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PHYTOCOENOLOGICAL ANALYSIS OF THE ASSOCIATION *Galio rotundifolii-Abietetum albae* Wraber (1955) 1959 ON MANJAČA MT (NW BOSNIA AND HERZEGOVINA)

FITOCENOLOŠKA ANALIZA ASOCIJACIJE *Galio rotundifolii-Abietetum albae* Wraber (1955) 1959 NA PLANINI MANJAČI (SZ BOSNA I HERCEGOVINA)

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Abstract

This research aimed to study phytocoenological characteristics of a fir-dominated community on silicate substrate at the locality of Sitnica on Manjača Mt, northwestern Bosnia and Herzegovina. This community originated from artificially forested mixed stands of fir and spruce planted in the habitat of the mountain Dinaric fir-beech forest, over a hundred years ago. With regular selective cuttings and natural regeneration, the structure shifted from even-aged to uneven-aged. In total, 18 phytocoenological relevés were made using the Braun-Blanquet method during the vegetation seasons of 2021 and 2022. Relevés were stored in Turboveg database. Ecological factors were calculated based on Ellenberg bioindicator values. Species composition was analyzed in terms of life form, geoelements and chorotypes. Our analysis indicates that collected relevés can be classified as the association *Galio rotundifolii-Abietetum albae* belonging to the alliance *Fagion sylvaticae*.

Kew words: *Abies alba*, Braun-Blanquet approach, ecological indices, forest communities, geoelements, vegetation

1. INTRODUCTON / UVOD

In Bosnia and Herzegovina (BiH) *Abies alba* is mainly found in montane mixed beech-fir or beech-fir-spruce zonal forests of *Abieti-Fagetum dinaricum* s.lat. (Stupar & Čarni, 2017). On the other hand, *Abies alba* dominated forests in BiH are rare, sparsely distributed and relatively poorly researched. Unlike in neighboring Croatia, these communities do not occur in large complexes in BiH, and they are weakly distinguished from the more extensive, already mentioned zonal forests, in whose elevational belt they are usually found (Ćirić et al., 1971).

The first fir-dominated community in BiH was recorded in the Herzegovinian mountains as a „fir forest on limestone cliffs“, and noted as *Rhamno-Abietetum* Fukarek 1957 (Fukarek, 1957). Association *Blechno-Abietetum* (Horvat

1938) Horvat in Cestar 1967, as well as *Galio rotundifolii-Abietetum* Wraber (1955) 1959, were noted to be present on silicate bedrock in central Bosnia (Stefanović, 1986) but no relevés were provided. The lack of relevés from these communities in BiH resulted in their unclear syntaxonomical, ecological and nomenclatural status. Furthermore, there is also no broader consensus on syntaxonomical position of fir-dominated communities, so Juvan et al. (2013) and Mucina et al. (2016) classify it into coniferous forests of *Vaccinio-Piceetea*, while according to Valachovič et al. (2021) they belong to mesic deciduous and mixed forests of *Carpino-Fagetea*.

One larger complex of such fir-dominated forests, which was not phytocoenologically investigated before, was found in the area of Sitnica on Manjača Mt in northwestern BiH. This paper presents the results of phytocoenological research of these stands to characterize them in terms of floristic composition and ecology and to put them in a wider syntaxonomical context.

2. MATERIAL AND METHODS / MATERIJAL I METOD RADA

Geographically, the researched area belongs to the northern border of the Dinaric mountain region, from which the Peripannonian part of BiH begins and extends further to the north. This particular area is located on the western edge of the plateau of the Manjača mountain, i.e. village Sitnica and the surrounding area (Figure 1). This area belongs to the lower montane vegetation belt with elevations ranging from 800 to 925 m and beech forests of *Aremonio-Fagion* as a zonal forest community. Inclination varies from flat to medium slopes. The bedrock is made up of Triassic rocks, mainly highly silicified (with chert, clay and sandstone) and dark bituminous limestone. In the western part (Kuk peak), there are marls and marl-like rocks with tuffs. On the eastern side, it is bordered by Cretaceous hard limestones (Vrhovčić et al., 1982). Dominant soils are Dystric Cambisols, with the sporadic occurrence of Calcocambisol and Colluvium. This area is characterized by a perhumid, moderate-continental mountain-type climate with an average annual temperature of around 7 °C and average annual precipitation of around 1200 mm (Eremija, 2011).

The investigated forest stands are dominated by fir. They originated from fir and spruce plantation, that was most probably established in this area before the First World War. However, the structure shifted from even-aged to uneven-aged with regular selective cuttings and natural regeneration, over decades. Albeit this plantation is located in the zone of montane beech forests, natural regeneration favored fir and spruce over beech.

We recorded a total of 18 relevés using the standard Central European phytocoenological method (Braun-Blanquet, 1964) during June and July of 2021 and 2022. The cover was evaluated for each layer separately, and the layers were divided according to height and life form into the following: A1 – the layer of tall trees (>20 m), A2 – the second layer of trees (10-20 m), B1 – the layer of tall shrubs (5-10 m), B2 – the middle layer of shrubs (1 - 5 m), B3 – the lower layer of shrubs (< 1 m), C – the layer of herbaceous plants including tree and shrub seedlings. For each relevé, we collected the following data: coordinates in WGS84, elevation, exposition, inclination and cover for each layer. Plots were placed only in stands with closed canopies and without visible signs of recent logging. We only sampled stands on Dystric Cambisol. The fixed plot size for relevé was defined to be 400 m^2.

The relevés were stored in Turboveg database (Hennekens & Schaminée, 2001) and exported to MS Excel for the preparation of the phytocoenological table and basic statistical analysis. Species nomenclature followed Euro+Med (2006) and Stupar et al. (2021).

All recorded relevés were presented in the phytocoenological table (Table 1). Assignment of the species to syntaxonomic groups was done according to Vukelić (2012) and Chytrý (2013), and life form was assigned to each species following Dřevojan et al. (2022). In case two or

more life forms were noted for the same species we followed Raunkiaer (1934). Horological spectra (Gajić, 1980; Pignatti et al., 2005) were calculated for each relevé using presence-absence data. We calculated average unweighted values for temperature, light, moisture, soil reaction, continentality and nutrients using indicator values according to Pignatti et al. (2005).

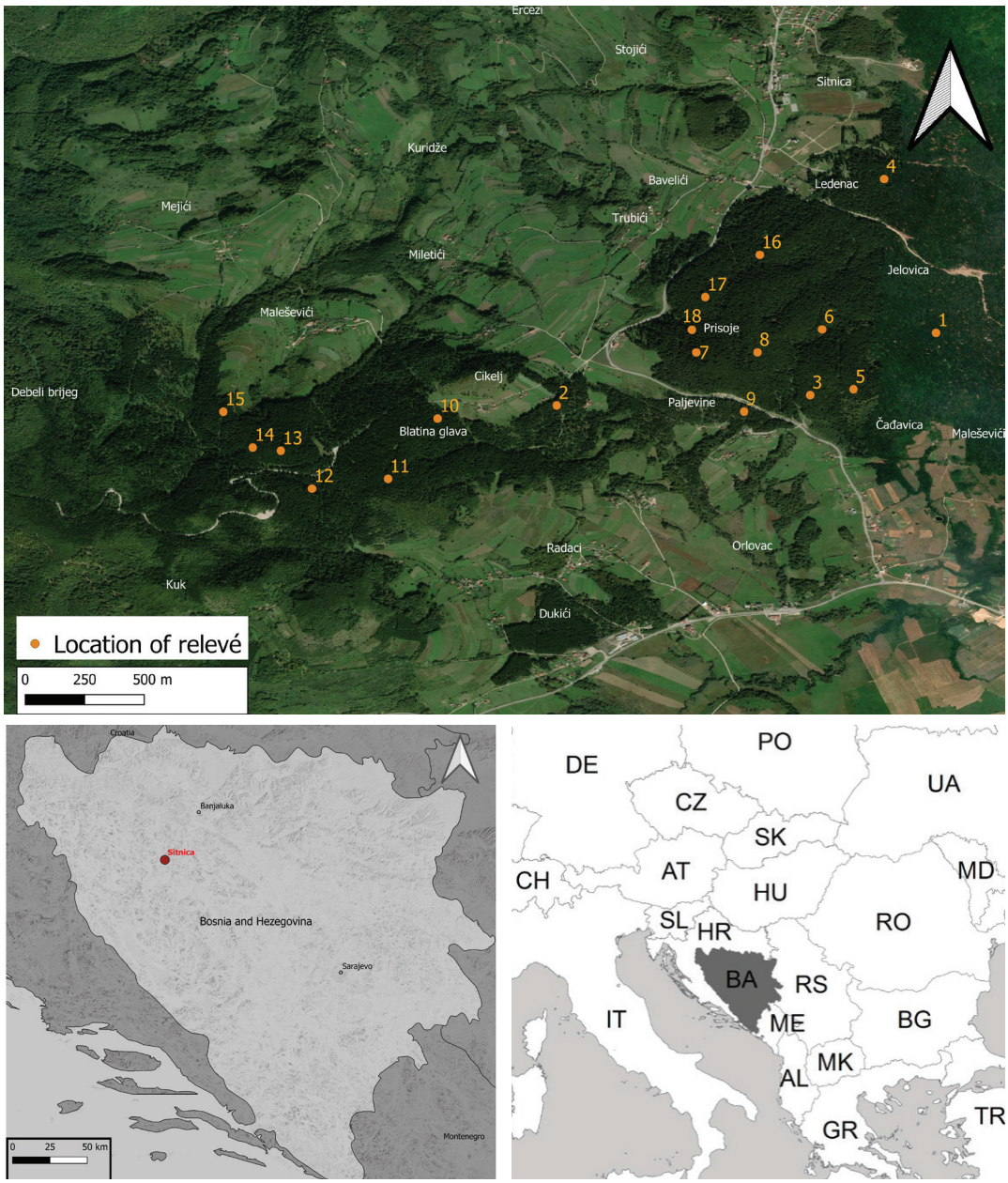

Figure 1. Location of the relevés inside researched area, and location of researched area in B&H / **Slika 1.** Položaj snimaka na istraživanom području, i položaj istraživanog područja u BiH

3. RESULTS AND DISCUSSION / REZULTATI I DISKUSIJA

3.1 Floristic and syntaxonomical analysis of the community / Floristička i sintaksonomska analiza zajednice

As shown in the phytocoenological table (Table 1), the closed canopy tree layer consists only of *Abies alba* and sometimes *Picea abies*. The shrub layer is species-rich and contains many species usually found in mesophilous forests of middle vegetation belts (*Rubus hirtus* agg., *Corylus avellana, Fagus sylvatica, Carpinus betulus, Acer pseudoplatanus*). Some species of higher altitudes and colder climates are also present (*Picea abies, Vaccinium myrtillus, Sorbus aucuparia*). The cover of the shrub layer varies, but it is usually below 50%. The herb layer is rich and mostly consists of mesophilous species that are common in deciduous forests of middle vegetation belts such as *Oxalis acetosella, Galium rotundifolium, Sanicula europaea, Lactuca muralis, Luzula luzulina, Geranium robertianum, Dryopteris filix-mas, Glechoma hirsuta, Carex sylvatica, Pteridium aquilinum, Epilobium montanum, Aremonia agrimonoides, Galium odoratum, Dryopteris dilatata* and *Carex digitata.* The cover of the herb layer is 60% on average.

Comparison of the floristic composition and descriptions of similar communities from central Europe (Boublík, 2010; Chytrý, 2013; Świerkosz et al., 2014; Valachovič et al., 2021) and BiH (Fu-

Table 1. Phytocoenological table of the *Galio rotundifolii-Abietetum albae* from Sitnica in BiH / **Tabela 1.** Fitocenološka tabela asocijacije *Galio rotundifolii-Abietetum albae* iz okoline Sitnice u BiH

Relevé number / Broj snimka	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	%
Longitude / Geografska dužina	16.941159	16.921132	16.934516	16.938421	16.93680	16.935144	16.92850	16.931733	16.931023	16.914845	16.912224	16.908212	16.906563	16.905081	16.903526	16.931852	16.928975	16.928263	
Latitude / Geografska širina	44.50732	44.503488	44.504036	44.515431	44.504345	44.50750	44.506284	44.506287	44.503166	44.50280	44.499613	44.49910	44.50110	44.501269	44.503158	44.511432	44.509206	44.507477	
Elevation / Nadmorska visina (m)	807	850	865	800	808	820	900	905	801	880	925	890	920	910	880	850	880	870	
Exposition / Ekspozicija	W	SE	S	E	E	N	W	E	NW	E	P	NE	SE	NW	P	SW	NW	NW	
Slope / Nagib (°)	5	25	10	5	5	15	15	35	15	25	0	20	10	5	0	5	7	30	
A1 coverage / A1 pokrovnost (%)	85	65	85	70	80	70	90	90	80	90	70	80	95	95	95	80	80	75	
A2 coverage / A2 pokrovnost (%)	5	20	0	0	5	0	0	0	10	0	20	0	0	0	10	5	0	0	
B1 coverage / B1 pokrovnost (%)	0	5	0	5	0	0	0	0	0	0	5	0	0	5	0	0	0	0	
B2 coverage / B2 pokrovnost (%)	0	5	0	0	5	5	2	0	5	5	5	5	0	0	0	5	5	5	
B3 coverage / B3 pokrovnost (%)	25	10	20	30	15	35	10	2	10	5	5	5	5	5	40	20	25	45	
C coverage / C pokrovnost (%)	40	30	50	30	40	50	35	75	40	80	75	80	80	95	85	70	70	50	
Species / Vrsta	Layer /sprat	*Galio rotundifolii-Abietetum albae*																	%
Abies alba	A1	4	3	4	4	5	4	4	5	5	5	4	4	5	4	4	3	4	3	100
Abies alba	A2	1	1	.	.	1	.	.	.	1	.	1	.	.	.	1	1	.	.	39
Abies alba	B1	.	.	.	1	.	.	.	.	.	.	1	.	.	1	.	.	.	.	17

Relevé number / Broj snimka		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	%
Abies alba	B2	.	+	.	.	.	.	.	.	1	1	1	1	.	.	.	.	.	.	28
Abies alba	B3	1	+	2	2	3	1	1	+	1	+	+	1	1	+	3	2	2	3	100
Abies alba	C	+	+	+	+	1	+	+	+	+	+	+	+	+	1	+	.	.	+	89
Picea abies	A1	.	3	3	2	1	1	1	.	1	1	.	2	.	2	2	1	1	2	78
Picea abies	A2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
Picea abies	B3	.	.	.	.	+	+	1	.	.	+	+	.	1	.	.	1	+	+	50
Picea abies	C	+	+	+	+	+	+	+	.	+	.	.	.	.	.	+	.	.	+	56
Rubus idaeus	B3	+	.	+	+	r	+	.	.	.	.	+	.	.	.	.	.	.	.	33
Oxalis acetosella	C	2	1	1	1	1	+	+	4	+	4	3	4	4	2	4	2	1	1	100
Galium rotundifolium	C	+	1	1	+	+	+	+	+	1	2	2	2	2	2	1	1	2	1	100
Lactuca muralis	C	2	1	1	.	+	+	+	+	+	+	+	+	+	.	+	+	1	+	89
Dryopteris filix-mas	C	1	+	.	.	+	1	.	+	.	+	.	+	+	1	+	+	+	2	72
Carex digitata	C	.	.	1	+	2	1	+	.	.	.	+	1	1	.	.	2	1	.	56
		Fagion sylvaticae																		
Sanicula europaea	C	1	.	+	.	+	+	3	2	+	+	+	+	1	3	+	1	3	2	89
Carex sylvatica	C	+	.	+	.	.	+	+	.	.	+	+	+	+	+	+	.	+	+	67
Galium odoratum	C	.	.	+	.	+	+	.	+	.	.	+	1	.	+	+	+	.	+	56
Athyrium filix-femina	C	1	.	.	.	.	1	.	+	.	.	+	.	+	2	1	2	.	1	50
Cardamine bulbifera	C	+	.	.	.	.	.	+	.	.	+	.	+	.	+	.	.	+	+	39
Lamium galeobdolon agg.	C	+	.	.	.	+	+	.	.	.	1	.	1	.	.	.	+	.	+	39
Viola reichenbachiana	C	+	.	.	.	.	+	+	.	.	+	+	+	+	.	.	.	.	.	39
Hordelymus europaeus	C	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	11
		Aremonio-Fagion																		
Aremonia agrimonoides	C	.	r	.	.	r	+	+	+	+	r	.	+	.	+	r	.	+	.	61
		Erythronio-Carpinion																		
Helleborus odorus	C	.	.	.	.	.	.	.	.	.	.	.	+	.	r	.	.	.	.	11
		Carpino-Fagetea																		
Corylus avellana	B2	.	.	.	.	.	1	1	.	.	.	1	.	.	.	.	1	.	1	28
Corylus avellana	B3	+	+	+	r	2	+	+	+	+	+	r	+	.	.	+	+	+	+	89
Corylus avellana	C	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	11
Fagus sylvatica	B2	.	.	.	.	.	+	.	.	1	.	.	.	.	.	.	1	1	.	22
Fagus sylvatica	B3	+	+	+	+	+	+	+	+	+	+	+	+	.	+	+	+	+	+	94
Fagus sylvatica	C	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	11
Carpinus betulus	B3	.	.	+	.	.	.	+	.	r	.	.	+	+	+	+	+	.	.	44
Carpinus betulus	C	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	6
Acer pseudoplatanus	B3	.	.	.	.	r	r	r	.	+	.	.	.	.	.	.	+	r	+	39
Fraxinus excelsior	B3	.	r	.	.	.	r	.	.	.	.	.	.	+	+	+	.	.	.	28

continued / nastavak na sljedećoj stranici

continuation of Table 1 / nastavak Tabele 1

Relevé number / Broj snimka		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	%
Hedera helix	B3	+	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	22
Ilex aquifolium	B3	.	.	.	.	.	.	.	.	.	.	.	.	r	r	+	.	.	.	17
Geranium robertianum	C	+	+	+	.	.	+	+	+	.	+	+	+	+	+	+	+	+	.	78
Glechoma hirsuta	C	1	.	.	.	.	+	+	.	.	+	+	+	+	+	1	1	+	+	67
Epilobium montanum	C	.	+	+	.	.	.	+	+	.	+	+	.	+	r	.	+	+	+	61
Circaea lutetiana	C	.	.	+	.	.	+	1	+	.	.	.	+	+	.	.	+	.	+	44
Drymochloa drymeja	C	.	.	2	.	2	.	.	.	3	.	+	.	.	+	.	+	+	+	44
Polystichum setiferum	C	.	.	+	.	.	1	+	+	.	.	+	.	1	.	.	.	.	+	39
Hieracium murorum agg.	C	.	.	.	.	.	.	+	.	+	+	+	.	+	+	.	.	.	+	39
Moehringia trinervia	C	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	+	+	.	22
Scrophularia nodosa	C	.	.	.	.	.	r	.	r	.	+	.	.	.	.	.	.	.	.	17
Melica uniflora	C	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	+	.	.	17
Anemone nemorosa	C	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	11
Epipactis sp.	C	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	11
Primula acaulis	C	.	.	.	.	.	.	.	.	.	.	r	.	+	.	.	.	.	.	11
Veronica montana	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	11
Symphytum tuberosum	C	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.	.	.	11
		Vaccinio-Piceetea																		
Luzula luzulina	C	.	1	1	1	1	+	.	+	+	1	2	.	2	2	2	2	1	1	83
Dryopteris dilatata	C	+	.	.	1	.	+	.	.	.	+	+	.	+	1	+	+	.	+	56
Vaccinium myrtillus	B3	.	+	.	1	.	.	.	+	+	.	+	.	+	.	.	1	.	.	39
Sorbus aucuparia	B3	+	.	.	r	+	+	.	.	+	.	.	.	.	.	.	+	.	.	33
		Quercetea pubescentis																		
Acer obtusatum	B3	.	.	.	.	.	.	.	.	.	r	+	r	+	+	+	.	.	.	33
Quercus cerris	B3	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	+	.	r	22
		Other species / Ostale vrste																		
Rubus hirtus agg.	B3	3	2	2	3	+	3	1	+	1	+	+	+	1	+	+	1	2	2	100
Pteridium aquilinum	C	.	+	+	.	.	.	.	+	+	+	+	+	+	+	+	+	.	.	61
Galeopsis speciosa	C	.	+	.	.	+	.	.	.	r	+	+	+	.	.	.	+	+	+	50
Clematis vitalba	B3	.	+	.	.	.	.	+	.	.	.	.	+	+	+	.	.	.	.	28
Sambucus nigra	B3	r	+	.	.	.	+	.	.	.	+	.	.	.	.	r	.	.	.	28
Sambucus racemosa	B3	.	.	.	.	.	.	.	.	.	.	+	.	.	r	.	.	.	.	11
Luzula luzuloides	C	.	.	2	.	.	+	.	1	1	+	.	.	.	.	.	+	.	+	39
Prunella vulgaris	C	.	.	+	.	+	.	.	.	.	+	.	.	.	.	.	.	+	+	28
Fragaria vesca	C	.	.	+	.	r	.	.	+	.	.	.	.	r	.	.	.	+	.	28
Clinopodium vulgare	C	.	.	.	.	+	+	.	.	.	.	.	r	.	.	.	.	+	+	28
Veronica officinalis	C	.	.	1	+	+	.	.	.	.	.	.	.	.	.	.	+	+	.	28

Relevé number / Broj snimka		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	%
Solanum dulcamara	C	.	+	r	.	r	.	.	.	.	r	+	.	.	.	.	.	.	.	28
Senecio ovatus	C	.	.	.	.	.	.	.	r	.	+	.	.	r	.	.	.	.	1	22
Hieracium racemosum	C	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	1	+	+	22
Viola alba	C	.	+	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	22
Ajuga reptans	C	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	+	22
Salvia glutinosa	C	.	.	.	.	.	.	.	+	+	.	.	r	.	.	.	.	.	.	17
Stachys sylvatica	C	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	17
Cruciata glabra	C	.	.	+	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	17
Prunus avium	C	.	.	.	.	.	.	.	.	r	.	.	.	.	r	.	.	+	.	17
Eupatorium cannabinum	C	.	.	+	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	11
Euphorbia amygdaloides	C	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	11
Melampyrum pratense	C	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	11
Carex pallescens	C	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	11
Lysimachia vulgaris	C	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	11
Veronica chamaedrys	C	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	11
Solidago virgaurea	C	r	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	11

Napomena / Note. These species are present in just single relevé / Sljedeće vrste su prisutne u samo jednom snimku: B3: *Acer campestre* (14), *Crataegus monogyna* (18), *Pyrus communis* subsp. *pyraster*, *Rubus plicatus* (6), *Quercus petraea* (10); C: *Carex brizoides* (1), *Polygonatum multiflorum* (2), *Campanula persicifolia* (3), *Dryopteris carthusiana* (4), *Melica nutans* (5), *Hypericum hirsutum* (6), *Actaea spicata*, *Aposeris foetida*, *Aquilegia nigricans* (7), *Gentiana asclepiadea*, *Maianthemum bifolium* (9), *Urtica dioica* (10), *Anemone ranunculoides*, *Brachypodium sylvaticum* (12), *Neottia nidus-avis* (14), *Prenanthes purpurea* (16), *Polypodium vulgare* (18).

karek, 1969; Stefanović, 1986) suggests that our relevés should be classified as *Galio rotundifolii-Abietetum albae* Wraber (1955) 1959, inside the alliance *Fagion sylvaticae* and the class C*arpino-Fagetea sylvaticae*.

Although the analyzed community is purely coniferous (Figure 4), the mesotrophic species of the *Fagetalia* order are dominant in the herb layer, which is congruent with *Galio rotundifolii-Abietetum*.

3.2 Ecological and functional traits of the community / Ekološke i funkcionalne osobine zajednice

The variation of occurrence of life forms per relevé is shown in Figure 2. Hemicryptophytes are most abundant with 52 recorded species (54.7 %) with average 57.1 % species per relevé. A high average number of species can be considered an indicator of a typical temperate climate zone (Uzunov & Gussev, 2003). Phanerophytes are the second most abundant group with 24 species (25.3%) with an average of 29.6% species per relevé. It should be pointed out that 13 species of trees were only recorded in the shrub layer making this number higher than expected. It is noted that phanerophytes are abundant in mesophilous coniferous forests in lower altitudes (deciduous vegetation belts) because many tree species from neighboring forests are present (Juvan et al., 2013). This process of constant germination and dying of young plants is permanent as long as there are nearby producers of seed, dispersal vectors, suitable conditions for germination and unsuitable factor for growth in later phases. In this way, those species are permanently present in lower layers but frequently absent from the tree layer. However, it is not clear why this community did not shift towards a beech community and could this be a permanent state like in some other monodomi-

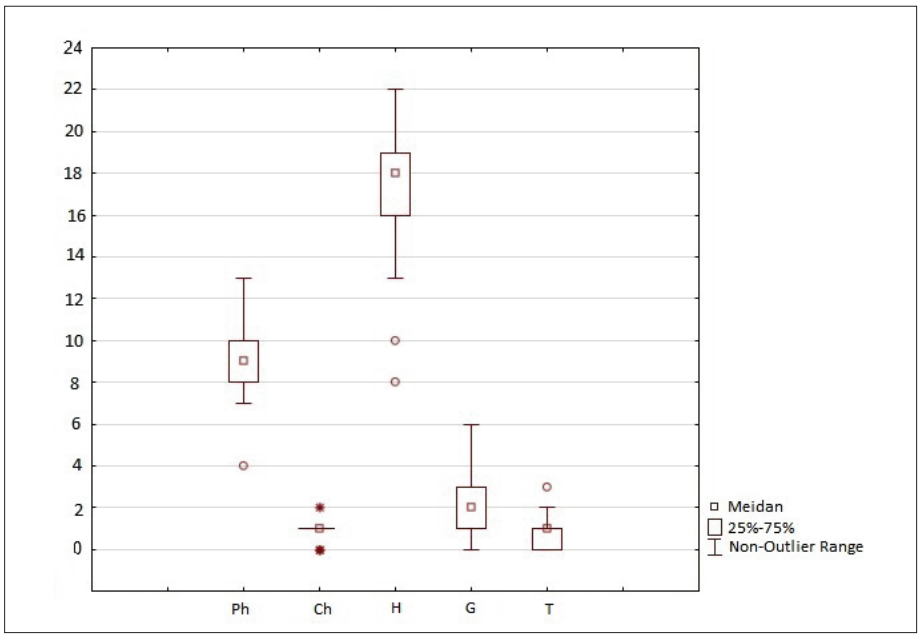

Figure 2: Variation of the number of different life forms per relevé: Ph - phanerophytes, Ch - chamaephytes, H - chamaephytes, G - geophytes and T - therophytes / **Slika 2.** Varijacija broja različitih životnih oblika po snimcima: Ph - fanerofite, Ch - hamefite, H - hemikriptofite, G - geofite i T - terofite

nant fir associations. Future research should determine this. We recorded 13 species (13.7%) of geophytes which is relatively low compared to other mesophilous forests. The reason for this can be the lack of ephemeral geophytes, which are more common in deciduous broad-leaved temperate forests (Koljanin et al., 2021), but also of rhizomatous species abundant in beech-dominated forests of mid and higher-elevations (Stupar & Čarni, 2017). The lowest number belongs to chamaephytes and therophytes, each having only 3 species recorded (3.2%). Chamaephytes have an average of 2.9% species per relevé while therophytes have 2,8% species per relevé. Chamaephytes are known to be the predominant life form in cold and dry climates (Di Biase et al., 2021) which makes this low number also expected. Therophytes are abundant in sites with thermo-xeric climatic conditions (Lazarina et al., 2019) as well as in sites under strong anthropogenic pressures (Kamberović et al., 2012) which makes their low number expected.

Ellenberg indicator values showed limited variation between relevés. The average values are: light - 4.39, temperature - 5.06, continentality - 4.64, moisture - 4.09, soil reaction - 4.03 and nutrients - 4.49. Such values are indicating the middle valence of ecological factors without extreme influences, which is consistent with the forests of class *Carpino-Fagetea*.

Horotypes are used to group species with similar distribution patterns. Such groups can be used to explain the origins and history of the development of particular floras (Passalacqua, 2015) but also to indicate climatic conditions (Abbate et al., 2012; Ferrer-Castán & Vetaas, 2003; Stupar & Čarni, 2017). In the case of the researched community, floristic composition is dominated by Eurasian, European and Boreal species (Figure 3). There is a relatively small percentage of Mediterranean and South European species. The lack of species characteristic for Illyrian floral province should also be pointed out since those are relatively common in nearby forests on limestone. Cosmopolitan elements are also in a small percentage which is expected as those are common in highly disturbed habitats (Kovačević et al., 2014).

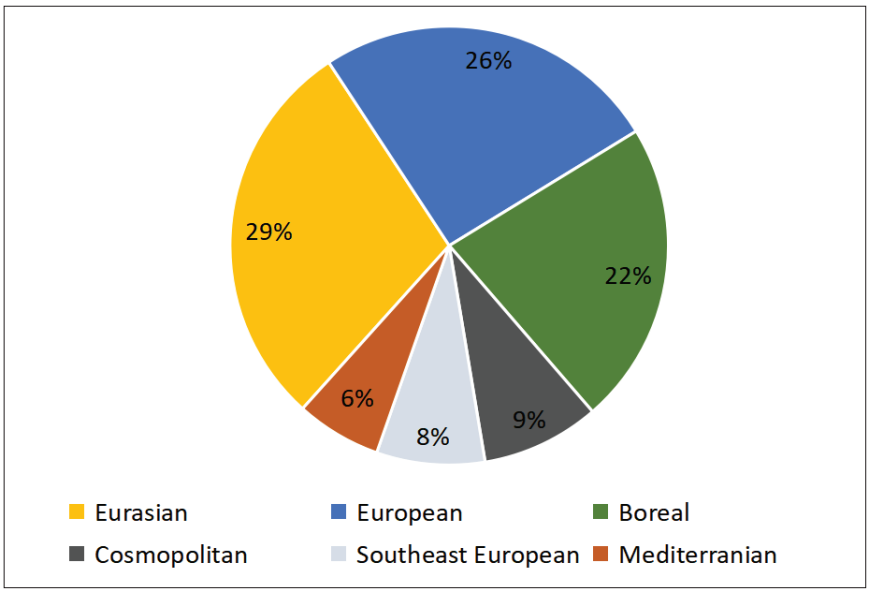

Figure 3. Proportions of horotypes / **Slika 3**. Udjeli horotipova

3.3 Notes on syntaxonomical position of the association / Napomene o sintaxonomskom položaju asocijacije

The syntaxonomical position of this association was often changed in the past, mostly due to changes in the position of their higher syntaxonomical units (suballiances and alliances). Marinček et al. (2006) classified *Galio rotundifolii-Abietetum* into the mesophilous coniferous alliance of *Abieti-Piceion* which is a part of the class *Vaccinio-Piceetea*. Juvan et al. (2013) also placed this association in the class *Vaccinio-Piceetea,* but in the dystrophic and acidophilous alliance *Piceion abietis*. On the other hand, Jarolímek et al. (2008) and Boublík (2010) placed it in the suballiance *Galio rotundifolii-Abietenion* of *Fagion sylvaticae*. Chytrý (2013) also considered this association to be part of the *Fagion sylvaticae* (not specifying the suballiance). Suballiance *Galio rotundifolii-Abietenion* was later included in the synonymy of *Abieti-Piceion* (Br.-Bl. in Br.-Bl. et al. 1939) Soó 1964 and hence relocated into the class *Vaccinio-Picetea* (Mucina et al., 2016). Contrary, Valachovič et al. (2021) considered *Abieti-Piceion* (Br.-Bl. in Br.-Bl. et al. 1939) Soó 1964 as a synonym of *Vaccinio-Abietion albae* (Oberd. 1962) Ujházy in Ujházy et al. 2021, alliance which they classify into acidophilous *Luzulo-Fagetalia*, while mesophilous coniferous *Galio-Abietetum albae* was classified into *Fagion sylvaticae*.

Among the species recorded in our community, species characteristic for the class *Vaccinio-Piceetea* (*Vaccinium myrtillus* and *Sorbus aucuparia*) come with low frequency, while more frequent *Luzula luzulina, Oxalis acetosella, Galium rotundifolium* and *Dryopteris dilatata* have wider ecological amplitude and are relatively regularly found in deciduous forests as well. This suggests that, although coniferous, investigated stands are floristically much closer to the class *Carpino-Fagetea*, which is congruent to the concept given by Valachovič et al. (2021). Similarly, although natural beech and mixed beech-fir forests from the surrounding area belong to the alliance *Aremonio-Fagion*, the floristic composition of studied communities (*Aremonia agrimonioides* is the only representative of the *Aremonio-Fagion*), which indicates that those belong to central European *Fagion sylvaticae*.

As *Galio-Abietetum* is distributed mostly in central Europe (Boublík, 2010), it should be pointed out that investigated stands are at the border of

Figure 4. Typical appearance of the association *Galio rotundifolii-Abietetum albae* in the Sitnica locality / **Slika 4.** Tipičan izgled asocijacije *Galio rotundifolii-Abietetum albae* na lokalitetu Sitnica

distribution and might show some peculiarities (e.g. *Acer obtusatum* and *Helleborus odorus*). Taking into consideration differences this association shows on a wider scale, comprehensive analyses with a larger number of relevés taken from the entire distribution area should be done to finally determine if there is only one association or there are two associations belonging to different classes.

4. CONCLUSION / ZAKLJUČAK

Abies alba dominated stands were analyzed on Manjača Mt. Although those stands were artificially planted, selective cuttings and natural regeneration helped these stands' structure shift from even-aged to uneven-aged while maintaining the main species in the tree layer (*Abies alba* and *Picea abies*).

Our results suggest that, based on collected and analyzed relevés, these stands belong to *Galio rotundifolii-Abietetum albae* Wraber (1955) 1959 classified in alliance *Fagion sylvaticae* of *Carpino-Fagetea*. A good basis for this classification approach is the herb layer, dominated by species of beech forests. This indicates a great similarity to forests dominated by beech.

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Sažetak

Šume u kojima dominira jela u Bosni i Hercegovini su samo djelimično istražene, bez sveobuhvatne fitocenološke analize. Jedan od glavnih razloga za izostanak takve analize je nedostatak fitocenoloških snimaka. Uz to, treba naglasiti kako na nivou Evrope još uvijek ne postoji konsenzus oko klasifikacije jelovih šuma. U okolini Sitnice (Manjača, sjeverozapadna B&H) prisutne su na značajnim površinama četinarske šume u kojima dominira jela. Ove sastojine su nastale pošumljavanjem jelom i djelomično smrčom, najvjerovatnije još prije Prvog svjetskog rata.

Sastojine se nalaze u pojasu bukovih šuma koje pripadaju svezi *Aremonio-Fagion*. Geološku podlogu čine silifikovani i bituminozni krečnjacima na kojima se dominantno javljaju distrični kambisoli. Kombinacijom prebornog sistema gazdovanja i prirodne obnove struktura sastojine je iz jednodobne prešla u raznodobnu. Promjena strukture nije praćena promjenama u sastavu vrsta drveća u gornjim spraatovima. Tako su jela i smrča i dalje jedine u spratu drveća dok su bukva i drugi lišćari prisutni samo u nižim spratovima grmlja ili kao ponik.

Ovaj rad je imao za cilj da doprinese poznavanju florističkih i ekoloških karakteristika jelovih šuma na istraživanom području kao i da utvrdi njihovu sintaksonomsku poziciju. Prikupljeno je ukupno 18 fitocenoloških snimaka (Tabela 1) u junu i julu 2021. i 2022. godine. Prilikom prikupljanja snimaka korištena je standardna fitocenološka metoda (Braun-Blanquet, 1964). Analizirane su vrijednosti ekoloških faktora, struktura životnih oblika i horotipovi.

Na osnovu florističkog sastava analizirane sastojine su svrstane u asocijaiju *Galio rotundifolii-Abietetum* Wraber (1955) 1959, koja pripada svezi *Fagion sylvaticae*. Ellenbergovi indeksi ukazuju da u sastojinama vladaju mezofilni uslovi. Struktura životnih formi je prikazana na grafiku (Slika 2) gdje je vidljivo da su najzastupljenije životne forme hemikriptofiti i fanorofiti. Analiza horotipova je pokazala veliki udio evropskih i evroazijskih vrsta (Slika 3). Balkanske i južnoevropske vrste su relativno slabo zastupljene što je u vezi sa izostankom ilirskih vrsta.

Ključne riječi: *Abies alba*, ekološki indeksi, geoelementi, metod Braun-Blanquet-a, šumske zajednice, vegetacija