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STRUCTURAL CHARACTERISTICS OF TREES OBTAINED THROUGH THE TRANSFORMATION OF SILVOPASTORAL SYSTEMS

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Abstract

The stands resulting from the transformation of silvopastoral systems present a series of specific structural, qualitative and synthesis characteristics. The structure of these stands is influenced by the species, their regeneration method and the time in which the massif state was achieved. The case study was carried out within the Codrii Cămării Forest District in Dobreşti, Bihor County, and has as its objectives the silvotechnical analysis and diagnosis of the stand formed by the transformation of a silvopastoral system. From the analysis of the horizontal, vertical and three-dimensional profiles made on the experimental samples in the studied stand, a series of differences are found between the base diameter, the base area, the total height, the pruned height and the crown diameter, for the analyzed trees. In some portions of the stand, the consistency index k varies in the range of 0.6 - 0.8, an aspect that negatively influences its growth and development process. Consequently, for the sustainable management of these stands with a specific structure, a series of works related to both mixed regenerations and young stands are necessary.

Key words: *silvopastoral system, transformation, stand, structural characteristics, silvotechnical interventions, sustainable management.*

INTRODUCTION

Within forest ecosystems, the forest phyto-cenosis, through the tree canopy, respectively the stand, builds their specificity. Currently, the forest can be defined in several ways, but the structural and functional characteristics are those that determine its specificity.

As a result, individual (isolated) trees and respectively tree biogroups are the defining elements of the forest phytocenosis and implicitly of the forest. Its interrelations with the forest zoocenosis and the elements of the forest site determine the establishment of a complex and unitary community of life, characterized by its own, specific environment. In this context, the forest offers forest products, services, and is characterized by a high mediogenic capacity (Crainic & Tăut, 2008; Cubbage, 2012; Nicolescu, 2009).

The expansion of forest areas, regardless of the owner and administrator, represents one of the strategies of national and international forestry policies (Abrudan et al., 2003).

The transformation of agrosilvopastoral systems into forest ecosystems represents a possibility for increasing (expanding) the national forest fund (Crainic et al., 2023). In this context, the areas occupied by individual trees and respectively by tree biogroups are included in the future stand, which will have a characteristic structure.

The woody vegetation on areas proposed for inclusion in the forest fund must be composed of tree species characteristic of the region's fundamental natural forest type and must exhibit a density index (k) greater than 0.4. Furthermore, the landowner is required to formally initiate the reclassification of the plot's land use to forestry, based on a technical-economic project specifically developed for this purpose.Individual trees exhibit a specific form, generally referred to as habitus, while trees within a closed stand are characterized by a forest (stand) form. (Crainic, 2024; Florescu & Nicolescu, 1996). Trees that grow in biogroups on the surface of agrosilvopastoral systems present an intermediate form, between the two forms presented previously. As a result, the structural elements of the future stand and implicitly its structure will have specific cha-racteristics in this case.The structural characteristics of stands can be highlighted in the horizontal plane and in the vertical plane. Those in the horizontal plane are represented by: composition, consistency, number of trees, average diameter, base area. In the vertical plane, the characteristics of stands are represented by: stratification, profile, closure and average height.

The qualitative characteristics are represented by: the origin and provenance of the stands, the production class, the quality, the age, the state of vegetation and the phytosanitary or health status.

A series of stand characteristics can be synthetically expressed through a series of indices, as follows: density and stocking indices, slenderness coefficient $Z_{\%}$ and spacing index $S_{\%}$ (Florescu & Nicolescu, 1996; Crainic et al., 2024) and provide important indications in the silvotechnical analysis and diagnosis process (Crainic et al., 2024; Crainic & Tăut, 2008; Nicolescu, 1995). The mathematical expressions related to these are presented in formulae 1-10.

$$I_N = \frac{N_{teren}}{N_{tabel}} \quad (1)$$

$$I_G = \frac{G_{teren}}{G_{tabel}} \quad (2)$$

$$I_v = \frac{V_{teren}}{V_{tabel}} \quad (3)$$

$$Z_{(\%)} = \frac{h}{d} \quad (4)$$

$$S_{(\%)} = \frac{a}{h_{dom}} \times 100 \quad (5)$$

$$S_{4(\%)} = \frac{a_4}{h_{dom}} \times 100 \quad (6)$$

$$S_{6(\%)} = \frac{a_6}{h_{dom}} \times 100 \quad (7)$$

$$h_{dom} = h + 0.15h = 1.15h \quad (8)$$

$$a_4 = \sqrt{\frac{10000}{N}} \quad (9)$$

$$a_6 = \sqrt{\frac{10000}{N\sqrt{\frac{3}{2}}}} \quad (10)$$

The meaning of the terms in formulae 1-10 is as follows: IN-density index determined based on the number of trees; I_G-density index determined based on the base area; I_V-density index determined based on the volume; N_{land}-number of trees per hectare, determined experimentally; G_{land}-base area per hectare, determined experimentally; V_{land}-volume per hectare, determined experimentally; N_{table}, G_{table}, V_{land}, theoretical values of the number of trees, area and volume, from the general production tables, for the same species, production class and age; $Z_{(\%)}$-slenderness coefficient of the stand; h-average height of the stand; d-average diameter of the stand; $S_{(\%)}$-Hart-Beking spacing index; hdom-dominant height of the stand; a-theoretical distance between trees;

S_4-spacing index related to the square disposal, a_4-theoretical distance between the trees when they are arranged in a square disposal; S_4-spacing index related to the quincunx disposal; a_6-theoretical distance between the trees when they are arranged in a quincunx device.

Also, the composition of the stands can be determined based on: the number of trees per hectare C_{pzN}; the base area per hectare C_{pzG} and the volume per hectare C_{pzV}.

Consequently, the structural and qualitative indicators related to a stand obtained through the transformation of an agrosilvopastoral system, provide a series of information regarding its structure and stability, as well as the complex of forest management practices that are necessary for sustainable management in the future (Crainic & Stamate 2009; Nair, 1993).

MATERIALS AND METHODS

The case study was carried out in Forest Compartment 60 of the forest fund of Dobreşti Commune, Bihor County. The respective forest fund is managed by the Codrii Cămării Forest District, within the Production Unit (P.U.) I Dobreşti - Figure 1.

The stand under study originated from the transformation and incorporation of an agrosilvopastoral system previously managed by the Dobreşti municipality into the communal forest fund. The research conducted in the case study is related to an ongoing doctoral study, which is being carried out in this location.

The objectives of the case study are represented by:

- analysis of the characteristics of the stand in Forest Compartment 60, which was formed by the transformation and introduction of an agrosilvopastoral system in the forest fund, during the period 2013-2024;
- establishment of the forest management practices necessary for the sustainable management of this stand.

The research methods used are represented by (Crainic et al., 2023): bibliographic documenttation, experiment, observation on the itinerary and stationary, statistical-mathematical inventtory, simulation, analysis, comparison and recording on digital photographic support.

Through bibliographic documentation, complex information was obtained regarding:
- structural and functional particularities related to agrosilvopastoral systems;

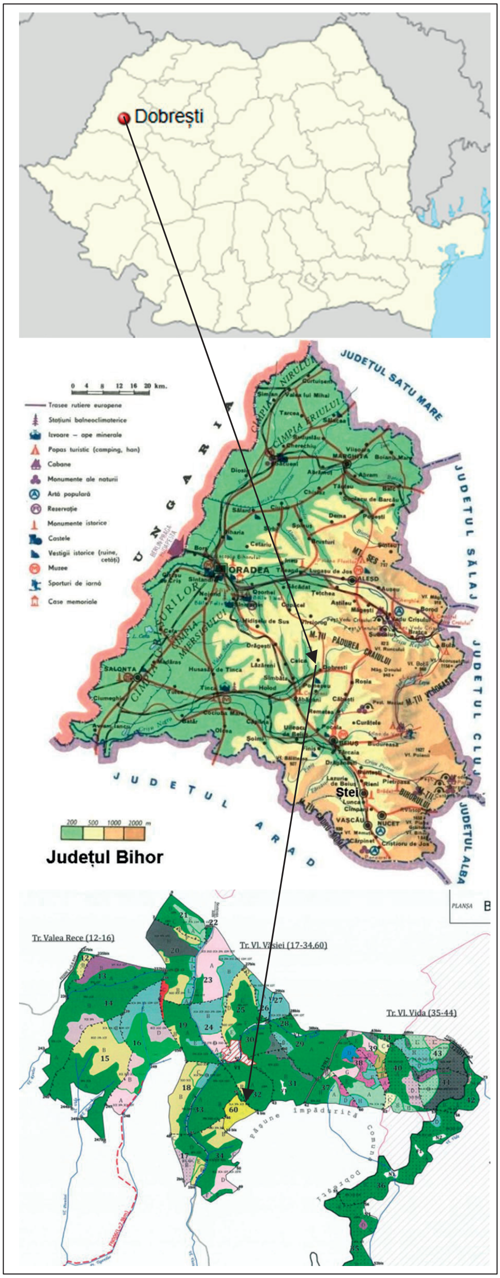


Figure 1. Research location (https://ro.wikipedia.org/wiki/Dobre%C8%99ti,_Bihor, https://pe-harta.ro/bihor/, Harta amenjistică a U.P. I Dobrești, 2018)

- specificities of the transformation and introduction of agrosilvopastoral systems into the national forest fund;
-structural characteristics related to the stands in the national forest fund;
- the complex of forest management practices necessary for the management of stands obtained through the transformation of agrosilvopastoral systems.

The experiment involved making observations, conducting a statistical and mathematical inventory, simulating the stand structure, and performing silvotechnical analysis and diagnosis.

Through observations, a current and pertinent analysis of the objective reality in the field, in the study area, was carried out. As a result, observations were made on the itinerary and respectively stationary, at certain fixed points, representative for the research carried out. On these occasions, the dynamics of the growth and development process of the established forest vegetation, as well as its health condition, were analyzed.

The statistical and mathematical inventories were carried out on experimental plots, randomly placed on the surface of compartment 60.

The specific elements of the experimental plots were established in accordance with the Biometrics of Trees and Stands in Romania (Giurgiu et al., 1972) and the Forest management plan in force, and are represented by:
- area of the statistical population - of the plot, S = 7.6 ha;
- class of homogeneity of the stand;
- variation coefficient of the volume;
- age of the stand T = 15-20 years;
- shape of the sample areas - circle;
- size of the experimental areas $S_i = 300\ m^2$;
- tolerance t = 10%;
- coverage probability p = 90%;
- number of experimental plots n = 14;
- distance between the centers of the experimental plots d = 54 m.

The 14 experimental surfaces, circular in shape, of established surface and radius, were placed with their centers in the corners of a square-shaped geometric grid (which was superimposed over the surface of plot 60), with the side equal to the distance d = 54 m, which was determined according to the methodology presented previously.

As a result, the following stages were completed in the statistical-mathematical inventory process:
- location of experimental areas on the field and materialization of their center;
- identification of the species,
- measurement of the basic diameter ($d_{1.30}$) at a height of 1.30 m from the plot;
- establishment of the quality class;
- establishment of the vegetation state;
- establishing the phytosanitary status.

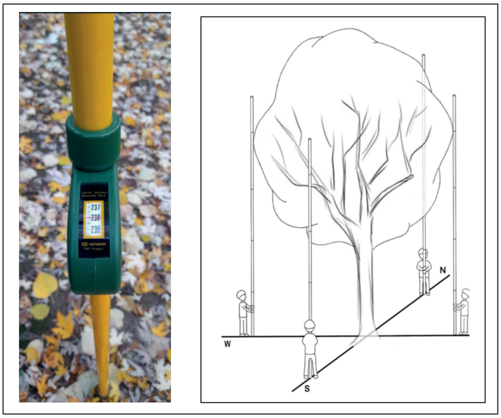
These data were recorded in field sheets, for each experimental area separately.

To simulate the spatial structure of the stand, inventories were carried out on rectangular experimental areas, 20 m long and 15 m wide, in its representative areas. As a result, two experimental plots of 300 m^2 were located, one area located in the area where the biogroups of naturally regenerated trees from seed were promoted, and the other in the area where forest vegetation was artificially installed through plantations. The inventory of each tree in the experimental sample area involved the following operations:
- determination of the planimetric position in a local rectangular coordinate system;
- the diameter of the crowns was measured in two perpendicular directions;
- measurement of the total height and the height to the base of the crown, respectively;
- identification of the species.

These data were recorded in a specific field sheet, in which the total number of trees, length L and width l of the experimental plot, and respectively the average slope angle of the land, were mentioned in the corresponding columns. Subsequently, the data entered in this form were implemented in an Excel spreadsheet file, and their processing was carried out with the PROARB 2.0 program (Popa, 1999; Crainic et. al., 2024). The height of the trees was measured using a telescopic rod, graduated in centimeters, which ensured high accuracy (Figure 2 a).

The crown diameter of the trees was determined along two perpendicular directions, after marking on the ground the extreme points of the crown's circumference in those directions (Figure 2 b).

The following materials were used to carry out the research:
- forest management of the production unit I Dobreşti and the related management map;
- tree caliper for measuring the basic diameter $d_{1.30}$ of the inventoried trees;
- telescopic rod for determining the heights of the inventoried trees, up to 8 meters;
- dendrometer for measuring heights greater than 8 meters;
- PROARB 2.0 program for simulating the projections of the stand in the analyzed samples;
- Excel program for data processing and results explanation;
- MapSys11 digital cartography program, for locating and placing the experimental plots on the forest map.



a. Telescopic rod measurement   b. Crown diameter

Figure 2. Aspects related to measuring the diameter of tree crowns, in two directions, with the telescopic rod (Crainic et al., 2024)

The experimental results obtained for the species in the inventoried stand were analyzed and compared with the theoretical values in the production tables, for the same species, production classes and ages.

Research, studies and observations at the aforementioned location began in the spring of 2013, and have been ongoing to this day.

RESULTS AND DISCUSSIONS

From the analysis and study of the description of the forest site and the vegetation related to compartment 60, presented in the forestry management related to P.U. I Dobreşti, and the observations made in the field, a series of important data were obtained, which are presented below.

As a result, the characteristics of the vegetation conditions and the stands in compartment 60 are represented by:
- area of the stand: 7.6 ha;
- typical luvic brown soil (2401);
- type of station: Phytoclimatic level of oak forests in the hilly area, with medium site quality, on luvisols with medium edaphic volume, and indicator flora consisting of grasses (5132);
- type of forest: Coastal sessile oak forest with *Gramineae* and *Luzula luzuloides*, of medium productivity (5131);
- land form: undulating slope;
- exposition: South-West;
- slope of the land: 22 g;
- altitude: 350-440 m;
- litter: continuous and thin layer;
- indicator flora: *Glecoma hirsuta - Geum urbanum;*
- forest type: natural fundamental of medium productivity, relatively even;
- current composition: the composition identified during the preparation of the forest management plan: 3Ce3Fa3La1Dt;
- target composition: 7Ce3Ca;
- exploitation age: 60 years;
- production class: III;
- vitality: normal;
- consistency: k = 0.7;
- growth: i_v = 1.2 m^3/ha/year.

After processing the recorded data related to the statistical-mathematical inventories, the total number of trees by species and diameter categories was obtained, for the cumulative area of the 14 experimental plots, respectively 0.42 ha. Subsequently, these results were extrapolated to the hectare (tables 1-8), in order to be able to compare them with the corresponding theoretical values from the production tables (Giurgiu et al., 1972).

Table 1. Number of trees registered on the experimental plots, and per hectare, for the *Quercus cerris* species

Crt. No.	D (cm)	Number of trees	
		pieces/0.42 ha	pieces/1.00 ha
1	4	64	152
2	6	113	269
3	8	117	279
4	10	77	184
5	12	54	128
6	14	43	102
7	16	17	41
8	18	13	32
9	20	9	21
10	22	5	13
11	**Total**	**513**	**1221**

Table 2. Number of trees registered on the experimental plots, for the *Larix decidua* species (La)

Crt. No.	D (cm)	Number of trees	
		pieces/0.42 ha	pieces/1.00 ha
1	4	8	18
2	6	16	39
3	8	12	29
4	10	6	15
5	**Total**	**42**	**101**

Table 3. Number of trees registered on the experimental plots, and per hectare, for the *Carpinus betulus* (Ca) species

Crt. No.	D(cm)	Number of trees	
		pieces/0.42 ha	pieces/1.00 ha
1	4	16	39
2	6	30	71
3	8	33	79
4	10	25	59
5	12	8	20
6	14	7	17
7	16	7	16
8	18	6	15
9	**Total**	**133**	**316**

Table 4. Number of trees registered on experimental areas, and per hectare, for the species *Fagus sylvatica*

Crt. No.	D (cm)	Number of trees	
		pieces/0.42 ha	pieces/1.00 ha
1	4	3	7
2	6	9	22
3	8	5	11
4	**Total**	**17**	**40**

Table 5. Number of trees registered on the experimental plots, for the *Quercus petraea* (Go) species

Crt. No.	D (cm)	Number of trees	
		pieces/0.42 ha	pieces/1.00 ha
1	4	13	31
2	6	17	41
3	8	22	52
4	10	10	24
5	12	8	19
6	**Total**	**70**	**167**

Table 6. Number of trees infested on the experimental plots, for the *Betula pendula* (Me) species

Crt. No.	D (cm)	Number of trees	
		pieces/0.42 ha	pieces/0.42 ha
1	4	5	11
2	6	17	40
3	8	20	47
4	10	15	35
5	12	9	21
6	14	7	17
7	**Total**	**72**	**171**

Table 7. Number of trees registered on the experimental plots, for the *Populus tremula* (Plt) species

Crt. No.	D(cm)	Number of trees	
		pieces/0.42 ha	pieces/0.42 ha
1	4	6	15
2	6	9	22
3	8	8	18
4	10	7	16
5	**Total**	**30**	**71**

The biogroups with turkey oak trees, which have regenerated naturally, are characterized by growth dynamics and active development, displaying lateral branches on the trunk at heights of 1.3-1.5 m (Figure 3).

Figure 3. Biogroup of trees of the Turkey oak species in the stand in compartment 60

From the analysis of the image in Figure 4, it can be seen that the biogroup formed by trees of the beech, hornbeam and larch species is relatively spaced, with shrub and subshrub vegetation also present between them.
From the field analysis conducted during the observations, it was found that the biogroup formed by trees of beech, sessile oak, and larch is spaced at a distance of approximately 4 meters, with shrub and subshrub vegetation present in the space between them, as shown in the image in Figure 4.

Figure 4. Biogroup of trees of larch, beech and hornbeam species in the stand in compartment 60

Specimens of hornbeam have naturally regenerated from seed and have established themselves in areas where the seedlings that were planted have dried out or were destroyed (damaged) by hunting species (Figure 5).

Figure 5. Biogroup of hornbeam trees in the stand in compartment 60

Figure 6. Specimens of the *Fagus sylvatica* species, which were planted in compartment 60 in 2013

From the analysis of the images in Figures 3 and 7, it can be seen that in biogroups with trees of the turkey oak and sessile oak species, artificial pruning must be carried out to remove branches from the base of the crown, to form a superior quality trunk (Florescu & Nicolescu, 1998).

Figure 7. Specimens of the *Quercus petraea* species, which were planted in compartment 60 in 2013

Figure 8. Specimens of the species Aspen - *Populus tremula* (Plt), naturally regenerated, in the stand in compartment 60

Also, the distribution of the number of trees by species and diameter categories per hectare was carried out for the stand in compartment 60 (Figure 9). Next, with the values of the number of trees by species and diameter categories, which were determined by extrapolation to the surface unit (ha), the unitary base area -g_i, multiple by diameter categories - $n_i \cdot g_i$, and cumulated per hectare was determined - $G = \Sigma n_i \cdot g_i$, for each species, and cumulated per hectare, for all species, with formulae 11, 12 and 13.

$$g_i = \frac{\pi \times d_i^2}{4} = 0{,}7854 \times d_i^2 \tag{11}$$

$n_i \cdot g_i$ (m^2) (12)

$\Sigma n_i \cdot g_i$ (m^2/ha) (13)

To determine the volume per species and respectively per stand, per hectare, the central diameter corresponding to the base area dgM was determined for each species, with formula 14.

$$d_{gM} = d_M + \frac{C \times \left(\frac{\sum gn}{2} - S_M \right)}{(gn)_M} \tag{14}$$

d_{gM} - central diameter of the base area;
d_M - lower limit of the median interval;
C - size of the interval between diameter categories;
$\Sigma n_i \cdot g_i$ - total (cumulative) base area;
S_M - cumulated base area up to the median interval;
$(gn)_M$ - the multiple base area of the median interval.

In the next step, the average height corresponding to the central diameter of the base surface was calculated - h_{dgM}, as the arithmetic mean of a number of 10-15 heights corresponding to trees with a base diameter $d_{1.30}$ equal to d_{gM} ± a diameter category, the case of the present study ± 2 cm.

The volume was determined by the volume series method, in accordance with the Biometrics of trees and stands in Romania (Giurgiu, Decei & Armăşescu, 1972). The experimental values, related to the base area and volume per species, reported per hectare, are presented synthetically in Tables 9 and 10.

Table 8. Record of the number of trees by diameter and species categories, per hectare, in the compartment 60

Crt. No.	D (cm)	Species (pieces/ha)							**N_{Stand} (pieces/ha)
		*N_{Ce}	N_{Ca}	N_{Fa}	N_{Go}	N_{La}	N_{Plt}	N_{Me}	
1	4	152	39	7	31	18	15	11	**273**
2	6	269	71	22	41	39	22	40	**504**
3	8	279	79	11	52	29	18	47	**515**
4	10	184	59	0	24	15	16	35	**333**
5	12	128	20	0	19	0	0	21	**188**
6	14	102	17	0	0	0	0	17	**136**
7	16	41	16	0	0	0	0	0	**57**
8	18	32	15	0	0	0	0	0	**47**
9	20	21	0	0	0	0	0	0	**21**
10	22	13	0	0	0	0	0	0	**13**
11	**Total**	**1221**	**316**	**40**	**167**	**101**	**71**	**171**	**2087**

*N_{Ce} - Total number of Turkey oak trees (*Quercus ceris*), per hectare.
**N_{Stand} - Total number of trees per hectare.

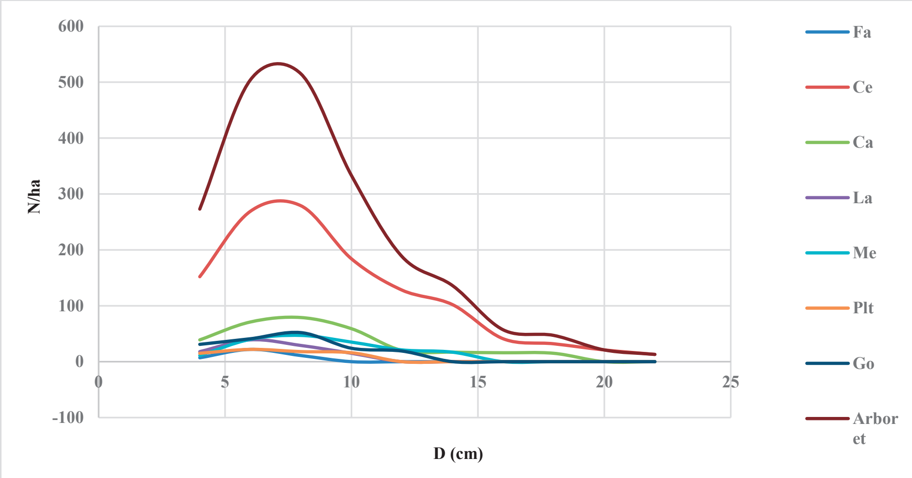


Figure 9. Distribution of the number of trees by diameter categories, per hectare, in the stand in compartment 60

Table 9. Evidence of multiple and cumulative base area, by species and by stand, per hectare, in the stand in compartment 60

Crt. No.	D (cm)	G (m^2./ha)							G_{Stand} (m^2./ha)
		$n_i \times g_{iCe}$	$n_i \times g_{iCa}$	$n_i \times g_{iFa}$	$n_i \times g_{iGo}$	$n_i \times g_{iLa}$	$n_i \times g_{iPlt}$	$n_i \times g_{iMe}$	
1	4	0,191	0,049	0,009	0,039	0,023	0,019	0,014	0,344
2	6	0,761	0,201	0,062	0,116	0,110	0,062	0,113	1,425
3	8	1,402	0,397	0,055	0,261	0,146	0,090	0,236	2,587
4	10	1,445	0,463	0,000	0,188	0,118	0,126	**0,275**	2,615
5	12	1,448	0,226	0,000	0,215	0,000	0,000	0,238	2,127
6	14	1,570	0,262	0,000	0,000	0,000	0,000	0,262	2,094
7	16	0,824	0,322	0,000	0,000	0,000	0,000	0,000	1,146
8	18	0,814	0,382	0,000	0,000	0,000	0,000	0,000	1,196
9	20	0,660	0,000	0,000	0,000	0,000	0,000	0,000	0,66
10	22	0,494	0,000	0,000	0,000	0,000	0,000	0,000	0,494
11	**Total**	***G_{Ce} = 9,610**	**G_{Ca} = 2,302**	**G_{Fa} = 0,126**	**G_{Go} = 0,820**	**G_{La} = 0,396**	**G_{Plt} = 0,297**	**G_{Me} = 1,137**	**G_{Stand} =14,688**

*G_{Ce} - the cumulative base area for the Turkey oak species (*Quercus cerris*).
**G_{Stand} - Cumulative base area of the stand.

Table 10. Volume records by species and by stand, per hectare, in the stand in compartment 60

Crt. No.	D(cm)	V (m^3./ha)							***V_{Stand} (m^3/ha)
		*$n_i \times Vu_{Ce}$	$n_i \times Vu_{Ca}$	$n_i \times Vu_{Fa}$	$n_i \times Vu_{Go}$	$n_i \times Vu_{La}$	$n_i \times Vu_{Plt}$	$n_i \times Vu_{Me}$	
1	6	2.421	0.639	0.154	0.41	0.273	0.198	0.28	4.375
2	8	5.301	1.422	0.165	1.04	0.406	0.324	0.705	9.363
3	10	6.072	1.829	-	0.816	0.36	0.496	0.875	10.448
4	12	6.400	0.96	-	1.007	-	-	0.84	9.207
5	14	7.446	1,173	-	-	-	-	0.969	9.588
6	16	4.059	1.488	-	-	-	-	-	5.547
7	18	4.128	1.800	-	-	-	-	-	5.928
8	20	3.423	-	-	-	-	-	-	3.423
9	22	2.600	-	-	-	-	-	-	2.600
10	**Total**	****V_{Ce}= 41,850**	**V_{Ca} = 9,311**	**V_{Fa} = 0,319**	**V_{Go} =3,273**	**V_{La} =1,039**	**V_{Plt} =1,018**	**V_{Me}=3,669**	**V_{Stand} = 60,479**

*$n_i \times Vu_{Ce}$- Multiple volume per diameter category for the Turkey oak species;
**V_{Ce}- Total volume for the Turkey oak species;
***V_{Stand} - total volume of the stand.

From the analysis of the data presented in Table 8, it is found that the total number of trees per hectare is N_{Crop} = 2087 pieces. Total base area of the stand per hectare G_{Crop} = 14,688 m^2/ha (table 9), and the total volume per hectare V_{Crop} = 60,479 m^3/ha (Table 10).
The composition of the stands was determined based on: the number of trees per hectare Cpz_N; the base area per hectare Cpz_G and the volume per hectare Cpz_V (table 11, figures 10-12). From the analysis of the elements presented in table 11 and in figures 10-12, it is found that it differs significantly, being influenced by the method of determination and respectively by the values of the dendrometric elements used.

Table 11. Evidence of structural characteristics related to the stand in compartment 60

Crt. No.	The values of the structural characteristics indices determined for the stand in compartment 60								
	*Cpz (N)	**Cpz (G)	***Cpz (V)	I_N	I_G	I_V	Z (%)	S_4 (%)	S_6 (%)
1	6Ce2Ca1Go1Me dis Fa La Plt	6Ce2Ca1Go1Me dis Fa La Plt	7Ce1Ca1Me1Go, dis La Plt Fa	0.7	1.2	1.1	67	26	28

*Cpz(N) - Composition depending on the number of trees;
**Cpz(G) - Composition depending on the base surface;
Cpz(V) - Composition by volume.

The Turkey oak, although not artificially regenerated, has the highest share, respectively 70%, the pioneer and secondary mixed species, represented by birch, aspen and hornbeam have a share of 20%, and the species sessile oak, beech, larch, bird cherry and ash, which were artificially introduced through plantations, account for 10% of the current composition of the stand.

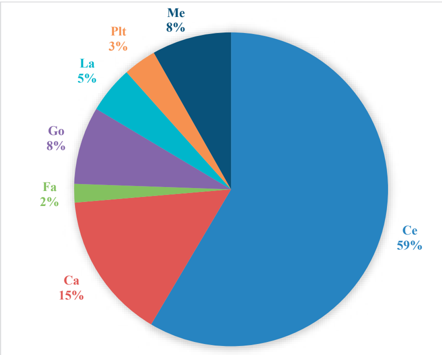


Figure 10. Composition of the stand in compartment 60, depending on the number of trees per hectare

The presence of oak species in a high proportion confirms the current trend of expanding their area in western Romania, an aspect also confirmed by a series of recent research (Pană et al., 2020)

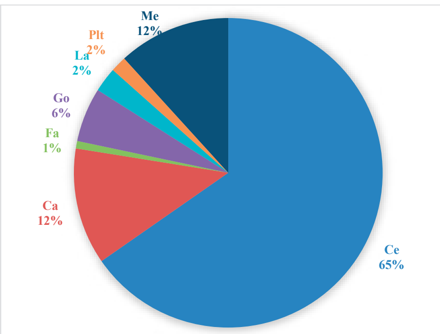


Figure 11. Composition of the stand in compartment 60, depending on the base area per hectare

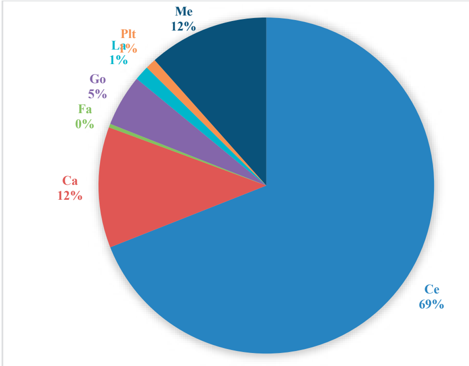


Figure 12. Composition of the stand in compartment 60, depending on the volume per hectare

The Hart-Beking spacing indices determined in the two variants have the values $s_{4\%}$ = 26% and $s_{6\%}$ = 28% (Table 11). Consequently, the stand is optimally spaced, and presents consolidated ecosystem stability.
The stand density index is sub-unit, and the density indices have super-unit values, in the range 1.1-1.2 (Table 11).
The value of the slenderness coefficient $Z_{\%}$ = 67% (Table 11) indicates that the stand is relatively stable to a possible destabilizing action of the prevailing winds, which blow in the studied area.
The complete destruction of biogroups of specimens of the species hornbeam, beech, larch, bird cherry and ash, on a cumulative area of approximately 1.8 ha, by deer and wild boar herds, determined a specific dynamics of the composition of the stand. As a result, grassy and shrubby vegetation has settled on this surface. The identified shrub species are represented by the mountain blackberry - *Rubus fruticosus* L., rosehip - *Rosa canina*, blackthorn - *Prunus spinosa*, hawthorn - *Crataegus monogyna Jacq.*, wild privet - *Ligustrum vulgare* L., dogwood - *Cornus sanguinea*, common spindle - *Eonimus europaeus*, warted spindle - *Euonymus verrucosus Scop.*

Also, a relatively small number of bird cherry, wild apple and wild pear specimens were identified, especially in areas with a lower stand stocking. Consequently, it is necessary to complete it with specific works, in preparation for the artificial installation of regeneration.

The data recorded on the field necessary for simulating the spatial structure of the stand Table 12 were processed with the PROARB 2.0 program, and the models for the stand structure in horizontal and vertical planes (Figures 13 and 16) and 3D perspective (Figures 14 and 15) were obtained for the two experimental plots.

In the parts where the stand has regenerated naturally, its spatial structure presents characteristics specific to the tree biogroups that have been integrated into the stand. As a result, some of the trees of the Turkey oak species present crowns with a large diameter, relatively low height and branches on a large portion of the trunk (Crainic, 2017, Fazal, Geertman & Toppen, 2012). Some of these branches dried up due to the fact that the massif state was achieved, and implicitly the natural pruning process was triggered.

The presence of biogroups of pioneering tree species, common poplar and birch, was found in the areas where the basic species did not naturally settle, which present a very active vegetation state (Dorog & Crainic, 2015).

In the areas where vegetation has been established artificially, by planting bare-rooted seedlings (Crainic et al., 2023) the tree stand has a relatively regular structure. In the areas where the seedlings planted in 2013 were affected, their completion was achieved in the following years, also through plantations. As a result, some differences were noticed between their main dendrometric characteristics, during the inventory and processing of the recorded data. A series of specimens of the larch species were identified, which were torn apart by specimens of the cervid species.

Table 12. Inventory of elements related to the simulation of the spatial structure of the stand in compartment 60, in the area with artificial regeneration

Crt. No.	X (m)	Y (m)	Dc1 (m)	Dc2 (m)	H (m)	He (m)	Species
1	0,5	0,5	3,124	3,552	5,625	2,438	La
2	4,5	0,5	3,142	3,811	5,353	2,951	Go
3	8,5	0,5	3,521	3,716	4,659	2,391	Fa
4	12,5	0,5	3,153	3,088	5,381	2,455	Go
5	15,5	0,5	3,181	3,322	5,526	2,449	La
6	19,4	0,5	3,838	3,771	6,005	2,659	Go
7	0,5	4,5	3,853	3,992	6,383	2,338	Ce
8	4,5	4,5	3,589	3,229	6,21	3,185	Ce
9	8,5	4,5	3,151	3,229	6,181	2,485	Go
10	12,5	4,5	3,165	3,552	5,708	2,779	Go
11	16,5	4,5	3,117	3,772	5,364	3,441	Go
12	19,8	4,5	3,658	3,732	5,449	2,665	Go
13	0,5	8,5	3,151	3,822	5,852	2,554	La
14	4,5	8,5	3,138	3,348	5,287	2,616	La
15	8,5	8,5	3,023	3,322	6,31	4,144	Ca
16	13,5	8,5	3,721	3,844	5,82	3,651	La
17	16,5	8,5	3,156	3,003	5,15	2,564	Fa
18	10,4	8,5	2,858	2,766	5,859	2,576	La
19	0,5	12,5	3,921	2,891	5,294	3,332	La
20	4,5	12,5	2,754	2,438	5,196	3,516	La
21	8,5	12,5	3,821	2,885	5,664	3,85	Ca
22	15,562	12,5	2,933	2,722	5,509	3,43	Fa
23	18,559	12,5	2,858	2,971	5,845	2,609	Fa
24	12,329	12,5	3,033	3,338	5,123	2,443	La
25	19,551	10,007	2,571	2,682	6,122	3,881	Ci

No. of trees
25
Slope
15
Profile length
20
Profile width
15

In the areas where the stand has regenerated naturally, its spatial structure presents characteristics specific to the tree biogroups that have been integrated into the stand (Figure 13).

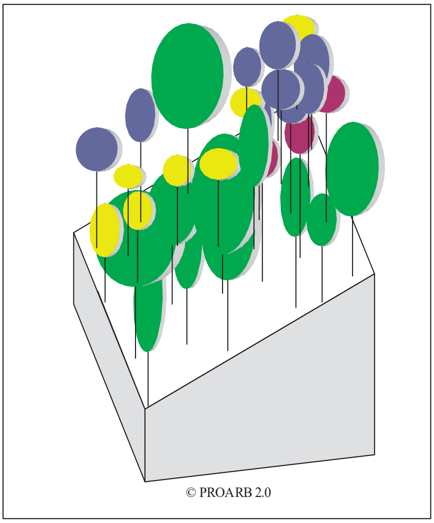


Figure 13. Horizontal and vertical structure of the stand in compartment 60, created with the PROARB 2.0 program, in the area with natural regeneration

In areas where the stand has been artificially regenerated, the stand has a relatively homogeneous spatial structure (Figure 14).

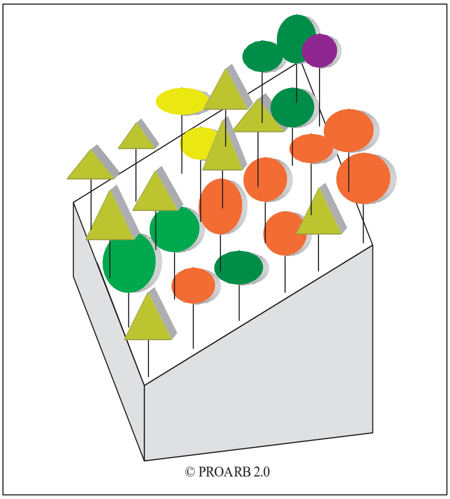


Figure 14. Horizontal and vertical structure of the stand in compartment 60, created with the PROARB 2.0 program, in the area with natural regeneration

The analysis and comparison of the obtained results substantiated (based on experimental and theoretical data) the conclusions regarding the structure and stability of the studied stand, as well as the specifics of the forest management practices necessary for the current phase of development.

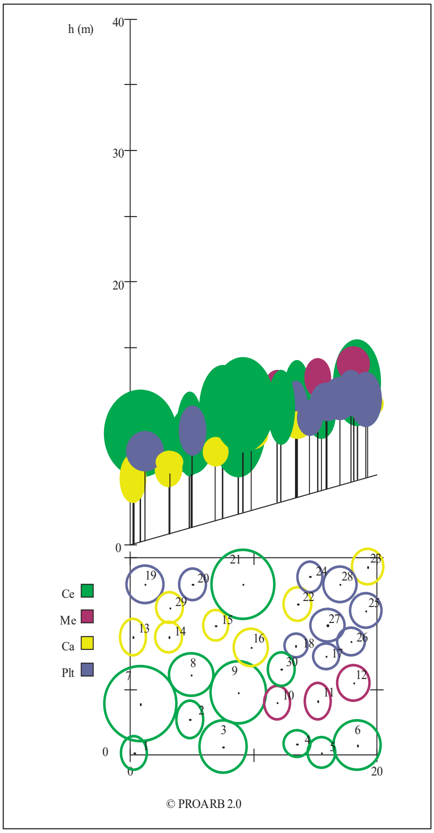


Figure 15. Perspective structure of the arboretum in compartment 60, created with the PROARB 2.0 program, in the area with natural regeneration

CONCLUSIONS

From the analysis of the results obtained by processing experimental data and field observations, it is observed that the stand in compartment 60, which was obtained by transforming an agrosilvopastoral system, presents a series of specific structural features, which are influenced
by the regeneration method and the works carried out over the 12 years.
The age difference between the biogroups of trees that were integrated into the stand and the seedlings that were planted, respectively, determined a series of differences in the homogeneity

of the dendrometric elements, an aspect that favored the outline of a relatively even structure.

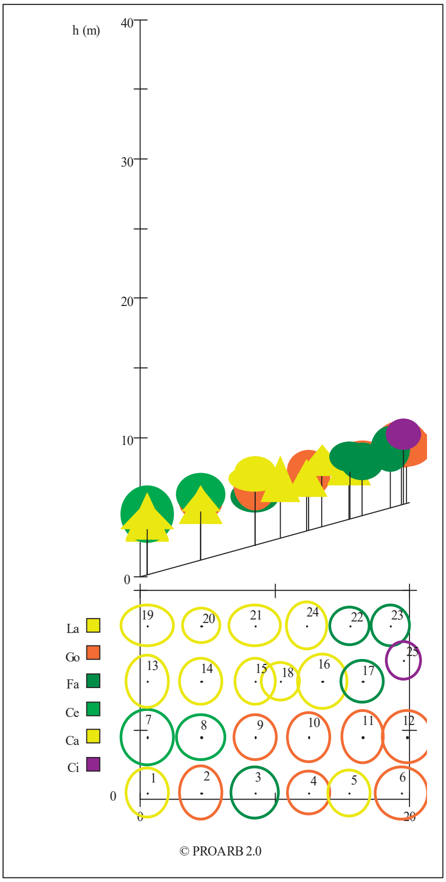


Figure 16. Perspective structure of the stand in compartment 60, created with the PROARB 2.0 program, in the area with artificial regeneration

For the optimal management of the stand in compartment 60, a series of works specific to the development stage and its structural particular-rities are necessary.

Consequently, on the areas where regeneration was destroyed by game animals, it is necessary to install forest vegetation through direct sowing, with acorns from native oak species, and with ash from neighboring beech stands.

The necessary forestry works are represented by clearings, artificial pruning and special hygiene works, to maintain an appropriate phytosanitary condition.

Adopting an exploitable age of 60 years ensures the conditions for promoting a future stable stand, which will build the fundamental natural type of forest through composition and structure.

The fencing of the perimeter of compartment 60 for a certain period of time is necessary to ensure its protection against fauna of hunting interest.

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