Pak. J. Bot., 57(5): 1737-1752, 2025. DOI: http://dx.doi.org/10.30848/PJB2025-5(34)

PHYTOCOENOTIC DIVERSITY AND MORPHOLOGICAL VARIABILITY STUDIES OF BEECH POPULATIONS IN OLTENIA REGION, S-W PART OF ROMANIA

NICULESCU MARIANA[1], IANCU PAULA[1]*, PĂNIȚĂ OVIDIU FLORIN[1] AND NUȚĂ ILIE SILVESTRU[1]

[1]*Department of Agricultural & Forestry Sciences, Faculty of Agronomy, University of Craiova*
**Corresponding author's paula.iancu@edu.ucv.ro*

Abstract

The present experiment was conducted to indicate the variability of some morphological characters of *Fagus sylvatica* depending on location and exposure in Oltenia region, Romania. The adaptation of beech at the edge of the distribution is essential in the context of the current climatic conditions and the species proves to have large ecological plasticity.

The analysis of some morphological characters established that in this region, placed in the interfluve Jiu-Danube rivers, within the arboretum it can be found both the infrataxon *F. sylvatica* ssp. *sylvatica* and *F. sylvatica* ssp. *moesiaca*. The altitude is an important factor in the presence of one or the other of the subspecies within the studied phytocoenoses, we discovered these species beginning to 90 until 1250 meters in stands of the hilly area and also in some stands in the plains area, where their presence was reported. The results highlight the fact that in the researched locations the variability of characters depends on water deficit and exposure, but its tolerance is increasing and further physiological studies will emphasize the compatibility and plasticity of these in response to current climate change.

Key words: Beech populations, Climate change, Distribution range, Forest habitat, Plant communities.

Introduction

Romania enjoys a rarely met diversity in Europe in terms of physical-geographic, floristic and fauna preserved in forest ecosystems with a great degree of naturalness (Giurgiu, 2010). Being at the interference of some large geographical regions, Romania receives different climatic influences: Central European, Iranian-Turanian and sub-Mediterranean-Illyric, which are felt more strongly in the character of the flora and vegetation (Niculescu, 2006).

Forests are one of the main natural resources and are of particular economic, ecological and aesthetic importance, representing an invaluable genetic background for flora and fauna and "a vital source of health benefits". Forest ecosystems contribute to the conservation of the landforms and the environment, playing an extremely important role against soil erosion and landslides.

Many forest formations grow on the territory of our country: spruce, fir, beech and fir mixtures, beech and spruce mixtures, pure beech, hornbeam-beech, sessile oak and beech, sessile oak, hornbeams, oak groves and hornbeams, acacia, willows and poplar and other species (Cojoacă & Niculescu, 2018).

Fagus sylvatica is a type of large tree that frequently exceeds the height of 40 m and the diameter of 1 m. It is a European species, being widespread in the west, center and south of the continent. It is an important forest species in Romania.

According to statistical data from the last years, beech represents 31% of the forest fund, amounting to about 2 million hectares. Thus, regarding the spread of beech in Romania, we can mention the fact that it also occupies large areas in Oltenia.

Oltenia is located in the south-west of Romania and includes all forms of relief, from north to south as follows: the mountainous area, the Sub-Carpathian hills, the Getic Plateau, the plain and the Danube meadows. It has a temperate-continental climate, varying from north to south.

The complexity of the relief determines a climate with a wide variety of shades. Mediterranean influences are felt in the west, winters are cold in the east while in the north, the mountains have a humid climate, with harsh winters on the highest peaks.

The beech forms a sub-area of spreading of its own on the hill and mountain layer, vegetating in the form of pure beech or mixed with other species depending on the eco-pedo-climatic conditions. Under optimal conditions the beech forms lush forests with trees with slender and vigorous stems, often with a special appearance. Physiological and structural variability of beech stands is closely correlated with the variability of ecological conditions and, implicitly, with climate changes in recent years. The altitudinal spread of *Fagus sylvatica* species in Romania is between 300-1400 m (1650 m) in the Bihor Mountains. Often can descend to the hilltop up to 150-200 m, on the northern slopes or along the narrow valleys (Milescu, 1967). Beech requires moderate temperature values and in Romania develops at altitudes between 600 - 1200 m (Șofletea & Curtu, 2007). They also estimated that climatic conditions from lower/higher altitudes (230-1300 meters) can be suboptimal or even restrictive for the beech. On Danube Valley, in Orşova and Moldova Nouă, the beech can be found up to 60 m altitude (Săvulescu, 1972). Insular beech appears in the north of Dobrogea at Luncavița, in the Oltenia Plain (Calopăr-Dâlga, Bucovăț-Craiova (found in the 90s), Stârmina-Drobeta Turnu Severin) and in the Muntenia Plain, at Snagov.

Some authors mentioned large ecological amplitude and can grow at altitudes from 50 m to over 2000 m which means high adaptability of the species and also significant variability.

In Romania, this species exhibits great variability presenting the following two subspecies: *Fagus sylvatica* L. ssp. *sylvatica* and *Fagus sylvatica* L. ssp. *moesiaca*, to which various varieties and forms are added on the basis of morphological characters (Popovic *et al.*, 2021).

Fagus sylvatica ssp. *sylvatica* is differentiated based on morphological characters: leaf, 5-7 cm in length, 4-5 cm wide and 6-8 pairs of nervures (Ciocârlan, 2009).

This infrataxon which was initially considered a geographic race (Domin, 1932) presents a special importance from an economic and scientific point of view due to the superior quality wood.

Fagus sylvatica L. ssp. *moesiaca* has longer leaf (9-12 cm) and wider (5-8 cm) and 8-10 pairs of nervures (Ciocârlan, 2009). In Romania, from geographical areas point of view, there are the following types: *F. s. transsilvanica* (Romania's Carpathians), *F. s. balcanica* (Balkans), *F. s. podolica* (Central Moldavian Plateau). Also, from climate and edaphic point of view, it can be met the next eco-types: Bucovina beech (cold climate), Banat beech (thermophilic climate), Beech from the Apuseni Mountains (thermophilic climate), Dobrogean beech (hot and dry climate), high altitude beech (Vâlcan, Parâng, Godeanu), low altitude beech (Danube Valley, Snagov).

Phytosociological analysis indicate that many Romanian forest communities are edified by *Fagus sylvatica* species: *Pulmonario rubrae-Fagetum* (Soó, 1964; Täuber, 1987) (inclusive *Taxetosum baccatae* (Comes & Tauber, 1977); *Leucanthemo waldsteinii-Fagetum* (Soó, 1964; Täuber 1987); *Symphyto cordati-Fagetum* (Vida, 1963); *Phyllitidi-Fagetum* (Vida, 1963); *Festuco drymeiae-Fagetum* (Morariu *et al*., 1968); *Hieracio rotundati-Fagetum* (Vida, 1963; Täuber 1987) (syn.: *Deschampsio flexuosae-Fagetum* (Soó, 1962); *Carpino-Fagetum* (Paucă, 1941); *Galio schultesii-Fagetum* (Burduja *et al*., 1973; Chifu & Ştefan, 1994); *Lathyro venetus-Fagetum* (Dobrescu & Kovács, 1973; Chifu, 1995); *Carpino-Fagetum cephalantheriosum* (Coldea, 1975); *Epipacti-Fagetum* (Resmeriţă, 1972); *Aremonio agrimonioidi-Fagetum* (Boşcaiu, 1971); *Fago-Ornetum* (Zólyomi, 1954); *Carpino-Fagetum* (Paucă, 1941); *Fagetosum orientalis* (Roman, 1974); *Geranio macrorrhizi-Fagetum* (Borza, 1933; Soó, 1964) and *Corylo colurnae-Fagetum* (Jov. 1955; Borhidi, 1963).

The beech has a special importance in the edification of the following types of natural habitats: *Luzulo-Fagetum* beech forests habitat (9110 Natura 2000 cod and 41.11 Paleartic classification code; *Asperulo-Fagetum* beech forests (9130 Natura 2000 code and 41.13 Paleartic classification code); Medio-European subalpine beech forests with *Acer* and *Rumex arifolius* (9140 Natura 2000 code and 41.15 Paleartic classification code); Medio-European limestone beech forests of the *Cephalanthero-Fagion* (9150 Natura 2000 cod and 41.16 Paleartic classification code); Illyrian *Fagus sylvatica* forests (*Aremonio-Fagion*) (91K0 Natura 2000 code and 41.1C Paleartic classification code); Dacian Beech forests (*Symphyto Fagion*) (91V0 Natura 2000 code and 41.1D2 Paleartic classification code); Dobrogean beech forests (91X0* Natura 2000 code and 41.1F Paleartic classification code).

Beech is playing a vital role in maintaining biodiversity. It provides shelter and food for a wide variety of animals and insect species and high-quality wood.

This study objective was to identify and analyze the distribution inside and outside its area of growth limit, presenting the variability of some morphological characters in relation to exposure and environmental conditions.

Material and Methods

Description of the study area: The analyzed areas are located in Oltenia region, part of the South-Western Romania, in interfluve Jiu-Danube, in the stands of hilly and plains areas, where the presence of beech was reported outside its area.

From the point of view of the state of protection, the studied forest plant communities are located in the protected areas:

1. ROSAC0045 Jiu Corridor
2. ROSAC0129 North of the Western Gorj
3. Iron Gates Natural Park

The studies were carried out in forest habitats located in the basins of some of the important rivers in Oltenia: Jiu, Sohodol, Vodiţa, Cerna and the Danube river.

From geographical point of view, the studies also include geomorphological formations: Oltenia Plain, Mehedinţi Plateau, Oltenia Subcarpathian, Cernei Mountains and Vulcan Mountains.

From an administrative point of view, the studied territory falls within the counties of Dolj, Gorj and Mehedinţi.

The researches were carried out both on slopes, inclination and different exposure. For the Vodiţa and Sohodol Forest (which also includes the Arcani Forest), specific evaluations were carried out in two research areas: southern and northern exposure (Table 1).

Data collection: To identify the taxa and infrataxa it was analyzed Romanian Flora (Săvulescu, 1972), Flora Europaea (Tutin *et al*., 1968) and Flora Alpina (Aeschiman *et al*., 2004).

The analyze of the vegetal carpet in the researched territory it was used methods of research characteristic of Central European phyto-sociological School and on the principles of Braun-Blanquet (1931).

The data were collected from 6 experimental areas with a size of 400 m^2 (40 x 100 m), installed in comparable stands in terms of vegetation conditions, structural and physiognomic features.

Table 1. Location of research areas.

Forest	Exp.	Coordinates		Altitude (m)	Annual average temperature (°C)	Annual average precipitation (mm)	Climate type
		Latitude	Longitude				
Vodiţa 1	N	44.711708	22.529989	300	8-10.5^0	760	Sub-Mediterranean
Vodiţa 2	S	44.712015	22.529665	400			
Sohodol	N	45.172440	23.040388	1050	10-12.5^0	951	Humid tropical
Arcani	S	45.180794	23.043871	1250			
Dâlga	E	44.166670	23.766670	125	9.1-10.8^0	518	Humid subtropical
Racoviţa	Plane	44.542198	23.379636	90	10-11^0	486	Temperate

Plant communities were identified according to the characteristic, edifying, dominant and differential species.

Their identification and coenotaxonomic classification was made using synthesis works of Coldea, 1991; Sanda *et al*., 1997 as well as Oberdorfer, 1992, Mucina *et al*., 1993 and Rodwell, 2002.

Statistical analysis of the floristic abundance of plant communities in which the studied species were found, was made using Syn-Tax 2000 statistic program giving a special attention to the calculation of the Sørensen index, by Group-Average method (WPGMA) and the achievement of dendrograms (Podani, 2001).

In addition to the data from the field, the plot descriptions found in the updated Forestry Management of the studied areas were also used for data processing.

Six forest subplots were analyzed as follows:

- Dâlga forest within the Segarcea Forest, production unit V, Dâlga, landscaping unit (subplot) 77C;
- Sohodol and Arcani forests within the Runcu Forest, Gorj county, production unit III, Bîlta, development unit (subplot) 35A (45.180794 - 23.043871) and production unit 4 Plescioara, development unit (subplot) 32A;
- Racovița Forest, within the Filiași Forest, production unit II Argetoaia, landscaping unit (subplot) 105 E;
- Vodița 1 and Vodița 2 Forest, Turnu Severin, production unit IV Vodița, landscaping unit (subplot - Vodița 1) 74 B and landscaping unit (subplot - Vodița 2) 74 D.

Variability analysis of ssp. *Fagus sylvatica* characters was made based on observations and determinations in 50 trees as concern height and diameter of stem, length, width and number of nervures of the leaves.

Statistical procedures: Obtained data were statistically calculated using IBM SPSS software and analysis of variance (ANOVA).

The significance of the differences was estimated with the LSD multiple comparison test at the $p \leq 0.05$ level.

The significance of differences between means was presented on letter basis, with significant differences between means marked with different letters (a, b, c - for population × exposure). It was also calculated correlation coefficients between characters and their significance by Pearson values.

The principal component analysis method explained by Hartmann & Jahn, 1967 was followed in the extraction of the components.

The percentage variability explained by each component were determined (Hartmann & Jahn, 1967; Sharma, 1996; Tadesse & Bekele, 2001).

Correlation and principal component analysis as well as bi-plot graphical display were performed.

Results

Following field research carried out in recent years in the Oltenia region, part of the South-Western Romania, in interfluve Jiu-Danube we found the beech often descends to altitudes between 90 and 1250 m, in these locations meeting in the form of well-closed phytocoenoses, climes, or as isolated individuals, in the area of oak forests.

Description of the sample areas from the phytocoenotic point of view Dâlga Forest: The dominant and edifying forest species are: *Quercus cerris* (50%), *Q. frainetto* (30%), *Fagus sylvatica* ssp. *moesiaca* (10%), other diverse hardwood species (10%), falling in terms of silvicultural in the forest type – Turkey oak - Hungarian oak of silvosteppe (Fig. 1). The sample area analyzed is characterized by: eastern exposure, undulating slope, slope 30%, 125 m altitude, terrain with weak slope, regeneration is natural, the vitality of this stand is normal, soil type luvosol albic-lithic. As for the age structure of the stand, it has the following components: *Quercus cerris*, 80-120 years; *Q. frainetto* 80-120 years; *F. sylvatica* ssp. *moesiaca*, 120 years; other various hardwood species - 120 years. It should be noted that *Ruscus aculeatus*, a Natura 2000 protected species, is found in this forest, with great abundance and dominance (Niculescu, 2023). Phytosociologically, the analyzed sample areas in this forest belong to the plant community: *Quercetum farnetto-cerris* (Georgescu, 1945; Rudski, 1949) (Table 2). In floristic composition of the phytocoenoses, it was observed that the beech tree is part of phytocoenoses in which the *Quercus cerris* and the canopy is prominent. The installation of beech in this area was influenced by the exposure and the existence of a climate with higher precipitation and atmospheric humidity. As the climatic conditions in the south of Oltenia have changed in recent years, periods of drought have become more and more frequent, atmospheric humidity has decreased significantly, the average temperature has increased, the dominant abundance of beech has decreased, the number of individuals being smaller and smaller, the beech in this forest entering regression. In this forest, the Turkey oak and Hungarian oak undergrowth predominate, with little participation of the beech, although it is represented by vigorous specimens, and the regeneration of the beech is good (Fig. 1). Thus, it is recommended as protective measures, the appropriate maintenance of the fundamental natural type of forest, but also the application of measures to maintain the beech in a state of favorable conservation, ensuring natural regeneration, considering that the beech is found at the lowest altitude from the south of Oltenia, being practically a relic of the beech groves, which a few decades ago occupied larger areas in the south of Oltenia, but gradually with the climate changes and the action of anthropogenic factors, the area occupied by this species was reduced to almost disappearing.

From a conservative point of view, this grove falls under the Natura 2000 habitat - 91M0 Pannonian-Balkanic turkey and sessile oak forests, and in the classification system of Palearctic habitats it falls under the type: 41.76.

Racovita forest: The dominant and edifying forest species are: *Fagus sylvatica* ssp. *moesiaca* 70%), *Quercus cerris* (20%), other various hardwood species (10%), falling from a silviculture point of view into the forest type - Mixed beech from the hill region. The sample area of this stand is characterized by: typical luvosol type soil, height 240 m, plain terrain, continuous-normal litter, normal vitality, structure of the relative-plural stand, the current character of the forest type – Natural fundamental of medium production. The age structure of the stand is as follows: *Fagus sylvatyica* ssp. *moesiaca*, 120-140 years; *Quercus* *cerris*, 80-120 years; other various hardwood species, 80-120 years. Phytosociologically, the forest areal under study belongs to the plant community: *Hieracio rotundi-Fagetum* (Vida, 1963; Täuber, 1987) (Syn.: *Luzulo-Fagetum* auct. roman., *Fagetum dacicum luzuletosum* (Beldie, 1951), *Deschampsio flexuosae-Fagetum* (Soó, 1962) (Table 2). This stand is dominated by *Fagus sylvatica* ssp. *moesiaca*, which achieves an average coverage of 70-80%. Although in the tree layer the beech should hold the weight, there is also a species of lower altitude, namely *Quercus cerris*. The eco-pedo-climatic conditions in this area allow the installation of this species next to beech, the Turkey oak being a euthermic - mesothermic, mesoxerophilous species, with an affinity for warm areas, with a long growing season. Due to the ability to grow on clayey, compact, hardly permeable soils, with a very variable humidity regime (excessively wet in the spring, very dry during the summer droughts), it fits very well in this area of the Jiu basin.

As a result of field research, it was found that the infrataxon *moesiaca* has an altitudinal distribution that does not exceed 700 m, while the typical species is found at higher altitudes that exceed this altitude. The shrub layer is not well developed and represented by *Crataegus monogyna, Sambucus nigra* and *Rosa canina*. The protective measures that are required to maintain the stands in a favorable state of conservation are based on the proper maintenance of the fundamental natural type of forest by promoting valuable native species in strict accordance with the seasonal conditions, in which the beech holds the largest share. From a conservative point of view, this grove is under the Natura 2000-9110 *Luzulo-Fagetum* beech forests habitat and in the classification system of Palearctic habitats it falls under the type: 41.11 (Niculescu & Alexiu, 2008; Niculescu, 2020).

Sohodol forest: The dominant and edifying forest species are: *Fagus sylvatyica* ssp. *sylvatica* (95%), other diverse hardy species (5%), falling from a silvicultural point of view mountain beech on skeletal soils with mull flora. The sample area analyzed is characterized by: northern exposure, undulating slope, 1050 m altitude, slope 20%, young forest in which rarefaction works have been carried out, regeneration is natural, the vitality of this stand is normal, calcareous substrate with soils of the rendzine type, skeleton-rich rendzinelitho-soils with mull-type humus, thin continuous stratum. Regarding the age structure of the stand, it has the following components: *Fagus sylvatica* ssp. *sylvatica*, 45-90 years; other various hardwood species 30-90 years. From phytosociologically point of view, the analyzed areas of this forest belong to *Phyllitidi-Fagetum* Vida (1959) 1963 plant community.

In this area, beech forests are frequently encountered in which the edifying species are *Fagus sylvatica* ssp. *sylvatica* and *Phyllitis scolopendrium*, occupying especially the slopes of the lower mountain layer. In the studied territory, from the Sohodol Valley, this association has fairly large areas in the valleys with a moderate or highwater regime, preferring slopes whose inclination is over 20%. This stand is dominated by *Fagus sylvatica* ssp. *sylvatica*, which achieves an average coverage of 70-80%. The grassy layer has a weaker development, and a rocky terrain. Species of *Symphyto-Fagion* alliance and *Fagetalia* order prevail when making up the grassy stratum. The rest of the coenotaxa are poorly represented. It is worth noting that in this forest, *Asplenium cetereach* (Fig. 2a) and *Athamanta turbith* (Fig. 2b), protected species, with high abundance-dominance, are found especially at the edge of the forest or in forest clearings, on the calcareous substrate.

Fig. 2. *Asplenium cetereach* and *Athamanta turbith* in the Sohodol Forest.

Fig. 1. *Fagus sylvatyica* ssp. *moesiaca* in Dâlga Forest.

Table 2. Floristic composition of the investigated plant communities from *Carpino-Fagetea* Jakus ex Passarge 1968 em Borhidi 1993 and *Quercetea pubescentis* Doing-Kraft ex Scamoniet Passarge 1959.

Plant community no.	1	2	3	4	5	6
Altitude m.o.s.	**125**	**240**	**900**	**1250**	**300**	**400**
Exposure	**E**	**-**	**NE**	**NV**	**N**	**E**
Inclination (in grades)	**30**	**-**	**20**	**38**	**40**	**15**
Canopy	**0.7**	**0.7**	**0.8**	**0.8**	**0.8**	**0.6**
Coverage of herbacaeous layer (%)	**70**	**60**	**40**	**30**	**60**	**80**
Area (m^2)	**400**	**400**	**400**	**400**	**400**	**400**
Number of relevées analyzed	**10**	**10**	**10**	**10**	**10**	**10**
Char. ass.						
Fagus sylvatica ssp. sylvatica	.	.	V	V	.	.
Fagus sylvatica ssp. moesiaca	II	V	.	.	V	V
Carpinus betulus	I	II	II	I	II	I
Abies alba	.	.	.	V	.	.
Picea abies	.	.	I	II	.	.
Quercus petraea ssp. dalechampii	V	.	.	.	I	V
Quercus cerris	V	II	.	.	.	I
Quercus frainetto	V	.	.	.	.	.
Fraxinus ornus	I	.	.	I	I	V
Tilia tomentosa	II	I	.	.	IV	V
Hieracium rotundatum	.	.	I	II	I	.
Phyllitis scolopendrium	.	.	V	III	V	.
Pulmonaria rubra	.	.	I	V	I	.
Symphytum cordatum	.	.	I	II	I	.
Luzula luzuloides	.	I	II	IV	V	II
Carpino-Fagetea						
Corylus avellana	I	I	II	I	III	I
Dryopteris filix-mas	.	I	III	III	IV	I
Athyrium filix-femina	.	I	III	IV	V	II
Cornus sanguinea	III	II	III	IV	II	III
Ligustrum vulgare	V	III	II	. c	III	IV
Acer pseudoplatanus	.	.	V	.	I	.
Acer campestre	IV	I	I	.	I	IV
Crataegus monogyna	V	I	.	.	.	V
Ulmus glabra	.	.	I	.	I	I
Poa nemoralis	V	V	V	II	V	IV
Euonymus europaeus	I	II	I	.	III	.
Euonymus verrucosus	IV	III	.	.	I	II
Cephalanthera damasonium	I	.	.	.	.	.
Cephalanthera longifolia	.	II	I	I	I	.
Cephalanthera rubra	.	.	.	II	III	.
Hedera helix	II	II	II	III	IV	I
Lonicera xylosteum	.	.	I	II	I	.
Melica nutans	I	.	I	II	I	.
Moehringiamuscosa	I	.	.	II	I	.
Milium effusum	I	.	.	I	.	.
Ranunculus ficaria	V	I	.	I	.	I
Brachypodium sylvaticum	V	V	IV	III	IV	V
Neottia nidus-avis	II	I	II	II	I	I
Carex digitata	I	.	.	I	.	I
Galanthus nivalis	V	III	.	I	I	II
Vicia dumetorum	V	.	.	.	.	I
Polystichum aculeatum	.	.	I	II	II	.
Geranium robertianum	III	I	.	III	.	I
Oxalis acetosella	.	.	.	III	IV	.

Table 2. (Cont'd.).

Plant community no.	**1**	**2**	**3**	**4**	**5**	**6**
Impatiens noli-tangere	.	.	I	II	.	.
Glechoma hirsuta	IV	I	.	II	.	I
Corydalis solida	V	II	.	I	I	.
Scilla bifolia	V	IV	II	I	I	III
Galium schultesii	I	IV	III	III	III	.
Pyrus pyraster	IV	I	.	.	.	I
Rosa canina	V	I	.	.	.	II
Clematis vitalba	III	II	.	.	.	II
Dactylis polygama	III	I	.	.	.	.
Staphylea pinnata	III	.	.	.	.	.
Scrophularia scopolii	I	I	I	.	.	I
Vicia sepium	II	.	.	.	.	I
Ulmus procera	.	.	I	.	I	.
Ajuga reptans	II	I	I	I	.	.
Cruciata glabra	II	I	.	I	.	I
Polygonatum latifolium	I	.	I	.	.	I
Platanthera chloranta	.	.	I	II	I	.
Quercus daleschampii	.	I	.	.	.	I
Melica uniflora	II	.	I	I	.	I
Ranunculus auricomus	IV	I	I	.	.	I
Veronica officinalis	III	I	I	.	.	I
Veronica chaemedrys	IV	.	.	.	.	I
Viola alba	II	.	.	.	.	I
Criciata glabra	III	I	.	.	.	II
Stachys officinalis	II	I	.	.	.	II
Fagetalia						
Galium odoratum	I	II	.	I	.	II
Tilia plathypyllos	IV	I	I	.	I	II
Tilia argentea	.	.	I	.	II	.
Mercurialis perennis	.	I	I	.	II	.
Anemone nemorosa	V	V	II	I	.	III
Anemone ranunculoides	V	V	II	II	III	I
Isopyrum thalictroides	V	V	II	II	III	.
Alllium ursinum	II	III	I	I	.	I
Salvia glutinosa	.	I	II	II	II	I
Actaea spicata	.	.	III	II	II	I
Sanicula europaea	.	II	III	.	.	I
Stachys sylvatica	.	III	IV	III	IV	I
Paris quadrifolia	.	.	.	III	I	.
Carex sylvatica	I	II	V	IV	IV	III
Veronica urticifolia	.	.	II	.	I	.
Circea lutetiana	.	II	III	II	IV	IV
Epilobium montanum	.	I	I	II	II	.
Daphne mezereum	.	.	I	II	I	.
Viola reichenbachiana	.	I	III	IV	IV	I
Campanula rapunculoides	III	II	I	I	I	II
Lamium galeobdolon	I	I	II	I	I	I
Cardamine impatiens	.	.	I	I	I	.
Rubus hirtus	.	.	III	I	II	.
Galeopsis speciosa	I	II	II	III	III	I
Lilium martagon	.	.	I	III	II	.
Arum maculatum	V	III	.	.	.	II
Myosotis sylvatica	.	I	II	III	II	.
Symphytum tuberosum	.	.	I	II	I	.

Table 2. (Cont'd.).

Plant community no.	1	2	3	4	5	6
Asarum europaeum	.	.	+	IV	.	I
Scophularia nodosa	I	I	I	I	.	.
Primula acaulis	III	.	.	.	.	.
Platanthera bifolia	.	I	II	II	III	.
Polygonatum multiflorum	I	III	.	II	II	I
Maianthemum bifolium	.	.	.	III	II	.
Euphorbia amygdaloides	II	II	IV	III	III	III
Dryopteris carthusiana	.	.	II	III	II	.
Hiercacium murorum	.	.	I	III	II	.
Gymnocarpium dryopteris	.	.	I	III	I	.
Lathyrus vernus	III	II	I	.	.	II
Mycelis muralis	III	III	V	IV	IV	V
Campanula trachelium	.	.	I	II	.	I
Hepatica nobilis	.	.	I	II	.	.
Epipactis helleborine	.	.	I	II	I	.
Gentiana asclepiadea	.	.	I	IV	III	.
Veronica montana	.	.	I	II	II	.
Phaegopterisconnetilis	.	.	II	III	.	.
Prenanthes purpurea	.	.	II	IV	I	.
Tilia cordata	II	II	I	I	.	I
Equisetum telmateia	.	.	.	II	I	.
Stellaria holostea	.	.	.	II	I	I
Geum urbanum	IV	III	I	II	I	I
Galium schultesii	I	III	.	III	II	II
Erythronium dens-canis	I	I	.	.	.	I
Pelltaria aliacea	.	.	.	III	III	.
Saxifraga rotundifolia	.	.	.	II	III	.
Geranium macrorrhizum	.	.	.	II	IV	.
Quercetalia pubescenti-petraeae						
Cornus mas	V	II	.	.	.	III
Vibunum lantana	II	II	.	.	.	II
Melitis melisophyllum	II	.	.	.	.	II
Campanula persicifolia	IV	III	II	I	II	I
Vincetoxicum hirundinaria	V	II	.	.	.	II
Calamintha sylvatica	.	.	.	I	.	II
Astragalus glycyphyllos	IV	III	.	.	.	II
Lathyrus niger	III	.	.	.	.	I
Tanacetum corymbosum	III	I	.	.	.	.
Allium flavum	II	.	.	.	.	II
Fragaria viridis	IV	I	II	I	I	III
Poa angustifolia	III	.	.	.	.	I
Buglossoides purpurocaerulea	V	.	.	.	.	I
Festuca heterophylla	III	.	.	.	.	.
Euphorbia cyparissias	II	.	.	.	.	I
Cytisum nigricans	II	.	.	.	.	I
Genista tinctoria	III	.	.	.	.	I
Festuca valesiaca	III	.	.	.	.	I
Sedum maximum	II	.	.	.	.	I
Ajuga genevensis	II	.	.	.	.	.
Carex tomentosa	II	.	.	.	.	.
Quercion frainetto et Fraxino orni-Cotinetalia						
Asparagus tenuifolius	V	.	.	.	.	.
Lychnis coronaria	IV	.	.	.	.	II
Potenthilla micrantha	IV	.	.	.	.	.

Table 2. (Cont'd.).

Plant community no.	1	2	3	4	5	6
Tamus communis	III	I	.	.	.	I
Sedum cepaea	II	.	.	.	.	.
Orchis purpurea	II	I	.	.	I	.
Crocus flavus	II	I	.	.	.	.
Helleborus odorus	IV	IV	.	.	.	I
Ruscus aculeatus	III	.	.	.	.	V
Aceritatarici-Quercion						
Acer tataricum	IV	.	.	.	.	I
Quercus pubescens	II	.	.	.	.	II
Inula salicina	II	.	.	.	.	.
Iris variegata	III	.	.	I	.	.
Symphyto – Fagion						
Dentaria bulbifera	.	.	II	III	IV	.
Dentaria glandulosa	.	.	I	III	IV	.
Festuca drymeia	.	.	I	I	V	.
Helleborus purpurascens	.	.	IV	III	V	.
Vaccinio – Piceetalia						
Orthilia secunda	.	.	.	I	II	.
Deshampsiaflexuosa	.	.	.	IV	II	.
Saxifraga cuneifolia	.	.	.	I	I	.
Sorbus aucuparia	.	.	.	III	II	.
Huperzia selago	.	.	.	I	II	.
Lycopodium annotinum	.	.	.	II	I	.
Campanula abietina	.	.	I	II	II	.
Listera cordata	.	.	I	I	I	.
Monesesuniflora	.	.	.	I	I	.
Melampyrum sylvaticum	.	.	.	I	I	.
Epilobietea angustifolii						
Rubus idaeus	.	.	II	III	III	.
Fragaria vesca	I	I	.	I	.	.
Variae Syntaxa						
Urtica dioica	I	II	.	I	.	.
Chelidonium majus	I	.	.	.	.	I
Sambucus nigra	III	II	I	.	I	II
Glechoma hederacea	.	II	.	I	I	.
Polypodium vulgare	.	.	I	I	I	.
Asplenium trichomanes	.	.	.	I	I	.
Lamium maculatum	II	I	II	I	I	I
Veronica officinalis	.	I	.	II	.	+
Doronicum austriacum	.	.	.	I	.	.
Chrysosplenium alternifolium	.	.	I	.	.	.
Ornithogalum umbellatum	I	I	.	.	.	.
Veronica serpyllifolia	I	.	.	.	.	.
Ornithogalum pyrenaicum	I	.	.	.	.	.
Gagea minima	I	.	.	.	.	.
Smyrnium perfoliatum	II	.	.	.	.	.
Asplenium cetereach	.	.	III	I	I	.
Athamanta turbith	.	.	III	.	I	.
Bryophytes various species	.	I	II	III	II	.

Legend: 1. *Quercetum farnetto-cerris* (Georgescu, 1945; Rudski, 1949) plant community (6 relevés, Dâlga Forest, 15. V. 2022; 12. VI. 2023); 2. *Hieracio rotundi-Fagetum* (Vida, 1963; Taubert, 1987) plant community (6 relevés, Racovița Forest, 7. V. 2022; 20. VI. 2023); 3. *Phylitidi-Fagetum* (Vida, 1963) plant community (6 relevés, Sohodol Forest, 21.V. 2022; 7.VII. 2023); 4. *Pulmonario rubrae-Fagetum* (Soó 1964; Täuber, 1987) plant community (6 relevés, Arcani Forest, 7. V. 2022; 27. VI. 2023); 5. *Phyllitidi-Fagetum* (Vida, 1963) plant community; (6 relevés, Vodița 1 Forest, 30. V. 2022; 19.VI. 2023); 6. *Orno-Quercetum praemoesicum* (Roman, 1974) plant community (6 relevés, Vodița 2 Forest, 10. V. 2022; 24. VI. 2023)

This type of beech tree found in the Vodița Valley, an integral part of the ″Iron Gates″ Natural Park, requires protection considering their old, conservative character and the evolution of the beech trees on the calcareous rocks in the southwest of Oltenia. For the future, the aim will be to maintain the stands corresponding to the fundamental natural type of forest, as well as to bring the other stands to this type through silvotechnical methods, at the same time trying to normalize the forest fund production in relation to age classes. In order to maintain a favorable condition for the conservation of this type of stand, it is recommended to maintain the basic natural type of forest as well as the correct application of the silvotechnical methods provided for in the current forestry management, the promotion of valuable native species, especially the beech, as an edifying and dominant species and the other accompanying forest species, especially the mountain maple (*Acer pseudoplatanus*) in strict accordance with seasonal conditions.

Under conservative point of view, this tree is under the Natura 2000 habitat-91V0 Dacian Beech forest (Symphyto-Fagion) and in the classification system of Palearctic habitats it falls under the type: 41.1D2.

Arcani forest: This forest dominant and edifying species are *Fagus sylvatyica* ssp. *sylvatica* (80%), *Abies alba* (10%), *Picea abies* (10%), falling from a silvicultural point of view in the category of normal mountain beech with mull flora. The sample area analyzed is characterized by: southern exposure, undulating slope, slope 38%, 1250 m altitude, rock on the surface-0.25, natural forest where conservation and natural regeneration support works have been carried out, thus in this forest we are talking about natural regeneration. The vitality of this tree is normal, rendzina soil type, cambic type, having a variable pH between 4.7-6.2. Regarding the age structure of the stand, it has the following components: *Fagus sylvatica* ssp. *sylvatica*, 90-190 years; *Abies alba*, 190 years; *Picea abies*, 150 years old. Phytosociologically, the sample areas analyzed from this forest belong to the plant community: *Pulmonario rubrae-Fagetum* (Soó, 1964; Täuber, 1987) (Table 2). In this area, mixed forests of beech with fir and spruce are frequently encountered, occupying especially steep slopes, on which slope breaks and light falls often occur, especially in the fir, in the winter when the wind is much stronger in the area. The arborescent layer of these phytocoenoses is edified by *Fagus sylvatica* ssp. *sylvatica* and *Abies alba*, in different codominance ratios. In some phytocoenoses, the spruce also appears with a much lower abundance-dominance. The coverage of the grassy layer varies depending on the compaction of the tree layer, slope, exposure, being between 20-60%, on sunny slopes or towards the top of the slope, in places where thinning works have been carried out, this being higher. The encountered shrub species are represented by: *Sambucus racemosa, Spiraea chamaedrifolia, Rubus idaeus*. In the analyzed phytocoenoses, in the grassy layer alongside the characteristic species *Pulmonaria rubra*, the species *Calamagrostis arundinacea, Oxalis acetosella, Luzula luzuloides, Carex digitata, Orthilia secunda, Actaea spicata, Galium odoratum, Paris quadrifolia, Prenanthes purpurea, Dryopteris carthusiana, Moneses uniflora, Melampyrum sylvaticum, Lycopodium annotinum*. Following the studies, it was found that the phytocoenoses have a mesophilic, micro-mesothermic and acid-neutrophil character. In these stands, limiting factors are represented by natural causes – wind blow and landslides. Sometimes floods are added, the anthropo-zoogenic factors, among which the pollution of forest ecosystems with household waste resulting from the intensification of tourism activities in the Sohodol river basin, an important tourist area in the southwest of Romania, is an important one. Thus, it is recommended to keep the current status of the protected area and to apply the conservation measures correctly, considering that the Arcani Forest is part of ROSAC0129 North of the Western Gorj protected area. It is also recommended the application of appropriate ecological management measures for the forest vegetation (conservation cuts and the promotion of natural regeneration with native species on the site, as well as recommendations regarding reforestation (avoiding the replacement of native species with "fast-growing" species), silvotechnical measures in order to prevent soil erosion phenomena, monitoring the evolution and dynamics of stands, so as to ensure their natural regeneration and development. From a conservative point of view, this tree is under the Natura 2000 habitat - 91V0 Dacian Beech forest (Symphyto-Fagion) and in the classification system of Palearctic habitats it falls under the type: 41.1D2.

Vodița forest 1: The dominant and edifying species of this forest are *F. sylvatica* ssp. *moesiaca* (90%) and *Tilia tomentosa* (10%). The sample area analyzed is characterized by: typical eutricambosol type soil, slightly undulating terrain, surface rock 0.1S, slope 40%, northern exposure. In this subplot, slight drying has been observed and conservation works and natural regeneration support are being carried out. The age structure of the stand is as follows: *F. sylvatica* ssp. *sylvatica*, 145 years and *Tilia tomentosa*, 105 years. Vitality is normal for beech and weak for linden. From a phytosociological point of view, the forest area under study belongs to the plant community: *Phyllitidi-Fagetum* Vida 1963 (Table 2). This plant community is found on calcareous slopes of Vodița Valley. In arborescent layer of identified plant community, the beech predominates, achieving an average coverage between 65 and 80%. *Fraxinus ornus*and *Corylus colurna* species are also found. We can also mention the fact that in the grassy layer of these phytocenoses the presence of the species *Geranium macrorrhizum*, *Peltaria alliacea, Saxifraga rotundifolia*, which have a high constancy together with the edifying species *Phyllitis scolopendrium*. Limiting factors: natural causes (windfalls, floods), but especially anthropo-zoogenic, among which irrational and illegal logging, intensive grazing, pollution of forest ecosystems with industrial and household waste, arson, intensification of activities is important of tourism, the uncontrolled collection of plant species with economic value (Niculescu & Alexiu, 2008). It is recommended to limit anthropic influences (grazing, tourism, exploitation of forest resources), especially forest exploitations, banning the collection of herbaceous plants with economic value. Adequate ecological management measures for the forest vegetation (conservation cuts and the promotion of natural regeneration with native species on the site, as well as recommendations regarding reforestation (avoiding the replacement of native species with "fast-growing" species) in the areas with irrational deforestation, in order to prevent the phenomena of soil erosion. Monitoring the stands, maintaining them in a favorable conservation state, observing and implementing all conservation measures, so as to ensure the natural regeneration and development of this type forest, considering that these are an integral part of the ″Iron Gates″ Natural Park. From a conservative point of view, this tree is in Natura 2000 habitat-91V0 Dacian Beech forest (Symphyto-Fagion) and in the classification system of Palearctic habitats it falls under the type: 41.1D2.

Vodita forest 2: The dominant and edifying forest species are: *Quercus petraea* ssp. *dalechampii* (60%), *F. sylvatica* ssp. *moesiaca* (20%), *Tilia tomentosa* (10%), *Fraxinus ornus* (10%). The sample area analyzed is characterized by: typical districambosoil, undulating terrain, 38% slope, southern exposure, altitude 400 m, continuous-thin litter. The age structure of the stand is as follows: *Quercus petraea* ssp. *dalechampii*, 40 years, *F. sylvatica* ssp. *moesiaca*, 40 years, *Tilia tomentosa*, 40 years, *Fraxinus ornus*, 40 years. Vitality is normal for all species. It is a young forest in which thinning works have been carried out. The forest area under study belongs to the plant community: *Orno-Quercetum praemoesicum* (Roman, 1974) (Table 2). This plant community is very rarely found in Romania, being specific to the thermophilic locations in the Danube basin from south-western area of Romania. Thus, in conditions of xericity and stony, calcareous substrate and slopes with a high degree of inclination and sunny, this type of stand is established in which *F. sylvatica* ssp. *moesiaca*, this plant community has a pronounced Balkan-sub-Mediterranean character. It is worth noting that in this forest as well as in the Dâlga Forest, located at a lower altitude and much further south, *Ruscus aculeatus* (Fig. 4) is found, with great abundance-dominance. In these stands, conservation cutting is recommended, promoting the natural regeneration of *Quercus petraea* ssp. *dalechampii* and *F. sylvatica* ssp. *moesiaca* species, considering that this stand has a special structure, is rarely found in Romania and is also part of the Park Natural ″Iron Gates″. At the same time, being a young forest, the linden should be monitored in terms of maintaining the abundance-dominance within favorable limits, taking into account the fact that it is a fast-growing species, so as not to affect the vitality and natural regeneration of the sessile oak and especially the beech. From a conservative point of view, this grove is in Natura 2000 habitat - 91M0 Pannonian-Balkanic turkey oak-sessile oak forests, and in the classification system of Palearctic habitats it falls under the type 41.76. In order to observe the floristic abundance of the phytocoenoses in which the studied species is also found, a dendrogram was made using the Syn-Tax 2000 statistical program and we gave a special attention to the calculation of the Sørensen index, using the Group-Average method (WPGMA) (Podani, 2001). Analyzing the dendrogram (Fig. 3), it is notice able the grouping of two clusters, with well-individualized branches, which high lights the separation of the phytocoenoses analyzed within the 6 stands.

The first groups of the phytocoenoses: 1, 6 and 2, having dissimilarity index values up to 0.30. The second cluster groups reliefs 3, 4 and 5, with dissimilarity index values up to 0.25. within them, the grouping of phytocoenoses 1 and 6, which is differentiated by the presence in these stand sand at the same time the high abundance-dominance of the species *Ruscus aculeatus* and *Quercus pubescens*, species indicative of xericity compared to the others trees. Also, the grouping of the phytocoenoses in the second cluster brought out the constant avoidance and abundance of the species: *Phyllitis scolopendrium*, *Geranium macrorrhizum, Pelltaria aliacea, Paris quadrifolia, Pulmonaria rubra, Cephalanthera rubra*, characteristic of typical forest of beech and combined forest of silver fir and beech.

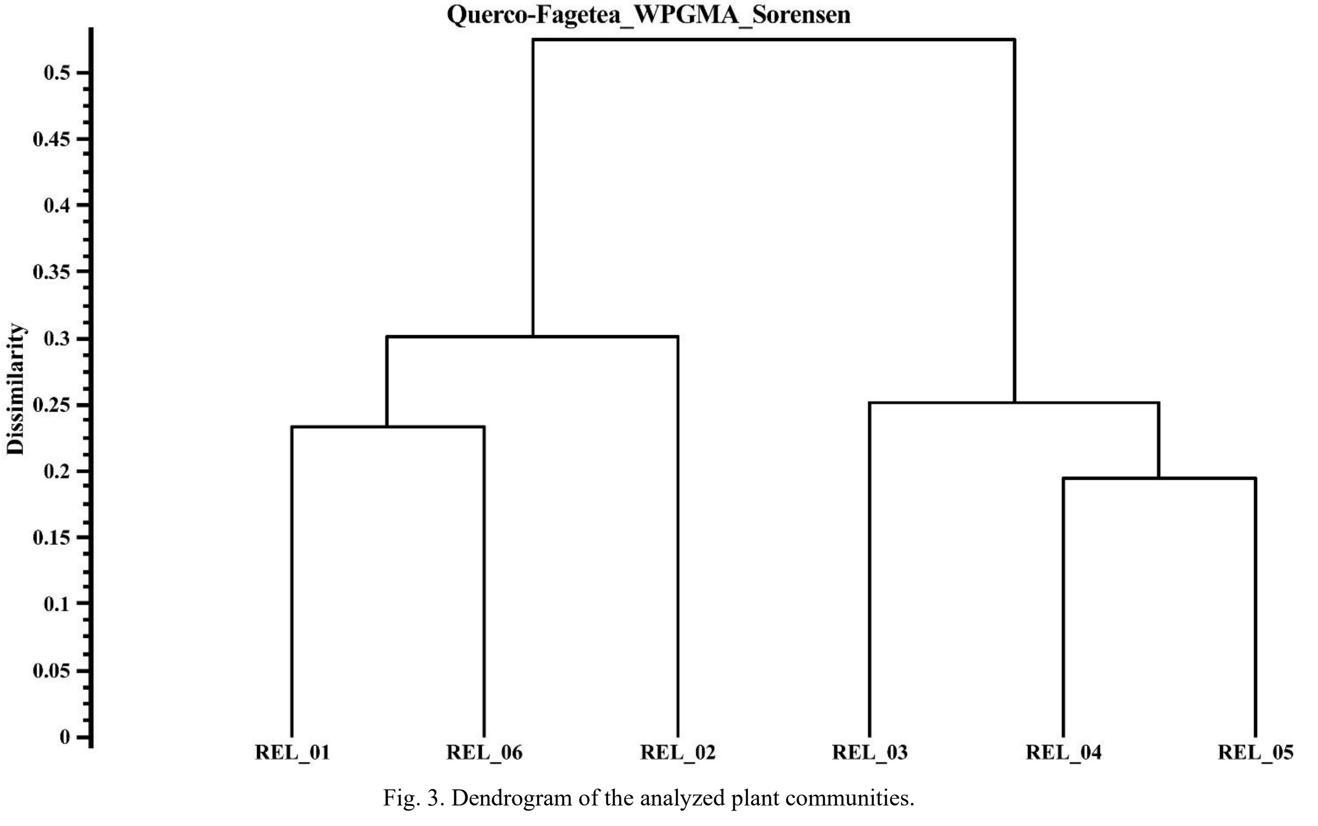

Fig. 3. Dendrogram of the analyzed plant communities.

Table 3. Comparative analysis of some morphological character variability analyzed by location.

	Stem height (m)	Stem diameter (cm)	Leaf width (cm)	Leaf length (cm)	No. of nervures/ leaf
Sohodol	18.4 ± 0.82^{d}	30.55 ± 13.55^{b}	4.825 ± 0.61^{b}	8.41 ± 1.01^{c}	8.15 ± 0.59^{c}
Arcani	15.9 ± 6.21^{e}	29.05 ± 7.34^{b}	4.805 ± 0.58^{b}	8.38 ± 1.00^{c}	8.2 ± 0.62^{c}
Vodița 1	21.5 ± 5.24^{c}	41.7 ± 9.54^{a}	6.86 ± 0.55^{a}	11.505 ± 0.60^{a}	9.95 ± 0.51^{a}
Vodița 2	19.9 ± 5.76^{cd}	38 ± 12.04^{a}	4.825 ± 0.61^{b}	8.41 ± 1.01^{c}	8.15 ± 0.59^{c}
Racovița	33.80 ± 10.02^{b}	25.17 ± 4.20^{c}	6.27 ± 1.32^{a}	11.87 ± 0.53^{a}	9.75 ± 0.43^{ab}
Dâlga	55.15 ± 23.41^{a}	28.70 ± 3.60^{b}	6.72 ± 0.88^{a}	10.66 ± 1.28^{b}	9.20 ± 0.89^{b}
LSD %	2.02	3.78	0.756	0.685	0.623

Table 4. Variability of correlation coefficient.

Character	**Stem diameter**					
Location	**Sohodol**	**Arcani**	**Vodița 1**	**Vodița 2**	**Racovița**	**Dâlga**
Stem height	0.845	0.101	0.493	0.766	0.677	0.723
Leaf width	0.111	-0.139	-0.425	0.140	0.115	0.284
Leaf length	0.051	-0.031	-0.367	0.166	0.291	0.122
No. of nervures	0.174	0.102	-0.587	0.477	0.334	0.167
Character	**Stem height**					
Location	**Sohodol**	**Arcani**	**Vodița 1**	**Vodița 2**	**Racovița**	**Dâlga**
Stem height	-	-	-	-	-	-
Leaf width	0.101	-0.337	-0.468	-0.031	0.361	0.416
Leaf length	0.059	-0.247	-0.492	-0.083	0.220	0.312
No. of nervures	0.207	-0.375	-0.270	0.334	0.081	0.298
Character	**Leaf width**					
Location	**Sohodol**	**Arcani**	**Vodița 1**	**Vodița 2**	**Racovița**	**Dâlga**
Stem height	-	-	-	-	-	-
Leaf width	-	-	-	-	-	-
Leaf length	0.739	0.728	0.741	0.739	0.090	0.912
No. of nervures	0.328	0.292	0.496	0.328	-0.199	0.876
Character	**Leaf length**					
Location	**Sohodol**	**Arcani**	**Vodița 1**	**Vodița 2**	**Racovița**	**Dâlga**
Stem height	-	-	-	-	-	-
Leaf width	-	-	-	-	-	-
Leaf length	-	-	-	-	-	-
No. of nervures	0.520	0.435	0.257	0.520	0.355	0.916

Statistical analysis of the morphological characters analyzed: In the researched locations as concern the stem height character, from the comparative analysis carried out, it was established that average values calculated for the northern exposure are significantly higher than those for the southern exposure.

Thus, highest average value was registered for the population in the Dâlga area (55.15 m), a value that is significantly different from all other calculated values.

It is followed by the average value of the population in the Racovița area (33.80 cm) (Table 3).

Regarding the diameter of the stem, the highest calculated average values are recorded in the Vodița area, regardless of the exposure, values that differ significantly from those in the Sohodol and Arcani area, which in turn do not differ statistically. Lowest average values were obtained for the Racovița and Dâlga areas.

In conclusion, we can say that the value expression of this character is conditioned by the ecological area and less by the exposure.

As concern leaf width character, highest average values are recorded for the Dâlga, Racovița and Vodița 1 areas, while for the Sohodol and Arcani area, the calculated average values do not differ from each other from a statistical point of view, nor from the Vodița 2 area.

So, only for the Vodița area the exposure has an important role in expressing the value of this character.

For leaf length and the number of nervures/leaf, the averages recorded for Vodița 1 differs significantly compared to those calculated for Vodița 2, while for the Sohodol area there is no differentiation between exposure.

Related to height and stem diameter characters, for the Sohodol North area, the evolution is similar.

Thus, the tendency of stem height to increase also increase in diameter, with the specification that this tendency is stronger for height than for diameter (Fig. 4).

For the Arcani area, the height has relatively constant values 18 m) for most of the trees, while the diameter is a character that varies in amplitude, so the evolution of the two characters is rather independent (Fig. 5).

For the Vodița1 area, once with the increasing evolution of stem height, the diameter of the stem also has an increasing but relatively sinusoidal (Fig. 6).

For the Vodița 2 area, the increasing of stem height is better duplicated by the same trend of the stem diameter character (Fig. 7). Variability of stem diameter and height is given in Figures 8 and 9 for Dâlga and Racovița area.

The comparative analysis of correlation coefficients (Table 4) led to the identification of correlative relationships, from significant to distinctly significant, both positive and negative.

Table 5. Total variance explained.

Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	3.827	76.536	76.536	3.827	76.536	76.536
2	1.004	20.076	96.612	1.004	20.076	96.612
3	0.147	2.944	99.556			
4	0.019	0.384	99.941			
5	0.003	0.059	100.000			

Table 6. Component matrix-extraction method: principal component analysis, 2 components extracted.

	Component	
	1	2
Stem diameter	0.107	0.980
Stem height	0.568	0.768
Leaf width	0.876	0.440
Leaf length	0.974	0.206
Leaf no. of nervures	0.985	0.150

Thus, among the two characters of the stem, the highest value is recorded for Sohodol North (0.845).

Also, other high values of this coefficient are registered for Vodița 2, Racovița and Dâlga.

It should be noted that the lowest value is recorded for Arcani. Thus, this correlation is not dependent on genotype, but rather on location or exposure. That is precisely why, within the same population, the value of this coefficient differs so much from North to South.

As concern PCA, the first two components explain 96.612% of total variance.

First component registers 76.536%, while second component 20.076 % (Table 5).

First component is given by the characters which obtain higher value for the first component are leaf width, leaf long and leaf no. of nervures, while the elements that obtain high value for the second component are stem diameter and stem height.

The first component is the ability of tree to form a foliar system with higher leaves, while the second component is represented by the capacity of the tree to develop well increased stem (Table 6).

The four groups based on the value of the two components were: (Fig. 10):

- The variant with both positive components Dâlga. This one has high results for both stem characters and for leaf height and average results for the other 2 analyzed characters.
- The variant with the first component positive and the second one negative is encountered in Racovița and Vodița 1.
  This variant has high values for leaf characters and medium values for the stem height.
- The variants with both negative components are Sohodol North and Arcani. Those ones have poor values for all analyzed characters.
- The variant with the first component negative and the second one positive is Vodița 2 which has reduced values for almost all characters, except for stem diameter.

Discussion

The distribution of *Fagus sylvatica* L. covers a broad bio-meteorological zone from temperate to warm climates (Ellenberg, 1996). From an ecological and socio-economical perspective, beech is one of the most important hardwood species in Europe. Due to climate change, it is estimated that beech has reached its xeric limit on many sites in the Carpathian Basin. Species limits are sensitive to changes in the climate so it is necessary to understand how this affect the growth of beech. This can be a reliable competitor with high tolerance to shadow and able to dominate the sites with broad spectrum of nutrient and hydrological regimes (Leuschner *et al*., 2001). The tree growth is a key ecological parameter of forests and an indicator of their condition (Dobbertin, 2005). The character increase is an integrative variable of tree response (Seidling *et al*., 2012) in the current changing environmental condition. There is a pattern in growth response of beech to climate change and a small number of some correlations between tree-ring widths and temperatures/precipitation in the alpine region and with higher absolute values for the continental region was mention by (Levanic *et al*., 2023).

The growth of beech in the South-west part of Romania in different levels of altitude and types of climate can be affected by present and future climate change. Environmental conditions influence the increase of beech so that further intensification of climate warming may affect the productivity in the Oltenia region, in interfluve Jiu-Danube.

The obtained results suggest that optimum temperatures and humidity is very important in determining species distribution.

The temperatures from summers are limiting factor for beech distribution in south-west Romania. Higher temperatures become a regional climatic factor which places the southern part at xeric range (Matyas *et al*., 2010). So, species growth is limited by water stress and can be replaced by other drought tolerant species, such as oaks and pines (Horvat *et al*., 1974; Ellenberg, 1996). Drought sensitivity is a key factor of limiting distribution of beech in southern and south-eastern Europe (Czúcz *et al*., 2011). Few studies suggest decline in beech regeneration (Peñuelas *et al*., 2007; Betsch *et al*., 2011; Aranda *et al*., 2015), rapid decline in growth (Jump *et al*., 2007; Piovesan *et al*., 2008) and massive range retraction (Kramer *et al*., 2010) once with warmer and drier climatic conditions.

Fagus sylvatica has adaptive features which are driven by the climate of the locality from which they originate. Species with extensive geographical ranges have the potential to exhibit a larger intraspecific variation in physiology, morphology, phenology, and growth rate (Soolanayakanahally *et al*., 2009). Climate change already has affected the forests of Himalayan fir (*Abies pindrow*) Hindu Kush region, northern Pakistan with large impact in distribution and their growth (Asad *et al*., 2024).

The response of trees from different phenological categories needs to be further studied in the future, with a view to the possibility of choosing the origins and biotypes with the greatest chances of adaptation in the current context of climate changes.

The desertification of the southern regions is very likely and this can have a particular impact because thermal stress (drought) is one of the main factors that determine the decrease in populations or even the increase in mortality in beech species. Therefore, there is an urgent need to protect and conserve the forest resources of the southwest region. However, beech trees found favorable climate and vegetation conditions even in the south limit. Even so, the existing beech populations from the eastern limit of the species distribution are remnants of a wider array of small beech populations having the same geographical origin as those from the Carpathian Mountain (Ciocîrlan *et al*., 2017).

It supposes that Southeast Europe is one of the most exposed regions on the continent at climate change and neglected of studies (Matyas *et al*., 2010). For the period 2051–2100, the severity of drought events may increase significantly in all scenarios compared with the control period 1951–2000 (Gálos *et al*., 2007).

In a similar study, Lupescu & Curcă, 2013 reported that the influence of exposition is strongest in marginal altitude of beech distribution, then the influence of temperature and moisture regime. They also said that exposition at middle altitude has a lower influence.

It is found that in certain locations (medium altitudes) where the amount of precipitation is close to optimal, beech grows better than in locations where it is considered a marginal habitat and where the environmental factors start to be limiting. However, the growth in height is double that in diameter for these locations as well, even if the pace is slower or their evolution more sinusoidal. Leuschner, 2020 included beech in the category of the species moderately drought-sensitive due to its potential to conserve water at the stand level and also some provenances posse significant potential to adapt to drier sites and to recover after drought periods. Identifying and improving the behavior of tree species in their range margins is essential to understand their future adaptability in the context of climate changes.

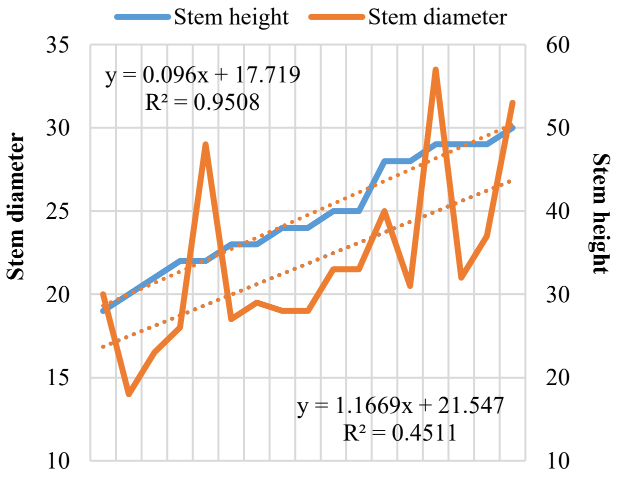

Fig. 4. Stem diameter and height in Sohodol area.

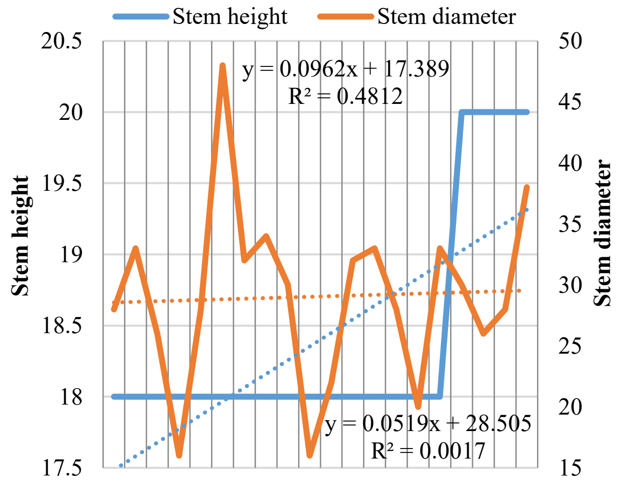

Fig. 5. Stem diameter and height in Arcani area.

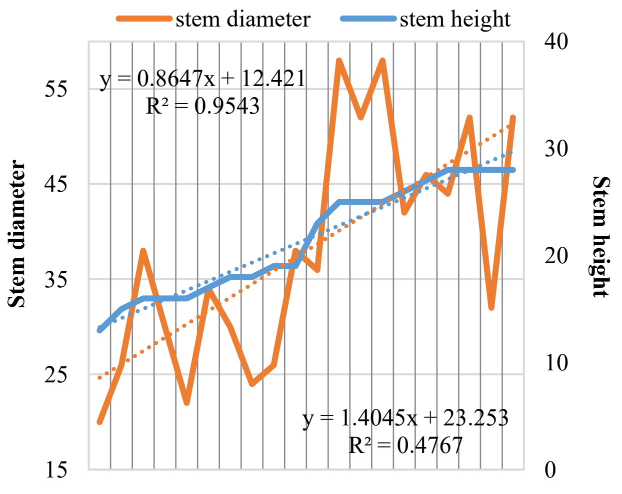

Fig. 6. Stem diameter and height in Vodița 1 area.

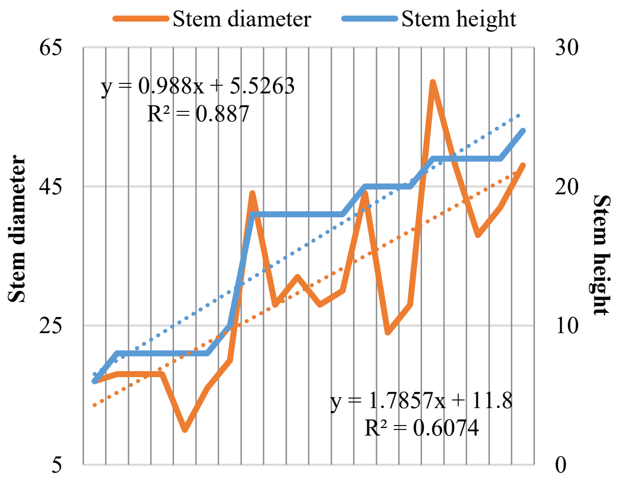

Fig. 7. Stem diameter and height in Vodița 2 area.

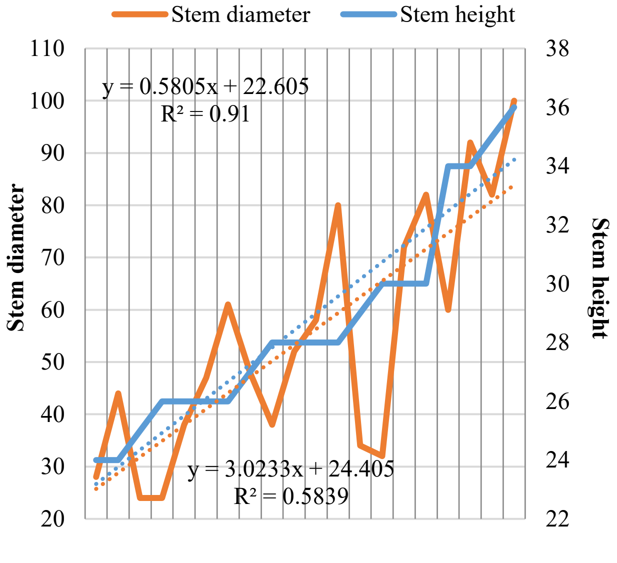

Fig. 8. Stem diameter and height in Dâlga area.

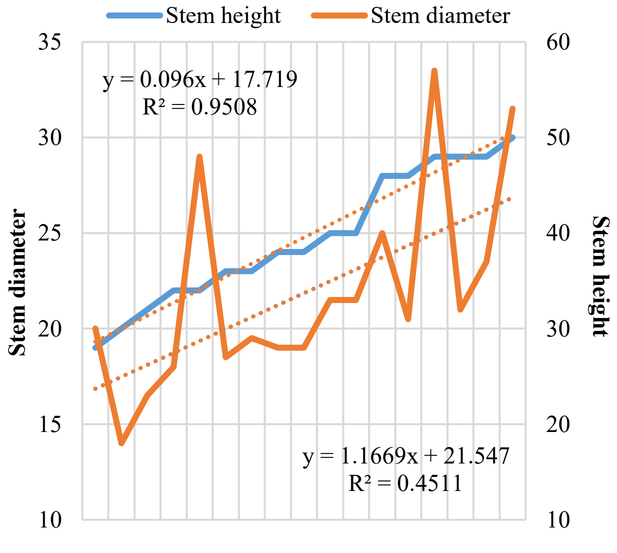

Fig. 9. Stem diameter and height in Racovița area.

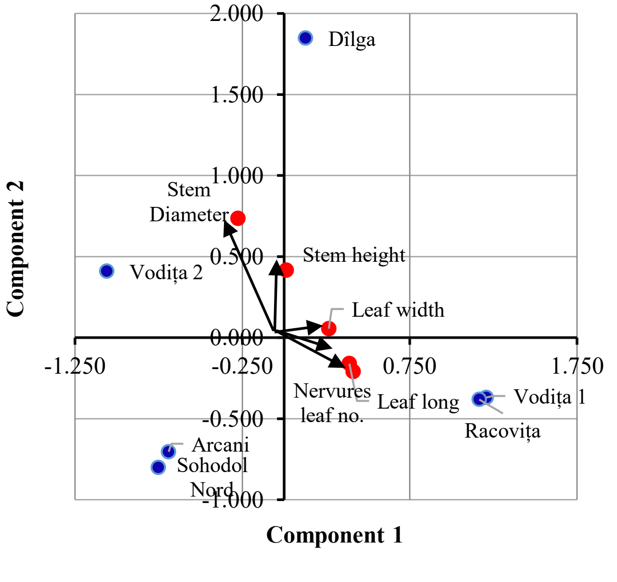

Fig. 10. Classification of variants according to the score of the two components.

Conclusions

From a phytosociological point of view, 6 forest areas were analyzed from plant communities of *Carpino-Fagetum* Syn.: *Querco-Fagetea* (Braun –Blanquet & Vlieger, 1937) Borhidi, 1963 and *Quercetea pubescentis* Doing - Kraft ex Scamoni & Passarge, 1959 classes. At the same time, it was observed that the beech enters the floristic structure of important forest habitats of conservation interest for Romania.

In some plant communities *Fagus sylvatica* ssp. *sylvatica* participates as an edifying species while in others *Fagus sylvatica* ssp. *moesiaca* is depending on the existing ecological and climatic conditions. The state of conservation of the trees analyzed is generally favorable. It was found that the climate changes of recent years, the prolonged drought, the aridity of soils in the south-west of Oltenia, especially affect the beech from population point of view, especially in the stands at lower altitudes, Dâlga and Racovita. In these places, the areas with beech forests were much more extensive, especially in the Dâlga Forest, where now we find only 20 specimens. Here, the beech grows near a stream, on an eastern slope, where the microclimatic conditions have allowed it to survive and, at the same time, a good regeneration has been observed in recent years. Thus, by reducing the limiting factors, the number of specimens could increase, and as regards the structure of the plant community from which it is made, a dynamic evolution can be noted. For the stem diameter and height characters, the exposure is very important, registering significant differences in favor of the values recorded on the northern exposure compared to those recorded on the southern exposure regardless of location.

Results analysis within the same geographical area indicate that exposure plays an important role in increasing the variability within the same population. The study shows that height and diameter traits can be influenced by environmental changes. So, to obtain more concrete results and to recognize the compatibility of *Fagus sylvatica* in this region in response to current climate change, studies based on physiological traits showing plasticity in response to altitude changes are needed.

References

Aeschiman, D., K. Lauber, D.M. Moser and J.P. Theurillat. 2004. Flora Alpina. Bologna*: Zanichelli*, 3: 323.

Aranda, I., F.J. Cano, A. Gascó, H. Cochard, A. Nardini, J.A. Mancha, R. López and D. Sánchez-Gómez. 2015. Variation in Photosynthetic Performance and Hydraulic Architecture across European Beech (*Fagus Sylvatica* L.) Populations Supports the Case for Local Adaptation to Water Stress. *Tree Physiol*., 35: 34-46.

Asad, F., M. Adil, S. Shaid and M. Ahmed. 2024. Dendrochronological study of *Abies pindrow* (Royle ex D. Don) Royle (Fir) as aspect of tree growth and climate change analysis in Hindu Kush, northern Pakistan. *Pak. J. Bot*., 56(5): 1973-1981.

Beldie, Al. 1951. Făgetele montane superioare din valea Ialomiţei şi valea Buzăului. Studiu fitocinologic comparativ. *Ed. Acad. RPR*, Bucureşti.

Betsch, P., D. Bonal, N. Breda, P. Montpied, M. Peiffer and A. Tuzet. 2011. Drought effects on water relations in beech: the contribution of exchangeable water reservoirs. *Agri. For. Meteorol*., 151(5): 531-543.

Borhidi, A. 1963. Die Zönologie des Verbandes Fagionillyricum I. Allgemeiner Teil. *Acta Bot. Acad. Sci. Hung*., 9: 259-297.

Borhidi, A. 1993. Magyar flora szociális magatar tástípusai, természetes ségiés relatívökoló giaiérték-számai. *A Környezet védelmiés Területfejlesztési Minisztérium Természetvédelmi Hivatalaés a Janus Pannonius Tudomán yegyetem Kiadványa*, pp. 93, Pécs.

Borza, Al. 1933. Retezatul, viitorul parc naţional al României, *Revista Carpaţi,* nr. I, Bucureşti.

Boşcaiu, N. 1971. Flora şi vegetaţia Munţilor Ţarcu, Godeanuşi Cernei, *Ed. Acad*., Bucureşti.

Braun-Blanquet, J. 1931. Overview of the lower Langue- doc vegetation. *Sigma Communication* (Support for Improvement of Governance and management Programme), 9, Montpellier, 35-40.

Braun-Blanquet, J. 1932. Plant Sociology (Transl. by G.D. Fuller and H.S. Conard), *New York*, xviii + 439 pp. Reprint 1966.

Braun-Blanquet, J. and Jenny, H. 1939. Vegetations Entwicklung und Bodenbil dung. Denkschr. *Der Schweiz. Naturforsch. Gesellsch*., 63, 2. Zürich.

Burduja, C. 1973. Raionarea floristică şi vegetaţia R. S. România. Parteaa II-a, *Universitatea Al. I. Cuza,* Iasi, pp. 291.

Chifu, T. 1995. Contributions a la syntaxonomie de la vegetation de la classe Carpino Fagetea (Br.-Bl et. Vlieger 1937) Jakucs 1960 sur la territoire de la Moldavie (Roumanie), *An. Şt. Univ. "Al. I. Cuza" Iaşi, a.II- a. Biol. Veget.*, XLI., 61-66.

Chifu, T. and N. Ștefan, 1994. Recherches phytosociologiques dans les hêtraiescollinaire du Plateau de Suceava. *An. Şt. "Univ. A. I. Cuza", Iasi (Serie nouă), aII-a. Biol. Veg*., 40(2):71-80.

Ciocârlan, V. 2009. Flora ilustrată a României, *Pteridophyta et Cormophyta*. Ed. Ceres, Bucureşti.

Ciocîrlan, E., N. Sofletea, F. Ducci and Al. Curtu. 2017. Patterns of genetic diversity in European beech (*Fagus sylvatica* L.) at the eastern margins of its distribution range. *iForest-Biogeosciences and Forestry*, 10(6): 916-922.

Cojoaca, F.D. and M. Niculescu. 2018. Diversity, distribution and ecology of the forest natural habitats in the Bratovoesti forest, Dolj county. *Sci. Papers. Ser. A. Agron.*, 61:453-457.

Coldea, G. 1975. Étude phytosociologique cencernant les hêtraies des monts Plopiș. *Rev. Roum. Biol., Ser. Bot*., 20(1): 33-41.

Coldea, G. 1991. Prodrome des associations végétales des Carpates du Sud-Est (Carpates Roumaines). *Documents Phytosociologiques*, N.S., 13, Camerino, 317-539.

Comes, I.C. and F. Taubert, 1977. Cenocorologia tisei (*Taxus baccata* L.) in Piatra Craiului. *Ocrot. Nat. Si a med. Inconj*., 21(1): 27-32.

Czúcz, B., L. Galhidy and C. Matyas. 2011. Present and forecasted xeric climatic limits of beech and sessile oak distribution at low altitudes in Central Europe. *Ann. Forest Sci.*, 68(1): 99-108.

Dobbertin, M. 2005. Tree growth as indicator of tree vitality and of tree reaction to environmental stress: A review. *Eur. J. For. Res*., 124: 319-333.

Dobrescu, C. and Att. Kovacs. 1973. Contribuții la fitocenologia pădurilor de "Fagion" din Podișul Central Moldovenesc. *Rev. Păd*., 88(11): 592-599.

Domin, K. 1932. Humifuse forms of some species and their ecological signification, *Bulletin de la Societe Botanique Tchecoslovaque* a Prague, Preslia, Vol. XI.

Ellenberg, H. 1996. Vegetation Mitteleuropasmit den Alpen. 5th ed. *E. Ulmer*, Stuttgart.

Gálos, B., P. Lorenz and D. Jacob. 2007. Will dry events occur more often in Hungary in the future? *Environ. Res. Lett*., 2: 034006.

Georgescu, C.C. 1945. Turkey oak as a type of forest, *Rev. Pad*., 53(8-9): 444-457.

Giurgiu, V. 2010. Pădurile și schimbările climatice. *Revista pădurilor*, Volume 3: 3-17.

Hartmann, F.K. and G. Jahn. 1967. Waldgesellschaften des mittel europäischen Gebirgsraumes nördlich der Alpen. *G. Fischer*, Stuttgart.

Horvat, I., V. Glavac and H. Ellenberg. 1974. Vegetation Südosteuropas. *Fischer*, Stuttgart, p. 768.

Jump, A., J. Huntand and J. Peñuelas. 2007. Climate relationships of growth and establishment across the altitudinal range of *Fagus sylvatica* in the Montseny Mountains, northeast Spain. *Ecosci.*, 14: 507-518.

Kramer, K., B. Degen, J. Buschbom, T. Hickler, W. Thuiller and M.T. Sykes. 2010. Modelling exploration of the future of European beech (*Fagus sylvatica* L.) under climate change. Range, abundance, genetic diversity and adaptive response. *Forest Ecol. Manag.*, 259: 2213-2222.

Leuschner, C. 2020. Drought response of European beech (*Fagus sylvatica* L.) A review. *Persp. Plant Ecol. Evol. System.*, 47: 125576.

Leuschner, Ch., K. Backes, D. Hertel, F. Schipka, U. Schmitt, O. Terborg and M. Runge. 2001. Responses at leaf, stem and fine root levels of competitive *Fagus sylvatica* L. and *Quercus petraea* (Matt.) Liebl. trees in dry and wet years. *For. Ecol. Manage*, 149: 33-46.

Levanič, T., D. Ugarković, I. Seletković, M. Ognjenović, M. Marušić and R. Bogdanić. 2023. Radial increment of beech (*Fagus sylvatica* L.) is under a strong impact of climate in the continental biogeographical region of croatia. *Plants,* 12: 2427.

Lupescu, M. and M. Curcă. 2013. The influence of site characteristics on beech growth in northeastern Romania. *J. Hort. For. Biotechnol.*, 17(3): 17-26.

Matyas, C., I. Berki, B. Czúcz, B. Galos, N. Moricz and E. Rasztovits. 2010. Future of beech in southeast Europe from the perspective of evolutionary ecology. *Acta Silv. Lign. Hung*., 6: 91-110.

Milescu, I. 1967. Beech - *Fagus sylvatica*. *Editura Agro-silvică*, Bucuresti, pp. 579.

Morariu, I., P. Ularu, M. Danciu and E. Lungescu. 1968. Făgetele de pe Măgura Coldei. *Bul. Inst. Polit., Ser., B-Econ. Forest. Brașov.*, 12: 97-101.

Mucina, L, K. Bültmann, J.P. Dierßen, T. Theurillat, A. Raus, K. Čarni, W. Šumberová, J. Willner, R. Dengler, M. Gavilán García, M. Chytrý, R. Hájek, D. Di Pietro, J. Iakushenko, F.J.A. Pallas, E. Daniëls, A. Bergmeier, N. Santos Guerra, M. Ermakov, J.H.J. Valachovič, T. Schaminée, Y.P. Lysenko, S. Didukh, J.S. Pignatti, J. Rodwell, H.E. Capelo, A. Weber, P. Solomeshch, C. Dimopoulos, S.M. Aguiar, L. Hennekens and L. Tichý. 2016. *Appl. Veg. Sci.,* 19(S.1): 1402-2001.

Mucina, L., G. Grabherr, T. Ellmauer and B. Wallnöfer. (Eds.). 1993. Die Pflanzengesellschaften Österreichs. Band I-III. G. Fischer, Jena.

Niculescu, M. 2006. Flora and vegetation in the upper basin of the Luncavat River (PhD. Thesis), Babes-Bolyai" University of Cluj-Napoca, Romania.

Niculescu, M. 2020. The distribution and structure of the plant communities found in the Dobriceni and Jgheaburi forests of the Govora River Basin, Romania. *Sci. Papers Series A. Agron.*, 63(2): 289-293.

Niculescu, M. 2023. Chorology, ecology and phytosociology of the *Ruscus aculeatus* L. in forest habitats from the South of Oltenia, Romania. *Sci. Papers. Ser. A. Agron.*, 66(2): 499-504.

Niculescu, M. and V. Alexiu. 2008. Dacian Beech forest (Symphyto-Fagion). In Natura 2000 in Romania: Habitat fact-sheets, Mounford, O., D. Gafta, P. Anastasiu, M.I. Bărbos, A. Nicolin, M. Niculescu and A.Oprea. Ed. Romanian Ministry of Environment and Sustainable Development.

Oberdorfer, E. 1992. Süddeutsche Pflanzen – gesellschaften, Teil IV: Wälder und Gebüsche 2, Stark berabeilete Auflage Texband, *Gustav Fischer Verlang Jena*, New York.

Paucă, A. 1941. Studiu fitocenologic în munţii Codru şi Muma. *St. Cerc., Acad. Rom*., Bucureşti, LI: 1-119.

Peñuelas, J., R. Ogaya, M. Boada and A.S. Jump. 2007. Migration, invasion and decline: changes in recruitment and forest structure in a warming-linked shift of European beech forest in Catalonia (NE Spain), *Ecography*, 30: 829-837.

Piovesan, G., F. Biondi, A. Di Filippo, A. Alessandrini and M. Maugeri. 2008. Drought-driven growth reduction in old beech (Fagus sylvatica) forests of the central Apennines, Italy. *Glob. Change Biol*., 14:1-17.

Podani, J. 2001. SYN-TAX 2000. Computer programs for data analysis in ecology and systematics. *User's manual. Scientia*, Budapest.

Popović, V., A. Lučić and L. Rakonjac. 2021. Variability of Morphological Traits of European Beech (*Fagus sylvatica* L.) Seedlings in Serbia. *SEEFOR*, 12(1): 83-89.

Resmeriţă, I. 1972. Flora, vegetaţia şi potenţialul productiv pe masivul Vlădeasa. *Editura Academiei*, Bucureşti.

Rodwell, J.S., J.H.J. Schaminée, L. Mucina, S. Pignatti and J.D. Dring Moss. 2002. The diversity of European vegetation – An overview of phyto-sociological alliances and their relationships to EUNIS habitats. *National Reference Centre for Agriculture, Nature and Fisheries*, [report no. EC-LNV 2002(054)], Wageningen.

Roman, M. 1974. Flora şi vegetaţia din nordul Podişului Mehedinţi, *Ed. Acad*., Bucureşti.

Rudski, I. 1949. Tipoviliš ćars kihšumajugo istočnog dela Šumadije. (Types of broadleaf forests of the southeastern part of Šumadije). *Beograd, Prir. Muz. Srps. Zem*., 25: 3-67.

Sanda, V., A. Popescu and N. Barabaş. 1997. Cenotaxonomia şi caracterizarea grupărilor vegetale din România. *St. Com., Muz. Şt. Nat. Bacău*, 14: 5-366.

Săvulescu, T. 1972. Flora of Romania. *Romanian Academy Publishing House*, Bucharest, Vol. 12, pp. 810.

Seidling, W., D. Ziche and W. Beck. 2012. Climate responses and interrelations of stem increment and crown transparency in Norway spruce, Scots pine, and common beech. *For. Ecol. Manag*. 284: 196-204.

Sharma, S. 1996. Applied Multivariate Techniques. *1st ed. John Wiley and Sons*, New York, p. 493.

Şofletea, N. and Al. Curtu. 2007. Dendrology. *Ed. Transilvania University*, Braşov.

Soó, R. 1962. Die regionalen Fagion-Verbände und Gesellschaften Südosteuropas. *Akadémiai Kiado*, Budapest.

Soó, R. 1964. Synopis systematico-geobotanica florae vegetationis que Hungariae, Budapest, I-V. Soolanayakanahally, R.Y., R.D. Guy, S.N. Silim, E.C. Drewesand W.R. Schroeder. 2009.

Soolanayakanahally, R.Y., Guy, R.D., Silim, S.N., Drewes, E.C., Schroeder, W.R 2009. Enhanced assimilation rate and water use efficiency with latitude through increased photosynthetic capacity and internal conductance in balsam poplar (*Populus balsamifera* L.). *Plant Cell Environ*., 32(12): 1821-1832.

Tadesse, W. and E. Bekele. 2001. Factor analysis of yield in grass pea (*Lathyrus sativus* L.). *Lathyrus Lathyrism Newsletter*, 2: 416-421.

Taüber, F. 1987. Contibuţii la sintaxonomia pinetelor carpato-dacice (Lathyro-Carpinetalia), *Contributii Botanice* (1991-1992), Cluj-Napoca, pp. 15-29.

Tutin, T.G., Heywood, V.H., Burges, N.A., Moore, D.M., Valentine, D.H., Walters, S.M., Webb, D.A. (Eds.) 1968-1993. Flora Europaea, Vols. 2-5 and Vol. 1, 2nd ed. Cambridge University Press, Cambridge.

Vida, G. 1963. Die zonalen Buchenwälder des Ostkarpatischen Florenbezirches (Transilvanicum) auf Grund Untersuchungen in Parâng-Gebirge. *Acta. Acad. Sci. Hung*. Budapest, 9, 1-2: 177-196.

Zólyomi, B. 1954. Phytocénologie et la sylviculture en Hongrie, *Acta Botanica Academiae Scientiarum Hungaricae*, 1.

(Received for publication 17 December 2024)