

## ECOLOGICAL, PRODUCTIVE AND SILVICULTURAL CATEGORISATION OF COPPICE BEECH STANDS IN THE AREA OF SARAJEVO CANTON<sup>1</sup>

### Ekološko-proizvodna i uzgojna kategorizacija izdanačkih sastojina bukve na području Kantona Sarajevo

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#### ABSTRACT

The paper represents a methodological approach in categorization of coppice beech stands in Sarajevo Canton area in relation to their ecological, productive, structural and silvicultural characteristics. For the collection of necessary data, method of temporary experimental surfaces, systematically allocated in squares 200 meters distant from each other has been used, in accordance to design of simple systematic sample. Concentric circles whose radius depend on tree diameter has been used as sample units (STOJANOVIĆ & DRINIĆ, 1975). Data have been conducted in 659 locations. Stands have been categorized in three categories in relations to predefined criteria of categorization based on stand environment, productiveness, structure, economic value and fostering needs. For each of the categories, average units of basic productive indicators of the stand have been determined: number of trees, basal area, volume and volume increment per year for marked and unmarked, as well as same indicators of marking timber volume and the intensity of felling. Statistical significance of difference between the indicators has been tested by the method of variant analysis. Based on the results, indirect conversion has been recommended for the first stand category, direct and combined conversion for second one, and third category didn't need conversion because they have predominantly protective character.

**Key words:** *beech, coppice stands, forest category, simplified system sample, direct, indirect and combined conversion.*

#### INTRODUCTION - *Uvod*

Coppice forests in Bosnia and Herzegovina were made in certain historical conditions as a result of spontaneous human influence. Forestry as a science did not have adequate significance, which made them isolated in terms of necessary care.

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<sup>1</sup> These researches have been conducted as part of scientific project under the name of "Research of ecological-productive and structural characteristics of coppice beech stands in Canton of Sarajevo area as a basis for their categorization", that has been realized in 2005 by the Cantonal Ministry of Economy.

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Missing legal regulative emphasized the isolation, where planned care was not adequately regulated. That kind of situation resulted in diversified approach and spontaneous realization of allowable cut. In the last period, according to forest management plans, only clear cut on large surface have been credited as coppice forests, despite the fact that there is a significant growing stock of 250 m<sup>3</sup>/ha and existence of significant number of trees with semen origin (PINTARIĆ, 2002). At that time, chemical industry needs for wood were needed to be satisfied.

From silvicultural aspect, coppice, beech forests were made by mistake as a try in regeneration of high forests (short regeneration period, forcing of selective cutting) as well as lack of care in reforestation of high forests after the cut (specially in developing stage of second growth, young wood and young stands). Coppice beech stands in this areas should have been of temporary character, because they were made by accident, and not as a planned forest management procedures. Beech forests in private ownership are a consequence of general bad condition of these forests and unskilled selective management system that have no justification in precise forest management (MATIĆ, S. ET AL., 2003).

Significance of research of ecological-productive, structural and coppice characteristics for these forest comes from their large share in total forest quantity. In forest registry of 2.710.00 ha, all coppice forests take around 918.000 ha (33,9%), whereas 347.000 ha are beech coppice forests. (STOJANOVIĆ, O., ET AL., 1986, 1986a).

Because of the large share these vegetative forms take, research of different aspects of these forests became an imperative in efforts of clarification of these forests condition. There some reasons for this like their growth tendencies and past errors recovery, methods of differentiation and optimal ways of conversion in higher silvicultural form, as well as their better productive usage.

Quality categorization of these forests is needed in our efforts to rise above current problems and consider solutions for conversion of these coppice beech forests in higher forms based on current ecological-productive, structural and silvicultural characteristics.

Linking and synchronizing the results of so far research with research of other authors, it is possible to suggest final measures in forest management of coppice beech forests.

#### **MATERIAL AND RESEARCH METHODS - *Materijal i metode istraživanja***

Research have been conducted in the area of Sarajevo Canton, managed by public enterprise "Sarajevo šume" d.o.o. Sarajevo. The total surface of area covered by forest land in jurisdiction of "Sarajevo šume" d.o.o. Sarajevo is 71.501 ha, whereas coppice forests share is 10.696,60 ha. Largest share of coppice forests belong to coppice beech forests - 6.510,50 ha. Research area map is shown in Picture 1, and it represents the area of three forest management area with borders of spatial and

managing differentiation of forests and polygons which represent beech coppice that represent object of this researching.

Having in mind the size of forest complex, a wide heterogeneity is presumable in aspects of climate, environment and orographic factors, which in the end results with presence of different formations and shapes of forests and forest communities.

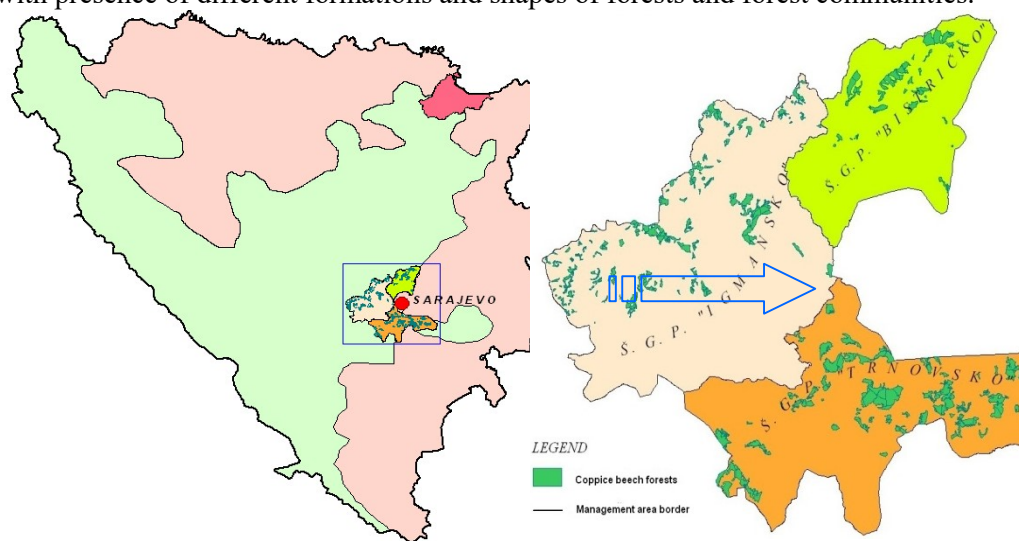


Figure 1. Representation of research area within Bosnia and Herzegovina showing territories of forestry and especially coppice beech forest stands.

*Slika 1. Prikaz područja istraživanja unutar BiH sa granicama šumsko-gospodarskih područja i površinama izdanačkih šuma bukve unutar ŠGP-a*

Looking at the structure of coppice forests of beech within three forest managing areas, it is easy to conclude that the largest beech forests are in area of management unit "Trnovsko" (55,6%), and then in management unit "Igmansko" (31,8%) and management unit "Bistričko" (12,6%). Area covered with mines in beech forests takes 9,92% out of all three areas.

For the collection of necessary data, method of temporary experimental areas has been used, designed on simple systematic sample. Temporary experimental areas where systematically arranged in square network within distance of 200 meters. Concentric circles has been chosen as unit samples (STOJANOVIĆ & DRINIĆ, 1975), whose radius depends on the size of tree diameter - PPS sample (ZÖHRER, 1980). The sample unit is a complex circle surface that consists of seven circles that have a joint center, while their radius size depends on the diameter of the tree. Data have been collected during 2005, when a numerous taxation elements and stand data have been collected.

Data necessary for measurement definition for coppice forests have been recorded in circle surfaces in 25 meter radius. In total of 659 stands, affiliation of

stands to certain category was evaluated, based on their current ecological - productive, structural and silvicultural characteristics.

All coppice beech stands have been categorized in three categories depending on habitat condition, structure, productivity, economical values, and silvicultural measures:

The first category are quality stands predominantly represent trees with shoots from root or shoots from healthy stumps. . This category is dominated by healthy and quality trees with significant number of trees from seeds origin, equally distributed in the stand. These stands are found in the best natural beech habitats. The management goal in these stands is their gradual conversion in high forests forms. That can be achieved by extension of silvicultural rotation, tending and thinning and creating condition for natural regrowth, and where that is not possible, artificial regrowth is recommended.

Second category is represented by bad quality and low economically valued stands, with relatively good habitat economic production, but current assets are not being adequately used. This category is predominantly inhabited with low quality trees, curve, with a lot of branches, low trees with sprouts from rotten stumps. This category also includes other species of trees like hornbeam, hazel, alder etc. The goal of forest management in these stands is direct conversion, reconstruction into higher silvicultural forms which can be achieve with clear cutting and reforestation with softwood and hardwood seedlings of good quality and high economical values. As well as combined conversion that represents natural reconstruction and artificial second growth.

The third category represents very low quality coppice trees stands. Their presence is usually conditioned by soil quality factors, and they are mostly represented in form of shrubbery and underbrush with significant number of species like white hornbeam, black ash, hawthorn, Italian maple and others, which indicate the xerothermic of habitat, shallow eroded soil in highly pedoclimatic dry and steep terrain. From economic point of view, these forests have low significance. The trees that inhabit these areas cannot grow to dimensions of high forms, where most of them are shrubs and bushes. In these areas, any attempt of conversion or rational production would be unsuccessful. Because of protective function these stands have, especially with good canopy, this category can be defined as protective one. In these areas all cuts and cultivation measurements should be stopped, and left to spontaneous growth.

In efforts to define the potential of territories in relations to conversion of stands in high quality stands, several methods have been considered: direct conversion, indirect conversion, combined conversion and no conversion. Basic methods and silvicultural steps have been explained through terms: conversion, reconstitution (restitution), substitution and reconstruction.

Besides that, on all experimental plots trial selective cutting have been done, which is recorded in appropriate forms.

### RESEARCH RESULTS - *Rezultati istraživanja*

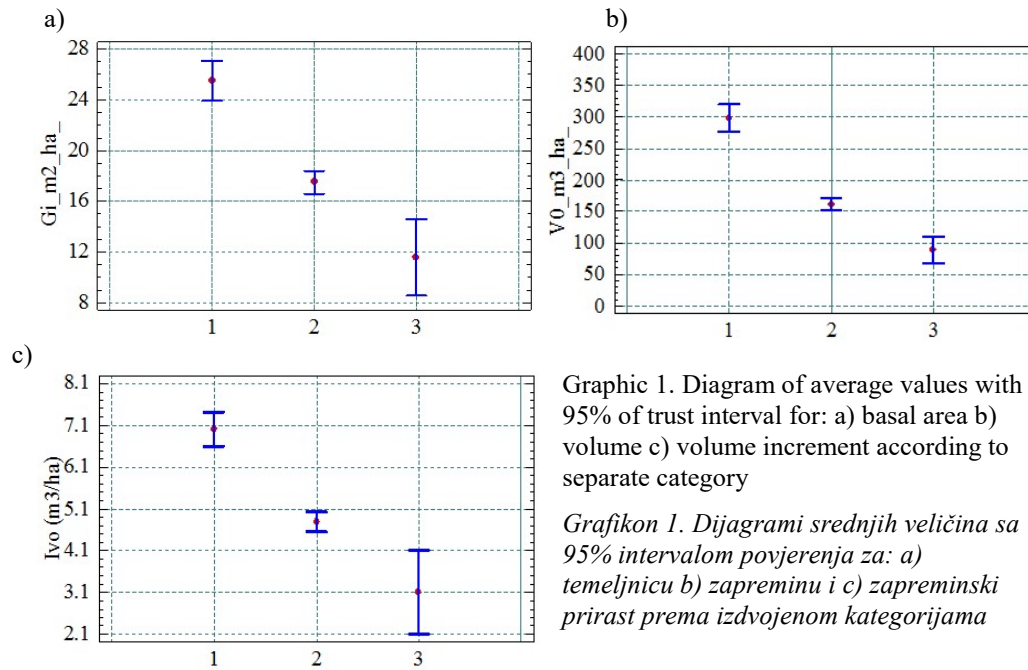
For every category, average indicators of structures and productivity of stands have been defined; number of trees, basal area, volume and volume increment per year. Statistical significance of these indicators for separate categories has been tested by ANOVA analysis. This gives credibility and justification of classification of stands in different categories.

Results of analysis for given indicators are represented in table 1 and in graphic 1 - a, b, c.

According to results of analysis between formed categories, only in relation to average number of trees there is no significant difference (95%). Relatively big difference in relation to other indicators, that are statistically significant, are clearly seen in diagrams of median units with 95% of trust intervals, graphic 1. It can be said that one homogeneity group is defined for each of the categories based on three production indicators.

Table 1 Results of ANOVA for analysis of categories of basic production indicators of stands.  
*Tabela 1. Rezultati ANOVA-e za analizu uticaja kategorija na veličinu osnovnih proizvodnih pokazatelja sastojina*

Source of Variation	Number of trees ( $N_i$ -kom/ha)				
	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	624352	2	312176	0.42	0.6601
Within groups	4.92794E8	656	751211		
Total (Corr.)	4.93419E8	658			
Source of Variation	Basal area ( $G\text{-m}^2/\text{ha}$ )				
	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	10081.9	2	5040.97	48.10	0.0000
Within groups	68753.9	656	104.808		
Total (Corr.)	78835.9	658			
Source of Variation	Volume ( $V_G\text{-m}^3/\text{ha}$ )				
	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	2.87838E6	2	1.43919E6	98.97	0.0000
Within groups	9.53923E6	656	14541.5		
Total (Corr.)	1.24176E7	658			
Source of Variation	Volume increment ( $Iv_G\text{-m}^3/\text{ha}$ )				
	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	777.789	2	388.895	52.56	0.0000
Within groups	4854.06	656	7.39948		
Total (Corr.)	5631.85	658			



Graphic 1. Diagram of average values with 95% of trust interval for: a) basal area b) volume c) volume increment according to separate category

Grafikon 1. Dijagrami srednjih veličina sa 95% intervalom povjerenja za: a) temeljnicu b) zapreminu i c) zapreminski prirast prema izdvojenom kategorijama

Results of conducted analysis are showing justification for categorization of coppice beech forest stands. Determined relations between categories and indicators, as well as analysis of other stand characteristics are extremely important in defining propositions and recommendations for selection of silvicultural measures which will lead to conversion in higher silvicultural form, for each formed category. Conducted statistical analysis, as well as determined indicators for production, structure and qualitative condition are showing that it is not possible to plan same or similar silvicultural measures for all stands in efforts to convert them to stands of high silvicultural form (BALIĆ, ET AL., 2006).

For that reason it is important to categorized coppice forest stands, in three mentioned category before taking any action duo forest management. And that is what has been achieved. The main goal is creation of possibilities for planning most suitable silvicultural measure for each category to convert in higher silvicultural form. To gain insight about felling intensity in next period, also about all changes after felling, for each category is established average and sum values of parameters before and after selections, also for marked wooden mass.

Comparing values of basic productivity indicators, before and after selections, it's possible to simulate condition and changes after felling all marked wooden mass as regular cutting.

For the first category of coppice beech stands calculated average values of taxative elements before and after selections, and values about conducted selections are represented in table 2.

Table 2. Basic production indicators for first category of coppice beech stands (condition before and after felling, characteristic of marking timber volume and cutting intensity)

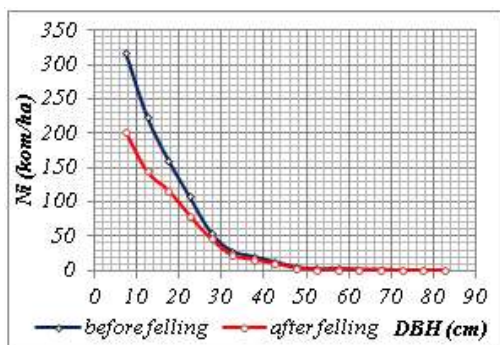
*Tabela 2. Osnovni proizvodni pokazatelji za prvu (I) kategoriju izdanačkih sastojina bukve (stanje prije i poslije sječe, karakteristike doznačene drvne mase i intenziteti zahvata)*

Taxative element	Condition before cut	Marked timber volume	Condition after cut	Cutting intensity (%)
$D_g$ (cm)	23,8	25,0	30,6	
$H_g$ (m)	19,0	17,4	24,0	
$i_d$ (mm/god)	2,9	2,5	3,8	
$P_v$ (%)	2,9	2,8	3,9	
$N$ (kom/ha)	940	293	647	31,2
$G$ (m <sup>2</sup> /ha)	25,5	6,6	18,9	26,0
$V_0$ (m <sup>3</sup> /ha)	298,7	74,8	224,0	25,0
$I_{v,0}$ (m <sup>3</sup> /ha)	7,0	1,6	5,4	22,3
broj ploha (n)	208	208	208	-

Surface content of stands of the first category is almost one third of all research stand surfaces (31,6%). Average quality class for this category is 2,3 and it represents a good quality stand habitat. Besides that, according to previously calculated high average values of stand indicators in phase before cutting (BALIĆ, 2011), these stands are characterized by good stand qualities. Based on data represented in Table 2, we can say that using indirect conversion of cutting down trees previously marked, we will have an increase of values in stand indicators. Increase of average diameter by 28,7%, median height by 26,4% and percentage of volume growth by 36,4%. Increase of indicator values is also influenced by "calculated shift" caused by negative selection of trees for cut. Marked trees in this case are mainly thin, scraggy, crooked, and sick. Besides these trees, all trees which are thick and semen origin but bad quality, branched and crooked are marked. That can be seen on average diameter basis of signed trees that is little larger than average diameter of all trees of first category, while average height is smaller by 1,6 m in average, confirming the thesis. By cutting signed trees, resulted values of the procedure would be: by number of trees 31,2%; by basal area 26%; by overall volume 25% and by volume increment per year 22,3%. This means that by felling marked trees, we would have 75 m<sup>3</sup>/ha of cut wooden mass, which is a large amount, no matter the fact that those are relatively bad quality trees, with small significance for forest production.

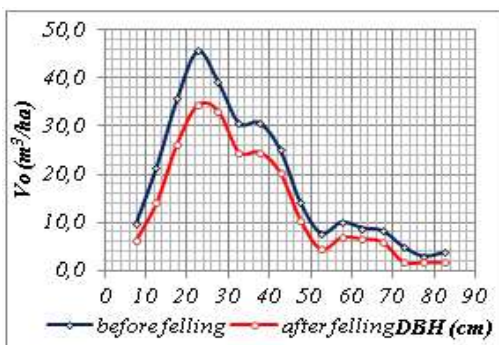
Simulations of diameter structure of trees before and after selection (before and after cut) for most important stand parameters are represented in graphics from 2 to 5.

Ecological, productive and silvicultural categorisation of coppice beech stands in area of Sarajevo canton



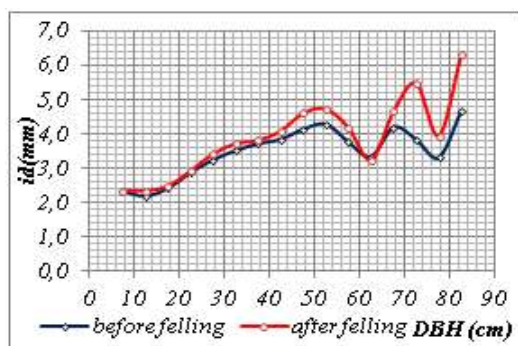
Graphic 2. Simulation of diameter structures for first category of coppice beech stands before and after felling.

Grafikon 2. Simulacije debljinskih struktura za prvu kategoriju izdanačkih sastojina bukve za stanje prije i poslije sječe.



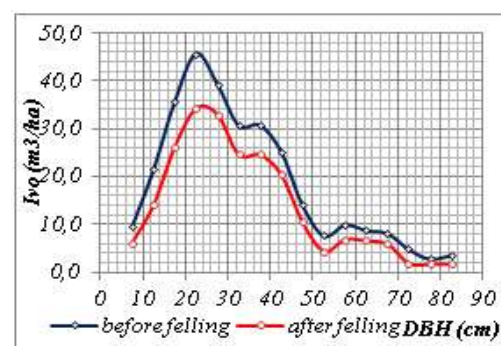
Graphic 3. Simulation of diameter structures of volume for first category of coppice beech stands before and after felling

Grafikon 3. Simulacije debljinskih struktura zalihe za prvu kategoriju izdanačkih sastojina bukve za stanje prije i poslije sječe.



Graphic 4. Simulation of average values of diameter increment per year presented by diameter degrees for first category of coppice beech stands before and after felling.

Grafikon 4. Simulacije prosječnih veličina godišnjeg debljinskog prirasta po debljinskim stepenima za prvu kategoriju izdanačkih sastojina bukve za stanje prije i poslije sječe.



Graphic 5. Simulation of average values of volume increment per year presented by diameter degrees for first category of coppice beech stands before and after felling.

Grafikon 5. Simulacije debljinskih struktura godišnjeg zapreminskog prirasta za prvu kategoriju izdanačkih sastojina bukve za stanje prije i poslije sječe.



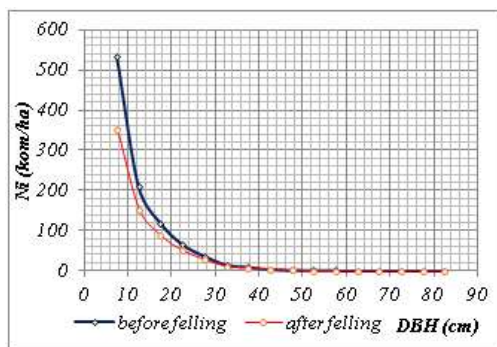
Same calculations and tables of determined parameters were given for stands group that belong to second category. Results were shown in Table 3.

Table 3 Basic production indicators for second category of coppice beech stands (condition before and after cuts, characteristic of marking timber volume and cutting intensity)

Tabela 3. Osnovni proizvodni pokazatelji za drugu (II) kategoriju izdanačkih sastojina bukve (stanje prije i poslije sječe, karakteristike doznačene drvne mase i intenziteti zahvata)

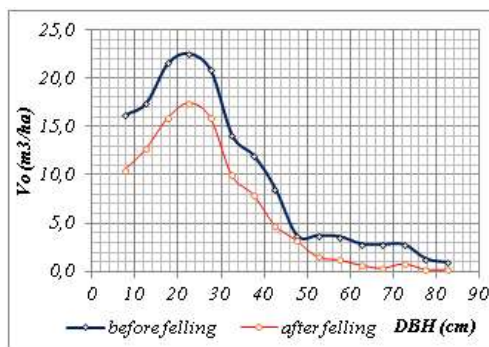
Taxative element	Condition before cut	Marking timber volume	Condition after cut	Cutting intensity (%)
$D_g$ (cm)	18,8	22,9	18,2	
$H_g$ (m)	12,6	12,5	12,5	
$i_a$ (mm/god)	3,1	2,9	3,3	
$P_v$ (%)	3,5	3,2	3,8	
$N$ (kom/ha)	1004	314	690	31,3
$G$ (m <sup>2</sup> /ha)	17,5	6,0	11,5	34,4
$V_0$ (m <sup>3</sup> /ha)	160,8	57,7	103,1	35,9
$I_{v,0}$ (m <sup>3</sup> /ha)	4,8	1,4	3,4	28,5
broj ploha (n <sub>i</sub> )	436	436	436	-

Simulations of thickness structures before and after signing (before and after cut) of most important stand parameters for second category were shown in graphics from 6 to 9.



Graphic 6. Simulation of diameter structures for second category of coppice beech stands before and after felling.

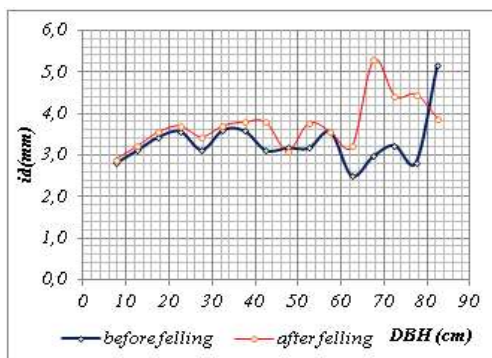
Grafikon 6. Simulacije debljinskih struktura za drugu kategoriju izdanačkih sastojina bukve za stanje prije i poslije sječe.



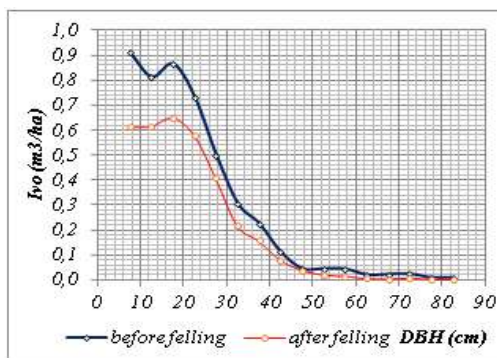
Graphic 7. Simulation of diameter structures of growing stock for second category of coppice beech stands before and after felling.

Grafikon 7. Simulacije debljinskih struktura zalihe za drugu kategoriju izdanačkih sastojina bukve za stanje prije i poslije sječe.

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Graphic 8. Simulation of average values of diameter increment per year presented by diameter degrees for second category of coppice beech stands before and after felling.  
*Grafikon 8. Simulacije prosječnih veličina godišnjeg debljinskog prirasta po debljinskim stepenima za drugu kategoriju izdanačkih sastojina bukve za stanje prije i poslije sječe.*



Graphic 9. Simulation of average values of volume increment per year presented by diameter degrees for second category of coppice beech stands before and after felling.  
*Grafikon 9. Simulacije debljinskih struktura godišnjeg zapreminskog prirasta za drugu kategoriju izdanačkih sastojina bukve za stanje prije i poslije sječe.*

According to data from table 3 and shown graphics, we can say that average quality class of all stands in second category is 3,7, which is 1,4 less quality comparing to the first category. All other average indicator units are significantly lower. Exception is the average numbers of trees which is slightly bigger than in first category. It is noticeable that all significant increase of average values of stand indicators ( $D_g$ ,  $H_g$ ) wouldn't change if all trees would be included by trial selection in all stands that belong to second category. Reason for that is all low quality trees that slow down growth of better trees are marked within all diameter classes, from thinnest to thickest. Results in intensity of felling which are higher in relation to growing stock and basal area in relationship to number of trees also confirm the conclusion.

This category is most common in the area of research and it takes almost 2/3 of the area (66,2%). Less than 10% of this surface is stand that is on shallow soils, all others are medium deep and deep soils. This category is a result and indicator of destructive human behavior on forest. Considering the productive potential of soil, we can assume that stands of this category will be a place for testing of scientific methods and knowledge in converting these forests into higher silvicultural forms. quality forests.

For all stands grouped in third category with area of 2,3%, conclusion is that their significance is mainly protective one. All silvicultural and meliorative measures would be in ineffective They are located on extremely narrow, shallow, eroded and rocky terrains. That is why these surfaces are marked as "no conversion" surfaces.

## DISCUSSION - *Diskusija*

All coppice beech forests are, in relation to site conditions, content, structure, productivity and economic value of the stand, divided in three categories. I, II and III. Basis for categorization of stands is exhibited in research methods and is part of methods of data collection needed for this research.

Based on conducted simulations before and after felling for first and second category, according to intensity of felling considering number of trees it is noticeable that high percentage of felling intensity shows silvicultural neglect of the stands. In both categories we find the same felling intensity where number of trees with cutting of marked trees would take down for 1/3. If we look at the felling intensity through growing stock and basal area, we find significant differences. In second category we find 10% higher felling intensity than in first category. That means that relatively equal reduction of number of trees is not proportional to reduction of basal area and growing stock. This is a consequence of dependence of basal area to number of tree and their diameter in the stand. Found disproportion can be explained by the fact that within second category we find stands with significant share of thick, heavily branched trees from coppice and seeding origin, with very bad quality, whose eradication lowers the size of diameter and volume of the stand. Participation of these trees in stands is significantly less in first category. Comparative analysis of change in values of average stand diameters before and after felling lead to that conclusion. Removing of marked trees in stands of first category, average stand diameter on basal area ( $D_g=23,8$  cm) would increase by 6,8 cm ( $D_g=30,6$  cm). On the other side, in case of removing marked trees in stands that belong to second category, size of average stand diameter would remain the same, even slightly less in relation to before felling.

Determined felling intensities are in accordance to similar researches in neighboring Serbia. In research done by ĆIRKOVIĆ (2004), conducted with the goal of determining the silvicultural measures in coppice beech stands in area of Ćemernika as part of mountain beech forest on acid brown soil on shale, the following felling intensity have been found: by the number of trees 20,1%, by basal area 24,3%, by growing stock 24,9% and by the volume increment 22,9%. For stands, conversion to higher silvicultural forms by indirect way of mixed selective thinning of moderate to intensive treatment, have been suggested. The goal of this thinning was gradual release of future trees and preparation of the stand for conversion to higher silvicultural forms.

Considering the problematic of melioration of low, degraded forests in Serbia, JOVANOVIĆ, ET AL. (1983), conclude that classification of devastated and degraded forests is needed for rational planning of silvicultural measures. Before the beginning of melioration, project for each object needs to be made. An elaboration with clear basis for classification based on vegetative, pedological and climate studies. For every object it is needed to determine the most promising silvicultural treatment. Authors suggest that, for current environment conditions, and low devastated forests, most

acceptable way of conversion is reconstruction (combined reconstruction with substitution) with conversion on safe areas of the stand.

STOJANOVIĆ, L.J. and KRSTIĆ (2003) implicated on the problems of coppice beech forest in Serbia, among others. Authors tried to implicate alarm on problems of coppice beech forests, mainly because the ways of natural regeneration, forest management and problems in degraded and devastated forests in Serbia. Related to that, every of the silvicultural forms, authors detailed basic objectives and silvicultural measures related to current stand condition. With categorization of breeding beech forests in good forests on good soil, bad forests on good soil, and bad forests on bad soil, it is possible to determine silvicultural and meliorative steps for each of the categories. Authors suggested conversion of, predominant, first category (55,1%) into higher silvicultural forms. For second category, area of 25,4%, restitution has been suggested with seeding and planting of beech. For third category forests no steps have been suggested in near future. Categorization of coppice forests was conducted in similar way by JEVTIĆ (1983) and DRAŽIĆ, ET AL. (1990). Authors classified coppice forests on degree of degradation, all in efforts to find optimal method of melioration.

KRSTIĆ, ET AL. (2004) as basis for categorization take the preservation degree of beech stands. Authors offered final suggestions on breeding procedures for different stands based on detailed research in coppice beech stands in management unit "Mali Jastrebovac II". According to them stands have been categorized in three groups at the time of maintenance: preserved, elaborated and devastated. For preserved stands, as adequate silvicultural treatment, conversion has been suggested, for elaborated, conversion and restitution, and for devastated, a combination of restitution and substitution. It is necessary to determine a degree of degradation of the forest and stands that will be used as base for final decision of method selection in melioration of the stands.

Different authors give different number of quality trees that could be a base for future conversion. PINTARIĆ (2002) thinks that number of those trees should be minimum 200 trees per ha, while KRSTIĆ (2004) and STOJANOVIĆ, L.J., ET AL. (1983, 2003, 2004) suggest at least 150 trees per ha. JOVANOVIĆ, ET AL. (1983) emphasize that number of quality trees per surface unit is variable depending on conversion potential and multiple of other factors (species, phase of growth, economic and productive potential). On the other side, MATIĆ, S. (1984) says that we can rely on 80-100 well spaced trees with proper care for a quality conversion. If the number of trees from seed is insignificant, then stand silvicultural measure is thinning with goal to prepare coppice stand for natural regeneration with regenerative felling in multiple rotation.

Accepting the determined results of the research, final suggestions can be made as meliorative measures, as a goal of rational usage for existing stand potential:

- For all those stands that are a part of the first category, indirect conversion is recommended. Greatest number of stands of this category needs to be regenerated in natural way or using regenerative felling, with additional seeding and planting of

authentic vegetation in parts where plants are missing. That kind of procedure is cheapest and most efficient as a conversion method into higher silvicultural forms. Determining factor for usage of this method is the fact that it is about the average quality coppice stands on good soil and that there is a decent number of quality trees on which future conversion could be based on.

- Most of the stands form second category need indirect and combined conversion. One of important arguments that go along the explanation for given recommendation is quantity, way of appearance, and quality of plants which are seed origin. Based on pre-calculated data on evidence of second growth and seedlings it has been noted that average number of small young trees ( $10\text{ cm} \leq h \leq 130\text{ cm}$ ) is 4.130 per ha, where 3.814 were  $10\text{ cm} \leq h \leq 50\text{ cm}$ , while number of trees  $50\text{ cm} \leq h \leq 130\text{ cm}$  were 496 per ha (BALIĆ, 2011). If we add number of tree originated out of seeding from first diameter class ( $0,1\text{ cm} \leq d_{1,3} < 5,0\text{ cm}$ ) in number of 130 per ha (registered as part of the stand), we can conclude that combined method is the most efficient way of conversion. This combination represents usage of indirect conversion in stands where is enough number of a quality second growth, and where there is a good productive potential of habitat, as well as direct conversion in stands where soil is so degraded and is not suitable to authentic vegetations that it needs thorough clear cutting of existing vegetation replacing with second growth and seedlings with adequate for the type of that soil.

Preliminary results of Second state forest inventory of B&H (2006-2009) also confirms previous thesis in relation of numerous second growth trees and point to abundant quantity of second growth from seed origin also in coppice beech stands. These numbers were found in coppice beech stands by the categories: high class  $10\text{ cm} \leq h \leq 50\text{ cm}$  - 3.363 /ha i  $50\text{ cm} \leq h \leq 130\text{ cm}$  - 576 /ha, while the number of trees with diameter  $0,1\text{ cm} \leq d_{1,3} < 5,0\text{ cm}$  was 243 /ha, which in total is 4.182 /ha (BALIĆ, 2011).

- For all stands that have been categorized in third category, no conversion is planned. These stands participate in total of 2,3% of the forest area and their main function is protective one. All silvicultural and meliorative measures would be ineffective. They are located on extremely narrow, shallow, eroded and rocky terrains. That is why these surfaces need to be signed as "no conversion" areas.

In terms of planning of the size of the sample for taxation estimation of coppice forests in future research, recommended categorization of these stands could be a good frame for estimation of sample size, as well as definition of number of necessary information that need to be recorded. Besides that, it is possible to put a research method choice in function of certain level of detailed significance of certain information. That means that most reliable data need to be set for the first category of coppice stands, little less for second category, while for the third category they just need to be an assessment.

## **CONCLUSIONS - *Zaključci***

Beginning with set goals of the research, realized by task completion whose results are part of this research, we can say next:

- Coppice beech stands on the area of Sarajevo Canton are highly productive. Determined research data show productivity levels of high silvicultural form: Determined sizes are consequence of high density forests, that lacked maintenance in the past.

- Depending on environmental habitats, structure, productivity, economic value of the stands and expected silvicultural measures, all coppice stands have been categorized in three categories. For each of the individual categories silvicultural measures and conversion methods have been recommended.

- Surface part of coppice stands of the first category is almost one third or 31,6% of total research area. Average quality class for this category is 2,4 which is a good indicator of stand quality with high average values of other indicators (before selection).

- For stands that belong to the first category, conversion to higher silvicultural forms is recommended, by indirect conversion.

- For stands of second category, that take 2/3 of the area and are usually in medium deep and deep soil, quality class is slightly lower (3,7 in average). Average sizes of other parameters are significantly lower in comparison to the first category. Number of trees is exception. This category is reflection and indicator of destructive influence of man on forest. Considering the productive potential of the soil it is presumable that stands of this category will be a place for testing and scientific research in converting these forests into higher silvicultural forms. Methods for conversion are indirect and combined conversion.

- For all stands of third category (low quality trees), with 2,3 % of covering area, no conversion is planned.

- At the end, the only objective determine the real state and quality categorization of these stands according to their existing condition and need for meliorative procedures as part of their conversion into higher silvicultural forms, represent a starting point for determining steps for planned management of coppice beech forests. Urgent approach is necessary in abandonment of template way of management favoring methods of direct conversion with substitution of different tree types. Most part of these forests should be converted into higher silvicultural forms using indirect and/or combined conversion.

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## **SAŽETAK**

U radu je predstavljena kategorizacija izdanačkih sastojina bukve na području Kantona Sarajevo uvažavajući njihove postojeće ekološko-proizvodne, strukturne i uzgojne karakteristike. Sastojine su prema unaprijed definisanim kriterijima kategorizacije, s obzirom na stanišne uslove, proizvodnost, strukturu, ekonomsku vrijednosti i uzgojne zahvate koje u njima treba provoditi, svrstane u tri kategorije. Na ukupno 659 stajališta sistematski raspoređenih po modelu kvadratne mreže na međusobnoj udaljenosti od 200 metara, procijenjena je pripadnost sastojine određenoj kategoriji šuma s obzirom na njihove trenutne ekološko-proizvodne, strukturne i uzgojne karakteristike.

Za svaku kategoriju utvrđene su prosječne veličine osnovnih proizvodnih pokazatelja sastojina za stanje sa i bez doznačenih stabala, te istih pokazatelja doznačene drvene mase kao i intenzitet zahvata. Statistička značajnost razlika između procijenjenih veličina osnovnih proizvodnih pokazatelja testirana je metodom analize varijanse. Na bazi dobijenih rezultata za sve sastojine koje pripadaju prvoj kategoriji preporučena je indirektna konverzija, za najveći broj sastojina iz druge kategorije predložena je direktna i kombinovana konverzija, dok je za sastojine treće kategorije ocijenjeno da nije potrebna konverzija jer imaju isključivo zaštitni karakter.