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Phytocoenological-pedological features of subalpine beech forests (as. *Ranunculo platanifoliae-Fagetum* Marinček *et al.* 1993) on northern Velebit

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Abstract

Background and Purpose: *Beech forests in the subalpine belt of Velebit (1-4) have not been extensively investigated so far, nor have their nomenclatural and systematic affiliation been analyzed according to the latest phytocoenological concepts (5-7). Phytocoenological research and adjustment were combined with the study and analysis of basic soil types and their pedophysiographic properties.*

Materials and Methods: *Phytocoenological research, encompassing the analysis of 11 relevés and comparisons with other relevant studies (3, 8, 9), follows classical principles of the Braun-Blanquet School (10). Taxonomic nomenclature was coordinated according to Nikolić (11-13). Pedophysiographic soil features were described by types and pedogenetic horizons on the basis of the profiles opened within the community.*

Results: *As many as 96 species, or 41 species per relevé on average, were registered in 11 phytocoenological relevés. The dominant layer of the community under study was characterized by* Fagus sylvatica, *with* Acer pseudoplatanus *also taking an important position and* Abies alba *featuring on the bottom boundary. There were no distinctly dominant species in the shrub layer, while the ground layer contained important species of the alliance* Aremonio-Fagion *and the order* Fagetalia. *The substrate of limestones with dolomite interbeds, dolomitized limestones, and calcareous breccias (14-17) supports a long series of subtypes and varieties of mollic leptosol and cambisols, luvisols in sinkholes and sporadic occurrences of rendzic leptosols.*

Conclusion: *Beech forests in the subalpine belt of northern Velebit at altitudes between 1,200 and 1,500 m manifest their affiliation to the association* Ranunculo platanifoliae-Fagetum *Marinček et al. 1993. The comparison with adjacent areas shows very high similarity in physiognomy, ecological conditions and floristic composition. Pedological research revealed exceptional variability of soil types over a relatively small space. The studied forests on northern Velebit take up approximately 6,000 ha. Presently, they belong to protective forests and are left to natural succession.*

INTRODUCTION

Pre-mountainous (subalpine) belt is the highest forest vegetation belt in Croatia generally beginning at altitudes above 1,200 m. Its lower part is characterized by beech forests of mainly protective character. In terms of physiognomy, beech differs from stands in lower belts, but pre-mountainous belt is not unique in this sense. As altitude increases, beech trees become smaller and assume a sable-like form, and even shrub-like appearance on the upper boundary. Beech forests of the subalpine belt have not recently been consistently investigated in Croatia. For this reason we will provide a brief overview of past research and a more detailed nomenclatural description.

Research overview

First description of the community at the level of subassociation *Fagetum sylvaticae croaticum australe subalpinum* was provided by Horvat *(1)*, who defined it with 15 phytocoenological relevés. These served as a basis for all subsequent comparisons and analyses of identical and affiliated stands. The relevés were taken on Velebit. Later, Horvat *(18)* describe a community in the western part of Croatia, where Horvat *et al.* *(2)* showed 13 relevés in a synthetic form and nameed it *Aceri-Fagetum illyricum* in the rank of association. Bertović *(19)* investigated ecological vegetational features on Zavižan on northern Velebit and provides two relevés of a pre-mountainous beech forest. Vukelić *(8)* provides 8 relevés from Risnjak National Park in Gorski Kotar, while Pelcer and Medvedović *(4)* proposed the criteria for subalpine beech forest zoning in the Dinaric part of Croatia. They divide the entire distribution range into two variants, the littoral one in which beech continues onto the maritime beech forest with *Sesleria*, and the continental one in which beech continues onto the belt of beech-fir forests, generally above 1,200 m. In the phytocoenological sense, they use 18 relevés to classify them into three subassociations: *typicum*, as the most important, inhabiting the continental side of the range, *adenostyletosum alliariae* in the elevated parts of the range with sable-like stems, and *seslerietosum autumnalis* for the littoral variant with a sub-Mediterranean influence and differentiating species of a thermophilic character. Trinajstić *(20)* described a new association *Doronico columnae-Fagetum* in the pre-mountainous belt of Biokovo, which differs considerably from other pre-mountainous beech stands in Croatia in terms of the number and sociological affiliation of the species. Other names used in Croatia are *Homogyno sylvestris-Fagetum* Borhidi 1963 *(21)* and *Homogyno alpinae-Fagetum* Borhidi 1963 *(22)*.

In Slovenia, the research associated with beech forests in the subalpine belt was intensified in the 1960s, resulting in papers by Marinček *(23, 9)* and Marinček *et al.* *(7)* who synthesised their views on nomenclature and taxonomy. An important point for the forestry in Croatia was the new sub-alliance described under the name *Saxifrago-Fagenion*, which encompasses two associations. Marinček divides the first association, *Ranunculo platanifoliae-Fagetum*, in three geographical variants, of which the one with the species *Calamintha grandiflora* belongs to the high-mountainous belt of beech forests in the western and central part of the Dinaric range, including northern Velebit. The second association contains taller growing shrub-like beech forests under the name *Polysticho lonchitis-Fagetum* Marinček in Poldini et Nardini 1993.

In the northernmost part of the pre-alpine beech forest range of the Illyrian character, Zukrigl *(24)* described the associations *Saxifrago rotundifoliae-Fagetum* Zukrigl 1989 (a synonym for *Ranunculo platanifoliae-Fagetum*) and *Myrhidi-Fagetum* Zukrigl 1989 (a synonym for *Aconito panniculati-Fagetum* /Zupančič 1969/ Marinček *et al.* 1993), which is also cited in the list of vegetation in Austria *(25)*.

In Bosnia, Fukarek *(26)* also describes the association *Aceri-Fagetum* Fukarek et Stefanović 1958 p.p. emend. in the Sutjeska National Park. He subordinates it to the alliance *Fagion illyricum* and divides it into five subassociations: *aceretosum, piceetosum, aposeridetosum, mughetosum* and *dolomiticum*. He points out that *Hacquetia epipactis, Omphalodes verna, Cardamine trifolia,* and *Dentaria polyphylla*, for example, are absent in the central part of Bosnia, but despite this reduction there is still a considerable number of species of the alliance *Fagion illyricum*. To sum up, the association of beech and sycamore (*Aceri-Fagetum* J. Bartsch et M. Bartsch 1940) belongs to the Central European area, it is subordinate to the alliance *Fagion* Luquet 1926, and finally, the name should not be used within the framework of Illyrian beech forests.

Research into soil types and their properties in the pre-mountainous belt of northern Velebit was intensified in the second half of the 20th century. The study of ecological-management forest types *(27)* and ecological-pedological features of particular localities *(19, 28)* or their wider areas *(29)* are of great importance for the science of forestry. One of the objectives of these studies is to establish interaction between forest vegetation and soil types and their particular properties. This interaction is frequently a starting point for a better understanding of the origin, development and distribution of a plant community. Soil properties in pre-mountainous beech forests in this paper are presented on the basis of earlier typological research mentioned above, as well as the authors' own research.

Ecological Features of the Study Area and the Stands

Subalpine belt on northern Velebit begins on the continental side at an altitude over 1,200 m. Above Krasno it ascends in the direction of some fifteen peaks, of which Mali Rajinac (1,699 m) is the highest. Almost the entire area is covered with forests, except for some vast, abandoned pastures in the succession toward forests occurring in Jezera, Alančić and the area around Zavižan.

The lithological structure is made up of Dogger limestones with interbeds of dolomites, malmic dolomitized limestones, and paleogenic calcareous breccias and limestones *(14-17)*. The prevailing calcareous rocks support a series of subtypes and varieties of mollic leptosols and cambisols, with luvisols occurring in sinkholes, while the specific physical weathering of the dolomite leads to the development of rendzic leptosols, mollic leptosols and cambisols.

According to the data from Zavižan Meteorological Station (1,594 m above the sea) for the 1961 – 1990 period, the climate is perhumid, moderately cold with an average annual air temperature of 3.5 °C and average annual precipitation of 1,900 mm. The high snow cover retained on the soil for almost 7 months is responsible for sable-like forms of beech stems in the bottom part, which makes these stands physiognomically recognizable. With an increase in altitude, beech assumes a curved form and a height of only several metres.

MATERIALS AND METHODS

Research on northern Velebit was based on 3 relevés of our own, 3 from the study of Vukelić *et al.* *(30)*, 4 relevés of I. Horvat *(1)* and 1 of S. Bertović *(19)*. To make our own phytocoenological relevés, we selected those protective stands which had been excluded from management and other impacts for some time and consequently had a stable floristic composition. In our research and description we relied on the classical central European phytocoenological method *(10)*, which resulted in 11 relevés in Table 1. The relevés were made in different parts of northern Velebit at altitudes between 1,320 and 1,500 m. The size of the relevés was 900 m^2. Plant nomenclature was taken from Nikolić *(11-13)*, while mosses were not determined.

Data for pedological profiles opened within the studied community were used to describe soil properties. Table 2 contains descriptive statistics by soil type and genetic horizons. The parameters include horizon thickness, particle size distribution, soil reaction in the suspension with H_2O and KCl, organic carbon and total nitrogen content, the C/N ratio, and physiologically active P_2O_5 and K_2O.

RESULTS

As many as 96 species, or 41 species per relevé on average, were detected in the 11 surveyed plots (Table 1). There were a total of 13 species of the alliance *Aremonio-Fagion* (I. Horvat 1938) Török, Podani & Borhidi 1989. The species *Calamintha grandiflora, Cardamine enneaphyllos, Aremonia agrimonoides, Cardamine polyphylla* and *Euphorbia carniolica* were particularly well represented. There were 37 species of the order *Fagetalia* Pawlovski in Pawlovski *et al*. 1928*,* of which *Fagus sylvatica* and *Acer pseudoplatanus* make up the tree layer, while *Galium odoratum, Mercurialis perennis, Prenanthes purpurea, Paris quadrifolia, Festuca altissima, Mycelis muralis* and *Cardamine bulbifera* take a distinct place with their constant presence and extensive cover. Of other systematic units, there were frequent occurrences of widely distributed species *Anemone nemorosa* and *Abies alba,* of which the latter was found in its upper growth boundary within beech-fir forests in Croatia. Characteristic and differentiating species of the association (*Adenostyles glabra*, *Polygonatum verticillatum*, *Ranunculus platanifolius*, *Saxifraga rotundifolia*, *Luzula sylvatica*, *Cicerbita alpina*) are very important diagnostically for differentiation and identification of the association. The participation degree of these species in the analyzed relevés is 1 and 2, while only the first two participate with the degree of 5. *Ranunculus platanifolius* was not evenly distributed and was even absent in some plots, whereas *Saxifraga rotundifolia* occured more frequently in higher position and rockier localities. Such a species ratio is very similar to that of Marinček *(9)* for the plots in Slovenia (Column 15, Table 1).

It was not possible to make an accurate typological classification on the basis of the analyzed relevés since the classification has not yet been standardized. Some individual relevés, such as 2 and 7, for example, may be attributed to the facie *Aposeris foetida*, and similar. Based on comparison with results of Slovenian authors *(9)*, the study area belongs to the association *Ranunculo platanifoliae-Fagetum*, variant *Calamintha grandiflora*. In Štokić Duliba, in the immediate vicinity of Baričević Dolac, we made preliminary relevés of the plots that show affiliation with the subassociation *seslerietosum* within the same association and variant *(31)*. Very stony areas were covered with autumn moor-grass, with a significant presence of thermophilic species in the floral composition. These stands will be investigated in detail in 2008.

Based on field observations and soil properties of the profiles opened within the community *Ranunculo platanifoliae-Fagetum*, presented in Table 2, it can be said that luvisols occur in the lower part of slopes and in sinkholes. Due to their specific position in the relief, they also have the deepest profile ranging from the minimal 53 to the maximal 75 cm. Cambisol, occurring on slopes, is the best represented soil of this community. It is slightly shallower than luvisol and ranges in depths from 37 to 60 cm. At higher and steeper positions or on slopes and above bulky limestones, there were shallower soils of mollic leptosol (brunic) and molic leptosol (humic) with depths from 38 to 43 cm, and 36 respectively.

All the investigated soils in A horizon had an equal clay content that varied from 39.2% in luvisols to 22.3% in mollic leptosols. Luvisol clay content increases slightly in the E horizon and was 1.5 times higher in the Bt horizon, which is characteristic for these soils with regard to their pedogenesis of clay mineral leaching. The clay content in B horizon in cambisols was 41.4%.

In terms of soil reaction in KCl, luvisol was acid across the profile, while cambisol and mollic leptosol (brunic) ware acid in A horizon but weakly acid in B, or AB horizon. As for the organic carbon content in A horizon, luvisol could be said to be highly humous, while all the other soils were richly humous. All the soils were very rich in total nitrogen. The mean value of the total nitrogen content was the lowest in luvisol and amounted to 4.3 g kg^{-1}. All the soils were relatively poorly supplied with physiologically active phosphorus. Cambisol and luvisol were equally well supplied with physiologically active potassium, but its amount in Mollic Leptosol was much lower.

TABLE 1

Floristic composition of the association *Ranunculo platanifoliae-Fagetum* in Northern Velebit and comparison with floral compositions of stands from another areas.

Association:		*Ranunculo platanifoliae-Fagetum* Marinček et al. 1993														
Subassociation:													Northern Velebit	Southern Velebit	Risnjak	Slovenia
Area:		Northern Velebit														
Source:		H	H	H	H	VB	VB	VT	VT	VT	B	VB				
Altitude (10 m) :		125	130	132	145	147	136	137	135	132	152	134				
Exposition:		SE	SE	S	NW	N	NW	N	NE	E	SE	N				
Inclination (grade):		15	12	20	27	15	25	5	35	10	20	10				
The number of species:		32	29	32	39	40	34	39	27	36	39	43				
The number of releves:		1	2	3	4	5	6	7	8	9	10	11				
Ass. – characteristic and differential species													Participation degree:			
Adenostyles glabra	C	+	1	1	+	+	.	2	2	1	3	3	5	.	.	4
Polygonatum verticillatum		1	+	+	+	+	.	1	+	+	1	1	5	3	3	5
Ranunculus platanifolius		1	.	1	+	.	.	.	.	.	+	+	2	2	4	3
Saxifraga rotundifolia		.	.	.	.	.	.	.	.	+	+	+	1	3	3	2
Luzula sylvatica		.	.	.	.	.	.	.	.	+	.	+	1	.	.	3
Cicerbita alpina		.	.	.	.	+	.	.	.	.	.	+	1	2	.	1
Saxifrago rotundifolii-Fagenion species																
Polystichum lonchitis		.	.	.	+	+	+	.	.	.	2	.	2	3	.	1
Adenostyles alliaria		.	.	+	+	+	.	.	.	.	.	.	2	4	.	2
Clematis alpina		.	.	.	.	.	.	.	.	.	.	.		.	.	1
Rhododendron hirsutum		.	.	.	.	.	.	.	.	.	.	.		.	.	1
Aremonio-Fagion species																
Rhamnus fallax	B	.	.	.	+	.	.	.	+	+	.	.	2	1	2	1
Daphne laureola		.	.	.	.	.	.	.	.	.	.	.		1	.	.
Calamintha grandiflora	C	.	.	.	+	+	+	.	+	+	+	1	3	3	3	3
Cardamine enneaphyllos		1	1	1	+	+	+	+	+	.	3	1	5	2	3	5
Aremonia agrimonoides		+	.	+	+	.	.	+	+	+	.	+	3	2	4	3
Knautia drymeia		.	.	.	.	+	.	.	.	.	.	.	1	.	.	.
Cardamine polyphylla		+	1	+	1	+	+	.	.	.	.	+	3	1	.	.
Helleborus multifidus		.	.	.	.	+	.	.	.	.	.	.	1	.	2	.
Geranium nodosum		.	.	.	.	+	.	.	.	.	.	.	1	.	.	.
Euphorbia carniolica		.	.	.	.	+	+	1	.	+	.	.	2	.	2	1
Vicia oroboides		.	.	.	.	+	.	+	.	.	.	.	1	.	2	3
Cardamine trifolia		.	.	.	.	1	2	.	.	.	.	3	1	2	3	4
Hacquetia epipactis		.	.	.	.	.	.	.	.	.	.	.		.	3	2
Cyclamen purpurascens		.	.	.	.	.	.	.	.	.	.	.		.	3	2
Homogyne sylvestris		.	.	.	.	.	.	.	.	.	1	.	1	.	4	1
Primula elatior		.	.	.	.	.	.	.	.	.	.	.		3	3	2
Helleborus niger		.	.	.	.	.	.	.	.	.	.	+		.	3	.
Lamium orvala		.	.	.	.	.	.	.	.	.	.	.		.	.	1
Sesleria autumnalis		.	.	.	.	.	.	.	.	.	.	.		.	.	1
Isopyrum thalictroides		.	.	.	.	.	.	.	.	.	.	.		.	.	1
Omphalodes verna		.	.	.	.	.	.	.	.	.	.	.				1
Fagetalia species															.	
Fagus sylvatica	A	4	4	3	5	5	5	5	5	4	4	5	5	5	5	5
Ulmus glabra		.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Fraxinus excelsior		.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Acer pseudoplatanus		.	.	.	.	.	.	.	.	+	.	+	1	4	4	5
Acer pseudoplatanus	B	.	.	.	+	+	.	.	.	.	.	+	1	.	3	.
Fagus sylvatica		1	3	3	1	+	1	1	2	+	1	1	5	.	4	.
Lonicera alpigena		1	.	1	1	+	+	.	.	+	.	.	3	4	2	2
Fraxinus excelsior		.	.	.	.	+	.			.	.	.	1	.	.	.
Daphne mezereum		.	.	.	.	.	.	.	+	.	.	+	1	.	4	4
Lonicera xylosteum		.	.	.	.	.	.	.	.	.	.	.		3	.	.

Galium odoratum	C	2	+	2	2	2	.	1	1	+	+	2	5	5	4	2
Cardamine bulbifera		.	.	+	1	+	+	+	.	+	.	.	3	3	.	3
Mycelis muralis		+	.	+	.	+	+	1	1	+	+	+	4	3	3	3
Lamium galeobdolon		.	.	.	+	2	3	+	+	+	+	1	4	3	3	.
Festuca altissima		+	.	+	1	.	+	1	2	+	.	+	4	.	3	2
Acer pseudoplatanus		+	.	1	.		.	.	.	.	.	.	1	.	2	.
Sanicula europaea		.	.	.	.	.	+	.	.	.	.	.	1	3	2	1
Viola reichenbachiana		+	.	+	.	+	+	+	.	+	+	+	4	3	3	1
Fagus sylvatica		1	+	2	.	+	.	+	2	4	.	.	4	.	3	.
Mercurialis perennis		.	1	1	2	1	3	2	3	1	5	.	5	2	5	4
Prenanthes purpurea		1	1	1	1	3	1	3	3	1	3	1	5	5	4	4
Actaea spicata		.	.	+	+	.	+	.	1	2	+	.	3	4	.	1
Melica uniflora		.	.	.	.	.	.	.	+	.	.	.	1	.	.	.
Carex sylvatica		.	.	.	.	.	.	+	.	.	3	+	1	2	3	2
Symphytum tuberosum		.	.	.	1	+	+	.	.	.	+	+	2	2	.	3
Euphorbia dulcis		+	.	1	.		.	+	.	.	.	+	2	.	.	.
Geranium robertianum		.	.	.	.	.	+			.	.	+	1	1	.	1
Euphorbia amygdaloides		+	.	.	.	+	+			.	+	+	2	.	4	3
Veronica montana		.	.	.	.	.	+			.	.	+	1	.	.	.
Paris quadrifolia		1	+	+	1	+	+	+	.	+	+	1	5	4	.	3
Polystichum aculeatum		.	.	+	+	.	+	+	.	.	.	+	2	.	.	2
Aruncus dioicus		.	.	.	+		.	.	.	.	.	.	1	.	.	.
Brachypodium sylvaticum		+	+	.	.		.	1	2	+	.	.	3	1	3	.
Galium sylvaticum		.	.	.	.	.	.	1	.	.	.	.	1	.	.	.
Heracleum sphondyllium		.	.	.	.	.	.	+	+	+	.	+	2	2	.	.
Pulmonaria officinalis		.	.	.	.	.	.	.	.	.	+	.	1	1	.	1
Carex pilosa		.	.	.	.	+	.	.	.	.	.	+	1	.	.	1
Allium ursinum		.	.	.	.	.	.	.	.	.	.	.	.	2	1	.
Corydalis cava		.	.	.	1	.	.	.	.	.	.	.	1	.	.	.
Phyteuma spicatum		+	1	.	+	.	.	.	.	.	+	.	2	2	4	3
Cirsium erisithales		.	+	+	+		.	+	.	+	.	.	3	2	5	.
Ranunculus lanuginosus		.	.	.	.	+	.	.	.	.	+	.	1	.	.	2
Hordelymus europaeus		.	.	.	.	.	1	2	.	+	.	.	2	2	.	.
Salvia glutinosa		.	.	.	.	.	.	.	.	.	.	.	.	2	3	.
Lilium martagon		.	.	.	.	.	.	.	.	.	.	.	.	.	3	2
Valeriana tripteris		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Neottia nidus avis		.	.	.	.	.	.	.	.	.	.	.	.	1	1	.
Epilobium montanum		.	.	.	.	.	.	.	.	.	.	.	.	.	2	1
Heracleum montanum		.	.	.	.	.	.	.	.	.	.	.	.	1	2	.
Campanula trachelium		.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Asarum europaeum		.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Circaea lutetiana		.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Allium victorialis		.	.	.	.	.	.	.	.	.	.	.	.	.		1
Stellaria montana		.	.	.	.	.	.	.	.	.	.	.	.	.		1
Lathyrus vernus		.	.	.	.	.	.	.	.	.	.	.	.	.		2
Polygonatum multiflorum		.	.	.	.	.	.	.	.	.	.	.	.	.		1
Quercetalia pubescentis species																
Sorbus aria	A	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.
Sorbus aria	B	.	+	.	.		.	+	.	.	.	.	1	.	1	.
Siler trilobum		.	.	.	.	+	.	.	.	.	.	.	1	.	3	.
Melittis melissophyllum		.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
Querco-Fagetea species																
Rosa arvensis	B	1	+	1	+	.	.	.	.	.	.	.	2	.	.	.
Anemone nemorosa	C	1	2	2	2	2	1	1	+	+	.	3	5	4	5	5
Carex digitata		.	1	1	.	.	.	.	+	.	.	.	2	.	.	1
Platanthera bifolia		+	.	+	.	.	.	.	.	.	.	.	1	.	.	.
Hepatica nobilis		.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Helleborus odorus		.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Aegopodium podagraria		.	.	.	.	.	.	.	.	.	.	.	.	.	.	1

Galium laevigatum		.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Cruciata glabra		.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Vaccinio-Piceetea species																
Abies alba	A	2	+	+	.	.	1	.	.	+	.	.	3	2	2	2
Picea abies		.	.	.	.	.	.	.	.	.	1	1	1	.	2	3
Sorbus aucuparia		.	.	.	.	.	.	.	.	.	+	.	1	2	1	.
Sorbus aucuparia	B	+	+	.	.	+	+			.	.	+	2	.	3	.
Vaccinium myrtillus		1	3	.	.		.	.	.	+	.	.	2	1	.	1
Rubus saxatilis		.	+	.	+		.			.	.	.	1	.	.	1
Abies alba		1	.	+	+	.	+	.	.	.	+	.	3	.	.	.
Rosa pendulina		.	.	.	.	.	+	+	.	+	.	.	2	.	3	2
Picea abies		.	.	+	.	.	.	.	.	.	+	.	1	.	.	.
Lonicera nigra		.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Oxalis acetosella	C	.	.	.	.	2	.	1	+	+	1	2	3	5	.	4
Abies alba		.	+	1	.	.	.	+	.	.	.	.	2	.	.	.
Hieracium sylvaticum		+	+	.	.	.	.	+	.	.	+	.	2	1	.	.
Maianthemum bifolium		+	+	.	.	.	.				+	.	2	1	.	3
Veronica urticifolia		+	+	+		.	.	+	.	+	+	.	3	1	3	2
Melampyrum pratense		.	.	.	.	.	.	+	1	.	.	.	1	.	.	.
Pirola chlorantha		.	+	.	.	.	+	.	.	.	.	.	1	1	2	.
Solidago virgaurea		.	.	.	.	.	.	.	.	.	.	.	.	.	2	1
Gentiana asclepiadea		.	.	.	.	.	.	.	.	.	+	.	1	.	2	3
Picea abies		.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Calamagrostis arundinacea		.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Luzula pilosa		.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
Valeriana tripteris		.	.	.	.	.	.	.	.	.	.	.	.	.	2	2
Aposeris foetida		.	3	+	+	.	.	2	1	+	.	.	3	.	3	2
Adenostyletalia species																
Ribes alpinum	B	.	.	.	+	.	+	.	.	.	.	.	2	.	.	1
Dryopteris filix-mas	C	.	.	.	1	+	+	+	.	.	.	+	2	4	3	3
Athyrium filix femina		.	.	.	.	.	.	.	.	.	.	+	.	4	2	3
Senecio ovatus		+	.	.	+	+	+	.	.	+	+	1	3	5	2	4
Petasites albus		.	.	.	.	1	.			.	.	.	1	3	.	.
Rubus idaeus		.	.	.	.	.	.	+	+	.	+	1	2	2	3	.
Doronicum austriacum		.	.	.	+	+	.	+	.	.	+	1	2	.	.	1
Aconitum lycoctonum ssp. *vulparia*		.	.	.	+	.	.	+	.	+	.	.	2	.	.	.
Milium effusum		.	1	.	1	.	.	+	.	.	.	.	2	2	.	1
Veratrum album		.	.	.	.	+	.	.	.	.	2	1	1	.	.	5
Veratrum lobelianum										.	.	.	.	2	.	.
Thalictrum aquilegifolium		.	.	.	.	.	.	.	1	+	.	.	1	1	2	.
Anthriscus sylvestris		.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Anthriscus nitida		.	.	.	.	.	.	.	.	.	.	.	.	.		1
Aconitum veriegatum		.	.	.	.	.	.	.	.	.	.	.	.	.		1
													.	.	.	.
Other species													.	.	.	
Rosa sp.	B	.	.	.	.	.	.	.	.	.	+	.	1	1	.	.
Fragaria vesca	C	+	.	+	.	.	+	.	.	.	+	.	2	1	2	.
Valeriana montana		.	1	+	+	+	.	.	+	.	.	.	3	.	.	.
Luzula luzuloides		.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Ranunculus thora		.	1	.	.	.	.	.	.	.	.	.	1	.	.	.
Buphtalmum salicifolium		.	.	.	.	.	.	.	.	.	.	.	.	2	1	.
Chaerophyllum sp.		.	.	.	.	.	.	.	.	.	.	.	.	3	.	.
Asplenium virde		.	.	.	.	.	.	.	.	.	.	.	.	1	.	.
Astrantia carniolica		.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Dryopteris expansa		.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Laserpitium krapfii		+	1	.	.	.	.	+	+	+	+	+	3	3	.	.

Explenation of abbreviations:
A – Tree layer, B – Shrub layer, C – Herb layer
"+ – 5 – Combined assessment of abundance and cover *(10)*

Source of releves:
VB – our own, VT *(30)*, H *(1)* and B *(19)*
Southern Velebit *(3)*, Risnjak *(8)*, Slovenia *(9)*

TABLE 2

Soil properties of luvisol, cambisol, mollic leptosol (brunic) and mollic leptosol (humic) are given on the basis of earlier synthesised pedological research (27, 29).

	Variable	Luvisol – N = 3				Cambisol – N = 10				Mollic leptosol (brunic) – N = 2				Mollic Leptosol – N = 1
		Mean	Minimum	Maximum	Std.Dev.	Mean	Minimum	Maximum	Std.Dev.	Mean	Minimum	Maximum	Std.Dev.	Measured value
	Profile depth (cm)	64,3	53,00	75,00	11,02	48,3	075,00	75,00	6,86	40,5	3,00	43,00	3,54	36,0
			A				A				*1*			A
	Horizon depth (cm)	10,0	6,00	17,00	3,46	7,5	4,00	10,06,0	2,22	14,5	17,00	17,00	3,54	36,0
Particle size distribution	2,0–0,2 mm	1,0	01,20	1,50	0,47	2,0	01,20	4,10	1,29	0,9	01,20	1,20	0,42	0,6
	0,2–0,2-0,02 mm	036,00	22,60	23,50	0,47	38,1	19,60	56,50	11,83	31,0	26,00	36,00	7,07	31,0
	0,02–0,002 mm	43,2	39,20	46,80	3,82	39,204	19,40	239,20	3,4	401,4	40,40	42,40	1,41	46,1
	< 0,002 mm	32,9	29,80	37,40	4,01	26,5	16,60	31,00	7,05	26,7	22,40	31,00	6,08	22,3
	pH (H_2O)	5,83	5,60	6,10	5,75	5,77	5,17	6,08	0,29	5,75	5,60	5,90	0,21	7,20
	pH (KCl)	4,73	4,40	5,10	0,35	5,22	4,40	5,10	0,35	4,90	4,40	5,10	0,28	6,60
	Org. C (g kg^{-1})	69,8	65,54	73,08	3,86	98,8	57,75	128,35	22,69	93,7	93,38	93,96	0,41	178,1
	Total N (g kg^{-1})	4,3	4,00	4,80	0,42	5,6	6,30	7,70	1,18	6,7	6,30	7,10	0,57	13,4
	C/N	16	14,74	17,40	1,34	18	1,341	25,20	4,28	14	13,15	14,91	1,25	13
	P_2O_5 (mg kg^{-1})	11,0	4,00	18,00	7,00	47,1	11,04,0	125,0	40,64	6,5	6,00	7,00	0,71	25,0
	K_2O (mg kg^{-1})	245,0	185,00	280,00	52,20	232,7	163,00	315,00	52,40	171,5	154,00	189,00	24,75	189,0
			E				B				AB			
	Horizon depth (cm)	12,3	11,00	14,00	1,53	40,6	29,00	29,00	7,17	19,00	19,00	31,00	8,49	
Particle size distribution	2,0–0,2 mm	0,4	0,200	0,40	0,06	0,6	0,20	1,00	0,28	0,3	0,20	0,40	0,14	
	0,2–0,02 mm	20,7	16,90	23,20	3,6035	24,5	13,60	35,20	5,75	26,3	24,10	28,40	3,04	
	0,02–0,002 mm	43,3	37,80	47,20	49,0	33,5	21,20	337,80	7,56	46,7	49,0	49,00	3,32	
	< 0,002 mm	35,6	30,40	38,60	4,55	41,4	38,60	55,70	9,49	26,8	22,20	31,40	6,51	
	pH (H_2O)	5,93	5,60	6,30	0,35	6,48	5,88	7,00	0,39	7,10	6,90	7,30	0,28	
	pH (KCl)	4,40	4,10	6,00	0,26	5,77	5,10	6,47	0,47	6,25	6,00	6,50	0,35	
	Org. C (g kg^{-1})	33,3	25,52	40,02	7,30	27,9	9,15	51,45	13,74	72,8	60,90	84,68	16,81	
	Total N (g kg^{-1})	2,1	1,40	2,70	0,67	3,2	4,400	4,40	0,77	5,5	4,50	6,40	1,34	
	C/N	16	14,82	18,23	1,95	9	2,18	15,59	4,47	13	13,23	13,53	0,21	
	P_2O_5 (mg kg^{-1})	9,3	0,00	14,00	8,08	5,9	0,00	1,00	5,82	14,0	0,00	2,00	1,41	
	K_2O (mg kg^{-1})	83,7	76,00	90,00	7,09	92,6	72,00	128,00	19,82	94,0	63,00	125,00	43,84	
			Bt											
	Horizon depth (cm)	45,3	42,00	49,00	3,51									
Particle size distribution	2,0–0,2 mm	0,1	0,100	0,10	0,06									
	0,2–0,02 mm	14,3	8,30	18,00	5,22									
	0,02–0,002 mm	30,9	21,10	43,70	11,59									
	< 0,002 mm	54,6	39,30	70,60	15,66									
	pH (H_2O)	6,23	5,70	6,80	0,55									
	pH (KCl)	4,77	4,20	5,50	0,67									
	Org. C (g kg^{-1})	19,3	13,34	26,68	6,77									
	Total N (g kg^{-1})	1,4	0,90	1,90	0,50									
	C/N	14	13,83	14,82	0,52									
	P_2O_5 (mg kg^{-1})	5,3	0,00	13,00	6,81									
	K_2O (mg kg^{-1})	90,0	76,00	109,00	17,06									

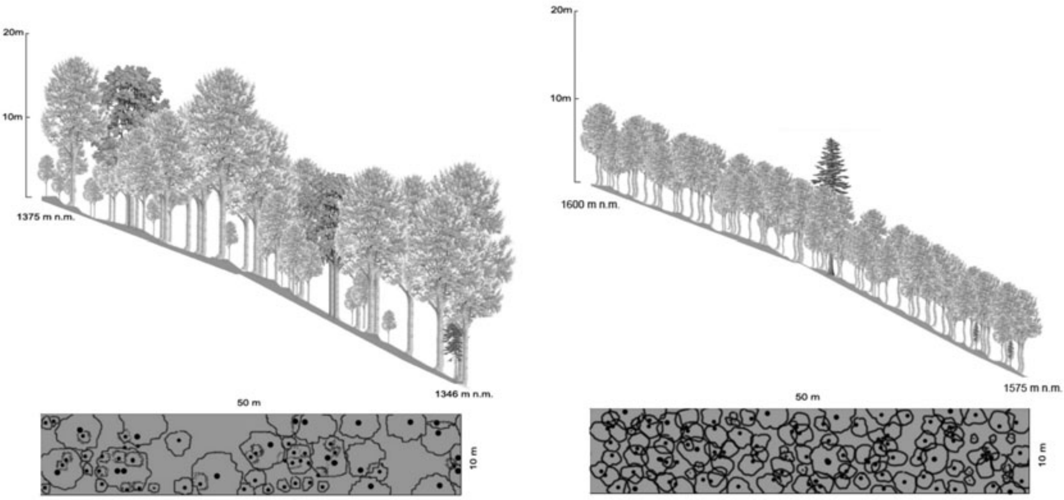

Figure 1. *Longitudinal profile and crown projection on the botton (left) and upper (right) boundary of association on the profile of Babić siča – Plješivica.*

DISCUSSION AND CONCLUSIONS

The analysis of the phytocoenological research results revealed a typical floristic composition for the community *Ranunculo platanifoliae-Fagetum*. The studied stands are moderately rich in species. Their physiognomy and ecological conditions are identical to those in other areas of this association and to the extensively investigated forests of Slovenia in particular. The subalpine belt in Slovenia is richer and more diverse in plant communities, due primarily to the distinctly pre-alpine and alpine phytocoenological areas there. Of diagnostically important species in the Croatian part, *Cirsium erisithales* occurs in relatively large quantities, but it has not been recorded in the relevés of Marinček. This species also occurs in Slovenian beech forests. Marinček and Šilc *(31)* record it in the area of Snežnik with the participation degree 4 and consider it a differentiating species of the subassociation *seslerietosum;* however, this does not apply to the Croatian area. Nevertheless, the associations reveal high similarity in composition, which can be seen from the comparison of Columns 12 and 15 in Table 1. The same can be concluded for the stands in the Risnjak massif presented in Column 14.

In relation to research by Slovenian authors, we hold the view that the association *Ranunculo platanifoliae-Fagetum* should be classified in the subalpine or pre-mountainous belt in Croatia, and not in the high-mountain or altimontane belt in which it has been classified *(9)*. The upper boundary of beech-fir forests in Croatia is relatively sharply defined and denotes the end of selection management and the beginning of the species considered differential and characteristic for *Ranunculo platanifoliae-Fagetum*, and partly for *Polysticho lonchitis-Fagetum*. In addition, the studied pre-mountainous beech forest association frequently forms the upper boundary of forest vegetation, especially on more southern slopes and peaks below 1,600 m. There are no characteristic stands of Mugho pine (*Pinetum mugi* s.l.) nor is there the association *Polysticho lonchitis-Fagetum*. As the floristic composition of these two beech communities differs only slightly, we maintain that the beech forest range above 1,200 m in Croatia should not be broken up into two vegetation belts.

More detailed research, planned for the next year, especially in the upper zone touching on the Mugho pine will indicate possible establishment of the other association *Polysticho lonchitis-Fagetum*. The relevés taken on northern Velebit from the cited studies have not showed the mentioned difference. The differentiating species, in the first place *Pinus mugo, Carex ferruginea, Salix appendiculata, Sorbus chamaemespilus, Lonicera coerulea, Ribes alpinum* and *Clematis alpina*, are absent in the beech forest that inhabits higher altitudes *(32)*. We are confident that the stands reconnoitred on Zečjak (1,623 m) and Šatorina (1,624 m) on central Velebit will be very interesting, since these areas consist only of bare stony tops (knolls) and have no anthropogenic impacts such as those in the Zavižan depression.

To conclude this phytocoenological survey, it may be said that some sixty relevés of pre-mountainous beech forests in Croatia are not sufficient for in-depth research. The studied stands represent the association *Ranunculo platanifoliae-Fagetum*, while the association *Polysticho lonchitis-Fagetum* and the differences between the two are yet to be defined.

The pre-mountainous beech forest *Ranunculo platanifoliae-Fagetum* has very broad pedological amplitude and occurs on mollic leptosol, rendzic leptosol, cambisol, luvic cambisol and luvisol *(27)*. The distribution of particular soil types is conditioned by the lithological structure and topography of the terrain. Higher and steeper positions support shallower soils of rendzic leptosol or mollic leptosol, the slopes feature cambisol, and the lower parts of the slopes and sinkholes contain luvisol. According to pedological research in the pre-mountainous beech forest in the Zavižan area, mollic luvisol accounts for about 10%, cambisol for about 70% and luvisol for about 20% of the total area.

As mentioned before, at higher elevations the community *Ranunculo platanifoliae-Fagetum* passes into the community *Polysticho lonchitis-Fagetum*. Due to the fact that the latter inhabits the most exposed parts of the relief, such as peaks and ridges, the occurrence of the shallowest soil, Mollic Leptosol lithic organogenic and Mollic Leptosol may be expected. In places in which dolomite layers come to the surface, the specific climatic conditions and more distinct physical weathering cause their fragmentation, thus leading to the formation of a suitable substrate for the development of rendzic leptosols. Neither these soils nor the community *Polysticho lonchitis-Fagetum* were included in the conducted pedological research.

From the forestry standpoint, beech forests in the subalpine belt are interesting primarily for their protective role in the areas of their distribution range. Due to their function in erosion prevention, soil protection and mitigation of climatic extremes, as well as the preservation of habitats of wild plant and animal species (e.g. the capercaillie), these forests have for the most part been proclaimed protective and have not been managed for the last twenty years. For this reason, they are slowly being transformed into secondary virgin forests which will serve for scientific-natural research and comparisons with other lower belts in Croatia. Stands at altitudes of 1,200 to 1,400 m used to be subject to management impacts. One such stand is presented in the real profile recorded on Babić Sića in North Velebit National Park (Figure 1). Beech trees are up to 20 m tall and vary in number from 900 to 1,200 trees per ha on average. There are about 5% of other tree species. The other profile, which differs profoundly in the physiognomic sense, was recorded 250 m higher and has never been systematically managed. Beech trees are only up to 5 m tall and exceed 1,800 pieces per ha, but no differences could be detected in their floristic composition that would separate these stands taxonomically. As already pointed out on several occasions, with an increase in altitude the physiognomic-morphological differences within beech stands become greater than the floristic ones *(33)*.

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