

Floristic Composition and Ecological Analysis of Beech and Bosnian Maple Forest (*Aceri obtusati-Fagetum* Fab., Fuk. & Stef. 1963) on Manjača Mountain (Bosnia and Herzegovina)

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ABSTRACT

The results of phytocoenological research in the community of beech and Bosnian maple (*Aceri obtusati-Fagetum* Fab., Fuk. & Stef. 1963) on the territory of Manjača Mountain in the southwestern part of the Republic of Srpska (Bosnia and Herzegovina) are presented in this paper. The spectrum of range of distribution types, and the spectrum of life forms and ecological conditions were determined for the community. Regarding the spectrum of floral elements, this community has Central European-Pontic-Central Asian-Sub-Mediterranean character, meaning that thermoxerophilic plant species participate in its composition, in addition to mesophilic species. In terms of the spectrum of life forms, the community has phanerophytic-hemicryptophytic character. According to the quantity of nitrogen in the soil, the community is predominantly mesotrophic, in terms of light it is semi-sciophilous, in terms of temperature it is mesothermal, in terms of soil reaction it is neutrophilic, and regarding soil moisture it has xeromesophilic character.

Keywords: community of beech and Bosnian maple; floristic composition; ecological conditions; Manjača Mountain

INTRODUCTION

European beech (*Fagus sylvatica* L.) is the most abundant broadleaved tree species in Europe (Brunet et al. 2010). Vascular plant species composition and richness of beech forests are highly variable among European regions and habitats (Ujházyová et al. 2016, Jiménez-Alfaro et al. 2018, Lelli et al. 2019). The fir-beech and pure beech forests of montane locations in the Illyrian-Dinaric region are the most significant beech forest units of south-eastern Europe (Bohn 2004). Beech forests in the Republic of Srpska (Bosnia and Herzegovina) have a wide distribution, which is conditioned by the ecological characteristics of the species itself, as well as the diverse ecological conditions of the habitat. They cover an area of 176,793 ha or 37.8% of the total forest growing stock of high forests with natural

renewal (Maunaga 2016). These forests thrive in diverse ecological conditions, where in addition to the wide climatic range, they also have a wide edaphic amplitude. A detailed study of the community of beech and Bosnian maple (*Aceri obtusati-Fagetum* Fab., Fuk. & Stef. 1963) was carried out by Fabijanić et al. (1963) in the Lepenica river basin, by Fukarek et al. (1967) in the Herzegovinian and western Bosnian Mountains, by Bucalo (1999) on Jadovnik Mountain and Brujić (2013) on Čemernica Mountain.

The community of beech and Bosnian maple represents the thermophilic variant of beech forests (Stefanović et al. 1983). In addition to Montenegro and Croatia, these forests are distributed in Bosnia and Herzegovina in the western Bosnian Mountains and western Herzegovina (Vojniković et al. 2017), and on some sites, they penetrate deeper into the interior of the country (the Lepenica basin

near Kiseljak, Igman Mt. near Sarajevo) (Stefanović 1986). Fabijanić et al. (1967) described the community in detail in Ormanje, Oštrik and Plješevac in the area of Lepenica, as well as on the southern slopes of Igman (Stupnik) and Bor within the Bjelašnica Mt., where it is connected to dolomites and rendzina, on southern exposures. In this community, the same authors found the presence of plant species of xerothermic pubescent oak forests (*Quercetalia pubescentis* Br.-Bl. (1931) 1932, and mesophilic beech forests of the Dinaric area (*Fagetalia* Paw. 1928 and *Fagion illyricum* Ht. 1938).

On Manjača Mt., the community occupies a small area in a belt of mountain beech forests. The primary objective of the paper is to study the ecological characteristics and floristic composition of the community. The results of these studies should contribute to the optimal use and preservation of the ecological and production values of the habitat and represent the starting point for planning the cultivation needs based on the principles of sustainable development.

MATERIALS AND METHODS

Manjača Mt. is situated in southwestern part of the Republic of Srpska (Bosnia and Herzegovina), about 40 km from Banja Luka. This massif extends from 44°28' of north latitude and 16° 56' of east longitude in the north-south direction, which deviates from the usual range of the Dinaric Mts. (Figure 1). From an orographic point of view, it belongs to the lower mountain zone and extends on average in the altitude range of 800-1150 m. The community of beech and Bosnian maple occurs on limestone bedrock,

on shallow organo-mineral black soil (Mollic Leptosol) with a pronounced portion of stones and rocks. The slope of the terrain is 10-15° and the exposure is south-southeast (Eremija 2008).

According to ecological and vegetational zoning of Bosnia and Herzegovina (Stefanović et al. 1983), the researched area belongs to western Bosnian limestone-dolomite area, and within it the researched area belongs to Ključ-Petrovac zone, which is geomorphologically characterised by appearance of plateaus with sinkholes and rising of higher limestone massifs on the edges.

Floristic characteristics of the studied community of beech and Bosnian maple have been determined based on five relevés (30 x 30 m) taken according to the Braun-Blanquet method (Braun-Blanquet 1964). Determination of species was carried out based on the "Flora of the Socialist Republic of Serbia" (Josifović 1970-1977, Sarić 1992). Spectra of floral elements were determined according to Gajić (1980), spectra of life forms according to the method by Kojić et al. (1997), and ecological characterization of plant species according to Kojić et al. (1997) and Ellenberg and Leuschner (2010).

RESULTS AND DISCUSSION

Community of beech and Bosnian maple with 41 plant species is not floristically very rich (Table 1). In addition to mesophilic elements of beech forests (*Fagetum illyricum*), species of xerothermic oak forests (*Ostryo Carpinion orientalis*) are included in its composition (Eremija 2008). The described community is significantly poorer from the beech and Bosnian maple forest on the Jadovnik Mt.

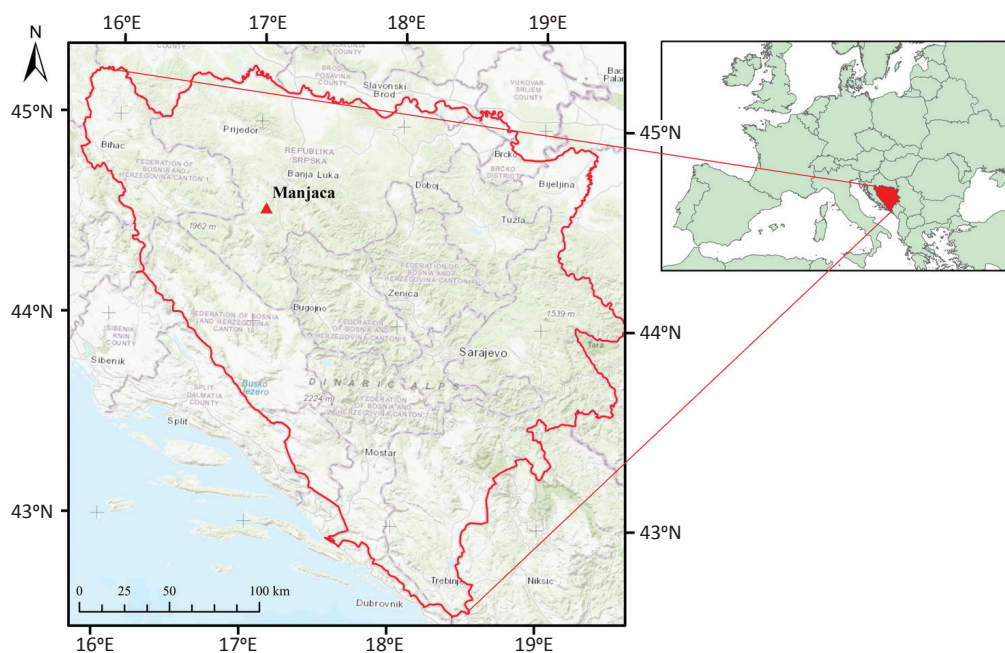


Figure 1. Map of Bosnia and Herzegovina with the position of Manjača Mt.

in Western Bosnia, which consists of 182 plant species (Bucalo 1999). This community on Čemernica Mt., which is separated from Manjača Mt. by Vrbas canyon, is described with 311 species on 17 relevés (Brujić 2013). The plant community described in the area of Manjača Mt. resides on limestone and organo-mineral black soil (Mollic Leptosol), as

opposed to the research by Fabijanić et al. (1963), Fukarek et al. (1967) and Bucalo (1999), in which it was described on dolomites (Rendzic). The reason for the low number of plant species can be linked to the specific edaphic and microclimatic conditions of the habitat, as well as the large surface rockiness.

Table 1. Diversity of plant species in the community of beech and Bosnian maple (*Aceri obtusati-Fagetum*).

Plant species	Floral element	Life form	Ecological characteristics				
			F	R	N	L	T
<i>Acer campestre</i>	Sub-Central European	phanerophyta	3	4	3	3	4
<i>Acer obtusatum</i>	Illyric-Apennine	phanerophyta	2	4	3	3	4
<i>Acer platanoides</i>	Sub-Central European	phanerophyta	3	3	3	2	3
<i>Acer pseudoplatanus</i>	Central European	phanerophyta	3	3	3	2	3
<i>Aremonia agrimonoides</i>	Eastern Sub-Mediterranean	hemicryptophyta	3	5	3	3	4
<i>Arum maculatum</i>	Central European	geophyta	4	3	3	2	3
<i>Asarum europaeum</i>	Eurasian	geophyta	3	4	3	2	4
<i>Astragalus glycyphyllos</i>	Sub-Pontic Central Asian	hemicryptophyta	2	3	2	3	4
<i>Brachypodium silvaticum</i>	Sub-South Siberian	hemicryptophyta	3	3	3	3	3
<i>Calamintha vulgaris</i>	Circumpolar	hemicryptophyta	3	4	2	4	3
<i>Carpinus betulus</i>	Central European	phanerophyta	3	3	3	2	4
<i>Corylus avellane</i>	Sub-Central European	phanerophyta	3	3	3	3	3
<i>Dactylis glomerata</i>	Sub-Eurasian	hemicryptophyta	3	3	4	3	3
<i>Daphne mezereum</i>	Sub-South Siberian	phanerophyta	3	4	3	2	3
<i>Dryopteris filix-mas</i>	Cosmopolitan	hemicryptophyta	3	3	3	2	3
<i>Euphorbia amygdaloides</i>	Sub-Atlantic Sub-Mediterranean	chamaephyta	3	4	3	2	3
<i>Evonymus latifolia</i>	Sub-Mediterranean	phanerophyta	3	4	3	2	4
<i>Evonymus verrucosus</i>	Sub-Pontic	phanerophyta	2	4	3	3	4
<i>Fagus sylvatica</i>	Central European	phanerophyta	3	3	3	2	3
<i>Festuca drymeia</i>	Sub-Mediterranean	hemicryptophyta	3	3	3	4	4
<i>Fragaria vesca</i>	Eurasian	hemicryptophyta	3	3	3	3	3
<i>Fraxinus ornus</i>	Sub-Mediterranean	phanerophyta	2	4	2	3	4
<i>Galium schultesii</i>	Sub-Pontic Sub-Pannonian	geophyta	3	4	2	3	3
<i>Geranium robertianum</i>	Sub-Circumpolar	therophyta	3	3	4	2	3
<i>Hedera helix</i>	Sub-Atlantic Sub-Mediterranean	phanerophyta	3	3	3	2	4
<i>Helleborus odoratus</i>	Central Balkan	hemicryptophyta	3	1	2	3	4
<i>Heracleum spondylium</i>	Eurasian	hemicryptophyta	3	3	4	3	2
<i>Hypericum perforatum</i>	Sub-Eurasian	hemicryptophyta	2	3	3	3	3
<i>Lathyrus venetus</i>	Pontic-Eastern Sub-Mediterranean	geophyta	2	3	2	2	4
<i>Lonicera xylosteum</i>	Eurasian	phanerophyta	3	3	3	3	3
<i>Melica uniflora</i>	Central European	geophyta	3	3	2	2	3
<i>Mercurialis perennis</i>	Sub-Central European	geophyta	3	4	3	1	3
<i>Mycelis muralis</i>	Central European	hemicryptophyta	3	3	3	2	3
<i>Polygonatum odoratum</i>	Sub-South Siberian	geophyta	2	3	2	3	3
<i>Polystichum aculeatum</i>	Cosmopolitan	hemicryptophyta	3	3	3	2	3
<i>Pulmonaria officinalis</i>	Sub-Central European	hemicryptophyta	3	4	3	3	3
<i>Quercus petraea</i>	Central European	phanerophyta	2	3	2	3	3
<i>Rhamnus fallax</i>	Balkan	phanerophyta	2	3	2	4	3
<i>Salvia glutinosa</i>	Sub-Central European	hemicryptophyta	3	3	4	3	3
<i>Tamus communis</i>	Sub-Atlantic Sub-Mediterranean	geophyta	3	4	3	3	4
<i>Tilia grandifolia</i>	Central European	phanerophyta	3	3	3	2	4

1, 2, 3, 4 and 5 - ecological indicator values (Kojić et al. 1997, Ellenberg and Leuschner 2010); F - soil moisture; R - soil reaction; N - nitrogen; L - light; T - temperature.

Spectrum of Floral Elements

Spectrum of distribution types is presented in Table 2. The species of Central European range of distribution type, which are represented by 34%, have the largest representation in the studied community. Plants belonging to Eurasian (22%), Pontic (10%), Sub-Mediterranean (10%), Balkan (7%), Sub-Atlantic (7%), Cosmopolitan (5%) and Circumpolar (5%) floral elements are less represented. As individual range of distribution types, the most represented are Central European (8), Sub-Central European (6) and Eurasian (4).

In general, the most represented plants are the plants of Central European and Sub-Atlantic range of distribution types with up to 41%, which indicate mesophilic nature of this community. Plants of xerophilic nature (Pontic, Sub-Mediterranean and Balkan range of distribution types) are represented by 27%, while plants with wide ecological amplitude (Eurasian and Cosmopolitan range of distribution types) are represented by 27%. Frigophilic plants (Circumpolar range of distribution type) are represented by 5%.

According to the spectrum of floral elements, this community has Central European-Pontic-Central Asian-Sub-Mediterranean character, meaning that in addition to mesophilic plant species it is also formed of thermoxerophilic species.

The community of beech and Bosnian maple on Manjača Mt. is characterized by equal shares of Central European and Sub-Atlantic distribution types (41%). The same applies to the community on Jadovnik Mt. On the other hand, the presence of xerophilic plants is much more pronounced

in the community found in the investigated area (27%). In comparison with the community described by Fukarek et al. (1967), the community on Manjača Mt. has a pronounced mesophilic character, which can be partly explained by its floristic-geographic position. If the same results are compared with those for the community on Čemernica Mt. (Brujić 2013), the high share of xerophilic plants can be observed, as a result of poorer edaphic conditions in the area.

Spectrum of Life Forms

Based on the analysis of life forms, it can be determined that, in community of beech and Bosnian maple, phanerophytes are dominant with 39% (Table 3). Hemicryptophytes are represented by 37%. They are adapted to living conditions in temperate and colder regions and as such represent percentage-wise the most numerous group of life forms in the region (Diklić 1984). Significant participation of geophytes indicates relative mesophilic nature of the habitat. From the group of chamaephytes, 2% of plants are identified, the same as annual species of therophytes. In terms of the spectrum of life forms, the community has phanerophytic-hemicryptophytic character.

Ecological Factors

Ecological factors in certain phytocoenoses are estimated based on the ecological indicator values of consisting plants (soil moisture, soil reaction, nitrogen supply, light and temperature). Knowledge of the ecology or relationship of forest trees towards conditions of the environment and biological characteristics of the species is of great

Table 2. Spectrum of floral elements in the community of beech and Bosnian maple (*Aceri obtusati-Fagetum*).

Individual range of distribution types	Number	Aggregate range of distribution types	Number	Share (%)	
Pontic-East Sub-Mediterranean	1				
Sub-Pontic	1				
Sub-Pontic-Central Asian	1	Pontic	4	10%	
Sub-Pontic-Sub-Pannonian	1				
Sub-Mediterranean	3				
East Sub-Mediterranean	1	Sub-Mediterranean	4	10%	27%
Balkan	1				
Central Balkan	1	Balkan	3	7%	
Illyric-Appennine	1				
Central European	8				
Sub-Central European	6	Central European	14	34%	41%
Sub-Atlantic Sub-Mediterranean	3	Sub-Atlantic	3	7%	
Eurasian	4				
Sub-Eurasian	2	Eurasian	9	22%	27%
Sub-South Siberian	3				
Cosmopolitan	2	Cosmopolitan	2	5%	
Circumpolar	1				
Sub-Circumpolar	1	Circumpolar	2	5%	5%
Total	41		41	100%	100%

Table 3. Spectrum of life forms of plants in the community of beech and Bosnian maple (*Aceri obtusati-Fagetum*).

Plant category	Phanerophytes	Chamaephytes	Hemicryptophytes	Geophytes	Therophytes
Number	16	1	15	8	1
Share (%)	39	2	37	20	2

importance in silviculture, as it provides a reliable starting point for determination of the cultivation approach and stand treatment, as well as the choice of appropriate methods of natural regeneration and forest tending (Krstić 2003).

Soil Moisture

By analyzing values of the ecological index for soil moisture, it can be concluded that in the community of beech and Bosnian maple, submesophytes are predominant with 76% (Table 4). Mesophilic plants are represented by 2%, while there are 22% of subxerophilic plants, indicating the xeromesophilic character of this community.

Soil Reaction

In terms of soil reaction, as an ecological factor in the studied community, neutrophilic plants are predominant with 64% (Table 5). Transitional plants of neutrophilic-basophilic character are represented by 32%. There are only 2% of basophilic plants, as well as acidophilic. The analysis of soil reaction as an ecological factor indicates that this community is of neutrophilic character.

Nitrogen

The relation of plants to the amount of nitrogen in soil indicates that predominant plants in the studied community are mesotrophic plants with 66% (Table 6). Transitional categories of plants, oligotrophic-mesotrophic and mesotrophic-eutrophic are represented by 24% and 10%,

respectively. Oligotrophic and eutrophic plants were not identified. According to the amount of nitrogen in the soil, the researched community has a mesotrophic character.

Light

In the researched community, the half-shade species are the most represented (semi-sciophytes) with 49% (Table 7). Sciophytes are represented by 2%, and transitional category sciophytes-semi-sciophytes are represented by 42%, which jointly makes 44% of plant species tending towards sciophytes. Sciophytes are far more represented than plants tending towards heliophytes, since transitional category (semi-sciophytes-heliophytes) is represented by 7%. Heliophytes were not identified. In terms of light as an ecological factor, this community has a semi-sciophilous character.

Temperature

In the community of beech and Bosnian maple, mesothermal plants are predominant, represented by 61%, while the plants of transitional mesothermal-thermophilic character are slightly less represented by 37% (Table 8). Thermophilic and frigophilic plants were not identified. According to temperature as an ecological factor, the researched community has mesothermal character, with increased share of plants tending towards thermophilic, which is a consequence of the presence of plants from oak forests.

Table 4. Spectrum of ecological groups of plants in terms of soil moisture in the community of beech and Bosnian maple (*Aceri obtusati-Fagetum*).

Plant category	Xerophytes (1)	Subxerophytes (2)	Submesophytes (3)	Mesophytes (4)	Hygrophytes (5)
Number	-	9	31	1	-
Share (%)	-	22	76	2	-

Table 5. Spectrum of ecological groups of plants in terms of soil reaction in the community of beech and Bosnian maple (*Aceri obtusati-Fagetum*).

Plant category	Acidophilic (1)	Acidophilic-neutrophilic (2)	Neutrophilic (3)	Neutrophilic-basophilic (4)	Basophilic (5)
Number	1	-	26	13	1
Share (%)	2	-	64	32	2

Table 6. Spectrum of ecological groups of plants in terms of the amount of nitrogen in the soil in the community of beech and Bosnian maple (*Aceri obtusati-Fagetum*).

Plant category	Oligotrophic (1)	Oligotrophic-mesotrophic (2)	Mesotrophic (3)	Mesotrophic-eutrophic (4)	Eutrophic (5)
Number	-	10	27	4	-
Share (%)	-	24	66	10	-

Table 7. Spectrum of ecological groups of plants in terms of light in the community of beech and Bosnian maple (*Aceri obtusati-Fagetum*).

Plant category	Sciophytes (1)	Sciophytes-Semi-sciophytes (2)	Semi-sciophytes (3)	Semi-sciophytes-Heliophytes (4)	Heliophytes (5)
Number	1	17	20	3	-
Share (%)	2	42	49	7	-

Table 8. Spectrum of ecological groups of plants in terms of temperature in the community of beech and Bosnian maple (*Aceri obtusati-Fagetum*).

Plant category	Frigophilic (1)	Frigophilic-mesothermal (2)	Mesothermal (3)	Mesothermal-thermophilic (4)	Thermophilic (5)
Number	-	1	25	15	-
Share (%)	-	2	61	37	-

CONCLUSIONS

The community of beech and Bosnian maple on Manjača Mt. occupies a small area in the belt of mountain beech forests. Compared to the same communities from other localities of the Dinaric area, it is characterised by low floristic diversity, which is the result of specific edaphic and microclimatic conditions of the habitat. In relation to the spectrum of floral elements, the community has Central European-Pontic-Central Asian-Sub-Mediterranean character, meaning that it is formed of thermoxerophilic plant species, in addition to mesophilic ones. According to the chorological spectrum, the most represented is Central European chorological group. In relation to the spectrum of life forms, the community has phanerophytic-hemicryptophytic character, which is common for the region. The examined plant community has an intermedial position between the mesophilic communities of the order *Fagetalia silvaticae* Pavl. 1928 and the xerothermic communities of the order *Quercetalia pubescentis* Br.-Bl. (1931) 1932. Based on the floristic analysis, it belongs to the sub-alliance *Ostryo-Fagenion illyricum* Borh. 1963, within the alliance of beech forests *Fagenion illyricum* Horv. 1938. Based on the ecological characteristics of plants in the community of beech and Bosnian maple, it can be concluded that in terms of soil

moisture this community is predominantly xeromesophilic; in terms of soil reaction, it has neutrophilic character; in terms of quantity of nitrogen in the soil, it is mesotrophic; in terms of light, it has semi-sciophilous character; and in terms of temperature as an ecological factor, it has mesothermal character.

Author Contributions

SE, SS, GČ conceived and designed the research, SE, SS, FJ and IČ carried out the field research, GČ and TČM processed the data, SB supervised the research and helped to draft the manuscript, SJ, SS, FJ and GČ wrote the manuscript. All authors have read and agreed to the final version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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