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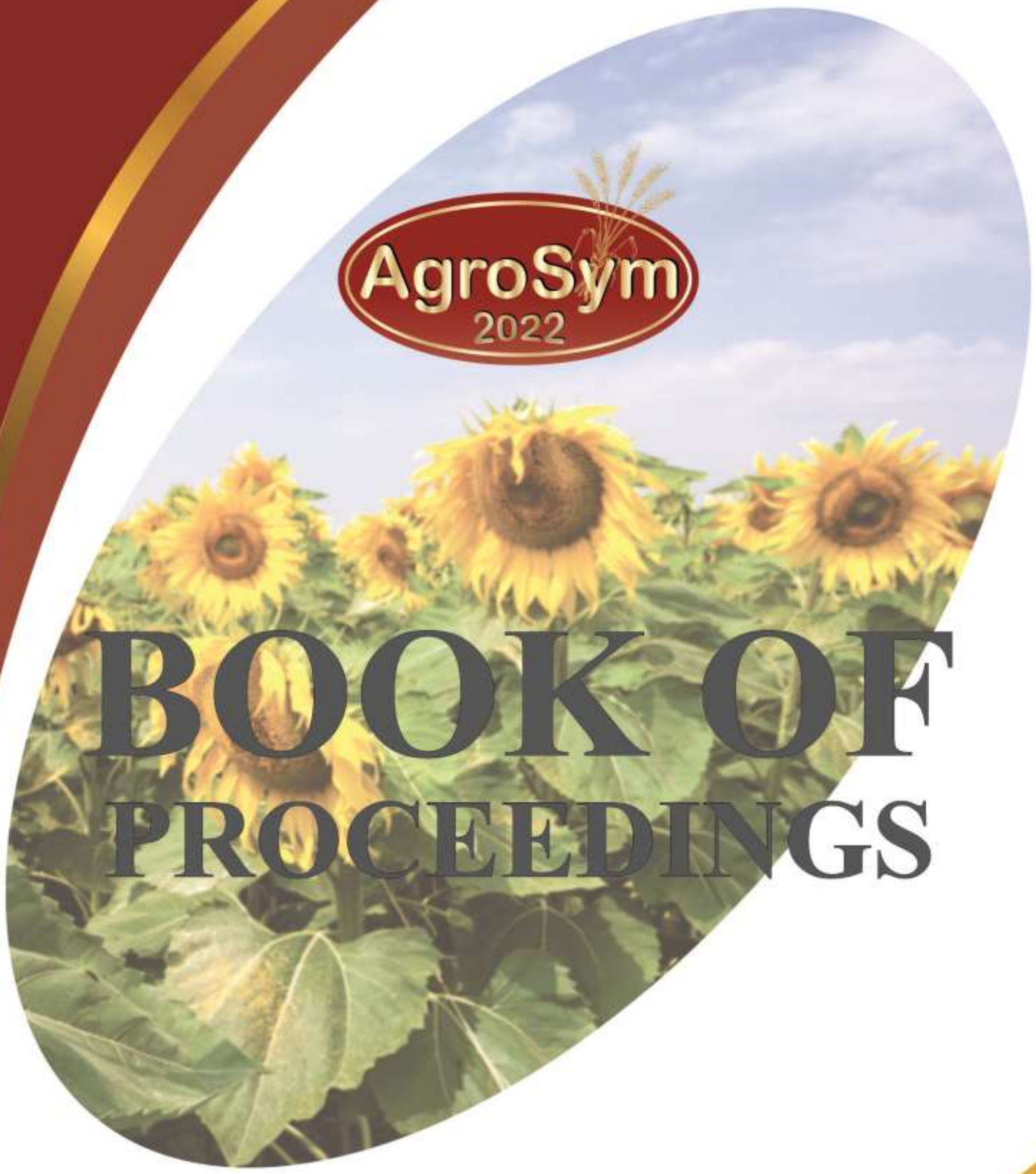

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CHANGES IN THE FLORISTIC COMPOSITION OF BEECH FORESTS (FAGUS SYLVATICA L.) AT TWO SITES IN SOUTHEASTERN SERBIA OVER A PERIOD OF 14 YEARS

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Abstract

European beech forests are generally poor in species. However, the composition and richness of vascular plants in these forests vary with region and site. Numerous factors can cause changes in the floristic composition and diversity of these forests over time, one of which is the type of management practice. The paper presents the results of research on the floristic composition and diversity of beech forests at two sites in southeastern Serbia (MU "Lomnička Reka" and MU "Bukovik II") over a period of 14 years. The number and cover of all plant species were recorded in the selected sample areas of each locality in 2008 and 2021. The studied beech stands grew in similar environmental conditions – on dystric cambisol and at the altitude ranging from 685 to 735 m. A total of 35 plants were registered at both sites in the period from 2008 to 2021. It was found that the average number of species per plot increased slightly in the research period at both sites. The number and cover of the species that indicate faster decomposition of organic matter and the formation of milder forms of humus such as *Festuca drymeia* Mert. &Koch, *Asperula odorata* L. and *Mercurialis perennis* L. did not change significantly over time. The most significant changes were related to the species that hinder natural regeneration, such as *Rubus hirtus*, whose increased presence was registered after those stands had been thinned, which resulted in the canopy opening.

Keywords: Beech forests, diversity, vegetation changes, forest management.

Introduction

Recent decades of vegetation studies related to forest ecosystems have revealed significant changes in plant diversity, extinction of rare and endangered species, increase in nitrophilic and acidophilic species, as well as drought-resistant species (Jantsch et al., 2013). Climatic changes (Walther et al., 2002; Baeten et al., 2010), air pollution (van Dobben and de Vries, 2010) and forest management methods have been cited as the major factors causing the changes in the vegetation of forest ecosystems. Forest management is one of the primary drivers of diversity and may enhance or reduce biodiversity depending on the applied measures (Kutnar et al., 2015; Horvat et al., 2017; Lelli et al., 2019). The diversity of ground vegetation is an important indicator of habitat quality and at the same time a measure of the impact of management on the environment. This is the reason why the composition, condition, or change of vegetation cover over time are key factors in various environmental studies and nature protection programs.
Beech forests are the most widespread in Serbia and cover 660,400 ha, 29.4% of the total forest area (Banković et al., 2009). Beech forests live in various environmental conditions, from the

submontane zone to the montane-subalpine zone. Apart from the broad climate amplitude, the beech is characterised by a wide edaphic amplitude. It grows on acidic silicate, basic, ultrabasic and carbonate substrates. The composition and richness of vascular plants in beech forests are highly variable among European regions and habitats, but European beech forests are generally poor in species. The aim of this research was to determine the change in the floristic composition and diversity of beech forests at two localities in southeastern Serbia over a period of 14 years, i.e. before and a couple of years after the implementation of silvicultural measures.

Material and Methods

The research was conducted in beech stands at two localities in southeastern Serbia – Veliki Jastrebac (MU "Lomnička Reka") and Bukovik (MU "Bukovik II"). The studied forest complexes are state-owned and managed by the "Srbijašume" state enterprise. The most important data are shown in Table 1. The localities are characterised by similar soil and climate conditions. The studied beech stands grow on district cambisol at an altitude of 685-735 m.

Table 1. Basic data on research plots in beech stands

	Altitude	*Aspect*	*Soil type*	*Age*
MU "Lomnička Reka"	735	W	Dystric cambisol	80-100
MU "Bukovik II"	685	E	Dystric cambisol	60-80

Floristic sampling was done on a floristically homogeneous surface area with a plot size of 900 m^2 (30 x 30 m). A complete floristic list of all vascular plants (tree, shrub, and herb layers, separately) was recorded for each plot using the Braun-Blanquet scale (Braun-Blanquet, 1964). The transformation of abundance and cover estimation of each species within phytosociological relevés was performed according to the Van Der Maarel method (1979). Species diversity was measured using the *Shannon Wiener* diversity index (H') (Shannon and Weaver, 1963); the Pielou Index was used for the estimation of species evenness (1975). JUICE 7.0 software was used to calculate all indices (Tichý, 2002). The spectrum of floral elements was determined according to the systematisation of geo-floristic elements by Gajić (1980); the spectrum of life forms and the indicator values of plants and ecological optimums were determined using the method of Kojić *et al.* (1997).

Results and Discussion

A total of 35 plant species were registered in the period from 2008 to 2021 at both studied localities (Table 2). Apart from the species typical of beech forests, the presence of the invasive species *Erigeron annuus* (L.) Pers. was also registered at the selected locality in the MU "Bukovik II" during the observation in 2021.

The average number of species in both studied stands ranged from 19 to 22 species per plot (Table 3), which was consistent with previous studies on the diversity of beech forests up to about 800 m (Ujházyová et al., 2016; Stajić et al., 2021). The number of species increased slightly from 2008 to 2021. To a certain degree, it was caused by the canopy opening that resulted from the silvicultural measures implemented in the stands. Light availability may affect the species richness in the herb layer (Axmanová et al., 2012; Dormann et al., 2020). The canopy

opening in these stands was partly induced by the action of an unfavorable abiotic factor (i.e. ice breakage) that hit most of eastern Serbia in 2014.

Table 2. Floristic composition of studied beech stands

Species	*2008*	*2021*	*2008*	*2021*
	MU "Bukovik II"		MU "Lomnička Reka"	
Abies alba Mill.			+	+
Acer platanoides L.	+	+	+	+
*Acer pseudoplatanus*L.	+	+	+	+
Arum maculatum L.			+	+
Asarum europaeum L.			+	+
Asperula odorata L.	+	+	+	+
Circaea lutetiana L.		+		+
Dipsacus pilosus L.		+		
Dryopteris filix-mas (L.) Schott	+	+		+
Epilobium angustifolium L.	+			
Euphorbia amygdaloides L.	+			
Fagus sylvatica L.	+	+	+	+
Festuca drymeia Mert. &Koch	+	+		
Fragaria vesca L.	+	+		
Fraxinus ornus L.			+	+
Geranium robertianum L.	+	+		+
Glechoma Waldst. & Kit.		+		
Hedera helix L.			+	
Lamium galeobdolon (L.) Crantz	+	+	+	+
Lathyrus venetus (Miller) Wohlf.		+		
Mercurialis perennis L.			+	+
Mycelis muralis (L.) Dum.	+	+		+
Polygonatum odoratum (Mill.) Druce			+	
Polygonatum verticillatum (L.) All.	+			
Polystichum aculeatum (L.) Roth	+	+	+	+
Populus tremula L.				
Prunus avium L.	+	+		
Pulmonaria officinalis L.	+		+	
Rubus hirtus Waldst. & Kit.	+	+	+	+
Ruscus hypoglossum L.	+	+		+
Stellaria media (L.) Vill.	+			
Sambucus nigra L.			+	+
Erigeron annuus (L.) Pers.		+		
Viola alba Bess.			+	+
Viola sylvestris Lam.	+	+		

The number and cover of the species that indicate faster decomposition of organic matter and the formation of milder forms of humus such as *Festuca drymeia* Mert. &Koch, *Asperula odorata* L. and *Mercurialis perennis* L. did not change significantly over time. The most significant changes were related to the species that hinder natural regeneration, such as *Rubus hirtus* Waldst. & Kit., whose increased presence was registered after the stands had been thinned, resulting in the canopy opening. Due to the dense canopy closure in the beech stand of the MU "Bukovik II", the presence of species that hinder natural regeneration, such as *Rubus hirtus* Waldst. & Kit. was not significant. On the other hand, the entire area of the beech stand in the MU "Lomnička Reka" was covered with this species, as a consequence of the intensive stand canopy opening.

The value of the Shannon Wiener diversity index ranged from 2.17 to 2.46; its value also increased in the period from 2008 to 2021, following the increase in the number of species.

Table 3. Species richness, Shannon Wiener diversity index (H') and species evenness

Forest community type	*Year*	*Species richness*	*Shannon Wiener diversity index (H')*	*Evenness*
MU "Bukovik"	2008	19	2.23	0.73
	2021	22	2.46	0.75
MU "Lomnička Reka"	2008	19	2.17	0.69
	2021	20	2.38	0.75

The spectrum of floral elements (Tables 4 and 5) shows that the Central European range type dominates in the studied beech forest communities. The share of plants of xerothermophilic character (Sub-Mediterranean and Balkan range types) increased compared to 2008 from 15.8% to 20% in the MU "Lomnička Reka" and 23.8% in the MU "Bukovik II". At the same time, the share of mesophilic plants (Central European and Sub-Atlantic range types) decreased from 57.9% to 50% in the MU "Lomnička Reka" (Tables 4) and from 47.4% to 42.9% in the MU "Bukovik II" (Tables 5). Such spectrum indicates the change in the site regime of temperature and water partly caused by the canopy opening in both stands. A slightly higher share of circumpolar plant type was also registered compared to 2008.

Table 4. Spectrum of floral elements – MU "Lomnička Reka"

Cumulative range types	2008		2021	
	Share (%)			
Sub-Mediterranean	10.5	15.8	15.0	20.0
Balkan	5.3		5.0	
Central European	52.6	57.9	45.0	50.0
Sub-Atlantic	5.3		5.0	
Eurasian	15.7	21.0	10.0	20.0
Cosmopolitan	5.3		10.0	
Circumpolar	5.3	5.3	10.0	10.0

Table 5. Spectrum of floral elements – MU "Bukovik II"

Cumulative range types	2008		2021	
	Share (%)			
Pontic	-	15.8	9.5	23.8
Sub-Mediterranean	10.5		9.5	
Balkan	5.3		4.8	
Central European	47.4	47.4	38.1	42.9
Sub-Atlantic	-		4.8	
Eurasian	15.8	17.3	14.3	19.1

Cosmopolitan	10.5		4.8	
Circumpolar	10.5	10.5	9.5	9.5
Adventive	-		4.8	4.8

The mean indicator values of environmental factors (Table 6) show that the studied beech stands grow in almost the same environmental conditions. The mean indicator values changed slightly over time in both stands. There is an evident change in the mean value of the environmental index obtained for temperature, whose value increased in both stands from 3.16 to 3.43 (MU "Bukovik II") and 3.21 to 3.35 (GJ "Lomnička Reka"). This result is in line with the analysis of the spectrum of floral elements, which revealed an increased share of plants of xerothermophilic character in the recent period.

Table 6. Average values of environmental indices

Year	Moisture	Soil reaction	Nitrogen	Light	Temperature
MU "Bukovik II"					
2008	3.11	3.16	3.11	2.63	3.16
2021	3.10	3.24	3.00	2.62	3.43
MU "Lomnička Reka"					
2008	3.05	3.32	2.95	2.16	3.21
2021	3.15	3.30	3.05	2.15	3.35

Conclusions

Research of the floristic composition and diversity of beech forests, which was conducted over a period of 14 years, showed that the average number of species increased slightly from 2008 to 2021 in both studied stands. This increase resulted from the canopy opening that was partly caused by silvicultural measures implemented in the stands and partly by the unfavorable influence of an abiotic factor (ice breakage) that hit the area of eastern Serbia in 2014. The analysis of the spectrum of floral elements revealed an increased share of plants of xerothermophilic character compared to 2008, i.e. a decrease in the share of mesophilic plants (Central European and Sub-Atlantic range types). Such spectrum indicates the change in the site regime of temperature and water partly caused by the canopy opening in both stands. This was further confirmed by an increase in the mean values of the environmental factor for temperature.

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