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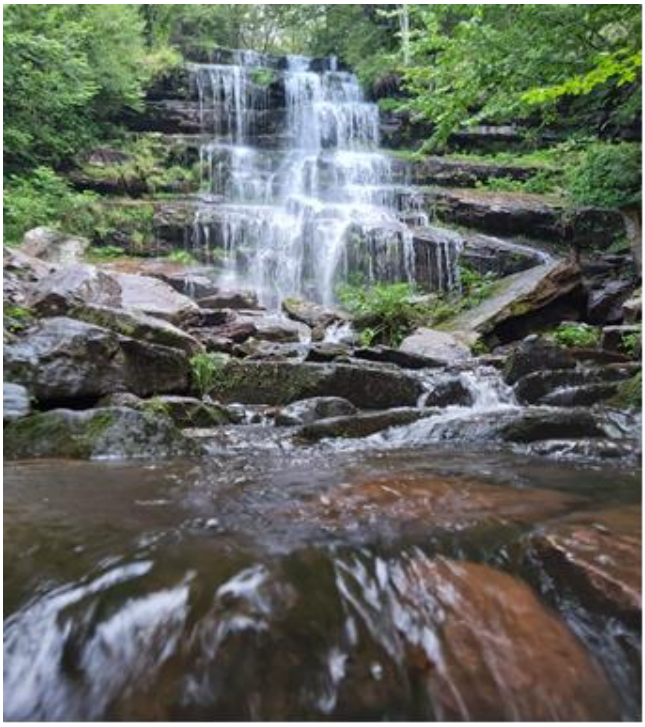

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COMPARISON OF FLORISTIC COMPOSITION OF SUBMONTANE BEECH FOREST AND ARTIFICIAL ESTABLISHED STANDS OF NORWAY SPRUCE ON Mt. KOSMAJ

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Abstract: *The paper presents the comparative characteristics of the floristic composition in the association of the submontane beech forest (Helleboro odori-Fagetum moesiacae Soo & Borhidi 1960.) and artificially established spruce stands (Picea abies (L.) Karst.) in the area of Kosmaj. According to the obtained results, the cover in the shrub and ground flora layers of the artificially established spruce stands increased significantly compared to the autochthonous beech forests, but the floristic diversity decreased. Regarding the spectrum of floral elements, a higher percentage of mesophilic (51%) and frigophilic plants (11%) was observed in the artificially established spruce stands compared to the beech forests. Significant differences could also be observed regarding the spectrum of life forms since there were twice as many phanerophytes in the artificially established spruce stands (48%) than in the beech forests (23%). This resulted from the open canopy of artificially established spruce stands and the influx of a greater amount of light, which made conditions favourable for an abundant shrub layer to develop in this community. A comparative study of the mean plant indicator values showed that in the artificially established spruce stands, the mean values of the ecological factors for moisture, light and soil nitrogen supply increased, while the value of the ecological factors for temperature and soil acidity decreased compared to the beech forests.*

Key words: *Fagus sylvatica*, substitution, floristic diversity, Kosmaj

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POREĐENJE FLORISTIČKOG SASTAVA BRDSKE BUKOVE ŠUME I VEŠTAČKIH PODIGNUTIH SASTOJINA SMRČE PODRUČJU KOSMAJA

Izvod: *U radu su prikazane uporedne karakteristike florističkog sastava zajednice brdske bukove šume (Helleboro odori-Fagetum moesiacae Soo & Borhidi 1960.) i veštački podignute sastojine smrče (Picea abies (L.) Karst.) na području Kosmaja. Rezultati su pokazali da se u veštački podignutoj sastojini smrče znatno povećala pokrovnost u spratu žbunja i prizemne flore u odnosu na autohtone šume bukve, ali se floristički diverzitet smanjio. U spektru flornih elemenata veštački podignute sastojine smrče uočava se veće procentualno učešće mezofilnih (51%) i frigorifilnih biljaka (11%) u odnosu na bukove šume. Prema spektru životnih oblika značajne razlike se ogledaju u prisustvu fanerofita, kojih ima duplo više u veštački podignutoj sastojini smrče (48%), nego u šumi bukve (23%). Ovo je posledica neskloplјenosti veštački podignutih sastojina smrče i priliva veće količine svetlosti, što je uslovilo bogat sprat žbunja u ovoj zajednici. Uporedna analiza srednjih indikatorskih vrednosti biljaka, pokazuje da se u veštački podignutoj sastojini smrče u odnosu na bukove šume, povećala prosečna vrednost ekološkog faktora za vlagu, svetlost i količinu azota, dok se vrednost ekološkog faktora za temperaturu i kiselost zemljišta smanjila.*

Ključne reči: *Fagus sylvatica*, supstitucija, floristički diverzitet, Kosmaj

1. INTRODUCTION

Recent disturbances in biological diversity worldwide and in Serbia have reached seriously worrying proportions. The most visible sign of the decline in biodiversity is the extinction of species with the increasing threat to the living world and its habitats. At the global level, the area of naturally regenerated forests has decreased, while there has been an obvious increase in the area of artificially established stands of various species (FAO, 2020). Reforestation with new tree species can do more harm than good to the ecosystem. It can, among other things, change the floristic composition and decrease floristic diversity (van Oijen *et al*., 2005; Atauri *et al*., 2005). It can further change soil properties and decrease its productivity (Van Calster *et al*., 2007; Miletić *et al*., 2013; 2020).

Our research was conducted in the territory of the Kosmaj Protected Area. Kosmaj was proclaimed a landscape of outstanding features in 2005. Since the mid-20th century, these coppice forests have been replaced with different conifer tree species, such as Austrian pine – *Pinus nigra* Arn., Scots pine–*Pinus sylvestris* L., Douglas fir – *Pseudotsuga menziesii* (Mirb.) Franco, Atlas cedar–*Cedrus atlantica* (Endl.) Carrière, Norway spruce (*Picea abies* (L.) Karst), etc. The introduction of tree species with decorative and aesthetic effects certainly improves the functions that forests in protected areas should have. However, this type of forest resources management entails certain environmental risks. Our research aimed to determine to what extent the establishment of artificial stands of Norway spruce (*Picea abies* (L.) Karst) on the site of the submontane beech forest (*Helleboro odori-Fagetum moesiacae* Soo & Borhidi 1960) in this area changed the floristic composition and diversity of these forests.

2. STUDY AREA, MATERIAL AND METHODS

Kosmaj is a relatively low mountain massif (626 m) that belongs to the Šumadija Mountain Range. According to Thornthwaite climate classification, the prevailing climate in the area is subhumid moist – C_2 type (Stajić, S., 2016). The mean annual air temperature is 12.3°C, and the mean annual precipitation is 696 mm.

Kosmaj has specific bedrock that consists of Neogene sands and clays, marls, limestones, breccias, sandstones and serpentinite. This type of bedrock has brought about significant pedological diversity in the area. Regarding phytogeography, this area belongs to the Balkan floristic province within the Central European region.

The floristic composition of the community of the submontane beech forest and the artificially established spruce stand was studied using 12 relevés collected in the submontane beech forest (*Helleboro odori-Fagetum moesiacae* Soo & Borhidi 1960) and three relevés in the spruce stand (*Picea abies* (L.) artificially established on this site. In doing so, we applied the Braun-Blanquet approach (Braun-Blanquet, 1964). Plant species were determined based on the following literature sources: Flora of Serbia IX (Josifović *et al*. 1972-1977, Sarić *et al*. 1986;1992; Stevanović *et al*. 2012). The spectra of floral elements were defined based on the systematisation of phytogeographical elements according to Gajić (1980) and the spectra of life forms using the method of Kojić *et al.* (1997). Plant indicator values and ecological optimums were determined using the method of Kojić *et al*. (1997).

3. RESULTS AND DISCUSSION

3.1 Floristic composition

Submontane beech forests (*Helleboro odori-Fagetum moesiacae* Soo & Borhidi 1960) typically occur at lower altitudes, in the climax zone of oaks, and are greatly conditioned by orographic conditions. They are found on cold slopes or in sheltered, shaded valleys with a specific microclimate (Tomić and Rakonjac, 2013). This community is widespread on Kosmaj, occurring at altitudes from 375 to 561 m above sea level and predominantly in cool exposures (Stajić *et al*., 2018). The ground flora cover ranges from 0.1 to 0.7. A total of 73 species were recorded within the submontane beech community (Table 1). Besides beech (*Fagus sylvatica*), the typical group includes the following species: *Lamium galeobdolon* (L.) Crantz, *Cardamine bulbifera* (L.) Crantz, *Acer campestre* L., *Helleborus odorus* Waldst. & Kit., *Mycelis muralis* (L.) Dum., *Circaea lutetiana* L., *Stachys sylvatica* L., *Carex sylvatica* Huds. and *Moehringia trinervia* (L.) Clairv.

Based on the analysis of the floristic composition, we can conclude that the investigated stands of Norway spruce (*Picea abies* (L.) Karst) were established on the site of the submontane beech forest (*Helleboro odori-Fagetum moesiacae* Soo & Borhidi 1960). Their altitude ranged from 460 to 470 m, the aspect was northeastern, and the slope was 10-14°. The ground flora cover ranged from 0.9 to

1.0, with a total of 27 species registered. The canopy closure was incomplete (0.6), which caused a higher presence of weed species in the shrub and ground flora layers, such as *Sambucus ebulus* L., *Rubus hirtus* Wald. & Kif., *Urtica dioica* L., *Rubus canescens* DC.

Table 1. *Floristic characteristics of the investigated stands*

Species	*B*	*NS*	*Species*	*B*	*NS*
Acer campestre	+	+	*Lathyrus vernus*	+	
Acer platanoides		+	*Lilium martagon*	+	
Ajuga reptans	+		*Luzula pilosa*	+	
Alliaria officinalis	+		*Melica uniflora*	+	
Allium ursinum	+		*Melittis melissophyllum*	+	
Asarum europaeum	+		*Mercurialis perennis*	+	
Asperula odorata	+		*Moehringia trinervia*	+	+
Athyrium filix femina	+	+	*Mycelis muralis*	+	
Atropa belladonna	+		*Neottia nidus avis*	+	
Bilderdykia convolvulus	+		*Picea abies*		+
Brachypodium pinnatum	+		*Pinus nigra*		+
Calamintha vulgaris	+		*Poa nemoralis*	+	
Cardamine bulbifera	+	+	*Polygonatum odoratum*	+	
Cardamine impatiens	+		*Polystichum setiferum*	+	
Campanula trachelium	+		*Prunus avium*	+	+
Carex pendula	+		*Pteridium aquilinum*	+	
Carex pilosa	+	+	*Pyrus pyraster*	+	
Carex sylvatica	+		*Quercus cerris*	+	
Carpinus betulus	+		*Quercus farnetto*	+	
Chaerophyllum hirsutum	+		*Quercus petraea*	+	+
Chaerophyllum temulum	+		*Ranunculus cassubicus*	+	
Chelidonium majus	+		*Ranunculus polyanthemos*	+	
Circaea lutetiana	+	+	*Rubus hirtus*	+	+
Cornus sanguinea		+	*Rubus canescens*		+
Crataegus monogyna		+	*Ruscus aculeatus*	+	
Clematis vitalba	+		*Ruscus hypoglossum*	+	
Dryopteris filix-mas	+	+	*Sambucus nigra*	+	+
Euphorbia amygdaloides	+		*Sambucus ebulus*		+
Fagus sylvatica	+	+	*Scrophularia nodosa*	+	
Festuca drymea	+		*Scrophularia vernalis*	+	
Fraxinus excelsior	+		*Stellaria media*	+	
Fraxinus ornus	+		*Stachys silvatica*	+	
Galeopsis speciosa		+	*Stenactis annua*	+	
Galium silvaticum	+		*Tamus communis*	+	+
Geranium robertianum	+	+	*Urtica dioica*	+	+
Glechoma hirsuta	+		*Veronica montana*	+	
Hedera helix	+	+	*Viola alba*	+	
Helleborus odorus	+		*Viola hirta*	+	
Juglans regia	+	+	*Viola odorata*	+	
Lamium galeobdolon	+	+	*Viola silvestris*	+	+
Lathyrus venetus	+				

Legend: B- Beech forests; NS-artificially established stands of Norway spruce

3.2 Spectrum of floral elements

The spectrum of floral elements (Table 2) indicated the dominance of mesophilic plants (Central European and Sub-Atlantic range of distribution types) in the investigated communities. A slightly higher percentage of these distribution types was recorded in the artificially established spruce stands (51%) than in the beech forest (48%). Also, a slightly higher share of xerothermophilic plants (Pontic, sub-Mediterranean and Balkan distribution types) can be observed in the mountain beech community (17%) compared to the artificially established spruce stands (15%), where some of the thermophilic species of the oak zone were absent. Artificially established spruce stands had a greater share of frigophilic plants (floral elements of northern regions and circumpolar). It amounted to 11%, compared to beech forests where it was as little as 4%. The share of plants with a wide ecological amplitude (Eurasian and cosmopolitan distribution types) was also higher in the beech forests (26%).

Table 2. *Spectrum of floral elements*

Range of distribution types	Beech		Norway spruce	
	Share (%)			
Pontic	4	17	7	15
Sub-Mediterranean	10		4	
Balkan	3		4	
Central European	38	48	44	51
Sub-Atlantic	10		7	
Desert	1	1	4	4
Eurasian	19	26	11	19
Cosmopolitan	7		8	
Circumpolar	7	7	7	11
Northern regions	-		4	
Adventive	1	1	-	-

3.3 Spectrum of life forms

Regarding the spectrum of life forms, both communities had dominant shares of phanerophytes and hemicryptophytes (Table 3). The beech forest had the highest share of hemicryptophytes (38%) which are also the largest group of life forms in our region (Diklić, 1984). The share of geophytes, whose presence indicates favourable soil conditions (moisture, soil structure and depth), was 25% in the beech community, while in the artificially established spruce stands, it was significantly lower (15%). Significant differences were reflected in the presence of phanerophytes, which were twice as many in the artificially established spruce stands (48%) than in the beech forest (23%). A larger share of phanerophytes resulted from the open canopy of Norway spruce stands and the greater influx of light, which made conditions favourable for a rich layer of shrubs to be formed in this community.

Table 3. *Spectrum of life forms*

Life forms	Beech		Norway spruce	
	Share (%)			
Phanerophytes	16	23	33	48
Nanophanerophytes	6		11	
Phanerophytic lianas	1		4	
Herbaceous chamaephytes		3		4
Hemicryptophytes		38		22
Geophytes		25		15
Therophytes		1		4
Therophytes / Chamaephytes		10		7

3.4 Plant ecological indices

Classification of plants into ecological groups was done based on their indicator values of the analysed ecological factors (moisture, soil acidity, soil nitrogen supply, light and heat). The mean indicator values of the studied ecological factors showed that regarding the moisture, the submontane beech community (*Helleboro odori-Fagetum moesiacae* Soo & Borhidi 1960.) was mesophilic; regarding the acidity of the soil, neutrophilic with an increased share of basophilic plants compared to acidophilic ones; regarding the soil nitrogen supply, it is mesotrophic; regarding the light sciophilous to semi-sciophilous; regarding the heat, it has a mesothermal character (Stajić *et al*., 2018).

A comparative study of the mean indicator values of some ecological factors (Table 4) shows that the mean value of the ecological factors for moisture, light and soil nitrogen supply increased in artificially established spruce stands compared to natural beech forests, while the value of the ecological factors for temperature and soil acidity decreased.

Table 4. *Mean plant indicator values*

	Moisture	Soil reaction	Nitrogen	Light	Temperature
Beech	2.99	3.25	2.99	2.56	3.37
Spruce	3.07	3.24	3.21	2.69	3.22

As a sciophilous species, spruce was accompanied by species adapted to cold and humid microsite conditions. On the other hand, the open canopy that resulted from tree dieback was favourable for the occurrence of plant species tending to be heliophytes and thus increased the mean value of the ecological factor for light. Given that the value of the ecological factor for soil acidity did not decrease significantly, we still cannot be sure if soil acidification has occurred.

The study of the floristic composition of the submontane beech forest and the artificially established spruce stands on Mt. Kosmaj point to notable differences between the observed communities. Norway spruce (*Picea abies* (L.) Karst.) is a conifer least used in the establishment of forest plantations in the area of Mt. Kosmaj. It is not unusual considering its main bioecological characteristics (alpine, mesophilic and sciophilic species). Given that Kosmaj, as a relatively low

mountain massif, did not prove to be a site favourable for the growth of this species, artificially established spruce stands were in very poor condition and individual trees had died back. Their death resulted in the partial opening of the stand canopy, which caused an abundant ground flora layer. Although the coverage of the ground flora in the artificially established spruce stand was much higher, the number of recorded species of vascular flora was significantly lower than in the natural beech forest.

Replacement of autochthonous beech forests with coniferous tree species has in most cases decreased the floristic diversity. Investigations in artificially established spruce stands on the site of submontane beech in the area of Bukovo (Cvjetićanin and Bjelanović, 2007) and Maljen (Kostić *et al*., 2012) also revealed a decrease in floristic diversity compared to autochthonous species of beech forests. Another research showed that the substitution of a natural beech forest with spruce affects soil degradation processes, i.e., the soil shows elements of podzolization to a smaller or greater extent (Knežević, 1992; Kostić *et al*., 2012). Norway spruce was found to have the most unfavorable impact on the soil, because this species, besides its unfavorable composition of forest litterfall, as shade-loving species, makes microclimatic conditions not favorable for the decomposition of organic matter (Knežević, 1992).

5. CONCLUSIONS

This paper presents the results of comparing the floristic composition of the submontane beech forest and Norway spruce stands (*Picea abies* (L.) Karst) artificially established on the beech site on Mt. Kosmaj. According to the results, artificially established spruce stands had a significantly higher cover in the shrub and ground flora layers than the autochthonous beech forests, but the floristic diversity decreased and many plant species typical of natural beech forests were missing. The spectrum of floral elements pointed to the dominance of mesophilic plants (Central European and sub-Atlantic distribution types) in the investigated communities and a higher share of frigophilic plants (floral elements of northern regions and circumpolar floral elements) in artificially established spruce stands (11%) compared to beech forests (4%). Regarding the spectrum of life forms, significant differences were noticed in the presence of phanerophytes, which were twice as many in the artificially established spruce stands (48%) than in the beech forest (23%), as a result of the spruce canopy opening and the influx of a greater amount of light. A comparative analysis of the mean indicator values for the ecological factors showed that the mean value of the ecological factors for moisture, light and soil nitrogen supply increased in the artificially established spruce stands, while the value of the ecological factor for temperature and soil acidity decreased.

The establishment of artificial spruce stands in this area affected the floristic composition of the forest, as the number of vascular flora species decreased compared to natural beech forests. The introduction of spruce into the site whose conditions were not suitable for its growth led to the poor health condition of the artificially established stands that were overwhelmed by weeds and decreased the number and coverage of species typical of beech forests.

Should they use conifer tree species, native or introduced, future reconstruction of coppice forests in this area should be done in smaller areas taking into account the bioecological characteristics of these conifer species.

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COMPARISON OF FLORISTIC COMPOSITION OF SUBMONTANE BEECH FOREST AND ARTIFICIAL ESTABLISHED STANDS OF NORWAY SPRUCE ON Mt. KOSMAJ

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Summary

The paper presents the comparative characteristics of the floristic composition in the submontane beech forest **(***Helleboro odori-Fagetum moesiacae* Soo & Borhidi 1960.) and artificially established stands of Norway spruce (*Picea abies* (L.) Karst.) on this site in the area of Mt. Kosmaj. The aim of the study was to determine to what extent the establishment of artificial spruce stands on the site of the submontane beech forest changed the floristic composition and floristic diversity of these forests.

The results showed that in the artificially established spruce stand, the cover of shrubs and ground flora increased significantly compared to the autochthonous beech forests, but the floristic diversity decreased. The spectrum of floral elements indicated the dominance of mesophilic plants (Central European and sub-Atlantic distribution types) in the investigated communities and higher participation of frigophilic plants (floral elements of northern and circumpolar regions) in artificially established spruce stands (11%) compared to beech forests (4%). According to the spectrum of life forms, significant differences were noticed in the presence of phanerophytes, which were twice as many in the artificially established spruce stand (48%) than in the beech forest (23%). This was due to the opening in the canopy of artificially established spruce stands and the influx of a greater amount of light, which made favourable conditions for an abundant shrub layer to be developed in this community. A comparative study of the mean indicator values of some ecological factors showed that the mean value of the ecological factors for moisture, light and soil nitrogen supply increased in artificially established spruce stands, while the value of the ecological factors for temperature and soil acidity decreased compared to natural beech forests.

The establishment of artificial spruce stands of in this area changed the floristic composition of these forests, as the number of vascular flora species decreased compared to the natural beech forests. The introduction of spruce into the site whose conditions were not suitable for its growth led to the poor health condition of the artificially established stands that were overwhelmed by weeds and decreased the number and coverage of species typical of beech forests.

The introduction of tree species with decorative and aesthetic effects certainly improves the functions that forests in protected areas should have. However, this type of forest resources management entails certain environmental risks. Therefore, if in the future reconstruction of coppice forests, conifer tree species (native or introduced) are used, they should be used in smaller areas taking into account the bioecological characteristics of the selected conifer species.