac, Vesna Golubović-Ćurguz, Nevena Čule, Suzana Mitrović

Summary

In the mining-power complex of the Kolubara basin, alongside the soil degraded by the open-pit lignite exploitation, the power and industrial plants are situated. Therefore, this area is under the great influence of the air-pollution, which is the result of the combustion of the great quantities of lignite, used as the energy material for the industrial facilities.

Pseudotsuga menziesii (Mirb.) Franco has for the first time been used in the area of Kolubara to recultivate by afforestation mechanically damaged soil of this type (Šmit and Veselinović, 1996). The high adaptability of this species has conditioned its selection among the coniferous trees used for afforestation of anthropologically damaged terrain.

The species chosen for the influence of air -pollutants analysis have been planted on deposol of REIK Kolubara coal field - more polluted area Zs with a larger number of pollutants in the air (SO_2, NO_3, CO); on Jelova Gora - less polluted area K1 with permitted SO2 concentration in the air; and culture of Douglas-fir species on acid brown soil on Juhor mountain – the unpolluted area K2.

Volume density of the total pine needle mesophyll, of healthy and damaged mesophyll cells, central cylinder intercellular spaces, resin channels and vascular bundles have been determined by stereologic analysis. This method has enabled quantitative evaluation of change in the dynamics in internal Douglas-fir pine needle structure caused by air-pollution.

Based on the research results the conclusion has been reached that the changes in micromorphological parameters on the level of light microscope are consisted of the decrease in volume density of the total chlorenchyma and the increase in volume density of intercellular spaces and epidermis.

PROMENE U UNUTRAŠNJOJ STRUKTURI ČETINA *Pseudotsuga menziesii* (Mirb.) Franco POD UTICAJEM AEROZAGAĐENJA

Milorad Veselinović, Dragana Dražić, Mihailo Ratknić, Ljubinko Rakonjac, Vesna Golubović-Ćurguz, Nevena Čule, Suzana Mitrović

Rezime

Na području rudarsko energetskog kompleksa kolubarskog basena, pored površine zemljišta degradiranog površinskom eksploatacijom lignita, locirana su i energetska i industrijska postrojenja tako da je, kao posledica sagorevanja velikih količina lignita koje se koristi kao energetski materijal za rad industrijskih objekata, ovo područje pod velikim uticajem aerozagađenja.

Pseudotsuga menziesii (Mirb.) Franco je na području REIK Kolubara, prvi put na našim prostorima korišćena za rekultivaciju pošumljavanjem mehanički oštećenih ze-

mljišta ovog tipa (Šmit i Veselinović 1996). Velika adaptivnost ove vrste je uslovila, da ona uđe u izbor četinarskih vrsta koje su korišćene za pošumljavanje na ovaj način antropgeno oštećenih terena.

Za analizu uticaja aeropolutanata na unutrašnju strukturu četina odabrane su kulture podignute na: deposolu ugljenog basena REIK Kolubara – jače zagađena sredina Zs sa većim brojem polutanata u vazduhu (SO_2, NO_3, CO); na Jelovoj gori – slabije zagađena sredina K1 sa dozvoljenom koncentracijom SO2 u vazduhu; i kulturi duglazije podignutoj na kiselosmeđem zemljištu na Juhoru – nezagađena sredina K2.

Stereološkim ispitivanjem određivani su: volumenska gustina ukupnog mezofila četine, zdravih i ozleđenih ćelija mezofila, intercelularnih prostora centralnog cilindra, smonih kanala, provodnih snopića. Ova metoda je omogućila da se kvantitativno proceni dinamika izmena unutrašnje strukture četina duglazije koje su nastale pod uticajem aerozagađenja.

Na osnovu rezultata ispitivanja zaključeno je da su se promene mikromorfoloških parametara na nivou svetlosnog mikroskopa sastoje se u smanjenju volumenske gustine ukupnog hlorenhima i povećanju volumenske gustine intercelulara i epidermisa.

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DEPENDENCE OF HIGH BEECH STAND FORM FACTOR AND FORM HEIGHT ON SITE AND STAND FACTORS

Miloš Koprivica, Bratislav Matović[1]

Abstract: Dependence of the high uneven-aged beech stands form factor and form height on the site and stand factors was studied. The data collected by the simple systematic sample in seven representative beech stands were the basis study materials. One hundred and sixty sample plots, circle-shaped, 500 m^2 size, in which all the trees above 10 cm diameter were measured, were set. Several dendrometrics and statistics methods were applied for data procession. The regression models for the estimate of the high beech stand form factor and form height were obtained. The gross and net influences of the site and stand factors were studied, and the most important of them were singled out: stand mean height (Lorey's), stand quadratic mean diameter and site class (tariff series). It was determined that the obtained results can be easily applied in practice.

Key words: beech, stand, volume, form factor, form height

ZAVISNOST ZAPREMINSKOG KOEFICIJENA I OBLIKOVISINE VISOKIH SASTOJINA BUKVE OD STANIŠNIH I SASTOJINSKIH FAKTORA

Izvod: Istraživana je zavisnost zapreminskog koeficijenta i oblikovisine visokih raznodobnih sastojina bukve od stanišnih i sastojinskih faktora. Osnovni materijal istraživanja činili su podaci prikupljeni u sedam reprezentativnih sastojina bukve, pomoću jednostavnog sistematskog uzorka. Postavljeno je 160 probnih površina, oblika kruga i veličine 500 m^2, na kojima je izvršen potpun premer svih stabala prečnika iznad 10 cm. Za obradu podataka primenjeno je više dendrometrijskih i statističkih metoda. Dobijeni su regresioni modeli za procenu veličine zapreminskog koeficijenta i oblikovisine visokih sastojina bukve. Sagledan je bruto i neto uticaj stanišnihi i sastojinskihi faktora, i izdvojeni najznačajniji: srednja visina sastojine (Lorajeva), srednji prečnik sastoji-

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ne po temeljnici, i bonitet staništa (tarifni niz). Utvrđeno je da se dobijeni rezultati mogu primeniti u praksi.

Ključne reči: bukva, sastojina, zapremina, zapreminski koeficijent, oblikovisina.

1 INTRODUCTION

There are numerous methods for the determination of the stand volume which are based on the total or partial measurement of the trees above the taxation limit. All methods are characterised by a level of accuracy and economic, i. e. efficacy.

The basic formula for calculating stand volume is: V = G H F, in which V is the volume, G is the basal area, H is the mean height (Lorey's) and F is the form factor. The elements of volume G, H and F should be determined very accurately, with regard to the objective of the determination of stand volume.

Although it is usually considered that the complete measurement of the stand is the most accurate method of calculation of it is volume, it is not always true. There are several reasons for it, and we noted that this method also implies the calculation of the mean height and form factor according to tree sample (Mirković and Banković, 1993).

Alongside the individual elements of stand of volume, their products HF or GF can also be determined. The first expression refers to so-called stand form height and is used more often that another expression. The direct application of the basic formula for determination of stand volume implies the knowledge of the elements of volume. The subject of this paper is the determination of the form factor and form height of the high uneven-aged beech stands in central Serbia. The problem had been partially studied before (Panic, 1971).

2 TASK AND AIM

Two tasks of this study were set:

- determine the dependence of the form factor and form height of the high beech stands (dependant variables) on the other most important taxation elements of the stand and site characteristics (independent variables) and
- analyze net influence of some taxation elements of the stand and site characteristics on the form factor and form height.

The aim is to define in theory the statistics dependence and achieve the results which can be implemented easily in practice, i.e. for fast and relatively cheap inventory of high beech stands.

3 MATERIAL AND METHOD

The numerous data collected on stands and their site within the project "*Method of estimate of quality and assortment structure of the high beech stands in Serbia*", which was implemented by Institute of Forestry from Belgrade (2005-2007), are used as material in this study. The choice of the stands used for study, the way of collection and procession of the data is presented in a great detail in the paper by Koprivica et al. (2005). In addition, in several papers the site and taxation characteristics of the

study stands are described (Koprivica and Matović, 2006, 2007; Koprivica et al. 2006, 2007). It is important to note that the study was conducted on the base of several high uneven-aged beech stands, selected in three forest areas: Severno Kučajsko, Podrinjsko-Kolubarsko, and Jablaničko. In all stands the systematic sample of the sample plot, circle-shaped and 500 m^2 size, in the square arrangement, at 100 m distance, was set. The total 160 sample plots were measured. The relevant data for each sample plot were processed separately, as average or aggregate size, translated into hectares (Table 1).

In the further analysis the characteristics of the sample plots are conditionally treated as the characteristics of the hypothetical stands, i.e. the starting point was the hypothesis that they can be equalized in theory. In this case, the variability of the taxation elements in the sample of the sample plots is somewhat greater than the variability of the taxation elements in the stand samples. Therefore, the greater reliability of the obtained models is to be expected when they are applied on the concrete beech stands.

Table 1- Statistics for taxation elements of the high beech forests in central Serbia (n = 160)

Taks elem	Statistics indicators							
	$X_{midle.}$	$X_{min.}$	$X_{max.}$	S	CV%	m%	a_3	a_4
F	0.49296	0.34314	0.55034	0.0294	5.97	0.94	-1.60	7.97
H_LF	14.304	4.712	19.442	2.778	19.42	3.07	-0.32	2.88
V	387.72	68.21	972.84	166.59	42.97	6.79	0.92	3.97
G	26.89	7.23	51.83	9.31	34.61	5.47	0.31	2.50
N	278.13	60.0	1200.0	149.29	53.68	8.33	2.46	14.11
H_l	28.91	13.73	40.33	4.95	17.12	2.71	-0.08	2.70
H	24.33	11.70	39.40	5.37	22.09	3.49	0.24	2.68
D_g	36.97	18.66	61.26	8.42	22.78	3.60	0.24	2.71
D	33.71	17.50	56.30	8.53	25.31	4.00	0.39	2.74
SK	0.833	0.14	1.00	0.17	20.57	3.25	-1.51	5.18
TN	3.281	1.00	8.00	1.60	48.72	7.59	0.51	2.62
NV	788.78	406.0	1030.0	196.68	24.93	3.94	-0.65	2.01
NT	21.99	6.0	42.0	8.91	40.49	6.40	-0.05	2.02
EK	3.65	1.0	8.0	2.52	69.13	10.93	0.76	1.98

Legend: F-stand form factor; H_lF – stand form height; V- stand volume per hectare; G- stand basal area per hectare; N- stand number of trees per hectare; H_L-mean stand height by Lorey; H- arithmetic mean stand height; D_g- stand quadratic mean diameter; D – arithmetic mean stand diameter; SK- stand canopy; TN- tariff series (site class); NV- stand altitude; NT- stand slope; EK- stand aspect

For the definition of the statistics relations between stand form factor (F) and stand form height (H_LF) as dependent variables and selected taxation elements of the stand (G, N, H_L, H, D_g, D, SK) and site characteristics (TN, NV, NT, EK) as the independent variables, the *method of simple and multiple regression* was applied. The *method of stepwise multiple regression* was applied for the selection of the "best" regression equation (model), and for the alleviating the consequences of co-linearity and multicolinearity between the independent variables the *method of ridge regression* was applied (Hadživuković et al. 1982; Hadživuković, 1991). Ezekiel's method was applied for analytical and graphical definition of net values (Ezekiel, 1953).

4 RESULTS

4.1 Form factor of beech high stands

Several regression models were obtained, which due to simplicity in the discussion will be marked as: *Model 0* – simple regression, *Model 1*- multiple regression as the best theoretic solution, *Model 2* – multiple regression as the best practical solution and *Model 3* – multiple ridge regression.

4.1.1 Model of simple regression

Upon the analysis of the matrix of the simple and partial coefficients of the linear correlation, it was concluded that stand form factor mostly depends on: mean stand height by Lorey, tariff series–site class and stand quadratic mean diameter.

Regression equations are:

$$F = 0.137425 + 0.0231704H_L - 0.000365438H_L^2 \quad (1)$$

$S_e = 0.02496$ $R^2 = 28.89\%$

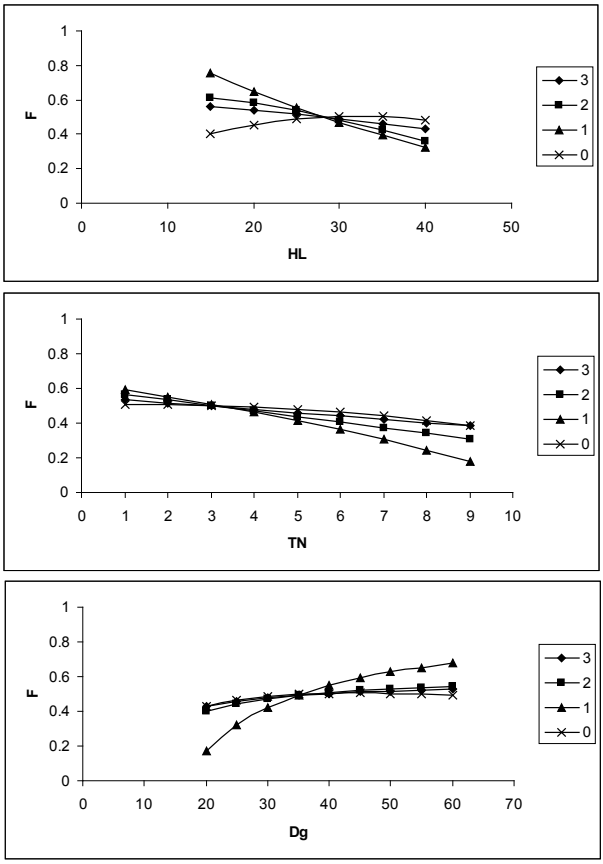
$$F = 0.502251 + 0.0054493TN - 0.00204198TN^2 \quad (2)$$

$S_{e=} 0.02451$ $R^2 = 31.42\%$

$$F = 0.735117 - 0.0026203D_g - 5.08537/D_g \quad (3)$$

$S_e = 0.02480$ $R^2 = 29.77\%$

The equations (1-3) are presented in Graph 1, as *Model 0.* By the increase of the mean value by Lorey and of the stand quadratic mean diameter, the form factor also increases, and it decreases by the increase of the tariff series (by decrease of site class). This dependence is logical to the professionals, but in all cases only around 30% of the total variability of the stand form factor is explained, and the standard error is high. In addition, there is an important linear correlation between all three independent variability, which is significant during the analysis of the net influence of some independent variables on dependent variable in the model of a multiple regression.



Graph 1- Dependence of beech stand for factor on other factors

4.1.2 Model of multiple regression as the best theoretic solution

This model was obtained by the method of a multiple regression. Stand form factor (dependent variable), numerous taxation elements of the stand and site characteristics (independent variables) were used as the initial variables. The original independent variables were also taken in the transformed form, as the square and reciprocal values.

The best solution is the following equation of a multiple regression,

$$F = 1.28079 - 0.027273H_L + 0.000184692H_L^2 + 0.00429302D - 0.0000330709D^2 + 9.79367/D - 0.0326681TN - 0.00185462TN^2 - 0.00000001854N^2 - 0.0000103734H - 15.1607/D_g \quad (4)$$

$S_e = 0.00322$ $R^2 = 98.88\%$

In the equation (4) it is seen that as the independent variables, the influence of which on dependent variable is significant by 99% probability, the following values are included: mean value by Lorey, arithmetic mean diameter, tariff series, a number of trees per hectare, arithmetic mean height and the stand quadratic mean diameter.

From this equation the equations of net regression, presented in Graph 1 as *Model 1*, are obtained. The influence of the mean height by Lorey on stand form factor seemed illogical, which can be explained as the consequence of the multicolinearity between the selected independent variables. Although *Model 1* is the best theoretic (statistics) solution, it can not be easily applied in the practice, since it requires the previous determination of six independent variables. Owning to it, the best solution which could be used in practice was searched.

4.1.3 Model of multiple regression as the best practical solution

The best equation of a multiple regression which can be applied is,

$$F = 1.21667 - 0.0141291H_L - 2.44963/H_L - 0.0319587TN - 4.30151/D_g \quad (5)$$

$S_e = 0.01302$ $R^2 = 80.89\%$

In the equation (5) the following values are included as independent variables: stand mean height by Lorey, tariff series and stand quadratic mean diameter. It is possible to determine these independent variables in the concrete stand in a rather simple way, which will be elaborated on later.

Three equations of a net regression, which are presented in Graph 1 as *Model 2*, are obtained from the equation (5). Some net influences are illogical, due to the presence of multicolinearity. By increase of the mean stand height by Lorey, unchanged tariff series and stand quadratic mean diameter the stand form factor decreases, and it would be logical to increases. By increase of tariff series (decrease of site class) and unchanged influence of the mean height per Lorey and stand quadratic mean diameter, stand form factor decreases, which is logical. Increase of the stand quadratic mean diameter, and unchanged influence of the stand height by Lorey and tariff series, the stand form factor increases.

In the equation (5) there is a statistically important linear correlation between the independent variables. The correlation coefficient between H_L and TN is -0.87, between H_L and D_g is 0.64, and between TN and D_g is -0.36. During the analysis of the structure of the model the colinearity of the variables with the higher correlation coefficient is of a particular importance (Koprivica, 1982). In this there is the colinearity between mean height by Lorey and tariff series, which resulted in the change of the matematical sign of the regression coefficient of the stand mean height in the equation of net regression in the comparison with the equation of the simple regression. In order to alleviate the problem of multicolinearity, the *method of ridge regression* was applied.

4.1.4 Model of the multiple ridge regression

The model was obtained by adding the coefficient $k = 0.05$, with the same independent variables as the *Model 2*. The *method of ridge regression* was applied in order to obtain the equation of a multiple regression with the stable coefficients (Hadzivukovic, 1991).

The following equation of a multiple regression was obtained,

$$F = 0.841378 - 0.00633599H_L - 0.580752 / H_L - 0.0190806TN - 2.86657 / D_g \quad (6)$$

$S_e = 0.01664$ $R^2 = 55.31\%$

By the comparison of the equations (5) and (6) it can be seen that there was a significant change of the coefficient regression, but that the mathematic sign of the parameters in front of the independent variables remained the same. The greatest change is in the value of the standard regression error, i.e. of the coefficient of the multiple regression. Thus, the equation (5) is better for the estimate of the stand form factor, and the equation (6) for the analysis of the net influence of the independent variables on the dependent variable. Three equations of net regression were also obtained and presented in Graph 1 as *Model 3*. It is seen that there is no important difference between the equation of net regression marked as *Model 2* and *Model 3.* Therefore, the problem of multicolinearity is only partially alleviated.

4.2 Form heigh of beech high stands

Form height of beech high stands was analyzed in the same way as the stand form factor.

4.2.1 Model of a simple regression

Upon the analysis of the matrix of the simple and partial linear correlation coefficients, it was concluded that in beech stand, form height mainly depends on the same factors as the stand form factor.

Regression equations are:

$$H_L F = -6.88831 + 0.94011H_L - 0.00695937H_L^2 \quad (7)$$

$S_e = 0.7207$ m $R^2 = 93.35\%$

$$H_L F = 19.4819 - 1.57797TN \quad (8)$$

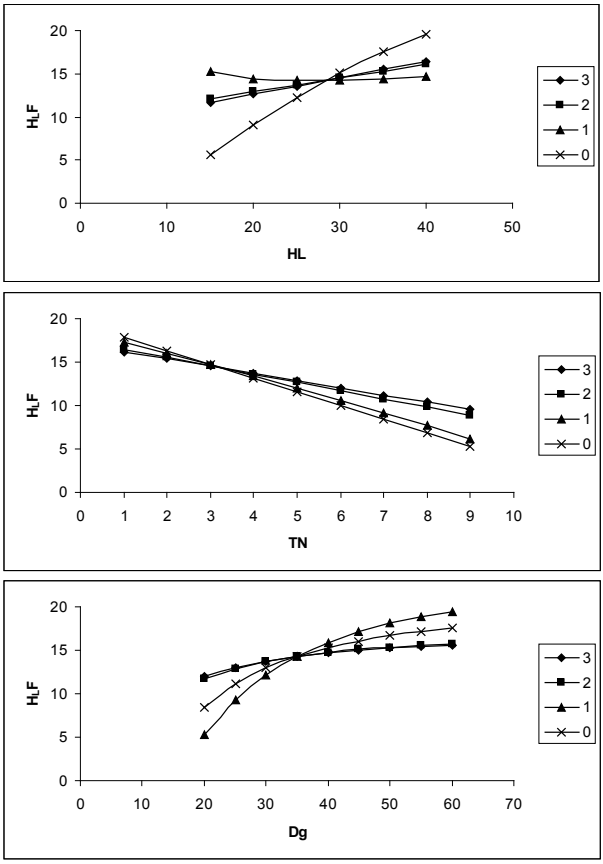
$S_{e=} 1.1661$ m $R^2 = 82.48\%$

$$H_L F = 22.1302 - 273.925 / D_g \quad (9)$$

$S_e = 2.0082$ m $R^2 = 48.06\%$

The equations (7-9) are presented in the Graph 2 as *Model 0.* By increase of the stand mean height by Lorey and stand quadratic mean diameter the stand form height also increases, whereas by the increase of the tariff series (by decrease of site class) it decreases. All these dependences are profesional logical. However, regardless of the statisti-

cally important determination coefficient, regression standard error is high, and there is an important linear correlation between all three independently variables.



Graph 2- Dependence of beech stand form height on other factors

4.2.2 Model of the multiple regression as the best theoretic solution

As the best theoretic solution the following multiple regression equation was obtained:

$$H_L F = 9.13555 + 0.111663 H_L + 0.177968 D_g - 0.00141294 D_g^2 - 384.427 / D_g + 0.0345579 D + 252.821 / D - 1.22148 TN - 0.0167313 TN^2 - 0.000580911 H^2 - 0.000000114024 NV \quad (10)$$

$S_e = 0.1015$ m $\quad R^2 = 99.88\%$

In the equation (10) it is seen that the following values, the influence of which on the dependent variable is important by 99% probability, were included as the independent variables: mean height by Lorey, quadratic mean diameter, arithmetic mean di-

ameter, tariff series, arithmetic mean height and altitude. From this equations the net regression equations, presented in Graph 2 as *Model 1* were derived. The influence of the mean height by Lorey on stand form height seemed illogical, which is the consequence of multicolinearity between the selected independent variables. Although *Model 1* is the best theoretic (statistical) solution, it can not be easily applied in practice, since it requires the previous determination of six independent variables.

4.2.3 Model of a multiple regression as the best practical solution

The best multiple regression equation which can be applied is

$$H_L F = 16.2749 + 0.159373 H_L - 0.946515 TN - 121.538 / D_g \quad (11)$$

$S_e = 0.3828$ m $\quad R^2 = 98.14\%$

In the equation (11) stand mean height by Lorey, tariff series and stand quadratic mean diameter were included. Therefore, the same variables were included as for the determination of stand form factor in a regression equation (5). It is possible to determine these independent variables in a rather simple way in a concrete stand. From the equation (11) three net regression equations were derived and presented in Graph 2, as *Model 2.*

Although the multicolinearity is present, all net influences are logical. By increase of the stand mean height by Lorey, and unchanged tariff series and stand quadratic mean diameter, stand form height increases. By increase of tariff series (decrease of site class), and unchanged influence of mean height by Lorey and stand quadratic mean diameter, stand form height decreases. By increase of stand quadratic mean diameter and unchanged influence of stand mean height by Lorey and tariff series, stand form height increases.

4.2.4 Model of a multiple ridge regression

In this case the model was also determined by adding coefficient $k = 0.05$, with the same independent variable as in *Model 2.*

Multiple regression equation is,

$$H_L F = 14.6631 + 0.19166 H_L - 0.834544 TN - 110.656 / D_g \quad (12)$$

$S_e = 0.3924$ m $\quad R^2 = 95.91\%$

By the comparison of the equations (11) and (12) it can be seen that there was no significant change of the regression coefficients and that mathematics signs in front of independent variables remained the same. Also, there was no important change of the regression standard error and multiple determination coefficients. Therefore, the regression equations are equally good for the calculation of stand form height, as well as for analyzing of the net influence of independent variables on dependent variable. The obtained equations of a net regression are presented in Graph 2, as *Model 3.*

5 APPLICATION OF RESULTS

The regression equations (5) and (11) are intended for practical use. In a concrete beech stand it is necessary to determine: tariff series (site class), mean height by Lorey and quadratic mean diameter. The problem can be solved by the application of *relascopy method.*

The work method will be decribed briefly: The stand structure (according to the tree thickness and their arrangement by stand area) should be determined first, and then the factor of tree counting should be selected, so that the average number of the trees by a sample plot would be 15-20 (Van Laar and Akca, 2007). The sample plots should be located in the stand by professional estimation, so that they represent the stand in regard to the volume of it. The number of sample plots should be 3-5. In each sample plot the trees which should be measured are to be marked (diamater at breast height is wider than the width of the measurement scale). Then, diameter at breast height and the height of all the selected trees should be measured. By these data, stand height curve can be drawn and tariff series (TN), i.e. site class can be determined. By the classification of trees per diameter class, the stand basal area per diameter class and total per hectare, i.e. G_1 , $G_{2\ldots}$ G_k and G will be obtained. Mean height of the trees per diameter class h_1 , h_2, $\ldots h_k$ should be read from height curve and stand mean height by Lorey (H_L). In order to determine the stand quadratic mean diameter (D_g), the number of trees in the stands per hectare should be also determined. It should be done separately for each diameter classl (dividing the number of the counted trees in diameter class, i.e. class basal area lper hectare $G_{i,}$ by the basal area of mean tree in diameter class g_i), and then add. After that, the stand mean basal area from the relation G/N is determined, i.e. mean diameter $D_{g.}$ By this method all the elements of stand necessary for the determination of stand form factor (F) or stand form height ($H_L F$) are determined.

Since the stand basal area G is known, the stand volume can be determined as well. It is clear that the stand volume determined in this way will not be accurate enough. If we want to increase the accuracy of the stand volume, the additional sample plots can be set. In them only the basal area per hectare, without the measurement of diameter and tree height can be determined. This type of the sample is two-phase, since in the first phase the stand basal area is determined in a great sample, and in the second the stand form factor or stand form height are determined in a small sample (Kangas and Maltamo, 2006). In theory, it is justifiable, because in the sample of plots, basal area is the most variable (CV = 34.61%), then stand form height (CV = 19.42%) and mean height per Lorey (CV = 17.12%), and the least variable stand form factor (CV = 5.97%). Coefficient of volume variability is 42.97%.

Example: In one beech high stand by the described method the following elements were determined: tariff series 5 (site class III), G = 30 m^2/ha, H_L = 25 m and D_g = 35 cm. By a regression equation (5) F = 0.48276, and by equation (11) $H_L F$ = 12.054 m. Therefore, stand volume is V = 30 x 25 x 0.48276 = 362 m^3/ha, i.e. V = 30 x 12.054 = 362 m^3/ha. By the classic measurement, by sample of 5% intensity, it was determined that the volume of this stand is 380 m^3/ha, with the double relative error +/- 11,0%. The real average volume of this stand ranges between 338 and 422 m^3/ha, by 95% probability. The average stand volume determined by the described method is also within these limits.

6 CONCLUSION

By the method of simple, multiple and net regression the dependence of high beech stand form factor and form height on the most important taxation elements of the stand and site factors was defined. The obtained models are significant in both theory and practice.

The answer to the question how the high beech stand form factor and form height change by the use of their tariff series, mean height by Lorey, and quadratic mean diameter, was obtained by the models of a net regression:

- if the other factors are unchanged, by the increase of tariff series (decrease of site class) the stand form factor and stand form height decrease,
- if the other factors are unchanged, by the increase of the mean height by Lorey, the stand form factor decreases, and the stand form height increases, and
- if the other factors are unchanged, by the increase of the stand quadratic mean diameter, the stand form faktor increases slowly, and stand form height increases at a fast pace.

The regression equations (5) and (11), by which according to three factors (stand mean height by Lorey, tariff series and stand quadratic mean diameter) we can accurately estimate the stend form factor and stand form height, as the basic elements for the determination of the volume of it, are most significant in practice. Given the reliability of the model, it is better to use equation for stand form height (11).

The decribed method of the application of results is aimed at the fast estimate of the high beech stand volume, as well as for the possible rough monitoring of the determined stands volume by some classical method. In all cases, the accuracy of stand volume depends upon the accuracy of its elements. During the analysis of the decribed method, one should bear in mind that neither by the use of the classic method, with the economically justified sample size, the estimate of the beech stand volume, aimed at the creation of the reliable management plans, most usually cannot be achieved. (Koprivica, 2006).

LITERATURE

Ezekiel, M. (1953): Methods of Correlation Analysis. John Wiley and Sons Inc., New York.

Hadživuković, S. (1991): Statistical methods. The Faculty of Agriculture, Novi Sad. *(Original- Statistički metodi. Poljoprivredni fakultet, Novi Sad)*

Hadživuković, S., Zegnal, R., Čobanović, K. (1982): Regressional analysis, Economic Review, Belgrade. *(Original- Regresiona analiza. Privredni pregled , Beograd)*

Kangas, A., Maltamo, M. (2006): Forest Inventory - Methodology and Applications. Springer. Dordrecht, The Netherlands.

Koprivica, M. (1982): Contribution to the knowledge of problems and limits in the application of methods of regressional and correlative analysis in forestry research. Forestry and wood procession, XXXVI, notebooks 10-12, Sarajevo. *(Original- Prilog poznavanju problema i ograničenja u primjeni metoda regresione i korelacione analize u šumarskim istraživanjima. Šumarstvo i predada drveta , XXXVI, sv. 10-12, Sarajevo)*

Koprivica, M., Miletić, Z., Tabaković-Tošić, M. (2005): Methodology of collection and procession of field data for analysis of quality and assortment structure of beech high stands in Serbia. Manuscript, Institute of Forestry, Belgrade. *(Original- Metodika prikupljanja i obrade terenskih podataka za proučavanje kvaliteta i sortimentne strukture visokih sastojina bukve u Srbiji. Rukopis. Institut za šumarstvo, Beograd)*

Koprivica, M., Matović, B. (2006): Regressional equations of volume and volume increment of beech trees in high forests in Serbia. The Collection of Papers, volumes 52-53, Institute of Forestry, Belgrade. *(Original- Regresione jednačine zapremine i zapreminskog prirasta stabala bukve u visokim šumama na području Srbije. Zbornik radova, tom 52-53. Institut za šumarstvo, Beograd)*

Koprivica, M., Matović, B. (2007): Variability and accuracy of estimation of taxation elements of trees by diameter classes in beech high stands. Forestry, 1-2, pp. 1-11. Belgrade. *(Original- Varijabilitet i preciznost procene taksacionih elemenata stabla po debljinskim klasama u visokim sastojinama bukve. Šumarstvo, 1-2, str. 1-11. Beograd)*

Koprivica, M. (2006): Reliability of results of beech height stand inventory by sample method. International Scientific Conference „ Sustainable use of Forest Ecosystems - The Challenge of the 21st Century". Donji Milanovac, Srbija. Proceedings, Institute of Forestry, Belgrade

Koprivica, M., Čokeša, V., Matović, B. (2006): Quality and assortment structure of the volume of beech height stands in Jablaničko forest area. International Scientific Conference „ Sustainable use of Forest Ecosystems - The Challenge of the 21st Century". Donji Milanovac, Serbia Proceedings, Institute of Forestry, Belgrade

Koprivica, M., Čokeša, V., Matović, B. (2007): Quality and assortment structure of the volume of beech height stands in Kolubarsko-Podrinjsko forest area. International Symposium . Ohrid, Macedonia.

Mirković, D., Banković, S. (1993): Forest Mensuration. The Institute for Textbooks and Teaching Devices. Belgrade. *(Original - Dendrometrija. Zavod za udžbenike i nastavna sredstva Srbije. Beograd)*

Panić, Đ. (1971): Results of the researches of beech stands in Serbia. The Collection of Papers, book X. The Institute of Forestry and Wood Industry, Belgrade. *(Original- Rezultati istraživanja bukovih sastojina na području Srbije. Zbornik, knj. X. Institut za šumarstvo i drvnu industriju, Beograd)*

Van Laar, A., Akca, A. (2007): Forest Measurement Springer. Dordrecht, The Netherlands.

DEPENDENCE OF HIGH BEECH STAND FORM FACTOR AND FORM HEIGHT ON SITE AND STAND FACTORS

Miloš Koprivica, Bratislav Matović

Summary

The dependence of the high uneven-aged beech stand form factor (F) and form height ($H_L F$) on the site and stand factors is analyzed is this paper. The data collected by the sample method in seven representative beech stands in central Serbia were the basis study materials. The systematic sample with the sample plots, circle-shaped, 500 m^2 size, set in the square arrangement, at 100 m distance, was applied. A total of 160 samples plots, in which all the trees were measured, were set. After the dendrometrics data procession, the method of a regression and correlation analysis was applied (simple, multiple, net and ridge regression). In the conducted analysis the sample plot was conditionally equalized with the stand. Several regression models by which the gross and net influence of the site and stand factors on the value and direction of the stand form factor and form height was analyzed. It was determined that the stand form factor and form height mainly depend on three factors: mean height (Lorey), quadratic mean diameter and tariff series (site class). The regression equations (5) and (11) are aimed for practical use. Given the reliability of the model, it is better to use the equation for stand form height (11). The beech stand form factor in the sample ranges between 0.34314 and 0.55034, the average value of it is 0.49296, and variation coefficient 5.97%. Beech stand form height ranges between 4.712 and 19.442 m, the mean value of it is 14.304, and variation coefficient 19.42%. The distribution of the form factors deviates greatly from the normal distribution, and the distribution of form heights is similar to the normal distribution. The method of the practical use of the results of the research, i.e of the quick estimate of beech stand volume, was also elaborated.

ZAVISNOST ZAPREMINSKOG KOEFICIJENA I OBLIKOVISINE VISOKIH SASTOJINA BUKVE OD STANIŠNIH I SASTOJINSKIH FAKTORA

Miloš Koprivica, Bratislav Matović

Rezime

U radu je analizirana zavisnost zapreminskog koeficijenta (F) i oblikovisine ($H_L F$) visokih raznodobnih sastojina bukve od stanišnih i sastojinskih faktora. Osnovni materijal za ovo istraživanje prikupljen je primenom metoda uzorka u sedam reprezentativnih sastojina bukve na području centralne Srbije. Primenjen je sistematski uzorak sa probnim površinama, oblika kruga i veličine 500 m^2, postavljenim u kvadratnom rasporedu na rastojanju 100 m. Postavljeno je ukupno 160 probnih površina na kojima je izvršen potpun premer svih stabala. Posle dendrometrijske obrade podataka primenjen je metod regresione i korelacione analize (jednostavna, višestruka, neto i ridž regresija). U provedenim analizama probna površina je "uslovno" izjednačena sa sastojinom. Dobijeno je više regresionih modela na bazi kojih je sagledan bruto i "neto" uticaj stanišnih i sastojinskih faktora na veličinu i tok zapreminskog koeficijenta i oblikovisine sastojine.

Utvrđeno je da zapreminski koeficijent i oblikovisina sastojine najviše zavise od tri faktora: srednja visina (Lorajeva), srednji prečnik po temeljnici, i tarifni niz (bonitet staništa). Za primenu u praksi namenjene su regresione jednačine (5) i (11). S obzirom na pouzdanost modela, bolje je koristiti jednačinu za oblikovisinu sastojine (11). Zapreminski koeficijent sastojina bukve u uzorku varira od 0,34314 do 0,55034, sa sednjom veličinom 0,49296 i koeficijentom varijacije 5,97%. Oblikovisina sastojina bukve varira od 4,712 do 19,442 m, sa srednjom veličinom 14,304 m, i koeficijentom varijacije 19,42%. Distribucija zapreminskih koeficijenata značajno odstupa od normalne distribzcije, a distribucija oblikovisina je slična noramalnoj distribuciji. Izložen je i postupak pratične primene rezultata istraživanja, odnosno brze procene zapremine sastojina bukve.

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THE ADVANTAGE OF USING GABIONS IN THE ANTIEROSION WORKS IN SERBIA

Vjačeslava Matić[1]

Abstract: The abundant precipitation in the winter and spring 2005-6 caused numerous torrential floods and landslides in the world and Serbia which endangered: people, animals, fields and highways. It once again reminded us of an easily accessible, cheap and efficient material: the stone in the barbed baskets of the double zinced wire, of the different dimensions and shapes, gabions, which are, alongside the aforesaid, long-lasting, flexible, and eco-friendly, and if they are made by norms –permanent solution to the many antierosion problems, urgent interventions and protection of life: people, animals and vegetation, as well as the prevention of the unforseeable material losses. This paper points to this unjustly neglected and important material, which is easily manipulated with and has significant advantages over other construction materials.

Key words: antierosion materials, eco-friendly materials, gabions, antierosion facilities, erosion, vegetation, metals, wire, stone

PREDNOST PRIMENE GABIONA U PROTIVEROZIONIM RADOVIMA SRBIJE

Izvod: Obilne padavine u zimu i proleće 2005-6. god. donele su brojne bujične poplave i klizišta i svetu i Srbiji, koja su ugrozila: ljude, životinje, naselja, njive i saobraćajnice. To je opet podsetilo na jedan, lako dostupan, jevtin i efikasan materijal: kamen u žičanim korpama od dvostruko pocinkovane žice, različitih dimenzija i oblika, gabione, koji su pored navedenog još i dugotrajni, fleksibilni, i ekološki, a ako su urađeni prema normama – trajno su rešenje za mnoge protiverozione probleme, hitne intervencije i zaštitu života: ljudi, životinja i vegetacije, kao i sprečavanje nesagledivih materijalnih

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gubitaka.Ovaj rad ukazuje na nepravedno zapostavljen i važan materijal, kojim se lako manipuliše i ima značajne prednosti u odnosu na druge konstrukcijske materijale.

Ključne reči: Protiverozioni materijali, ekološki materijali, gabioni, protiverozioni objekti, erozija, vegetacija, metali, žica, kamen

1 INTRODUCTION

Gabions, barbed or synthetic baskets of the different shape and dimensions filled with stone, can be more widely used in the antierosion works, since they have significant advantages over other materials and elements.

There are appropriate norms for the construction of the gabion facilities.

Gabions are used for the close up of the river banks and embankment breaches.

They are used for the consolidation of landslides.

They are used for the construction of roads.

They are used for the protection of the inhabited places in the terrains shaped as uneven parallel bars.

They are used in hydrotechnical forest or agricultural works, i.e. for maintanance of the channel.

They are used for amelioration of the hilly terrains, for hydrotechnical, forest and agricultural works, during the construction of the facilities for the improvement of the slopes and maintanance of the facilities.

They are used for the protection of the roads from rockslide by using the wire of the high resistance.

They are designed for the improvement of the torrent and river basins as: transversal facilities, regulation facilities shaped as letter „T" as well as longitudinal facilities.

2 MATERIAL AND METHODS

Gabions are used for the protection of the river banks and close up of the embankment breaches.

This use is particularly important in the situations such as the ones occured this spring in Banat, Southern Serbia, etc. Owing to the one-hundred-year snow and abundant spring rains, which caused the embankment breach in Romania and Tamish flooding, and long-lasting rains of heavy intensity caused flooding in Vojvodina and other water currents in the vicinity of Vučje and in Resavski and Jablanički Counties, which required the quick reaction, exceeding of embankments and close up of the breaches, and it is most easily achieved exactly by gabions, particularly if they have been already formed and deposed in the vicinity of the critical inhabited places.

Rockslides of the banks and breaches of the slopes do not appear abruptly, but as the consequence of the permanent limited erosion in the form of squints, teardowns, etc. The consequence of the tearing down of the river bank is catastrophic and therefore the timely intervention is necessary in order to avoid catastrophies and consequences. Because of it the importance of material and works by which the appearance of these phenomena are prevented is comprehensible.

The previous experience taught us that the most efficient toll for close up and blocking of the cracks and rockslides are barbed baskets of the paralelopiped type. The ad-

vantage of this type of gabions is reflected in its possibility to be used in all conditions of the water regime, from the river source to the mouth, whether as the intervention of the temporary character or the permanent protective object.

The technique of the work with gabions in rockslide of the river banks and earth damps, consists of throwing the finished elements in the channel, i.e. by the endangered bank. The number and quantity of gabions depend on the size of the rockslide and by them the peak elevation which completely protects the critical place of the bank and embankment must be reached.

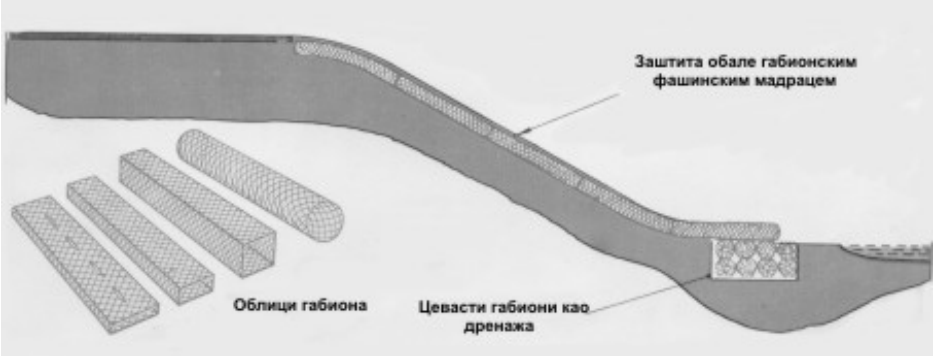
In this situation at the moment of the intervention the finished elements of the smaller dimensions ((2x1x0.5 m and 2x1x1 m) of the paralelopiped shape or 2x0.8 m of the cylindric shape are used.

Table 1 - Dimensions

Open mesh (cm)	Basic dimensions and data					
	Length (m)	Width (m)	Height (m)	Volume (m^3)	Mass of the empty basket (kg/piece)	
Wire Diameter (mm)					2.8	2.5
6x8 cm	2.0	1.0	0.5	1.0	16.4	14.10
	2.0	1.0	1.0	2.0	22.7	19.5
	3.0	1.0	0.5	1.5	22.7	19.5
	3.0	1.0	1.0	3.0	31.5	27.0
Wire Diameter (mm)						
8x10 cm	2.0	1.0	0.5	1.0	15.6	14.7
	2.0	1.0	1.0	2.0	21.5	20.2
	3.0	1.0	0.5	1.5	21.5	20.2
	3.0	1.0	1.0	3.0	29.6	27.8

The smaller elements are easier to be manipulated with, and at the same time there is a possibility of the better arrangement. Throwing and arrangement of the gabions are done from the edge to the centre of the rockslide and by this in the first place the expansion of the opening is prevented.

There is a similar experience in the European neighbouring countries. The interventions of this kind are frequently conducted in the neighbouring Italy, particularly in the Po River and its tributaries, as well as in other water courses.



Picture 1

At fast rivers the greatest danger for the work aimed at the bank protection and for the gabions themselves is the ablation of the material beneath the facility, but particularly here the flexibility of the gabions, which settle and move by closing the flowing and stopping the further ablation of the material, is demonstrated.

The great ability of changing the shape and position of the gabion elements and adaptibility to all possible deformations is an important component of the stability of the facility, even in the effect of the strongest circulations.

The finished gabons are positioned in the different ways: by lowering down the wooden or iron inclined plane, by throwing, tipping from the lorry, etc.

Filling in by gabion elements in the pieces (rintusa) provides the good conditions for construction, on the base of the eventually superstructed facility of the symmetrical geometrical form.

The superstructure can be subsequently shaped by the additional gabion elements, which strengthens the whole facility.

The result of all these processes is that there is a strong likelyhood that the problem of rockslides and breaches on the river embankments will be solved by positioning gabions in the endangered place, immmediately and with the sufficient, previously prepared gabions, which, of course, can be always expected at the critical points of water currents. It should be mentioned that during the construction of gabions and use of them by rivers, seas, highways and other facilities the approriate norms should be applied consistently: on the thickness and quality of the wire, on the way of weaving, assembling and connecting of the gabion elements, as well as on the gabions themselves, filling them by the different stone fractions, during which connecting with as little as possible hollows is recommended, by which the possible, natural settlement with the undesirable consequences, that can appear after a certain period of time, is avoided.

Putting of the barbed trusses, in the longitudinal and transversal sense is obligatory, as well as vertical, if necessary.

Gabions must be safetely connected with the appropriate wire for weaving, before or during filling, by which monolithy of the facility is achieved and the danger of the greater deformations of the base is avoided.

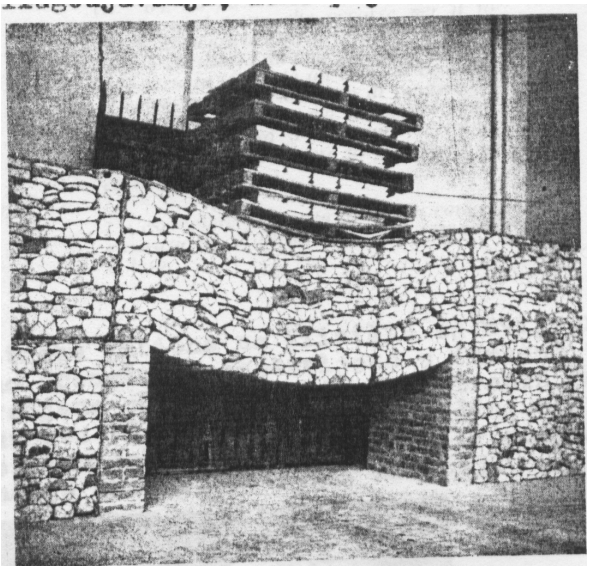
The wide bases and favourable cuts of the facilities should be anticipated by the projects, by which the protection from the pressure and lift is provided, and the danger from erosion and water hit is reduced.

During the transport gabions must not be damaged in no way (zinced layer).

For the protection from abrasion erosion, the front of the gabion is protected by wooden longitudinal beams placed on the facilities or pounded into the ground. The gabions which are in contact with the sea water must be controlled at least once in half a year. These facilities can be protected also by pounding wooden pilots, between which boards are placed, by which the runoff of the smaller fractions is prevented. The minimal free high of the pilot is 25-30 cm.

3 RESULTS OF THE RESEARCH AND DISCUSSION

Load testing on the gabions dimensions 3x1x1 m, mesh open 8x10 cm, diameter 2.7 m, filled with 3m3 , filled with 3m3 pebbles of the total mass 5,400 kg and loaded with 7,800 kg of zinced and lead boards, showed that the wire did not broke and no damage occured:



Picture 2

$f_p = F/P;$
$f_p = 0.26$ kg/cm^2
F – load (kg)
P – area (cm^2)

Because of this feature and drainage ability, gabion facility is the most economical of all known systems and types for the overhaul of landslides.

The low cost provides a wide use of numerous facilities such as:

- drainage of the supporting walls
- channel lining
- partition of the water courses, etc.

Gabions are frequently used for consolidation of soil. It is known that the attempts were made in the past and in the present to solve the problem of landslides by massive retaining walls which should by its mass resist the lift of the Earth mass in motion.

Frequent failures of such landslide by concrete and stone walls in cement mortar, owining to breaking of them and dysfunction, led to extraction of the drainage systems, in order to extract water as the main cause of landslide, as well as to the combination of the retaining walls and drainage.

The result of this experience is the use of the gabion facilities with the drainage ability are as efficient as the retaining walls, and overcome the shortcomings of the both systems.

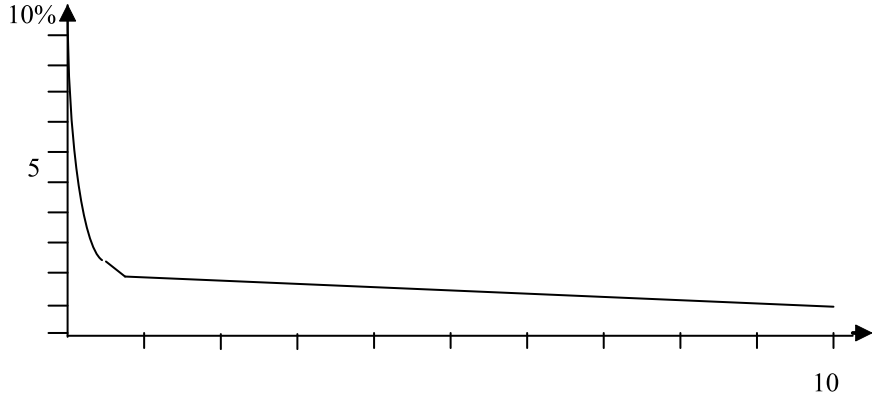
The gabion buildings have appeared as the ideal solution, and this topic is particularly relevant this spring, owining to the long and cold winter and great quantitity of precipitation, which caused the massive occurence of the landslides in Serbia and particularly endangered the highways.

It is possible to accelerate to a certain extent the methods of interventions within the previosly determined compensation fall by system of gabion brinks used for fixing the channel in the first phase of the maintanance.

Among the systems for calculation of the compensation fall the most practical is the comparison of the parts of the channels which is intended for the improvement, with the parts where the works were done previously or where water current is stabilized in a natural way. In this way by procession of numerous data and long-time experience in our conditions two graphs are suggested.

The first graph refers to the water courses which carries the material of the greater dimensions. Curve is the medium value of the falls in the adapted water courses of the river basins up to 10km2. Another graph refers to the basins which carries the material of the smaller dimensions, i.e. small gravel, sand and mud.

The studies must be conducted more carefully during the works in the basins of the greater importance, in order to prevent building of the immobile and reduntant facilities, which, above all, can cause the undesirable consequences.



Graph 1- Determination of the compensation fall for silt smaller than 15cm

Gabions easily adapt to the changes of the conditions and acting forces in the landslide, they are elastic and they pose no danger to the stability and functionality of the total solution, whereas concrete walls break, and dry walls tear down and fall.

The practice showed that gabion facility is able to resist all the forces: pressure, strain, torsion, etc. Therefore, it is hard to find such a facility which reached the level of delapidation, even it were poorly done. It should be said that the gabion norms must be strictly followed, regarding the quality of the used material and the way in which the elements are connected during construction and their protection by the additional trusses.

The explanation is simple when it is known that the deformation spread to some gabion elements and that the facility gain the characteristics of the reinforced concrete structure with the great possibility of authomatic adaptation, both of some baskets and the stone in it. This characteristic and drainage ability give the advantage to the gabion facilities over the all other system of overhauling of the landslides.

The low cost provides a wide use for the great number of facilities such as:

- Drainage of the supporting walls
- Channel lining
- Partition of water courses, etc.

It must be emhasized that during the drainage of the landslids by gabions, block of the perforated concrete elements is placed in the solid terrain, below the all surfaces of

landslides (if there are more of them). By this the bottom of drainage is made impereable as well. On the stone base it is enough to make only loose stone dum.

4 CONCLUSIONS

Gabions are irreplaceable for both the retaining walls, established on the stable ground, and smaller walls, during modelling of landslide area, with the foundations in the landslide body. These facilities can be deformed but do not lose its efficiency, except in the case of the catastrophies.

The retaining-drainage gabion wall is characteristic, since it provides the weak air crculation regarding drainage of the ground behind the facility, it sustains the changes of the forces and pressure and elastically deformed in the extreme conditions, in contrast to other constructive facilities which fall down frequenly.

The gabions are also frequently used for other surface facilities: kinetic components and channels for collection and water divert from the landslide body, for the aforesaid reasons. Gabion cover is easy and economical construction, with small consumption of wire and stone material from the place of construction and the vicinity of it, which is cheaper than building of the dry walls.

Gabion layer can be easily covered by earth and planted by seed, or the spontaneous vegetation is given a chance to form the layer of its own and thereby protect the soil from erosion for a long period, by which the important ecological and aestethical characteristics are also achieved.

By gabions the channels are also lined and steps are made, particularly when the channel has the greater fall, by which the velocity of water, shear force and damage of the facility are reduced.

During the overhaul of the landslides the smaller water courses, which flow by their legs and are the causes of their occurence, are improved most frequenly. Often only one bank is shaped as uneven parallel bars, so in this environment, stiff transversal constructions break and lose its function, in contrast to the elastic gabion constructions. Therefore, the known systems of partitions, which take effect, are made of them. It is most important for gabion wire to be of high quality and long-lasting, since it is subject to abrasion by silt, which is easily achieved, and the proof of it are about one-hundred-year old facilities. The facility easily adapts to the terrain and is seized and enhanced by vegetation, before the abrasion process are dominant, and such places can be easily and cheaply overhauled and kept in good conditions.

After the final settlement of the facility, the topping is covered with the thin layer of concrete and by it the reinforced concrete structure is achieved.

This is not to be understood as the proof that gabion facilities are unique and irreplaceable, but as the attempt to draw attention of the professionals and scientists to the peculiarities and advantages of this material and its constructions.

LITERATURE

K r u e d e n e r , A . (1950): Ingenieur – Biologia. Reinhardt Werlag, Munchen/Basel.

K o h n k e , B . (1972): Soil conversion, Svjetlost, Sarajevo.

M a t i ć , V. (1999): Antierosion protection and slope improvement along comunication lines. Monograpf, Environmental protection of urban and suburban settlements, Vollume II, Novi Sad.

Matić, V., Ille, N. (1999): The use of different materials for lining of small water currents and their influence on the environment, Ekologija, Belgrade.

Matić, B. (2000): Modern antierosion materials, Monograph, Faculty of Forestry, Belgrade.

THE ADVANTAGE OF USING GABIONS IN THE ANTIEROSION WORKS IN SERBIA

Vjačeslava Matić

Summary

The stiff antierosion, regulation and protective facilities, made of classic construction material (concrete, stone, wood, etc), as a rule break and lost their function owing to the changes of the natural conditions and acting forces and components: soil, water regimes, pressures, lifts, undermining, landslides, cliffs, uneven resistance of the banks, etc.

Only elastic, flexible, durable and eco-friendly gabion facilities, which quickly adopt to nature, surrender to vegetation (the only real antierosion protection), and are cheap, represent the real, permanent and efficient solution to numerous problems of erosion-torrential science and profession.

PREDNOST PRIMENE GABIONA U PROTIVEROZIONIM RADOVIMA SRBIJE

Vjačeslava Matić

Rezime

Krute protiverozione, regulacione i zaštitne građevine, od klasičnih konstrukcijskih materijala (beton, kamen, drvo i dr.), zbog promene prirodnih uslova i reagujućih sila i činilaca: zemljišnih, vodnih režima, pritisaka, potisaka, potkopavanja, kliženja, urvanja, nejednake otpornosti obala i dr., po pravilu pucaju i gube funkciju.

Samo elastične, fleksibilne, trajne i ekološke, gabionske građevine, koje se brzo uklapaju u prirodu i prepuštaju vegetaciji (jedinoj prirodnoj protiverozionoj zaštiti, a pored toga su i jevtine, predstavljaju prava, trajna i efikasna rešenja mnogih problema erozionističko-bujičarske nauke i struke.

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STEM PROFILE MODELING USING NEURAL NETWORKS

Pero Radonja[1]

Abstract: Stem profile modelling by neural networks, NN, by method based on the artificial intelligence is presented in this paper. The programs *newff, train* and *sim,* which are part of the program package MATLAB were used. The method of obtaining stem profile models or stem profile functions based on the use of NN, was illustrated with several examples. Since the modelling is based on the use of modified Brink's function, MBF, proved to be most suitable method until now, we compared these two methods. The size of the standard error of modelling was the base of the comparison. The data from the enclosed tables show the superiority of the modelling method based on NN.

Key words: stem profile function, neural networks, standard error of modeling, stem volume.

MODELIRANJE PROFILNE FUNKCIJE DEBLA POMOĆU NEURONSKIH MREŽA

Izvod: U radu je prikazano modeliranje profilne funkcije debla pomoću neuronskih mreža, NM, odnosno pomoću postupka baziranog na veštačkoj inteligenciji. Iskorišćeni su programi koji se nalaze u programskom paketu MATLAB. Postupak dobijanja modela profilne funkcije na osnovu korišćenja NM, ilustrovan je sa više primera. S obzirom da se do sada kao najpogodniji postupak pokazalo modeliranje bazirano na primeni modifikovane Brinkove funkcije, MBF, uporedili smo ova dva postupka. Veličina standardne greške modeliranja bila je osnov poređenja. Podaci iz priloženih tabela jasno pokazuju superiornost postupka modeliranja baziranog na NM.

Ključne reči: profilna funkcija debla, neuronske mreže, standardna greška modeliranja, zapremina debla.

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Translation: Marija Stojanović

1 INTRODUCTION

It is clear that in the practice the real stem profile (morphological curve), must be presented analytically, i.e. approximated with some function. In this paper the approximations of the real stem profile, i.e. *stem profile functions* are obtained in two ways.

The method of obtaining profile function based on the use of neural networks, NN, (of the appropriate configuration) i.e. artificial intelligence is presented in a great detail. The basic data on the profile functions obtained by use of the classic method based on the use of the modified Brink's function, MBF, are also presented.

Accuracy of stem profile modeling is obviously of a great importance in the forestry, which is reflected in numerous papers related to this topic which have been published so far. For instance: Max and Burkhart, 1976; Kozak, 1988; Riemer et al., 1995; Bi, 2000; Kozak, 2004; Rojo et al., 2005; Radonja et al., 2005a, etc. Artificial intelligence is also widely used for modeling of different biological processes (Zhang et al., 2000; Radonja et al., 2003; Radonja et al., 2004; Radonja et al., 2005b; Hanewinkel, 2005, etc.). The programs which refer to NN were used from the voluminous program package MATLAB (Beale, 1993). The programs which define, train and test NN were used. It is needed to define the input parameters which depend on the practical usage and readily available data.

2 MATERIAL AND METHOD

2.1 Data

The data used in this paper refer to 31 even-aged spruce stands (*Picea abies* L. Karst.) from the region of Bosnia (Maunaga, 1995). The measurements were made on one or two trees from each stand, so there are 42 trees in total, and on each tree 13 pairs of data were measured (diameter-height). Diameter was measured on very surface (zero level), at breast height, of the same relative heights, (Hohenadl sections, *0.1H, 0.3H,....,0.9H*) and some other characteristic stem heights (lengths). The studied stands are situated at the altitude of 550-1350 meters, and the age of the tree ranges from 12 to 130 years. Site quality ranges from I to V. The sizes of the sample plots depend on the number of trees per ha and age of the trees and range from 0.05 and 0.5 ha.

The basic data of some trees (tree stem), height, radius (measured diameter/2) at breast height, age, and the habitat altitude, depending of the ordinal number, are presented in the Tables 1-4.

Table 1 - Basic data of the trees, ordinal number 1-10

Sprouce, Ordinal number N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Age [years]	130	127	105	103	100	95	90	81	68	63
Height *H* [m]	32.6	29.7	29.8	28.31	34.1	36.15	29.2	24.22	19.7	19.95
Radius, *d*/2 [cm]	21.6	21.6	16.95	16.2	24.2	17.4	14.7	15.0	12.1	9.45
Altitude [m]	1, 350	1,300	1,000	1,000	1,060	1,000	900	1,260	900	900

Table 2- Basic data of the trees, ordinal number 11-20

Sprouce, Ordinal number N	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Age [years]	56	53	50	44	39	36	33	30	16	14
Height *H* [m]	19.5	18.7	21.6	19.8	16.5	16.3	15.7	13.2	6.3	5.8
Radius, *d*/2 [cm]	9.2	10.4	9.0	8.6	9.0	6.9	6.7	6.7	3.5	3.0
Altitude [m]	1,300	1,160	1,000	900	1,000	950	1,050	990	550	635

Table 3- Basic data of the trees, ordinal number 21-30

Sprouce, Ordinal number N	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Age [years]	12	97	130	127	88	85	92	70	67	82
Height *H* [m]	5.65	35.0	31.45	30.6	34,82	34.35	34.52	29.5	28.10	25.50
Radius, *d*/2 [cm]	4.4	23.5	21.65	21.35	17.55	17.90	17.40	17.3	17.20	15.90
Altitude [m]	800	1,060	1,350	1,300	1,000	1,000	1,000	1,100	1,100	1,260

Table 4 - Basic data of the trees, ordinal number 31-42

Sprouce Ordinal number N	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**
Age [years]	84	86	71	71	83	82	47	72	83	53	54	78
Height *H* [m]	25.18	31.44	27.2	26.45	24.36	22.50	21.01	26.80	23.15	22.46	22.38	20.40
Radius, *d*/2 [cm]	14.95	14.30	14.2	14.15	14.10	14.10	10.85	14.00	13.60	13.35	13.00	12.10
Altitude [m]	1,260	900	1,050	1,050	1,260	1,270	1,000	1,080	1,270	1,155	1,155	900

2.2 Method

In this paper the focus of attention is the determination of the profile function by applying NN. For each tree, i.e. obtained profile function, the standard errors of modelling will be calculated. Also, we will present the results of the application of the classic method, i.e. value of the standard error of modelling of profile functions obtaining by the use of MBF, (Riemer et al.,1995; Radonja et al., 2005a).

In order to apply NN, we need to configure it first. Configuration of NN is done by **newff** program (Beale, 1993). From experience, for this problem, we choose the number of the layers of the NN and form of the transfer, i.e. activation function of the individual neuron. For training, i.e. learning of NN we will use Levenberg-Marquardt algorithm. In this way we have defined all parameters relevant to the configuration feed-forward NN. This network implies that we bring the data to its entrance, and that the coefficient adjusting is done by feedback from the exit.

The procedure of training is performed by another special program, **train,** which is stopped when the assigned total error of training is achieved. This program can also

be stopped by specification of the maximum number of steps of estimation, EPOCHS. Testing of NN, i.e. of the obtained profile function is done by program **sim,** which the parameters are: trained NN and arbitrary entrance data.

3 PROCEDURE OF OBTAINING PROFILE FUNCTION

The procedure of obtaining profile function can be divided in three phases. In the first phase the parameters of program ***newff*** are defined. It is in the first place the range of the values of the input data, the number of layers and number of neurons per NN layers, the type of neuron (*tansig* or *purelin)* and training method (*trainlm* or some other). In the analyzed case it is needed to apply two-layer NN with two *tansig* neurons in the hidden layer (Haykin, 1994). *Tansig* neuron has hyperbolic tangent sigmoid transfer function. The stated problem can be solved in two-dimensional space, so the greater number of NN layers is not needed. One *tansig* neuron can not provide real variability of the profile function, whereas three neurons introduce the variability which do not exist in real profile functions. In the output layer of NN we will use one neuron with linear transfer function.

In addition, it is needed to define how frequently (after how many steps, iterations) the current value of the training error is to be shown, *trainParam.show*, what is the size of the adjusting step (size of the adjusting increment) *trainParam.lr*, maximum number of adjusting steps *trainParam.epochs,* and target size of the training error *trainParam.goal.* It is clear that the training procedure finishes before the maximum number of adjusting steps is achieved, if the target error is achieved earlier. If the training method fails, i.e. the target error is not achieved, the procedure is finished after the maximum number of adjusting steps. At the end of the first phase we have **c**onfigured NN by **o**rdinal **n**umber, *ON*, *netCNNON*.

In the second phase program ***train,*** with three input parameters, vectors, is used. The first parameter is NN, *netCNNON,* with the set of the initial coefficients. The input vectors are also input data, height vector and radius vector. Training of the specified, configured NN is done with 13 measured pairs of data, height-radius. Upon the training procedure, the trained NN, *netTNNON*, is obtained.

Testing of the trained NM, *netTNNON* is done in the third phase by the program ***sim,*** for which the input parameters, vectors, *netTNNON,* and new input data vector, are indepent variables. In the aim of the accurate realization of the form of the profile function we use a few hundred, and even thousand, input data representing independent variable.

4 ILLUSTRATING OF THE PROCEDURE OF OBTAINING PROFILE FUNCTIONS

We will illustrate the procedure of obtaining concrete profile functions with the data which refer to a 130-year-old and an 83-year-old spruces. The basic data for these spruces are given by ordinal numbers 23 and 39 in the Tables 3 and 4.

Depending on the initial coefficients which depend on the configured NN and values generated by generators of the random numbers, in the case of 130-year-old spruce, the course of NN training can have different forms, which is presented in figures 1 and 2.

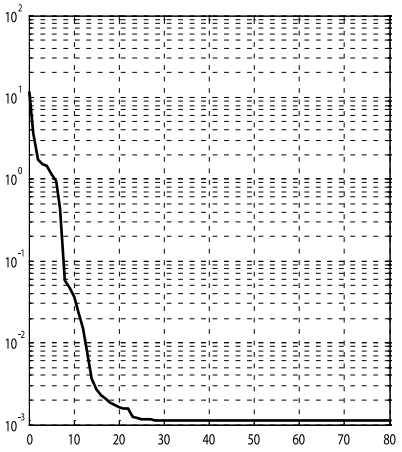

Fig. 1- Training error (I case)

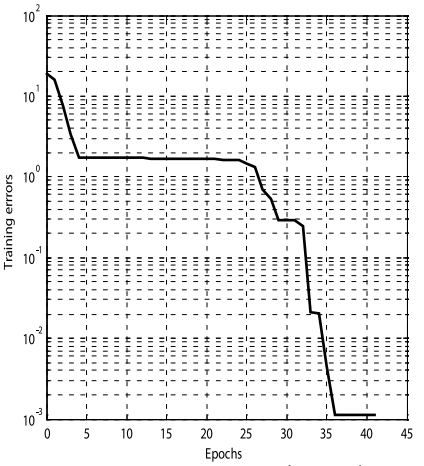

Fig. 2- Training error (II case)

At the end of the training procedure, the training errors in both cases have similar values, about 10^{-3}, and the obtained profile functions are very similar, which is presented in Figs. 3 and 4. The modelling error of the profile function presented in Fig. 3 is 0.1683, which is almost half the size of the error when MBF is used, which is 0.3378, as presented in the table 7, by the ordinal number 23.

Modelling errors in Fig. 5 range between -0.5 and +0.2, whereas the symmetrical limits of the of the maximal error in Fig. 6 range between -0.3 and +0.3. However, the initial values of the coefficients can be such that the training error converges to significantly greater value, as it is presented in Fig. 7, where it reached only $4 \cdot 10^{-1}$, therefore 400 time greater value. If the training procedure fails, the linear profile function is obtained, Fig. 8.

Now we are going to simultaneously observe the successful and unsuccessful modellings for a 83-year-old spruce. The successful training procedure of NN is presented in Fig. 9. We see that at the end of the training procedure, training error (sum of the squared errors in all points of adjustment) is about $3 \cdot 10^{-4}$. When the training procedure fails, Fig. 10, the training error is approximately $3 \cdot 10^{-2}$, i.e. about 100 times bigger.

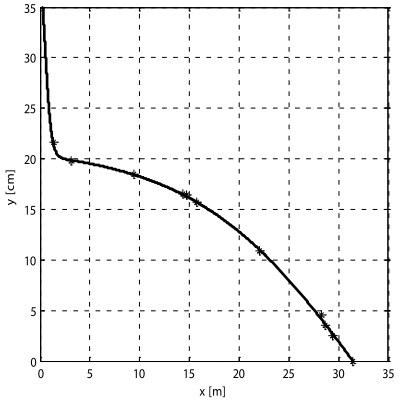

Fig. 3- Profile function (I case)

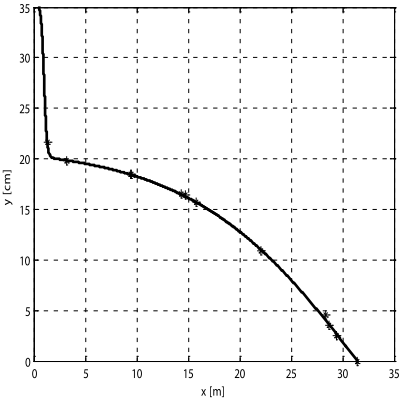

Fig. 4- Profile function (II case)

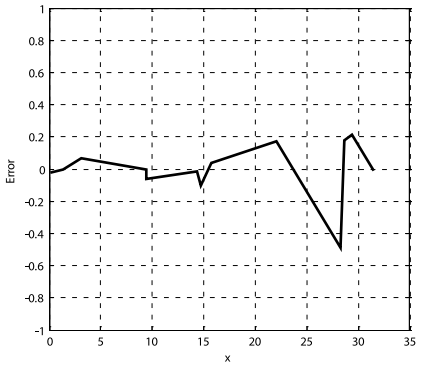

Fig. 5- Modelling errors (I case)

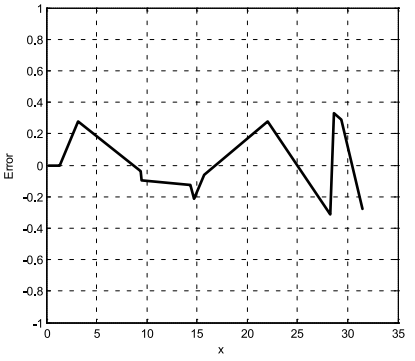

Fig. 6- Modelling errors (II case)

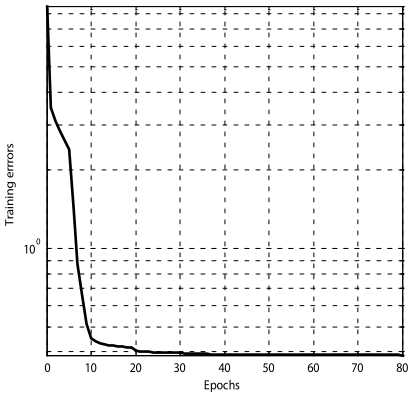

Fig. 7- Training error

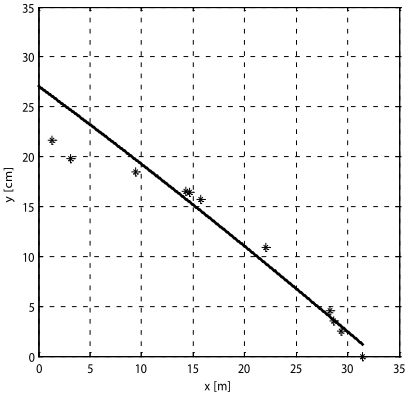

Fig.8- Profile function

(training procedure failed)

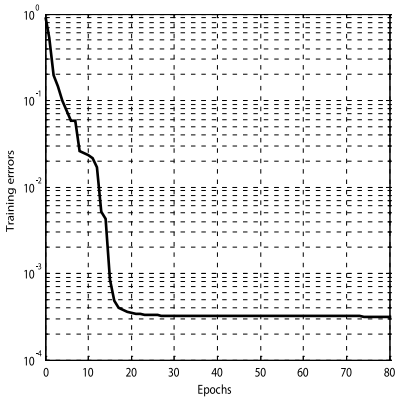

Fig. 9- Training error

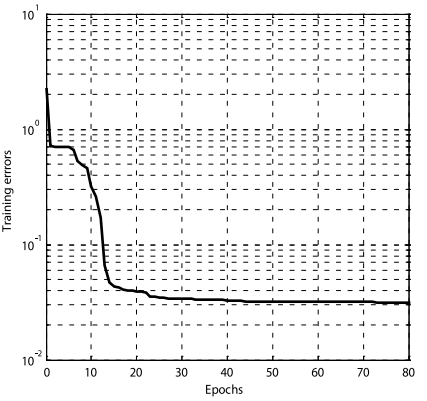

Fig. 10- Training error

(training procedure failed)

In Fig. 11 the obtained profile function which has the standard modelling error 0.0891, which is almost half size of the error obtained when MBF is used, which is 0.1746,

as it is presented in Table 8, by ordinal number 39. When the training procedure fails, the profile function has very slightly convex shape, which is presented in Fig. 12.

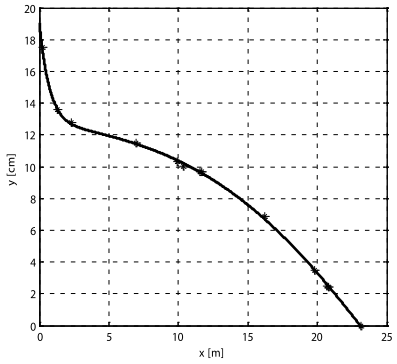

Fig.11- Profile function (83-year-old spruce)

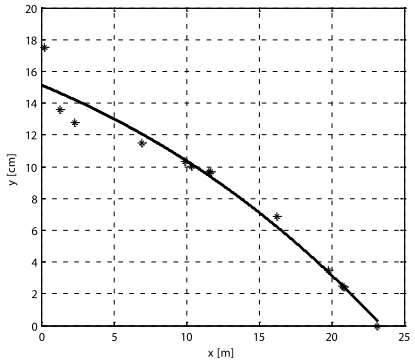

Fig. 12- Profile function (training procedure failed)

The individual modelling errors are presented in Figs. 13 and 14. When the training procedure fails, modelling errors are approximately ten times bigger.

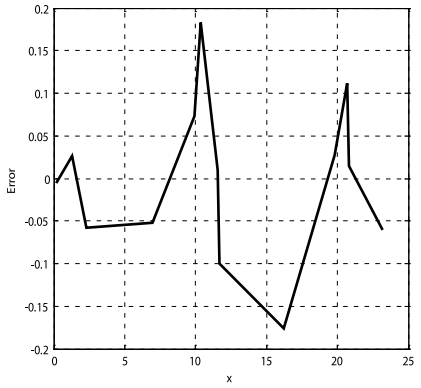

Fig. 13- Modelling errors

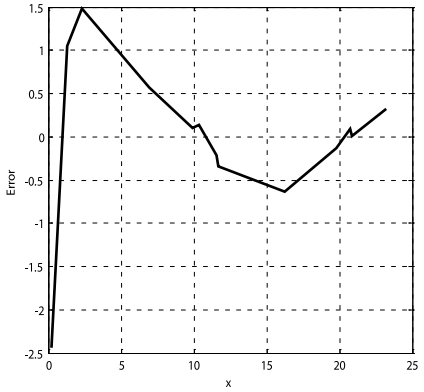

Fig. 14- Modelling errors (training procedure failed)

5 REZULTS

In the previous chapter the method of obtaining profile functions for two spruce trees was presented. Likewise, the modelling standard error of the models obtained in this way, ***Sem*[NN],** was compared with the ***Sem*[MBF],** when the profile function was obtained by application of MBF. In the following Tables, Tables 5-8, the modelling standard errors for the profile functions obtained by both aforesaid methods for the all analyzed spruce trees are presented.

Table 5- Size of the modelling standard error, ordinal numbers , 1-10

Spruce, Ordinal number N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Sem[NN] [cm]	0.335	0.099	0.226	0.1544	0.2580	0.1500	0.089	0.068	0.087	0.0785
Sem[MBF] [cm]	0.3880	0.2910	0.2610	0.1708	0.3850	0.4000	0.094	0.148	0.156	0.0908

Table 6- Size of the modelling standard error, ordinal numbers , 11-20

Spruce, Ordinal number N	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Sem[NN] [cm]	0.065	0.0571	0.0707	0.1718	0.0897	0.0595	0.0983	0.0638	0.0651	0.0399
Sem[MBF] [cm]	0.1726	0.0938	0.1263	0.3470	0.1072	0.079	0.122	0.0721	0.0897	0.0463

Table 7- Size of the modelling standard error, ordinal numbers 21-30

Spruce Ordinal number N	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Sem[NN] [cm]	**0.0793**	**0.2299**	**0.1683**	**0.1300**	**0.2341**	**0.1263**	**0.0697**	**0.1288**	**0.1422**	**0.0861**
Sem[MBF] [cm]	**0.1355**	**0.2613**	**0.3378**	**0.2204**	**0.2967**	**0.1516**	**0.0859**	**0.1341**	0.1658	0.0937

Table 8- Size of the modelling standard error, ordinal numbers 31-42

Spruce Ordinal number N	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**
Sem[NN] [cm]	0.1138	0.1166	0.1045	0.1456	0.0411	0.1145	0.1092	0.0787	0.0891	0.0957	0.0729	0.0622
Sem[MBF] [cm]	0.2596	0.2095	0.1182	0.1647	0.0861	0.1226	0.3024	0.1881	0.1746	0.0987	0.3251	0.0684

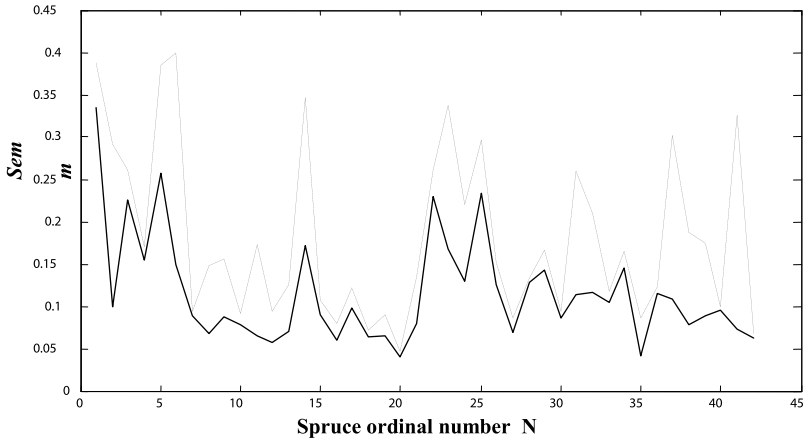

Fig. 15- Sem[NN] and Sem [MBF] for all the observed trees

The analysis of the results presented in Tables 5-8 show that there are several cases when ***Sem*[NN]** is between 2.5 and three times smaller than ***Sem*[MBF]**, the spruce by

ordinal numbers 2, 6, 11 and 37. Also, there are several cases when ***Sem*[NN]** is two times smaller than ***Sem*[MBF]**, the spruce by the ordinal numbers 8, 14, 23, 31, 32, 35, 38 i 39. The superiority of the method based on the application of NN with regard to the size of ***Sem*** is most easily perceived when they are graphically presented in the same picture ***Sem*[NN],** solid line and ***Sem*[MBF],** dotted line, for all the observed trees, as it is done in Fig. 15.

6 CONCLUSION

The base for comparison of the stem profile models, i.e. stem profile functions, obtained by using neural networks and modified Brink's function, was the size of the standard modelling error. The analysis of the obtained results shows the superiority of models based on neural networks. The smaller standard modelling error is the result of the fact that the hyperbolic tangent sigmoid function in models based on the use of neural networks better approximates the biological process than the exponential functions which are used in modified Brink's function.

LITERATURE

Beale, M. (1993): Neural Network Toolbox, Version 6.0.0.88, Release12, September 22, 2000, MATLAB 6 R12.

Bi, H. (2000): Trigonometric Variable-Form Taper Equations for Australian Eucalypts. Forest Science 46 (3) : 397-407.

Hanewinkel, Marc (2005): Neural networks for assessing the risk of windthrow on the forest division level: a case study in southwest Germany, European Journal for Forest Research, Number 124 : 243-249.

Haykin, S. (1994): Neural Networks: A Comprehensive Foundation, Macmillan College Publishing Company, New York. 696 p.

Kozak, A. (1988): A variable-exponent taper equation, Can J For Res 18: 1363-1368.

Kozak, A. (2004): My last words on taper equation. For Chron 80 (4): 507-515.

Maunaga, Z. (1995): Productivity and structural characteristics of same-age stands of spruce in Republic Serbian, Ph. thesis, Univ. of Belgrade, Faculty of forestry, Belgrade, (in Serbian with English abstract). 170 p.

Max, T.A., Burkhart, H.E. (1976): Segmented polynomial regression applied to taper equations, Forest Science 22(33), pp. 283-289.

Radonja, P., Koprivica, M., Lavadinović, V. (2003): Modeling current annual height increment of young Douglas-fir stands at different sites, P.249-257 in Modelling Forest Systems A. Amaro, D. Reed and P. Soares (eds.) CABI Publishing**,** Wallingford, UK.

Radonja, P., Stankovic, S., Popovic, Z. (2004): Specific Process Models Obtained From General Ones**,** WSEAS TRANSACTIONS on SYSTEMS**,** Issue 7(3) Sept.2004, Pub. by WSEAS Press, Athens, Greece, : 2490-2495.

Radonja, P., Koprivica, M., Matović, B. (2005a): Application of modified Brink's function in stem profile and volumes modeling. Forestry, N^{0}4, Vol. (LVII): pp. 1-10. *(Original- Primena modifikovane Brinkove funkcije za modeliranje profila i zapremine debla, Šumarstvo, N^{0}4,Vol.(LVII): pp.1-10)*

Radonja, P., Stanković S., Koprivica M., Matović, B (2005b): Neural networks in the modelling of the process with the extremely different exponen-

tial functions. Proceedings of the XIII Telecommunication forum TELFOR 2005, November 22-24th, CDROM, Belgrade. *(Original- Neuronske mreže u postupku modeliranja procesa sa izrazito različitim eksponencijalnim zakonitostima, Zbornik radova XIII Telekomunikacionog foruma TELFOR 2005, 22-24. novembra).*

Riemer, T., von Gadow, K., Sloboda., B. (1995): Ein Modell zur Beschreibung von Baumschaften, Allg Forst Jagdztg 166(7): 144-147.

Rojo, A., Perales, X., Sanchez-Rodriguez, F., Alvarez-Gonzalez, J.G., von Gadow, K. (2005): Stem taper functions for maritime pine (*Pinus pinaster* Ait.) in Galicia (Northwestern Spain). Eur J Forest Res 124 : 177-186.

Zhang, Qi-Bin, Richard J. Hebda, Qi-Jun Zhang, and Rene I. Alfaro (2000): Modeling tree-ring growth responses to climatic variables using artificial neural networks. Forest Science, 2(46) : 229-239.

STEM PROFILE MODELING USING NEURAL NETWORKS

Pero Radonja

Summary

Stem profile modelling was performed by the method based on the artificial intelligence, i.e. by neural networks, NN. The programs *newff, train*, and *sim*, which are part of the programme package MATLAB were used. The method of obtaining model of stem profile based on the application of NN, is illustrated with two examples, of the spruces 130-year-old and 83-year-old. The data used in this paper refer to 31 even-aged spruce stands (*Picea abies* L. Karst.) from the region of Bosnia (Maunaga, 1995). The measurements were made on one or two trees from each stand. There are 42 trees in total and 13 pairs of data, diameter-height, were measured on each tree. The studied stands are situated at the altitude of 550-1350 meters, and the age of the tree ranges from 12 to 130 years. Site quality is between I and V. The sizes of the sample plots depend on the number of trees per **ha** and age of the trees and range from 0.05 and 0.5 **ha**. Since the modelling based on the application of the modified Brink's function, MBF, has proven to be the most suitable method so far, we compared these two methods. The size of the standard error of modelling was the base of the comparison. The data from the enclosed Tables as well as their graphic presentation clearly demonstrate the superiority of the modelling method based on NN. The smaller standard modelling error in models based on the use of NN is the result of the fact that hyperbolic sigmoid function better approximates the biological process than the exponential functions which are used in modified Brink's function.

MODELIRANJE PROFILNE FUNKCIJE DEBLA POMOĆU NEURONSKIH MREŽA

Pero Radonja

Rezime

Modeliranje profilne funkcije debla izvršeno je pomoću postupka baziranog na veštačkoj inteligenciji odnosno pomoću neuronskih mreža, NM. Iskorišćeni su programi *newff, train* i *sim*, koji se nalaze u programskom paketu MATLAB. Postupak dobijanja

modela profilne funkcije na osnovu korišćenja NM, ilustrovan je sa dva primera, smrča starosti 130 i 83 godine. Podaci koji se koriste u ovom radu potiču iz 31 jednodobne sastojine smrče (*Picea abies* L. Krast.) iz regiona Bosne. Merenja su obavljena na jednom ili na dva stabla iz svake sastojine. Ukupan broj stabala iznosi 42 i na svakom stablu izmereno je 13 parova podataka, prečnik-visina. Posmatrane sastojine nalaze se na nadmorskim visinama od 550-1.350 metara a starost stabala je od 12 do 130 godina. Bonitet staništa se kreće u granicama od I do V. Veličine oglednih površina zavise od broja stabala po hektaru i od starosti stabala i kreću se od 0.05 do 0.5 ha. S obzirom da se do sada kao najpogodniji postupak pokazalo modeliranje bazirano na primeni modifikovane Brinkove funkcije, MBF, uporedili smo ova dva postupka. Veličina standardne greške modeliranja bila je osnov poređenja. Podaci iz priloženih tabela kao i njihova grafička prezentacija jasno pokazuju superiornost postupka modeliranja baziranog na NM. Manja standardna greška modeliranja kod modela baziranih na primeni NM javlja se zbog toga što tanges hiperbolična sigmoidna funkcija bolje aproksimira biološki proces od eksponencijalnih funkcija koje se koriste kod modifikovane Brinkove funkcije.

Reviewer: Prof. Srđan Stanković, PhD, School of Electrical Engineering, Belgrade, Serbia

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GENERALIZED STEM PROFILE MODEL BASED ON NEURAL NETWORKS

Pero Radonja[1]

Abstract: Generalized stem profile model is used in forest inventory and serves for the more accurate determination of volume and assortment structure of standing trees and whole stands in some region. It is suggested in this paper that the generalized model should be obtained as the mean value of the normalized, individual, separate profile function models. The individual models are obtained by the use of neural network, NN, for which the programs from the program package MATLAB were used. The volumes based on the generalized model obtained in this way were also calculated, and then the referent volumes were calculated in a separate way. The referent volumes were calculated by the use of profile functions obtained by the application of modified Brink's function, MBF. The values of the volumes obtained in these two different way, were compared by regression method, for all the trees in the observed region.

Key words: generalized stem profile function, neural networks, standard modelling error

GENERALIZOVAN MODEL PROFILNE FUNKCIJE DEBLA BAZIRAN NA NEURONSKIM MREŽAMA

Izvod: Generalizovan model profilne funkcije debla nalazi primenu kod inventure šuma i služi da se što tačnije odredi zapremina i sortimentna struktura dubećih stabala i celih sastojina u nekom regionu. U ovom radu predloženo je da se generalizovan model dobije kao srednja vrednost normalizovanih individualnih, pojedinačnih modela profilne funkcije. Individualni modeli su dobijeni koristeći neuronske mreže, NM, pri čemu su korišćeni programi koji se nalaze u programskom paketu MATLAB. Izračunate su zapremine na bazi ovako dobijenog generalizovanog modela a zatim posebno i referentne zapremine. Referntne zapremine su izračunate koristeći profilne funkcije koje su do-

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bijene na bazi modifikovane Brinkove funkcije, MBF. Regresionim postupkom izvršeno je za posmatrani region, poređenje veličina svih ovako dobijenih zapremina.

Ključne reči: generalizovana profilna funkcija debla, neuronske mreže, standardna greška modeliranja.

1 INTRODUCTION

Generalized stem profile model, GSPM, is usually calculated for some region, because of which it is often called regional stem profile model. This method implies that the generalized model is obtained as the mean value of all the normalized individual, separate, profile function models. The individual models are obtained by the use of neural network, NN, for which the programs from the program package MATLAB, (Beale, 1993) were used. It should be mentioned that there are increasingly number of papers in which NN are used for the modelling of the different biological processes (Zhang et al., 2000; Radonja et al., 2003; Radonja et al., 2004; Hanewinkel, 2005; Radonja et al., 2005b, etc.).

GSPM is used for forest inventory and serves for the more accurate determination of volume and assortment structure of the standing trees and whole stands. The most popular papers which deals with this topic are (Hui and Gadow, 1997) and (Korol and Gadow, 2003). The generalized models are also elaborated in other papers (Radonja et al., 2006a; Radonja et al., 2006b; Matovic et al., 2007). The object is to find GSPM for the observed region which enables the calculation of the approximate values of the individual profile functions.

It is clear that the individual profile functions, obtained only by using GSPM and basic measured stem values, *diameter at breast height,* ***d,*** and *total height,* ***H,*** deviate from the original individual profile function obtained by the detailed measurement of stem. The approximate values of these functions enable the calculation of the approximate values of the individual volumes as well as the volumes of the whole stands. The satisfactory accuracy of the calculated volume enables the successful forest inventory and optimal usage of the forest resources.

Individual volumes deviate from the real volumes. Nevertheless, as it will be presented, these deviations are of the different directions, so the partial cancellation of the introduced (induced) errors occur. The stand volume calculated on the base of the generalized model was considerably more accurate than the one calculated by the use of some other methods, which are also based on only known, measured, basic stem values, i.e. tree stem.

2 MATERIAL AND METHOD

2.1 Data

The observed set of data is made of the data collected from 31 even-aged spruce stands (*Picea abies* L. Karst.) from the region of Bosnia (Maunaga, 1995). The observed stands are situated at the altitude of 550-1,350 meters, and the age of the tree ranges from 12 to 130 years. The measurements were made on one or two trees of each stand. Since 13 pairs of data were measured on each tree and the total number of trees is 42, there are

546 pairs of data (diameter-height). Site quality ranges between I and V, and the sizes of the sample plots depend on the number of trees and range between 0.05 and 0.5 ha.

In Figs. 1 and 2 the values of the total height of trees and radius at breast heights as a function of age are presented.

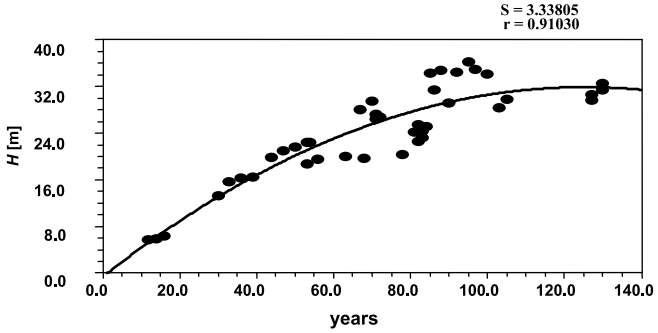

Fig. 1- Tree heights as a function of age

The graphical review of the profile function actually refers to the dependence of radius on the tree height. It should be remarked that there is no function of the dependence of diameter at breast height on the height, stem length. Because of it, the radii calculated according to the measured, readily available diameters at breast height are presented in Fig. 2.

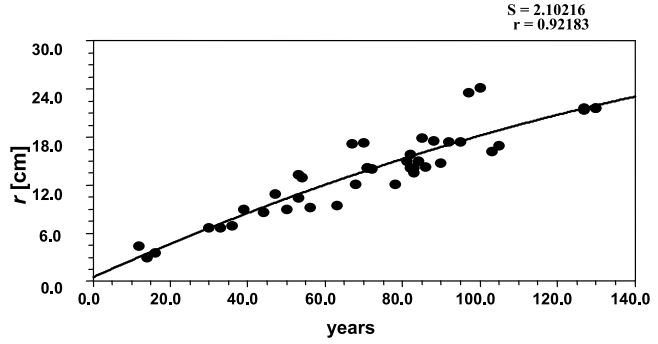

Fig. 2- Radii at breast height as a function of age

In the following Table (Table 1) the basic statistical values of the total height ***H*** and diameter at breast height, ***d*,** of the observed data set are presented.

Table 1- The basic statistical values of the total height, ***H*** *and diameter at breast height,* ***d****, of the observed data set.*

	H [m]	***d*** [cm]
Minimum	**5.65**	**6.0**
Maximum	**36.15**	**48.4**
Average	**24.28**	**27.57**
Standard deviation	7.86	10.58

The survey of the altitudes at which the measured trees are situated is presented in Fig. 3. It can be seen that the oldest trees are most usually situated at the highest altitudes, whereas the younger trees are usually situated at lower altitudes.

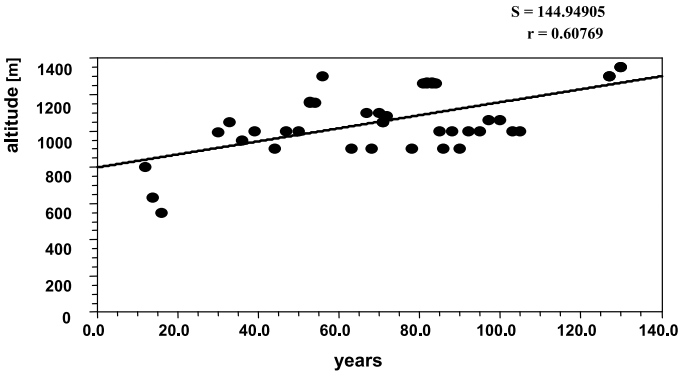

Fig. 3- *The survey of the altitudes at which the measured trees are situated*

2.2 Method

At the first step the individual profile functions, i.e. *individual models of stem profile,* IMSP, by the use of NN, i.e. programs *newff, train* and *sim*, from the program package MATLAB (Beale, 1993), are defined. Two-layer NN with two *tansig* neurons in the hidden layer and one neuron with the linear transfer function are used. *Tansig* neuron has hyperbolic tangent sigmoid transfer function (Haykin, 1994). In addition, the stem profile functions based on the use of modified Brink's function, MBF, are calculated. These functions are obtained by fitting the measured pairs of data for each tree by using MBF (Riemer et al.,1995) and (Radonja et al., 2005a).

It is suggested in this paper that the generalized method should be obtained as the mean value of the all normalized individual stem profile models which are obtained by using NN. The individual models are normalized at the second step by $\boldsymbol{H}$ and the greatest radius value, obtained by measurement of the diameter of the observed tree on the very surface.

3 CALCULATION OF THE INDIVIDUAL PROFILE MODELS

We will illustrate the calculation of the individual profile models with two tree, the first one, 72-year-old trees ($\boldsymbol{H}$=26.8m and $\boldsymbol{d}$=28cm) and the second, 130-year-old trees ($\boldsymbol{H}$=32.6m and $\boldsymbol{d}$=43.2cm). In the first case the training method NN is presented in Fig. 4 and it is seen that it practically finishes after 10 steps, when the training error reaches $2.5 \cdot 10^{-4}$. The obtained profile function is presented in Fig. 5. Modelling error is presented in Fig. 6 and it can be seen that it ranges between -0.15 and +0.15. Standard modelling error, $\boldsymbol{S}_{em}$, is 0.0787, whereas in the case when MBF is used it is more than double, i.e. 0.1881. The normalized profile function for normalized $\boldsymbol{x}$ coordinate, 0.2 has the normalized $\boldsymbol{y}$ coordinate, 0.65, Fig. 7.

In the second case the training process, Fig. 8, is practically performed in 80 steps when the training error reaches the value $4.5 \cdot 10^{-3}$. In Fig. 9 the obtained profile function is presented, and in Fig. 10 modelling error which ranges between -0.5 and +0.5. It is seen

that we obtained greater modelling error for the higher training error. Standard modelling error, S_{em}, is now 0.3348. When MBF is applied, standard modelling error is higher, i.e. 0.3876. In Fig. 11 the normalized profile function is presented. For the normalized x coordinate equals 0.2, the value of the normalized y coordinate is 0.5,

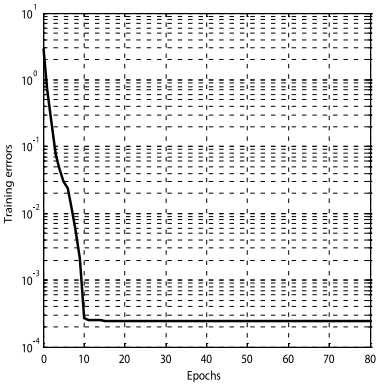

Fig. 4- Training method

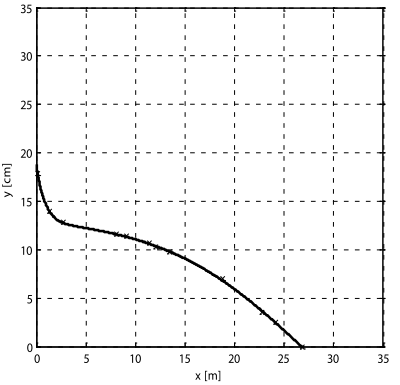

Fig. 5- Profile function o 72-year-old trees

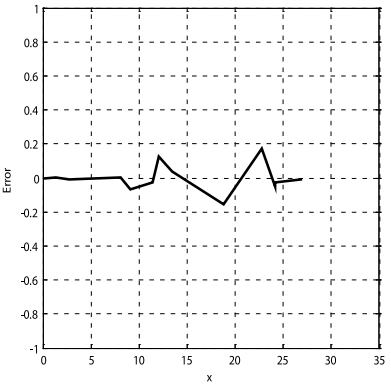

Fig. 6- Modelling errors (72-year-old trees)

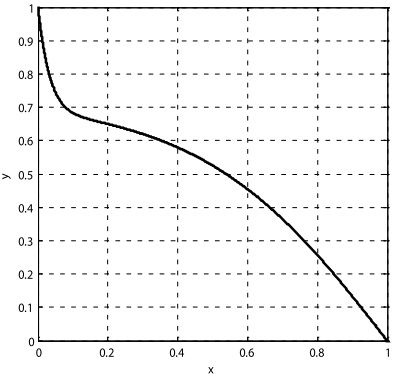

Fig. 7- Normalized profile function (72-year-old trees)

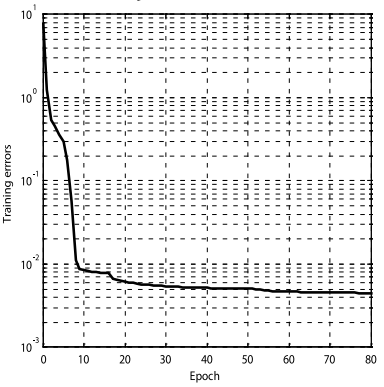

Fig. 8- Training method (130-year-old trees)

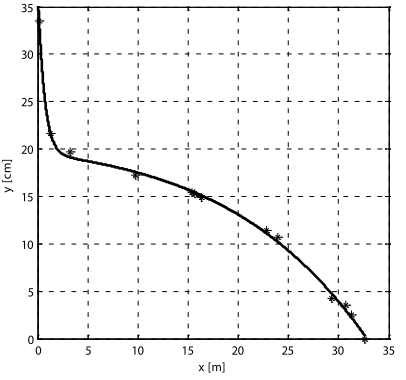

Fig. 9- Profile function of 130-year-old trees

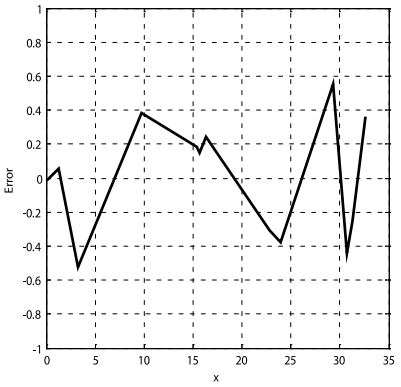

Fig. 10- Modelling errors (130-year-old trees)

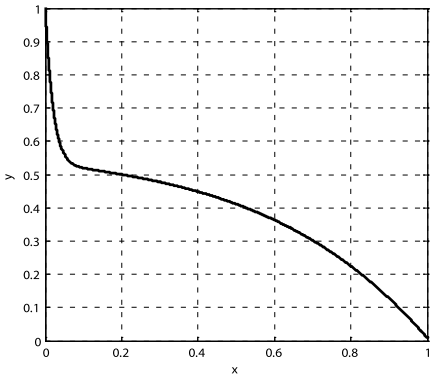

Fig. 11- Normalized profile function (130-year-old trees)

4 GENERALIZED STEM PROFILE MODEL

In the same way as it was done for 72-year-old and 130-year-old trees, the normalized profile functions were determined for the all other trees from the observed sample. The mean value of first 21 normalized profile models is presented in Fig. 12 by the dashed line.

The mean value of the remaining 21 normalized profile models is presented in Fig.12 by the dotted line. It can be seen that another mean value practically represents the verification of the first mean value since the very similar results are obtained in the both cases. The mean value of the all individual normalized profile models from the observed sample, i.e. GSPM, is presented by the whole unbroken line.

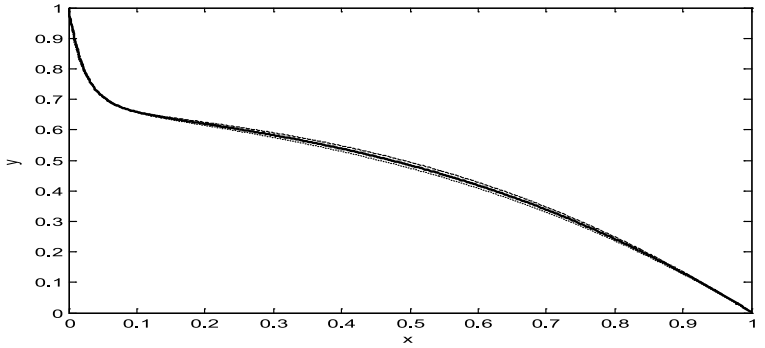

Fig. 12- Generalized stem profile model, GSPM

5 GENERATION OF THE INDIVIDUAL MODELS BY GSPM

The profile functions presented in Figs. 5 and 9 represent the *original individual stem profile models,* OISPM. By denormalization based on GSPM, total height ***H*** and diameter at breast height ***d,*** the *generated individual stem profile model,* GISPM, is obtained. Since the denormalization GSPM is performed only by two original dimensions, ***H*** and ***d***, it is clear that GISPM can be equal to OISPM at only two points. Denormalization method is performed so that GISPM transverses characteristically points OISPM, radius

at breast height (1.3; ***d/2***) and final point (***H;0***). It is clear that denormalization along ***x***-axis is performed by ***H***. In addition, the relative breast height, 1.3/***H***, is calculated for the observed tree, and from Fig. 12 the value of the normalized ***y*** coordinate, y_{norm}, is read. Value ***y(0)*** by which the denormalization is performed along ***y***-axis is calculated by the relation:

$$y(0)=(d/2) \,/\, [y_{norm}(1.3/H)] \tag{1}$$

We should note that ***y(0)*** obtained in this way most usually is not equal to the radius value which was originally measured at the very ground of the observed stem.

6 CALCULATION AND ESTIMATION OF VOLUME

The volumes of the individual trees will be calculated on the assumption that we deal with the symmetric geometric figures which are formed by the rotation of the profile function around the ***x*** axis. Volume is obviously the value of the definite integral in which sub integral function is the square of the profile function, (Riemer et al.,1995), by relation (2).

$$V(x) = \pi \int_0^x y^2(x)dx \tag{2}$$

The volumes obtained by the application of profile functions which are determined by the use of MBF, ***V(MBF)***, will be regarded as the referent volumes.

When MBF is used sub integral function is integrable function, so it is possible to obtain analytical expression for calculation of volumes (Riemer et al.,1995) and (Radonja et al., 2005a).

When NN is used for the definition of profile function, since the sub integral function is not integrable function in this case, volumes, ***V(NN)***, are in principle calculated by numerical integration. However, in the observed case it is possible to use *inner vector product* instead of numerical integration.

We will estimate individual volumes by the use of generated individual stem profile model, GISPM. The estimated volumes obtained in this way, ***V(GSPM)***, will be compared with the calculated volumes, ***V(MBF)*** and ***V(NN),*** by regressive method.

We will first compare the volumes which are calculated when the profile functions are obtained by NN, ***V(NN)***, with the referent volumes, ***V(MBF),*** Fig. 13.

It is seen that the results of the both methods are practically the same. The standard error of estimate S_{VE} is very low (0.00651), and correlation coefficient, r_{VE}, is very high (0.99997). Coefficients of the regression line, ***a*** and ***b***, are 0.00320 and 0.99758. We see that translation along ***y*** axis is very low and the tangent of angle is close to one. However, since the modelling errors are lower, 0.0787 and 0.3348, when NN is applied, than the modelling errors 0.1881 and 0.3876, obtained when MBF was applied, it can be said that NN enables the obtaining of volumes which are closer to the real values.

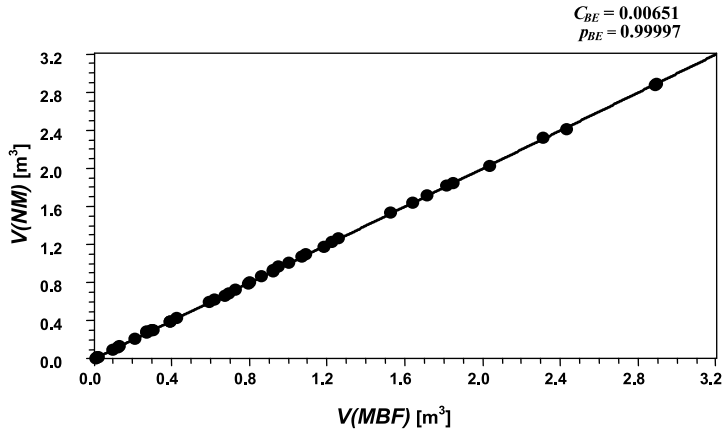

Fig.13- Volumes based on the use of NN and classic MBF procedure
a=0.00320 b=0.99758

Fig. 14 is obtained by the comparison of the estimated volumes based on GSPM with referent volumes.

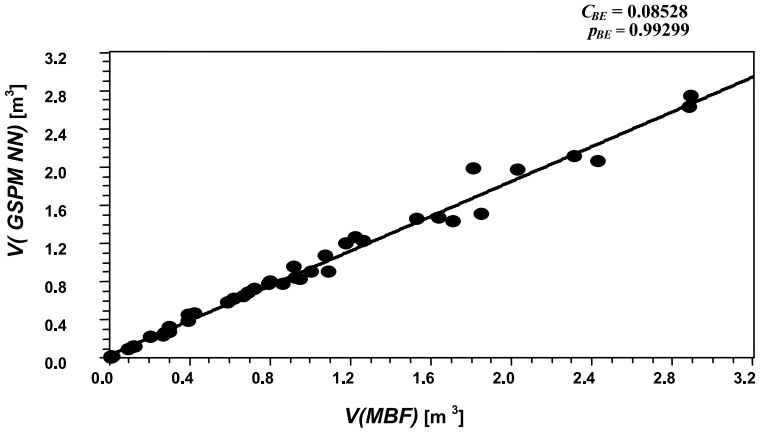

Fig. 14- Volumes based on GSPM and classic MBF procedure
a=0.03257 b=0.90998

The standard error of estimate is 0.08528, and correlation coefficient is 0.99299. The translation along ***y*** axis is 0.03257, and tangent of the angle penetrated by the regression line is 0.90998.

When GSPM is generated by the method suggested by Korol and Gadow (Korol and Gadow, 2003), the very similar result would be obtained. S_{VE}=0.08795 and r_{VE}=0.99371, whereas the values of the coefficients of the regression line are: ***a***=0.03792 ***b***=0.99047. It is seen that both S_{VE} and r_{VE} of the GSPM generated by NN are somewhat lower. In addition, the coefficient **a** is also lower, which is good. However, unfortunately, the coefficient **b** deviates more from the unit, than in the case when Korol-Godow method is used.

In the following Fig. 15 the comparison of the volumes estimated by using GSPM with the volumes obtained when NM is used for profile function modelling is presented.

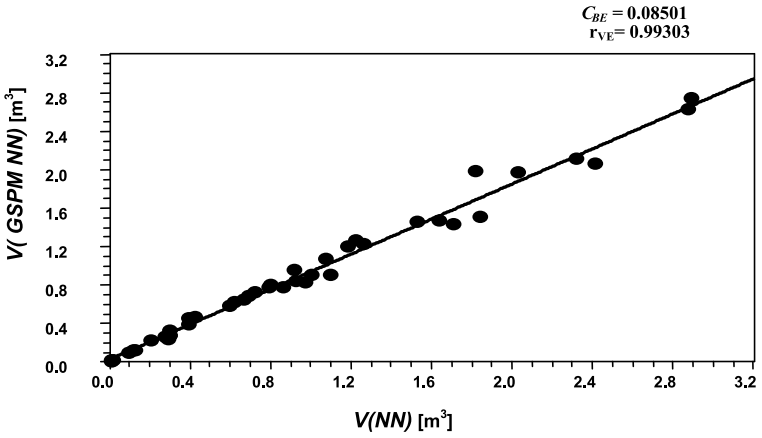

Fig. 15- Volumes based on GSPM and NN,
***a**=0.02965 **b**=0.91220*

The standard error of estimate is now 0.08501, and correlation coefficient is 0.99303. The translation along ***y*** axis is 0.02965, and tangent of the angle penetrated by regression line is 0.91220. It can be said that by the comparison of the estimated volumes, *V(GSPM)*, with the referent, *V(MBF),* or with *V(NN),* practically the same results are obtained. The standard error of estimate is somewhat lower 0.08501 to 0.08528, but the correlation is somewhat higher, 0.99303 to 0.99299. The translation along ***y*** axis is somewhat lower, 0.02965 to 0.03257, and at the same time the coefficient of the direction is closer to one, 0.91220 to 0.090998.

7 CONCLUSION

The results presented in Fig. 14, in regard with the value S_{VE} (0.08528) and value of the slope of the regression line, b=tngα=0.90998 (α is very similar to 45^0 angle), show that the real volumes *V(MBF)* can be approximated to the volumes estimated by using GSPM, *V(GSPM).* In other words, the volumes estimated by using GSPM can be sometimes used for forest inventory.

LITERATURE

Beale, M. (1993): Neural Network Toolbox, Version 6.0.0.88, Release12, September22, 2000, MATLAB 6 R12.

Hanewinkel, Marc, (2005): Neural networks for assessing the risk of windthrow on the forest division level: a case study in southwest Germany, European Journal for Forest Research, Number 124 : pp. 243-249.

Haykin, S. (1994): Neural Networks: A Comprehensive Foundation, Macmillan College Publishing Company, New York. 696 p.

Hui,G.Y., von Gadow, K. (1997): Entwicklung und Erprobung eines Einheitsschaftmodells fuer die Baumart Cunninghamia lanceolata. Forstw Cbl 116 : 315-321.

Korol, M., von Gadow, K. (2003): Ein Einheitsschaftmodell fuer die Baumart Fichte. Forstw Cbl 122 : 1-8.

Matovic, B., Koprivica, M., Radonja, P. (2007): Generalized taper models for Norway spruce (*Picea abies* L. Karst.) in Bosnia and west Serbia. Allgemeine Forst- und Jagdzeitung, No.178. Jg., 7/8, pp.150-155.

Maunaga, Z. (1995): Productivity and structural characeristics of same-age stands of spruce in Republic Serbian, Ph. thesis, Univ. of Belgrade, Faculty of forestry, Belgrade, (in Serbian with English abstract). 170 p.

Radonja, P., Koprivica, M., Lavadinovic, V. (2003): Modeling current annual height increment of young Douglas-fir stands at different sites, P.249-257 in Modelling Forest Systems A.Amaro, D.Reed and P.Soares (eds.) CABI Publishing, Wallingford, UK.

Radonja, P., Stankovic, S., Popovic, Z. (2004): Specific Process Models Obtained From General Ones, WSEAS TRANSACTIONS on SYSTEMS, Issue 7(3) Sept.2004, Pub. by WSEAS Press, pp.2490-2495.

Radonja, P., Koprivica, M., Matović, B. (2005a): Application of modified Brink's function in stem profile and volumes modeling. Forestry, N⁰4, Vol. (LVII): pp. 1-10. *(Original- Primena modifikovane Brinkove funkcije za modeliranje profila i zapremine debla, Šumarstvo, N⁰4,Vol.(LVII): pp.1-10)*

Radonja, P., Stanković S., Koprivica M., Matović, B (2005b): Neural networks in the modelling of the process with the extremely different exponential functions. Proceedings of the XIII Telecommunication forum TELFOR 2005, November 22-24th, CDROM, Belgrade. *(Original- Neuronske mreže u postupku modeliranja procesa sa izrazito različitim eksponencijalnim zakonitostima, Zbornik radova XIII Telekomunikacionog foruma TELFOR 2005, 22-24. novembra).*

Radonja, P., Koprivica, M., Matovic, B. (2006a): Generation of the subclass of the model of biological process by the application of neural networks Proceedings of the 50th conference ETRAN 6-8. june 2006,. Notebook 1, pp. 137-140, Belgrade. *(Original- Radonja, P., Koprivica, M., Matović, B. (2006a): Generisanje podklase modela biološkog procesa primenom neuronskih mreža. Zbornik radova 50. konferencije ETRAN-a, Sveska 1, str. 137-140, Beograd)*

Radonja, P., Stankovic, S., Drazic, D., Matovic, B. (2006b): Generalized Models Based on Neural Networks and Multiple Linear Regression. P. 279-284 in Proceedings of the 5th WSEAS Int. Conf. on CSECS 2006, Dattatreya, G. R. and James P. Durbano. (eds.). Dallas, Texas, USA, November 1-3, CDROM, Pub. by WSEAS Press.

Riemer, T., von Gadow, K., Sloboda., B. (1995): Ein Modell zur Beschreibung von Baumschaften, Allg Forst Jagdztg 166(7): 144-147.

Zhang, Qi-Bin, Richard J. Hebda, Qi-Jun Zhang, and Rene I. Alfaro. (2000): Modeling tree-ring growth responses to climatic variables using artificial neural networks. Forest Science, 2(46) : 229-239.

GENERALIZED STEM PROFILE MODEL BASED ON NEURAL NETWORKS

Pero Radonja

Summary

Generalized stem profile model, GSPM, is usually calculated for some region, because of which it is often called regional stem profile model. Generalized stem profile model is used in forest inventory and serves for the more accurate determination of vo-

lume and assortment structure of standing trees and whole stands in some region. It is suggested in this paper that the generalized model should be obtained as the mean value of the all normalized individual stem profile models. The individual models are obtained by the use of neural network, for which the programs from the program package MATLAB were used. The observed set of data is made of the data collected from 31 even-aged spruce stands (*Picea abies* L. Karst.) from the region of Bosnia (Maunaga, 1995). The measurements were made on one or two trees of each stand. The observed stands are situated at the altitude of 550-1,350 meters, the age of the tree ranges from 12 to 130 years, and on each tree 13 pairs of data (diameter-height) are measured. The volumes were estimated by using the generalized model obtained in proposed way, and then the referent volumes were separately calculated. Referent, real volumes were calculated by the use of the profile functions obtained by the application of the modified Brink's function. The comparision of the volumes obtained in this way in the observed region was made by the regression method. The obtained results show that the real volumes can be approximated to the volumes estimated by using the generalized stem profile model. In other words, the volumes estimated by using GSPM can be sometimes used for forest inventory.

GENERALIZOVAN MODEL PROFILNE FUNKCIJE DEBLA BAZIRAN NA NEURONSKIM MREŽAMA

Pero Radonja

Rezime

Generalizovan model profilne funkcije debla, GMPFD, obično se računa za neki region i zato se često zove i regionalan model profilne funkcije. Generalizovan model profilne funkcije debla nalazi primenu kod inventure šuma i služi da se što tačnije odredi zapremina i sortimentna struktura dubećih stabala i celih sastojina u nekom regionu. U ovom radu predloženo je da se generalizovan model dobije kao srednja vrednost normalizovanih individualnih, pojedinačnih modela profilne funkcije. Individualni modeli su dobijeni koristeći neuronske mreže, pri čemu su korišćeni programi koji se nalaze u programskom paketu MATLAB. Posmatrani skup podataka čine podaci sakupljeni iz 31 jednodobne sastojine smrče (*Picea abies* L. Karst.) iz regiona Bosne (Maunaga, 1995). Merenja su obavljena na jednom ili na dva stabla svake sastojine. Posmatrane sastojine nalaze se na nadmorskim visinama od 550-1350 metara, starost stabala je od 12 do 130 godina, a na svakom stablu izmereno je 13 parova podataka (prečnik-visina). Izračunate su zapremine na bazi ovako dobijenog generalizovanog modela a zatim posebno i referentne zapremine. Referntne, realne, zapremine su izračunate koristeći profilne funkcije koje su dobijene na bazi modifikovane Brinkove funkcije. Regresionim postupkom izvršeno je za posmatrani region, poređenje veličina svih ovako dobijenih zapremina. Dobijeni rezultati pokazuju da je realne zapremine moguće aproksimirati sa zapreminama izračunatim na bazi generalizovanog modela profilne funkcije debla. Drugim rečima dobijene zapremine moguće je uspešno koristiti kod inventure šuma.

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PHYTOCENOLOGICAL CHARACTERISTICS OF HUNGARIAN OAK AND TURKEY OAK WITH HORNBEAM FOREST (*Carpino betuli-Quercetum farnetto-cerris*) IN THE AREA OF BOGOVAĐA

Snežana Stajić, Ljubinko Rakonjac, Vlado Čokeša[1]

Abstract: The results of the study of the vegetation in the series of the sample plots set in the mixed Hungarian oak and Turkey oak forest in Bogovađa are presented in this paper. Having in mind that in this area the Hungarian oak and Turkey oak forest is climatogene and that the stands are in the very vicinity of "Bogovađa" Monastery, the protected area of the cultural-historical values, all these data point to the importance of their study, particularly regarding the determination of the appropriate raising measurements, taken in order to improve their condition, and in the aim of performing all the functions which these forests have. According to the floristic composition, it is determined that all the observed stands belong to the ecological variant of the Hungarian oak and Turkey oak forests, which is here conditioned orographically conditioned – Hungarian oak and Turkey oak forests with hornbeam Carpino betuli-Quercetum farnetto-cerris (Rud.1949) Jov.1979.

Key words: Hungarian oak and Turkey oak forest, floristic composition, Bogovađa.

FITOCENOLOŠKE KARAKTERISTIKE ŠUME SLADUNA I CERA SA GRABOM (*Carpino betuli-Quercetum farnetto-cerris*) NA PODRUČJU BOGOVAĐE

Izvod.- U radu su prikazani rezultati proučavanja vegetacije u serijama oglednih površina postavljenih u mešovitoj šumi sladuna i cera na području Bogovađe. Imajući u vidu da je ovo područje u kome je šuma sladuna i cera klimatogena, i da se radi o sastojinama koje se nalaze u neposrednoj blizini manastira "Bogovađa", kao zaštićenog prostora kulturno istorijske vrednosti, sve ovo ukazuje na značaj njihovog proučavanja, posebno kada se radi o određivanju odgovarajućih uzgojnih zahvata koji treba da dovedu do unapređenja njihovog stanja, a u cilju ispunjavanja svih funkcija koje ove šume imaju.

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Na osnovu florističkog sastava utvrđeno je da sve istraživane sastojine pripadaju ekološkoj varijanti šume sladuna i cera, koja je ovde orografski uslovljena -šuma sladuna i cera sa grabom *Carpino betuli-Quercetum farnetto-cerris* (Rud.1949) Jov.1979.

Ključne reči: Šuma sladuna i cera, floristički sastav, Bogovađa

1 INTRODUCTION

Hungarian oak and Turkey oak thermophilic forests are dominant in the zonal vegetation of the greatest part of Southeast Europe. According to Tomic, Z. (2004), Horvat, I., Glavač, V. and Elenberg, H. (1974), there are four widely acknowledged regional zones of association *Quercetum farnetto–cerris*: moesiacum in Serbia and North Bulgaria; macedonicum in Macedonia and North Greece; dacicum in South Romania; thracicum in South Bulgaria and the European part of Turkey.

Hungarian oak and Turkey oak forest is the most widely spread zonal forest of Serbia, and has been one of the first associations to be described in our country. It is to be found in all parts of Serbia, from Vojvodina to Kosovo and Metohija, and from Drina to Timok, under the different climate, geological and orographic conditions, which caused the diversity of this forest and the division in a great number of syntaxa. Besides the typical climazonal forest *Quercetum farnetto - cerris* Rud. 1949, a great number of associations, which according to Tomić, Z. (2004) represent different ecological or geographical variants of the typical Hungarian oak and Turkey oak forest, have been described in Serbia.

2 OBJECTIVE AND WORK METHOD

The research was conducted in 2005 in Valjevo in Forest Management Unit "Bogovađa". Phytocenological records were taken by Braun-Blanqet method, aimed at the determination of the phytocenological origion of the research forest. The pedological profiles were opened and soil samples were taken for analysis, in order to define pedological origion.

The forest complex "Bogovađa" is situated in the upper upstream part of Kolubarski Basin, at a distance of about 4 km to the mouth of Ljig River to Kolubara River to the south.

The total area of this forest management unit managed by Forest Directorate Valjevo is 379.61 *ha*. The complex is located from 130 to 235 meters above sea level, terrain is rather conical, intersected by depressions and valleys of the numerous water flows. The terrains of Bogovađa forests are located in the area where Hungarian oak and Turkey oak forest (*Quercetum farneto-cerris* Rudski 1949) is climatogen, and at the same time most extensive phytocoenosis in this forest complex.

The data by hydrometeorological station Valjevo, located at 174 m above sea level, are used for the definition of the climate conditions in the studied area of Bogovađa.

3 RESEARCH RESULTS AND DISCUSSION

According to the research done by Glišić, M. (1968), climatogene Hungarian and Turkey oak forests *Quercetum farneto-cerris* Rudski is present in the terrains of forest complex Bogovađa in two basic variants:

Rusco-Quercetum farnetto-cerris Jov. 1951. - Hungarian oak and Turkey oak forest with Butcher's broom is the most extensive forest phytocoenosis of Bogovađa. It is located in the different altitudes, expositions and slopes, so can be considered to be basic, climatogene association of this complex. It is understandable, as the Bogovađa terrains gradually descend in the direction to the north, i.e. they are exposed to the Pannonian Plateau, and thereby belong to the area of this variant of forest with Butcher's broom;

Carpino betuli-Quercetum farnetto-cerris (Rud. 1949) Jov.1979. - Hungarian oak and Turkey oak forest with hornbeam, which is orographically conditioned here, and because of it is considered to be the ecological variant of Hungarian oak and Turkey oak forest.

3.1 Climate characteristics

The basic characteristics of air temperature for this area are presented in Table 1. It can be seen from the presented data that the mean annual temperature of the observed area is 10.7° C, and mean temperature of vegetation period is 16.9° C. The coldest month is January, with the mean monthly temperature is 0.2° C, and the warmest month is July, the mean temperature of which is 20.4° C.

Table 1 - Mean monthly air temperature (C°)

	MONTH												Veget. period	Average annual
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C
Average	0,2	2,0	6,6	10,5	15,9	18,9	20,4	19,8	16,1	10,7	5,3	2,1	16,9	10,7
Min.	-4,5	-3,4	2,9	8,3	13,4	17,4	19,2	17,3	13,5	8,2	2,5	-0,8	15,9	9,9
Maks.	4,1	6,8	9,0	13,6	18,0	21,1	22,1	21,4	19,2	13,1	8,0	5,1	17,9	11,2

The average sum of the annual precipitation in the analysed period for the observed area is 836.8 mm (Table 2). Out of this quantity 514.8 mm fall in the vegetation period. The most rainy month is June – 119.0 mm, then May and July – 94.6 mm and 84.0 mm of precipitation.

The least quantity of precipitation is reported in February (49.0 mm), and then in January (50.8 mm) and in December (52.5 mm). In regard of the sum of the annual precipitation there are very striking differences between some years in the analysed period.

Table 2- Sums of the monthly precipitation for hydrometeorological station Valjevo

	MONTH												Veg. period	Σ annual
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII		
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
Aver.	50,8	49,0	51,0	68,1	94,6	119,0	84,0	84,9	64,2	60,7	65,1	52,2	514,8	836,8
Min.	10,0	16,0	8,0	40,0	35,0	32,0	9,0	35,0	2,0	11,0	15,0	2,0	411,0	699,0
Maks.	113,0	100,0	113,0	106,0	185,0	193,0	194,0	218,0	143,0	175,0	125,0	113,0	696,0	1010,0

Analysing the climate factors we came to the conclusion that Bogovađa belongs to the zone of the moderate continental climate, with somewhat more humid climate from Posavina and West part of Serbia.

By Lang's bioclimate classification this area belongs to the humid climate in which weak forests develop, and by Thorntweite climate classification, the observed area is characterised by the humid mean climate.

3.2 Soil conditions

By the detailed research it was determined that the soil is pseudogley luvisol (leached soil with the elements of pseudogleying).

The depth of the soil solum is at least 100 cm. Humus accumulative horizon is from 7 to 14 cm deep, by texture content it belongs to the class of loams, small crusty structures with the unstable structural aggregates. Beneath it the eluvial horizon, of the heavier textural content, which belongs to the class of clay loam, is situated. The clay content increases with the depth of profile, and texture class turns into clay. The down part of the eluvial horizon and iluvial horizon are subject to the processes of pseudogleying. In the down part of eluvial horizon iron and manganese concretions, which means that anaerobic conditions ocassionally occur in these parts of profile as well. The characteristic marbling is notable in the iluvial horizon, which is the consequence of the frequent setting and long duration of the antioxidative conditions.

Although the morhological signs of pseudogleying are clearly present in the profile, index of clay transfer in almost all studied profile is no higher than 2.5. which is, according to the classification of soils of Yugoslavia (Škorić et al., 1985), maximum value for pseudogleys. Because of it, the soil is classified as pseudogley luvisol.

3.3 Floristic composition

The phytocenologic table is made of ten records, and by the floristic composition it was determined as the association of Hungarian oak and Turkey oak with hornbeam - *Carpino betuli-Quercetum farnetto-cerris* (Rud. 1949) Jov. 1979 is present. In the tree layer alongside Hungarian and Turkey oak, hornbeam is also present as the edifier. Of the other species in the tree layer the following types are present: common lime, big-leaved linden, black ash, and Sessile oak.

In the shrub layer besides edifier lame, hornbeam, maple tree, hawthorn, black ash, Tatar maple, dwarf honeysuckle and blackberry, whereas wild rose, wild pear, European cornel and service tree are less frequent.

In the layer of the ground plants, besides the offspring of the mayor edifiers, Hungarian and Turkey oak, the most frequent species are: *Ruscus aculeatus, Carpinus betulus, Lonicera caprifolium, Hedera helix, Glechoma hirsuta, Helleborus odorus, Ligustrum vulgare, Veronica chamaedrys, Acer tataricum, Polygonatum multiflorum, Rosa arvense, Tammus communis.*

Less frequent species are: *Euphorbia amygdaloides, Galium cruciata, Melica uniflora, Fragaria vesca, Viola silvestris, Daucus carota, Calamintha officinalis, Primula vulgaris, Cytisus hirsutus, Ruscus hipoglossum, Asperula odorata, Glechoma hederaceae, Hepatica nobilis, Sorbus domestica, Viola tricolor, etc.*

In the forest phytocenosis of Bogovadja the numerous tertiary relicts are still present, which are typical for the Mediterranean. One of them is *Ruscus aculeatus,* or Butcher's broom, *Tamus communis,* and many other species.

The presence of these species dating from Tertiary and research done by the different authors, particularly Horvat, I. in Croatia and Slovenia, as well as Jovanović, B. and Dunjić, R. in North Serbia (quoted by Glišić, 1968), it was proved that huge water mass of Pannonian Sea during the cold Dilivium (Ice Age) alleviated climate extremes and that the colder weather conditions were not fatal to the Tertiary flora in the area to the South of the former Pannonian Sea. Because of it the tertiary relicts adapting to the recent conditions are still present in this area.

According to floristic composition and greater percentage of mesophilic plants, the association of Hungarian oak and Turkey oak with hornbeam is classified as the separate ecological variant of mesophilic character. This association, as Glišić, M. (1968) reported is floristical and ecological transitive form between the Turkey and Hungarian oak forest and Sessile and Hungarian oak forest.

The specter area of the plant type for Hungarian and Turkey oak with hornbeam - *Carpino betuli-Quercetum farnetto-cerris* (Rud.1949) Jov.1979 is presented in Table 3.

Table 3- Specter of area types of association Carpino betuli-Quercetum farnetto-cerris (Rud.1949) Jov.1979.

Individual area types	Number	Sum area types	Number	Percentage (%)	
Pontic-pannonian	1	Pontic	3	6,2	27,1
Pontic-sub-mediterranean	1				
Pontic-east-sub-mediterranean	1				
Submediteranski	4	Submediterranean	8	16,7	
East-sub-mediterranean	4				
Sub- balkan	1	Balkan	2	4,2	
Mid- balkan	1				
Mid-european	5	Mid-european	14	29,2	41,7
Sub-mid-european	9				
Sub-atlantic-sub-mediterranean	6	Sub-atlantic	6	12,5	
Eurasian	5	Eurasian	10	20,8	22,9
Sub-eurasian	5				
Cosmopolitan	1	Cosmopolitan	1	2,1	
Circumpolar	3	Circumpolar	4	8,3	8,3
Sub-circumpolar	1				
Total :	48	Total:	48	100	100

In this community the plants of the Mid-European area are dominant, with 29.2%, whereas the plants of the Eurasian area are less dominant (20.8%), followed by the plants of Sub-Mediterranean area (16.7%), Sub-Atlantic (12.5%), circum-polar (8.3%), Pontic(6,2%), Balkans (4.2%), and cosmopolitan plants (2.1%), which are the least frequent.

According to the above facts, it can be said that mesophilic plants (of Mid-European and Sub-Atlantic area type), which account for 41.7%, are more dominant than xero-

termophilic plants (of Pontic, Sub-Mediterranean and Balkan type of area), which account for 27.1%, as well as than the plants of the wide amplitude (of Eurasian and cosmopolitan area types), which account for 22.9%. The least dominant are frigophilic plants (of circum-polar area type), which account for only 8.3%. By the specter of area types in the community of Hungarian and Turkey oak the mesophilic plants are dominant.

Table 4- Phytocenological table

Association	*Carpino betuli-Quercetum farnetto-cerris* (Rud.1949) Jov.1979.										
Number of record	1	2	3	4	5	6	7	8	9	10	
Date of record	21.06.05.										The level of presence
Field mark	OP1	OP1	OP2	OP2	OP3	OP3	OP4	OP4	OP5	OP5	
Location	Bogovađa										
Management unit	Bogovađa										
Department	18	18	10	10	18	18	17	17	17	17	
Size p.p. (m^2)	600	600	600	600	600	600	600	600	600	600	
Altitude (m)	212	211	210	210	207	211	210	210	210	210	
Exposition	N-NE	N-NE	S-SW	S-SW	N	N	N-NW	N-NW	N-NW	N-NW	
Slope	7	5-7	3	-	3	7	4	6	4	7	
Canopy	0.8	0.8	0.7	0.7	0.8-0.9	0.8	0.8-0.9	0.8-0.9	0.8	0.8	
Altitude -mean (m)	29	28	26	26	25	23	24	27	25	25	
Diameter - mean (cm)	35	34	27	27	26	27	27	27	26	26	
Distance (m)	2 -5	2 -5	2 -5	2 -5	2–5	3–5	2–5	2–5	2–5	2–5	
Geological base	Marl and clays										
Soil	Pseudogley luvisol										
I LAYER											
Quercus cerris	3.3	3.3	2.1	2.2	3.3	3.3	3.3	3.3	2.2	2.2	V
Quercus farnetto	2.2	2.2	3.3	3.3	2.2	2.2	2.2	3.3	3.3	3.3	V
Carpinus betulus	2.2	2.2	2.2	1.2	1.1	2.2	1.1	1.1	2.2	2.1	V
Tilia argentea	+.1		+.1	+.1	1.1	+.1		1.1	1.1	+.1	IV
Tilia grandifolia			+.1			+.1	+.1		+.1		II
Fraxinus ornus			+.1	1.1							I
Quercus petraea	+	+									I
II LAYER											
Carpinus betulus	1.1	2.1	2.2	2.3	2.1	1.1	2.1	1.1	2.1	1.1	V
Tilia argentea	1.1	1.1	1.1	+.1	2.1	1.1	1.1	1.1	1.1	1.1	V
Crataegus monogyna	1.1	1.1	1.1	+.1	+.1	1.1	1.1	1.1	1.1	1.1	V
Acer campestre	1.1	1.1	+.1	+.1	+.1	1.1	+.1	+.1	+.1	1.1	V
Fraxinus ornus	1.1	1.1	1.2	1.1	1.1	+.1	1.1	1.1	1.2	2.2	V
Acer tataricum	1.1	1.2	2.1	1.1	+.1	+.1	+.1				IV
Lonicera caprifolium	4.4	3.3	2.2	3.3		2.2			3.2	2.2	IV
Rubus hirtus	2.2	2.2	2.2	1.2			2.2	2.1			III
Pyrus pyraster	+.1	+.1			+.1	1.1		+.1			III
Rosa arvensis	+.1	1.1	2.1	1.1							II
Cornus mas	+.1	1.1	+.1	1.1							II

Association	*Carpino betuli-Quercetum farnetto-cerris* (Rud.1949) Jov.1979.										
Number of record	1	2	3	4	5	6	7	8	9	10	
Quercus cerris									1.1	+.1	I
Sorbus domestica	+.1	1.1									I
Sorbus torminalis				+.1							I
Prunus avium										+.1	I
III LAYER											
Quercus cerris	1.1	1.1	1.1	1.1	1.1	1.1	1.1	2.1	+.1	1.1	V
Quercus frainetto	1.1	1.1	2.1	1.1	1.1	1.1	1.1	1.1	+.1	+.1	V
Carpinus betulus	+.1	1.1	2.2	3.2	+.1	1.1	+.1	1.1	1.2	2.2	V
Rubus hirtus	2.2	1.2	1.2	+.2	1.2	2.2	1.2	+.2	2.2	2.2	V
Lonicera caprifolium	3.3	2.2	2.2	4.3	1.1	2.2	1.1	2.1	3.3	2.3	V
Hedera helix	1.1	1.1	1.2	1.1	+.1	1.1	+.1	1.1	1.1	+.1	V
Ruscus aculeatus	3.3	3.2	1.2	2.2	1.2	+.2	1.2	2.2	2.2	2.1	V
Glechoma hirsuta	2.1	1.1	1.1		2.2	2.1	2.2	1.2	2.2	2.2	V
Veronica chamaedrys	+.1	1.1	+.1	1.2	+.1	+.1		+.1		+.1	IV
Helleborus odorus	+.1	+.1			+.1	+.1	+.1	+.1	+.1		IV
Ligustrum vulgare	1.2	+.2			1.2	1.2		1.2	1.2	+.2	IV
Galium silvaticum			1.1	+.1	+.3	1..3		+.3	2.2	2.1	IV
Euphorbia amygdaloides	+.1		1.2	+.1	+.1		+.1		+.1		III
Acer tataricum	1.1	1.2				+.1		+.1	+.1	+.1	III
Polygonatum multiflorum	+.1	+				+.1	+.1	+.1			III
Viola silvestris		1.2			+.1	+.1	1.1	+.1			III
Rosa arvense	+.1	1.1	+.1	1.1					+.1		III
Cardamine bulbifera	+.1				+.1	+.1	+.1				II
Mycelis muralis	+.1				+.1		+.1	+.1			II
Tamus comunis	+.1	+	1.1	+.1							II
Fraxinus ornus		+							3.2	2.2	II
Melica uniflora	+.1		+.1	+.2							II
Prunus avium					+.1	+.1		1.1			II
Galium cruciata	+.2		+.2	+.2							II
Fragaria vesca	+.1		+.1	1.1							II
Daucus carota	+.1		+.1	+.1							II
Musci sp.					+	+		+			II
Ruscus hypoglossum									1.1	+.1	I
Primula vulgaris	+.1					+.1					I
Calamintha officinalis	+.1	1.1									I
Veronica pseudochamedrys			+.1	1.1							I
Stelaria holostea									1.1	+.1	I
Crataegus monogyna			+.1	1.1							I
Poa nemoralis			1.2	+.2							I
Tilia argentea			1.2	1.1							I
Carex pilosa						+.1	1.1				I
Nefrodium filix mas					+.1			+.1			I

Association	*Carpino betuli-Quercetum farnetto-cerris* (Rud.1949) Jov.1979.										
Number of record	1	2	3	4	5	6	7	8	9	10	
Chamaecytisus hirsutus		+.1		+.1							I
Dactuylis glomerata			+.1							+.1	I
Asarum europeum	1.1	+									I
Asperula odorata	+.2										I
Glechoma hederaceae	1.1										I
Hepatica nibilis	+										I
Geranium robertianum	+.1										I
Sorbus domestica	+.1										I
Viola tricolor	+.1										I
Polygonatum odoratum										+.1	I

The ratio of plants to life forms in the community of Hungarian oak and Turkey oak is presented in Table 5.

Table 5- Life forms of plants from association Carpino betuli-Quercetum farnetto-cerris (Rud.1949) Jov.1979

Life form						
Fanero-phytes	Nano-fane-rophytes	Fanerophyte lianas	Herbeceous hamephytes	Hemi-cryptophytes	Geophytes	Terophytes/ hamephytes
P	np	pl	zc	H	g	th
24%	17%	2%	6%	24%	21%	6%
43%						

In this association fanerophytes are dominant, since they account for 43% (pure fanerophytes, nanofanerophytes and fanerophyte lianas), whereas chemiocrytophytes, accounting for 24%, followed by geophytes, which account for 21%, are less frequent, which points to the moisturer climate and edaphic conditions. The least dominant are terrophytes, accounting for 6%, the percentage of which is equal to the percentage of herbaceous hamephytes. It means that this community is of fanerophytic-hemicriptophytic character, with a high percentage of geophytes.

4 CONCLUSION

By the phytocoenosis research conducted in the series of the sample plots it was determined that the observed stands belong to Hungarian oak and Turkey oak with hornbeam *Carpino betuli-Quercetum farnetto-cerris* (Rud.1949) Jov.1979. This variant of Hungarian and Turkey oak belongs to the mesophilic variant of Hungarian oak and Turkey oak forest, with a significant percentage of mesophilic species.

Differential species is hornbeam, which alongside Hungary and Turkey oak edifier dominate in the tree layer. In the bush floor alongiside edifiers lame, hornbeam, maple tree, hawthorn, black ash, Tatar maple, dwarf honesuckle and blackberry are present, whereas wild rose, wild pear, European cornel and service tree are less frequent.

In the layer of the ground plants, alongside the offspring of the mayor edifiers, Hungarian and Turkey oak, the most frequent species are: *uscus aculeatus, Carpinus betulus, Lonicera caprifolium, Hedera helix, Glechoma hirsuta, Helleborus odorus,*

Ligustrum vulgare, Veronica chamaedrys, Acer tataricum, Polygonatum multiflorum, Rosa arvense, Tammus communis.

Less frequent species are: *Euphorbia amygdaloides, Galium cruciata, Melica uniflora, Fragaria vesca, Viola silvestris, Daucus carota, Calamintha officinalis, Primula vulgaris, Cytisus hirsutus, Ruscus hipoglossum, Asperula odorata, Glechoma hederaceae, Hepatica nobilis, Sorbus domestica, Viola tricolor, etc.*

According to the specter of area types in Hungarian oak and Turkey oak community with hornbeam mesophilic plants are dominant (Mid-European and Sub-Atlantic area type), which account for 41.7%. By the analysis of the forms of the plants of the association of the Hungarian oak and Turkey oak with hornbeam, it was determined that this association is of fanerophyte- chemicryptophyte character with a high percentage of geophytes.

REFERENCES

Antić, M., Marković, D. (1971): Characteristics of soil forms under the forests communities of Bogovadja complex, The Collection of Papers of The Institute of Forestry and Wood Industry Number 10, Belgrade. *(Original- Osobine zemljišnih tvorevina pod šumskim zajednicama kompleksa Bogovađa, Zbornik radova Instituta za šumarstvo i drvnu industriju br. 10, Beograd)*

Cvjetićanin, R. (1999): Taxonomy and cenoecology of Balkan oak (*Quercus dalechampii* Ten.) on serpentines of central and Western Serbia, Doctoral Thesis, The Faculty of Forestry, Belgrade. *(Original- Taksonomija i cenoekologija balkanskog hrasta kitnjaka (Quercus dalechampii Ten.) na serpentinitima centralne i zapadne Srbije, Doktorska disertacija, Šumarski fakultet, Beograd)*

Cvjetićanin, R., Vučković, M., Krstić, M. (1995): Productive effects and change of the floristic composition in the coniferous stands established on beech site, Forestry Number 4, Belgrade. *(Original- Proizvodni efekti i promena florističkog sastava u sastojinama četinara podignutim na staništu bukve , Šumarstvo br. 4, Beograd)*

Černjavski, P., Jovanović, V. (1950): Forest sites and appropriate dendroflora in Serbia, Annual Report of The Faculty of Agriculture and Forestry 1, Belgrade. *(Original- Šumska staništa i odgovarajuća dendroflora u Srbiji, Godišnjak Poljoprivredno-šumarskog fakulteta 1, Beograd)*

Gajić, M. (1959) Association *Quercetum confertae-cerris serbicum* Rudski and *Quercetum montanum* Cer. et Jov in Rudnik mountain and their sites, Bulletin of The Faculty of Forestry 16, Belgrade. *(Original- Asocijacija Quercetum confertae-cerris serbicum Rudski i Quercetum montanum Cer. et Jov. na planini Rudnik i njihova staništa, Glasnik Šumarskog fakulteta 16, Beograd)*

Glišić, M. (1968): Forest phytocoenosis of forest complexes »Bogovadja«, Collection of Papers of The Institute of Forestry and Wood Industry 8, Belgrade. *(Original- Šumske fitocenoze šumskog kompleksa "Bogovađa", Zbornik radova Instituta za šumarstvo i drvnu industriju 8, Beograd)*

Glišić, M. (1977): Regressional successions and degradational phases of Hungarian and Turkey oak (*Quercetum farnetto-cerris* Rudski) in Grdelicka gorge, Forestry number 5, Belgrade. *(Original- Regresione sukcesije i degradacione faze sladuna i*

cera (Quercetum farnetto-cerris Rudski) u Grdeličkoj klisuri, Šumarstvo br. 5, Beograd)

Jovanović, B. (1954): Phytocoenosis *Quercetum confertae-cerris* as the biological indicator, Bulletin of The Faculty of Forestry 8, Belgrade. *(Original- Fitocenoza Quercetum confertae-cerris kao biološki indikator, Glasnik Šumarskog fakulteta 8, Beograd)*

Jovanović, B. (1986): Serbian forest of Hungarian and Turkey oak *Quercetum farnetto-cerris serbicum*), Allgemeine Forst Zeitschrift, 759-761. *(Original- Srpska šuma sladuna i cera (Quercetum farnetto-cerris serbicum), Allgemeine Forst Zeitschrift, 759-761)*

Jovanović, B., Dunjić, R. (1951): Contribution to the knowledge of oak forests of Jasenica and vicinity of Belgrade, The Collection of Papers of The Serbian Academy of Sciencies and Arts 11, The Institute of Ecology and Biogeography 2, Belgrade. *(Original- Prilog poznavanju fitocenoza hrastovih šuma Jasenice i okoline Beogarda, Zbornik radova SAN 11, Institut za ekologiju i biogeografiju 2, Beograd)*

Stojanović, LJ. (1988): The suggestion of the most favourable silvicultural methods in Hungarian and Turkey oak forest in the forest complex Bogovadja, Bulletin of The Faculty of Forestry, Belgrade. *(Original- Predlog najpovoljnijih uzgojnih mera u šumi sladuna i cera u šumskom kompleksu Bogovađa, Glasnik Šumarskog fakulteta, Beograd)*

Škorić, A., Filipovski, G., Ćirić, M. (1985): Classification of soils of Yugoslavia. Sarajevo 1985. *(Original- Klasifikacija zemljišta Jugoslavije. Sarajevo 1985)*

Tomić, Z. (2000): Phytocoenosis *Quercetum farnetto-cerris scardicum* Krasn.1968 in Lipovica near Prishtina, Bulletin of The Faculty of Forestry number 82. *(Original- Fitocenoza Quercetum farnetto-cerris scardicum Krasn.1968. u Lipovici kod Prištine, Glasnik Šumarskog fakulteta br.82)*

Tomić, Z. (2004): Forestry photocoenology, Belgrade. *(Original- (2004): Šumarska fitocenologija, Beograd)*

PHYTOCENOLOGICAL CHARACTERISTICS OF HUNGARIAN OAK AND TURKEY OAK WITH HORNBEAM FOREST (*Carpino betuli-Quercetum farnetto-cerris*) IN THE AREA OF BOGOVAĐA

Summary

Hungarian oak and Turkey oak forest is most widely spread zonal forest of Serbia, and has been one of the first associations to be described in our country. The results of the study of the vegetation in the series of the sample plots set in the mixed Hungarian oak and Turkey oak forest within the forest complex Bogovađa are presented in this paper. Bogovađa belongs to the zone of the moderate continental climate.

The terrains of Bogovađa forests are located in the area in which Hungarian oak and Turkey oak forest (*Quercetum farneto-cerris* Rudski 1949) is climatogene. By the floristic composition it was determined that this forest belong to the ecological variant Hungarian oak and Turkey oak forest, which is in this area orographic – Hungarian and Turkey oak forest with hornbeam *Carpino betuli-Quercetum farnetto-cerris* (Rud.1949) Jov.1979. Differential species is hornbeam, which besides Hungarian oak and Turkey oak edifier dominates in the tree layer. In the shrub layer besides edifier

lame, hornbeam, maple tree, hawthorn, black ash, Tatar maple, dwarf honey suckle and blackberry.

In the layer of the ground plants, besides the offspring of the mayor edificators, Hungarian and Turkey oak, the most frequent species are: *uscus aculeatus, Carpinus betulus, Lonicera caprifolium, Hedera helix, Glechoma hirsuta, Helleborus odorus, Ligustrum vulgare, Veronica chamaedrys, Acer tataricum, Polygonatum multiflorum, Rosa arvense, Tammus communis.*

According to the specter of area types in Hungarian and Turkey oak community with hornbeam mesophilic plants are dominant (Mid-European and Sub-Atlantic area type), which account for 41.7%. By the analysis of the forms of the plants of the community of the Hungarian and Turkey oak with hornbeam, it was determined that this community is of fanerophyte- chemicryptophyte character with a high percentage of geophytes.

FITOCENOLOŠKE KARAKTERISTIKE ŠUME SLADUNA I CERA SA GRABOM (*Carpino betuli-Quercetum farnetto-cerris*) NA PODRUČJU BOGOVAĐE

Snežana Stajić, Ljubinko Rakonjac, Vlado Čokeša

R e z i m e

Šuma sladuna i cera je najšire rasprostranjena zonalna šuma Srbije, i predstavlja jednu od prvih asocijacija opisanih sa našeg područja. U radu su prikazani rezultati proučavanja vegetacije u serijama oglednih površina postavljenih u mešovitoj šumi sladuna i cera u okviru šumskog kompleksa "Bogovađa". Bogovađa pripada zoni umereno kontinentalne klime.

Tereni bogovađskih šuma nalaze se u području gde je šuma hrastova sladuna i cera (*Quercetum farneto-cerris* Rudski 1949) klimatogeno uslovljena. Na osnovu florističkog sastava utvrđeno je da je ovo ekološka varijanta šume sladuna i cera, koja je ovde orografski uslovljena - šuma sladuna i cera sa grabom *Carpino betuli-Quercetum farnetto-cerris* (Rud.1949) Jov. 1979. Diferencijalna vrsta je grab, koji pored edifikatora sladuna i cera dominira u spratu drveća.

U spratu žbunja pored edifikatora javljaju se najčešće lipa, grab, klen, glog, crni jasen, žešlja, orlovi nokti i kupina, itd. U sloju prizemnog bilja, pored podmlatka glavnih edifikatora, sladuna i cera, najveću stalnost imaju: *Ruscus aculeatus, Carpinus betulus, Lonicera caprifolium, Hedera helix, Glechoma hirsuta, Helleborus odorus, Ligustrum vulgare, Veronica chamaedrys, Acer tataricum, Polygonatum multiflorum, Rosa arvense, Tammus communis.*

Prema spektru areal tipova u zajednici sladuna i cera sa grabom preovlađuju mezofilne biljke (srednjeevropskog i subatlanskog areal tipa) koje učestvuju sa 41,7%. Analizom životnih oblika biljaka zajednice sladuna i cera i grabom utvrđeno je da je ova zajednica fanerofitsko-hemikriptofitskog karaktera sa velikim učešćem geofita.

Reviewer: Mihailo Ratknić, Ph.D, Institute of Forestry, Belgrade

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THE MOST FREQUENT SWEET CHESTNUT DISEASES IN VRANJE AREA

Zlatan Radulović[1]

Abstract: Sweet chestnut (*Castanea sativa* Mill.) is one of the most endangered tree species. Its survival in our country does not depend on the climate as much as on the sensitivity to fungus *Cryphonectria parasitica* (Murrill) Barr which causes "chestnut blight". Besides this fungus, grave damages to Sweet chestnut are also caused by species from *Phytophthora* genus causing "chestnut ink disease". This paper states the fungi which appear most frequently on chestnut in two localities in the vicinity of Vranje. The total of 13 fungal species was reported. The most significant of them is *Cryphonectria parasitica,* which is present in both localities. In both localities the I_{zs} is extremely high (2.93 and 2.5), which points to the fact that the tree damage is great. The most significant species reported on leaves is *Mycosphaerella maculiformis*, and on the fruits *Stromatinia pseudotuberosa* is of the highest significance.

Key words: Sweet chestnut, *Cryphonectria parasitica*, *Phytophthora* spp., health condition index

NAJČEŠĆE BOLESTI PITOMOG KESTENA NA PODRUČJU VRANJA

Izvod: Pitomi kesten (*Castanea sativa* Mill.) spada u najugroženije vrste drveća. Njegov opstanak kod nas ne zavisi toloko ni od klime koliko od osetljivosti prema gljivi *Cryphonectria parasitica* (Murrill.) Barr. koja izaziva "rak kore kestena". Pored ove gljive velike štete na pitomom kestenu izazivaju i vrste iz roda *Phytophthora* koje izazivaju "mastiljavu bolest" kestena. U radu su navedene gljive koje se najčešće javljaju na kestenu na dva lokalitete u okolini Vranja. Ukupno je zabeleženo prisustvo 13 vrsta gljiva. Najveći značaj ima vrsta *Cryphonectria parasitica*, koja je prisutna na oba lokaliteta. I_{ZS} na oba lokaliteta je veoma visok (2,93 i 2,5) što ukazuje da je stepen oštećenja stabala veliki.

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Translation: Marija Stojanović

Najznačajnija vrsta konstatovana na lišću je *Mycosphaerella maculiformis*, a na plodovima najveći značaj ima *Stromatinia pseudotuberosa*.

Ključne reči: pitomi kesten, *Cryphonectria parasitica*, *Phytophthora* spp., indeks zdravstvenog stanja

1 INTRODUCTION

Sweet chestnut (*Castanea sativa* Mill.) is a European species belonging to the *Fagaceae* family and *Castanea* genus. Thirteen species from this genus have been described so far. Besides the Sweet chestnut significant species in America are: *Castanea dentata* (Marsh.) Borkh, in Japan: *Castanea crenata* Siebold & Zucc., and in China: *Castanea mollissima* Blume.

The chestnut in Serbia is, according to Glišić's research (1975), present in Vršački Breg, a few localities in Fruška Gora, in Gučevo, Kostajnik near Kučevo, near Prijepolje (Hisardžik Village), near Prokuplje (Čukovac Village), near Čačak (Trnava Village), near Niš (in Gorica and Seličevica), in localities near Vranje and Kruševac, and between Peć and Prizren, where the number of it is highest. Since Sweet chestnut is economically very valuable tree species, it is the subject of many researches all over the world. In almost every neighbouring country and most Mediterranean countries there are intensive activities aimed at Sweet chestnut natural population research and genetic resources protection, as well as at the possibilities of the range expansion, which is required by the industries of these countries.

In Serbia, as well as in all parts of Europe, the Sweet chestnut is one of the most endangered tree species. Its survival in our country does not depend so much on the climate but rather on sensitivity to fungus *Cryphonectria parasitica* (Murrill) Barr which causes "chestnut blight" and species from genus *Phytophthora*, agents of chestnut "ink disease".

The dessication of the American chestnut (*Castanea dentata* (Marsh.) Borkh.), caused by fungus *Cryphonectria parasitica* (Murrill) Barr is one of the greatest botanical catastrophes in history of the mankind. The first trees infected by this fungus (former name *Endohtia parasitica* (Murr.) & And.) were registered in New York zoo in 1904. More than 3.5 trillions of American chestnut trees had been destroyed by 1950, which endangered its survival as well (Rittenour, 2005).

In Europe, *C. parasitica* was first registered in Italy in 1938, whence it spread to the most European countries. According to the reports by Robin and Heiniger (2001), its presence has not been reported only in the Netherlands and Great Britain.

2 MATERIAL AND METHOD

In Sobina locality chestnut is present in the belt between 600 m and 800m above sea level, at S and SE exposures. The age of the observed chestnut trees is between 40 and 100 years. In Muhovac locality it is present in the belt at altitudes above 800m, at NE and E exposures. The tree age is between 40 and 70 years.

Sweet chestnut health condition was studied in the localities Sobina and Muhovac in the vicinity of Vranje. The total of 197 trees was inspected and on every tree visible disease symptoms or the presence of fruiting bodies were reported. In cases where the

cause could not be determined macroscopically samples were taken for laboratory analysis. The isolation was performed on Malt-agar (MEA) and Potato-dextrose agar (PDA). The fungi were identified by keys of Dennis (1978), Sutton (1980), Courtecuisse (1999) and Carmichael et al. (1980).

The method used for evaluation of damages caused by fungus *Cryphonectria parasitica* was described by Juhásová et al. (2004). The trees were assessed against the following criteria:

0 - healthy trees without symptoms;
1 - smaller and yellow leaves;
2 - dry brown leaves and the beginning of canker wound formation (change of bark colour);
3 - dry brown leaves, open canker wounds on the tree;
4 - more than 2/3 of tree crown with dried branches,
5 - almost completely dead trees with numerous large canker wounds.

The damage degree was expressed by health condition index (I_{zs}) obtained by the formula:

$$I_{ZS} = \frac{1n1+2n2+3n3+4n4+5n5}{n}$$

In formula the symbols stand for:
n – total number of assessed trees,
n1…n5 – the number of trees in the appropriate category of injure

The intensity of other disease occurrences was determined against the following criteria:

1 – intensity of occurrence of disease agent or pest is weak (up to 10% of diseased plants);
2 – intensity of occurrence of disease agent or pest is medium (10 – 25% of diseased plants),
3 – intensity of occurrence disease agent or pest is strong (25 – 60% of diseased plants),
4 – intensity of occurrence of disease agent or pest is extremely strong (60 – 90% of diseased plants).

3 RESULTS

The damaged degree expressed by $I_{zs,}$ in the examined localities is presented in the following table:

Table 1- The results of the assessment of the damages caused by fungus C. parasitica

Locality	Number of assessed trees	Number of damaged trees (per categories)						
		0	1	2	3	4	5	(I_{ZS})
Sobina	129	12	10	30	28	21	28	2.93
Muhovac	68	9	11	13	15	12	8	2.5
Total	197	21	21	43	43	33	36	

In Sobina locality 129 trees were assessed and I_{ZS} is 2.93. In locality Muhovac 68 trees were assessed and I_{ZS} is 2.5.

On examined trees besides *C. parasitica* the presence of another 12 fungi species was reported. In table 2 give index fungi species reported, intensity of occurrence and locality:

Table 2- Fungi reported on the Sweet chestnut

Fungi species	Plant organ	Intensity of occurrence	Locality	
			Sobina	Muhovac
Mycosphaerella maculiformis (Pers.) Schroet.	leaf	3	+	+
Cytospora intermedia Sacc.	branches and stem	1	+	+
Vuilleminia camedens (Nees.) Maire.	branches and stem	1	+	-
Schizophyllum communae Fr.	branches and stem	1	+	+
Trametes hirsuta (Wulfen.) Pilát	branches and stem	1	+	+
Armillaria sp.	root	1	+	+
Phytophthora sp.?	root	1	+	-
Stromatinia pseudotuberosa Rehm.	fruit	1	-	+
Trichothecium roseum Link.	fruit	1	+	+
Alternaria tenuis Nees.	fruit	1	-	+
Penicillium sp.	fruit	1	+	+
Aspergillus sp.	fruit	1	+	-

The species *Mycosphaerella maculiformis* was reported on leaves on approximately 25-60% of trees (intensity of occurrence 3). However, the attack intensity on leaves is very low.

On the branches and stem in both localities the presence of species *Cytospora intermedia* Sacc., *Vuilleminia camedens* (Nees.) Maire, *Schizophyllum communae* Fr., *Trametes hirsuta* (Wulfen.) Pilát and *Cryphonectria parasitica* (Murrill.) Barr. was reported. The intensity of occurrence of other fungi is low (up to 10% of diseased plants), except for species *Cryphonectria parasitica*.

On the roots of 5 trees the presence of *Armillaria* sp. Was reported and on 2 trees symptoms typical for *Phytophthora* genus were determined .By the subsequent laboratory analysis the presence of species from *Phytophthora* genus was not proved.

By the laboratory analyses conducted on fruits the following species were reported: *Stromatinia pseudotuberosa* Rehm., *Penicillium* sp., *Aspergillus* sp., *Trichothecium roseum* Link. and *Alternaria tenuis* Nees.

4 DISCCUSSION

C. parasitica has the greatest significance for the survival of Sweet chestnut of all the reported fungi. It is very frequent in the investigated localities. The I_{zs} in both localities is extremely high (2.93 and 2.5), which points to the fact that the damage degree of trees is very high. In locality Sobina on 12 trees out 129 investigated no disease symp-

toms were observed, and the large number of trees is in the desiccation phase. In locality Muhovac the situation is a little better. Assessing the damages caused by *C. parasitica* in Slovakia Juhásová et al. (2004) report the I_{zs} values during 1999, ranging from 1.11 to 2.36. The I_{zs} values in the next year ranged from 1.11 to 3.50. The highest values (2.36 and 3.50) were reported only in one case (an orchard), while I_{zs} values in other cases were lower than 2.

In Europe, *C. parasitica* was first registered in Italy in 1938, whence it spread to the most European countries. According to the reports by Robin and Heiniger (2001) its presence was not reported only in the Netherlands and Great Britain. The chestnut blight in Former Yugoslavia, according to Krstić (1950), was recorded for the first time in "Panovac" forest in Slovenia in 1950, and in Serbia, according to Marinković and Karadžić (1985), its presence was first recorded in area of Kosovo and Metohija in 1975.

In the beginning the pathogenicity of this fungus was expressed in Europe, almost to the same degree as in America. However, Biranghi discovered in 1951 that 85% of the infected trees seemed "surprisingly healthy". By the subsequent research Grente obtained atypical isolates from canker wounds of these trees in 1964, white-colored and of reduced virulence. He called this phenomenon hypo-virulence.

During 1969 it was proved that hypo-virulence is caused by the presence of double ribonucleic acid (dsRNK), which is transferred by conidia but not by ascospores. Transferring by contact of hyphae (anastomosis) is the most frequent but it is conditioned by vegetative compatibility. In 1992 it was proved that dsRNK is of viral origin.

Insertion of hypo-virulent fungus forms in infected chestnut stands is used as a biologic method of fight. This has been the only acceptable method in fighting against *C. parasitica* so far. For the successful application of this method it is necessary to determine the number of vegetative compatibility types (vc) of fungus present in infected chestnut stands. If the number of vegetative compatibility types (vc) is lower, the method is more successful. The number (vc) types is conditioned by sexual reproduction of different fungal genotypes. The lower number of dominant (vc) fungal types in Europe is conditioned by a rare occurrence of perithecia, which enabled a more successful hypo-virulence application than in America where the number of (vc) types is much higher. Giving the outline of the previous researches, Robin and Heiniger (2001) report that in Europe the presence of 40 (vc) types were determined, by which EU-2 is dominant in the west and north-west and EU-12 in the south and east of Europe.

Besides *C. parasitica*, large damages on chestnut are also caused by the species belonging to *Plythophthora* genus. In Sobina locality the symptoms typical for species of this genus were reported (ink colour beneath the bark) on two trees. By the subsequent laboratory analyses the presence of species from *Plythophthora* genus was not proved. *Phytophthora cinnamomi* Rand. and *Phytophthora cambivora* (Petri.) Buis, which cause the chestnut ink disease, are the most frequent on chestnut. Prior to the epidemic of *Cryphonectria parasitica* fungus, in the 1930s, the ink disease represented the main threat to survival of Sweet chestnut.

In the period after 1995, in a few European countries an increase of chestnut desiccation, which was caused by *Plythophthora* genus species, was reported. By the subsequent researches besides species *P. cinnamomi* and *P. cambivora* from the soil on which the chestnut dessicated species *P. cactorum*, *P. citricola*, *P. megasperma*, *P. cryptogea* and *P. syringae* were isolated. In the Balkans, according to Milev and Sotirovski (2007) only two species *P. cambivora* and *P. cactorum* were reported on chestnut, while the most

pathogenic species *P. cinnamomi* are present only in countries which are located to the north. Portela et al. (1999) report that the interaction of several factors predisposed chestnut to the attack by the species of this genus. As the most significant factors, he reports a low fertility and bad soil aeration, as well as butt end and root injuries, caused by extracting of stumps and soil cultivation.

Considerable damages to chestnut are caused by the species from *Armillaria* genus. However, their presence in the both localities was reported on only 5 trees. Of the fungi reported on the leaves the most significant is *Mycosphaerella maculiformis*. It is frequently present in the both localities, but small foliages have been infected so far. If the conditions for its development become favorable in the foreseeable future, significant damages might be expected as well.

The physiologically weakened trees will simultaneously lose assimilation organs owning to the influence of *C. parasitica,* which will inevitably accelerate their desiccation. *M. maculiformis* causes leaf spots on many broadleaf species, but is the most frequent on Sweet chestnut. The fungus survives through the winter on fallen leaves in perithecium stage. In spring ascospores are released, which initiate the primary infections. In the infected place small characteristic polygonal necrosis with darker edges appear. In case of a stronger attack necrosis group and cover the whole leaf. On the area covered in necroses in the summer an imperfect stage of this fungus is formed, which is described as *Cylindrosporium castaneicolum*. The conidiae at this stage have, according to Haltofová (2003), 2-4 partitions, and their measures are 39-58 µm x 2.3-3.3 µm. Sometimes picnidia are also formed, i.e. the second imperfect stage of development of this fungus called *Phyllosticta maculiformis*. Both conidia and picnospores form the secondary infections during summer.

Of all species reported on the fruits in chestnut groves, *Stromatinia pseudotuberosa* has the greatest significance. Although it most frequently appears on acorns, it causes significant damages to chestnut fruits as well, causing the mummification of them. The fruits can become infected while they are on trees but most fruits get infected upon falling from the tree. In the first phase of the attack yellow spots are formed on the fruit with thinner rims which gradually become larger. The cracks with grey fungal mycelia appear later. In the end the whole fruit blackens and becomes mummified. Next autumn, apothecia begin to grow on such a fruit. In them asci with ascospores 8-10 µm x 5-6 µm are formed (Lazarev, 2001).

Other species (*Penicillium* sp., *Aspergillus* sp., *T. roseum* and *A. tenuis*) cause damages due to inappropriate collecting and seed transport or unsuitable storage.

5 CONCLUSION

Based on the research of Sweet chestnut health condition conducted in localities Sobina and Muhovac in the vicinity of Vranje the following conclusions might be drawn:

- Out of 197 Sweet chestnut trees inspected only on 21 there were no visible exterior signs of disease.

- The total of 13 fungi species was reported and the largest number was reported on branches, stem and fruits, 5 on each.

- Out of all fungi species reported *C. parasitica* has the greatest significance for Sweet chestnut survival. It is very frequent in the investigated locations. The I_{zs} in the both localities is extremely high (2.93 and 2.5), which points to the fact that degree of tree damage is high. In Sobina locality on 12 trees out 129 inspected no disease symptoms

were observed, and the large number of trees is in the desiccation phase. In locality Muhovac the situation is a little better.

- Besides *C. parasitica*, large damages on chestnut are caused by the species genera *Plythophthora* and *Armillaria* but their presence in these localities is not significant for now.

- The species *Mycosphaerella maculiformis* was reported on leaves on approximately 25-60% of trees (intensity of occurrence 3). However, the attack intensity on leaves is extremely low. It can become a more significant danger if the attack intensity increases. In that case, the physiologically weakened trees will due to the *C. parasitica* influence simultaneously lose the assimilation organs, which will inevitably accelerate the desiccation of them.

- Out of all species reported on fruits, *Stromatinia pseudotuberosa*. has the greatest significance. Although it appears most frequently on acorns, it causes significant damages to chestnut fruits as well, causing the mummification of them. Other species (*Penicillium* sp., *Aspergillus* sp., *T. roseum* and *A. tenuis*) can cause damages due to inappropriate collecting and seed transport or unsuitable storage.

LITERATURE

Carmichael, J. W., Kendrick W. B., Conners, I.L., Sigler L. (1980): Genera of *Hyphomycetes*. The University of Alberta Press.

Courtecuisse, R. (1999): Mushrooms of Britain&Europe. Harper Collins *Publishers*, London.

Dennis, R.V.G. (1978): British *Ascomycetes*. J. Cramer, Vaduz.

Diamandis, S., Perlerou, C. (2001): The mycoflora of the chestnut ecosystems in Greece. For. Snow Landsc. Res. 76, 3: 499–504, 499.

Glišić, M. (1975): Sweet chestnut (*Castanea sativa* Mill.) in Serbia and his biological and ecological variability. Phd disertacion, Belgrade. *(Original- Pitomi kesten (Castanea sativa Mill.) u Srbiji i njegov biološki i ekološki varijabilitet. Doktorska disertacija, Beograd)*

Haltofová, P. (2003): Inventarizace a zdravotní stav kaštanovníku setého *(Castanea sativa* Mill.*)* v České republice, Brno.

Juhásová, G., Adamćiková, K., Ivanová, H., Kobza, M. (2004): Situation of damage caused by *Cryphonectria parasitica* to forest stands and orchards of *Castanea sativa* by 2001 in Slovakia. Hort. Sci. 31, (3), 102-108.

Krstić, M. (1950): *Endothia parasitica* in our country. Plant protection, 2, 113-116. *(Original- Endothia parasitica u našoj zemlji.Zaštita bilja, 2, 113-116)*

Lazarev, V. (2001): Infectious diseases of forest trees, Belgrade. (*Original- Infektivne bolesti šumskog drveća, Beograd)*

Marinković, P., Karadžić, D. (1985): Most important diseases in nurseries, plantations and forest of Kosovo. Forestry, 2-3, 29-38. *(Original- Najvažnije bolesti u rasadnicima, kulturama i šumama Kosova. Šumarstvo, 2-3, 29-38)*

Милев, М., Сотировски, К. (2007): Обречен ли е обикновеният кестен? www.gorabg-magazine.info/kesten 07_07.htm

Portela, E., Aranha, A., Martins, A., Pires, A.L. (1999): Soil factors, farmer's practices and chestnut ink disease: some interactions. Acta Horticulturae, 494: 433–441.

Rittenour, R.,W. (2005): The biological potential of *Cryphonectria parasitica* strains containg an infectiosus cDNA copy of hypovirus CHV1-Euro7.1-78, Morgantown.
Robin, C., Heiniger, U. (2001): Chestnut blight in Europe:Diversity of *Cryphonectria parasitica*, hypovirulence and biocontrol. For.Snow. Landsc. Res. 76,(3), 361-367.
Sutton, B.C. (1980): The Coleomycetes. Fungi Imperfecti with Pycnidia Acervuli and Stromata. CAB- Commonwealth Mycological Institute, Kew, Surrey, England (696p.)

THE MOST FREQUENT SWEET CHESTNUT DISEASES IN VRANJE AREA

Zlatan Radulović

Summary

In localities Sobina and Muhovac in the vicinity of Vranje a total of 13 fungi species was reported. Out of all species reported, *Cryphonectria parasitica,* which causes "chestnut blight" has the greatest significance for the survival of Sweet chestnut. Its presence is extremely high, which can be concluded from the values of I_{ZS} (2.5 and 2.93).

Besides *C.parasitica*, large damages on chestnut are caused by species from genera *Plythophthora* and *Armillaria* but their presence in these localities is not significant for now.

The species *Mycosphaerella maculiformis* was reported on leaves. It can become a significant danger if the attack intensity increases. In that case, the physiologically weakened trees will due to the *C. parasitica* influence simultaneously lose assimilation organs, which will inevitably cause the dessication of them.

Out of all species reported on fruits, *Stromatinia pseudotuberosa* has the greatest significance. Although it appears most frequently on acorns, it causes significant damages to chestnut fruits, causing the mummification of them. Other species (*Penicillium* sp., *Aspergillus* sp., *T. roseum* and *A. tenuis*) can cause damages due to inappropriate collecting and seed transport or unsuitable storage.

NAJČEŠĆE BOLESTI PITOMOG KESTENA NA PODRUČJU VRANJA

Zlatan Radulović

Rezime

Na lokalitetima Sobina i Muhovac u okolini Vranja konstatovano je prisustvo 13 vrsta gljiva. Od svih konstatovanih vrsta najveći značaj za opstanak pitomog kestena ima *Cryphonectria parasitica*, koja izaziva "rak kore kestena". Njeno prisustvo je veoma veliko što se vidi iz visokih vrednosti I_{ZS} (2,5 i 2,93).

Pored *C. parasitica* na kestenu velike štete izazivaju i vrste rodova *Phytophthora* i *Armillaria* ali njihovo prisustvo za sada na ovim lokalitetima nije veliko.

Na lišću je prisutna *Mycosphaerella maculiformis*. Ona može predstavljati značajniju opasnost ako se intenzitet napada poveća. U tom slučaju fiziološki slaba stabla usled

dejstva *C. parasitica* ostaće istovremeno bez asimilacionih organa što će neminovno ubrzati njihovo sušenje.

Od vrsta konstatovanih na plodovima najveći značaj ima *Stromatinia pseudotuberosa*. Iako se najčešće javlja na plodovima hrasta značajne štete pričinjava i plodovima kestena izazivajući njihovu mumifikaciju. Ostale vrste (*Penicillium* sp., *Aspergillus* sp., *T. roseum* i *A. tenuis*) mogu izazvati značajnije štete samo ako se plodovi nepravilno sakupljaju i transportuju, ili nepravilno skladište.

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COLLISION BETWEEN FORESTRY AND ENVIRONMENTAL LEGISLATIVE RESEARCH - CASE STUDY AND STATEMENTS IN SERBIA

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Abstract: The productive function of the forests often imposes as dominant, often excluding the possibilities that the other aims of it completely serve to the materialisation of the common good. As the renewable resources, the forests should be exploited in such a way and to a such extent to preserve their biological variety, improve their productivity, ability to regeneration, vitality and their potential to perform the ecological, economic and social functions in the present and future. These and similar requirements are the subject of the laws from the domain of forestry and natural environment. The great number of legal and sub-legal acts in these domains unavoidably lead to the inter-connection, but to collision as well. Collision between the forestry and environmental legislation is often presented in a negative way, and the connection is based on the inter-sector co-operation. Today the national legislations are adapting to the international legislation, and the conventions on the environmental protection are globally ratified and adopting.

The new participants in the processess of the environmental protection join the old ones, forming the front, for sometimes non-critical views on the general market need for the forest products. The increasing number of the promoters of the environmental protection can give the picture that the business is made on the use of the natural resurses. Therefore, it is needed to perceive how ecological, social, economic and political problems influence the forest and environment.

The subject of the research within the part of the new project FOPER (Improvement of the capacities of the forestry policy and economics in the region of the Southeastern Europe) called: "Collision and Linkages between Forest and Environmental Legislation

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in Serbia" particularly refers to the relations of the legislations of these two sectors and their practical implementation in Serbia. The study which is underway also refers to the both questions from the different point of view, but influences the social dimension and benefits which are connected to the environment and forestry. The study and research are aimed at the relation of the legislative and issues which refer to the integration of the forestry and environmental legislative in the National Park Fruška Gora. The initial investigative method is based on the questionnaires and interviews conducted in the first phase of the work.

Key words: forestry, natural environment, social local community, conflict, collision

STAVOVI PREMA REGULATIVI ŠUMARSTVA I ŽIVOTNE SREDINE - PRISTUP STUDIJE SLUČAJA U SRBIJI

Izvod: Kolizija između šumarskog i zakonodavstva u oblasti životne sredine generalno se predstavlja negativno, dok je povezanost zasnovana na međusektorskoj saradnji. Nije zanemarljiv ni uticaj lokalnog stanovništva kao vlasnika i korisnika šuma i ne vladinih organizacija. Danas se nacionalna zakonodavstva prilagođavaju međunarodnim, a konvencije o zaštiti životne sredine globalno se ratifikuju i usvajaju. Novi učesnici u procesima zaštite životne sredine priključuju se starim, formirajući front, za ponekad i nekritičke stavove prema opštoj potrebi tržišta za proizvodima od šume. Sve brojniji proklamatori žaštite životne sredine mogu stvoriti sliku da je biznis zasnovan na korišćenju prirodnih resursa. S toga, potrebno je uočiti kako ekološki, socijalni, ekonomski i politički problemi utiču na šumu i životnu sredinu.

Predmet istraživanja u okviru dela novog projekta FOPER (Unapređenje kapaciteta šumarske politike i ekonomike u regionu jugoistočne Evrope) pod nazivom: Suprotnosti i veze između legislative šumarstva i zaštite životene sredine "Collision and Linkages between Forest and Environmental Legislation in Serbia" se baš odnosi na relacije legislative ova dva sektora i njihovu praktičnu implementaciju u Srbiji. Studija koja je u toku izrade i odnosi se na oba pitanja sa različitog stanovišta ali u svakom slučaju ima uticaj na socijalnu dimenziju i koristi koje se odnose na životnu sredinu i šumasrtvo. Studija i istraživanje je usmereno na relacije legislative i pitanja koja se odnose na integraciju zakonodavstva šumarstva i životne sredine u nacionalnom parku Fruška Gora.

U radu će biti prikazan početni postupak istraživanja baziran na upitnicima i intervijuima koji su obavljeni u početnoj fazi rada.

Ključne reči: šumarstvo, prirodna sredina, legislativa, socijalna dimenzija, konflikt, suprotnosti

1 INTRODUCTION

The subject of the research is the conflict connected to forest and environment protection legislation and its implementation in practice in Serbia, in form of a procedure conducted within the framework of FOPER project on conflicts. Both of the policies refer to the same topic from different points of view, and as such they influence the social dimension of environment protection and forestry usefulness. In that sense, it is necessary

to find the answer and connection between these legislations, and social dimension as primary.

While conducting researches in forest policy areas a multiple connection between different regulations in forestry and environment areas has been noticed. The existence of a number of laws and by-laws regulating the said sectors has been noted. It was observed that certain attitudes toward sensitive questions like the conflict among forest and environment sectors reveal new cases. In our effort to transparently represent the research process and problem we have not hesitated to conduct research by reviewing the existing bibliography, as well as studying familiar cases in practice. By opening the discussion about conflict problems in forestry we have become the participants in public argument, i.e. the meticulous revision of forest and environment legislation strictly because of the reason that some disagreements are more than apparent to us, as the founders of the study, and even more to colleagues for whom these problems are every day work. We have recognized that the conflict is not the state of the forced consensus rather it is a debate (Hellstrom, 2001).

Research should discover how different pressure groups treat the legislation and its implementation. Identifying the main interests of every pressure group leads to conclusion about the stimulating factors of forest policy. Where are the point references in legislation and what connections have the positive influence on pressure groups? Some researches have been conducted on forest legislation and on environment protection laws, but as separate cases.

The aims of this research are to:

- form a clear picture on conflicts among laws on forestry and environment protection;
- find out which types of conflicts exist in legislation of forestry and environment and who the main participants are;
- review conflicts between forestry and environment protection including legislation, content and implementation, mark the influence of conflicts on forest management and environment protection in the selected case;
- state the reasons for improving the legislation content and application in forestry and environment protection.

The subject of the research will be focused on integration of forest and environment protection legislation in Fruska Gora National Park. The conflicting sides are private forest owners, joined in their association. The conflict is about the welfare of soil/forest and the influence of leading factors on forest and environment protection legislation. National Park Fruska Gora represents the unique example, regarding the dispersed structure of the protected areas, cooperation of 77 private forest owners in Beocin and 17 existing monasteries. The National Park is an important recreational area for citizens of the second largest city in Serbia, Novi Sad. Easy access from Novi Sad direction and good traffic infrastructure in National Park, large pressure of visitors, intensive mushroom and forest fruits collecting cause serious problems to management.

Fruska Gora is a good example for showing the true situation in the forestry legislation area and environment protection, taking into consideration the fact that this is highly protected area, as well as the area with private land and forests (forest owner association), an example providing the opportunity to see how National Park operates today, what are the problems and conflicts, and in the end, which steps are to be taken into direction of adopting conditions for sustaining local forestry.

The short review of protected natural resources in Serbia

The first regulation concerning fauna protection in Serbia was Visocnaja decree from 1840, prohibiting deer and doe hunting, introducing the fence season for rabbits, "wild goats" and "birds good for eating". The first protected area in Serbia's territory was Obedska bara placed under protection in 1874. The Assembly of Serbia passed the first Law on forests in 1891.

The significance of common – national interest is pointed out by the report of the Assembly board stating among the rest:" Forests are nowhere and can never be the property of one generation, they are the general treasure, which every generation is obliged to preserve, and thus undamaged, in the state they were inherited, passed on to the generation to come. They can only enjoy the interest, but the main must not be chipped." The first protected natural resources were declared in Serbia in 1948; those were forest reserves: Ostrozub, Mustafa, and Feljesana Serbia in 1960. As a result of the decades of work on protection and improvement of natural in the Majdanpek area. National Park Furska gora was the first proclaimed national park in heritage 1032 natural resources were protected in Serbia i.e. 6. 5% of Serbia's territory.

The following resources are under protection:

5 national parks,

13 nature parks,

72 nature reserves,

31 area of historic and cultural significance,

13 areas of remarkable characteristics,

256 nature monuments,

642 nature rarities (215 plant and 427 animal species), while there are 179 plant and animal species, and mushrooms under controlled use and trade.

The legal aspect of Serbian protected natural resources

The states have, in accordance with the United Nation Chart and principles of international law, sovereign rights to exploit their resources according to their ecological policy, and the responsibility to make sure that the activities in their jurisdiction or control do not cause damage to environment of other countries or areas outside the borders of national jurisdiction.

Nature protection is normatively regulated directly, with more laws and by-laws (laws on hunting, fishing, forest, water, etc.) totally more than 130 different law regulations. Among others, there are by-laws: enactments on general reserves, special nature reserves, nature parks, areas of remarkable characteristics, nature monuments, as well as the enactments on establishing fence season for certain species, on prohibition of collecting certain species in some areas of Serbia, etc. Considering that nature and environment protection is an area in which a large number of regulations have not been conformed to the European Union regulations, the process of their harmonizing is under way.

According to the Code of categorizing protected natural resources classified into 3 categories:

I category – natural resources of extreme significance;

II category – natural resources of great significance;

III category – natural resources of significance.

According to the Law on environment protection there are six types of natural resources:

- National Park
- Nature Park
- Area of remarkable characteristics
- Nature reserves (general and special)
- Nature monument
- Nature rarities.

National Parks are placed under the protection of law. Nature reserves, nature rarities, nature resources protected on the basis of international enactments, and the area of remarkable characteristics making an ambient whole with the cultural wealth of some significance are placed under the protection by an enactment of the Government of Republic of Serbia. Other natural resources are placed under the protection either by a decree or a city on which territory the natural resource is located on, or local self-government. State enterprises manage National Parks which characteristics are represented in table number 1. Other natural resources are managed by administrators/owners appointed by an enactment on natural resource protection (individuals, legal persons, non-governmental organizations, and local self – government).

Table 1- National parks in Serbia

Natural resource name	Year of appointing		Category		Area (ha)	Administrator
	First appointment	Revision	IUCN	RS		
NATIONAL PARKS						
Tara	1981	1993	II	I	19,200,00	SE NP Tara
Kopaonik	1981	1993	V	I	11,800,00	SE NP Kopaonik
Šar planina	1986	1993	II	I	39,000,00	SE NP Šar planina
Fruška gora	1960	1993	V	I	25,393,00	SE NP Fruška Gora
Đerdap	1974	1993	IV	I	63,680,45	SE NP Đerdap

The easiest and most rational way of improvement for the said inter sector relationships when collisions occur is the comparative review of legal regulations abided by both activities and applied in terms of which forests in protected natural resources are managed in the end. The most significant laws and regulations applied in environment protection are stated here:

- Law on environment protection. «Official Journal RS», number: 135/04
- Law on environment protection SEIZED TO BE VALID with 135/04 – except regulations determining air protection, natural resource protection and noise protection «Official Journal RS», number: 66/91, 83/92, 53/93, 67/93, 48/94, 53/95, 135/04
- Law on strategic evaluation of influences on environment «Official Journal RS», number: 135/04
- Law on evaluation of influence on environment «Official Journal RS», number: 135/04
- Law on integrated stopping and control of environment pollution «Official Journal RS», number: 135/04

- Decree on establishing the Project list under the mandatory influence evaluation and the Project list for which evaluation of influences on the environment might be requested «Official Journal RS», number: 84/05
- Code on request content about the need for influence evaluation and content of requests for determining scope and body of the study on environment influence evaluation «Official Journal RS»,number: 69/05
- Law on national parks «Official Journal RS», number: 39/93, 44/93, 53/93, 67/93, 48/94
- Law on fish farming «Official Journal RS», number: 35/94, 38/94
- Law on handling waste matter «Official Journal RS», number: 25/96, 26/96
- Law on ionized radiation protection «Official Gazette SRJ», number: 46/96, 85/05
- Decree on systematic testing of radio nuclide content in the environment.

Regulations from the other areas applied in the area of environment protection:

- Law on forests «Official Journal RS», number: 46/91, 83/92, 54/93, 60/93, 53/93, 67/93, 48/94, 54/96
- Decree on establishing of forest protection and improvement for 2005 «Official Journal RS», number: 20/05
- Code on conditions and criteria for allotment and use of resources for forest protection and improvement «Official Journal RS», number: 58/04

Ratified international contracts of significance for Republic of Serbia

- Law on confirmation of Biologic diversity convention «Official Gazette SRJ — international contracts», number: 11/01
- Law on confirmation of International convention on trading in endangered species of wild flora and fauna «Official Gazette SRJ — international contracts», number: 11/01
- Law on confirmation of Basel convention on controlling the cross-border moving of dangerous wastes and their disposal «Official Gazette SRJ- international contracts», number: 2/99
- Law on confirmation of the United Nation Framing convention on climate change with annexes, «Official Gazette SRJ — international contracts», number: 2/97
- Montreal protocol on substances damaging the ozone layer »Official Gazette SFRY — international contracts», number: 16/90 »Official Gazette of Serbia and Montenegro — international contracts», number: 24/04
- Vienna convention on ozone layer protection, with appendices I and II »Official Gazette SFRY — international contracts», number: 1/90
- International convention on bird protection »Official Gazette SFRY», number: 6/73
- Convention on swamps of international significance especially as swamp birds habitat - «Official Gazette SFRY — international contracts», number: 9/77
- European convention on animal protection in international traffic »Official Gazette SRJ — international contracts», number: 1/92
- Convention on cooperation in protection and sustainable use of the river Danube »Official Gaze SCG- international contracts», number: 4/2003
- Montreal amendment on Vienna convention on substances damaging the ozone layer
- »Official Gazette SCG — international contracts», number: 2/2004.

Theory base

Conflicts emerge at numerous levels, such as interhuman, intercultural, situational. The complexity of the factors which are in touch with the policy on the natural resources management, such as different interest groups, scientific and technical uncertainty, variety of the cultural differences, bring to light conflicting and controversial decisions and conflicting situations, which are very often complex (Walker&Daniels, 1997a).

There are numerous interactions between people who are mutually dependent and who perceive that their interests are not identical, or there is a tension between them (Walker&Daniels, 1997a). different definitions, which appeared during the time. Generally, it can be said that the conflicts consist of interests, aims, aspirations, of at least two or more interest sides, communication and interaction, negotiation, coming into agreement and tactical behaviour. Conflicts are communicative

In accord with the all known theories, our definition with two key elements: mutual dependence and perception, is: a conflict is a communicative interaction between the mutually dependent participants/sides with the similar interests, aspirations, stretegic behaviour and differences in the perceptions.

The concept of interdependence implies that each interest group has some power, more or less, to influnce the joint decision-making. Three types of the "interest groups" /groupings appear in some conflicting situations: primary groups (main participants), secondary groups (indirectly involved) and peripheral groups. The possible roles of groupings can be direct participant in the conflict, mediator in the coflict, or an indirect role (Walker&Daniels, 1997a).

Conflict can consist of the different elements: constitutional (essential), procedural and relational (connective). Constitutional element includes the tangible (visible, which can be defined, measurable) "object" which the group perceives: "what to do, which decision to make, where to go, how to distribute resources or other objects" (Walker&Daniels, 1997b).

Constitutional conflicts in the integration of the forestry and environmental protection legislation are essential in the laws (For example: Legal theories). Process/ procedural conflicts are related to the implementation of the laws (For example: Theories on participation). Relational conflicts are essentally connected to the relation between those responsible for forestry and environmental protection, or between the authorities and population.

Recognizing the main conflicts between the forestry legislation and environmental protection in the state, with their subject matter, participants and intensity, defining their understanding, the conflict management can be understood in the triangle of the three interconnected dimensions – content, procedure and relations – and it can be reflected in numerous topics connected with the views of the interest groups and their opinion on the influence on the development of policy, in the aim of giving interest communities an important voice in the proccess.

The strategies of the conflict managements must take into account the specific circumstances in which the conflict appear. However, the complex conflicting situations cannot be solved ever, but they can be well "channelled", so that they would not become devastating. Therefore, the term managament is the broader concept which includes, but does not require the solution. It is the way of the improvement of the situation (Walker&Daniels, 1997a).

The role of the conflict in identification of participation and definition of problems: for now it lacks in the discussion, by which the importance and contribution of the social conflicts in the political discussion are recognized. Usually, the conflict is seen as the destructive force which should be reduced or eliminated. The conflict should be "managed". Nevertheless, the participats cannot be defined without the conflict. They define themselves in the relation with the others and "others" are recognized by the recognition of the differences. Therefore, the recognition of the differences lead to setting limits between "oneself" and "others" (Shannon, 2003).

People react to conflicts in different ways and choose various strategies: adapting, cooperation, avoidance and competition. Competition and cooperation are opposite strategies and conflicting situations are significantly differently motivated (Walker&Daniels, 1997a).

2 METHODOLOGICAL APPROACH TO RESEARCH

Data of the total study consist of the opinion of the representatives of the relevant interest groups, derived from the constructed questionnaire. At least, the following group will be used for the interview: employed in the Ministry of Agriculture, Forestry and Water Management, Ministry of the Environmental Protection, public enterprises, national parks and associations of the private forest owners.

The aim of the project is to collect the opinion of the interest groups on the legislation in the forestry and environmental protection.

The following should be included in the data collecting:

- forest resources – finding where the use of the forest resources is at conflict with the environmental protection
- forest regulation and reguation on the environmental protection where the conflicts and overlapping emerge
- reports, interviews, articles, laws
- Public enterprises, "Vojvodinašume" and "Srbijašume", National parks
- Interest groups important for data collection in NP Fruška Gora are:
- "Association of the Private Forest Owners", which has the forests within the boundaries in NP
- Ministries of Forestry, Agriculture and Water Management and Environmental Protection.

The questionnaires will be used in order to collect pieces of information from the interest groups to describe, compare or explain their knowledge, feelings, values and behaviour with regard to the conflicts in general. The survey shall be quantitive and qualitative. The questionnaires and interviews will be conducted in the conversation with the subject, face to face, which was done in the first phase of the research by conducting interviews, checking validation of the questionnaire, so-called "pre-testing". Subjects and interviews will be used for the check at the national level, questionnaire for the regional research will also be conducted.

By means of the questionnaire the basic data on the professional groups of the employees would be collected, on their views and opinion on the conflicts, opinion and beliefs on the way the aforesaid conflicts influence their work, or on the implementation of the short-term and long-term plans, etc. The subjects should discover the reasons/

find justification for the possible complement and incorporation of legislation where the conflict emerges.

In this study some data collected in the field, mainly through interviews, can be useful, since they can give a better insight into the social component of this problem, which, together with the legal (forestry and environmental protection) frame which can improve the relations between the different public sectors, between the state and private sectors, can give a chance to the local population as well during the decision-making.

The data obtained by the method of the questionnaires is necessary to show by tables, graphs, and do the statistical analysis. In this way the results, instruments for making concrete conclusions, are obtained.

The most important approaches to environmental management are: sustainable management, development and protection of forests, preservation of biodiversity, acknowledgement of the rigths of the traditional owners and respecting of the national legislation and signed by the international convensions, including the principle of precaution.

According to the report (Tomić, 2004) on the application of the forestry legislation the fact that the application of the regulation poses a problem for about 2/3 of the employed is clearly visible. The employed subjects of the public institutions, public enterprises, owners of the private forests, as well as experts from the forestry sector and the domain of environment consider that the forestry legislation is not adapted to the needs of the forestry within the new industrial system. The same number of the subjets are of the opinion that the forestry legislation promotes and supports the sustainable forest management in the appropriate way. More than 70% of the subjects emphasize that there are difficulties regarding harmonizing the legal regulation of the aforesaid laws (environmental protection) with the forestry legislation, or think that the harmonisation is not good enough.

3 RESULTS

The first part of the future results is formation and determination of the questionnaire, which is a very complex activity requiring time and several versions which are examined in a great detail and brought into accord with the basic concept of the research, metodological approach and national peculiarities and assumptions.

This questionnaire is the type of the interview which is done with the representatives of several institutions. We should have the same attitude towards all potential subjects and put the same questions to them. It does not mean that the subjects should not say more than it is required from them in the questionnaire, and would be important for the research.

The research deals with discrepancy/ conflict which in the great number of cases is at the first sight hidden from the public discussion, for different reasons. Our aim is to realize whether the implementation of the current legislation cause conflict from the point of view of the subjects. This research will give us the clearer picture of the problems and conflicts in the professional environment. After the arrangement of the results, they will be published in the scientific magazine, also as the relevant scientific conclusion which will help the policy makers as the directive during the making of the future decisions.

The basic questionnaire is shown in the further text:

Date of the Interview (dd.mm.year):_____

The Number of the Interview: _____

The Time of the Start (hh:mm)_____ and end (hh:mm) _____

Nº _ Name and Surname _____

Name and Surname of the Subject _____

Date of the Organization : _____

Place of the Interview: _____

Position : _____

Date of the Data Inclusion (dd.mm.year): _____

Main Questions	Auxiliary questions
1. Do you encounter the disagreements between the different interest groups in your everyday work?	**a Who/ What are the main causes of the conflicts?** 1 Different aims of the management 2 Knowledge and skills 3 Content of the law 4 Human and technical capacities 5 Ownership and user rights 6 Values 7 Tradition 8 Overuse of land 9 System and aims of management 10 Domestic population and their attitude
Describe them by topics, history, intensity and participants:	**b Who is most involved in the disagreements?** 1 Responsible ministries /Authorities /Administration 2 Forestry enterprises 3 Private wood-processors 4 NVO 5 Managers of the protected areas 6 Local administration 7 Local population 8 Private forest owners 9 Different interest associations (hunters...)
2 Does the implementation of the current legislation cause conflicts? If it is correct, please, state which the regulation is in question and describe the conflicts by topics, history, intensity?	**c For the better understanding of the conflict, I need:** 1 Education and Training 2 Greater funds 3 Better technology 4 More comprehensible /Contemporary laws 5 Better communication with the local population 6 Better communication with the employees in the Public enterprise/ National park 7 More intensive cooperation with the forestry inspection/ inspection of the protection 8 Other

3 Describe the role of the participant in the conflict. Why do they behave?	**d What can be useful for the improvement and solving of the conflicts?** 1 Communication / help pf faculties or investigative institutes 2 Propaganda (pieces of information, advertisement); 3 Media 4 Funds 5 Public relations of my enterprise (PR) 6 Improvement of the laws 7 Better technology and mechanisation 8 Harmonisation between the offer /demand and /strategy 9 The Government to hear my voice 10 Other
4 Decribe the conflict management, what was the previous situation in comparison with the current situation?	**e Which processes are the ways for conflict management?** 1 Certification 2 Participation of the public in the formulation of the regulation 3 Improvement of the national norms and regulations 4 The creation of staff 5 Training for improvement of the knowledges and skills 6 Formation of the joint bodies between the Government and Public enterprises and private forest owners 7 Horizontal communication between the Ministries 8 Introduction of faculties and scientific institutions 9 Well-developed training of the forestry sector in the domain of the environmental protection 10 Better understanding of the persons responsible for protection of the forestry issues 11 Other, if there is something, please, state

In pre-testing, the subjects mainly showed a good will to cooperate, and if we have a right approach towards everyone as an individual, it is possible to obtain useful information about the aforesaid problems and conflicts. Despite the initial disagreement and aversion to this way and approach to scientific-investigative work, usually caused by inertion, which, we have to admit, is new in this country, well-trained and skillful pollsters are able to discover conflicts. However, not completely. Also, depending on the level of the subject's view of the situation it is possible to determine the conflicts which, of course, we are all aware of. The conflicts are omnipresent, they existed in the past, they exist now, and they will emerge in the future. The scientists have the task to determine and define the conflicts, as well as to find ways to manage them (conflict management), which, as the theory says, includes the solution of this phenomenon, but does not require it.

4 CONCLUSION

It is evident that there is a great number of laws and sub-legal act which are related with the same area. By interpreting and judging them as such, each of the sectors can in theory justify its activity. In practice, it causes misunderstanding, disagreements and even the open coflict between the forestry and environmental protection legislation, since they are simly used double and impartially as the legal remedy. The views of the people which are in touch with these laws also confirm the theory.

The management and solution of the collision between the forestry sector and legislation which is related to the protected natural resources to a great extent depends upon the inter-sector cooperation, investement in the sectors, as well as monitoring and appraisal of the sectors. The international and regional cooperation becomes a key to the improvement of the legislation and contributes to the investment in the sectors, which is reflected in the connecting of the legal regulations.

We believe that the syenergy between the scientific approach and practical experience can better clarify the possible conflicts between the forestry and environmental protection legislation, as well as their future solution.

LITERATURE

Hellstrom, E. (2001): Conflict Cultures – Qualitative Comparative Analysis of Environmental Conflicts in Forestry. Silva Fenica. Monographs 2. p.12.

Tomić, N. (2005): Institutional development and construction of the capacities for national forest program of Serbia: Third Report of the Ministry of Agriculture, Forestry and Water Management, Forest Directorate. *(Original- Institucionalni razvoj i izgradnja kapaciteta za nacionalni šumarski program Srbije: Treći izveštaj Ministarstvo poljoprivrede, šumarstva i vodoprivrede uprava za šume)*

Walker, G.B., Daniels, S.E. (1997a): Foundations of Natural Resource Conflict: Conflict Theory and Public Policy. Oregon State University. USA. p.p. 13-25.

Walker, G.B., Daniels, S.E. (1997b): Foundations of Natural Resource Conflict: Conflict Theory and Public Policy. Oregon State University. P. 17: In Hocker, J.L. and Wilmot W.W. 1995. International conflict, 4th ed. Dubuque, IA: Brown and Benchmark.

Shannon, M. (2003): Cross-Sectoral Policy Impacts Between Forestry and other sectors.Chapter 5. Mechanisms for coordination. FAO Forestry Paper 142.

COLLISION BETWEEN FORESTRY AND ENVIRONMENTAL LEGISLATIVE RESEARCH - CASE STUDY AND STATEMENTS IN SERBIA

Radovan Nevenić, Ljubinko Rakonjac, Zoran Poduška, Renata Gagić, Nenad Petrović, Denis Čokić

Summary

The productive function of the forests often imposes as dominant, often excluding the possibilities that the other aims of it completely serve to the materialisation of the common good. As the renewable resources, the forests should be exploited in such a way and to a such extent to preserve their biological variety, improve their productivity, ability to regeneration, vitality and their potential to perform the ecological, economic and social functions in the present and future. These and similar requirements are the subject of the laws from the domain of forestry and natural environment. The great number of legal and sub-legal acts in these domains unavoidably lead to the inter-connection, but to collision as well. Collision between the forestry and environmental legislation is often presented in a negative way, and the connection is based on the inter-sector cooperation. Today the national legislations are adapting to the international legislation, and the conventions on the environmental protection are globally ratified and adopting. The new participants in the

processess of the environmental protection join the old ones, forming the front, for sometimes non-critical views on the general market need for the forest products. The increasing number of the promoters of the environmental protection can give the picture that the business is made on the use of the natural resurses. Therefore, it is needed to perceive how ecological, social, economic and political problems influence the forest and environment.

The subject of the research within the part of the new project FOPER (Improvement of the capacities of the forestry policy and economics in the region of the Southeastern Europe) called: "Collision and Linkages between Forest and Environmental Legislation in Serbia" particularly refers to the relations of the legislations of these two sectors and their practical implementation in Serbia. The study which is underway also refers to the both questions from the different point of view, but influences the social dimension and benefits which are connected to the environment and forestry. The study and research are aimed at the relation of the legislative and issues which refer to the integration of the forestry and environmental legislative in the National Park Fruška Gora.

STAVOVI PREMA REGULATIVI ŠUMARSTVA I ŽIVOTNE SREDINE - PRISTUP STUDIJE SLUČAJA U SRBIJI

Rezime

Proizvodna funkcija šuma nameće se kao dominantna, isključujući često mogućnosti da njene ostale namene služe u potpunosti ostvarenju opšte društvenog dobra. Kao obnovljivi resurs šume bi trabalo eksploatisati na takav način i u takvom obimu da se održava njihova biološka raznovrsnost, unapređuje proizvodnost, sposobnost obnavljanja, vitalnost i njihov potencijal da u sadašnjosti i budućnosti ispunjavaju ekološke, ekonomske i društvene funkcije. Ovakvi, a i slični zahtevi predmet su zakona iz oblasti šumarstva i životne sredine. Postojanje velikog broja zakonskih i podzakonskih akata u ovim oblastima neminovno dovodi do međusobne povezanosti ali i kolizije. Kolizija između šumarskog i zakonodavstva u oblasti životne sredine često se predstavlja negativno, a povezanost je zasnovana na međusektorskoj saradnji. Danas se nacionalna zakonodavstva prilagođavaju međunarodnim, a konvencije o zaštiti životne sredine globalno se ratifikuju i usvajaju. Novi učesnici u procesima zaštite životne sredine priključuju se starim, formirajući front, za ponekad i nekritičke stavove prema opštoj potrebi tržišta za proizvodima od šume. Sve brojniji proklamatori žaštite životne sredine mogu stvoriti sliku da je biznis zasnovan na korišćenju prirodnih resursa. S toga, potrebno je uočiti kako ekološki, socijalni, ekonomski i politički problemi utiču na šumu i životnu sredinu.

Predmet istraživanja u okviru dela novog projekta FOPER (Unapređenje kapaciteta šumarske politike i ekonomike u regionu jugoistočne Evrope) pod nazivom: Suprotnosti i veze između legislative šumarstva i zaštite životene sredine "Collision and Linkages between Forest and Environmental Legislation in Serbia" se baš odnosi na relacije legislative ova dva sektora i njihovu praktičnu implementaciju u Srbiji. Studija koja je u toku izrade i odnosi se na oba pitanja sa različitog stanovišta ali u svakom slučaju ima uticaj na socijalnu dimenziju i koristi koje se odnose na životnu sredinu i šumasrtvo. Studija i istraživanje je usmereno na relacije legislative i pitanja koja se odnose na integraciju zakonodavstva šumarstva i životne sredine u nacionalnom parku Fruška Gora.

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INTEGRAL MANAGEMENT PLAT AS A TOOL FOR INTEGRAL PROTECTION OF NATIONAL PARK "MAVROVO" IN R. MACEDONIA

Makedonka Stojanovska, Nataša Lozanovska[1]

Abstract: This paper analyzes the present situation concerning the management of the national park "Mavrovo" in R. of Macedonia and gives the tracks for its future management according to EU regulative.

According to the Law on Nature in R. Macedonia, which is harmonized to EU regulative, the national parks are obligated to make an integral management plan. In that direction the process of establishing integral management plan of NP "Mavrovo" has been started and as the new Law regulation requires it well have a strong participative approach. Application of the integral management plan will secure also a better protection of the area because the local population is involved directly in the process. They are going to be educated about the importance of the forest area and the biodiversity, cultural heritage and other components within this area. Also, the income derived from the national park area, and the attachments that people form with the area, often become an important component of the local community and all stakeholders.

At this moment it can be said that the integral management plan is needed because it will balance economic development in the area with the need for conservation and protection of its unique natural resources.

Key words: nature, protection, management, legislative.

1 INTRODUCTION

We need to analyze the present situation with the management of the national parks and gives the tracks for future management of the national park according to EU regulative. Protected areas play an important role in the evolving challenge of maintaining a sustainable world. Not only do they provide refuges for biological diversity, but they play an equally significant role in the changing economic and social basis of local

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communities and nations. That protected areas are increasingly becoming a source of tourist revenue is not surprising. The income derived from the protected area, and the attachments people form with the area, often become an important component of the local community. However, the cultural and economic effects of protected areas and their management may disproportionately impact the local community, perhaps leading to resentment toward the park. Actions affecting the protected area may be controversial because of those effects. Conducting consultation and achieving the support of local constituencies will be essential to the success of any protected area planning effort.

The objective of preserving natural areas is frequently impacted by the desire to encourage recreational use, particularly with respect to government goals for economic development and the role of nature-based tourism or ecotourism within those programs. The two goals of preservation and use are frequently in conflict, with disagreement about which should receive priority. Protected areas represent a legitimate and important source of income and stability, but the increasing recognition and capacity of protected areas to generate revenue can lead to economic dependency, which in turn increases pressures to maximize financial returns. In the face of this pressure, protected area managers still must act as guardians of the values for which the area was established, and as well as the biophysical and social impacts of increased tourism. These are the kinds of contentious contexts in which protected area managers increasingly, but inevitably, conduct and implement planning processes. It is through planning that managers can provide not only technical expertise, but also interact collaboratively with affected publics to ensure support and implementation of actions to protect the natural resource values of protected areas.

2 INFORMATION

Park profile

The National Park "Mavrovo" was founded with the law regulations of R. Macedonia in 1994, in which were included and named as protected areas the place around the territory of Mavrovo and its forest land. According this law NP " Mavrovo" is founded because of its special natural beauties, historical and scientifically meaning of the forest and the forest landscapes around Mavrovo.

The NP Mavrovo is located on the mountains: Sar Planina, Korab and Bistra. The NP "Mavrovo" is located in the Group of Sar Planina Mountains and it is part of the Sar-Pines Sistem. According to the last border setting it takes parts from the Sar, the whole massif of Korab, Montaigne Desat and Bistra. Its geographical impalement is between 41' 30" and 41' 52" northern latitude and between 20' 30" and 20' 45" eastern from Grinich. The NP "Mavrovo" lays between the two parallels that mark the area of the subtropical climate of Macedonia, in its modified Mediterranean climate in the southern part Povardarie. The primary motive for foundation of the Park was the previous foundation of the artificial lake Mavrovo Lake and its hydro energetic system. The natural beauties of this area make these ideas come true. Also the Sarplanina group of Mountains has given its part in foundation of this nature. The mountains from this group together make one natural orthographic area made of different orthographic integrity. In the group of Sara Mountains there are included several beautiful mountains of Macedonia, and few of the most beautiful mountain pastures in the Balkan. With the Lake Mavrovo one of the most complicated hydro technical problems is been solved. The flow of the river is been

changed from the Adriatic see to the Aegean see where the hydro-electrical centrals are been build. The altitudes of the park are truly developed; it has all needed characteristics of high Montaigne relief.

The main geographical and orthographical position of the park is from Mediterranean way that includes Mountain Korab and Sara, but excludes Bistra and Blajnica. The lowest altitude point in the park is located in the flow of river Radika with 600 m absolute height, and the highest altitude point is on the Mountain Korab with 2764 m. On today's territory of the park there are 52 Mountain picks with height over 2000m above see level officially market on the maps.

Forest fund

According to the last forest inventory in Republic of Macedonia, the toatl area of the NP "Mavrovo" is 73 088 ha, from witch 30 920 are covered with forests and it is been devided in 6 forest areas: "Mavrovo", "Bistra I", "Bistra II", "Desat", "Korab", and "Gorna Radika".

The wood mass of NP "Mavrovo" is 4152789 m, from witch 2555987 or 61, 5% belongs to high quality wood and 1597802 m or 38, 5% to low quality wood. The biggest amount of wood mass has the forest enterprise unit "Mavrovo" with 1247247 m or 30 % from the total wood mass of NP "Mavrovo". The annual growth is 70638 or 54, 1 %

From the whole area under forests of 30919, 24 ha, 27269, 08 ha or 88, 2% of them belong in forests and only 3650, 15 ha or 11, 8% are left for the forest land. With high quality wood there are 10067, 06 ha or 36, 9 %, and with low quality wood there are 17120, 05 ha or 63, 1 %. The greatest area belongs to forest enterprise unit "Desat" with 6175, 91 ha or 20 % of the whole area.

Why review the management plan?

It is necessary to review the plan in order to adapt the park's management orientation to current realities and challenges. Moreover, because of major changes in the Law on Nature where the national parks and protected areas are obligated to establish a new management plan according to EU regulations. The issues regarding ecological integrity, visitor experience, dialogue with local communities, partnerships with regional players, and finalization of heritage presentation will also receive prominent treatment in the preliminary management plan, which will be presented at the public consultation. The park's great challenge is to preserve its ecological integrity while providing visitors with a quality experience and contributing to the public's education. The park must also take into account regional communities' social and economics realities.

The major themes addressed

Preserving the ecological integrity of the park's ecosystems and cultural resources.

Presenting our cultural and natural heritage for the benefit of current and future generations.

Providing a safe, enriching, and high-quality visitor experience while respecting cultural and natural resources.

Offering activities that are appropriate for a national park.

Offering interesting and stimulating educational activities.

Involving local communities, organizations and visitors in the preservation of the park's ecological integrity, the protection of its cultural resources and the presentation of this heritage.

Supporting efforts to preserve biodiversity in the Mavrovo's greater ecosystem.

Contributing to the success of regional tourism.

Management plan

"Mavrovo" has a set a priority for future working (preparing an area plan according to the Law on Nature preservation section 103)

It has been formed a Tim for preparation of the Plan, and simultaneously preparation of the estimation of the value of the park had been started. E.g. Preparation pf the management plans.

According to the Law on Nature preservation they need to prepare a Study on the subject: Other alternative sources of financing the protected area of the National Park "Mavrovo". "Mavrovo" according the Law regulations is planning to hire an independent advisory consultant from the area of protection of the environment, for coordination and implementation of projects for biodiversity, development, donations and grants and ctr.

"Mavrovo" in its territory has its own safari park for (*Cervus elaphus*)**.** If we know that "Mavrovo" fulfils al its obligations, there is an existence of optimal conditions for continuance of the estimated measures, there are optimal conditions for continuance of the sustainable usage, management, and raising of the plantations in "Mavrovo". Because of their great condition, as well for the optimalisation of the full growth and development of the forest and the rest of the living flora and fauna they proposed a suitable protection measures but also, existence of all other measures.

There are few protected areas and they represent special a recognizable units, and with them they manage to control the activities in the different parts of the Park. According to the new Law on Nature preservation it is predicted a new division of the park in four areas.

- Strictly protected area
- Zone of active management
- Zone of sustainable management
- Protective vest

And in the new plan that comes they are obligated to make new area division. In the new management plan also they need to make several changes like for example full control over the unloved harvesting and transport of all kinds of forest products (they need to make regulations about proper usage).

According to the new Law on Nature preservation "Mavrovo" has been taken under concession the management of the Mavrovo Lake and River Radika. According to the agreement for concession they are obligated every year to increase the number of lake fauna with (*Salmo farioides* Kar) and with (*Salmo Montenegritis*) with purpose of conservation and protection of those species, and protection of the biodiversity of the waters in NP "Mavrovo". Protection of the Land fauna makes a great deal in the plan for protection, The Park has made a one year program for their protection. They had predicted health protection measures with help of the local veterinary center.

A physical protection of the park is been predicted with the plan for protection from the greatest treats and destructors of the flora and fauna in the Park, they have a

great help and coordination with the local police. They need to implement and carry out the plan on Fire protection. The protection of the park is in great danger of those who fish and haunt without permit ion, and also from the illegal logging.

The education of the employees makes a great difference in the better management of the park. The park employees will be educated on protection from forest fires (first aid after injury, protection of the fireman's and ctr.). According to the Law on nature preservation they are obligated to found security service thru reconstruction of the one that already exist. The hired security workers need to be trained properly for their work task. They need to implement proper education to the other employees in Administration on high tech working and proper registration of the forest, as well as taking courses on English Language. Knowing the fact that the digital data processing thru usage of the software cooled GIS is becoming a necessity for proper presentation, analyzing and collecting data, NP "Mavrovo" are planning educate two employees for its usage. These activities are planed to be competed in the frames of this project, "For environment preservation, economic development and promotion of Eco-sustainable tourism of NP "Mavrovo" and thru the walleye of River Radika".

Protection of rare and endangered Species, and preservation of the habitats and cultural and historical legacies

According to the Law on Natural preservation act 103 NP "Mavrovo" had prepared an operational plan for Fire protection, and it is fulfilling all its duties and activities (direct and indirect) witch are predicted with this plan. The protection of the natural and historical legacy plays an important role in this management plan. There are many objects that are named as cultural heritage and with that they are protected with the Law (monasteries, churches, old houses and ctr.).

The security employees will get a proper training on getting public services on the tourists like for example explaining the facts about the park to the visitors (about, foundation, borders of the park, the existing flora and fauna).

The preparation of a new systematization of NP "Mavrovo" is on its way in which are predicted changes in the marketing-communication sector and services to the visitors, they will deeply develop those issues. They will prepare informational places, road pointers and recreational paths. Many of the employees will be trained for working as a tourist guides. They will increase the coordination with the sky-centre and the other tourist's facilities with one purpose increase of the tourist's offer of "Mavrovo".

According to de Law on Nature preservation Act 74 NP "Mavrovo" does an integral management of the whole territory. In that are included the caves and their protection as nature legacy. In that direction they are planning to make a program of visiting and sight seeing of the cave, who will include also the measures for its protection, and the conditions that need to be respected for its full preservation. If everything is going to be fulfilled than they can get the license of caves proper management. With that license they will have the chance for enlarging the tourists offer for cultural educational and tourist-recreational offer of the National Park. If they can manage to realize that, they can get other way to finance NP "Mavrovo".

If they constitute a web page they according to the needs for proper and easy information, with following the World trends, they can enlarge the number of the potential visitors, with giving them all the information's they need to know about NP "Mavrovo".

In order to get a new and improved infrastructure of the tourists offer they are planning to build tourist-recreational paths around the Lake Mavrovo and River Radika, and around the monastery St. Jovan Bigorski.

They are also planning to build mountain paths, to rebuild few tour locations, like picnic places, promenades, fountains, nature houses and information tables (maps and ctr.).

Volunteering and other activities

The volunteering of the local population and the citizenship sector, that are been implemented partially, at the beginning of their education for the possibilities for development of the rural tourism, thru accommodation of groups of visitors and production and selling of healthy food, protection of the flora and the fauna in the places where they live, thru rising of the public awareness, and their participation in working activities like forestation of bear land and other activities.

All the time there are special happenings (promotions), and ctr. that helps increasing the amount of visitors and admirers of the park. The educational activities come from the idea that all the educational facilities can establish educational teaching and classes on the territory of the park, all with purpose better and easier understanding of the matter about nature from the students. Like for example:

- Elementary schools teaching in the nature (Biology, zoology)
- High schools (Schools for working in the nature, from the area of forestry, ecology, hunting and ctr.)
- Highly educational institutions (Faculty of Forestry, Faculty of Natural Science, Pharmacy Faculty and ctr.)

NP "Mavrovo" would like to help within its own range to all interest educational institutions for studying in practise, in the area that is in the studying interest of the student.

NP "Mavrovo" would like to help to all initiatives for children's fun and education like for example the children's happening, the building of the "Snow City" in winter.

Obligatory monitoring of the park

NP "Mavrovo" it is obligated, thru properly trained people and security service to be on the field and look after the park and the activities within during 24 ours a day. The security activities are compound of:

- The numbered and the health state of the parks fauna, with special accent of protection of the indentured species with the Law on hunting (bears, wild cats, reindeers, eagles and ctr.) and to look out for all the animals that live in the parks territory.
- They need to make monitoring of the total complex picture of the flora, the fitocenosis communities, their health condition, their proper development and ctr.
- In the critical period, during the summer, they need to make monitoring from specially selected strategic places, 24 ours a day, from the danger of appearance of forest fires (like the greater destructors of the complete flora and fauna in the park).
- It has been predicted full time monitoring of the numbered and the health condition of the realest in the nature species of (*Cervus elaphus*), how it is readapted

in the nature and recognition and elimination with time of the predators, and protection from the anthropogenic factor (people who hunt with out permit ion).

Activities in the field of scientific research

The need for scientific researches is arising from the fact that the flora and the fauna in the park is very reach with various species, thanks to the developed orography and the great configuration of the mountings in the park. But it is not properly researched, and the information's about it are in small amount, not enough fragmented. Knowing the fact that in Mavrovo there are from 1200 to 1300 different kinds of plant species, classified in 295 subspecies and 87 families, there are been predicted activities in that purpose for new researches and systematisation on few more important groups of plants, that we consider are not enough researched, and we can number the endemic and the relict, the glacial relicts, and the group of rear plants, fungous, and animals that live in the parks territory.

Because of the fact that the official web site of Republic of Macedonia stands that in 1996 are made special satellite measurements of the altitudes of the mountings, and they have come to unconfirmed conclusion that the altitude of the mountain pick "Korab" it is not 276 m above the see level but it is 100 meters more high. If we manage to prove these measurements that is 100 meters higher, that will represent a sensation in the scientific world, because of that we will have opportunities for new and much greater scientific research. Lead by that fact we will consult and we will hire recognised scientific institutions, so they can properly rediscover the truth about that measurement.

Ways and conditions for giving parts of the protected areas under concession of legal and private persons

According to the Law on nature preservation Act 135 annex 6 they are obligated to give permit ion for doing some business actions. Is that going to influence somehow on the flora and the fauna, locally or wider, will that destroy the natural and the landscape values of the park? After they will give or not their permit ion for business actions, The Government is the one that have the final word for issuing that permit ion for business actions in protected area..

3 CONCLUSION

According to all these above mentioned activities that the NP Mavrovo is going to complete, it is more than obvious that some radical steps going to be taken. Partnership, cooperation and ongoing dialogue between the park and regional players will have a contribution to the region's sustainable development, the preservation of its biodiversity and the success of the regional tourism.

LITERATURE

Butler, R.W. (1996): The concept of carrying capacity for tourism destinations: Dead or merely buried? Progress in Tourism and Hospitality Research, vol. 2.

Graefe, A.R., Kuss, F.R., Vaske, J.J. (1990): Visitor Impact Management: The planning framework. Washington DC: National Parks and Conservation Association.

Graham, R. (1989): Visitor management and Canada's National Parks. In R. Graham and R. Lawrence, eds., Towards serving visitors and managing our resources. Waterloo, ON: Tourism Research and Education Center, University of Waterloo.
Hammitt, W. E., Cole, D.N. (1987): Wildland Recreation: Ecology and Management. New York : Wiley.
Haas, G.E., Driver, B.L., Brown, P.J., Lucas, R.C. (1987): Wilderness management zoning. Journal of Forestry, vol. 85.
Hendee, J.C., Stankey, G.H., Lucas, R.C. (1990): Wilderness Management. Golden, CO : North American Press.
Lee, K.N. (1993): Compass and Gyroscope : Integrating Science and Politics for the Environment. Washington, DC : Island Press.
Lindberg, K., McCool, S.F., Stankey, G.H. (1997) Rethinking carrying capacity. Annals of Tourism Research, vol. 24.
Machlis, G.E., Tichnell, D.L. (1985): The state of the world's parks: An international assessment for resource management, policy, and research. Boulder, CO, Westview Press.
Mandis Roberts Consultants (1997): Developing a Tourism Optimisation Management Model (TOMM), a model to monitor and manage tourism on Kangaroo Island, South Australia. (Final Report). Surry Hills, NSW: Mandis Roberts Consultants.
Mccool, S.F. (1996): Limits of Acceptable Change: A Framework for Managing National Protected Areas: Experiences from the United States. Unpublished paper. Missoula, MT : School of Forestry, University of Montana.
Manning, R.E., Lime, D.W., Hof, M., Freimund, W.A. (1995): The Visitor Experience and Resource Protection (VERP) process: The application of carrying capacity to Arches National Park. George Wright Forum, vol. 12.
Martin, S., McCool, S.F., Lucas, R.C. (1989): Wilderness user perceptions of campsite impacts. Environmental Management, vol. 13.
Shelby, B., Heberlein, T.A. (1986): Carrying capacity in recreation settings. Corvallis, OR : Oregon State University Press.
Stankey, G.H., McCool, S.F. (1991): Recreational use limits: The wildland manager's continuuing dilemma. Western Wildlands, vol. 16.
Stankey, G.H., McCool, S.F. (1992): Managing recreation use of marine resources through the limits of acceptable change planning system. Unpublished paper. Missoula, MT: School of Forestry, University of Montana.
Stankey, G.H., McCool, S.F. (1993): Managing tourism and recreation in protected habitats: Prerequisites for effective strategies. Paper presented at Second World Congress on Tourism for the Environment, Porlamar, Isla de Margarita, Venezuela, September 26 - October 2, 1993.

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POTENTIALS OF FOREST ZABRAN IN SAVA'S FORLAND NEAR OBRENOVAC FOR FUNCTION OF RECREATION

Milijana Cvejić, Suzana Mitrović[1]

Abstract: The ocassional flooded area in Sava's forland near Obrenovac belongs to the category of the forest with the reduced productive function. The researches conducted during 2008 for the needs of the creation of the Plan for reconstruction, recultivation and arrangement of the devasted area in the location Zabran in Sava's forland near Obrenovac, demonstrated the need for the recreational use of this area. Creation of the Plan for the use of the devastated forest area for function of recreation in the open area (by the Project Cvejić, M, 2008), the recreational needs of the inhabitans will be satisfied and the current forest vegetation will be preserved.

Key words: forest, nature protection, recreation

PRIKAZ PLANA KORIŠĆENJA DELA ŠUME ZABRAN U FORLANDU SAVE KOD OBRENOVCA ZA PREUZIMANJE REKRACIONE FUNKCIJE

Izvod: Povremeno plavno područje u forlandu Save kod Obrenovca pripada šumi sa umanjenom proizvodnom funkcijom. Istraživanja koja su obavljena tokom 2008. godine za potrebe izrade Plana sanacije, rekultivacije i uređenja devastirane površine na lokaciji Zabran u forlandu Save kod Obrenovca, su pokazala da postoji potreba za rekreacionim korišćenjem ovog područja. Planom korišćenja devastiranog šumskog područja za funkciju rekreacije na otvorenom (po projektu Cvejić, M., 2008), zadovoljile bi se rekreacione potrebe stanovnika i očuvanje postojeće šumske vegetacije.

Ključne reči: šuma, očuvanje životne sredine, rekreacija

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INTRODUCTION

The recreational function of the forest is the secondary, non-profitable function in the relation with the primary, productive function (Forest Law, (Official Gazette of the Republic of Serbia, Number 46/1991, 83/1992, 54/1993, 60/93 i 54/1996). The use of forest Zabran in the part of the forland for the function of recreation has not been analyzed and planned so far. The forland of forest Zabran is spontaneously used nowadays for the recreation despite of its nature limitations. The aim of the paper is the review of the Plan for arrangement and use of the devastated area in the location Zabran in Sava's forland near Obrenovac.

2 OBJECT OF RESEARCH AND METHOD OF WORK

The area of the research includes the part of forest Zabran in Sava's forland near Obrenovac, between the Sava River flow in the northeast, to the embankment and part of the forest in the protected part, at the west vorder of the area. South border consists of the current camp, and the north border consists of the digged channel. The investigated area covers an area of 42,100 m^2. The area is flooded occasionaly and characterized by the deep level of the ground water.

The method of work included the field researches and procession of the data from the readily-available studies and plans: Study on the condition of the current forest vegetation (Zabran- picknic's forest, 2004 – 2008), Plan for the general arrangement of the part of the Obrenovac's forest Zabran (2007), as well as the data from the archives of the Hydrometerological Service of Serbia, for the Belgrade area (2007).

The analysis of the collected data was conducted by the following method in the creation of the plan, i.e. assessment of the suitability of the area for the function of recreation.

3 RESULTS OF THE WORK

3.1 Nature characteristics of the area

3.1.1 Climate

Obrenovac is characterized by the moderate-continental climate [2]. Mean monthly temperatures reflect the regularity in the range between the minimum in January and maximum in July. There are between 30 and 40 days with the maximal temperature (temperature sometimes reaches 40-42°C). As a rule, winters are severe and changeable. The greatest difference between the hottest and coldest day is 16.7°C.

The early frosts occur in November, and late frosts occur in late March, which is not expected to have an adverse effect on the vegetation. The average period devoid of frost lasts between 180 and 215 days. The sunshine lasts between 2,000 and 2,100 hours. The minimum of precipitation is in February and September (434 mm), and maximum is in May and June (691 mm). The precipitation in the form of hail most usually occurs in May and June, but it can also occur in the period April-September. The snow layer varies from year to year, in regard of the depth and duration. The depth ranges between 5 and 70 cm, and the duration of it between 2 and 66 days. Southeastern wind kosava is the

[2] The Hydrometeorological Service of Serbia for Belgrade Station (2008), Climate, Belgrade

important characteristic of this region. It mainly occurs in winter and spring, as well as in autumn months. Most usually it is dry and cold wind, reaching the speed from 18 to 40 km/h, and usually blows in the strong gusts, which at the moments reaches the storm speed, from 90 to 115 km/h. The second wind in this area is west-northwestern wind. It mainly occurs in summer, and it is less intensive than kosava. It also causes soil drain.

Analysing the total climate characteristics, regularity in the course of the mean annual tempeture amplitude, duration of the sunshine, occurrence and intensity of the kosava wind, quantity and rhytm of the precipitation in the summer and winter month, as well as the limit values of the criteria of the climate suitability by Turowski (1972)[3], it can be concluded that the investigated area, in relation to the climate characteristics, have potentials for the development of the recreation function.

3.1.2 Vegetation and pedological characteristics

Forland in Zabran (unprotected part of the alluvial plane in the very vicinity of Sava's water flow) belongs to (Forest-industrial base Košutnjačke forests, 2004 – 2008*)* spatial entities IVa and IVb. The vegetation of forland consists of the pedunculate oak and ash (*Fraxino-Quercetum-roboris-subnundatum)* association on marshy chernozem (humogley), with the characteristics of γ-gley. The association of ash with the clump of mixed pedunculate oak trees at an altitude of 73 m is characterized by the strong antropogenic influence, open canopy, with the cleared shrub layer. The root system of pedunculate oak and ash is additionally moistened by the ground and occasionally by the flood water. Thanks to the capillary raising of ground water, plants are very well-supplied with the soil moisture. Within the forland, in the depression, the ash (*Fraxinus angustifolia*) on alluvial soil (fluvisol) was reported in the small area, where the material of the heavy mechanical composure is present in all layers. These soils are under the permanent influence of the flood and ground waters. The productive potential of this alluvium is not very high. The parasitic plant mistletoe (*Viscum album*) was also observed. Syberian elms demonstrated tolerance to flooding, high level of the ground water and exposure to sun.

Against the criterion of suitability of the percentage of the forest of forland Zabran established by Turowski (1972), it can be concluded that this criterion satisfied the optimal suitabilities, i.e. 60% of the territory is covered by forest, whereas the other parts of the analysed territory, i.e. 40% are open areas and meadows.

3.2 Zabran in Sava's forland

3.2.1 Description of the condition

Forest Zabran is the area where during the year, and particularly during the period from spring to late autumn, a great number of people come for rest and recreation.

The facilities built in the forest point to the fact that the visitors are interested in staying in the area of forest Zabran. In the protected part of the forest lodge and the small number of the private houses (weekend cottages) are situated, as well as the children's

[3] Climate (Turowski): For all climate properties linear function was used. The intervals of measuring were determined according to the average minimal and maximal values of the suitabilities of the climate propertise. Thus, the mean annual temperature was taken in the interval 0 - 10 °C, mean annual precipitation in the interval 500 –1200 mm. For the mean annual sunlit the interval is 1,340–1,915 hours, by which the low values are unfavourable, whereas maximal values are very favourable.

playground, catering facilities with the accompanying contents, trimmed path, and shooting club "Odisej", and several wooden facilities with the sitting eaves.

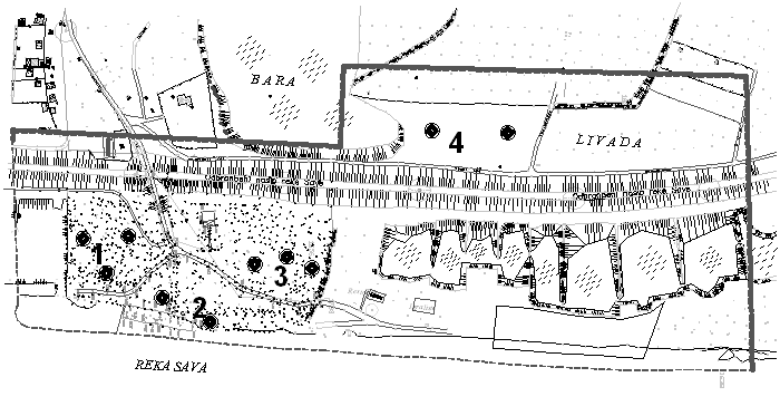
In the area of forest Zabran in the forland the restaurants "Savska terasa" and "Alpska koliba" are located, as well as the improvised camp. Zabran is the favourite vacation area of the citizens of Obrenovac, isolated from the noise, ideal for the nature-lovers.

In accord with the Forest Law ("The Official Gazette of the Republic of Serbia", number 46/1991, 83/1992, 54/1993, 60/93 and 54/1996) forest Zabran has the economical forest status. This fact points to the implementation of the arrangement measures which do not imply the picnic-recreational forest function. Therefore, previously it was impossible to implement all the arrangement measures necessary for the apropriate arrangement of this complex, since it will enable this forest to serve for the needs of vacation and recreation, which will be its priority function.

3.2.2 The previous use of the investigated part of forest Zabran

The field researches showed that this part of the forest is spontaneosly used for the purpose of recreation. The following recreational activities were observed: camping, barbecuing, swimming, boating, canoeing, motorbiking. All these activities are done in an unorganized and elemental way. The consequence of this use is the neglected and slovenly look of this area. Currently, the elements for children's play which are located in the area freely, without the clear picture of the concept of area and the real needs of the visitors, are situated in the planned area (Picture 1).

Picture 1- The current use of the area of forest Zabran in forland for function of recreation



Legend: 1 - The place of the spontaneous gathering of the campers; 2 - Access to the river and camp and the use of the motor vehicles; 3 - The place of barbecuing; (in the plots 1, 2 and 3 the following are inscribed: the current forest vegetation and earth paths), 4 - Meadow used as rifle range.

According to the review of the current positions of the recreational activity of the visitors it may be concluded that there is a need for the arrangement and transfer of this area in the organized recreational zone which would be able to satisfy both daily and weekend needs of the citizens of Obrenovac and wide vicinity.

3.2.3. Planned development of the recreational function in the location of Zabran

Ecology fund (investor of the Plan) analysed the needs of the citizens for the recreational use of this part of the forest, which is defined by the project task (increase the number of the recreational activities, provide the good communication and accessibility to all the recreational facilities, preserve the current vegetation).

Respecting the nature peculiarities of this area, and in accord with the project aim and analysis of the suitablity for the recreation, the plan for the use of the investigated area was suggested. The plan anticipates the composition and functional contents: the type of the highway, the size of the plot, the type of activity, load of the area according to the number of visitors per unit of area and time of stay, which is presented in Table 1.

Among the elements which have been already set for the children's recreation, the new facilities for the active and passive recreation are suggested by the Plan draft of the use. The whole area of the forest Zabran in forland was divided into zones with the contents and accompanying elements for the different types of recreations, for which the need arose in this part of the terrain.

Table 1- Planned content of the investigated area by zones

Zone 1: CAMPSITE		Area 7,124.0 m^2	
Component of the zone	Additional equipment	Size	Unit
Area of Zone 1 for camp-trailers		7,124	m^2
Asphalted path	Path3	121	m
Earthen path	Path1a, b, c	167	m
Total length / Area of the Paths		288/744	m/m^2
The total number of parking places	PP	26/312	piece/ m^2
Activities:			camping
Number of visitors			100 camp-trailers
The time of stay of visitors			since early spring to late autumn
Load of the area of Zone1 by the additional equipment 10.5%			

Zone 2: BEACH		Area: 5,780m^2	
Component of the zone	Additional equipment	size	unit
Total area of Plot T3		5,780	m^2
Total length /Area of Asphalted path	Path4, Path5, Path6	290/580	m/ m^2
Stands used for sitting, sunbathing, watching of the sports events,ramp for lauchning boats in water		346	m^2
The total length of stands		58	m
Activities:			grass sports, children's play, sunbathing, swimming, water sports, walk along „health path"
Number of visitors 30 / ha			
The time of stay daily stay, greatest number of visits at weekend			
Load of the Zone2 by the additional equipment 16%			

Zone 3: BARBECUING		Area: 6,699m^2	
Component of the zone	Additional equipment	size	unit
The total area of Plot T3		6,699	m^2
The total length of the earthen path	Path8	451	m
The total number of Parking places	PP	37	pieces
Park mobiliar	Shade, hearthen, logs	30	pieces
Activities: barbecuing, nature vacation, walk along „health path“, children's play			
The number of visits			20/ha
The time of stay		daily stay, the greatest number of visits at weekend	
The load of area of Zone3 by the additional equipment			18%

Zone 4: RIFLE RANGE		Area: 8,387m^2	
Component of the zone	Additional equipment	Size	Unit
Total area of Plot T4		8,387	m^2
Protective belt		408	m^2
Park mobiliar	Bench, shade, sets of rubbish bins, changing rooms, storage room, toilet	35	pieces
Vegetation	*Acer pseudoplatanus*	8	pieces
Activities: sports events –shooting with the provided accompanying facilities			
The number of visits			20/ha
The time of stay number of visits is reported only in the time of sports event			
The load of the area of Zone4 by the additional equipment			6.9%

Zone 5: GREAT PARKING AREA		Area 8,340m^2	
Component of the zone	Additional equipment	size	unit
The total area of Plot T5		8,340	m^2
The total length of the asphalted path		288	m
The total number of Parking places	PP	386	pieces
Vegetation	*Acer pseudoplatanus*	78	pieces
	Ulmus pumila	52	pieces
	130		pieces
Activities: parking and access of the visitors to the recreational facilities and restaunts in forland			
The load of the area of Zone4 by the additional equipment		386 parking places 100%	
Time of stay		daily stay, the greatest number of visits at weekend	
The number of visitors			-

Highways out of recreational zones			
Asphalted paths	Paths 1, 2, 7, 9	1022	m
The number of parking places			63 p.p

THE TOTAL PLANNED AREA FOR FUNCTION OF RECREATION IN FOREST ZABRAN
42,110 m^2

The Plan for the use anticipitates five zones for active and passive recreation, by which the highways connect recreational zones and activities within them, which make the all parts of the park in this part of area of forest Zabran in forland be arranged and easily accessible.

3.2.3.3 The description of the project recreational zones

Zone 1 Campsite, covering an area of 7,142 m^2 is the area arranged for easy and organized access of the vehicles with camp-trailers. The area aimed for the camp was arranged within the current forest. On the earthen base the paths made of broken stone (smoothed huge gravel) were marked, in the aim of the preservation of the nature condition of the ambient totality, providing drainage ability of the terrain and reduction of the quantity of dust in the summer months. By the rim of the camp zone the parking places for the visitors of Zabran are provided.

It is possible to reach the Zone 1 (Camp) from two directions (Path 1 and Path 3), by the asphalted paths which descend to this area from the embakment (Path 9). In the aim of the prevention of the unorganized enters to the campsite along the path (Path 1) the construction of the parking areas with the fence made of wooden logs, at a distance of 50cm, in the direction to the forest, is planned. The kerbs were set by the rims of the parking area in the direction to the highway and are of the greater dimensions in the direction to the forest in order to hinder the enter to the vehicles to the places of the camp which are not aimed for parking in one more way. The activities done in the Zone 1 are: camping, access to the catering facility on the river, parking by the rim of the zone, launching boats in water, water sports.

Zone 2 (Beach) is the zone aimed for active recreation of children and grown-up. The pedestrian paths in the Zone 2 are dimensioned in the dimension of the one-way vehicle-pedestrian paths for serving, 3m wide. The pedestrian paths connect all the contents in the Zone 2. "The health path" is aimed for walking in the park and path for walking on the river bank are made of coloured asphalt, by the method of construction of bicycle paths, on the base of armoured concrete, with white garden kerbs which are dipped in the concrete pillow.

In the sub-unit intended for nautical-aero zone the stands on the already built concrete layer with the sitting and sunbathing stairs made of armoured concrete were set, the dimensions of the stands are 0.29/1.00/6, with 4 prongs of stairs.

In the zone of the beach the base which is well-drained was built of the layers of the huge and small gravel. In the location of Zone 2 the sanitary elements are also anticipated: changing rooms, showers, toilets and accompanying catering stands of the temporary seasonal character, necessary for the recreational function in this location. The activities in the Zone 2 are: grass sports, children's play, water sports, relaxation in the cafeterias, the walk along the "health path".

Zone 3 is the zone for the passive recreation – barbecuing. In the sub-unit of the recreational zone "barbecuing" the construction of the facilities made of hard materials is not allowed. Within the current forest vegetation the second part of the path "health path" and areas for vacation (9 sitting sets of the type "Smrčak", 3 hearths, and 18 sitting logs) were built. Owning to the occasional flooding of the terrain, the facilities on the surface were anchored in the concrete base, with the starlike steel construction for the increasing of the stability. The activities in the Zone 3 are: barbecuing, nature vacation, the walk along "health path", children's play.

Zone 4 is the location used as rifle range, (8.387 m^2). By the project it was supplemented with the mobiliar for the accommodation of the visitors of this sports event (wood bench, set "Smrčak", rubbish bins) whereas in the protective embarkment – from the protected side the necessary accompanying facilities (two changing rooms, two store rooms, one sanitary facility) are located. Along with the position and quantities of the accompanying contents necessary in this area, the obligatory measures of protection are also anticipated by the project: enclosing of the location for this sports event and the protection of the visitors. The activities in the Zone 4 are: sports event – shooting with the provided accompanying facilities.

Zone 5 is the great parking area, zone in which the parking area in 5 rows with 386 parking places was built. For greening and providing of the shade in the parking areas of the great open parking area (8,340 m^2) the following species are anticipated: Siberian elm *(Ulmus pumila*) 78 seedlings and Sycamore maple (*Acer pseudoplatanus)* 52 seedlings, which are well-adapted to insolation and soil conditions. The base in the parking area is made of concrete raster elements, which are filled with soil substratum and grassed. The parking zone is connected with the catering facilities in the forland belt by the stairs of wooden steps, which are set in the embarkment and which by their form and material serve the function. The acitivities in the Zone 5 are: parking and access of the visitors to the recreational facilities and restaurants in the forland.

The highways within the whole recreational area out recreational zones are dimension in the dimension of two-way vehicle-pedestrian path with and without parking area and covered by asphalted cork on the base of the armoured concrete with concrete kerbs.

3.2.4. Load of the part of the forland in Zabran for function of recreation by the planned way of use

The load of the area of Zone 1 (Campsite) by the additional equipment is 7.44 m^2, which accounts for 10% of the total area of the plot 1 (7,124 m^2); The number of the visitors is determined by the number of areas for camp-trailers in 100 m^2. The visit to the campsite implies the stationing of the vehicles with camp-trailers for a longer period, i.e. for the period since the early spring to the late autumn, when the nature condition are no longer favourable to the stay in the open.

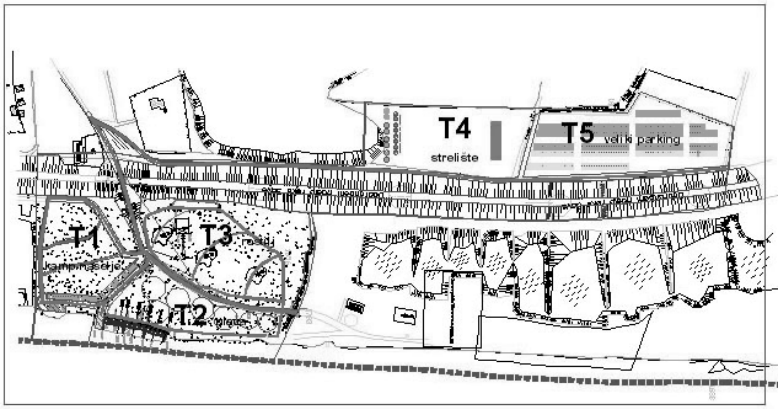
The load of the area of Zone 2 (Beach) by the additional equipment is 926 m^2 of the used space with 30 visitors/ha, which accounts for 16% load in relation with the total area of the plot 2 (5,780 m^2). The number of visits is constant in the period spring-autumn with the increased load on weekend days.

The load of the area of Zone 3 (Barbecuing) by the additional equipment is 30 park elements in 1,211 m^2 with 20 visitors/ha, which accounts for 18% of the total area of the plot 3 (6,699 m^2). The number of visits is constant in the period spring-autumn with the increased loading on weekend days.

The load of the area of Zone 4 (Rifle range) by the additional equipment is in 8, 340 m^2 20 visitors/ha and 35 equipment elements, which accounts for 6.9% of the total area of the plot 4 (8,387 m^2). The number of visits is reported only during the sports event.

The load of the area of Zone 5 (Great parking area) by the additional equipment is 386 parking places in 4,632 m^2 with 3,708 m^2 of the access highways, which accounts for 100% of the total area of the plot 5 (8,340 m^2). The number of visits is constant in the period spring-autumn with the increased load on weekend days, which is presented in the Picture 2.

Picture 2- Planned use of the area of forest Zabran in forland for function of recreation



Legend: 1 - Zone 1 – Campsite; 2 - Zone 2 – Beach for the active recreation by water; 3 - Zone 3 – Barbecuing and other types of the passive recreation *(in the plots 1, 2, and 3, the current forest vegetation is inscribed);* 4 - Zone 4 – Rifle range– the area arranged for sports events; 5 - Zone 5 –Zone of the great parking area

By this plan of the use of the area for function of recreation the maximal used area in 42,110 m^2, without distrubing the current forest vegetation, organized, arranged area with the clearly defined and highways by the well-connected plots for function of recreation, was obtained. Beside the exterior communication by the plan of use the connection on the plots between the recreational activities was also provided. The plan of the use also enables the accession to the motor vehicles to the very location, by which the vehicles park in the parking areas intended for it, which are set in the very forest by the rim of the forest highway, and no tree was removed but the parking areas were set between the existent ones. By the project the sufficient number of recreational facilities was provided, and the existent forest vegetation is not endangered.

4. DISCUSSION AND CONCLUSIONS

The plan of the use anticipates the new organisation of the activities, despite of the fact that the riparian part of the forest is flooded twice a year for several months. By the plan the zones and highways of higher and lower orders are anticipated, by which the following results are achieved:

- By planning the recreational function in the unprotected part of forest Zabran the logical sequence to this function in the protected part of the forest, where the researches showed that the current territorial behaviour of the visitors in accord with the use of the area for recreation, was achieved.

- Planning the forest land in Zabran by the river for function of recreation, contributes to the increase of the offer of the recreational activities in this area;
- Plan suggests that by the future forest management the ratio of the areas should be preserved, which will enable the further improvement of the forest suitability for recreation;
- By planning the use of the area for recreation function without destroying of the current vegetation the stability of the forest ecosystem is preserved;
- By setting of the drainage bases in the zones of the recreational areas the technical reconstruction of the complete area is performed.
- By introduction of the function of recreation in the forestthe conditions for the control of the destructive activities in the forests are made more favourable.

LITERATURE

Cvejić, J. (1998): Tourism and recreation – preparation of lectures. The Faculty of Forestry in Belgrade. *(Original- Turizam i rekreacija - priprema predavanja. Šumarski fakultet u Beogradu)*

Vlatković, S. (2001): Environment and forest functions. Public Enterprise for Forest Management "Srbijashume", The Institute of Forestry, Belgrade. *(Original- Životna sredina i funkcije šuma. Javno preduzeće za gazdovanje šumama „Srbijašume", Institu za šumarstvo, Beograd)*

Vučićević, S. (1999): Forest and environment. PE "Srbijashume" Belgrade, The Faculty of Forestry of University in Belgrade, Belgrade. *(Original: Šuma i životna sredina. J.P."Srbijašume" Beograd, Šumarski fakultet univerziteta u Beogradu, Beograd)*

Hydrometeorological Service of Serbia for Belgrade station (2008), Climate, Belgrade. *(Original- Hidrometeorološki zavod Srbije za stanicu Beograd (2008), Klima, Beograd)*

Plan for general arrangement of Zabran vacation area in Obrenovac, (2007), Obrenovac. *(Original: Plan opšteg uređenja izletišta Zabran u Obrenovcu, (2007), Obrenovac)*

Forest Law of the Republic of Serbia (Professional Gazette of the Republic of Serbia, numbers 46/1991, 83/1992, 54/1993, 60/93 i 54/1996). *(Original- Zakon o šumama RS ("Službeni glasnik RS", br. 46/1991, 83/1992, 54/1993, 60/93 i 54/1996)*

Forest-industrial base Koshutnjachke forests. Obrenovac – Zabran in forland, (2004-2008): PE "Srbijashume", "Forest Management Unit" Belgrade. *(Original: ŠPO Košutnjačke šume. Obrenovac-Zabran u forlandu, (2004–2008): JP" Srbijašume "Šumsko gazdinstvo" Beograd)*

POTENTIALS OF FOREST ZABRAN IN SAVA'S FORLAND NEAR THE OBRENOVAC FOR FUNCTION OF RECREATION

Milijana Cvejić, Suzana Mitrović

Summary

The possibilities of the use of forest in alluvium for function of recreation were researched. The researches showed that for the determination of the type of recreation

in relation to the potentials of the area and needs of the users it is adequate to apply the method of suitability estimation of the area for function of recreation.

The results of the researches show that by the technical-surface terrain reconstruction it is possible to completely use the location for the different types of active and passive recreation, by using adequate and accompanying equipment, without endangering of the current condition of the forest vegetation. The plan of the arrangement and use of the devastated area in location Zabran in Sava's forland near Obrenovac was presented. This plan for the use of the area enables the area for 100 camp-trailers, 449 parking places, 45 elements of recreational equipment, 138 of newly-established seedlings, 2,340 m of paths to be provided on 42,110 m^2, which is in accord with the permitted load of the zone for recreation in the forest by the preservation of the stability of the forest ecosystem.

PRIKAZ PLANA KORIŠĆENJA DELA ŠUME ZABRAN U FORLANDU SAVE KOD OBRENOVCA ZA PREUZIMANJE REKRACIONE FUNKCIJE

Milijana Cvejić, Suzana Mitrović

Rezime

Istraživana je mogućnosti korišćenja šume u aluvijumu za funkciju rekreacije. Istraživanja su pokazala da je za određivanje tipa rekreacije u odnosu na potencijale područja i potrebe korisnika adekvatno primeniti metodu vrednovanja pogodnosti područja za preuzimanje funkcije rekreacije.

Rezultati istraživanja pokazuju da je lokaciju uz tehničko-površinsko saniranje terena moguće kompletno iskoristiti za različite vidove aktivne i pasivne rekreacije uz adekvatnu osnovnu i prateću opremu a da se pritom postojeće stanje šumske vegetacije ne ugrozi. Dat je prikaz plana uredjenja i korišćenja devastirane površine na lokaciji Zabran u forlandu Save kod Obrenovca. Ovako planirano područje omogućava da na 42.110 m^2 bude obezbeđen prostor za 100 kamp prikolica, 449 parking mesta, 45 elemenata opreme za rekreaciju, 138 novoposađenih sadnica, 2340 m staza, što odgovara dozvoljenom opterećenju zone za rekreaciju u šumi uz očuvanje stabilnosti šumskog ekosistema.

Reviewers: Prof. Jasminka Cvejić, Ph.D, Fakulty of Forestry, Belgrade, Dragana Dražić, Ph.D,, Institute of Forestry, Belgrade

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EROSION PROCESS IN LOCALITY MEDENOVAC-KARAVANSALIJA IN ROGOZNA

Mihailo Ratknić, Svetlana Bilibajkić, Sonja Braunović[1]

Abstract: This paper deals with the definition of the condition of the erosion process in the area Medenovac-Karavansalija in Rogozna and calculation of the mean annual erosion sediment yield and discharge. Since the mean coefficient of erosion for the area Medenovac-Karavansalija in Rogozna is Z=0.282, this area can be classified into the Category IV of the destructiveness. According to the type of the erosion surface and combined erosions are dominant, wheras deep erosion is present sporadically. The total sediment yield in the area Medenovac-Karavansalija is W annual =17172,32 m^3year^{-1}, whereas the annual specific sediment yield is Wspec=291.99 $m^3year^{-1}km^{-2}$. The sediment discharge which refers to the area Medenovac-Karavansalija is V=6796,19 m^3god^{-1}, and the specific quantity of sediment, i.e. quantity of the sediment per 1 km^2 of area is Vspec=115.56 $m^3km^{-2}year^{-1}$. According to the calculated coefficient of erosion Z, sediment yield and discharge in the area Medenovac-Karavansalija, the most typical category of erosion is weak erosion.

Key words: erosion processes, coefficient of erosion, sediment yield, bedload and suspended sediment discharge

EROZIONI PROCESI NA LOKACIJI MEDENOVAC – KARAVANSALIJA NA ROGOZNI

Izvod: U ovom radu definisano je stanje erozionih procesa na području Medenovac – Karavansalija na Rogozni i obračunata je srednje godišnja produkcija i pronos erozionog nanosa. Srednja vrednost koeficijenta erozije za područje Medenovac – Karavansalija na Rogozni iznosi Z=0,282 pa se područje može svrstati u IV kategoriju razornosti. Po tipu erozije preovlađuju površinska i mešovita erozija, dok je dubinska prisutna sporadično. Ukupna produkcija nanosa na području Medanovac-

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Translation: Marija Stojanović

Karavansalija iznosi Wgod=17172,32 m^3god^{-1}, a srednja specifična produkcija nanosa je Wspec=291,99 $m^3god^{-1}km^{-2}$. Količine pronosa nanosa koje se odnose sa područja Medanovac-Karavansalija iznose V=6796,19 m^3god^{-1}, a specifična količina nanosa tj. količina nanosa koja se odnosi sa 1 km^2 područja iznosi Vspec=115,56 $m^3km^{-2}god^{-1}$. Na osnovu sračunatih vrednosti koeficijenta erozije Z, produkcije i pronosa nanosa na istraživanom području Medenovac – Karavansalija najzastupljenija kategorija erozije je slaba erozija.

Ključne reči: erozioni procesi, koeficijent erozije, produkcija nanosa, pronos vučenog i suspendovanog nanosa

1 INTRODUCTION

The phenomenon of soil erosion is one of the oldest problems of the human civilization. The problems of erosion and soil loss can be traced back to the beginning of agriculture. In recent times, the problem of soil erosion has occured more frequently, due to the increase in population and agricultural pressure. This paper deals with the definition of the condition of the erosion process in the area Medenovac-Karavansalija in Rogozna and calculation of the mean annual erosion sediment yield and discharge.

2 INVESTIGATED AREA AND WORK METHOD

The investigated area is located in the terittory of the following cadastral municipalities: Banja, Lopužnje, Bare, Negotinac, Brđani, Odojeviće, Vučja Lokva, Rajetiće, Izbice, Trnava, and Kašalj and covers an area of 58.81 km^2. It is limited by the following coordinates of kilometer network (i.e. North latitude and East geographical longitude): along X-axis: 4 764 928 – 4 777 075, along Y-axis: 7 465 575 – 7 474 603.

The relief of area is made of low, medium and high mountain terrains. The belt from 900 to 1,200 meters above sea level accounts for 83.43% of the territory, the belt above 1,200 meters above sea level accounts for 4.41%, and the belt below 800 meters above sea level accounts for only 2.96% of the territory.

The greatest part of the investigated area, i.e. 70.61% has the angles of inclination of the terrain from 15 % to 30%. The inclinations from 6 % to 15 % cover 28.64 % of the area, and the area with the inclinations from 0 % to 5% cover 0.75% of the area.

The sunlit slopes, south and southeast exposures account for 16,66% of the territory, neutral exposures account for 40.35% of the territory, and cold exposures account for 32.99% of the area.

The climate with the expressive continental characteristics is typical for this area.

The formation of mainly shallow to mid-deep soils on the different bedrocks with the different percentage of skeleton is conditioned by the relief of the area.

The basic soil types registered in Rogozna are: limestone (Lithosol), syrozem on loose bedrock (Regosol), colluvial soil (Colluvium), eutric ranker, dystric ranker,eutric brown soul (Eutric cambisol), acid brown soil (Dystric cambisol), illimerised soil (Luvisol), marshy-gley soil (Eugley) and recent alluvial deposit (Fluvisol).

Soil erosion belongs to the group of the most widespread processes which is the result of the interection of the large number of factors and the study of it requires inter-

discipline approach based on the analytical and synthesis level. The complexity of this process points to the application of the complex methodology which is based on catrographic, teledetection and empirical methods.

By cartographic methods, based on the topographic map, the necessary numerical data were obtained: area of the total territory, areas and circumferences of watersheds and subwatersheds, flow length, mean altitude, medium slope of drainage basin, flattened slope of flow, etc.

By the analysis of geological and pedological maps, as well as by field research (taking samples of bedrock and soil and the laboratory analysis of them) the necessary data on geological and pedological base were obtained.

The teledetection methods based on the analysis of satellite photos combined with the detailed recognition of the terrain were applied in the method of the spatial definition of the intensity of erosion.

The empirical methods were used for the calculation of the mean annual bedload and suspended sediment yield and discharge.

The empirical form of Professor S. Gavrilović is most frequently used in our scientific and professional practice:

$$W\ year = T \times Hgod \times \pi \times \sqrt{Z^3} \times F \qquad m^3\,year^{-1}$$

For the determination of coefficient of erosion Z the analytical method of Professor S. Gavrilović was applied:

$$Z = Y \times X \times a \times (f + \sqrt{I_{sr}}) \qquad m^3\,year^{-1}$$

The analytical method of Professor B. Poljakov was obtained by the use of the diagram of the dependence between coefficients Z and a was also applied.

The ratio of bedload to suspended sediment was determined by the form of Professor B.V. Poljakov:

$$V = \rho \frac{M_0 F}{10^3 \gamma_1} \times 31.5 \times 10^6 \left(1 + \beta / \gamma_2\right) \qquad (m^3\,year^{-1})$$

3 THE RESULTS OF THE RESEARCH

By the field visit and classifying of the investigated area it was determined that by the level of endangerment by erosion all the categories of destructiveness are present, with the different presence percentage.

Very weak erosion was reported on good grass and forest areas, on flat areas and the least inclined areas, regardless of the type and condition of the vegetation cover.

Table 1- *Erosion condition in the area Medenovac – Karavansalija in Rogozna*

The Category of Erosion	**Area (ha)**	**%**
Excessive	7.78	0.13
Strong	700.63	11.91
Medium	635.47	10.80
Weak	2680.93	45.57
Very weak	1858.71	31.59
Total	5883.52	100.0

The dominant category of erosion is weak erosion, which is reported on 45.57 % of the area. The high percentage of the areas subjected to the weak erosion is in the accord with the structure of the soil usage, since forest and grass areas, as well as the areas used for field crop production of gentle inclinations are dominant here.

The medium erosion is mostly found in the zones of the village areas in the areas which are used in field crop production, as well as in grass and forest areas of the lower quality, i.e. canopy.

The intensive erosion processes are not expressive.

Picture 1- Extensive erosion

By the data obtained by the detailed terrain recognition, analysis of the satelite photos, data on the geological and pedological base, climate factors, as well as data on the vegetation arrangement, the coefficient of erosion (Z) for the area Medenovac-Karanvansalija was determined analitically, by the separation of hydrological units (watersheds and inter-watersheds) by the methodology of Professor S.Gavrilović.

$$Z=Y\times X\times a\times (f+\sqrt{\mathbf{I}_{sr}}) \qquad (m^3\,year^{-1})$$

where:

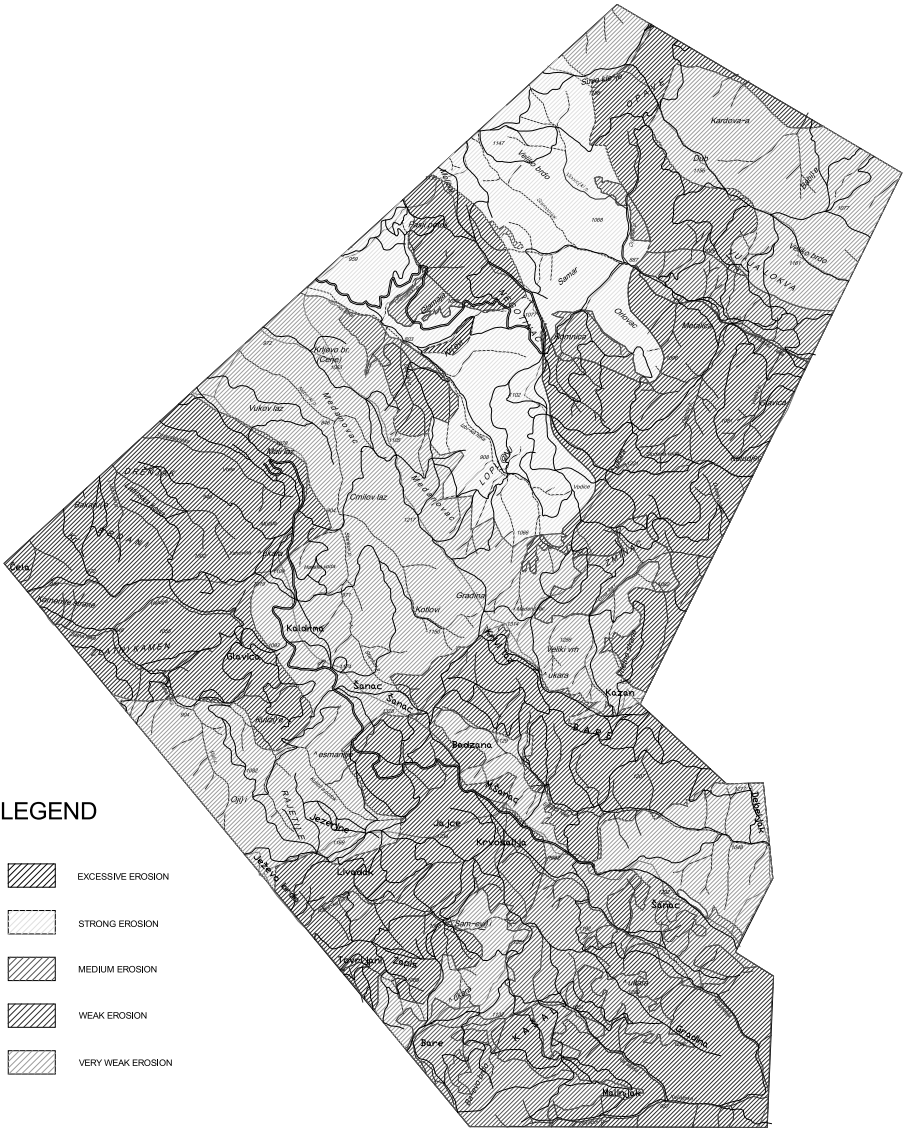
Y – is the reciprocal of the coefficient of soil resistance to erosion, depending of the geological base, climate and types of the pedological form;

X × a – is the coefficient of the arrangement of the watershed (area) and refers to the protection from the influence of atmospherilia and erosion forces by the natural conditions, vegetation, etc. (coefficient X) or by the artificially created conditions, anti-erosive technical or biological works in watershed (area) (coefficient a);

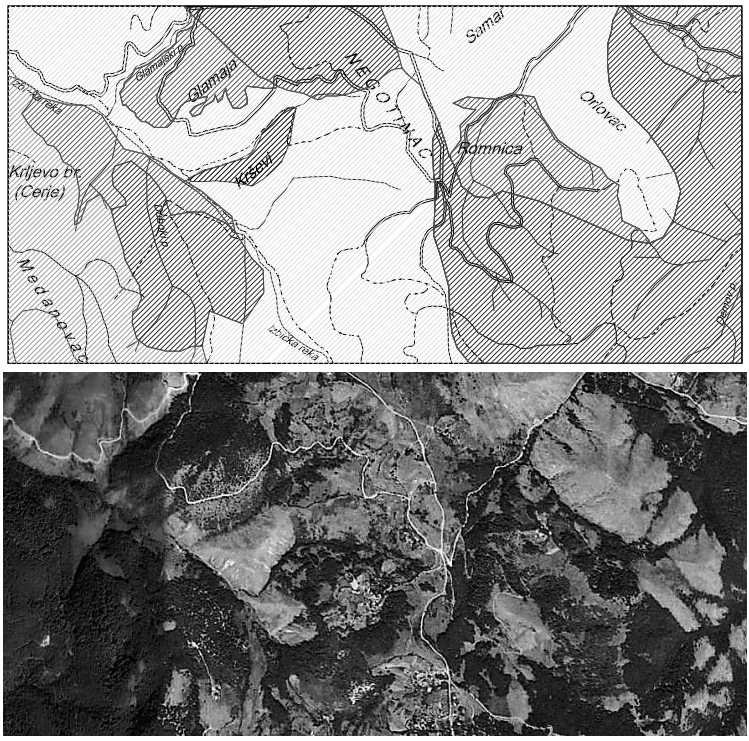
f coefficient - is the numerical equivalent to the visible and clearly expressed erosion processes in watershed (area);

J mean – mean slope of drainage basin, i.e. of erosion area.

The calculation of coefficient of erosion by the methods of Professor S. Gavrilović (Z) and Professor B.V. Poljakov (a) is presented in the Table 2.



Picture 2- Erosion map



Picture 3- Detail from satelite survey used for map errosion producing

Table 2- Coefficient of erosion for the area Medenovac-Karavansalija

Ordinal number	The name of the watershed	Y	X × a	f	J_{sr}	Z	a
1	Kašaljska river	0,95	0,35	0,37	0,183	0,27	1,40
2	Barska river	0,95	0,33	0,42	0,109	0,24	1,20
3	Crnačka river	0,90	0,30	0,46	0,247	0,26	1,38
4	Vučjalokvarska river	0,85	0,42	0,50	0,150	0,32	1,70
5	Inter-watershed number 5	0,80	0,40	0,40	0,272	0,29	1,50
6	Inter-watershed number 6	0,80	0,42	0,42	0,261	0,31	1,52
7	Izbička river	0,82	0,48	0,50	0,135	0,34	1,78
8	Netvrčki brook	0,85	0,34	0,41	0,153	0,23	1,19
9	Inter-watershed number 10	0,85	0,41	0,46	0,226	0,32	1,70
10	Zlatna river	0,85	0,35	0,41	0,147	0,24	1,20
11	Rajetička river	0,90	0,36	0,43	0,168	0,27	1,40

The calculated mean value of coefficient of erosion for the observed watersheds and subwatersheds ranges between Z=0.23 (Netvrčki potok) and Z=0.34 (Izbička river). Since the mean coefficient of erosion for the area Medenovac-Karavansalija in Rogozna is Z=0.282, this area can be classified into the Category IV of the destructiveness. According to the type of the erosion surface and combined erosions are dominant, wheras deep erosion is present sporadically.

The mean annual erosion sediment yield (total bedload and sespended sediment) was calculated by the form of Professor S. Gavrilović.

$$W\ year = T \times H\ year \times \pi \times \sqrt{Z^3} \times F \qquad m^3\ year^{-1}$$

Where:

W year – total yield (erosion sediments production for the observed hydrological unit in $m^3\ year^{-1}$);

T – temperature coefficient of the area (watershed);

$$T = \sqrt{\frac{t^0}{10}} + 0{,}1;$$

t^0 – mean annual air temperature of the area (watershed) expressed in degrees Celsius;

π – Ludolf's number

F – area of the drainage basin in km^2;

Z – coefficient of erosion according to Professor S. Gavrilović

The calculation of the mean annual erosion sediment yield for the separated hydrological units is presented in Table 3.

The total sediment yield in the area Medenovac-Karavansalija is W year=17172,32 $m^3 year^{-1}$, and mean specific sediment yield is Wspec=291.99 $m^3\ year^{-1} km^{-2}$.

The highest specific sediment yield is in the watershed of Izbička river Wspec=384.99 $m^3 year^{-1} km^{-2}$, and the lowest specific sediment yield is in the watershed of Netvrčki brook Wspec=214.20 $m^3 year^{-1} km^{-2}$.

Table 3- Mean annual erosion sediment yield

Num.	The name of the watershed	**t (^{0}C)**	**T**	**Hgod (mm)**	**π**	**Z**	**F km^2**	**Wgod $m^3 god^{-1}$**	**Wgod km^{-2} $m^3 god^{-1} km^{-2}$**
1	Kašaljska river	9,2	1.01	612,33	3,14	0,27	7,84	2135,98	272,45
2	Barska river	9,2	1.01	612,33	3,14	0,24	5,45	1244,37	228,32
3	Crnačka river	9,2	1.01	612,33	3,14	0,26	3,39	827,76	257,45
4	Vučjalokvarska river	9,2	1.01	612,33	3,14	0,32	10,66	3747,30	351,53
5	Inter-watershed number 5	9,2	1.01	612,33	3,14	0,29	2,99	906,79	303,27
6	Inter-watershed number 6	9,2	1.01	612,33	3,14	0,31	0,45	150,83	335,18
7	Izbička river	9,2	1.01	612,33	3,14	0,34	7,61	2929,81	384,99
8	Netvrčki brook	9,2	1.01	612,33	3,14	0,23	5,28	1130,99	214,20
9	Inter-watershed num. 10	9,2	1.01	612,33	3,14	0,32	3,84	1349,87	351,53
10	Zlatna river	9,2	1.01	612,33	3,14	0,24	7,48	1707,87	228,32
11	Rajetička river	9,2	1.01	612,33	3,14	0,27	3,82	1040,75	272,45

The bedload and suspended sediment discharge was calculated by the form of Profesor B.V. Poljakov:

$$\mathbf{V} = \rho \frac{\mathbf{M}_0 \mathbf{F}}{10^3 \boldsymbol{\gamma}_1} \times 31.5 \times 10^6 \left(1 + \boldsymbol{\beta} / \boldsymbol{\gamma}_2\right) \qquad (m^3\,year^{-1})$$

Where:
V – total volume of bedload and suspended sediment in $m^3\,year^{-1}$
ρ - mean annual water muddiness in gr m^{-3}

$$\rho = \alpha \times a \times b \times c \times d \times e \times f \times \sqrt{\mathbf{i} \times 10^8} \qquad (gr\,m^{-3})$$

Where:
a coefficient of erosion according to Poljakov determined by the transformation of coefficient of erosion Z according to Profesor Gavrilović
i flattened slope
a coefficient which refers to the vegetation condition in the watershed
b coefficient which refers to the watershed arrangement
c coefficient which refers to digging areas
d coefficient of the slope form in watershed
e coefficient of the river network density
f coefficient which refers to the mechanical soil composition
M_0 Module of the mean annual water runoff from the watershed in $l\,s^{-1}\,km^{-2}$
F area of the watershed in km^2
γ_1 bulk density of the suspended sediment in KN m^{-3}
γ_2 bulk density of the bedload in KN m^{-3}
β ratio of bedload and suspended sediment weight obtained by the use of the tables

The calculation of the bedload and suspended sediment for the separated hydrological units is presented in Table 4.

The calculated quantities of sediment discharge which is carried away from the area Medenovac-Karavansalija are V=6796,19 m^3 $year^{-1}$. Approximately 30% of the total quantity of the sediment discharge is carried away from the watershed. It was adopted that all the sediment yield from the inter-watershed is carried away out of the border of the investigated area. The greatest percentage of the bedload which reaches the border of the area is 23%, and is present in Crnačka river. The mean value of the bedload for the separated watersheds is 21.0%.

Note: The sediment yield was not calculated separately for the subwatersheds. It was adopted that all the calculated quantities of yield reached the border of the observed area from the subwatersheds.

4 CONCLUSION

The calculated mean value of coefficient of erosion for the observed watersheds and subwatersheds ranges between Z=0.23 (Netvrčki brook) and Z=0.34 (Izbička river). Since the mean coefficient of erosion for the area Medenovac-Karavansalija in Rogozna

Table 4- Calculation of the bedload and suspended sediment discharge

N	The name of the watershed	α	a	b	c	d	e	f	Iur	ρ	M_0 $l\,s^{-1}\,km^{-2}$	F km^2	γ_1 $KN\,m^{-3}$	γ_2 $KN\,m^{-3}$	β	V $m^3\,god^{-1}$	V_{sus} $m^3\,god^{-1}$	$V_{vuč}$ $m^3\,god^{-1}$
1	Kašaljska river	1,4	0,65	0,70	0,70	0,75	0,65	0,65	0,060	346	6,0	7,84	10	17	0,46	651,11	512,69	138,42
2	Barska river	1,2	0,65	0,75	0,75	0,75	0,65	0,65	0,045	272	6,0	5,45	10	17	0,44	352,69	280,17	72,52
3	Crnačka river	1,38	0,65	0,70	0,70	0,75	0,65	0,65	0,090	418	6,0	3,39	10	17	0,52	248,16	267,81	80,35
4	Vučjalokvarska river	1,7	0,70	0,70	0,70	0,70	0,65	0,70	0,038	362	6,0	10,66	10	17	0,42	909,52	729,34	180,18
5	Inter-watershed number 5	1,5										2,99				906,79		
6	Inter-watershed number 6	1,5										0,45				150,83		
7	Izbička river	1,7	0,70	0,70	0,70	0,70	0,65	0,70	0,075	508	6,0	7,61	10	17	0,49	941,08	730,65	210,43
8	Netvrčki brook	1,19	0,65	0,70	0,70	0,65	0,65	0,65	0,075	285	6,0	5,28	10	17	0,49	366,32	284,40	81,92
9	Inter-watershed number 10	1,7										3,84				1349,89		
10	Zlatna river	1,2	0,70	0,70	0,70	0,70	0,65	0,65	0,053	280	6,0	7,48	10	17	0,45	500,73	395,84	104,89
11	Rajetička river	1,4	0,70	0,70	0,70	0,70	0,65	0,65	0,060	348	6,0	3,82	10	17	0,46	319,09	251,25	67,84

is Z=0.282, this area can be classified into the Category IV of the destructiveness. According to the type of the erosion surface and combined erosions are dominant, wheras deep erosion is present sporadically.

The total sediment yield in the area Medenovac-Karavansalija is W year=17172,32 $m^3 year^{-1}$, and mean specific sediment yield is Wspec=291.99 $m^3 year^{-1} km^{-2}$.

The quantities of the sediment discharge which refer to the area Medenovac-Karavansalija is V=6796,19 $m^3 god^{-1}$, and the specific quantity of sediment, i.e. quantity of the sediment per 1 km^2 of area is Vspec=115.56 $m^3 km^{-2} year^{-1}$.

According to the calcultated coefficient of erosion Z, sediment yield and discharge, the most frequent category of erosion in the investigated area Medenovac-Karavansalija is weak erosion, which is in the accord with the way in which the soil is used (the territory is mainly covered by forest and grass areas).

LITERATURE

Gavrilović S. (1972): Engineering on torrential flows and erosion, Magazine "Construction", Special edition, Belgrade. *(Original- Inženjering o bujičnim tokovima i eroziji, časopis »Izgradnja«, specijalno izdanje, Beograd)*

Kostadinov S. (1996): Torrential flows and erosion, The Faculty of Forestry, Belgrade. *(Original- Bujični tokovi i erozija, Šumarski fakultet Beograd)*

Report on the current condition and quality of the environment in the locality Medenovac- Karavansalija in the Rogozna mining field (2008): The Institute of Forestry, Belgrade. *(Original- Izveštaj postojećeg stanja i kvaliteta životne sredine na lokaciji Medenovac-Karavansalija u rudnom polju Rogozna (2008): Institut za šumarstvo, Beograd)*

EROSION PROCESS IN LOCALITY MEDENOVAC-KARAVANSALIJA IN ROGOZNA

Mihailo Ratknić, Svetlana Bilibajkić, Sonja Braunović

Summary

The phenomenon of soil erosion is one of the oldest problems of the human civilization. The problems of erosion and soil loss can be traced back to the beginning of agriculture. In recent times, the problem of soil erosion has occured more frequently, due to the increase in population and agricultural pressure.

This paper deals with the definition of the condition of the erosion process in the area Medenovac-Karavansalija in Rogozna and calculation of the mean annual erosion sediment yield and discharge. The investigated area covers an area of 58.81 km^2. The methology applied in this paper is based on the catrographic, teledetection and empirical methods.

By the data obtained by the detailed terrain recognition, analysis of the satelite photos, data on the geological and pedological base, climate factors, as well as data on the vegetation arrangement, the coefficient of erosion (Z) for the area Medenovac-Karanvansalija was determined analitically, by the separated hydrological units (watersheds and inter-watersheds) by the methodology of Professor S.Gavrilović.

Since the mean coefficient of erosion for the area Medenovac-Karavansalija in Rogozna is Z=0.282, this area can be classified into the Category IV of the destructiveness. According to the type of the erosion surface and combined erosions are dominant, wheras deep erosion is present sporadically.

The mean annual erosion sediment yield (total bedload and sespended sediment) was calculated by the form of Professor S. Gavrilović.

The total sediment yield in the area Medenovac-Karavansalija is W year=17172,32 $m^3 year^{-1}$, and mean specific sediment yield is Wspec=291.99 $m^3 year^{-1} km^{-2}$.

The bedload and suspended sediment discharge was calculated by the form of Profesor B.V. Poljakov:

The quantities of the sediment discharge which refer to the area Medenovac-Karavansalija is V=6796,19 $m^3 god^{-1}$, and the specific quantity of sediment, i.e. quantity of the sediment per 1 km^2 of area is Vspec=115.56 $m^3 km^{-2} year^{-1}$.

According to the calcultated coefficient of erosion Z, sediment yield and discharge, the most frequent category of erosion in the investigated area Medenovac-Karavansalija is weak erosion, which is in the accord with the way in which the soil is used (the territory is mainly covered by forest and grass areas).

EROZIONI PROCESI NA LOKACIJI MEDENOVAC – KARAVANSALIJA NA ROGOZNI

Mihailo Ratknić, Svetlana Bilibajkić, Sonja Braunović

Rezime

Fenomen erozije zemljišta spada u najstarije probleme ljudske civilizacije. Sa počecima poljoprivrede javljaju se problemi erozije i gubitka zemljišta. U novije vreme, sa porastom stanovništva i agrarnog pritiska, problem erozije zemljišta je sve prisutniji.

U ovom radu definisano je stanje erozionih procesa na području Medenovac – Karavansalija na Rogozni i obračunata je srednje godišnja produkcija i pronos erozionog nanosa. Istraživano područje zahvata površinu od 58.81 km^2.

Primenjena metodologija u ovom radu zasniva se na katrografskim, teledetekcionim i empirijskim metodama.

Na bazi podataka dobijenih detaljnim rekognosciranjem terena, analizom satelitskih snimaka, podataka o geološkoj i pedološkoj podlozi, klimatskim činiocima, kao i podataka o rasporedu vegetacije, analitički je određen koeficijent erozije (Z) za područje Medenovac – Karavansalija i to po izdvojenim hidrološkim jedinicama (slivovima i međuslivovima) metodologijom prof. S. Gavrilovića.

Srednja vrednost koeficijenta erozije za područje Medenovac – Karavansalija na Rogozni iznosi Z=0,282 pa se područje može svrstati u IV kategoriju razornosti. Po tipu erozije preovlađuju površinska i mešovita erozija, dok je dubinska prisutna sporadično. Proračun srednje godišnje produkcije erozionih nanosa (ukupni vučeni i suspendovani nanos) izvršen je po obrascu prof. S.Gavrilovića.

Ukupna produkcija nanosa na području Medanovac-Karavansalija iznosi Wgod=17172,32 $m^3 god^{-1}$, a srednja specifična produkcija nanosa je Wspec=291,99 $m^3 god^{-1} km^{-2}$.

Proračun pronosa vučenog i suspendovanog nanosa izvršen je prema obrascu prof. B.V Poljakova:

Količine pronosa nanosa koje se odnose sa područja Medanovac-Karavansalija iznose V=6796,19 m^3god^{-1}, a specifična količina nanosa tj. količina nanosa koja se odnosi sa 1 km^2 područja iznosi Vspec=115,56 $m^3km^{-2}god^{-1}$.

Na osnovu sračunatih vrednosti koeficijenta erozije Z, produkcije i pronosa nanosa na istraživanom području Medenovac – Karavansalija najzastupljenija kategorija erozije je slaba erozija, što je u skladu je sa načinom korišćenja zemljišta (na području su pretežno zastupljene šumske i travne površine).

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