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PHYTOCOENOSES OF COMMON SPRUCE (*Picea abies* (L.) Karsten) IN THE ALTIMONTANE AND SUBALPINE BELT OF CROATIA

FITOCENOZE OBIČNE SMREKE (Picea abies (L.) Karsten) U ALTIMONTANSKOM I SUBALPSKOM POJASU HRVATSKE

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Abstract

Three associations of common spruce in the altimontane and subalpine belt of the Croatian Dinaric Mountain range have been described using the Central European phytocoenological method (Braun-Blanquet 1964). These associations differ in terms of ecological conditions, floral composition, and partially of their distribution range. Spruce forests of western Croatia (Gorski Kotar) belong to the association *Lonicero caeruleae-Piceetum* Zupančič (1976) 1999, which were identified in Croatia for the first time with nine new phytocoenological relevés. The association *Laserpitio krapfii-Piceetum abietis* Vukelić, Alegro et Šegota 2010 is developed as a permanent stage on steep, north-facing, cold and rocky mountains between 1100 and 1500 m a. s. l., mostly on Mount Velebit. The association *Hyperico grisebachii-Piceetum* (Bertović 1975) Vukelić, Alegro, Šegota et Šapić 2010 extends predominantly above 1400 m a. s. l., often on inaccessible, distinctly rocky, open tops and upper steep stony exposed slopes of northern Velebit and Bjelolasica.

Key words: *Picea abies* (L.) Karsten, forest communities, altimontane and subalpine belt, Dinaric range, Croatia

Sažetak

Prema standardnoj srednjoeuropskoj fitocenološkoj metodi (Braun-Blanquet 1964) opisane su tri asocijacije obične smreke u altimontansko-subalpskom pojasu hrvatskih Dinarida. Međusobno se razlikuju prema ekološkim uvjetima, flornom sastavu, a dijelom i prema arealu (slika 1, tablice 2 i 3). Smrekove šume zapadne Hrvatske (Gorski kotar) pripadaju asocijaciji Lonicero caeruleae-Piceetum Zupančič (1976) 1999 koja je sa devet novih fitocenoloških snimaka (tablica 1) prvi puta utvrđena u Hrvatskoj. Asocijacija Laserpitio krapfii-Piceetum abietis Vukelić, Alegro et Šegota 2010 razvijena je kao trajni stadij na strmim, sjevernim, hladnim i sjenovitim padinama između 1100 i 1500 m, uglavnom na Velebitu. Asocijacija Hyperico grisebachii-Piceetum (Bertović 1975) Vukelić, Alegro, Šegota et Šapić 2010 rasprostire

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se pretežno iznad 1400 m nadmorske visine na često neprohodnim, izrazito stjenovitim, otvorenim vrhovima i gornjim strmim kamenitim izloženim padinama sjevernoga Velebita i Bjelolasice.

Ključne riječi: *Picea abies (L.) Karsten, šumske zajednice, altimontansko-subalpski pojas, dinarsko gorje, Hrvatska*

INTRODUCTION
UVOD

The Dinaric area in the Republic of Croatia above an altitude of 1200 m covers 76,000 ha, or only 1.4% of the area. Of this, over half are under forests, while the rest consists of scrub communities, mountain clearings, grasslands and rocks. The forest cover is completely dominated by the subalpine beech forest, while spruce in Croatia, unlike the Alps and the Carpathians, does not constitute a special height belt, nor does it form large complexes as it does in Slovenia and Bosnia and Herzegovina. It is developed as a permanent stage and inhabits localities that are not conducive to the growth of beech and fir stands; therefore, spruce is favoured by local climatic and orographic factors across its entire natural range, which gives it precedence over beech and fir (Beck-Mannagetta 1901, Horvat 1925, 1938, 1950, 1962, 1963, Anić 1959, Horvat, Glavač i Ellenberg 1974 et al.).

Phytocoenoses containing spruce as the edifying species are found in three large massifs in Croatia: Risnjak in Western Croatia, Bjelolasica in the Central Dinaric range and Velebit. The floral composition of spruce communities growing on these massifs differ from one another as a consequence of their biogeographic position and floral-genetic development, general ecological factors, macro and micro-climatic features of particular associations, and anthropogenic impacts. Spruce forests of Western Croatia are still under the alpine influence; even their macro-climate differs significantly from other Dinaric areas in Croatia. For example, the average annual temperature in the subalpine belt of Northern Velebit is 3.5 °C, and the average annual rainfall is 1898 mm (meteorological station Zavižan, 1594 m above sea level, period 1961-1990, data from the State Hydro-Meteorological Service). At Veliki Risnjak, situated about 100 m lower in Gorski Kotar, the average annual temperature is about 2 °C and the precipitation quantity is higher by almost 2000 mm than on Zavižan.

Spruce forests in the altimontane and subalpine belt of Croatia were described by Ivo Horvat (1950, 1962) as a macro-association *Piceetum croaticum subalpinum.* He presented this association in a synthetic form with 19 relevés (in Cestar 1967), comprising mainly the Gorski Kotar area. Subsequent research into spruce forests of Croatia (Bertović 1975, Vukelić et al. 2010a, Vukelić et al. 2010b) highlighted their heterogeneity, so two new associations were described. The association *Hyperico grisebachii-Piceetum* (=*Calamagrostio variae-Piceetum* Bertović 1975 nom. Illeg.) was identified in the rocky part of Velebit above an altitude of 1400 m. The second association, *Laserpitio krapfii-Piceetum abietis* Vukelić, Alegro et Šegota 2010, is developed as a permanent stage on steep, north-facing, cold and shady slopes between 1100 and 1500 m above the sea. However, both these associations are distributed mainly on Velebit, while stands from Western Croatia growing towards the border area with Slovenia, which were also included in Horvat's complex of *Piceetum subalpinum,* are not part of them. For this reason, we surveyed the Risnjak massif and Bjelolasica areas, compared the stands with the results of earlier research into spruce forests of Croatian and adjacent areas, and defined them into three independent associations in terms of ecology and floral composition.

MATERIALS AND RESEARCH METHODS
MATERIJALI I METODE ISTRAŽIVANJA

Research was conducted using the method of the Zurich-Montpellier Phytocoenological School with a six-point scale. The relevés were entered into the Turboveg database (Hennekens & Schaminée

2001) and were statistically processed in the Primer 6 software (Clarke & Gorley 2001). We used MDS (Non-metric Multi-Dimensional Scaling) and the UPGMA (Unweighted Pair-Group Method Using Arithmetic Averages) agglomerative hierarchical method with the Bray-Curtis similarity index. The average Ellenberg's ecoindicator values (Ellenberg 1979) of the communities were calculated by means of the JUICE 7.0 software (Tichý 2002) and were compared in STATISTICA 8.0 (StatSoft Inc. 1984-2008) using the Kruskal-Wallis test ($p<0.05$).

The floristic composition was classified according to the social affiliation of the species, plant nomenclature was coordinated according to the Flora Croatica Database (Nikolić 2008), and mosses were adjusted according to Koperski et al. (2000).

The floristic composition and structure of spruce stands in Croatia are presented on the basis of 54 phytocoenological relevés, of which 19 are by I. Horvat (Cestar 1967), 6 are by S. Bertović (1975), and 29 relevés have been investigated by the authors in the past two years. Horvat's relevés were not taken into consideration for statistic analysis because they are not in the analytical form. Nine new relevés of the association *Lonicero caeruleae-Piceetum* are presented in the analytical Table 1. Three associations from Croatia and two from Slovenia (Acceto 2006, Zupančič 1999) are given in the synoptic form in Table 2. One of them (column 1) represents the association *Lonicero caeruleae-Piceetum* from research by Zupančič exactly as he described it.

RESEARCH RESULTS AND DISCUSSION
REZULTATI ISTRAŽIVANJA I RASPRAVA

The statistical analysis of 35 analytical relevés, as well as the comparison in Table 2 shows three clearly distinct associations (Figure 1). The sociological affiliation of the species in particular associations (Table 3) points to their mutual differences. These differences are the consequence of the biogeographic position and floral-genetic development, general ecological factors, macro- and micro-climatic features of a particular association and anthropogenic impacts.

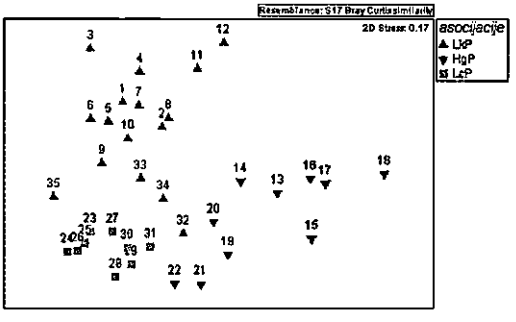

Figure 1 Multi-Dimensional Scaling
Slika 1 Multidimenzionalno skaliranje

Subalpine Forest of Spruce with Blue-Berried Honeysuckle
(Lonicero caeruleae-Piceetum abietis Zupančič (1976) 1999 corr.*)*

The association named *Piceetum subalpinum dinaricum* was established by Zupančič in 1976 on Slovenia's Snežnik, which forms a coherent ecological-vegetational unit with the Risnjak area, i.e. with Western Croatia. In his later works (1994,1999), Zupančič renamed the association into *Lonicero caeruleae-Piceetum* and defined *Lonicera caerulea* subsp. *borbasiana* and the moss *Sanionia uncinata* as the characteristic species of the association, while *Lycopodium annotinum* and *Vaccinium vitis-idaea*

were identified as locally differential species. With the exception of the moss *Sanionia uncinata,* other species participate significantly in the subalpine spruce forests of Gorski Kotar. In addition to the geomorphological, ecological and other similarities, this is the most important reason that the stands from Gorski Kotar have, for the time being, been added to the association *Lonicero caeruleae-Piceetum.* It must be stressed, however, that more detailed research is necessary in order to make the final determination. The floristic composition of the association is given in Table 1. Compared to the other two associations, the composition is considerably dominated by the species of spruce forests of the class *Vaccinio-Piceetea* (51:36:39) (Table 3).

Table 1 Floristic composition of association *Lonicero caeruleae-Piceetum* in Croatia
Tablica 1 Floristički sastav asocijacije Lonicero caeruleae-Piceetum u Hrvatskoj

Ass. Lonicero coeruleae-Piceetum												
Number of releve / *Broj snimke*			1	2	3	4	5	6	7	8	9	Presence degree / *Stupanj udjela*
Locality / *Lokalitet:*			G1	G2	Li1	Li2	MB	BS1	BS2	BS3	SS3	
Exposition / *Ekspozicija*			i	sz	si	ji	si	si	si	si	i	
Inclination / *Nagib* (°)			40	45	10	20	30	40	45	35	30	
Altitude / *Nadmorska visina* (m)			980	1010	960	1050	995	1020	1210	1205	1290	
Relevé area / *Površina snimke* (m²)			400	400	600	400	900	600	400	400	400	
Cover / *Pokrovnost (%)* A			80	60	90	80	75	95	85	70	65	
B			60	50	70	50	60	40	70	60	70	
C			80	80	80	90	65	70	70	85	70	
D			80	80	70	60	55	25	50	60	65	
Floristic composition / *Florni sastav*												
Char. and diff. species of association / *Svojstvene i razlikovne vrste asocijacije*												
a	Lonicera nigra	B	1	1	1	2	+	+	+	+	.	5
a	Lonicera caerulea borbasiana		.	.	.	.	.	+	+	+	+	3
a	Lycopodium annotinum	C	+	+	1	3	2	.	2	2	2	5
a	Vaccinium vitis-idaea		.	.	.	.	1	.	+	1	.	2
a	**Vaccinio-Piceenion**											
	Polystichum lonchitis		+	+	.	.	+	.	+	+	.	3
	Luzula sylvatica		+	.	.	.	+	.	.	.	.	1
	Luzula luzulina		.	.	.	.	+	.	.	.	+	1
	Plagiothecium undulatum	D	.	+	+	+	+	.	.	.	.	3
	Rhytidiadelphus loreus		.	.	.	.	.	+	1	1	1	3
	Mylia taylori		.	.	.	.	+	.	.	.	.	1
	Rhizomnium punctatum		.	.	.	.	.	.	.	+	.	1
b	**Abieti-Piceenion**											
	Abies alba	A	2	1	1	2	+	2	1	+	2	5
	Abies alba	B	3	3	2	2	1	+	+	.	2	5
	Clematis alpina		3	1	1	1	1	2	2	1	2	5
	Valeriana tripteris	C	3	2	1	2	+	1	2	1	+	5
	Dryopteris expansa		1	1	+	+	+	.	+	+	+	5
	Veronica urticifolia		1	+	+	1	+	.	1	1	+	5
	Abies alba		+	+	+	+	.	+	+	.	.	3
	Dryopteris dilatata		+	1	+	+	.	.	+	+	.	3
	Adenostyles alpina		.	.	.	.	.	+	+	.	2	2
	Streptopus amplexifolius		+	+	.	.	.	.	.	.	.	1

c	**Vaccinio-Piceion**											
	Picea abies	A	4	4	4	4	5	4	3	4	4	5
	Picea abies	B	1	+	+	+	+	.	1	.	1	4
	Picea abies	C	.	+	+	+	+	+	.	+	+	4
	Hieracium murorum		.	.	+	.	+	.	+	+	+	3
	Bazzania trilobata	D	.	.	.	.	+	.	.	.	.	1
d	**Vaccinio-Piceetea, Piceetalia**											
	Sorbus aucuparia	A	.	.	.	.	.	.	1	+	+	2
	Rosa pendulina	B	4	3	1	1	1	2	2	2	1	5
	Vaccinium myrtillus		1	.	1	3	2	2	3	3	2	5
	Sorbus aucuparia		.	.	+	+	+	+	+	+	+	4
	Rubus saxatilis		.	.	.	.	1	.	.	.	.	1
	Homogyne sylvestris	C	3	2	2	2	.	1	+	1	+	5
	Gentiana asclepiadea		1	1	1	1	1	+	+	+	+	5
	Maianthemum bifolium		1	1	1	1	2	+	1	+	+	5
	Oxalis acetosella		1	1	+	.	+	+	+	+	1	5
	Huperzia selago		+	+	+	.	1	1	1	1	+	5
	Phegopteris conectilis		1	1	1	1	.	.	+	+	.	3
	Calamagrostis arundinacea		+	1	.	+	1	3	.	1	.	3
	Gymnocarpium dryopteris		.	.	.	.	+	.	.	+	.	1
	Melampyrum velebiticum		.	.	.	.	+	.	.	.	.	1
	Sorbus aucuparia		.	.	.	.	.	.	.	.	+	1
	Polytrichum formosum	D	2	2	2	1	1	1	1	1	1	5
	Dicranum scoparium		1	1	1	1	1	2	2	2	1	5
	Rhytidiadelphus triquetrus		+	+	+	+	.	.	.	1	.	3
e	**Erico-Pinion, Erico-Pinetalia**											
	Cirsium erisithales	C	+	.	.	+	1	+	.	.	+	3
	Calamagrostis varia		.	.	.	.	.	+	+	+	3	2
f	**Aremonio-Fagion**											
	Rhamnus alpinus fallax	B	+	.	.	.	.	.	.	.	.	1
	Cardamine trifolia	C	2	1	1	+	+	+	+	+	1	5
	Euphorbia carniolica		+	+	+	+	.	.	.	.	.	3
	Cardamine enneaphyllos		.	.	1	.	+	1	+	+	.	3
	Scopolia carniolica		.	.	.	.	.	+	+	+	+	3
	Calamintha grandiflora		.	.	.	.	+	.	.	+	.	1
	Aremonia agrimonoides		+	.	.	.	.	.	.	.	.	1
	Omphalodes verna		.	.	+	.	.	.	.	.	.	1
	Cyclamen purpurascens		.	.	.	.	+	.	.	.	.	1
g	**Adenostylon, Adenostyletalia**											
	Rubus idaeus	B	+	.	+	1	+	.	+	.	+	3
	Salix grandifolia		.	+	.	.	1	.	+	+	+	3
	Dryopteris filix-mas	C	+	+	+	+	+	+	+	1	+	5
	Polygonatum verticillatum		1	1	+	+	+	.	.	+	+	4
	Athyrium filix-femina		+	+	+	+	.	.	+	+	+	4
	Ranunculus platanifolius		2	1	1	.	.	.	+	1	1	3
	Doronicum austriacum		+	+	+	+	.	.	.	+	.	3

	Veratrum album		+	+	+	.	.	.	+	+	+	3
	Saxifraga rotundifolia		.	.	.	.	.	+	+	+	+	3
	Aruncus dioicus		3	3	1	.	.	.	.	.	.	2
	Cicerbita alpina		.	.	.	+	.	.	.	.	+	1
	Senecio ovatus		.	.	.	.	.	+	.	+	.	1
h	**Fagetalia**											
	Fagus sylvatica	A	+	.	.	.	.	1	1	+	.	3
	Fagus sylvatica	B	.	+	+	+	.	+	.	.	.	3
	Daphne mezereum		+	+	.	.	+	+	+	+	.	3
	Acer pseudoplatanus		.	.	+	+	+	+	.	.	+	3
	Lonicera alpigena		.	.	.	+	.	+	+	+	.	3
	Sambucus racemosa		.	.	.	.	+	.	+	+	+	3
	Prenanthes purpurea	C	1	1	+	1	+	+	+	+	+	5
	Solidago virgaurea		+	+	+	1	+	+	+	+	1	5
	Paris quadrifolia		+	+	+	+	.	.	1	+	.	3
	Mercurialis perennis		1	1	+	.	+	1	.	+	.	3
	Mycelis muralis		+	.	+	+	.	+	+	.	1	3
	Polystichum lobatum		1	1	+	.	.	.	+	+	.	3
	Actaea spicata		+	+	.	.	.	+	+	+	+	3
	Galeobdolon luteum		+	+	.	.	.	+	.	.	+	3
	Phyteuma spicatum		.	+	.	.	+	+	+	+	+	3
	Asplenium scolopendrium		.	.	.	.	.	+	.	+	+	2
	Polygonatum multiflorum		.	+	.	.	+	.	.	.	.	1
	Symphytum tuberosum		.	+	.	.	.	.	.	+	.	1
	Geranium robertianum		.	.	.	+	.	.	.	+	.	1
	Melica uniflora		.	+	.	.	.	.	.	.	.	1
	Carex sylvatica		.	.	.	+	.	.	.	.	.	1
	Viola reichenbachiana		.	.	.	.	+	.	.	.	+	1
	Fagus sylvatica		.	.	.	.	+	.	.	.	.	1
	Acer pseudoplatanus		.	.	.	.	.	+	.	.	.	1
	Epilobium montanum		.	.	.	.	.	.	.	+	1	1
	Asarum europaeum		.	.	.	.	.	.	.	+	.	1
	Melica nutans		.	.	.	.	.	.	.	.	+	1
	Neckera crispa	D	+	1	+	+	.	1	.	.	2	3
i	**Querco-Fagetea**											
	Sorbus aria	A	.	.	.	.	.	+	.	.	.	1
	Taxus baccata		.	.	.	.	.	+	.	.	.	1
	Sorbus aria	B	+	.	.	+	.	.	.	.	.	1
	Anemone nemorosa	C	2	1	1	1	+	+	+	1	1	5
	Carex digitata		+	+	+	.	+	.	.	.	.	3
	Carex ornithopoda		.	.	.	.	.	1	+	+	.	2
	Anemone hepatica		.	.	.	.	+	+	.	.	.	1
	Convallaria majalis		.	.	.	.	1	.	.	+	.	1
	Ctenidium molluscum	D	3	3	3	2	1	3	2	3	1	5
j	**Asplenietea trichomanes**											
	Asplenium viride	C	+	+	1	+	+	.	1	+	.	4
	Asplenium trichomanes		.	+	+	.	.	+	.	+	+	3

	Moehringia muscosa		+	.	.	.	+	+	.	+	.	3
	Polypodium vulgare		+	.	.	.	.	+	.	+	.	2
	Asplenium ruta muraria		.	.	.	.	.	+	.	.	.	1
	Corydalis ochroleuca		.	.	.	.	.	.	+	.	.	1
	Cystopteris alpina		.	.	.	.	.	.	.	+	.	1
	Cystopteris fragilis		.	.	.	.	.	.	.	.	+	1
I	**Other species** / *Ostale vrste:*		.	.	.	.	.	.	.	.	.	.
	Fragaria vesca	C	.	.	.	+	.	.	.	.	.	1
	Silene pusilla		.	.	.	.	.	.	+	.	.	1
	Mahovine / *Mosses*	D										
	Tortella tortuosa		+	+	+	1	2	+	+	1	+	5
	Fissidens dubius		+	+	2	+	.	+	+	+	1	5
	Eurhynchium striatum		+	.	+	+	+	.	.	.	.	3
	Isothecium aloperuroides		.	+	.	+	.	+	+	.	.	3
	Mnium marginatum		+	.	+	.	.	.	.	+	1	3
	Plagiochila porelloides		.	.	.	.	.	+	+	1	1	3
	Mnium thomsonii		.	.	.	.	.	+	+	+	.	2
	Schistidium apocarpum		.	.	.	.	+	.	.	.	+	1
	Brachythecium velutinum		.	.	+	+	.	.	.	.	.	1
	Leucobryum glaucum		.	.	+	+	.	.	.	.	.	1
	Scapania aspera		.	.	.	.	.	+	.	+	.	1
	Hypnum andoi		.	.	+	.	.	.	.	.	.	1
	Metzgeria furcata		.	.	.	.	+	.	.	.	.	1
	Neckera pumila		.	.	.	.	+	.	.	.	.	1
	Syntrichia ruralis		.	.	.	.	+	.	.	.	.	1
	Jungermannia leiantha		.	.	.	.	.	+	.	.	.	1
	Neckera complanata		.	.	.	.	.	+	.	.	.	1
	Blepharstoma trichnophyllum		.	.	.	.	.	.	+	.	.	1
	Bryum capillare		.	.	.	.	.	.	+	.	.	1
	Cephalozia catenulata		.	.	.	.	.	.	+	.	.	1
	Cirriphyllum piliferum		.	.	.	.	.	.	+	.	.	1
	Lophozia ascendens		.	.	.	.	.	.	+	.	.	1
	Lophozia incisa		.	.	.	.	.	.	+	.	.	1
	Riccardia palmata		.	.	.	.	.	.	+	.	.	1
	Tritomaria exsecta		.	.	.	.	.	.	+	.	.	1
	Scapania umbrosa		.	.	.	.	.	.	+	.	.	1
	Eurhynchium angustirete		.	.	.	.	.	.	.	+	.	1
	Bryum flaccidum		.	.	.	.	.	.	.	+	.	1
	Calipogeia fissa		.	.	.	.	.	.	.	+	.	1
	Pedinophyllum interruptum		.	.	.	.	.	.	.	+	.	1
	Pseudolaskea catenulata		.	.	.	.	.	.	.	+	.	1
	Rhynchostegium murale		.	.	.	.	.	.	.	.	1	1
	Atrichum undulatum		.	.	.	.	.	.	.	.	+	1
	Plagiothecium laetum		.	.	.	.	.	.	.	.	+	1

Locality / *Lokalitet:* Gašparac (G), Lividraga (L), Bijele stijene (BS), Samarske stijene (SS), Markov brlog (MB)

Along with the already mentioned differentiating species and compared to the other two subalpine spruce communities in Croatia, the phytocoenosis *Lonicero caeruleae-Piceetum* is characterized by higher participation of the species *Calamagrostis arundinacea, Abies alba, Gentiana asclepiadea, Solidago virgaurea, Phegopteris connectilis,* while of other syntaxa, *Cardamine trifolia* is particularly distinct. On the other hand, compared to the ecologically and physiognomically similar community *Laserpitio krapfii-Piceetum,* the species *Melampyrum velebiticum, Calamagrostis varia, Carex ornythopoda, Campanula rotundifolia* agg., and a larger number of the species of the order *Fagetalia* are either absent or are less well represented.

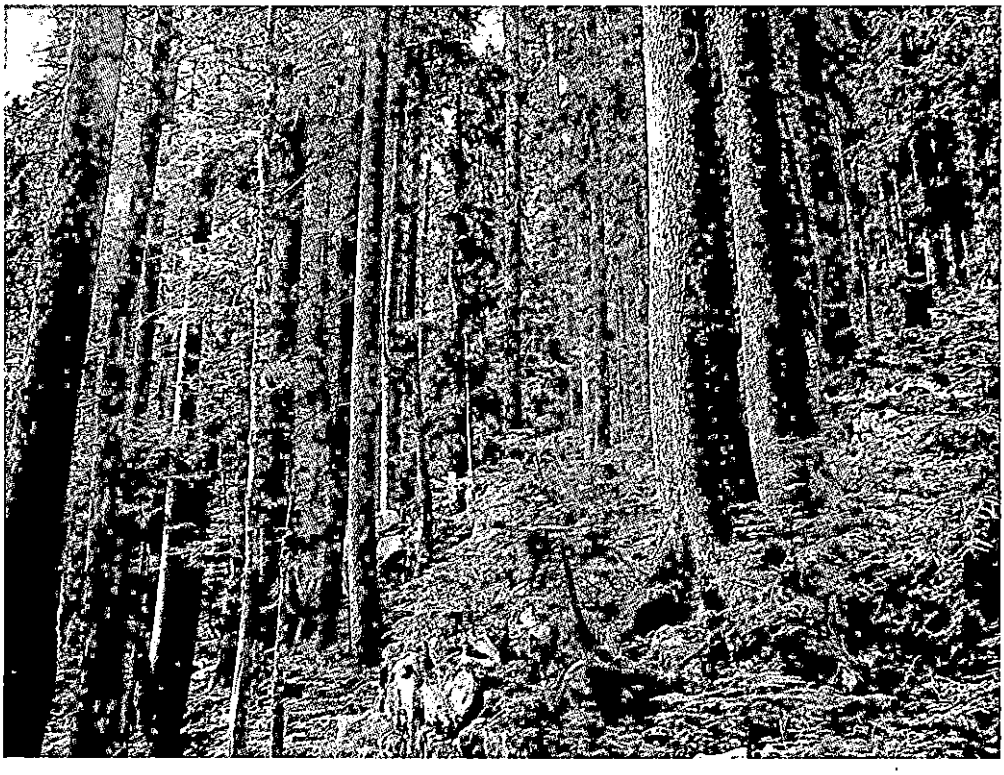

Figure 2 Association *Lonicero caeruleae-Piceetum* in locality Gašparac in Gorski Kotar
Slika 2 Asocijacija Lonicero caeruleae-Piceetum na lokalitetu Gašparac u Gorskome kotaru

The most representative stands of this association are located in the rocky massif of Risnjak (Figure 2), especially in the Smrekovac area, as well as in several localities of Velika Kapela, where Bijele and Samarske Stijene are particularly prominent.

Subalpine Forest of Spruce with *Laserpitium krapfii*
(Laserpitio krapfii-Piceetum abietis Vukelić, Alegro et Šegota 2010*)*

The association *Laserpitio krapfii-Piceetum abietis,* researched and determined by Vukelić, Alegro and Šegota (2010), only partially encompasses Horvat's macro-association *Picetum croaticum*

subalpinum from 1950. The community belongs to the altimontane and subalpine belt of the Dinaric area in Croatia. It is predominantly developed on steep, north-facing, cold and closed sinkholes and depressions, where snow is high and of long duration and altitudes range from 1100 to 1500 m. As a rule, the phytocoenosis *Hyperico grisebachii-Piceetum* occurs above it.

The phytocoenosis *Laserpitio krapfii-Piceetum* has macro-climatic features of a pre-alpine beech forest in whose belt it is situated. However, the decisive factor for its occurrence is the microclimate modified primarily by the relief, altitude and other geomorphological factors (Cindrić 1973).

The characteristic species of the association is *Laserpitium krapfii,* the differentiating species are *Knautia drymeia, Petasites albus, Euphorbia amygdaloides, Symphytum tuberosum, Adenostyles alliaria, Melampyrum velebiticum* and *Campanula rotundifolia* agg., while *Valeriana montana, Geranium sylvaticum* and *Trollius europaeus* have diagnostic importance.

The phytocoenosis of spruce with *Laserpitium krapfii* is developed as a permanent stage on more humid, colder and shadier sites. Locally, it descends into sinkholes and lower slopes to the beech-fir forest, and is therefore richer in the *Adenostyletalia* species in relation to the other two associations (Table 3). Due to dolomitized limestone and breccia, which supply the soil (calcomelanosol and cambisol) with large quantities of calcium, as well as to strong impacts of zonal beech forests on the narrower and smaller complexes of these spruce stands, the best represented elements are those of the order *Fagetalia* and lower units, which makes them the differentiating species of beech forests. The average soil pH determined in water for the layer of 0 to 5 cm in depth is 5.50.

Subalpine Forest of Spruce with *Hypericum richeri* ssp. *grisebachii*
*(*As. *Hyperico grisebachii-Piceetum* (Bertović 1975) Vukelić, Alegro, Šegota et Šapić 2010*)*

The association *Hyperico grisebachii-Piceetum* is distributed above 1400 a.s.l. (slightly lower on Samarske Stijene). It often covers inaccessible, distinctly rocky tops, ridges, hips, karren, and very steep sunny slopes high up. The stoniness of the terrain, always above 50%, is the essential feature of the site of spruce forest with *Hypericum richeri* ssp. *grisebachii* and significantly contributes to the broken tree canopy and the structure of shrubs and ground vegetation. The soils are generally different sub-types of calcomelanosol, ranging from organogenic, organomineral to browned soils, and less frequently shallow cambisol (Bakšić et al. 2010). The ecological amplitude of the occurrence of the community is very narrow, whereas the specific conditions of the relief, pedology and climate (represented by Zavižan Meteorological Station) are not favourable for the successful development of forest vegetation.

In relation to the other two, the community is poorer in spruce species, as well as in the species of the order *Fagetalia* and *Adenostyletalia* (Table 3). Due to the rocky mountain tops and ridges where it occurs, it is much richer in the species of primary and secondary mountain screes and pastures of the class *Asplenietea trichomanis* and *Seslerietea albicans*. The differentiating species of the association, *Salix appendiculata, Sambucus racemosa, Juniperus communis* subsp. *nana, Achillea clavenae, Gentiana lutea* subsp. *symphyandra,* and locally *Festuca bosniaca* and *Convallaria majalis* reflect exactly these conditions. The high participation of the species of the class *Erico-Pinetea* and lower units - *Calamagrostis varia, Cirsium erysithales*, and even *Carex ornithopoda,* deserves special mention. The number and the cover of the species of the orders *Fagetalia* and *Adenostyletalia* is considerably lower than in the phytocoenosis *Laserpitio krapfii-Piceetum* (31:45), which occurs in lower positions.

Although the phytocoenosis does not have any commercial significance, its protective and natural-scientific importance is very high. The most important stands are found in the National Park of North Velebit and on Samarske Stijene, and less so on other rocky tops of Velika Kapela and the Risnjak massif. Its composition is not uniform in this entire distribution range: the high ridges which it inhabits are relatively remote enclaves with their geobotanical and horologic specific features. Some particular localities contain rare and protected species, e.g. Samarske Stijene with *Berberis croatica, Leontopodium alpinum, Saxifraga paniculata* and others.

Other Differences in the Constitution of Site and Vegetation

In addition to the already highlighted differences between particular associations, their phytocoenological analysis also indicates the general floristic-vegetational characterisation in terms of their position in the entire Dinaric massif. It is partly explained in the works of Vukelić et al. 2010a and 2010b and will not be repeated here.

Table 2 Phytocoenoses of Common Spruce in the Altimontane and Subalpine Belt
Tablica 2 Fitocenoze obične smreke u altimontanskom i subalpskom pojasu

	Number of column / *Broj stupca*:		1	2	3	4	5	6
	Number of releves / *Broj snimaka*:		39	19?	9	17	10	16
Char. and diff. species of ass. / *Svojstvene i razlikovne vrste asocijacija*								
a	Lonicera nigra	B	5	5	5	3	1	1
	Lonicera caerulea borbasiana		4	4	3	.	5	2
	Lycopodium annotinum	C	5	5	5	3	2	1
	Vaccinium vitis-idaea		4	4	2	3	3	3
b	Sanionia uncinata	D	3	.	.	.	.	1
j	Campanukla justiniana	C	.	.	.	5	.	.
	Silene hayekiana		.	.	.	2	.	.
g	Salix appendiculata	B	3	5	3	3	5	3
d	Juniperus communis nana		.	4	.	1	5	1
h	Sambucus racemosa		.	.	3	1	4	3
l	Gentiana lutea	C	.	.	.	.	4	1
k	Achillea clavenae		.	.	.	.	3	1
l	Festuca bosniaca		.	.	.	.	3	.
i	Convallaria majalis		.	.	1	.	3	1
c	Laserpitium krapfii		.	1	.	.	4	4
h	Petasites albus		.	.	.	1	1	4
f	Knautia drymeia		2	.	.	.	.	4
h	Euphorbia amigdaloides		1	.	.	.	.	3
g	Adenostyles alliariae		1	.	.	.	.	4
d	Melampyrum velebiticum		.	.	1	.	3	3
l	Campanula rotundifolia agg.		.	.	.	.	2	4
e	Aquilegia nigricans		.	.	.	.	1	2
d	Huperzia selago		5	5	5	4	2	2
	Calamagrostis arundinacea		5	5	3	.	.	2
b	Clematis alpina	B	3	4	5	5	5	2
a	Polystichum lonchitis	C	2	3	3	1	5	4
d	Maianthemum bifolium		4	5	5	1	2	3
	Homogyne sylvestris		4	5	5	5	3	4
g	Doronicum austriacum		4	2	3	.	2	4
h	Melica nutans		2	3	1	2	3	3
	Solidago virgaurea		2	2	5	3	2	1
b	Adenostyles alpina		3	2	2	4	5	3

i	Carex digitata		3	.	3	4	2	3
e	Calamagrostis varia		1	.	2	5	5	4
h	Mercurialis perennis	C	2	.	3	2	3	3
l	Hypericum richeri grisebachii		.	3	.	.	4	5
	Valeriana montana		.	.	.	.	2	4
a	**Vaccinio-Piceenion**							
	Luzula sylvatica	C	5	3	1	4	1	3
	Luzula luzulina		1	3	1	.	1	2
	Listera cordata		1	5	.	.	.	.
	Moneses uniflora		1	2	.	.	.	.
	Melampyrum sylvaticum		4	.	.	.	.	.
	Rhytidiadelphus loreus	D	5	5	3	.	2	2
	Plagiothecium undulatum		2	2	3	.	.	.
	Mylia taylori		2	5	1	1	.	1
	Mnium spinosum		1	2	.	.	.	.
	Rhizomnium punctatum		1	.	1	1	.	.
	Peltigera leucophlebia		2	.	.	.	.	.
	Mnium orthorrhynchium		.	.	.	3	.	.
b	**Abieti-Piceenion**							
	Abies alba	A	1	5	5	5	2	1
	Abies alba	B	4	5	5	3	2	3
	Veronica urticifolia	C	4	5	5	2	3	5
	Valeriana tripteris		4	5	5	5	3	4
	Abies alba		1	4	3	3	.	1
	Dryopteris expansa		5	.	5	1	.	3
	Streptopus amplexifolius		.	3	1	.	.	2
	Dryopteris dilatata		.	5	3	.	.	1
	Saxifraga cuneifolia		1	.	.	1	.	.
c	**Vaccinio-Piceion**							
	Picea abies	A	5	5	5	5	5	5
	Picea abies	B	5	5	4	5	4	3
	Sorbus chamaemespilus		1	.	.	.	.	1
	Hieracium murorum	C	4	4	3	3	3	5
	Picea abies		2	4	4	4	2	.
	Bazzania trilobata	D	1	2	1	2	.	1
d	**Vaccinio-Piceetea, Piceetalia**							
	Sorbus aucuparia	A	1	1	2	2	2	3
	Vaccinium myrtillus	B	5	5	5	5	5	5
	Rosa pendulina		5	4	5	5	4	5
	Sorbus aucuparia		5	4	4	3	2	4
	Rubus saxatilis		3	5	1	.	2	4
	Pinus mugo		.	1	.	1	2	.
	Oxalis acetosella	C	5	5	5	3	3	5
	Gentiana asclepiadea		5	5	5	4	2	3
	Orthilia secunda		.	2	.	3	1	.
	Gymnocarpium dryopteris		5	.	1	2	2	3

	Phegopteris connectilis		3	5	3	.	.	.
	Sorbus aucuparia		1	2	1	2	.	1
	Aposeris foetida		3	1	.	.	.	1
	Avenella flexuosa		1	1	.	.	.	.
	Luzula pilosa		2	1	.	.	.	.
	Dicranum scoparium	D	2	5	5	5	5	5
	Rhytidiadelphus triquetrus		4	5	3	1	3	2
	Polytrichum formosum		4	5	5	4	3	3
	Hylocomium splendens		3	5	.	1	2	.
	Hypnum cupressiforme		2	2	.	5	2	.
	Pleurozium schreberi		1	2	.	.	.	.
	Polytrichum commune		2	.	.	2	.	.
	Dicranum polysetum		4	.	.	.	.	.
	Grimmia pulvinata		.	.	.	5	.	.
	Leucobryum glaucum		.	.	.	2	.	.
e	**Erico-Pinion, Erico-Pinetalia**							
	Amelanchier ovalis	B	.	.	.	1	.	.
	Cirsium erisithales	C	4	4	3	3	5	5
	Buphthalmum salicifolium		.	.	.	2	1	.
	Erica carnea		.	.	.	3	.	.
	Epipactis atrorubens		.	.	.	2	.	.
f	**Aremonio-Fagion**							
	Rhamnus alpinus fallax	B	.	1	1	1	1	1
	Cardamine enneaphyllos	C	4	3	3	2	1	5
	Aremonia agrimonoides		1	1	1	2	.	3
	Euphorbia carniolica		1	.	3	.	.	2
	Cardamine trifolia		3	3	5	1	.	1
	Calamintha grandiflora		1	1	1	.	.	.
	Cyclamen purpurascens		.	.	1	2	.	1
	Omphalodes verna		.	.	1	1	.	.
	Scopolia carniolica		.	.	3	.	1	.
g	**Adenostylon, Adenostyletalia**							
	Rubus idaeus	B	3	4	3	4	4	5
	Ribes alpinum		1	.	.	.	2	1
	Ribes petraeum		.	1	.	.	.	1
	Salix glabra		2	.	.	.	.	.
	Polygonatum verticillatum	C	4	4	4	1	4	5
	Dryopteris filix-mas		2	1	5	2	2	3
	Veratrum album		4	4	3	.	2	3
	Senecio ovatus		1	.	1	2	3	2
	Saxifraga rotundifolia		1	.	2	1	.	2
	Ranunculus platanifolius		1	3	3	.	1	2
	Athyrium filix-femina		4	2	4	.	.	2
	Viola biflora		2	.	.	.	3	3
	Aconitum lycoctonum vulparia		1	.	.	.	2	1
	Cicerbita alpina		1	.	1	.	.	3

	Aruncus dioicus		1	.	2	.	.	1
	Geranium sylvaticum		.	.	.	.	1	4
	Chaerophyllum cicutaria		2	.	.	.	.	.
	Senecio ovirensis		2	.	.	.	.	.
h	**Fagetalia**							
	Fagus sylvatica	A	1	2	3	3	2	4
	Acer pseudoplatanus		1	1	.	.	.	1
	Fagus sylvatica	B	4	2	3	3	1	4
	Daphne mezereum		3	2	3	5	2	4
	Lonicera alpigena		1	3	3	2	3	2
	Acer pseudoplatanus		1	1	3	2	.	3
	Rubus hirtus		1	.	.	.	.	.
	Prenanthes purpurea	C	2	4	5	4	3	5
	Phyteuma spicatum coeruleum		3	4	3	1	2	4
	Mycelis muralis		.	1	3	4	2	4
	Paris quadrifolia		2	2	3	.	2	4
	Symphytum tuberosum		2	.	1	.	1	5
	Viola reichenbachiana		1	.	1	.	2	3
	Polystichum aculeatum		1	.	3	1	.	2
	Geranium robertianum		.	.	1	.	.	1
	Galeobdolon luteum		2	.	3	.	1	3
	Epilobium montanum		.	.	1	1	1	2
	Actaea spicata		1	.	3	.	3	1
	Thalictrum aquilegifolium		2	.	.	.	.	3
	Fagus sylvatica		.	.	1	2	.	1
	Gymnocarpium robertianum		.	.	.	3	.	1
	Festuca altissima		1	.	.	2	.	2
	Acer pseudoplatanus		1	.	1	.	.	.
	Ranunculus lanuginosus		2	.	.	.	.	.
	Carex pilosa		2	.	.	.	.	1
	Carex sylvatica		.	1	1	.	.	.
	Heracleum sphondylium		.	.	.	.	2	2
	Poa nemoralis		.	.	.	.	2	1
	Euphorbia dulcis		.	2	.	.	.	.
	Asplenium scolopendrium		.	.	2	.	.	.
	Asarum europaeum		.	.	1	.	1	.
	Neckera crispa	D	.	.	3	4	1	1
	Eurhynchium zeterstedti		2	.	.	1	.	.
i	**Querco-Fagetea**							
	Sorbus aria	A	.	.	1	1	.	1
	Taxus baccata		.	.	1	.	.	.
	Sorbus aria	B	.	1	1	2	2	1
	Cotoneaster tomentosa		.	.	.	.	1	.
	Anemone nemorosa	C	5	5	5	.	2	4
	Anemone hepatica		.	.	1	2	.	1
	Carex ornithopoda		.	.	2	.	2	1

	Pteridium aquilinum		.	.	.	2	.	.
	Ctenidium molluscum	D	4	.	5	5	4	5
	Isothecium myurum		2	.	.	3	.	.
j	**Asplenietea trichomanes**							
	Moehringia muscosa	C	1	3	3	1	1	5
	Asplenium viride		5	2	4	.	4	3
	Cystopteris fragilis		1	.	1	1	2	1
	Asplenium trichomanes		.	4	3	3	1	1
	Asplenium rura-muraria		.	.	1	3	1	1
	Polypodium vulagre		.	.	2	2	.	.
	Cystopteris alpina		.	.	1	.	2	.
	Asplenium fissum		.	.	.	.	2	.
	Kernera saxatilis		.	.	.	2	.	.
k	**Seslerietea albicans**							
	Aster bellidiastrum	C	1	3	.	.	1	.
	Campanula scheuchzeri		1	.	.	.	2	.
	Erigeron polymorphus		.	.	.	1	1	.
	Galium anisophyllum		.	.	.	.	2	1
	Carlina acaulis simplex		.	.	.	.	2	1
	Ranunculus carinthiacus		.	.	.	.	2	2
	Phyteuma orbiculare		.	.	.	.	2	.
l	**Ostale vrste** / *Other species:*							
	Rosa pimpinellifolia	B	.	.	.	.	.	1
	Salix capraea		.	.	.	.	.	1
	Fragaria vesca	C	3	3	1	3	.	2
	Silene pusilla		.	.	1	.	2	1
	Ajuga reptans		.	.	.	.	1	1
	Luzula luzuloides		1	1	.	.	.	1
	Dryopteris carthusiana		1	.	.	.	2	.
	Polygonum viviparium		1	.	.	.	1	.
	Trolius europaeus		1	.	.	.	.	2
	Festuca nigrescens		1	.	.	.	.	1
	Carex brachystachys		.	.	.	2	1	.
	Poa alpina		.	.	.	.	2	2
	Epilobium angustifolium		.	.	.	.	2	1
	Thymus praecox		.	.	.	.	2	1
	Solanum dulcamara		.	.	.	.	2	1
	Dryopteris villarii		.	.	.	.	2	1
	Deschampsia caespitosa		2	.	.	.	.	.
	Carex brizoides		2	.	.	.	.	.
	Parnassia palustris		2	.	.	.	.	.
	Heliosperma alpestre		2	.	.	.	.	.
	Melampyrum pratense		.	2	.	.	.	.
	Orchis maculata		.	2	.	.	.	.
	Carex atrata		.	2	.	.	.	.
	Carduus acanthoides		.	.	.	.	2	.

	Geranium macrorrhizum		.	.	.	.	2	.
	Silene vulgaris		.	.	.	.	.	2
m	**Mahovine** / *Mosses*							
	Tortella tortuosa	D	5	5	5	5	4	5
	Plagiochila asplenoides		3	3	.	3	.	.
	Mnium undulatum		1	2	.	.	.	.
	Fissidens cristatus		3	.	.	3	.	.
	Schistidium apocarpum agg.		.	.	1	.	2	2
	Mnium marginatum		.	.	3	.	1	1
	Fissidens dubius		.	.	5	.	1	2
	Eurhynchium striatum		.	4	3	.	.	.
	Scaponia aspera		.	2	1	.	.	.
	Isothecium alopecuroides		.	.	3	.	.	3
	Mnium thomsonii		.	.	2	.	.	1
	Rhynchostegium murale		.	.	1	.	.	2
	Eurhynchium angustiarte		.	.	1	.	.	1
	Brachythecium velutinum		.	.	1	.	.	1
	Metzgeria furcata		.	.	1	.	.	1
	Plagiomnium undulatum		.	.	.	1	1	.
	Fissidens adianthoides		.	.	.	1	1	1
	Thuidum tamariscinum		.	.	.	.	1	1
	Dicranella sp.		.	.	.	.	1	1
	Plagiochila porelloides		.	.	3	.	1	.
	Fissidens sp.		.	4	.	.	.	.
	Sphagnum sp.		.	2	.	.	.	.
	Dicranum montanum		.	.	.	4	.	.
	Brium cappilare		.	.	.	3	.	.
	Encalypta streptocarpa		.	.	.	3	.	.
	Homalothecium sericeum		.	.	.	2	.	.
	Porella platyphylla		.	.	.	2	.	.
	Scapania nemorea		.	.	.	2	.	.
	Cirriphyllum tenuierve		.	.	.	2	.	.
	Pteryginandrum filiforme		.	.	.	2	.	.
	Ditrichum flexicaule		.	.	.	2	.	.
	Mnium sp.		.	.	.	.	.	2
	Ctenidium sp.		.	.	.	.	.	2

1 - *Lonicero coeruleae-Piceetum* (Slovenija; Zupančič 1999)
2 - *"Piceetum croaticum subalpinum"* (Gorski kotar, Velebit; Horvat in Cestar 1964)
3 - *Lonicero coeruleae-Piceetum* (Gorski kotar; Vukelić i dr. 2010)
4 - *Campanulo justinianae-Piceetum abietis* (Slovenija; Accetto 2006)
5 - *Hyperico grisebachii-Piceetum abietis* (Sjeverni Velebit, Samarske stijene; Vukelić et al. 2010)
6 - *Laserpitio krapfii-Piceetum* (Sjeverni Velebit ; Vukelić et al. 2010)

A -Trees / *drveće* B - Shrubs / *grmlje* C - Undergrowth / *prizemno rašće* D - Mosses / *mahovine*
a-f - sinsystematic affiliation / *sistematska pripadnost*

*The table excludes species that are represented in only one column with presence degree 1 / *Izostavljene su vrste koje se pojavljuju samo u jednom stupcu sa stupnjem udjela 1*

Subalpine spruce forests in Western Croatia are similar to spruce forests of the Dinaric and subalpine region of Slovenia. They contain boreal spruce species, such as *Lonicera nigra, Lycopodium annotinum, Huperzia selago, Listera cordata, Calamagrostis arundinacea* and *Rhytidiadelphus loreus*. On the other hand, spruce forests of Velebit show greater similarity with Bosnian and Herzegovinian subalpine communities *Sorbo-Piceetum* Fukarek 1964 and *Pyrolo-Piceetum* (Fukarek 1969) Zupančič 1990, although there are also a number of species that differentiate them. For example, about thirty species that constantly occur in spruce forests of Northern Velebit are either absent or occur very rarely in the related forests of Bosnia and Herzegovina: *Campanula rotundifolia* agg, *Knautia drymeia, Calamagrostis varia, Polystichum lonchitis, Clematis alpina, Adenostyles alpina, Maianthemum bifolium, Heracleum sphondyllium, Doronicum austriacum, Melica nutans, Actaea spicata, Mercurialis perennis, Petasites albus, Carex digitata, Moehringia muscosa, Silene vulgaris* and others. On the other hand, these associations contain species which are either not represented or are less frequent in sub-alpine spruce forests of Velebit, such as *Homogyne alpina, Melampyrum sylvaticum, Moneses uniflora, Orthillia secunda, Listera cordata, Rhytydiadelphus loreus, Plagiotecium undulatum, Avenella flexuosa, Pleurozium schreberi, Corallorrhiza trifida, Pyrola rotundifolia, Pulmonaria obscura, Knautia dinarica, Scabiosa leucophylla* and others. In conclusion, going from the north-west towards south-east of the Dinaric range, the alpine-boreal and Central European species are completely absent or their participation is decreasing, while the Illyrian and Balkan species are gradually occurring or their presence is increasing (Horvat 1953, Zupančič 1980, 1988, 1990, Vukelić i dr. 2010a).

Table 3 Number of species by syntaxonomic categories
Tablica 3 Broj vrsta prema sintaksonomskim kategorijama

	Lc-P	*Hg-P*	*Lk-P*	*Lb-P*	*Hg-P*	*Lk-P*
	number of species			%		
Vaccinio-Piceenion	14	8	8	8.7	6.2	5.2
Abieti-Piceenion	8	5	9	4.9	3.9	8.8
Vaccinio-Piceion	5	4	5	3.1	3.1	3.2
Vaccinio-Piceetea, Piceetalia	25	19	17	15.4	14.7	11
Spruce species ∑	**52**	**36**	**39**	**32.1**	**27.9**	**25.2**
Erico-Pinion, Erico-Pinetalia	**2**	**4**	**3**	**1.3**	**3.1**	**1.9**
Aremonio-Fagion	9	3	7	5.6	2.3	4.5
Adenostyletalia	**13**	**12**	**19**	**8**	**9.3**	**12.3**
Fagetalia	**24**	**20**	**28**	**14.8**	**15.5**	**18.1**
Querco-Fagetea	8	7	7	4.9	5.4	4.5
Asplenietea	8	7	5	4.9	5.4	3.2
Seslerietea albicans	**1**	**8**	**6**	**0.6**	**6.2**	**3.9**
Other	**6**	**21**	**15**	**3.7**	**16.3**	**9.7**
Moss	39	11	26	24.1	8.6	16.7
∑	**162**	**129**	**155**	**100**	**100**	**100**

The three associations differ in terms of ecological factors (Table 4). The association *Hyperico grisebachii-Piceetum* proved to be the coldest, containing the least humidity and nutrients, the lowest acidity degree and the highest amount of light, thus reflecting the subalpine rocky terrains and open sites in which it grows. The association *Lonicero caeruleae-Piceetum* has the highest acidity degree and site humidity. This is also understandable, since the area in which it occurs is colder than the rest of Croatia and receives a much higher amount of rainfall. In such conditions, the decomposition of the organic floor is the poorest, causing the highest acidity by the formation of raw humus. In terms of light conditions, humidity, acidity and nutrient wealth, the association *Laserpitio krapfii-Piceetum* is between the two previous ones.

Table 4 Comparison of ecological indicator values (Kruskal-Wallis test; p<0,05)
Tablica 4 Usporedba ekoindikatorskih vrijednosti (Kruskal-Wallis test; p<0,05)

Ecological factor	LkP		HgP		LcP	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Light	4.87	0.300	5.26	0.251	**4.26**	0.240
Temperature	4.00	0.334	**3.66**	0.248	3.99	0.148
Continentality	3.64	0.171	**4.09**	0.133	3.79	0.096
Moisture	5.37	0.140	**5.21**	0.193	5.40	0.113
Soil reaction	6.04	0.353	6.10	0.203	**5.58**	0.248
Nutrients	4.96	0.277	**4.40**	0.422	4.93	0.230

CONCLUSIONS
ZAKLJUČCI

The results of the analysis and comparison of the floristic composition, ecological conditions, distribution range and physiognomy of the recorded stands show three clearly distinct associations with the following synsystematic affiliation:

Class: *Vaccinio-Piceetea*
Order: *Vaccinio-Piceetalia*
Alliance: *Vaccinio-Piceion*
As: Lonicero caeruleae-Piceetum abietis Zupančič (1976) 1999 corr.
Laserpitio krapfii-Piceetum abietis Vukelić, Alegro et Šegota 2010
Hyperico grisebachii-Piceetum (Bertović 1975) Vukelić, Alegro, Šegota et Šapić 2010

The association *Lonicero caeruleae-Piceetum* with the characteristic species *Lonicera caerulea* subsp. *borbasiana*, *Lonicera nigra* and *Sanionia uncinata* was identified in the Gorski Kotar area. In relation to the other two associations, the prevailing species of this association are those of spruce forests of the class *Vaccinio-Piceetea.* In terms of Ellenberg's ecoindicator values, it proved to be the most acidophilic and contains the least amount of light.

The association *Laserpitio krapfii-Piceetum* belongs to the altimontane and subalpine belt of the Dinaric area in Croatia. It is predominantly developed on steep, north-facing, cold and closed sinkholes and depressions. It has macro-climatic features of a pre-alpine beech forest in whose belt is occurs. The characteristic species of the association is *Laserpitium krapfii*, while species of the order *Fagetalia* and lower units constitute the differentiating species.

The association *Hyperico grisebachii-Piceetum* extends above an altitude of 1400 m. and inhabits the tops of Samarske Stijene, and less so other rocky tops of Velika Kapela and the Risnjak massif. The differentiating species of the association include *Salix appendiculata*, *Sambucus racemosa*, *Juniperus communis* subsp. *nana, Achillea clavenae,* and *Gentiana lutea* subsp. *symphyandra.* The species of the class *Erico-Pinetea* should be pointed out for reasons of their high participation. The amount and cover of the species of the orders *Fagetalia* and *Adenostyletalia* is much lower than in the phytocoenosis *Laserpitio krapfii-Piceetum,* which occurs in lower positions.

REFERENCES
LITERATURA

Acceto, M., 2006: *Campanulo justinianae-Piceetum abietis* var. ass. nov. v Dinarskem gorstvu južne Slovenije. Razprave SAZU, 47/1, p. 65-101.

Anić, M., 1959: Šumarska fitocenologija, II (skripta). Šumarski fakultet Sveučilišta u Zagrebu, Zagreb.

Bakšić, D., N. Pernar, J. Vukelić, B. Vrbek, 2011: Pedofiziografske značajke i sadržaj i sadržaj teških metala Pb, Cd i CU u smrekovim šumama sjevernoga Velebita i Štirovače. Croatian Journal of Forest Engineering, 32/1, p. 111-120.

Beck - Mannagetta G, 1901: Die Vegetationsverhältnisse der illyrischen Länder. In Engler u. Drude: Vegetation der Erde, 4, Leipzig, p. 549.

Bertović, S., 1975: Ekološko-vegetacijske značajke okoliša Zavižana u sjevernom Velebitu. Glas. šum. pokuse 18, p. 5–75.

Braun-Blanquet, J., 1964: Pflanzensoziologie. Grundzüge der Vegetationskunde. Springer, Wien – New York.

Cestar, D., 1967: Prirast smreke u šumama gorskog i pretplaninskog područja Hrvatske. Disertacija, Šumarski fakultet Sveučilišta u Zagrebu.

Cindrić, Ž., 1973: Poredbena mikroklimatološka istraživanja u nekim predplaninskim fitocenozama područja Zavižana. U: Glavna meteorološka stanica Zavižan, 1594 m, 1953–1973. RHHMZ RH, p. 46–53, Zagreb.

Clarke, K. R., Gorley, R. N., 2001: Primer v5. User Manual/Tutorial. Primer-E Ltd, Plymouth.

Ellenberg, H. 1979: Zeigerwerte der Gefäßpflanzenflora Mitteleuropas. Scripta Geobot. No 9, p. 9–160.

Fukarek, P., 1969: Prilog poznavanju biljnosocioloških odnosa šuma i šibljaka Nacionalnog parka "Sutjeska". Akad. Nauka i umjet. BiH 11/3, p. 189–291, Sarajevo.

Hennekens S. M., J. H. J. Schaminée, 2001: TURBOVEG, a comprehensive data base management system for vegetation data. Journal of Vegetation Science, 12, p. 589 –591.

Horvat, I., 1925: O vegetaciji Plješevice u Lici. Geogr. Vest. 1, p. 114-123, Ljubljana.

Horvat, I., 1938: Biljnosociološka istraživanja šuma u Hrvatskoj. Glas. šum. pokuse 6, p. 127–279, Zagreb.

Horvat, I., 1950: Šumske zajednice Jugoslavije. Institut za šumarska istraživanja, p. 73, Zagreb.

Horvat, I., 1953: Vegetacija ponikava. Geografski glasnik 14-15, p. 1-22.

Horvat, I., 1962: Vegetacija planina zapadne Hrvatske. Acta biol. 2., JAZU., Zagreb, 30, p. 1–179.

Horvat, I., 1963: Šumske zajednice Jugoslavije. Šumarska enciklopedija, I. izdanje (2), p. 560–590.

Horvat, I., V. Glavač & H. Ellemberg, 1974: Vegetations Südosteuropas, G. Fischer Verlag, Stuttgart.

Koperski, M., M. Sauer, W. Braun, S. R. Gradstein, 2000: Referenzliste der Moose Deutschlands. Bundesamt fur Naturschutz, Bonn – Bad Godesberg.

Nikolić, T. (ur.), 2012: Flora Croatica, baza podataka. On-line (http:/hirc.botanic.hr/fcd). Botanički zavod, Prirodoslovno-matematički fakultet, Sveučilište u Zagrebu.

StatSoft, Inc., 2008: STATISTICA (data analysis software system), version 8.0, www.statsoft.com

Tichý, L., 2002: JUICE 6.3, software for vegetation classification. Journal of Vegetation Science, 13, p. 451-453

Vukelić, J., A. Alegro, V. Šegota, 2010a: Altimontansko – subalpska smrekova šuma s obrubljenim gladcem (*Laserpitio krapfii-Piceetum abietis* ass. nova) na sjevernom Velebitu (Hrvatska). Šumarski list 134/(5-6), p. 211-228.

Vukelić, J., A. Alegro, V. Šegota, I. Šapić, 2010b: Nomenklaturno-fitocenološka revizija asocijacije *Calamagrostio variae-Piceetum dinaricum* Bertović 1975 nom. Illeg. U Hrvatskoj. Šumarski list 134/(11-12), p. 559-568.

Zupančič, M., 1980: Smrekovi gozdovi v mraziščih dinarskega gorstva Slovenije. SAZU, Dela 24, p. 1–262.

Zupančič, M., 1988: Ilyrische und balkanische Arten in den subalpinen Fichtengesellschaften der zentralen Balkanhalbinsel. – Satureia, 4, p. 33–42, Salzburg.

Zupančič, M., 1990: Smrekovi gozdovi Evrope in Balkanskega polotoka, III. Biološki vestnik, 38/3, p. 5–22, Ljubljana.

Zupančič, M., 1994: Popravki imen nekaterih rastlinskih združb v luči novega kodeksa. Hladnikia, 2, p. 33-40, Ljubljana.

Zupančič, M., 1999: Smrekovi gozdovi Slovenije. SAZU, Dela 36, p. 1–222.