

BEECH VIRGIN RESERVES IN SERBIA

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ABSTRACT

Ostojić D., Jovanović B. & Kisin B. (2008): **Beech virgin reserves in Serbia. Proceedings of the III Congress of Ecologists of the Republic of Macedonia with International Participation, 06-09.10.2007, Struga.** Special issues of Macedonian Ecological Society, Vol. 8, Skopje.

Beech reserves represent the oldest forms of protection in Serbia. Today, in Serbia, there are altogether 11 beech reserves, and their natural value is based on typicalness, representativeness, original character and conservation of the autochthonous Balkan beech community (*Fagetum moesiacaе serbicum*). This paper presents in detail 6 Strict Nature Reserves of pure beech virgin forests. They are: Danilova Kosa, Feljeshana, Kukavica, Vinatovača, Golema Reka and Busovata. In this study, the taxation values of the Reserves were analysed as the indicators of total productivity, development, vitality and stability. The study shows that beech virgin reserves are specific, rare and conserved forest ecosystems which, after 50 years of protection and spontaneous process of natural regeneration justify the designated category of protected areas of exceptional significance.

Key words: beech, nature reserve, virgin forest

Introduction

Beech forests occupy almost a half of the forested area in Serbia. Beech occurs on all hilly and mountain massifs in various structural forms, forming pure and mixed stands, both with broadleaves, and with conifers. The adaptability to altitudinal climate belts and different sites with a wide range of vertical distribution from 100 to 1700 m, make beech a dominant forest species.

According to Jovanović & Cvjetičanin (2005), beech genus (*Fagus* L.) consists of broadleaf tree species distributed in the north temperate belt. There are 10 beech species: Balkan beech (*Fagus moesiaca*), European beech (*Fagus sylvatica*), oriental beech (*Fagus orientalis*), Crimean beech (*Fagus taurica*), American beech (*Fagus grandifolia*), Japanese beech (*Fagus japonica*), Sieboldi beech (*Fagus sieboldii*), and three species of Chinese beech (*Fagus longipediolata*, *Fagus engleriana*, *Fagus tian-taiensis*). In Serbia, in addition to the most widely distributed Balkan beech - *Fagus moesiaca* (Domin, Maly) Czeczott, this genus includes also European beech (*Fagus sylvatica*) and oriental beech (*Fagus orientalis*).

Thanks to the distribution and representation of beech genus, and thanks to the diversity of species,

beech forest reserves are the oldest protection forms in Serbia. From 1948 to date, 11 beech reserves have been designated and placed under total protection. Of these 11 designated Reserves, 6 Reserves are pure beech virgin forests. They are: Danilova Kosa, Feljeshana, Kukavica, Vinatovača, Golema Reka and Busovata. These Reserves represent a special natural value expressed by their originality, representativeness and the age of beech forests. The protection of beech virgin communities made it possible to conserve all the autochthonous, phytocoenological, structural and ecological characteristics of pure beech forests, and in this way also to conserve the biodiversity of Serbian forests. The significance of virgin ecosystems is best explained by Mlinsek (1968): “*In the intact nature, we are getting the answers to numerous questions on forest growth and development. In a virgin forest, we learn by which laws forest stands grow and regenerate and about the permanent attempts of nature to adapt the living world to environmental conditions. Virgin forests are characterised by permanent dynamicity - stand conditions change in front of our eyes. Only the change is permanent. Each stand exists only once.*”

The value, significance and protection of beech forests has been and still is the subject of interest of numerous scientists. In Serbia, beech

virgin forests were reported by Stojisavljević (1983), Džomić (1985), Stojanović et al. (1995), Stamenković & Vučković (1986), Stamenković et al. (1988), Stojanović et al. (1999), Kisin (2006) etc.

Material and Methods

The aim and the task of this study was to present and analyse comparatively the most valuable protected areas under beech forests, i.e. after 50 years of protection, to determine the characteristics and the state of beech strict forest Reserves in Serbia. The professional-documentary material consisted of the Protection Studies for each of the forests, and ten-year forests management plans, i.e. special forest management plans for the concrete region (Management Unit). Taking into account that these are strictly protected areas in which the forest ecosystem dynamics can be studied and the obtained results can be applied in the same or structurally close forest ecosystems, this paper presents the summary taxation elements, as the indicators of production values, vitality and total stability of the protected beech stands. The data are processed for each Reserve individually, and the calculated results are presented textually, in tables and figures.

Investigated Areas

Main natural values of the investigated Reserves

1. Strict Nature Reserve Danilova Kosa is situated in West Serbia, East of the river Drina, at about 4 km from the settlement Krupanj. It belongs to the compartment 132/b, MU "Istočna Boranja". The area of Danilova Kosa is a steep terrain of dissected slope, with dominant east aspect and altitude from 680 to 750 m. Parent rock in the Reserve consists of granites and granodiorites about which the zone of contact-metamorphic rocks occurs. The soil cover consists of acid-brown soil. The Reserve is characterised by a conserved forest community *Fagetum montanum serbicum* Rudski 1949 Em. (B. Jovanović 1967) covering the area of 6.00 ha. Strict Nature Reserve Danilova Kosa was protected by the Institute for the Protection and Scientific Study of Natural Rarities of PR Serbia (Decision number 619 dated 1950). As one of the first designated Reserves in Serbia, it is characterised by the basic values of typicalness, representativeness and original character of beech stands, with a high number of exceptional specimens of trees up to 200 years old. In the area of the Reserve, there are several protected species of flora and fauna, of which we shall emphasise holly *Ilex aquifolium*, fern species hard-fern *Blechnum spicant*, and butcher's broom *Ruscus hipoglossus*.

2. Strict Nature Reserve Feljeshana is in East Serbia, in the area of North Kučaj on the north slopes

of mountain Homolje, near the place Breza, in MU "Crna Reka" within the Forest Estate presented by Queen Natalija to Belgrade University in 1903. This University Domain, known under the name "Natalijino", belongs now to the Faculty of Forestry. Total area of the protected area is 15.28 ha, at the altitude from 420 to 550 m. Parent rock in the upper part of the virgin forest consists of limestone, and in the lower part, it consists of amphibole schists. The soil cover in the Reserve is composed of diluvial soil materials and eutric brown soils. The Reserve was protected by the Institute for the Protection and Scientific Study of Natural Rarities of PR Serbia (Decision number 25/50 dated 1950). Virgin forest Feljeshana is classified as a forest of montane beech (*Fagetum montanum asperulosum typicum*), in which the dominant species is beech. It is a well-conserved autochthonous forest community of Balkan beech whose basic value is the original virgin character. The area of the Reserve is completely prohibited for any anthropogenic activities. This enabled the development of a forest community with trees aged up to 300 years, of imposing diameters and heights of more than 40 m, with very high wood volume, which is another indicator of good conservation and value of this virgin forest.

3. Strict Nature Reserve Kukavica is situated in Southeast Serbia, in the central part of the mountain Kukavica, below its highest peak Vljajna (1442 m), at the altitude ranging from 700 to 1200 m. Based on the valid forest division, the Reserve Kukavica includes compartments 27/a, 27/b, 31/a, 31/b and 31/c, which belong to Management Unit Kukavica II, total area 75.76 ha. Parent rock of the mountain massif Kukavica consists predominantly of schists, and the soil belongs to the development series on acid siliceous rocks. The intact natural forest ecosystem with a complete canopy, with favourable site conditions, with thin beech trees aged about 140 years, was protected by the Municipality Vladičin Han (Decision number 021-26/80-4 dated 1980). It encompasses a vegetation belt of about 500 m and represents one of the best conserved high pure beech virgin stands (*Fagetum moesiacaе serbicum*) on the territory of Serbia.

4. Strict Nature Reserve Vinatovača is situated in East Serbia, on mountain Beljanica, in the area of Gornja Resava, in the upper catchment of the river Resava, in the valley of the stream Vinatovac. The Reserve is located at the altitude from 630 to 870 m, of Northeast aspect. Based on the valid forest division, it includes the compartments 50/a, 50/b, 51/b and 51/c of the Management Unit "Vinatovača-Vrtačelje", total area 37.43 ha. Parent rock consists of chlorite-sericite schists in the lower part, and of limestone in the upper part of the Reserve. The soil cover consists of brown soil. The designated Reserve Vinatovača is a pure beech virgin stand (*Fage-*

tum moesiaca montanum serbicum Rud.) located at an extremely favourable site of a beech stand. Individual trees are up to 46 m high, with strong diameters at breast height above 1 m and aged about 200 years. The conditions for beech development are optimal here so beech, by increasing the tree numbers and crown coverage, as well as by the development of the root system and by a significant percentage in the formation of the thick layer of litter, has suppressed gradually all other species, forming pure stands. Beech virgin stand is protected and designated as a Strict Nature Reserve by the Decision of the Institute for the Protection and Scientific Study of Natural Rarities of PR Serbia, number 595, in 1957. Thanks to its exceptionality and good conservation, the Reserve Vinatovača was evaluated by IUFRO (International Union of Forest Research Organisations) members in 1986 as a representative rarity, also for Europe.

5. The Strict Nature Reserve Golema Reka was designated in 1981 within the Park of Nature "Stara Planina". The Reserve belongs to the catchment of the river Golema Reka, at the altitude from 1,250 to 1,350 m. Parent rock consists of limestones and dolomites. Soil is a type of humus brown acid soils. The boundaries of the Reserve encompass a forest community of montane beech (*Luzulo-Fagetum serbicum* Mišić et Popović 1954). This virgin forest community is autochthonous on Mt. Stara Planina. The Reserve was designated in 1980 and it includes 16 compartments of the Management Unit "Babin Zub-Orlov Kamen-Golaš", total area 34.60 ha. As the protected forest is the value of special significance, both in qualitative and in quantitative senses, further implementation of the strict protection regime in this area will ensure the complete conservation of the existing gene pool of the community, in the aim of supporting the virgin type of beech forests.

6. The Strict Nature Reserve under the name Busovata is situated in East Serbia, on the mountain Beljanica, at the place called Busovata. This stand of beech forest (*Fagetum moesiaca montanum serbicum*) was designated as the Strict Nature Reserve by the Decision of the Municipality Žagubica number 633-2/75, in 1975. The protected area covers 15.86 ha in the compartment 21/a of the Manage-

ment Unit "Beljanica" (today, according to the new Special Management Plan this area is renamed in 4/c compartment of the Management Unit, total area 14.60 ha). At the time of the designation, the area of the Reserve was the best conserved and the least exploited part of beech forest in this region, and one of the points which represent the ecological entity with a spontaneous development of a well-conserved autochthonous forest vegetation in this region.

Based on the presented characteristics of the investigated virgin Reserves, it can be concluded that they are distributed in the typical Serbian beech region, at the altitudes from 420 to 1350 m. It is a case of extremely favourable site conditions and the site of high quality which is the result of bedrock conditions. Namely, geological basis of the beech virgin forests mostly consists contact area of schists and carbonated sediments. After analyses of many virgin stands in Serbia, it is recognized that carbonates are usually in hypsometric upper part of it, and silicate, that are represented by schists and phillites, in lower part. We may conclude that surface flow of precipitations by acidity of silicate basement. Almost all beech reserves and their stands were formed and have been conserved at the contact zone of two different parent rocks, acid rocks (schists/phyllites) and limestones, which supported the genesis of the soil of exceptionally favourable chemical and physical properties, which are also favourable to beech.

Results and Discussion

The stand state of 6 beech virgin stands (Danilova Kosa, Feljeshana, Kukavica, Vinatovača, Golema Reka and Busovata) was analysed based on the processing of the detailed taxation data presented in Tab. 1.

The analysis of taxation elements of 6 virgin Reserves with beech (Tab. 1) shows the following: Reserve "Danilova kosa" has the smallest number of trees - 143 trees/ha. Reserve "Feljeshana" has the lowest average wood volume - 595 m³/ha. The highest number of trees - 433 trees/ha was measured in the Reserve "Golema reka", and the highest wood volume, amounting to 729 m³/ha was measured in the Reserve "Danilova kosa". Number of trees doesn't correlate with wood volume, meaning

Tab. 1. Stand state in the Reserves

Reserve	Area (ha)	Number of trees per ha	Volume (m ³ /ha)	Volume increment (m ³ /ha)	Increment (%)
Danilova Kosa	6.73	143	729	11.7	1.6
Vinatovača	27.60	177	709	12.3	1.7
Kukavica	31.95	182	689	10.3	1.5
Busovata	14.60	196	653	6.6	1.5
Golema Reka	34.60	433	644	11.6	1.8
Felješana	15.28	260	595	5.4	0.9

that stands with the smallest tree numbers have the largest wood volumes. The Reserve “Golema Reka” grows at the highest altitude (1250 – 1350 m), compared to other Reserves, at the transition of montane beech belt into subalpine beech belt. It shows a high degree of productivity, i.e. its increment percentage is 1.8. Simultaneously, this stand is the best user of site conditions, and it attains excellent values of wood volume and volume increment. Also, in the case of the Reserve “Golema Reka”, based on the values of structural elements, it can be concluded that this is the optimal phase of stand development, and it is probably the youngest stand in comparison with other Reserve stands.

The first place by productivity and potential

is occupied by beech virgin forest Reserve “Danilovakosa”, with the average wood volume of 729 m³/ha, followed by the Reserve Vinatovača with average wood volume of 709 m³/ha and Reserve “Kukavica” with 689 m³/ha average wood volume. The values of average volume increment in the above Reserves range from 10.3 to 12.3 m³/ha, which confirms their total high productivity, and significant biological stability.

One should bear in mind that in the analysis of Reserve “Vinatovača” and Reserve “Kukavica” only reduced area which comprised the most homogeneous representative part was included. In case of Reserve “Vinatovača” that area was 27.60 ha (compartment 50/a) out of total area (37.43 ha). Representa-

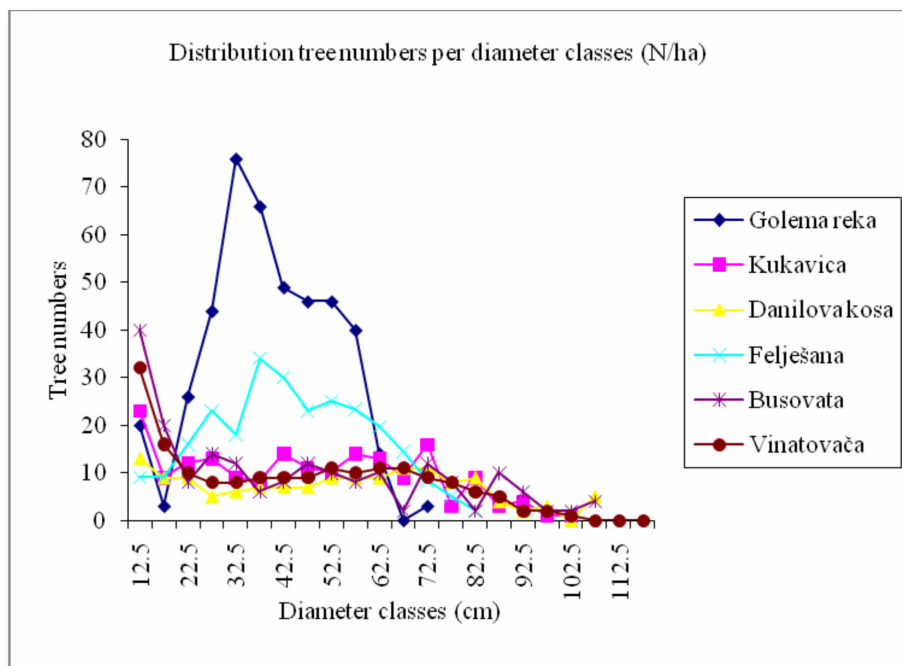


Fig. 1. Distribution of tree numbers per diameter classes in the Reserves

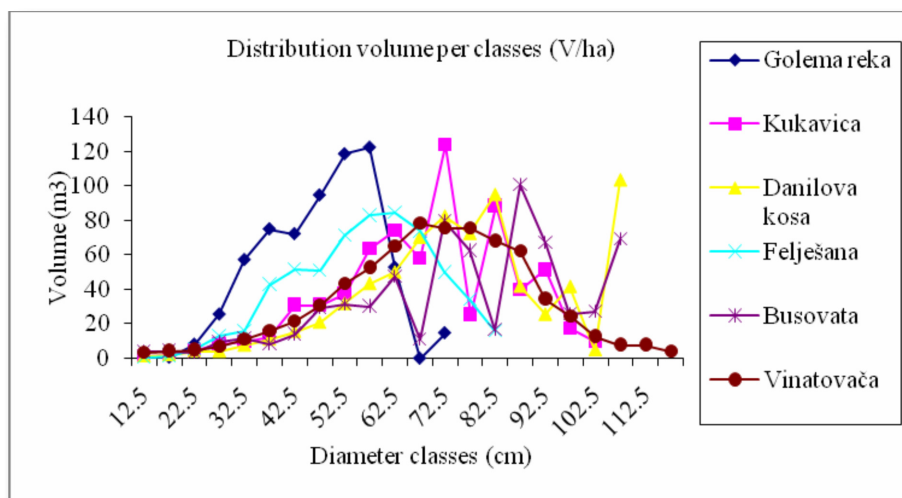


Fig. 2. Volume distribution per diameter classes in the Reserves

tive area in Reserve "Kukavica" was 31.95 ha (compartment 27/a) out of total area (75.76 ha).

Pure beech forests in all six Reserves also have exceptional values of average volume increment. This is the case of the best quality virgin beech forests in Serbia, if we compare the obtained values with the average wood volume of high beech forests in Serbia, which amounts to 217 m³/ha, and the average volume increment amounting to 4.5 m³/ha (Medarević et al. 2003).

Interesting results regarding beech virgin forests were provided by the analysis of the distribution of the number of trees and volume per diameter classes.

The study Reserves, based on present state and appearance throughout a greater part of the area and based on the tree age of about 260 years, are in the terminal stage of development. According to Mlinshek (1968), this stage consists of two sub-stages (stage of aging and stage of decomposition). In some parts, there are signs of decomposition of individual old trees followed by the occurrence of initial stages with abundant regeneration. The prevalent stages in the study stands are the stage of aging and the stage of regeneration.

The distribution of tree numbers per diameter classes (Fig. 1) in beech virgin forests in Serbia under strict protection regime lasting for more than 50 years shows the structure characteristic of all-aged forests, with several maxima and a percentage of decrease towards the stronger diameter classes. The occurrence of a greater number of poorly expressed maxima, indicates that this is the case of the stands consisting of tree groups of different ages, which is the consequence and the characteristics of virgin, reserve, intact (without management treatments) areas, as in this case. The distribution line of the Reserve Golema Reka shows some deviations from the structure characteristic of all-aged forests. The occurrence of a strongly expressed maximum in the 32.5cm class, and then the sharp decrease towards the stronger diameter classes confirms the character which is close to an even-aged stand.

The distribution of stand volume per diameter classes (Fig. 2) also shows the distribution with several maxima, pointing to the all-agedness. In this distribution, the carriers of volume are the medium strong and strong stems, while the percentage of tree volume of thinner diameter classes is individual and relatively neglectful.

The analysed distributions indicate that the resulting changes in diameter structure and volume distribution per diameter classes are simultaneously the consequences of stand aging and the appearance of the regeneration.

In the reserve stands, after 50 years of the implementation of strict regime of protection and spontaneous natural regeneration, the accumulation

of wood volume resulted in the stages of aging and stagnation, i.e. in decomposition of the study stands, which conditions a gradual degradation of individual (largest-diameter) trees of considerable sizes and the formation of initial gaps in their place. By all means, this recruitment process depends also on other factors, primarily on the quantity of light reaching the ground and on the yield of beech nuts.

Conclusions

Based on the detailed processed data of 6 beech virgin Strict Nature Reserves, it can be concluded as follows:

- In Serbia, there are 11 beech Reserves, but in this paper present characteristic of 6 virgin reserves by which pure stands of montane beech forests (*Fagetum moesiacae montanum*) are protected. This is a relatively high number which confirms the fact that beech is the principal tree species of our growing stock.
- All protected beech reserves have been conserved thanks to forestry professionals who proposed their protection.
- The greatest number of the Reserves exist and are designated in the Serbian beech region, where the largest conserved areas of beech forests are located.
- Beech virgin forests most often occur and survive at places where parent rock consists of acid rocks and limestones. Namely, they occur at places of contact of acid rocks and limestones, which enables the leaching of limestones and leads to the formation of deep soils of favourable physical and chemical properties.
- Geological basis of the beech virgin forests mostly consists contact area of schists and carbonated sediments. After analyses of many virgin stands in Serbia, it is recognized that carbonates are usually in hypsometric upper part of it, and silicate, that are represented by schists and phillites, in lower part. We may conclude that surface flow of precipitations by acidity of silicate basement.
- After the 50-year long implementation of protection, beech virgin forests are in different stages of development, from the initial to the terminal stage, with the age of dominant trees about 260 years.
- In the most homogeneous parts of the Reserves, the stands belong to the terminal stage of development.
- Based on the analysis of taxation elements within 6 Reserves, represented at individual levels of each investigat-

ed strict Nature Reserve, it can be concluded as follows: the smallest number of trees of 143 trees/ha was found in the Reserve "Danilova kosa", and the lowest average wood volume of 595 m³/ha was found in the Reserve named "Felješana". On the contrary, the highest number of trees - 433 trees/ha, was found in the Reserve "Golema reka", while the highest wood volume of 729 m³/ha was measured in the Reserve "Danilova kosa".

- The highest volume increment was calculated in the Reserves "Vinatovača" (12.3 m³/ha) and "Danilova kosa" (11.6 m³/ha), and the lowest productivity was assessed in "Felješana" with 5.4 m³/ha.
- The attained volume and volume increment values, per individual Reserves point to some biological properties, and therefore they show which maxima can be attained by beech as tree species in this region.
- The values of volume and volume increment, as the main indicators of productivity, per individual Reserves are up to three times higher than the average volume in beech forests in Serbia, which is 217 m³/ha and 4.55 m³/ha, respectively.

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Summary

Beech is a dominant forest tree species which forms pure and mixed stands, creates the highest wood volume and occupies almost a half of the forest-covered area in Serbian forests. In Serbia, in addition to Balkan beech *Fagus moesiaca* (Domin, Maly) Czeczott, as the most widely distributed species, the genus *Fagus* also includes European beech (*Fagus sylvatica*) and eastern beech (*Fagus orientalis*). Protection of forests, as a part of nature protection, cannot be imagined without the protection of the most significant factor of Serbian forests – beech. Today, in the protection system in Serbia, Strict Nature Reserves mainly represent and include the specific forest systems, in which the forest ecosystem dynamics can be studied and the obtained results can be applied in the same or structurally close forest ecosystems. This paper presents the analysis of 6 Reserves, which are represented by typical pure beech virgin Reserves: Danilova Kosa, Felješana, Kukavica, Vinatovača, Golema Reka and Busovata. The above Reserves are the most valuable beech virgin forests, not only in Serbia, but also in a wider area of the region.

The analysis of indicators of internal structure in all six virgin beech Reserves shows the increase of biodiversity at the ecosystem, species and genetic levels.

The common characteristic of all beech virgin forests is that parent rock is composed of acid rocks (schists, phyllites, etc.) and limestones. Namely, the forests grow at places where acid rocks and limestones are in contact, which enables the leaching of limestones and leads to the formation of deep soils of favourable physical and chemical properties. Geological basis of the beech virgin forests mostly consists contact area of schists and carbonated sediments. After analyses of many virgin stands in Serbia, it is recognized that carbonates are usually in hypsometric upper part of it, and silicate, that are represented by schists and phyllites, in lower part. We may conclude that surface flow of precipitations by acidity of silicate basement.

Based on the present state of the Reserves, which is the result of 50-year-long spontaneous process of natural regeneration, the stands in the greatest part of the area are about 260 years old and they belong to the terminal stage of virgin forest development. Total life cycle of virgin forests is estimated to about 350-400 years. The stands are defined as high stands, close to all-aged/even-aged beech forests in which the tree distribution per diameter classes ranges from 12.5 to 117.5 cm.

Based on the analysis of taxation elements in all 6 Reserves, we can conclude as follows:

The smallest number of trees of 143 trees/ha was found in the Reserve "Danilova kosa". On the contrary, the highest number of trees - 433 trees/ha, was found in the Reserve "Golema reka". The highest wood volume of 729 m³/ha was measured in the Reserve "Danilova kosa", and the lowest average wood volume of 595 m³/ha was found in the Reserve named "Feljeshana". The highest volume increment was calculated in the Reserves "Vinatovača" (12.3 m³/ha) and "Danilova Kosa" (11.7 m³/ha), and the lowest productivity was assessed in "Felješana" with 5.4 m³/ha.

The tree distribution per diameter classes shows the structure close to uneven-aged, with several maxima, i.e. several age groups of trees, and the structure close to even-aged, which is characterised by a bell-shaped curve, with one expressed maximum.