VEGETATION OF SUBALPINE BUSHES DEVELOPED BY *PINUS MUGO* IN THE VLADEASA MOUNTAINS-WESTERN CARPATHIANS

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RESEARCH ARTICLE

Abstract
The aim of the research consists in the development of a phytocenological, ecological, bioeconomic and ecoprotective study of the subalpine bushes developed by Pinus mugo in the Vlădeasa Mountains.
A total of 8 phytocenological surveys were conducted in the sampling areas, i.e. the most representative of the phytocenoses of the association Calamagrostio villosae-Pinetum mugo, Sanda et Popescu 2002.
A floristic inventory was carried out in which the species we found were filled in into a synthetical association table while observing the affinity criteria for the coenotaxa, alliance, suballiance, order, and vegetation class to which they are subordinated.
The phytocoenoses of the subalpine bushes were analyzed based on tables, histograms, diagrams regarding their share in ecological classification by categories of lifeforms, phytogeographical elements, affinity of the ecological behaviour with respect to soil moisture, air temperature, chemical reaction of the soil as well as belonging to the genetic karyotype. Scientific, economic, ecoprotective, and bioeconomic relevance were also subjected to study.
We draw seven conclusions in which the research results are synthesized.

Keywords: plant association, phytotaxa, bushes, *Pinus Mugo,* natural habitat
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INTRODUCTION

The subalpine bushes developed by *Pinus mugo* have an exceptional protective role of the subalpine habitat preventing soil erosion.

From all the Western Carpathians, only the Boceasa and Vladeasa Mountains are areas of forests and subalpine bushes included in the protected area, SCI ROSCI0016 sites including the plots 104C, 117E, 123C, 123D, 124D of Management Unit I Boceasa and ROSPA0081, encompassing natural habitats of community interest sheltering rare species of plants in endangered ecosystems as well as populations of birds of global conservation interest, such as: *Circaetus gallicus* (the Short-toed Snake Eagle), *Aquila chrysaetos* (the Golden Eagle), *Falco peregrinus* (the Peregrine Falcon), *Bonasa bonasia* (the Hazel Grouse), *Strix uralensis* (the Ural Owl), *Bubo bubo* (the Eagle Owl), *Aegolius funereus* (the Tengmalm's Owl or the Boreal Owl), *Glaucidium passerinum* (the Eurasian Pygmy Owl), *Dryocopus martius* (the Black Woodpecker), *Picoides tridactylus* (the Eurasian Three-toed Woodpecker), *Ficedula albicollis* (the Collared Flycatcher), *Ficedula parva* (the Red-breasted Flycatcher).

The bushes developed by *Pinus mugo* as well as the pure spruce or beech forests mixed with resinous forests represent the living and nesting place of protected bird species but also migration stops, while the rocky areas are the favorites places of predatory bird species.

Buteasa Mountain (Boceasa) including Buteasa Peak, and Gropoiu Glacier, is part of the Natura 2000 site, has an area of 372.6 ha and the specification ROSCI0016 and it shelters plant species with high conservation value such as *Pinus mugo*, *Alnus viridis*, *Gentiana punctata*, *Aconitum variegatum ssp. paniculatum, Juniperus sibirica*, *Soldanella montana*, *Arnica montana*, *Campanula rotundifolia ssp. kladniana*, *Vaccinium gaultherioides*, *Hypericum richeri* Vill. ssp. *grisebachii* (Bois.) Nyman.

The Vladeasa Mountains provides an attractive tourist landscape thanks to their very varied landforms, the very rich vegetation and fauna in terms of species, natural resources, forest fruits, edible mushrooms, clearly marked and well-maintained tourist routes.

The goal of our research paper is to carry out a phytosociological, ecological, bioeconomic and eco-protective study of the bushes developed by *Pinus mugo* in the Vladeasa Mountains.

To reach the proposed goal, we set the following objectives to achieve:

- Floristic inventory of phytocoenoses developed by *Pinus mugo*,
- Study of the living soil cover of the subalpine bushes and the classification of the species in the association table according to their affinity to the coenotaxa, suballiance, alliance, order, and vegetation class to which they are subordinated,
- Ecological characterization of the cormoflora of the subalpine bushes in terms of distribution by the type of lifeform, phytogeographical elements, belonging to the environmental indices categories, soil moisture, air temperature and chemical reaction of the soil as well as the belonging to the genetic element (karyotype).

So far, specific detailed research works on forest ecosystems-subalpine bushes of *Pinus mugo* within the Vladeasa Massif have not been done except for the ones carried out by Resmerita (1970), and Burescu L.I.N (2018), and those conducted in the neighboring areas i.e. Padis Plateau, by Togor (2016).

MATERIAL AND METHOD

The research work was carried out on Vladeasa Mountain and Buteasa Mountain.

The biological material consists in the phytocenoses of the association *Calamagrostio villosae-Pinetum mugo*, Sanda et Popescu 2002, spread in the subalpine floor as wide strips of 350-450m on rough terrain with variable slopes (ranging between 4-34°), with surface rankers, gravels, rocks, boulders on skeletal soils but also on districambosoils, acid brown soils.

To establish the structure of living soil cover of the bushes, we employed the phytocenological research methods of the Central European school developed by Braun-Blanquet (1964) adapted to Romania's vegetation characteristics by Borza et Boscaiu (1965).

We selected the plant association defined by Géhu et Rivas-Martinez (1981), as the basic coenotaxa unit for the study of phytocoenoses.

The field research was carried out by traveling on the itinerary but also stationary, during the years 2021-2022, following the estimation of the thickness, and the degree of soil coverage with the estimation of the indices of abundance and dominance, according to the Braun-Blanquet et Pavillard system (1928) corroborated with the consistency indices (K=I-V) and highlighting the degree of fidelity of the species to the environment of the coenotaxa of the phytocoenoses in the case of the *Calamagrostio villosae-Pinetum mugo* association.

We carried out eight phytocenological surveys from the most representative communities of *Pinus mugo* bushes during their optimal vegetation period within areas of 400m^2, 600m^2, and 1200m^2. Among the eight surveys aforementioned, one phytocenological survey was carried out in the Gropoiu glacial caldera, at the altitude of 1,730m, three surveys were conducted on Buteasa Mountain, at altitudes of 1,795m, 1,753m, and 1,758m, and four surveys were carried out on Vladeasa Mountain, at altitudes of 1,822m, 1,836m, 1,823m, and 1,825m.

The surveys' results were inputted into the synthetic phytosociological table, being analyzed cenotaxonomically and in terms of consistency, and providing scientific information regarding the affiliation of the type of lifeforms, phytogeographic elements, ecological indices (moisture, temperature, chemical reaction of the soil), and the type of genetic karyotype.

In order to classify the phytocoenoses of the subalpine bushes by coenotaxa units, suballiance, alliance, and vegetation class, we reviewed the traditional floristic ecological systems of the authors Tüxen (1955), Braun-Blanquet (1964), Soó (1964-1980), Borza et Boscaiu (1965), Oberdorfer (1992), Mucina (1997), Rodwell et al. (2002), Pott (1995), Borhidi (1996), Sanda et al. (2008), Coldea et al. (2012), and Chifu et al. (2014).

To classify the cormoflora by categories of lifeforms we used the system developed by Raunkier (1937), and improved by Braun-Blanquet (1964), Sanda et al. (2003), Burescu et Toma (2005), and Ciocarlan (2009).

With regard the categories of phytogeographic elements, we studied the works developed by Meusel et Jäger (1922) and Coldea et al. (2006).

Cormoflora of the subalpine bushes was then analyzed in terms of the ecological indices categories (soil moisture, air temperature, chemical reaction of the soil) according to Ellenberg (1979) for Central Europe on a scale ranging from 1 to 9 and for Romania according to Sanda et al. (2003) using a 1 to 6 scale.

The research results were processed statistically and presented graphically in tables, histograms, and diagrams.

Table.1 ***Calamagrostio villosae-Pinetum mugo*** **Sanda et Popescu 2002**

Bio.	E.f.	M	T	R	2n	Survey no.	1	2	3	4	5	6	7	8	K	ADm
						Altitude (mamsl)	1730	1795	1753	1758	1822	1836	1823	1825		
						Grass cover (%)	100	90	100	100	80	100	100	100		
						Exposure	-	SV	-	-	S	-	E	SE		
						Slope (°)	-	28-34	-	-	4-8	-	12-18	8-12		
						Surface (m^2)	1200	1200	1200	1200	400	1200	1200	1400		
H	Eua	4	2,5	1,5	P	As. *Calamagrostis villosa*	3	2	3	4	3	4	4	2	V	41,8
MPh	Alp-Ec	0	2	0	D	As. *Pinus mugo*	5	5	5	5	5	5	5	5	V	87,5
						Pinion mugi et Junipero-Pinetalia mugi										
mPh	Arct-Alp	2,5	1,5	4	D	*Juniperus sibirica*	+	+	+	.	+	+	+	+	V	0,43
H	Alp-Carp-B	3,5	2	1,5	P	*Soldanella montana*	.	+	1	+	+	+	+	+	V	1
H	Cp	0	0	1	P	*Deschampsia flexuosa*	+	+	.	+	+	+	.	.	IV	0,43
H	E	2,5	2,5	2	DP	*Luzula luzuloides*	+	.	.	.	2	+	+	+	IV	2,43
H	Alp-Carp-B	0	0	3	D	*Laserpitium krapfii*	+	+	.	.	+	+	.	.	III	0,25
H	End	3,5	2	2	P	*Campanula abietina*	+	+	.	.	.	.	.	+	II	0,18
mPh	Alp-Carp-B	4	2	2	D	*Salix silesiaca*	.	.	.	.	.	+	+	.	II	0,12
						Vaccinio-Piceetea										
H	Alp-E	3,5	2,5	2,5	P	*Homogyne alpina*	+	+	1	1	+	+	+	+	V	1,62
Ch(nPh)	Cp	0	2	1	D	*Vaccinium myrtillus*	2	2	2	2	1	1	2	2	V	14,37
Ch(nPh)	Cp	3	2	1	D	*Vaccinium vitis-idaea*	.	+	+	+	+	+	+	+	V	0,43
H	Ec	3,5	2,5	2	DP	*Luzula sylvatica*	+	.	+	+	.	+	+	.	IV	0,31
MPh	E	0	0	0	D	*Picea abies*	.	+	+	.	+	+	+	+	IV	0,37
H	End	0	2,5	0	P	*Campanula napuligera*	+	.	.	.	.	+	.	.	II	0,12
H(G)	Alp-E	3	2	0	P	*Gentiana punctata*	.	.	+	.	.	+	+	.	II	0,18
H	Arct-Alp	3	2	1	D	*Hieracium alpinum*	.	+	.	.	+	+	.	.	II	0,18
H(G)	Cp	4	3	3	D	*Oxalis acetosella*	.	.	+	+	.	+	.	.	II	0,18
H	Arct-Alp	2,5	1	2	DP	*Festuca supina*	+	+	.	.	+	.	.	.	II	0,18
						Juncetea trifidi										
Ch(nPh)	Arct-Alp	3,5	0	1	D	*Vaccinium gaultherioides*	+	.	.	.	+	.	+	1	III	0,81
						Nardo-Callunetea										
H	E	3	2,5	3	P	*Arnica montana*	+	+	+	.	+	+	.	+	IV	0,37
H	Cp-Bo	3	0	0	DP	*Festuca rubra*	.	.	.	.	+	+	.	.	II	0,12
H	Alp-Carp-B	2,5	2,5	3	N	*Hypericum richeri ssp. grisebachii*	+	.	.	.	.	+	+	.	II	0,18
H	E	0	0	1,5	D	*Nardus stricta*	.	.	.	.	.	+	+	.	II	0,12
						Betulo-Adenostyletea										
H	Alp-Carp-B	3,5	3	4	P	*Achillea distans*	+	.	.	.	.	.	+	.	II	0,12
H	Alp-Carp-B	3,5	1,5	4	DP	*Aconitum variegatum ssp. paniculatum*	.	.	+	+	.	+	+	.	II	0,18
H	Ec	4	2	4	P	*Geantiana asclepiadea*	.	.	.	+	.	+	.	.	II	0,12
						Seslerietea albicantis										
H	End	2,5	2	0	DP	*Campanula kladniana*	+	+	.	.	.	.	+	.	II	0,18
						Epilobietea angustifolii										
nPh	Cp	3	3	3	DP	*Rubus idaeus*	+	.	.	+	.	+	.	.	II	0,18
H	Eua	3,5	3	3	P	*Senecio nemorensis*	+	+	.	.	.	.	.	.	II	0,12
						Variae syntaxa										
						Cetraria islandica	.	.	.	.	+	1	+	+	III	0,81
						Cladonia rangiferina	.	.	.	.	+	+	.	.	II	0,12

Species found in a single survey: *Thymus glabrescens* (2) +; *Deschampsia caespitosa* (1) +; *Solidago virgaurea* (1) +; *Athyrium distentifolium* (1) +; *Doronicum austriacum* (1) +; *Dryopteris cristata* (3) +; *Veratrum album* (5) +; *Agrostis capillaris* (6) +; *Polytrichum juniperinum* (6) +.

Location and date of surveying: 1-46°41'845''N, 022°42'903''E Gropoiu (27.08.2022), 2-46°42'005''N, 022°42'767''E, 3-46°41'760''N, 022°42'826''E, 4-46°41'678''N, 022°42'641''E, Boceasa Mountain (27.08.2022), 5-46°45'646''N, 022°47'723''E, 6-46°45'605''N, 022°47'689''E, 7-46°45'513''N, 022°47'771''E, 8-46°45'420''N, 022°47'786''E, Vladeasa Mounatin (09.09.2022).

RESULTS AND DISCUSSIONS

The phytocenosis, respectively the forest ecosystem gathers 33 species, of which two species belong to lichens, which means a high biodiversity, considering the altitude of the subalpine floor as well as the critical climatic conditions. (see Table 1)

The species that develop and instill the physiognomy of the phytocenosis are the *Calamagrostis villosa* from *Poaceae* family with a coverage of 41.8%, maximum consistency (K=V) and the *Pinus mugo* bush with a coverage of 87.5%, and a maximum consistency (K=V) found in relation of codominance (see Figure 1). Along with the characteristic species, there is a rich nucleus totaling seven species subordinated to the alliance and order ***Pinion mugi et Junipero Pinetalia mugi*** (*Soldanella montana*, *Juniperus sibirica*, *Laserpitium krapfii*, *Campanula abietina, Salix, silesiaca*), class ***Vaccinio-Piceetea*** (*Homogyne alpina*, *Vaccinium myrtillus*, *Vaccinium vitis-idaea*, *Luzula sylvatica*, *Picea abies*, *Hieracium alpinum*, *Campanula napuligera*, *Gentiana punctata*) totaling 11 species. A relatively large number of species (11) are transgressive, and belonging to classes ***Juncetea trifidi*** (*Vaccinium gaultherioides*), ***Nardo-Callunetea*** (*Festuca rubra*, *Arnica montana*, *Hypericum richeri ssp. grisebachii*), ***Betulo-Adenostyletea*** (*Aconitum variegatum ssp. paniculatum*, *Achillea distans*), ***Seslerietea albicantis*** (*Campanula kladniana*), ***Epilobietea angustifolii*** (*Rubus idaeus*, *Senecio nemorensis*).

Figure 1. ***Calamagrostio villosae-Pinetum mugo***, Sanda et Popescu 2002 (original picture taken on 27.08.2022, on Boceasa Mountain)

The analysis of the spectrum of lifeforms shows the dominance of hemicryptophytes (74.1%), followed at a great distance by phanerophytes (16%) and camephytes (9.6%) (see Figure 2), since they adapt best to the subalpine environment.

A good knowledge of lifeforms is paramount because it highlights the adaptation of the plant corm to the living environment for the purpose of protecting regenerative buds during unfavorable seasonal conditions.

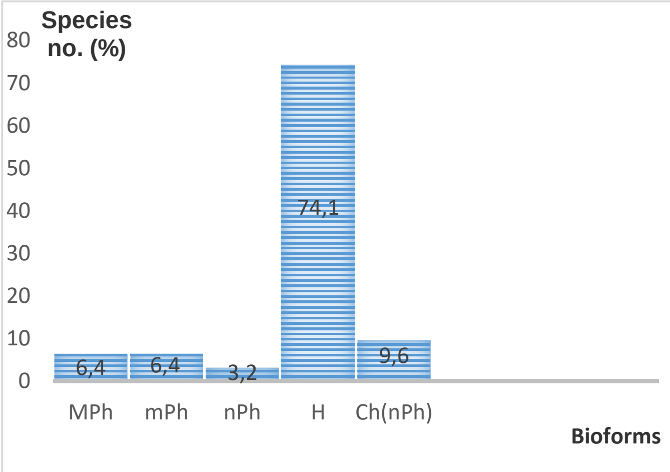

Figure 2. **Spectrum of lifeforms from the *Calamagrostio villosae-Pinetum mugo* association**

The spectrum of the phytogeographical elements that make up the flora of the subalpine scrubs in the Vladeasa Mountains highlights the share of circumpolar species (19.3%) on a par with the Alpine-Carpatho-Balkan ones (19.3%), followed by the Arctic-Alpine (12.9%) and European (12.9%) species, proving the close ties with the boreal flora of the North Polar Circle, and with that of the Alps and the Balkan Mountains. Eurasian and Central European species have a low share of 9.6% followed by endemites, Alpine-European species i.e. 6.4% and Alpine-Central European species i.e. 3.2% (see Figure 3 below).

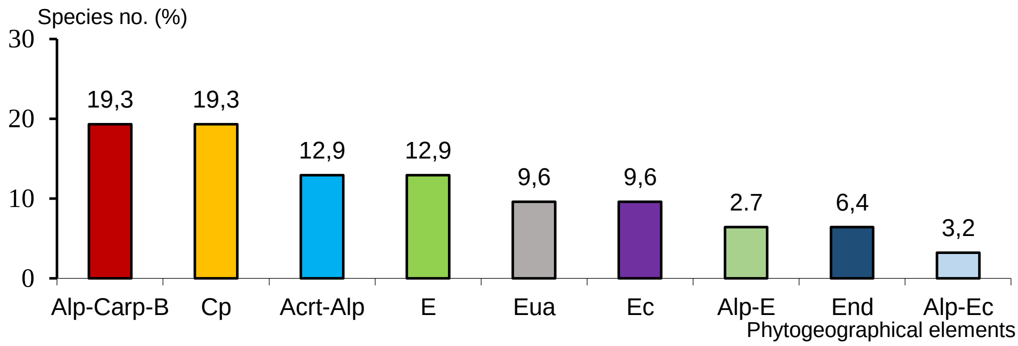

Figure 3. **Spectrum of phytogeographical elements from the *Calamagrostio villosae-Pinetum mugo* association**

The chart of the ecological indices shows the fact that depending on the soild moisture, the majority species are mesophilic (45.1%) followed by euryhydra (22.6%), xeromesophilic (16.1%), and mesohygrophilic species (i.e. 16.1%) (see Table 2).

In terms of air temperature, microthermal species predominate (58%), followed by eurythermal ones (19.3%), micromesothermal species (12.9%) and cryophiles (9.6%).

Strongly acidophilic species (25.8%) are the ones predominating in phytocenoses, followed by euriionic ones (19.3%), acidophilic (19.3%), acid-neutrophilic (19.3%) and weak-acid-neutrophilic species with a share of 16.1% (see Figure 4).

Table 2

Ecological indices for the *Calamagrostio villosae-Pinetum mugo* association

Ecological indices		1	1.5	2	2.5	3	3.5	4	4.5	0
M	sp. no.	-	-	-	5	6	8	5	-	7
	%	-	-	-	16.1	19.3	25.8	16.1	-	22.6
T	sp. no.	1	2	11	7	4	-	-	-	6
	%	3.2	6.4	35.4	22.6	12.9	-	-	-	19.3
R	sp. no.	8		6		6		5		6
	%	25.8		19.3		19.3		16.1		19.3

M=Soil moisture
T=Air temperature
R=Chemical reaction of the soil

The karyological spectrum of subalpine *Pinus mugo* bushes is dominated by polyploid species (38.8%) capable of phytosociological competition, of colonizing the bare space in a habitats facing hostile living conditions, very low temperatures, strong winds, strongly acidic and acidic soils, poor in assimilable mineral substances.

Diploid species have a steady percentage of 35.5%, ensuring the gene pool necessary for the evolution of phytocenosis populations through allopolyploidy and autopolyploidy followed by diplo-polyploid species (22.6%) while those with unknown karyotype have an insignificant presence (i.e. (3.2%) (see Figure 5).

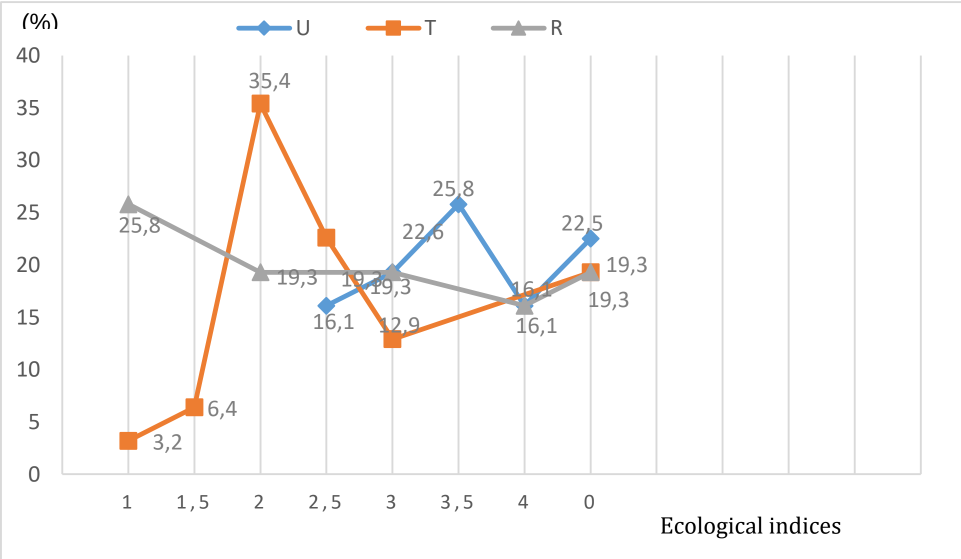

Figure 4. **Diagram of ecological indices for the *Calamagrostio villosae-Pinetum* mugo association**

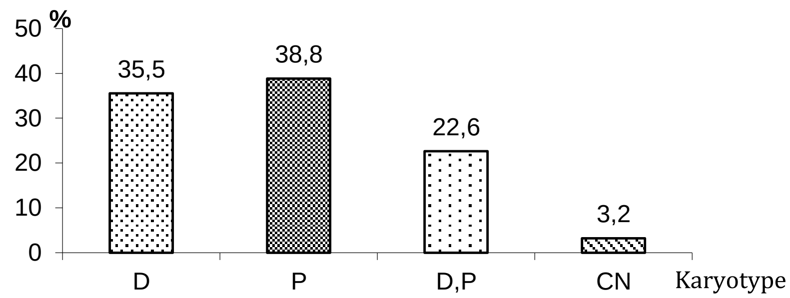

Figure 5. K**aryological spectrum of the *Calamagrostio villosae-Pinetum mugoi* association**

A significant number of rare, vulnerable, endemic species found shelter in the phytocoenoses of the association *Calamagrostio villosae-Pinetum mugo* (Sanda et Popescu 2002) such as: *Pinus mugo*, *Soldanella montana*, *Juniperus sibirica*, *Arnica montana*, *Campanula kladniana*, *Campanula napuligera*, *Campanula abietina*, *Gentiana punctata*, *Hypericum richeri ssp. grisebachii*, *Vaccinium gaultherioides*, *Aconitum variegatum ssp. paniculatum*.

Economic relevance

The ecosystem developed by *Pinus mugo* bushes in the Vladeasa Mountains is the home to medicinal herbs (*Gentiana punctata*, *Arnica montana*, *Juniperus sibirica*, *Vaccinium myrtillus*, *Vaccinium vitis-idaea*, *Vaccinium gaultherioides*, *Picea abies*, *Aconitum variegatum ssp. paniculatum*) as well as to fodder plants (*Festuca rubra*, *Agrostis capillaris*, *Nardus stricta*).

The thickets of *Pinus mugo* have no economic relevance for the forest mass; however, they have a pedological importance favoring the genesis of a thin layer of soil. These are included in the natural habitat of community interest NATURA 2000 4070* R3105 Southeast Carpathian bushes of mountain pine (*Pinus mugo*) with alpine rose whose conservation requires the designation of Special Areas of Conservation (ASC) - Habitats Directive, Annex I - in Romania, Donita et al. (2005). In terms of eco-management measures, the clearing of *Pinus mugo* thickets in order to exploit the meadows, as well as their burning, is prohibited.

CONCLUSIONS

The floristic inventory of the subalpine bushes gathered in the plant association *Calamagrostio villosae-Pinetum mugo*, Sanda et Popescu 2002, gathers a total number of 33 taxa of which 31 cormophyte species and two species of lichens, which shows the multitude of Arctic, Alpine, Artic-Alpine, Artic-Balkan elements, Carpathian endemic species.

The analysis of the ecological categories of lifeforms shows the majority share of hemicryptophyte species (74.1%) followed by phanerophytes (16%) and camephytes (9.6%).

The spectrum of phytogeographical elements with regard to the genetic center of origin as well as the geographical distribution area in which the speciation process took place shows us the share of circumpolar (19.3%) and Alpine-Carpatho-Balkan (19.3%) species followed by Arctic-Alpine and European species with the percentage of 12.9%.

The ecological indices of the phytocenosis of the *Pinus mugo* thickets suggest that they have a mesophilic (45.1%), microthermal (58%) and a strongly acidophilic (25.8%) nature.

Cytogenetic analysis shows the share of polyploid species (38.8%) followed by diploid (35.5%) and diplo-polyploid (22.6%) species.

The subalpine bushes of *Pinus mugo* in the Vladeasa Mountains are not relevant from economic standpoint, but they represent the vegetation that provides the subalpine ecosystem with essential environmental services in critical situations, land stability and soil protection (prevention of soil erosion, landslides, and avalanches).

The bibliographic index encloses 32 references of the authors whose scientific works were consulted.

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