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RIPARIAN FOREST COMMUNITIES ALONG WATERCOURSES IN THE SUTJESKA NATIONAL PARK (SE BOSNIA AND HERZEGOVINA)

OBALNE ŠUMSKE ZAJEDNICE UZ VODOTOKE U NACIONALNOM PARKU SUTJESKA (JI BOSNA I HERCEGOVINA)

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Abstract

The paper deals with the floristic and ecological diversity of the riparian forest and scrub communities of the Sutjeska National Park in SE Bosnia and Herzegovina. Watercourses of the NP are represented by montane to submontane small rivers and creeks with fast-flowing water and frequent strong but short floods. This caused specific types of riverine forest vegetation to develop along their banks. Classification and ordination methods of numerical analysis were applied on 42 relevés sampled in the field. The classification has revealed five ecologically interpretable relevé groups: (1) willow scrub of *Salix eleagnos* and *S. caprea* on fertile fine grained deposits; (2) forests of *Alnus glutinosa* and *Salix alba* also on finer deposits; (3) narrow strips of *Alnus glutinosa* along the low banks of smaller streams; (4) narrow strips of *Alnus glutinosa* along the steep banks of wider streams; (5) thermo-mesophilous scrub of *Salix eleagnos* and *Ostrya carpinifolia* on gravel beds. All five groups are floristically and ecologically well distinguished. While groups 1 and 3 are similar to already described communities from Central Europe (*Salicetum eleagno-purpureae* and *Stellario nemorum-Alnetum glutinosae*, respectivelly), groups 4 and 5 most probably present, up to date, undescribed associations. Group 2 is rather floristically and ecologically heterogeneous, and as such possess transitional character (between *Salicion albae* and *Alnion incanae* alliances). Ordination revealed ecological gradient from nutrient rich (groups 1 and 2) to less nutrient rich communities (groups 4 and 5).

Key words: *Alnion incanae, Alnus glutinosa*, ecological gradient, phytosociology, *Salicion eleagno-daphnoidis, Salix eleagnos*, vegetation

1. INTRODUCTION / UVOD

Although riparian forest and vegetation along the montane and submontane streams is relatively well studied across temperate Europe (Sburlino et al., 2012; Chytrý, 2013; Dakskobler et al., 2013; Kalníková & Kudrnovsky, 2017), the same cannot be said about Bosnia and Herzegovina (B&H). This type of vegetation in B&H was mentioned from Treskavica and Bjelašnica Mts. (Fukarek, 1957), Vranica Mt. (Lakušić et al., 1979), and Čemernica Mt. (Redžić et al., 1986) but without any relevés, while there was one published relevé from Neretva river valley (Redžić et al., 1992). The only systematic study of this vegetation in B&H, up to date, was undertaken within the research of deciduous forests on Vranica Mt. (Barudanović, 2003; Barudanović & Redžić, 2006). This resulted in low level of knowledge of these communities in B&H in

terms of their species composition, ecology, syntaxonomy, but also their conservation status.

The same can be stated for the Sutjeska National Park, the oldest and second largest national park in B&H (Stupar, 2011). Although its flora and vegetation have been studied for a long time, not all habitats were equally investigated. Besides alpine and canyon non-forest habitats (Lakušić, 1968, 1970; Lakušić et al., 1969, 1987a, 1987b), as well as forest habitats of virgin forest Perućica (Fukarek & Stefanović, 1958; Fukarek, 1969, 1970; Fabijanić & Manuševa, 1984), other plant communities remained fairly underinvestigated. This is particularly true for the vegetation of diverse tree and scrub formations along the fast flowing, gravel-bed watercourses. These habitats were reported for the first time by Fukarek (1969) but with very little detail provided. The only more detailed study of riparian forest communities in Sutjeska National Park, up to the present, was made by Fukarek (1970) bringing five relevés from *Alnus glutinosa* formations along the Perućica stream in the virgin forest Perućica.

Syntaxonomically, this vegetation belongs to two alliances of two different classes: a) alder-ash and oak riparian floodplain forests on nutrient-rich alluvial soils in the nemoral zone of Europe (*Alnion incanae* Pawłowski et al. 1928, *Alno glutinosae-Populetea albae* P. Fukarek et Fabijanić 1968) and b) willow scrub on the gravelly stream banks in the submontane to subalpine belts of the Alps, the Pyrenees and the Carpathians (*Salicion eleagno-daphnoidis* (Moor 1958) Grass 1993, *Salicetea purpureae* Moor 1958) (Mucina et al., 2016). Albeit they are physiognomically and floristically different these communities are similar in a way that they thrive in the areas of constant periodic fluctuations of water level, with periods of flooding and periods of drought, and consequently disturbed and undeveloped soil (Ellenberg, 2009).

These communities have been under extensive human impact for a long time. They are especially sensitive to management measures which aim to change flood regime (hydroelectric power plants, stream regulations, gravel excavation etc.). That is why they are among the Europe's most endangered habitats (Kalníková & Kudrnovsky, 2017). They are listed in the Annex I of Habitats Directive as priority habitat 91E0* - Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) and habitat 3240 - Alpine rivers and their ligneous vegetation with *Salix eleagnos* along their banks (Council of the European Communities, 1992).

The objective of this paper was to classify riparian tree and scrub communities of the Sutjeska National Park, to characterize them by their species composition and ecology and to reveal ecological drivers of their floristic composition variation. This work also aims to start the process of settling these important plant communities into syntaxonomical scheme of national, regional and European level.

2. MATERIALS AND METHODS / MATERIJAL I METODE

The field research was conducted inside Sutjeska National Park (Fig. 1) in southeastern Bosnia and Herzegovina over a four-year period (2014–2017). Established in 1962 by the border between Bosnia and Herzegovina and Montenegro, Sutjeska National Park, encompassing the area of 16 052 ha, is the oldest, and until recently the largest national park in Bosnia and Herzegovina (Stupar, 2011). In terms biodiversity, this area is one of the most important parts of Bosnia and Herzegovina (Redžić et al., 2009; Redžić, 2012; Lubarda et al., 2014).

We studied riparian tree and scrub vegetation along the watercourses of Sutjeska National Park, which included narrow streamside forests, gravel bar formations or woodland of wider floodplains, dominated by *Alnus glutinosa* and/or *Salix eleagnos*.

Study included streams Sutjeska, Hrčavka, Jabučica and Izgorka. All of these watercourses belong to the Sutjeska river watershed which drains to the Drina river (Zubčević, 1969). They are gravel-bed, fast flowing and impetuous streams whose narrow steep valleys often transform into canyons, while

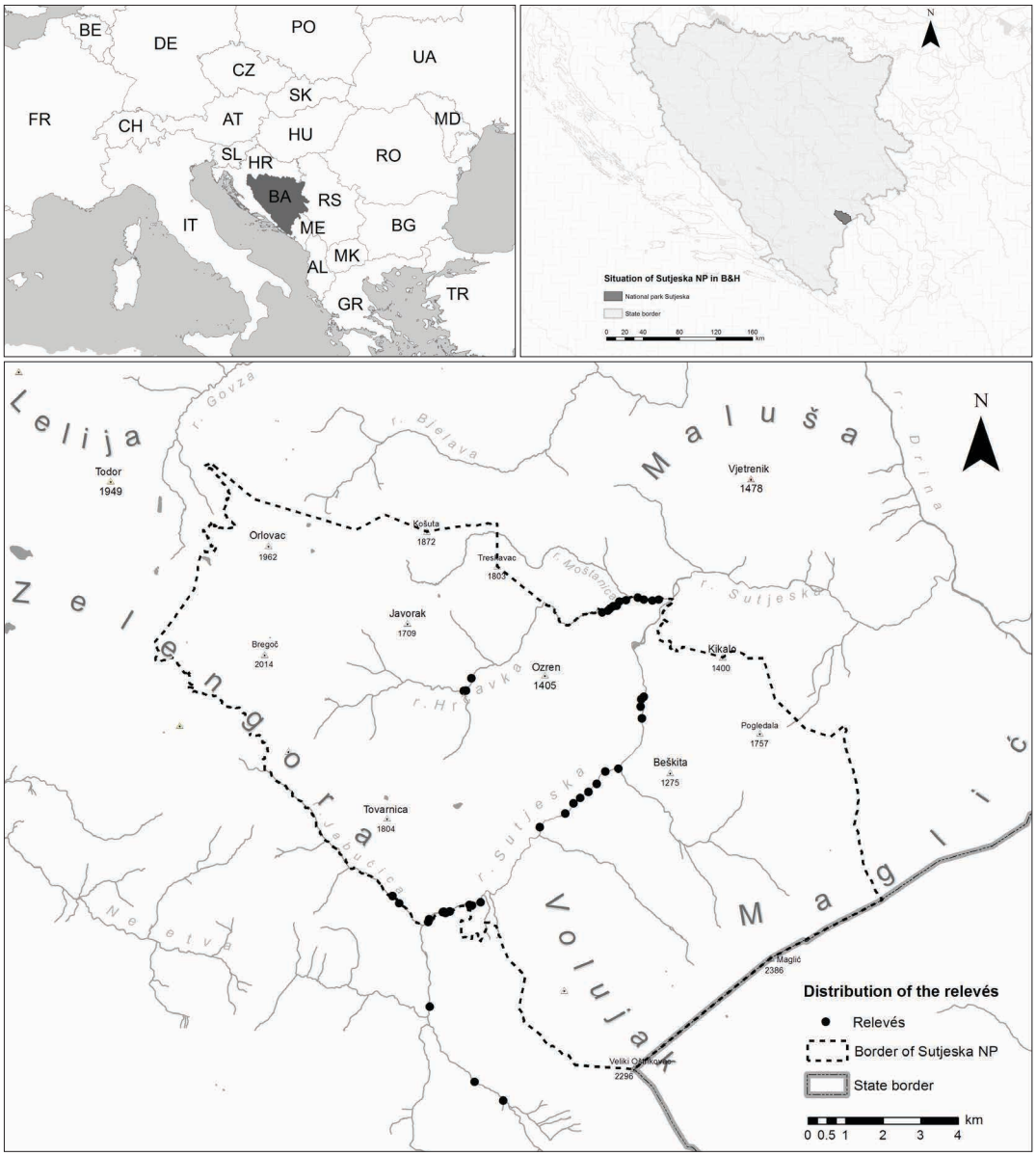

Figure 1. Location of the relevés with location of the Sutjeska National Park in B&H (upper right) / **Slika 1**. Položaj lokaliteta snimaka sa položajem Nacionalnog parka Sutjeska u BiH (gore desno)

gentle slope or flat flood plains are rare and small (Bušatlija, 1969). They cut their beds through a variety of bedrocks including flysch, limestone and dolomites, schists and shales (Trubelja & Miladinović, 1969). The elevation ranges between 530 and 1000 m. These streams are prone to frequent and often dramatic changes of water level; e.g., for the Sutjeska river minimum low water is 20 cm, maximum high water is 370 cm, while the mean annual water is 80 cm (Zubčević, 1969).

Vegetation sampling was performed using the Central European phytosociological method (Braun-Blanquet, 1964). Relevés were made only in typical stands with closed canopy, while all structurally degraded stands, mosaics and transitional communities were not taken into account.

A total of 42 relevés was compiled in the Turboveg database (Hennekens & Schaminée, 2001) and exported to JUICE 7 software (Tichý, 2002) for further analysis. Although during the sampling vertical structure was recorded in seven vegetation layers, for the means of numerical analysis it was reduced to four layers: tree layer (A), higher shrub layer (B1), lower shrub layer (B2) and herb layer (C). Mosses were discarded due to inconsistent sampling. Taxonomy and nomenclature followed The Plant List (The Plant List. Version 1.1, 2013). Taxa from taxonomically critical groups (*Chamaecytisus hirsutus, Hieracium bifidum, Lamium glaeobdolon, Leucanthemum vulgare* and *Taraxacum officinale*) were combined into aggregates (agg.). Three relevés from Izgorka stream were made outside, but in close vicinity of National park (Figure 1).

Hierarchical classification of the data set was done using Modified TWINSPAN algorithm (Roleček et al., 2009) with three pseudospecies cut levels (0%, 5%, 25%) and Whittaker's beta-diversity as a measure of cluster heterogeneity. We subjectively accepted the classification level of five clusters as being most ecologically interpretable. Floristic differences among clusters were revealed by calculating their diagnostic species on the basis of species frequency. Only species with frequency above 50% in particular cluster were considered diagnostic if they fulfill additional criterion that the difference in species frequency between the particular cluster and other clusters is more than 40% (Hrivnák et al., 2013).

Species ecological indicator values (EIVs) for light, temperature, moisture, soil reaction and nutrients (Pignatti et al., 2005) were used to show ecological relationships among the relevés and to explain environmental gradients underlying the main ordination axes. Unweighted average EIVs were plotted onto DCA (detrended correspondence analysis) ordination diagram in CANOCO 4.5 software (ter Braak & Šmilauer, 2002). Square root transformed cover data were used as the input data.

3. RESULTS AND DISCUSSION / REZULTATI I DISKUSIJA

3.1 Classification and ordination of relevés / Klasifikacija i ordinacija snimaka

Numerical classification led to delimitation of five ecologically interpretable groups of relevés (Figure 2). They are characterized by distinctive floristic composition with clearly defined lists of diagnostic species (Table 1; full version in Electronic supplement 1). First level of division separates more nitrophilous groups of relevés (groups 1–3) on the left side from less nitrophilous groups 4 and 5 on the right side of dendrogram. This is also shown on DCA ordination plot (Figure 2). Our communities are ordinated along the nutrient gradient, with nutrient indicator values being strongly negatively correlated with the first axis (r = -0.78). The only EIVs correlated with the second axes at statistically significant level is temperature (r = 0.342) which suggests that relevés in the upper part of DCA plot are more thermophilous (groups 1 and 5), as oppose to relevés in the lower part of plot which are more mesophilous (groups 2 and 4). Relevés from the group 3 occupy intermediate positions.

Group 1 encopases nitrophilous willow scrub with *Salix elaeagnos* and *S. caprea* which is developed at the places where stream valleys widen resulting in lower and flatter banks, which causes more often but less rapid flooding and deposition of finer particles of fertile sand and silt (Figure 3). Syngeneticaly they are developed from tall herbs communities dominated by *Petasites hybridus*. Its floristic composition is similar to that of *Salicetum eleagno-purpureae* Sillinger 1933 subass. *petasitetosum hybridi* (Šilc et Čušin 2000) Oriolo et Poldini 2002 known from NW Slovenia (Dakskobler & Rozman, 2013), but since community is rare in the study area, it was recorded in only three localities, which is not enough to be more conclusive about its syntaxonomy. Dominant species are *Salix elaeagnos* in the lower tree layer and *Petasites hybridus* in the herb layer, while diagnostic species indicate nutrient rich soil: *Urtica dioica, Lunaria rediviva, Salix caprea* etc., while some of them indicate

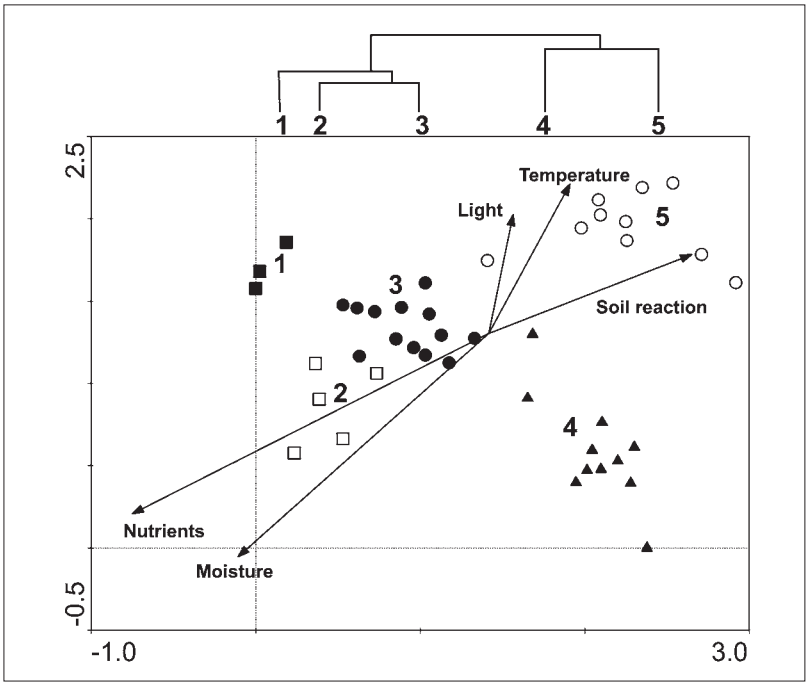

Figure 2. Dendrogram of classification and DCA ordination plot with EIVs passively projected. Eigen values of the first two axes are 0.412 and 0.233. 1: willow scrub of *Salix eleagnos* and *S. caprea* on fertile fine grained deposits; 2: forests of *Alnus glutinosa* and *Salix alba* also on finer deposits; 3: narrow strips of *Alnus glutinosa* along the low banks of smaller streams; 4: narrow strips of *Alnus glutinosa* along the steep banks of wider streams and 5: thermo-mesophilous scrub of *Salix eleagnos* on gravel beds. Number of the groups on graphs correspond to those used throughout the text and in Table 1. / **Slika 2**. Klaster dijagram i DCA ordinacijski dijagram sa pasivno projektovanim vrijednostima ekoloških indikatorsih vrijednosti. Svojstvene vrijednosti prvih dvaju osa su 0,412 i 0,233. 1: nitrofilne zajednice sive vrbe; 2: sastojine vrba i crne jove na riječnim polojima; 3: trakaste formacije pod krošnjama crne jove uz potoke; 4: trakaste sastojine crne jove sa lipama i mirisnom žljezdačom i 5: gusti šibljaci sive vrbe na šljunkovitim nanosima. Brojevi grupa na dijagramima odgovaraju onima korištenim u tekstu i u Tabeli 1.

somewhat wetter soil conditions: *Galium aparine, Carduus personata, Telekia speciosa* etc. (Table 1, column 1).

Group 2 is represented by forest stands developed on finer deposits of low banks which are inundated for a longer periods of time (Figure 4). They are found in hillside depressions or rills and springs along the riverbed, which keeps these stands wet even during the driest period. However, it should be stressed that microrelief of these stands is a mosaic of depressions and little hummocks, resulting in uneven distribution of soil moisture. This is why these nitrophilous communities are a mixture of mesophilous and hygrophilous species: *Petasites hybridus, Ranunculus repens, Lysimachia nummularia, Carex remota, Solanum dulcamara, Scutellaria altissima, Geum urbanum, Circaea lutetiana, Carex sylvatica, Primula vulgaris* etc. (Table 1, column 2). Besides *Alnus glutinosa*, tree layer is dominated by *Salix alba* and much less *S. fragilis*. Because of heterogeneous site conditions, which can mainly be ascribed to human impact, there are only three diagnostic species for this community: *Salix alba, Carex pendula and Veronica montana*. Floristic composition puts these stands somewhere in between forests of *Salicion albae* Soó 1951 and those of *Alnion* incanae Pawłowski et al. 1928. In order to gain better perspective on their syntaxonomical position, more relevés from wider area (preferably whole country) are needed.

Figure 3. Nitrophilous formations of *Salix eleagnos* and *S. caprea* alongside the Hrčavka river / **Slika 3**. Nitrofilne šikare sive vrbe i ive uz Hrčavku (© Đ. Milanović)

Figure 4. Hygrophilous riparian forests of *Alnus glutinosa* and *Salix fragilis* in the Sutjeska river valley / **Slika 4**. Higrofilne šume crne jove sa krtom vrbom na polojima uz rijeku Sutjesku (© Đ. Milanović)

Table 1. Synoptic table of riparian forest communities in Sutjeska National Park. Values are percentage frequency with cover range in superscript. Diagnostic species are shaded. Group numbers correspond to those used in text and in Fig. 2 (A – tree layer, B1 – higher shrub layer, B2 – lower shrub layer, C – herb layer). Full table is given in Electronic supplement 1. / **Tabela 1**. Sinoptička tabela obalnih šumskih zajednica u Nacionalnom parku Sutjeska. Vrijednosti predstavljaju frekvenciju u procentima sa rasponom pokrovnih vrijednosti u superskriptu. Dijagnostičke vrste su osjenčene. Brojevi grupa odgovaraju onima korištenim u tekstu kao i na Slici 2 (A – sprat drveća, B1 – gornji sprat žbunja, B2 – donji sprat žbunja, C – sprat zeljastih biljaka). Cijela tabela je data u Elektronskom dodatku 1.

Group No. / Broj grupe		**1**	**2**	**3**	**4**	**5**
No. of relevés / Broj snimaka		**3**	**5**	**13**	**11**	**10**
Group 1 / Grupa 1						
Urtica dioica	C	100 $^{+-4}$	40 $^{+-1}$	46 $^{r-+}$	.	10 $^{+}$
Heracleum sphondylium	C	100 $^{+}$	20 $^{+}$	15 $^{+}$	36 $^{r-+}$	40 $^{+}$
Anthriscus nitidus	C	100 ^{1}	20 $^{+}$	15 $^{r-+}$	9 $^{+}$	.
Stellaria nemorum	C	100 ^{2}	.	23 $^{+-2}$	.	10 $^{+}$
Carduus personata	C	100 $^{+-2}$	20 $^{+}$	23 $^{+}$	.	.
Salix caprea	A	100 $^{1-4}$	.	.	.	.
Salix caprea	B1	.	.	.	.	10 ^{r}
Lunaria rediviva	C	100 $^{+-3}$	20 $^{+}$	31 $^{+}$	.	10 $^{+}$
Tanacetum macrophyllum	C	100 $^{+-1}$	.	.	.	.
Senecio ovatus	C	67 $^{+}$	.	15 $^{+}$	.	.
Arabis turrita	C	67 $^{r-+}$	20 $^{+}$	.	.	10 $^{+}$
Telekia speciosa	C	67 $^{+-1}$	.	23 $^{r-+}$	9 $^{+}$	10 $^{+}$
Rubus hirtus	B2	67 $^{r-1}$	.	23 $^{+}$	.	10 $^{+}$
Silene dioica	C	67 $^{+}$	.	8 ^{r}	.	.
Veronica chamaedrys	C	67 $^{+-1}$	.	.	.	20 ^{r}
Galium aparine	C	67 $^{+-1}$	.	23 $^{r-+}$	.	20 $^{r-+}$
Group 2 / Grupa 2						
Carex pendula	C	33 $^{+}$	80 $^{1-4}$	8 $^{+}$	.	20 $^{+}$
Veronica montana	C	.	80 ^{1}	23 $^{r-2}$	.	.
Salix alba	A	.	80 $^{3-4}$	8 ^{2}	.	.
Salix alba	B2	.	40 $^{r-1}$	.	.	.
Group 3 / Grupa 3						
Helleborus odorus	C	.	.	85 $^{r-1}$	9 $^{+}$	40 $^{+}$
Geranium phaeum	C	.	.	77 $^{+-1}$	9 $^{+}$	10 $^{+}$
Symphytum tuberosum	C	.	.	69 $^{r-1}$	27 $^{+}$	20 $^{+}$
Asperula taurina	C	.	.	69 $^{+-1}$	.	10 $^{+}$
Cardamine bulbifera	C	.	.	69 $^{+-1}$	9 $^{+}$	30 $^{r-+}$
Chaerophyllum hirsutum	C	.	.	62 $^{+-1}$	27 $^{+-1}$	10 $^{+}$
Malus sylvestris	B2	.	.	62 $^{r-2}$	.	10 $^{+}$

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continuation of Table 1 / nastavak Tabele 1

Group No. / Broj grupe		**1**	**2**	**3**	**4**	**5**
Anthriscus sylvestris	C	.	.	54 +	.	10 r
Glechoma hirsuta	C	.	.	54 r-1	9 +	.
Euonymus europaeus	B2	.	.	54 r-1	.	.
Group 4 / Grupa 4						
Tilia cordata	A	.	.	.	36 1-3	.
Tilia cordata	B2	.	.	8 +	91 +-2	20 +
Lactuca muralis	C	33 +	20 +	31 r-+	73 +-1	30 r-+
Adenophora liliifolia	C	.	.	.	73 1-2	.
Lactuca pancicii	C	.	.	15 +	64 +-3	10 +
Fagus sylvatica	A	.	.	.	55 1-3	10 +
Fagus sylvatica	B2	.	.	38 r-+	91 +-2	60 +-2
Group 5 / Grupa 5						
Fragaria vesca	C	33 r	.	31 +-1	9 +	100 +
Ostrya carpinifolia	A	.	.	.	27 +-2	90 1-3
Ostrya carpinifolia	B2	.	.	.	18 +-2	90 +-2
Clinopodium vulgare	C	.	.	.	.	80 +-1
Carex digitata	C	.	.	.	18 r-+	70 +-1
Calamagrostis varia	C	.	.	.	9 +	70 +-1
Carex flacca	C	.	.	.	.	60 +-1
Tamus communis	C	.	.	8 +	18 +	60 r-+
Hieracium sabaudum	C	.	.	.	18 +	60 r-+
Melampyrum pratense	C	.	.	.	.	60 +
Non-diagnostic constant species						
Alnus glutinosa	A	.	100 3-5	100 4-5	100 2-5	40 1-2
Alnus glutinosa	B2	.	80 r-2	46 +-2	27 +-2	50 +-2
Salix eleagnos	A	100 2-4	.	8 1	9 3	90 2-4
Salix eleagnos	B1	67 +-2	.	.	9 +	80 +-4
Stachys sylvatica	C	100 +	40 +	62 +-1	9 r	10 +
Lamium maculatum	C	100 1-2	20 +	54 +-2	.	.
Geranium robertianum	C	100 +-2	40 +	92 r-1	9 r	30 r-+
Bromus benekenii	C	100 +	20 +	31 +	36 +	80 +-1
Lamium galeobdolon agg.	C	67 +-2	40 +	92 +-1	18 +	10 +
Solanum dulcamara	C	67 r-+	60 +-1	8 r	27 r-+	10 r
Festuca gigantea	C	67 r-+	20 +	38 r-+	27 +	50 +
Ulmus glabra	A	.	.	.	9 2	.
Ulmus glabra	B2	67 +	20 +	38 +-2	45 r-+	50 r-+
Geum urbanum	C	33 +	100 +	77 +-2	.	30 +

Group No. / Broj grupe		**1**	**2**	**3**	**4**	**5**
Scutellaria altissima	C	33 $^{+}$	80 $^{+\cdot1}$	69 $^{r\cdot2}$	45 $^{+\cdot1}$	30 $^{r\cdot+}$
Circaea lutetiana	C	.	80 $^{+\cdot2}$	62 $^{+\cdot2}$	.	10 $^{+}$
Equisetum arvense	C	33 ^{r}	60 $^{r\cdot1}$	31 $^{r\cdot+}$	64 $^{+\cdot1}$	30 $^{r\cdot+}$
Crataegus monogyna	B1	.	40 $^{+}$	92 $^{r\cdot2}$	27 $^{+}$	90 $^{r\cdot2}$
Corylus avellana	B1	.	40 $^{+\cdot2}$	92 $^{r\cdot4}$	27 $^{+\cdot3}$	80 $^{2\cdot2}$
Carpinus betulus	A	.	.	8 $^{+}$	18 $^{1\cdot2}$	20 $^{1\cdot2}$
Carpinus betulus	B2	.	20 ^{1}	69 $^{r\cdot2}$	45 $^{+\cdot2}$	90 $^{+\cdot2}$
Hedera helix	B2	33 ^{r}	20 $^{+}$	23 $^{+\cdot4}$	100 $^{+\cdot3}$	70 $^{+\cdot3}$
Dactylorhiza fuchsii	C	33 ^{r}	.	38 $^{r\cdot+}$	100 $^{r\cdot+}$	80 $^{+\cdot1}$
Petasites kablikianus	C	.	.	23 $^{+\cdot1}$	91 $^{+\cdot2}$	50 $^{+\cdot2}$
Sesleria autumnalis	C	.	.	.	64 $^{r\cdot1}$	80 $^{+\cdot2}$
Eupatorium cannabinum	C	33 $^{+}$	20 ^{1}	31 $^{+}$	55 $^{+\cdot1}$	60 $^{+}$
Solidago virgaurea	C	.	.	.	55 $^{+}$	70 $^{+}$
Campanula trachelium	C	.	.	46 $^{r\cdot+}$	55 $^{+}$	60 $^{r\cdot+}$
Aruncus dioicus	C	33 ^{1}	.	38 $^{r\cdot+}$	55 $^{+}$	50 $^{r\cdot+}$
Petasites hybridus	C	100 $^{1\cdot5}$	60 $^{1\cdot3}$	77 $^{r\cdot2}$	27 $^{+\cdot2}$	30 $^{+}$
Sambucus nigra	B1	100 $^{r\cdot2}$	80 $^{+\cdot2}$	85 $^{+\cdot2}$	9 $^{+}$	.
Carex sylvatica	C	67 $^{+}$	60 $^{r\cdot1}$	92 $^{r\cdot3}$	9 $^{+}$	40 $^{+\cdot1}$
Salvia glutinosa	C	67 $^{+}$	.	69 $^{+}$	100 $^{+}$	40 $^{+}$
Pulmonaria officinalis	C	67 $^{+}$	60 $^{+}$	85 $^{r\cdot+}$	36 $^{+}$	40 $^{+}$
Ajuga reptans	C	67 $^{+}$	60 $^{+}$	23 $^{r\cdot+}$	.	80 $^{+}$
Acer campestre	A	.	.	15 $^{1\cdot2}$	.	10 $^{+}$
Acer campestre	B2	.	80 $^{+\cdot1}$	100 $^{r\cdot2}$	27 $^{+}$	100 $^{+\cdot1}$
Primula vulgaris	C	.	80 $^{r\cdot+}$	54 $^{r\cdot+}$	36 $^{r\cdot+}$	70 $^{r\cdot1}$
Chaerophyllum aromaticum	C	.	80 $^{+\cdot5}$	62 $^{+\cdot2}$	73 $^{+\cdot2}$	10 $^{+}$
Brachypodium sylvaticum	C	33 $^{+}$	40 $^{+\cdot1}$	77 $^{+\cdot2}$	100 $^{1\cdot3}$	100 $^{1\cdot4}$
Clematis vitalba	B2	100 $^{+}$	20 $^{+}$	92 $^{r\cdot1}$	100 $^{+\cdot1}$	90 $^{+\cdot2}$
Dactylis glomerata	C	67 $^{+}$	40 $^{+}$	62 $^{r\cdot1}$	82 $^{+}$	100 $^{+\cdot1}$
Acer pseudoplatanus	A	33 ^{1}	.	31 $^{+\cdot1}$	45 $^{+\cdot2}$	10 $^{+}$
Acer pseudoplatanus	B2	.	100 $^{+\cdot2}$	85 $^{r\cdot2}$	91 $^{+\cdot2}$	100 $^{r\cdot2}$
Peucedanum aegopodioides	C	.	100 $^{+\cdot1}$	92 $^{+\cdot2}$	82 $^{+}$	60 $^{+}$
Aegopodium podagraria	C	33 $^{+}$	60 $^{+}$	100 $^{+\cdot3}$	64 $^{+\cdot1}$	100 $^{+\cdot1}$
Cornus sanguinea	B1	.	60 $^{+\cdot2}$	85 $^{r\cdot2}$	82 $^{+\cdot2}$	100 $^{+\cdot2}$
Rubus caesius	B2	.	60 $^{1\cdot2}$	100 $^{+\cdot4}$	91 $^{+\cdot3}$	100 $^{+\cdot2}$
Scrophularia nodosa	C	67 $^{r\cdot+}$	20 $^{+}$	31 $^{+}$	.	20 $^{+}$
Rumex sanguineus	C	67 $^{r\cdot+}$	20 $^{+}$	31 $^{r\cdot+}$	.	10 $^{+}$

continued / nastavak na sljedećoj stranici

continuation of Table 1 / nastavak Tabele 1

Group No. / Broj grupe		**1**	**2**	**3**	**4**	**5**
Galeopsis speciosa	C	67 +	40 +	.	.	.
Rhamnus alpina subsp. *fallax*	B1	67 +	.	31 r-2	18 r-+	20 r-+
Ranunculus repens	C	33 r	60 +-1	38 +-1	18 +	10 +
Lysimachia nummularia	C	.	60 +-1	38 +-1	.	20 +
Carex remota	C	33 +	60 +-3	46 +	.	.
Allium ursinum	C	33 r	20 4	69 r-3	45 +-1	20 +
Oxalis acetosella	C	33 r	20 +	54 r-1	.	30 +
Angelica sylvestris	C	.	40 +-1	23 +-1	73 +	.
Elymus caninus	C	33 +	.	23 +	73 +-1	40 r-+
Veronica urticifolia	C	33 +	.	8 +	64 +-1	20 r-+
Mercurialis perennis	C	.	40 +-1	23 r-+	64 +-1	10 1
Euphorbia amygdaloides	C	33 r	20 +	46 +	36 +	80 +
Valeriana officinalis	C	33 +	20 +	15 +	36 +	70 r-+
Prunus avium	B1	.	.	.	.	10 +
Prunus avium	B2	.	20 +	38 +	.	60 r-+
Acer platanoides	B2	33 r	.	23 r-+	36 r-1	60 r-+
Hieracium bifidum agg.	C	.	.	.	45 +-2	60 +
Viola reichenbachiana	C	.	.	46 r-+	27 r-+	60 +
Rosa arvensis	B2	.	20 +	46 r-1	9 r	50 +
Galium sylvaticum	C	33 +	20 r	.	9 +	50 +
Fraxinus excelsior	A	.	.	23 1-2	27 +-2	20 +-1
Fraxinus excelsior	B2	100 r-+	80 2-2	92 +-2	100 r-2	100 r-2

Group 3 includes narrow strips of black alder along the river banks, with fully closed canopy which hampers the sidelight penetration (Figure 5). Their floristic composition is very homogeneous with lots of mesophilous species of neighboring beech forests. These rather mesophilous communities are shortly flooded only during the highest water levels, while the amount of the new sediment deposited is reduced. It is very well differentiated from other groups by diagnostic species which are: *Geranium phaeum, Asperula taurina, Helleborus odorus, Symphytum tuberosum, Cardamine bulbifera, Glechoma hirsuta* and *Euonymus europaeus* (Table 1, column 3). Besides *Alnus glutinosa* in a tree layer, constant species are: *Crataegus monogyna, Corylus avellana, Rubus caesius, Clematis vitalba, Aegopodium podagraria, Peucedanum aegopodioides, Lamium galeobdolon* agg., *Geranium robertianum, Carex sylvatica* etc. These forests are floristically closest to the Central European *Stellario nemorum-Alnetum glutinosae* Lohmeyer 1957 of the alliance *Alnion incanae*, but their precise syntaxonomical status still needs to be determined, taking into account relevés from the whole country and also from the region.

Group 4 includes streamside black alder forests developed along the banks of wider streams, which enables the penetration of more sidelight, thus enabling the growth of a number of light loving species, especially tall herbs (Figure 6). Unlike previous, these forests are developed on more or less steep river banks where ravine and scree forest communities quickly take over on steep and rocky colluvial soil. That is why this community is floristically related to the alliance

Figure 5. Mesophilous riparian forests of *Alnus glutinosa* along lower reaches of the Hrčavka river / **Slika 5**. Mezofilne šume crne jove u donjem dijelu Hrčavke (© Đ. Milanović)

Figure 6. Mesophilous streamside formations of *Alnus glutinosa* and *Adenophora liliifolia* alongside the Sutjeska river / **Slika 6**. Mezofilne trakaste sastojine crne jove sa mirisnom žljezdačom uz Sutjesku (© Đ. Milanović)

Fraxino excelsioris-Acerion pseudoplatani P. Fukarek 1969. In the study area this community is typically developed only along the Sutjeska river, while, outside of the national park, it is common along other bigger watercourses in the upper part of the Drina river catchment (Tara, Piva and Drina; unpublished data). Floristic composition is also very homogeneous with *Alnus glutinosa* and *Fagus sylvatica* dominating the tree layer, while constant in lower layers are *Salvia glutinosa, Dactylorhiza fuchsii, Clematis vitalba, Hedera helix, Elymus caninus, Veronica urticifolia, Petasites kablikianus, Sesleria autumnalis, Angelica sylvestris, Peucedanum aegopodioides, Aegopodium podagraria, Dactylis glomerata, Solidago virgaurea, Eupatorium cannabinum, Mercurialis perrenis, Aruncus dioicus, Brachypodium sylvaticum* and seedlings of *Tilia cordata, Fraxinus excelsior* and *Acer pseudoplatanus*. Diagnostic species are *Tilia cordata* (seedlings layer), *Fagus sylvatica* (tree layer), *Lactuca muralis, Adenophora liliifolia* and *Lactuca pancicii* (Table 1, column 4). It does not have to be stressed that syntaxonomical position of this community with several important species of southern distribution (*Lactuca pancicii, Peucedanum aegopodioides* and *Sesleria autumnalis*) is yet to be determined.

Group 5 is represented by closed canopy thermo-mesophilous scrub of *Salix elaeagnos* and *Ostrya carpinifolia* developed over gravel bars which can be several meters deep and sometimes quite away from the river bed (Figure 7). They are flooded only during the highest and strongest spates, but as *Salix elaeagnos* is able to anchor itself in the gravel with strong tap roots it keeps the deposits on place and enables the less resistant elements to colonize the soil. These gravel bars are at least one meter higher then middle summer water which causes dry periods, but bitter willow can withstand this dry periods by following the retreating water with its roots which branch out horizontally (Ellenberg, 2009). This closed canopy scrub is a part of natural successional series which goes from open gravel bars with annual plants and bitter willow saplings, over semi open formations with young bitter willow shrub. Floristic composition

Figure 7. View on thermo-mesophilous stands of *Salix eleagnos* and *Ostrya carpinifolia* from their edge in the Sutjeska river valley / **Slika 7**. Pogled na sklopljene sastojine sive vrbe i crnog graba u dolini Sutjeska sa njihovog ruba (© Đ. Milanović)

is rather homogeneous being a combination of thermophilus, mesophilous and hygrophilous elements. Special feature of this community is regular appearence of *Ostrya carpinifolia* along with *Salix elaeagnos* in the upper layer (which is 3–5 meters high). Diagnostic species are mostly those of drier and warmer habitats: *Ostrya carpinifolia, Clinopodium vulgare, Fragaria vesca, Calamagrostis varia, Carex flacca, Carex digitata, Tamus communis, Hieracium sabaudum* and *Melampyrum pratense* (Table 1, column 5). Besides *Ostrya carpinifolia* and *Salix eleagnos* in a tree layer, constant species are: *Euphorbia amygdaloides, Valeriana officinalis, Rosa arvensis, Crataegus monogyna, Corylus avellana, Hedera helix, Sesleria autumnalis, Rubus caesius, Cornus sanguinea, Peucedanum aegopodioides* etc. By its floristic composition this community does not corespond to any to date described bitter willow community, so its syntaxonomical status is yet to be confirmed.

It should be noted that the seedlings of the mesophilous *Acer pseudoplatanus, Fraxinus excelsior, Carpinus betulus* and *Acer campestre* occur in almost every relevé recorded. Seedlings of *Fagus sylvatica, Prunus avium, Acer platanoides* and *Tilia platyphyllos* are a little less often, but still very frequent. This could be ascribed to the exceptionally fertile soil, which is favorable for young plants of these species. However, in a tree layer only occasional *Acer pseudoplatanus, Fraxinus excelsior, Carpinus betulus* and *Tilia cordata* are to be found only on the driest sites.

3.2 General overview / Zaključna razmatranja

When compared to similar communities in B&H and Europe, the vegetation of riparian forests and scrub of the Sutjeska National Park shows some peculiarities. First, it is striking that *Alnus incana*, species otherwise common along gravel-bed streams in the montane belt of surrounding areas (Fukarek, 1957; Lakušić et al., 1978; Barudanović, 2003; Šilić, 2005), does not occur in study area. This was already pointed out by Fukarek (1970) who was surprised that, along the stream Perućica at the elevations of around 1000 m, instead of *Alnus incana*, one encounters stands with *Alnus glutinosa*. He explains it by heavy soils developed over shales, but this explanation does not cover other, much bigger, areas of *Alnus glutinosa* stands in national park over mainly carbonate bedrock.

Furthermore, the distinct character of these communities is also pronounced by two Balkan endemic species that seem to be bound to these forests (except for group 1): *Peucedanum aegopodioides* and *Lactuca pancicii*. There is also important role of thermophilous S European *Sesleria autumnalis* for groups 4 and 5, and SE European *Ostrya carpinifolia* (group 5).

Besides Perućica, where Fukarek (1970) described *Alnetum glutinosae (montanum)* Fuk., 1969. prov., streamside black alder forests in B&H were studied also on Vranica Mt. (Barudanović, 2003; Barudanović & Redžić, 2006). In addition to acidophilous *Blechno-Alnetum* Barudanović 2003, there was also *Alnetum glutinosae* (Fukarek 1969) Barudanović 2003 reported. However, there are large discrepancies between its relevés and those from originally described association (Fukarek, 1970). If we consider also groups 3 and 4, we can conclude that systematic research of this type of vegetation is very much needed in B&H in order to resolve syntaxonomical issues. According to Vukelić (2012), lack of systematic study of these forests is also the problem in Croatia. Similarly, syntaxonomy is unresolved in Serbia too, since various types of streamside black alder forests are all known under the name *Aegopodio podagrariae-Alnetum glutinosae* Karp. et Toth 1961 (*Alnetum glutinosae fluviatile* B. Jov. (1953) 1985) (Jovanović, 1997).

There is also a problem in a higher level of syntaxonomy of streamside black alder forests (groups 3 and 4). While group 3 most probably belongs to *Alnion incanae* being very similar to *Stellario nemorum-Alnetum glutinosae*, group 4 shows floristic composition of ravine and scree forests of *Fraxino-Acerion*.

Although *Salix eleagnos* scrub is known to exist along upper and middle reaches of many mountain streams in Dinarides (Milanović et al., 2015), they were never systematically investigated. Up to date, there is only one published relevé of this scrub in B&H (Redžić et al., 1992).

This association was described from Neretva river valley (Diva Grabovica) as *Petterio-Salicetum eleagni* Redžić et al. 1992. Although this relevé shows pronounced thermophilous character, it still differs from our group 5 in some elements, but most notably in the lack of *Ostrya carpinifolia*.

Scrub of *Salix eleagnos* was also described from Perućica stream by Fukarek (1969) but without relevés. From description, we can conclude that he studied low open shrubby stands of bitter willow. These open formations are transitional communities between mobile gravel shoals with rare seedlings and saplings of bitter willow, towards more permanent and closed formations of bitter willow (group 5), and concur to *Salicetum incanae* prov. described from valleys of Pećka Bistrica, Mileševska reka, Lim and Đetinja in Serbia (Jovanović & Tucović, 1965).

Keeping in mind that group 1 shows big resemblance to already known *Salicetum eleagno-purpureae* Sillinger 1933 subass. *petasitetosum hybridi* (Šilc et Čušin 2000) Oriolo et Poldini 2002 and probably belongs to alliance of *Salicion eleagno-daphnoidis*, we should stress the peculiar floristic composition of group 5 which we could not relate to any of the already described communities.

Special attention needs to be payed to heterogeneous forests of group 2, since there seems to be a problem in syntaxonomy of these mosaicked swampy/mesophilous woodland habitats also in Serbia (Jovanović, 1997).

At the end, it should also be mentioned that rare and endangered *Adenophora lilifolia*, a plant species listed on Annex II of EU Habitats Directive (Council of the European Communities, 1992) is diagnostic species for group 4. This species' distribution in B&H is not quite clear yet but, this locality, along with several others discovered recently (Redžić & Šoljan, 1988; Milanović & Stevanović, 2009; Ballian & Šarić, 2015), suggests that it could be more common in B&H than thought before.

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Sažetak

Priobalna šumska vegetacija uz brze vodotoke u Bosni i Hercegovini do danas nije značajno istraživana. Samo nekoliko objavljenih radova (Fukarek, 1970; Redžić et al., 1992, Barudanović, 2003) obrađuje ove biljne zajednice na temelju fitocenoloških snimaka. Od toga su na području Nacionalnog parka Sutjeska registrovane šume crne jove u gornjem dijelu Perućice te šikare sive vrbe u blizini ušća Jabučice (Fukarek, 1970).

Tokom četverogodišnjih istraživanja u periodu 2014–2017. godine istraživane su šumske zajednice uz brze vodotoke Sutjesku, Hrčavku, Jabučicu i Izgorku, u kojima dominira crna jova (*Alnus glutinosa*) ili siva vrba (*Salix eleagnos*) (Slika 1). Fitocenološki snimci uzimani su po standardnom centralnoevropskom metodu (Braun-Blanquet, 1964), unešeni u Turboveg (Hennekens & Schaminée, 2001), odakle su eksportovani u Juice (Tichý, 2002) za dalju analizu. Za klasifikacijiu fitocenoloških snimaka korišćen je modifikovani TWINSPAN algoritam (Roleček et al., 2009), dok je ordinacija zasnovana na DCA analizi izvršena pomoću programa CANOCO 4.5 (ter Braak & Šmilauer, 2002).

Numerička klasifikacija izdiferencirala je 42 fitocenološka snimka u 5 jasno floristički i ekološki izdijeljenih grupa (Slika 2): (1) šibljaci sive vrbe (*Salix eleagnos*) i ive (*Salix caprea*) na nanosima sitnijeg granulometrijskog sastava; (2) šume crne jove (*Alnus glutinosa*) i bijele vrbe (*Salix alba*) na sličnim finijim nanosima; (3) uske trakaste formacije crne jove uz manje-više položene obale manjih vodotoka; (4) uske trakaste formacije crne jove uz strme obale širih vodotoka; (5) termo-mezofilne šikare sive vrbe i crnog graba (*Ostrya carpinifolia*) na šljunkovitim nanosima. Ovako poredane grupe prate opadajući gradijent nitrofilnosti, što pokazuje snažna negativna korelacija na prvoj osi DCA dijagrama (Slika 2), obzirom da su prve tri grupe znatno nitrofilnije nego posljednje dvije. Na istom dijagramu sa drugom osom značajnije od ostalih faktora koreliše temperatura izdvajajući grupe (1) i (5) kao termofilnije od mezofilnih (2) i (4), dok se grupa (3) nalazi između njih.

Dok grupe (1) i (3) odgovaraju već opisanim asocijacijama iz srednje Evrope (*Salicetum eleagno-purpureae* (Slika 4) i *Stellario nemorum-Alnetum glutinosae* (Slika 6), respektivno), grupe (4) (Slika 7) i (5) (Slika 8) najvjerovatnije predstavljaju do danas neopisane asocijacije. Grupa (2) (Slika 4) je floristički i ekološka vrlo heterogena i zauzima prelazni karakter između sveza *Salicion albae* i *Alnion incanae*. Među pronađenim biljnim vrstama ističe se novo nalazište mirisne žljezdače (*Adenophora liliifolia*), dok bi neki endemiti i subendemiti JI Evrope (*Peucedanum aegopodioides, Lactuca pancicii, Ostrya carpinifolia*) mogli biti dijagnostički važni za razlikovanje balkanskih obalnih šumskih zajednica uz brze vodotoke od srodnih asocijacija iz centralne Evrope. Međutim, da bi se stekla preciznija sintaksonomska slika obrađenih zajednica potrebno je provesti sistematska istraživanja ovih i sličnih zajednica na nivou cijele BiH u kontekstu vegetacije Evrope.

Ključne riječi: *Alnion incanae, Alnus glutinosa*, ekološki gradijent, fitocenologija, *Salicion eleagno-daphnoidis, Salix eleagnos*, vegetacija