Quality and Assortment Structure of Beech High Forests in Serbia

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Abstract – The paper presents research results on quality and assortment structure of uneven-aged beech high forests in Central Serbia. Eleven representative stands of submontane beech forest (*Fagenion moesiacae submontanum* B. Jov. 1976) and montane beech forest (*Fagenion moesiacae montanum* B. Jov. 1976) were selected. Their altitude ranges from 450 m to 1350 m. Site class ranges from I/II to III/IV, canopy closure from 0.7 to 0.9 and volume from 290 m^3/ha to 522 m^3/ha. Total area of the stands is 241.9 ha. Sample plots of 500 m^2 were established in a systematic grid of 100 x 100 m. From silvicultural aspect, 16% of the standing volume (384 m^3/ha) is class one, 39% is class two and 45% is class three. From the aspect of forest utilization 37% of the volume is class one, 34% is class two, 19% is class three, and 10% is class four. In the assortment structure of the average stand volume, industrial wood accounts for 42%, cordwood 48% and waste 10%. It has been concluded that beech high forests in Serbia have unfavourable quality and assortment structure. This situation should be improved in future by taking adequate management measures.

European beech / stand volume / stand structure / wood quality / assortments

1 INTRODUCTION

Beech is a dominant tree species in the forests of Serbia since it accounts for 60% of the total tree volume of all high forests (Stojanović et al. 2005). In the past different management systems of beech forests were used the main ones were: selection felling system, regeneration felling system, and group selection system.

Until the planned conversion of beech virgin forests into productive forests at the beginning of the twentieth century, selection management system was solely applied (single tree selection). The system was used up to the sixties. The selection system then was assessed as unsuitable for beech forests and it was replaced with the management system of group selection felling. This system was developed by Milin (1988) both in theory and in practice, and was introduced in the period from 1960 to 1990. The system was later also considered as unsuitable for beech forests and a new change of management system was implemented. The system of forest management by regeneration felling with short regeneration periods was proposed. This system is still the most commonly applied in management plans, but it is seldom put into practice.

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Generally, there is a great difference between management planning of beech high forests in Serbia and putting these plans into operation. Depending on the stand structure (even-aged, uneven-aged and selection stands with various transitional forms), either regeneration, group selection or selection felling is planned. However, single tree selection felling and selection felling of trees in small groups are most commonly used in practice. This is due to a number of reasons, particularly to the wrong approach to claim that most uneven-aged forests are almost even-aged and to determine the intensity of felling on stand level, rather than on management class level. Beech stands in Serbia are predominantly group-selection all-aged, while there is an insufficient confidence of the measured stand parameters, required for the planning of the forest management on the stand level (Koprivica 2006).

Implementation of different management systems of beech high forests in Serbia and their frequent change have resulted in exceptionally heterogeneous structural development of beech high forests, which has had a particularly unfavourable influence on the quality and natural regeneration of the stands.

Inventory of these forests is still focused on the size and diameter structure of the basic taxation elements: number of trees, basal area, volume and volume increment. Evaluation of the quality and assortment structure of stands and overall classification of forest management units has not been given enough consideration. In forest management plans data on stand quality structure are usually given descriptively, while their assortment structure is determined based on the experience gained during the assortment production in a particular locality or region. However, this approach is often subjective in its nature and there is a permanent need for development, improvement and application of a more objective and precise method of assessing quality and assortment structure of stands.

Dendrometry textbooks (Mirković-Banković 1993, Pranjić-Lukić 1997) describe several methods of assessing quality and assortment composition. However, different methods have different reliability as well as different potentials for their practical implementation. Therefore, the Institute of Forestry in Belgrade has initiated a research project under the title "Method of assessment of quality and assortment structure of beech high forests in Serbia". The project was successfully carried out in the period of 2005 to 2007. A part of the obtained results has been published so far (Koprivica et al. 2006, 2007, 2008, 2009).

The task and the aim of this paper is analyze and synthesize the results of older and recent investigations of the quality and assortment structure of beech stands in order to determine more precisely the quality of beech high forests in Serbia and to plan suitable management measures.

2 STUDY AREA AND METHOD

The research was performed in eleven high, pure, uneven-aged beech stands, selected from six forest complexes located in Central Serbia. These are: Severno Kučajsko, Jablaničko, Podrinjsko-Kolubarsko, Donje-Ibarsko, Golijsko and Rasinsko with a total area of 241.9 ha. Average stand area is 22.0 ha, while individual stand areas range from 9.8 ha to 32.3 ha. Average altitude of the stands is 850 m, while individual stand altitudes ranging from 445 m to 1330 m. Average slope is 21°, individually from 11° to 27° . The most frequent exposure is northwest. Parent rock consists of different types of rocks (sandstone, slates, limestone, granite, gneiss, granodiorite, andesite, etc.). The most frequent soil type is acid brown soil (dystric cambisol), with the depth of approximately 40 to 80 cm. The stands belong to the submontane (*Fagenion moesiacae submontanum* B. Jov. 1976) and montane beech forests (*Fagenion moesiacae montanum* B. Jov. 1976). By silvicultural treatment and structure, they are group-selection uneven-aged stands of beech high forest, in operational (economic) use.

Average site class is II/III, ranging from I/II to III/IV. Average canopy closure degree is 84%, ranging from 69% to 94%. Average percentage of beech in the stand volume is 97%, stand mean diameter is 34 cm and Lorey's mean height 28 m. The average number of trees (with diameter above 10 cm) per hectare is 298, basal area 27 m^2/ha, volume 384 m^3/ha, volume increment 8.3 m^3/ha (Koprivica et al. 2006, 2007, 2008).

A special method was designed (Koprivica et al. 2005) for collecting and processing data needed for the research of quality and assortment structure of beech high forests in Serbia. We shall present only the basic characteristics of the applied method. The size and the structure of taxation elements, particularly the volume and its quality and assortment structure, were determined by partial measurement (samples). Simple circular sample plots, sized 500 m^2 were used. They were distributed in the stands in a 100 m quadratic grid. The intensity of sampling was 5% of the stand area. Altogether there were 242 sample plots. The quality of the 3611 trees in all sample plots was evaluated by using three different methods: the method of the Faculty of Forestry in Belgrade (Stamenković-Vučković 1988), the method of the Faculty of Forestry in Sarajevo (Matić 1977) and Priesol`s method (Mirković-Banković 1993).

In this paper we used Matic`s (Matić 1977) method. This method includes two classifications of trees: silvicultural-technical and technical. The first classification is used to determine the quality of the growing stock and the yield, while the second is used to determine the proportions of assortments in the stand volume, as well as in the marked volume. The classifications are based on the diameter and the quality of the trees, or more precisely trunks. The silvicultural-technical classification is defined primarily from the aspect of silviculture, while the technical classification is defined from the aspect of forest utilization. The second classification is derived from the first one. The criteria for these classifications are described in detail in the paper by Matić, V. (1977).

This paper gives only the general characteristics of these classifications. According to their diameter, trees are classified in the following categories: 5-10, 10-20, 20-30, 30-50, 50-80, and above 80 cm, while their quality is assessed according to different criteria. A number of different stem characteristics are assessed: origin, health condition, leaf colour, forks, butt end, tree trunk, sweep, twist, dents, damage, frost cracks, overtopping, supression, crown damage, snapped or dry tops and infection. According to silvicultural-technical classification, there are three classes of trees:1, 2 and 3. The first class is the best, while the third is the worst.

The first silvicultural-technical class comprises healthy and normally formed trees, with trunks beginning at the stump, suitable for the production of logs of the best and good quality (or potentially so when a tree reaches mature stage). Leaves should be healthy and green. The third silvicultural-technical class comprises severely damaged, diseased and decaying trees, as well as healthy trees which can be used only for the production of fuel and pulp wood, and possibly the lowest quality logs (e.g. „wolfs"). The second silvicultural-technical class (2) comprises all other trees.

According to technical classification, trees are classified into four classes: 1, 2, 3 and 4. The first class is the best, while the fourth is the worst. Trees are classified according to their previously established silvicultural-technical and diameter class, while taking other criteria into consideration as well, primarily those relating to the technical quality of trees. For example, a tree with a dry or a snapped top classified as a tree of the third silvicultural-technical class can be classified as a tree of the first technical class because the quality of its trunk is the same as the quality of a tree in the first silvicultural-technical class etc.

The provisional marking of the trees for felling was performed exclusively for silvicultural purposes (positive selection).

The assortment structure was assessed by the stand assortment tables for beech in Bosnia (Vukmirović 1971), with some corrections (Koprivica et al. 2005). These assortment tables show the proportion of forest assortments in the total volume of the trees (with diameter above 3 cm at the thinner end) expressed in percentage. The inputs in these tables are technical class and diameter class, as well as the kind of assortment, the proportion of which is assessed. For a given technical class, the percentage of a particular kind of assortment, by its diameter class can be read directly from the tables. The total tree volume, previously classified into technical and diameter classes, is used to determine assortment structure expressed in m^3. The volume of each class is simply multiplied by the appropriate percentages read from the tables and then they are added up.

Field data were processed with the SORTIMENT computer software which was specially designed for this purpose (Marković et al. 2007).

3 RESULTS

Out of the numerous study results, we shall only present the results concerning the size and structure of the basic beech stand taxation elements. The focus will be naturally on the stand volume.

3.1 Size and structure of beech stand taxation elements

The average values for the number of trees (N), basal area (G), volume (V) and volume increment (I_v) of the beech stands (per hectare at the time of measurement) are presented in *Table 1*, while *Table 2* shows the values for the marked part of the stands and *Table 3* for the unmarked part.

The average per hectare value of the taxation elements of all stands at the time of measurement was as follows: number of trees 298, basal area 27.0 m^2, volume 383.9 m^3 and volume increment 8.3 m^3.

Table 1. Beech stand taxation elements (total)

Elements	Stand										
	33a	42a	42b	122a	27a	31a	46a	8a	8b	44a	116a
N	274	321	308	214	259	301	298	352	482	294	314
G, m^2	33.4	31.7	31.5	29.0	23.1	21.5	23.2	30.8	29.5	31.0	22.2
V, m^3	522.4	379.6	333.2	503.6	353.7	290.8	316.0	385.2	361.0	502.0	289.9
I_v, m^3	8.6	6.6	5.0	10.5	8.0	6.4	10.1	8.9	6.7	9.2	8.0

Table 2. Beech stand taxation elements (marked part)

Elements	Stand										
	33a	42a	42b	122a	27a	31a	46a	8a	8b	44a	116a
N	135	179	142	110	127	155	136	146	230	110	167
G, m^2	19.0	17.1	17.2	14.0	10.6	9.9	11.5	12.2	11.8	13.7	11.8
V, m^3	304.5	203.3	189.1	242.1	159.8	130.7	157.8	152.9	142.1	229.1	152.9
I_v, m^3	4.3	3.3	2.3	4.9	3.6	2.7	4.7	3.3	2.2	3.5	3.9

The average per hectare value of the taxation elements of the part which is included in the provisional marking of all stands is: number of trees 145, basal area 13.2 m^2, volume 188.6 m^3 and volume increment 3.7 m^3.

Table 3. Beech stand taxation elements (unmarked part)

Elements	Stand										
	33a	42a	42b	122a	27a	31a	46a	8a	8b	44a	116a
N	139	142	166	104	132	146	162	206	252	184	147
G, m^2	14.4	14.6	14.3	15.0	12.5	11.6	11.7	18.6	17.7	17.3	10.4
V, m^3	217.9	176.3	144.1	261.5	193.9	160.1	158.2	232.3	218.9	272.9	137.0
Iv, m^3	4.3	3.3	2.7	5.6	4.4	3.7	5.4	5.6	4.5	5.7	4.1

The average per hectare value of the taxation elements of the part which is not included in the provisional marking of all stands is: number of trees 154, basal area 13.8 m^2, volume 195.3 m^3 and volume increment 4.6 m^3.

The given data on the existing state of beech stands and the part which has not been included in the provisional marking of trees clearly show that the current state of beech high forests in Serbia is very bad. Provisional marking included on the average: 48.5% of trees, 48.9% of basal area, 49.1% of volume and 44.6% of volume increment.

Distribution of stand volume per diameter classes is one of the most important parameters of the quality and assortment structure – in the sense that, with approximately the same quality of healthy trees, the stand with a higher percentage of larger diameter trees is more valuable. In order to better understand the differences in the stand volume structures per diameter classes; their percentage distribution is presented in *Table 4.*

Table 4 shows that in all stands altogether the percentage of the trees with diameter above 60 cm (threshold diameter of felling size) is 26.7% of the average volume. The volume of the trees with diameter above 60 cm in individual stands range from 0 to 41.0%. It can be assumed that the stands with a higher percentage of thicker trees have better quality and assortment structure, but this cannot be proven yet. Above all, it depends on the quality of the trees.

The volume of the trees included in the provisional marking in the stands is presented in *Table 5.* The table shows that the percentage of the trees with diameters above 60 cm in the provisionally marked volume of all stands amounts to 36.0% in the average. Individual stand percentages of the trees with diameters above 60 cm are in the range from 0 to 52.0%. This is in accordance with the percentage distribution of the stand volume presented in *Table 4.* It further shows that provisionally marked trees are distributed in all diameter classes, which supports the previous conclusion that the trees were exclusively marked from the aspect of silviculture (stand tending).

Table 4. Structure of the beech stand volume per diameter classes,in %

Stand	Diameter class (cm)									Total, %
	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
33a	2.4	6.1	11.7	12.6	26.2	21.5	10.3	7.2	2.0	100.0
42a	1.7	9.5	24.1	27.6	24.6	10.7	1.8	-	-	100.0
42b	1.9	7.9	9.9	28.7	27.5	17.4	6.7	-	-	100.0
122a	1.6	4.0	9.5	18.9	21.5	29.7	12.1	2.7	-	100.0
27a	3.4	8.8	18.9	20.5	26.1	18.0	4.3	-	-	100.0
31a	4.7	10.6	21.3	38.2	11.0	11.2	3.0	-	-	100.0
46a	4.9	9.3	14.7	21.0	29.0	13.2	7.9	-	-	100.0
8a	1.7	15.5	35.8	30.9	16.1	-	-	-	-	100.0
8b	6.6	20.8	27.6	26.8	18.2	-	-	-	-	100.0
44a	3.3	6.5	9.5	16.0	19.2	21.0	21.2	3.3	-	100.0
116a	5.4	10.2	24.4	26.8	16.0	10.4	4.5	2.2	-	100.0
Average, %	3.3	8.7	17.2	22.9	21.2	16.3	8.1	2.0	0.3	100.0

Table 5. Structure of the provisionally marked volume in the beech stands per diameter classes, in %

Stand	Diameter class (cm)									Total, %
	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	
33a	1.8	3.8	9.4	8.3	24.7	22.9	13.4	12.3	3.4	100.0
42a	1.9	10.9	23.9	24.1	20.3	15.6	3.3	-	-	100.0
42b	1.6	5.1	6.5	20.1	24.3	30.6	11.8	-	-	100.0
122a	1.7	5.3	11.1	15.3	20.2	27.7	13.0	5.7	-	100.0
27a	3.8	11.5	18.6	14.2	26.3	20.8	4.8	-	-	100.0
31a	6.8	10.8	14.1	30.4	11.6	19.7	6.6	-	-	100.0
46a	4.7	7.6	13.3	14.4	24.9	19.3	15.8	-	-	100.0
8a	2.4	16.7	27.6	31.8	21.5	-	-	-	-	100.0
8b	12.0	18.0	9.7	28.2	32.1	-	-	-	-	100.0
44a	2.8	5.1	4.0	8.7	16.6	21.3	34.3	7.2	-	100.0
116a	5.8	11.2	17.9	29.7	11.0	14.9	5.2	4.3	-	100.0
Average, %	3.6	8.3	13.5	18.5	20.1	19.5	11.9	4.1	0.5	100.0

However, intensity of marking (per volume) is rather high and amounts to around 49.1%. Intensity of marking in individual stands ranges from 39.4% to 58.2%. Apart from the high percentage of the trees with diameter above 60 cm in the stand volume, this is primarily the consequence of the poor quality of the trees. The percentage of the trees with diameter above 60 cm in the unmarked average volume of all stands is 17.6%, while there are no trees with diameter above 80 cm.

3.2 Quality structure of beech stand volume

The study results include the quality structure of the existing stand volume, provisionally marked volume, and the stand volume which would remain after the provisional marking (tree felling) has been carried out.

The percentage distribution of the existing stand volume per silvicultural and technical classes is shown in *Table 6*.

Table 6. Quality structure of the existing beech stand volume, in %

Stand	Silvicultural class			Total, %	Technical class				Total, %
	1.	2.	3.		1.	2.	3.	4.	
33a	10.8	36.4	52.0	100.0	27.9	36.1	24.6	11.4	100.0
42a	11.3	39.6	49.1	100.0	38.9	36.6	18.5	6.0	100.0
42b	5.9	22.0	72.1	100.0	18.5	22.7	39.9	18.9	100.0
122a	30.2	43.3	26.5	100.0	56.0	33.0	9.3	1.7	100.0
27a	24.6	45.9	29.5	100.0	57.9	26.3	10.2	5.6	100.0
31a	17.3	35.1	47.6	100.0	37.7	31.4	17.4	13.5	100.0
46a	5.0	35.6	59.4	100.0	25.2	39.3	22.0	13.5	100.0
8a	6.9	42.9	50.2	100.0	23.7	38.3	26.9	11.1	100.0
8b	10.0	43.7	46.3	100.0	26.1	33.7	20.7	19.5	100.0
44a	19.7	47.5	32.8	100.0	44.2	37.0	13.5	5.3	100.0
116a	9.5	32.6	57.9	100.0	26.6	32.8	25.0	15.6	100.0
Average, %	15.5	39.5	45.0	100.0	37.4	34.0	18.9	9.7	100.0

Table 6 shows that the quality structure of the existing beech stand volume is rather unfavourable. The percentage of the trees of the third (the lowest) silvicultural class in the existing volume is 45.0%, ranging from 26.5% do 72.1%. The percentage of the trees of the third and fourth technical class (the lowest classes) in the existing volume is approximately 28.6%, ranging from 11.0% to 58.8 %. This results in an exceptionally high intensity of the provisionally marked volume, 49.1%, ranging from 39.4% to 58.2%, which means that practically half of the existing stand volume should be removed in the next three or four decades. This is the consequence of the high share of trees with large diameters and poor quality, and the failure to apply adequate tending measures in the past. Approximately 23.5% of the trees in the stands are strongly damaged or affected by canker or decay. The volume of such trees accounts for 25.5% of the existing beech stand volume.

We came to similar conclusions in our earlier investigations for the Jablaničko and Severno-Kučajsko forest areas, where the quality structure of the volume of the beech stands was also rather unfavourable (Koprivica et al. 2006, 2008). However, the quality structure of the volume of the beech stands in Kolubarsko-Podrinjsko forest area was far better (Koprivica et al. 2007). The best quality beech stands are in the Boranja (122a i 27a) and Željin (44a) region.

Earlier studies concluded that the quality of beech high forests in Serbia was far from being satisfactory (Mirković 1971). The recent evaluations of the quality of beech forests in Serbia have proven the same fact (Stojanović et al. 2005).

The quality structure of the volume of the trees included in the provisional marking in the stands is presented in *Table 7*. It shows that the provisional marking includes mostly trees of the third silvicultural class, on average 71.8%, ranging from 49.8% to 96.8%, then trees of the second and finally a negligible percentage of the first class trees. The share of the third and fourth technical classes (together) in the provisionally marked volume accounts for about 46.4%, ranging from 17.4% to 87.0%. Therefore, the quality structure of the provisionally marked volume is much less favourable than the quality structure of the existing stand volume, which could have been expected. In short, the planned volume yield of the beech high forests has a rather unfavourable quality structure, which will be more clearly shown in the analysis of the assortment structure of the stand volume.

Quality structure of the unmarked tree volume in the beech stands is shown in *Table 8*. The data show the quality structure of the stand volume which should be achieved in the next three to four management periods (30–40 years) by applying the stand tending principle of positive selection.

Table 7. Quality structure of the marked beech stand volume in %

Stand	Silvicultural class			Total, %	Technical class				Total, %
	1.	2.	3.		1.	2.	3.	4.	
33a	-	26.4	73.6	100.0	10.2	36.3	35.2	18.3	100.0
42a	1.3	24.1	74.6	100.0	15.1	44.0	29.8	11.1	100.0
42b	-	3.2	96.8	100.0	2.1	10.9	54.8	32.2	100.0
122a	11.9	38.3	49.8	100.0	35.5	47.1	14.0	3.4	100.0
27a	7.1	41.2	51.7	100.0	39.6	30.7	17.6	12.1	100.0
31a	0.5	20.0	79.5	100.0	15.2	29.7	27.1	28.0	100.0
46a	-	13.7	86.3	100.0	0.8	46.1	27.2	25.9	100.0
8a	-	20.3	79.7	100.0	6.2	30.0	39.1	24.7	100.0
8b	-	11.4	88.6	100.0	5.2	19.6	30.4	44.8	100.0
44a	8.1	35.0	56.9	100.0	22.9	46.3	20.4	10.4	100.0
116a	-	11.4	88.6	100.0	7.0	30.2	34.4	28.4	100.0
Average,%	3.4	24.8	71.8	100.0	16.5	37.1	27.8	18.6	100.0

Table 8. Quality structure of the unmarked volume of the beech stands, in %

Stand	Silvicultural class			Total, %	Technical class				Total, %
	1.	2.	3.		1.	2.	3.	4.	
33a	25.9	50.4	23.7	100.0	52.6	35.8	9.9	1.7	100.0
42a	22.8	57.5	19.7	100.0	66.3	28.1	5.4	0.2	100.0
42b	13.5	46.8	39.7	100.0	40.0	38.3	20.2	1.5	100.0
122a	47.1	48.0	4.9	100.0	75.2	19.8	4.9	0.1	100.0
27a	39.0	49.8	11.2	100.0	73.0	22.7	4.1	0.2	100.0
31a	31.0	47.4	21.6	100.0	56.1	32.7	9.5	1.7	100.0
46a	10.0	57.4	32.6	100.0	49.6	32.5	16.8	1.1	100.0
8a	11.4	57.8	30.8	100.0	35.2	43.8	18.9	2.1	100.0
8b	16.4	64.7	18.9	100.0	39.7	42.7	14.4	3.2	100.0
44a	29.4	58.0	12.6	100.0	62.1	29.2	7.6	1.1	100.0
116a	20.2	56.3	23.5	100.0	48.5	35.8	14.6	1.1	100.0
Average, %	27.2	53.5	19.3	100.0	57.4	31.2	10.3	1.1	100.0

The average share of the third silvicultural class in the provisionally unmarked volume accounts for 19.3%, while the third and the fourth technical class amounts to 11.4%. This goal is difficult to attain in the management practice, but we should do our best to reach it. Naturally, we should also consider a very important issue of natural regeneration of the beech stands and the intensity of tree growth above the taxation limit (10 cm).

3.3 Assortment structure of the beech stand volume

Table 9 presents the assortment structure of the existing volume of the beech stands. The assortment structure of the existing volume in the studied beech stands is unfavourable. The share of the best quality assortments (FT/TL and PT1) is 60.3 m^3/ha or 15.7%. The percentage of industrial wood in the volume is 41,7%, cordwood 48.4% and waste 9.9%.

Table 9. Assortment structure of the existing volume of the beech stands, in m3/ha

Stand	Volume of the products and waste, m^3/ha									Total, m^3/ha
	FT/TL*	PT1	PT2	PT3	C	O1/O2	O3	S	OTP	
33a	31.5	40.7	64.4	77.1	85.0	70.1	68.6	28.2	56.8	522.4
42a	26.5	34.2	47.7	52.7	65.6	47.6	44.4	25.2	35.7	379.6
42b	12.1	18.4	32.8	49.3	61.1	52.5	47.5	19.0	40.5	333.2
122a	55.3	60.0	72.0	69.5	69.4	49.5	54.8	28.1	45.0	503.6
27a	38.0	38.4	43.7	46.3	54.4	40.9	37.9	23.0	31.1	353.7
31a	17.9	24.2	32.7	38.8	51.6	41.0	35.7	19.9	29.0	290.8
46a	15.8	23.6	38.3	42.9	56.0	45.0	42.0	19.5	32.9	316.0
8a	14.6	22.6	41.9	53.9	78.1	59.2	47.8	28.2	38.9	385.2
8b	11.8	20.7	35.9	44.2	75.6	60.6	47.8	27.1	37.3	361.0
44a	44.0	51.4	68.9	68.9	75.3	57.7	60.0	27.9	47.9	502.0
116a	13.3	20.0	31.9	38.7	53.7	44.3	38.5	19.1	30.4	289.9
Average, m^3/ha	26.9	33.4	47.2	52.6	64.5	50.3	47.2	23.8	38.0	383.9
%	7.0	8.7	12.3	13.7	16.8	13.1	12.3	6.2	9.9	100.0

* FTTL –veneer log and rotary log, *PT1, PT2 i PT3* – saw logs of the first, second and third class, C- pulpwood,*O1, O2 i O3* – fuelwood of the first, second and third class, S- small round billets and OTP - waste

Table 10 shows the assortment structure of the provisionally marked volume of the beech stands. The assortment structure of the provisionally marked volume of all the stands is on average rather unfavourable, which is due to unfavourable quality structure. The share of the best quality assortments (FT/TL and PT1) is 20.2 m^3/ha or 10.7%. The percentage of the main groups of products is as follows: industrial wood 36.2%, cordwood 52.4% and waste 11.4%.

Table 10. Assortment structure of the marked volume of the beech stands, in m^3/ha

Stand	Volume of products and waste, m^3/ha									Total m^3/ha
	FT/TL	PT1	PT2	PT3	C	O1/O2	O3	S	OTP	
33a	11.1	17.9	34.9	47.5	49.1	46.4	45.6	14.4	37.6	304.5
42a	7.9	12.8	24.4	29.0	37.3	30.7	26.9	13.1	21.2	203.3
42b	2.3	4.8	14.0	29.5	35.8	34.8	31.5	9.1	27.4	189.2
122a	19.0	24.2	35.5	34.7	36.0	27.5	28.7	13.4	23.0	242.0
27a	13.8	14.0	18.7	20.6	25.7	22.5	18.9	10.3	15.3	159.8
31a	4.5	6.5	12.4	17.5	24.2	22.7	19.2	8.2	15.5	130.7
46a	3.2	7.7	18.1	22.3	27.8	26.2	24.8	8.7	19.0	157.8
8a	2.9	4.8	13.3	20.8	31.8	28.4	22.4	10.6	17.9	152.9
8b	2.3	4.0	9.3	15.4	28.8	30.4	24.0	9.8	18.1	142.1
44a	14.0	19.7	32.6	32.7	33.5	29.2	32.1	10.8	24.5	229.1
116a	3.7	6.5	14.0	20.7	28.5	28.0	23.5	9.4	18.6	152.9
Average m^3/ha	8.3	11.9	21.5	26.6	32.3	29.0	26.7	10.8	21.5	188.6
%	4.4	6.3	11.4	14.1	17.1	15.4	14.2	5.7	11.4	100.0

It is interesting to see the assortment structure of the unmarked volume of the beech stands *(Table 11).* Although this structure can be calculated from the data in *Tables 9 and 10*, we will present it here in full to make the study of the stand volume structure complete. As a matter of fact, this is a model which should be strived for in the beech forest management and which can be brought about by changes in the quality structure of the trees in the stands.

The data in *Table 11* show that the difference in assortment structure of unmarked stand volume is smaller than the difference in the marked volume. The share of the best quality assortments (FT/TL and PT1) is 40.1 m^3/ha or 20.5%. The percentage of the main groups of products is as follows: industrial wood 47.0%, cordwood 44.4% and waste 8.6%.

Table 11. Assortment structure of the unmarked volume of the beech stands in m3/ha

Stand	Volume of products and waste, m^3/ha									Total, m^3/ha
	FT/TL	PT1	PT2	PT3	C	O1/O2	O3	S	OTP	
33a	20.4	22.7	29.5	29.6	36.0	23.7	23.0	13.8	19.2	217.9
42a	18.6	21.4	23.2	23.7	28.3	16.9	17.6	12.1	14.5	176.3
42b	9.8	13.6	18.8	19.8	25.3	17.7	16.0	9.9	13.1	144.0
122a	36.3	35.8	36.4	34.8	33.3	22.0	26.1	14.8	22.1	261.6
27a	24.2	24.4	25.0	25.6	28.7	18.4	19.0	12.7	15.9	193.9
31a	13.4	17.8	20.3	21.2	27.4	18.3	16.5	11.7	13.5	160.1
46a	12.6	15.8	20.3	20.6	28.2	18.8	17.3	10.7	13.9	158.2
8a	11.7	17.7	28.6	33.1	46.3	30.9	25.4	17.6	21.0	232.3
8b	9.5	16.7	26.5	28.9	46.8	30.2	23.8	17.3	19.2	218.9
44a	30.0	31,7	36.7	36.1	41.7	28.5	27.8	17.1	23.3	272.9
116a	9.7	13.6	17.9	18.0	25.1	16.3	15.0	9.6	11.8	137.0
Average m^3/ha	18.6	21.5	25.5	26.2	32.2	21.1	20.3	13.1	16.8	195.3
%	9.5	11.0	13.1	13.4	16.5	10.8	10.4	6.7	8.6	100.0

4 DISCUSSION AND CONCLUSION

The results of the quality and assortment volume structure of the studied beech stands show that according to the quality of their volume, the stands can be classified into three groups: the stands of good, medium and poor quality. Stands 122a, 27a, 44a belong to the group of good quality, stands 42a, 33a, 31a, 46a medium quality and 116a, 8a, 42b, 8b are poor quality stands.

In order to give a full insight into the quality of the studied beech stands, we applied the stratified sample. The quality and assortment structure of the present volume, provisionally marked volume and unmarked volume are compared (*Table 12* and *13*).

Table 12. Quality structure of the volume of all beech stands, together

Stand volume	Silvicultural class(%)				Technical class (%)				
	1.	2.	3.	Total	1.	2.	3.	4.	Total
Present	15.5	39.5	45.0	100.0	37.4	34.0	18.9	9.7	100.0
Marked	3.4	24.8	71.8	100.0	16.5	37.1	27.8	18.6	100.0
Unmarked	27.2	53.5	19.3	100.0	57.4	31.2	10.3	1.1	100.0

The data in Table 12 show that the quality of the trees i.e. their volume in the studied beech stands in Serbia is rather bad. The percentage of the third silvicultural class in the marked volume is 71.8%, while the third and the fourth technical class account for 46.4%. The percentage of the third silvicultural class in the provisionally unmarked volume amounts to 19.3%, while the third and the fourth technical class make 11.4% altogether.

Table 13. Assortment structure of the volume of all beech stands, together

Stand volume	Products and waste (%)								
	FT/TL	PT1	PT2	PT3	C	O1/O2	O3	S	OTP	Total
Present	7.0	8.7	12.3	13.7	16.8	13.1	12.3	6.2	9.9	100.0
Marked	4.4	6.3	11.4	14.1	17.1	15.4	14.2	5.7	11.4	100.0
Unmarked	9.5	11.0	13.1	13.4	16.5	10.8	10.4	6.7	8.6	100.0

Unfavourable quality structure of the stand volume has a negative impact on their assortment structure, i.e. the structure of the present volume, provisionally marked volume and unmarked volume. The share of the best quality assortments (FT/TL and PT1 in the present stand volume is 15.7% (10.9% in the marked volume and 20.5% in the unmarked volume). The percentage of the main groups of products in the above three states of the stand volume is the following:

Stand volume	Industrial wood (%)	Cordwood (%)	Waste (%)	Total (%)
Present	41.7	48.4	9.9	100.0
Marked	36.2	52.4	11.4	100.0
Unmarked	47.0	44.4	8.6	100.0

To improve the present unfavourable quality and assortment structure of beech stands in Serbia, an appropriate management system should be implemented consistently, which implies that tending and regeneration measures should be applied in a permanent, planned and professional way. Since these are all pure uneven-aged beech stands, we think that the forest management should continue to support the group-selection structure of stands. This statement is further supported by the following facts: the present structural and spatial development of beech stands, the present state and emergence of regrowth, unfavourable tree quality on a large area, and steep terrain on which the stands are located. Apart from their production function, there are numerous other forest functions which should be taken into consideration in forest management planning and practice. To put it briefly, it is our opinion that only a „permanent forest" can fulfil all the requirements of multifunctionality.

Management should gradually strive towards achieving a quality and assortment structure for unmarked volume calculated in this research. We think that in the next four decades, disciplined and professional work can improve the existing unfavourable quality and assortment structure of beech high forests in Serbia.

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