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SYNTAXONOMY AND SYNECOLOGY OF SILVER FIR (*ABIES ALBA* MILL.) MIXED FORESTS FROM SOUTH-EASTERN CARPATHIANS (ROMANIA)

Gheorghe COLDEA, Liviu FILIPAȘ
National Institute of Research and Development for Biological Sciences, Institute of Biological Research
Cluj-Napoca, Republicii Street 48, **RO-400015 Cluj-Napoca, Romania**
e-mail: gheorghe.coldea@icbcluj.ro

Abstract: We re-evaluate and clarify the syntaxonomic position of the fir–beech and spruce–fir mixed forests in Romania. The syntaxa described from the South-Eastern Carpathians are well differentiated both floristically and ecologically along gradients of soil fertility and elevation. For the first time, the floristic composition of fir–beech and spruce–fir mixed forests from the studied area are presented in a unified, comparative framework. The mixed fir forest communities, characterized by the presence of *Rubus hirtus* and *Galium rotundifolium* and developed on slightly acidic soils in the hilly-submontane belt, are assigned to a new syntaxon in accordance with the current Carpathian coenotaxonomic system. This new syntaxon (*Rubo hirti-Abietetum albae* ass. nova hoc loco) is exclusively distributed in the Romanian Carpathians.

Key words: bioclimatic belts, floristic composition, *Rubo hirti-Abietetum*, mixed fir forests, Romanian Carpathians, soil fertility, syntaxonomy

Introduction

In Europe, the natural range of the suboceanic species *Abies alba* Mill. is confined to central and southern regions, primarily within the montane vegetation belt [10]. In the south-eastern Carpathians, palynological studies have distinguished a subphase of silver fir forests within the mixed beech–fir forest phase, characteristic of the Subatlantic period (2,700 B.P. – present) [14]. The forest succession phases described by Pop (1932) [40] in the Romanian Carpathians were subsequently confirmed and chronologically refined using C^{14} dating [29], within the broader palaeoecological framework proposed by Orombelli and Ravazzi (1996)[39].

The near-simultaneous establishment of beech and silver fir in the south-eastern Carpathians at the beginning of the Subatlantic period resulted in forest communities of broadly similar composition, owing to the comparable local ecological requirements of the two species. Silver fir mixed forests lack their own characteristic species when compared with beech forests. This is evident in both their natural distribution — predominantly within the montane vegetation belt — and in the species composition of the herb layer, which contains several Carpathian elements typical of *Symphyto cordati–Fagion* Vida 1963, such as *Symphytum cordatum*, *Cardamine glanduligera*, *Pulmonaria rubra*, *Festuca drymeja*, *Hepatica transsilvanica*, *Hieracium transsilvanicum*, *Aconitum lycotonum* ssp. *moldavicum*, *Ranunculus carpathicus*, and *Silene heuffelii* [1, 5, 6, 16, 44].

In contrast, beech–fir mixed forests of the western Carpathians are much more diverse and are assigned to two alliances: *Fagion sylvaticae* Luquet 1926 and *Symphyto cordati–Fagion* Vida 1963. Here, such mixed forests exhibit a higher species richness [8, 46]. The floristic composition of beech–fir forests described from the Alps also differs from that of the south-eastern Carpathians [27, 28, 31, 37]. Likewise, silver fir mixed forests described from the western Balkans display a distinct species composition [33, 35].

The first phytosociological data on beech–silver fir mixed forests in Romania were published by Borza (1946)[4] from the Semenic Mountains (Gărâna locality, 1,000–1,300 m a.s.l.), under the name *Abieto–Fagetum semenicense*. Later, Beldie (1951)[1], in his study carried out in the upper montane region of Valea Ialomiței and Valea Buzăului (1,000–1,230 m a.s.l.), described a new syntaxon: *Fagetum dacicum* Beldie 1940 *abietosum* 1951. Subsequent descriptions of silver fir–spruce mixed forests from the upper montane belt were either included in the syntaxon *Piceetum montanum–Abietosum* Borza 1959 or recognised as new taxa, such as *Pulmonario–Abieti–Fagetum* (Knapp 1942) Soó 1962 [47], or *Saxifrago cuneifoliae–Abieto–Piceetum* (Borhidi 1971). At the same time, certain phytocoenoses of fir and beech from the western part of the southern Carpathians were grouped in *Chrysanthemo rotundifolii–Piceo–Fagetum* [6]. The mixed fir-beech forests — and locally with hornbeam — predominantly occurring in the hilly and submontane areas (520–800 m a.s.l.) of the Eastern Carpathians were classified into different syntaxa despite having a broadly similar floristic composition [13, 19, 20, 21, 25].

The syntaxonomic position of fir–beech and fir-spruce mixed forests in the South-Eastern Carpathians has not been fully clarified, either in earlier works [7, 17, 44], or in more recent studies [12, 15, 30]. Therefore, the main objectives of the present study were: a) the re-evaluation of phytocoenological relevés carried out in various areas of the South-Eastern (Romanian) Carpathians and their assignment to the current coenotaxonomic system; b) the detailed characterization of the floristic structure of a newly described syntaxon for Romanian vegetation; c) the comparative analysis of the species composition of the main types of fir mixed forests, classified into sub-alliances and alliances.

Material and Methods

The forests dominated by silver fir occupy the largest areas in the eastern part of the Romanian Carpathians (approximately 80%), whereas in their southern and western sectors, these forest types are present over smaller areas [23]. As of 2005, the beech–fir mixed forests covered more than 450,000 ha across Romania [24].

A total of 412 phytocoenological relevés from various massifs in the Romanian Carpathians were analysed. The relevés were classified at association level according to their compositional similarity as well as the local environmental factors — landforms, lithological substrate, and soil — that influence the floristic composition. The assignment of the distinguished forest associations into appropriate suballiances, alliances, and orders was performed based on the characteristic species of higher-rank syntaxa, as defined by several key references [3, 8, 33, 34, 36, 38].

The taxonomic nomenclature of the species listed in the phytosociological tables followed Sârbu et al. (2013)[42], whereas the sytaxonomic nomenclature was inspired from the monographs concerning the forest vegetation within the Carpathian basin [15, 46].

To highlight the structural differences between beech–fir and spruce–fir mixed forests, the forest associations were compared by species. Such analysis took into account both the diagnostic species and regional species i.e., those conferring phytogeographical and ecological individuality to syntaxa (Table 2).

QGIS v3.28 software [https://docs.qgis.org] was used for mapping the location of the surveyed mixed forests.

Results and Discussion

The forests dominated by *Abies alba* and and those dominated by *Fagus sylvatica* exhibit highly similar floristic composition, largely due to their comparable pedoclimatic requirements [26]. These two forest types have coexisted in the same habitats for extended periods, leading to overlapping ecological niches and shared structural traits within mixed forest communities. Recent studies of fir–beech mixed forests showed that *Abies alba* generally accounts for only 10–20% of the tree layer composition [22]. Earlier phytocoenological investigations on fir and fir–beech mixed forests in the Romanian Carpathians classified these communities into different syntaxa, such as *Symphyto cordati–Fagetum* Vida 1963 em. Tauber 1987 [6, 16, 19, 20, 25, 32], based on characteristic species and altitudinal range. A more recent synthesis by Coldea (2015)[15] proposed a refined approach, suggesting that mixed mountain forests of beech and fir, as well as those integrating fir and spruce, should be classified primarily according to their characteristic species. Within this framework, the beech–fir forests were incorporated into the alliance *Symphyto cordati–Fagion*, while the fir–spruce forests were placed into *Piceion excelsae* Pawl. et al. 1928.

Based on their floristic composition and altitudinal distribution, the silver fir mixed forests of the South-Eastern Carpathians (Romania) can be divided into two distinct groups: (a) fir and beech mixed forests of the hilly and submontane belt, and (b) spruce and fir mixed montane forests.

a) Fir and beech mixed forests of **the hilly and submontane belt**.

In Romania, the syntaxonomic position of beech–fir mixed forests from hilly and submontane areas had not been clarified until now. We classify these phytocoenoses in the association *Rubo hirti-Abietetum albae* ass. nova (Table 1). The first phytocoenological data on such fir–beech, and occasionally hornbeam, mixed forests were published by Chifu (1972)[11] and Chifu et Ștefan (1973)[13] from the marginal hills of the Neamțului Depression and Nemțisorului Valley. The authors assigned the relevés performed on south-eastern slopes (10–25°) to the *Abieti-Fagetum* Knapp 1942. The phytocoenoses occurring at the base of slopes, where *Galium rotundifolium* was present, were considered by the mentioned authors as ascribable to *Abietum dacicum* Beldie 1967, which is anyway an invalid name [44, art.34].

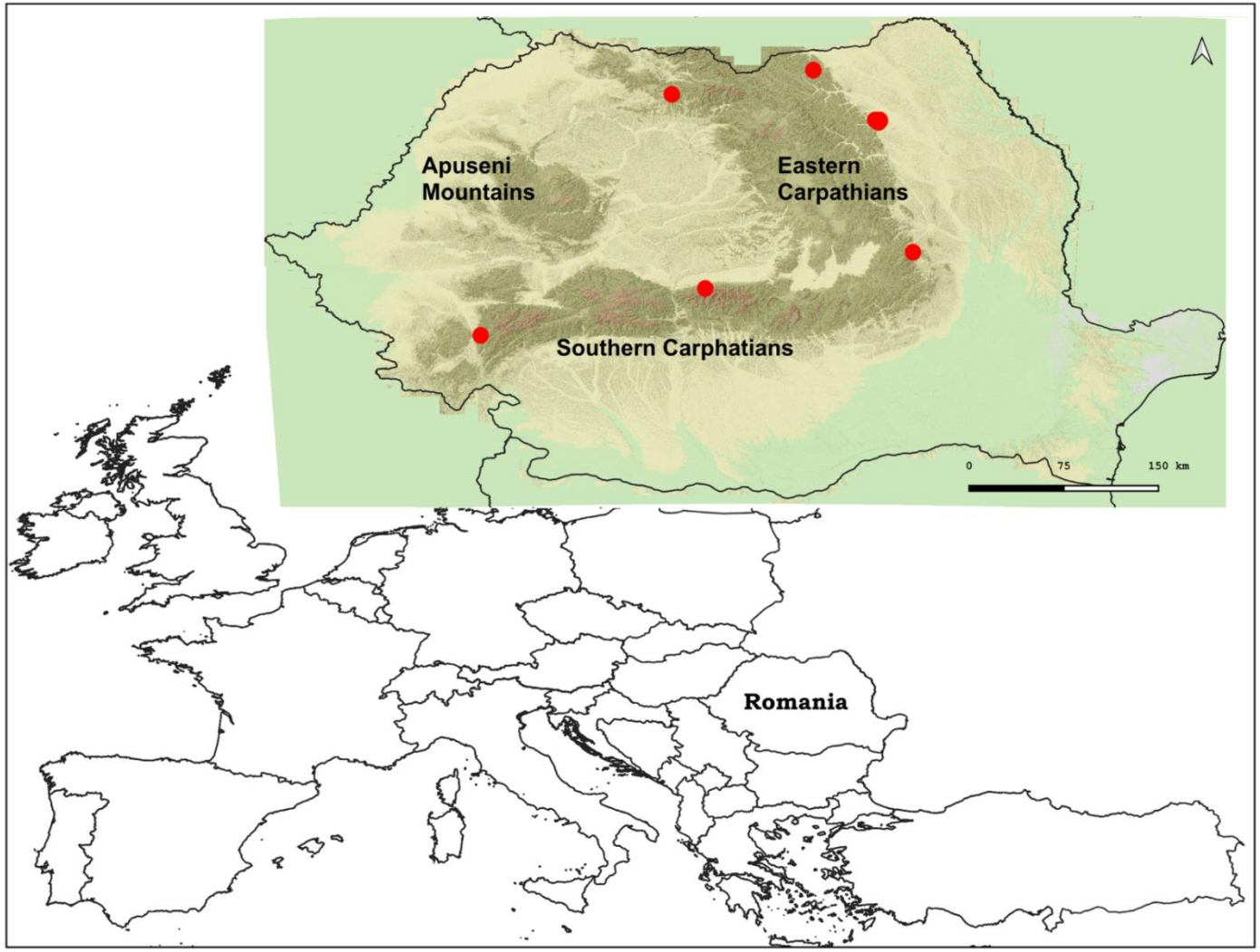

Fig. 1: Geographical distribution of the mixed fir forests of *Rubo hirti-Abietetum* in the Romanian Carpathians, based on the current available data.

Special attention was given to this forest type by Danciu & Lazăr (2000)[21], who published several relevés from the Ţibleş Mountains and Obcina Mare (northern part of the eastern Romanian Carpathians) and provided a chorological map (UTM system) of *Galium rotundifolium* distribution in Romania. This map, based on both literature and herbarium data, shows that *Galium rotundifolium* is a rare species in Romania.

Table 1: Relevés of *Rubo hirti – Abietetum albae* ass. nova (holotype: relevé 8)

Relevé no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8***	**9**	**10**	**11**	**12**	**13**
Altitude (m a.s.l.)	800	700	750	540	670	730	530	520	600	610	630	850	700
Aspect	NE	W	NW	W	NE	NE	SW	S	S	N	NE	E	-
Slope (degrees)	20	15	30	20	25	35	5	5	20	4	6	20	0
Tree cover (%)	60	80	85	90	90	90	85	90	90	85	80	60	80
Herb cover (%)	20	15	40	20	20	20	50	40	10	70	60	10	70
Area (m^2)	400	400	400	400	400	400	400	400	400	400	400	400	400
Diagnostic of association													
Rubus hirtus	2	+	2	+		+	+	+	+	2	1	1	+
Galium rotundifolium	1	+	+	+	1	+	+	+	+	+	+	+	+
Abies alba	1	4	4	5	5	5	5	5	4	5	5	4	+
Symphyto-Fagenion et Symphyto-Fagion													
Festuca drymeja	4									+	+		+
Pulmonaria rubra										+	+	+	
Hepatica transsilvanica								+	+			+	+
Symphytum cordatum							+						+
Cardamine glanduligera				+			+						
Hieracium transsilvanicum		+	+		+			+	+				+
Aconitum l. ssp. Moldavicum													+
Fagetalia et Carpino-Fagetea													
Fagus sylvatica	3			+	+	+	+	+	2	+	+	1	2
Carpinus betulus				+	+	+	+	+	+				3
Acer pseudoplatanus						+	+	+		+	+	+	2
Galium odoratum	+	+	+	+	+	+		+	+	2	3	+	1
Mycelis muralis	+	+	+		+	+	+		+	+	+	+	+
Viola reichenbachiana	+	+	+	+		+	+	+	+	+	+	+	
Epilobium montanum	+	+	+				+			+			
Salvia glutinosa	+	+	1		+		+	+		+		+	+
Athyrium filix-femina	+	+	1	+		+	+	+		+	+		1
Dryopteris filix-mas	+	+	1	+	+	+	+		+	+	+		2
Euphorbia amygdaloides	+	+				+	+	+	+	+		+	
Lamium galeobdolon	+	+	+		+		+						+
Cardamine impatiens	+				+	+				+			+
Brachypodium sylvaticum	+	+		+	+	+	+		+				
Luzula luzuloides	1	2	2		+		+	+	+	+		+	3
Gymnocarpium Dryopteris		+	+							+	+		1
Carex sylvatica		+					+		+	+	+	+	
Sanicula europaea		+	+		+		+	+		+	+	+	+
Cardamine bulbifera					+				+	+	+		
Hieracium murorum					+					+			

Relevé no.	1	2	3	4	5	6	7	8*	9	10	11	12	13
Maianthemum bifolium			+	+			+	+		+			
Prenanthes purpurea												+	+
Polystichum setiferum					+								
Milium effusum				+						+			
Pulmonaria officinalis							+	+					+
Galium schultesii								+					+
Asarum europaeum									+				+
Pulmonaria montana ssp porciusii								+	+				
Circaea lutetiana							+		+	+	+	+	+
Carex digitata										+			
Anemone ranunculoides										+			+
Scrophularia nodosa	+		+				+			+	+		
Veronica urticifolia										+		+	
Polystichum aculeatum													+
Fraxinus excelsior													+
Moehringia trinervia													+
Poa nemoralis							+						+
Calamagrostis arundinacea	+												+
Piceetalia s.l.													
Picea abies		1	1	+						+	+	+	+
Sorbus aucuparia										+	+	+	
Vaccinium myrtillus													+
Oxalis acetosella	+	+	2	2	2	1	3	2	+	1	1	+	+
Deschampsia flexuosa													+
Orthilia secunda	+	+					+	+				+	
Luzula sylvatica		+											
Pyrola uniflora							+	+					
Monotropa hypopitys							+	+				+	
Dryopteris dilatate					+	+							
Companions													
Geranium robertianum		+	+		+	+	+	+	+	+	+		
Populus tremula						+							+
Betula pendula				+									+
Quercus robur (juv.)					+			+					
Crataegus monogyna							+						
Salix caprea										+			+
Rosa canina										+	+	+	
Rubus idaeus	+	1	2							+	+		+
Veronica officinalis	+	+	+					+					
Stellaria nemorum	+												
Petasites albus	+												
Senecio sylvaticus	+												
Prunella vulgaris	+	+	+							+			+
Fragaria vesca		+	+	+		+	+	+		+	+		+
Gnaphalium sylvaticum		+						+					
Senecio ovatus		+	+		+	+				+			
Clinopodium vulgare		+			+	+							
Impatiens noli-tangere						+	+		+	2	1		+
Stachys sylvatica				+			+				+	+	
Polygonatum verticillatum					+		+						

Relevé no.	1	2	3	4	5	6	7	8*	9	10	11	12	13
Lapsana communis				+	+	+	+	+		+			
Hieracium maculatum				+		+							
Glechoma hederacea				+	+	+		+	+	+			+
Campanula rapunculoides					+								
Hieracium sabaudum				+	+		+						
Hieracium umbellatum						+	+						
Sambucus nigra				+			+		+	+	+		+
Ajuga reptans							+	+	+	+			
Atropa bella-donna							+						
Carex remota										+			
Urtica dioica	+	+							+	+	+		
Campanula persicifolia													+
Hypericum hirsutum													+
Polypodium vulgare		+			+			+					+
Doronicum austriacum													+
Eupatorium cannabinum													+
Corylus avellana									+				+
Aremonia agrimonoides												+	
Bryophytes													
Dicranum scoparium								+			+		
Eurhynchium striatum				+	+	+			+				
Hylocomium splendens			+	+	+	+			+				
Polytrichum formosum		+	+	+			+	+	+		+		
Pleurozium schreberi					+			+					
Brachythecium velutinum					+	+	+		+				
Plagiomnium undulatum		+	+	+					+				
Plagiochila asplenioides				+					+				

*** Holotype**

Localities of relevés: 1 –Țibleș Mountains [21]; 2-3 – Obcina Mare [13]; 4 – Dealul Cărbunelui; 5-6 – Dealul Mălinului; 7 – Dealul Chiriac; 8-9 – Dealul Cărbunelui [11]; 10-11 - Soveja, Poiana Punga [19]; 12 – Cracul Branului [6]; 13 – Valea Căprăreț [24].

Phytosociological data on beech–fir mixed forests containing *Rubus hirtus* and *Galium rotundifolium* from the eastern Romanian Carpathians [19, 20] and the southern Carpathians (Căprăreț Valley) [25] were published later (Fig. 1). By comparatively analysing the floristic structure of these forests in the Romanian Carpathians (based on several representative relevés published by the aforementioned authors) with those described in Central Europe [37, 46] under the name *Galio rotundifolii-Abietetum* Wraber 1959, we notice clear similarities in the floristic structure (many shared species of the order *Fagetalia*), but also some differences given by the regional species characterizing the alliance *Symphyto cordati-Fagion* (Table 1).

The phytocoenoses assigned to *Rubo hirti-Abietetum* develop on clay-rich soils (pelosol and preluvosol) in depression areas within the hilly–submontane belt, at altitudes around 750 m a.s.l. [11, 13]. Danciu & Lazăr (2000)[21] also reported that beech–fir mixed forests containing *Galium rotundifolium* in the herb layer occur on soils with moderate humus content and moderately acidic reaction (districambosoil and prepodzol). In terms of floristic structure, fir dominates the tree layer, with beech becoming dominant only locally. Characteristic species of the suballiance *Symphyto cordati-Fagenion* Boșcaiu et al. 1982 and the alliance *Symphyto cordati-Fagion* Vida 1959 [15] are present with high frequencies. In addition, species characteristic of the order *Fagetalia* and the class *Carpino-Fagetea* [34] sometimes appear with

high relative cover (up to 15 %) in the herb layer of the analysed phytocoenoses. In the bryophyte layer, *Eurhynchium striatum*, *Polytrichum formosum*, *Plagiomnium undulatum*, *Atrichum undulatum*, and *Plagiochila asplenioides* occur frequently.

Table 2: Floristic composition of *Abies alba* mixed forests from South–Eastern Carpathians (Romania). The numerical values represent species frequencies, expressed as percentages.

Syntaxon no.	**1**	**2**	**3a**	**3b**	**4**
Number of relevés	23	51	221	19	98
Altitude (m a.s.l.)	500-850	520-1100	650-1250	700-1250	1000-1320
Diagnostic of association					
Abies alba	100	100	79	78	100
Rubus hirtus	96	53	47	47	53
Galium rotundifolium	52				
Festuca drymeja	17	76	14	37	11
Pulmonaria rubra	13	12	57	37	24
Hieracium transsilvanicum	18	4	8	21	60
Diagnostic of subassociation					
Taxus baccata				100	
Asplenium viride		3		26	
Carex alba		+		16	
Symphyto-Fagenion et Symphyto-Fagion					
Symphytum cordatum	9	4	25	21	10
Cardamine glanduligera	30	25	39	42	11
Rubus hirtus ssp. romanicus	96	53	47	47	53
Aconitum l. ssp. moldavicum	4	4	3		2
Hepatica transsilvanica	9		4	37	3
Euphorbia carniolica			7		2
Silene heuffeli			2		2
Ranunculus carpaticus			4		7
Helleborus purpurascens		8	2		
Pulmonaria montana ssp. porciusii	13				
Fagetalia					
Fagus sylvatica	74	96	99	95	86
Fraxinus excelsior	4		5	16	
Acer platanoides		10	4	16	
Umus glabra		4	5	11	
Lonicera xylosteum		10	15	32	22
Daphne mezereum		4	20	42	27
Anemone nemorosa	4	27	19	11	5
Circaea lutetiana	39	8	19	32	12
Asarum europaeum	4	12	16	21	14
Gentiana asclepiadea	17	22	14	16	15
Carex sylvatica	26	18	22	95	22
Sanicula europaea	56	12	22	53	14
Euphorbia amygdaloides	74	22	47	74	34
Veronica montana		18	8		2
Paris quadrifolia		6	16	16	13
Actaea spicata	4	2	25	58	21
Isopyrum thalictroides		4	10	11	4
Epilobium montanum	22	8	36	16	25
Mycelis muralis	65	35	34	53	59
Prenanthes purpurea	9	22	1	5	5
Maianthemum bifolium	49	2	11		24

Syntaxon no.	1	2	3a	3b	4
Pulmonaria officinalis	30	14	2	21	2
Luzula luzuloides	52	35	38	42	53
Mercurialis perennis	4	12	39	53	25
Adoxa moschatellina			2	11	
Myosotis sylvatica	22	6	10	21	13
Dentaria bulbifera	30	27	33	16	13
Lamium galeobdolon	22	41	31	53	23
Salvia glutinosa	56	10	33	63	37
Stachys sylvatica	82		19	16	2
Veronica urticifolia	4	6	13	32	27
Cardamine impatiens	22		10		
Phegopteris connectilis			2		2
Lathyrus vernus		10	5	16	
Allium ursinum		2		11	
Galium odoratum	83	57	61	68	24
Anemone ranunculoides	9		2	11	
Hepatica nobilis		8	4	16	
Neottia nidus-avis		2	10		6
Milium effusum	9	10	11		9
Polystichum setiferum	9	4	4		
Viola reichenbachiana	69	16	30	68	27
Scrophularia nodosa	17		8	11	2
Symphytum tuberosum		10	2	16	
Lilium martagon		6	3		4
Hordelymus europaeus		4	3	5	
Festuca altissima		2	1		
Polygonatum verticillatum	17	24	22	21	28
Gymnocarpium robertianum	13	4	10		22
Carex digitata	4	10	8	21	
Epipactis helleborine			12	37	
Melica uniflora	4	2	2	21	
Carpino-Fagetea					
Quercus petraea	4	8		11	
Tilia cordata		8	2	11	
Carpinus betulus	48	10	10	5	
Acer pseudoplatanus	39	14	38	63	43
Acer campestre	4		3	16	
Crataegus monogyna	13	6	6	16	
Corylus avellana	17	14	24	37	23
Cornus mas				5	
Euonymus europaeus			6		
Athyrium filix-femina	65	43	57	58	62
Dryopteris filix-mass	74	61	65	58	65
Moehringia trinervia	17	2	17	11	12
Poa nemoralis	9	6	24	37	14
Brachypodium sylvaticum	35		16	47	5
Oxalis acetosella	74	61	71	79	94
Glechoma hirsute	13	10	15	26	7
Hedera helix		2	4	32	
Impatiens noli-tangere	48		16	32	11
Polystichum aculeatum	4	4	10	26	10
Cephalanthera damasonium	4		4	11	
Cephalanthera rubra				5	
Cephalanthera longifolia			1	11	
Stellaria holostea		4	3		
Melica nutans			1	11	
Lunaria rediviva			2		

Syntaxon no.	1	2	3a	3b	4
Lathyrus venetus				11	
Polygonatum hirtum		2			
Vaccinio-Abietenion et Piceion abietis *sl*					
Picea abies	22	20	76	53	92
Sorbus aucuparia	9	18	21	26	43
Orthilia secunda	13	4	6	47	16
Moneses uniflora	4		1		16
Soldanella major			1		
Vaccinium myrtillus	4	8	3	11	33
Luzula sylvatica	9	24	9	37	20
Melampyrum sylvaticum			3	11	18
Crocus banaticus		4			
Homogyne alpina			4		13
Corallorhiza trifida		4	2		1
Calamagrostis villosa			5		10
Soldanella hungarica			1	16	1
Soldanella oreodoxa			1		1
Huperzia selago					20
Lycopodium annotinum					10
Vaccinium vitis-idaea					10
Leucanthemum rotundifolium			5		9
Athyrium distentifolium			2		6
Lonicera caerulea					7
Pyrola rotundifolia					2
Campanula abietina		2	2		21
Dryopteris dilatate	35	10	10	11	18
Streptopus amplexifolius					6
Goodyera repens			1	21	
Epipogium aphyllum					
Monotropa hypopitys	13	2	1		
Companions					
Geranium robertianum	83	18	49	58	33
Betula pendula	13	4	5	16	14
Deschampsia flexuosa		2			1
Populus tremula	9	2	3	11	2
Rosa penduline			4	16	14
Ribes alpinum		2	6		
Rosa canina	9	4	7		
Sambucus racemose		4	8	5	10
Campanula trachelium	4	2			7
Doronicum austriacum	9	8	7		5
Rubus idaeus	35	28	11	47	49
Sambucus nigra	35	2	9		
Viburnum lantana			2		
Stellaria nemorum	4	8	19	16	16
Adenostyles alliariae		2			1
Calamagrostis arundinacea	9	27	13	37	28
Polypodium vulgare	9		8	37	15
Asplenium trichomanes		2	5		
Circaea alpina			4		10
Lamiun maculatum		2	11		
Cardamine flexuosa			1		
Cystopteris fragilis		10	9	16	4
Epilobium angustifolium					3

Syntaxon no.	1	2	3a	3b	4
Alliaria petiolate	9		3		
Listera ovata			1		
Carex remota	26		7	11	
Clematis vitalba			4	21	
Geum urbanum	9		7	16	
Urtica dioica	26		24		16
Galium aparine				11	
Senecio ovatus	36		31	37	43
Digitalis grandiflora		2	5	21	
Galeopsis speciosa		2	8	10	
Lapsana communis	35		6	5	
Campanula persicifolia			7		13
Chrysosplenium alternifolium			5	11	
Rumex obtusifolius			1		
Fragaria vesca	56	8	30	47	51
Doronicum columnae			3	16	
Veronica chamaedrys			1		2
Ranunculus repens			1		
Spiraea chamaedrifolia		2	1	16	14
Ribes uva-crispa		10	1		1
Saxifraga rotundifolia		2			1
Arum orientale				16	
Primula vulgaris			1		
Aposeris foetida		4			
Glechoma hederacea	43	6	14	21	1
Ajuga reptans	52	4	10	16	11
Hypericum maculatum	9		3		4
Veronica officinalis	22	8	4	16	21
Carex Pilosa		2	11		
Aegopodium podagraria		2	2	11	
Festuca gigantea	4	4	3		
Polygonatum odoratum		6	3	11	
Valeriana tripteris			2	5	2
Verbascum lanatum			1		
Galium schultesii	9	2	17	53	
Stachys alpina		2	2		
Campanula rapunculoides	9		9	11	
Atropa bella-donna	9			11	
Dryopteris carthusiana	22		5		19
Blechnum spicant		6			
Cicerbita alpina					1
Sorbus torminalis		2		5	
Petasites albus	4				
Epipactis atrorubens			2		
Saxifraga cuneifolia			1	32	4
Laserpitium latifolium				5	
Cornus sanguinea		2	2	21	
Sedum telephium subsp. *maximum*		2			
Dactylis polygama				21	
Cirsium erisithales			1		
Crocus vernus			1		
Tanacetum corymbosum				16	
Eupatorium cannabinum			1	11	
Senecio doria			1	16	
Silene dioica			3		
Prunus avium		2	4	5	
Hieracium murorum	17		5		10

Syntaxon no.	1	2	3a	3b	4
Carex pendula			2	32	
Arabis turrita		2			
Gymnocarpium robertianum				21	
Prunella vulgaris	35		1	5	
Bryophytes					
Polytrichum juniperinum			14		
Dicranium scoparium			10		18

1 – *Rubo hirti-Abietetum albae*; **2** - *Festuco drymejae-Abietetum albae* Filipaş et al. 2013; **3a** - *Pulmonario rubrae-Abietetum albae* Beldie ex Coldea 2015; **3b** - *Pulmonario rubrae-Abietetum taxetosum baccatae* Comes et Tauber 1977; **4** - *Hieracio transsilvanici-Abietetum albae* (Borhidi 1971) Coldea 1991.

The sub-Atlantic, sub-Mediterranean species *Galium rotundifolium*, which floristically and ecologically individualizes the syntaxon *Rubo hirti-Abietetum albae*, occurs in Romania in hilly and submontane areas between 520 and 850 m a.s.l. [13, 19, 21, 24], Considering their floristic structure, and the occurrence of regional species characteristic of beech forests — *Festuca drymeja, Pulmonaria rubra, Symphytum cordatum, Hepatica transsilvanica, Cardamine glanduligera* — the assignment of these fir mixed forests to the alliance *Symphyto cordati-Fagion* Vida 1963 and the order *Fagetalia* (Table 2, column 1) is more appropriate than to the order *Piceetalia* [27].

The syntaxon *Festuco drymejae-Abietetum* Filipaş et al. 2013 comprises phytocoenoses dominated by fir and beech in submontane to montane areas, at elevations between 950 and 1150 m a.s.l. (Table 2, column 2). These mixed fir–beech forests typically occur on moderately steep, sunny slopes. They develop on preluvosoils — brown loamy and reddish-brown soils — that are slightly acidic and have moderate moisture. In the tree layer, fir (*Abies alba*) and beech (*Fagus sylvatica*) are usually co-dominant, while other species, such as *Picea abies* and *Acer pseudoplatanus* occur only sporadically. The herb layer is dominated by *Festuca drymeja*, accompanied by characteristic species of the alliance *Symphyto cordati-Fagion*. Species characteristic of spruce-dominated forests occur only sporadically [30, 32].

b) Silver-fir mixed **montane** forests.

The phytocoenoses ascribed to *Pulmonario rubrae-Abietetum* Beldie 1951 ex Coldea 2015 (Table 2, column 3a) [syn. *Fagetum dacicum abietosum* Beldie 1951, *Abietetum dacicum* Beldie 1967] occur frequently within the montane belt of the Romanian Carpathians, typically on moderately inclined slopes. They develop on districambosols of moderate fertility (V = 60–80 %), weakly acidic, and featuring mull-type humus [2]. The herb layer contains regional species of the South-Eastern Carpathians at high frequencies, supporting their assignment to the alliance *Symphyto cordati-Fagion* and the class *Carpino-Fagetea*.

When this type of fir–beech mixed forests occurs on basic soils (rendzine) overlying limestones, they often host *Taxus baccata*, a tertiary relict species. For this particular type of forest phytocoenosis, a new subassociation was described in Romania by Comes & Tauber (1977)[18] (Table 2, column 3b). These basiphilous communities can be considered, to some extent, homologous to those documented in the Alps and grouped within the association *Pyrolo-Abietetum* Oberd. 1957 [27, 37, 41], although the latter host also several characteristic species of *Piceion abietis* because of the partly debasified upper soil layer.

The fir–spruce mixed forests of the Romanian Carpathians can be assigned to *Hieracio transsilvanici-Abietetum* (Borhidi, 1971) Coldea 1991 (Table 2, column 4). These phytocoenoses are mainly distributed throughout the entire montane belt, between 1000 and 1350 m a.s.l., where they develop on acidic districambosols and cryptopodzols formed over crystalline schists and eruptive rocks. Such pedological conditions favour a herb layer rich in acidophilous species characteristic of the alliance *Piceion* [34, 36, 43]. Owing to their higher altitudinal position, the proportion of deciduous forest herb species is lower than in *Pulmonario rubrae-Abietetum* communities. From a floristic and ecological perspective, *Hieracio transsilvanici-Abietetum* shows affinities with *Vaccinio-Abietetum* Oberd. 1957 described in Central Europe.

Conclusions

We assigned the five forest associations dominated by fir within the framework of the latest Carpathian coenotaxonomic system as follows:

Class *Carpino-Fagetea sylvaticae* Jakus ex Passarge 1968
Ord. *Fagetalia sylvaticae* Pawlowski 1928
All. *Symphyto cordati-Fagion sylvaticae* Vida 1959
Suball. *Symphyto-Fagenion* Boşcaiu et al. 1982
1. Ass. *Rubo hirti-Abietetum* ass. nova hoc loco
2 Ass. *Festuco drymejae-Abietetum* Filipaş et al. 2013
3. Ass. *Pulmonario rubrae-Abietetum* Beldie ex Coldea 2015
4. Ass. *Pulmonario rubrae-Abietetum taxetosum baccatae* Comes et Tauber 1977
Class *Vaccinio-Piceetea* Br.-Bl. in Br.-Bl. et al. 1939
Ord. *Piceetalia abietis* Pawl et al. 1928
All. *Piceion abietis* Pawl et al. 1928
Suball. *Vaccinio-Abietenion* Oberd. 1962
5. Ass. *Hieracio transsilvanici-Abietetum* (Borhidi 1971) Coldea 1991

All five syntaxa including the fir-beech and fir-spruce mixed forests from Romania are rather well differentiated along the altitudinal and soil fertility gradients. The phytocoenoses assigned to *Rubo hirti-Abietetum* occupy hilly and submontane areas, while those of *Festuco drymejae-Abietetum* are typically distributed within the submontane belt. In contrast, *Pulmonario rubrae-Abietetum* and *Hieracio transsilvanici-Abietetum* predominantly occur in the montane belt.

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SINECOLOGIA ȘI SINTAXONOMIA PĂDURILOR MIXTE DE BRAD (*ABIES ALBA* MILL.) DIN CARPAȚII SUD-ESTICI (ROMÂNIA)

(Rezumat)

În lucrare se caracterizează, ecologic și floristic, cele patru asociații forestiere de brad (*Abies alba*), în amestec cu *Fagus sylvatica* și/sau *Picea abies*, identificate pe teritoriul Carpaților Sud-Estici (România). Asociația *Rubo hirti-Abietetum* este descrisă nouă pentru România. Pe baza speciilor caracteristice și regionale, asociațiile forestiere edificate de brad sunt încadrate în sintaxoni de rang superior, conform sistemului cenotaxonomic carpatic actual.

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