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PLANTS AS INDICATORS OF SITE CONDITIONS IN MIXED FORESTS OF SESSILE OAK AND HORNBEAM IN THE AREA OF KOSMAJ MOUNTAIN IN SERBIA

Snežana STAJIĆ*[1], Vlado ČOKEŠA[1], Zoran MILETIĆ[1], Violeta BABIĆ[2], Saša EREMIJA[1], Zoran PODUŠKA[1], Miroslava MARKOVIĆ[1]

[1]Institute of Forestry, Belgrade, Republic of Serbia
[2]Faculty of Forestry, University of Belgrade, Republic of Serbia
*Corresponding author: snezanastajic@yahoo.com

ABSTRACT

The paper presents ecological properties of plant species, occurring in the forest of the sessile oak and hornbeam community (*Querco petraeae-Carpinetum betuli* Rudski 1949. s.l.) in the area of Kosmaj in Serbia. The sessile oak and hornbeam forests in Serbia are conditioned by orographic and edaphic factors, i.e., they occur as extrazonal vegetation and cover significantly smaller areas than in the Illyrian province. In the area of Kosmaj, these forests occur at lower altitudes (300 - 400 m), with eastern to northeastern aspects, and the slope of 15-23°. Differentiation of flora was done according to membership in certain ecological plant groups, according to most significant ecological factors: soil humidity, soil acidity, quantity of nitrogen in the soil, light and temperature. According to the indicator values of plant species, the community of sessile oak and hornbeam is mesophilic in terms of humidity (F – 2.88), neutrophilic-basophilic (R – 3,32) in terms of acidity, mesotrophic in terms of soil nitrogen supply (N – 2,82), semisciophilic regarding light (L – 2,85), and mesothermal in terms of heat (T – 3,39). Indicator values of plants are suitable to indirectly assess environmental conditions and can help to estimate the conditions, for which no measurements are available. Therefore, they can be used as useful indicators in monitoring environmental changes.

Keywords: *Indicator values of plants, sessile oak and hornbeam forests, Serbia.*

INTRODUCTION

Environmental factors have an important impact on the structures and dynamics of plant communities. Species composition and changes in abundance and coverage of individual species are useful indicators in studying and monitoring environmental changes. At the same time, indirect assessment of site conditions, through indicator values of plants has become common usage in nature conservation management. Ellenberg indicator values (Ellenberg et al., 1991) are the most commonly used to estimate site conditions from species composition, when measured values of environmental variables are not available (Hill et al., 1997; Axmanova et al., 2012). Knowledge of ecology, i.e., relationships of plant species to environmental conditions and biological species characteristics is of great importance in silviculture. It provides firm grounds on which stand silvicultural approaches and treatments can be determined and appropriate methods of natural regeneration and forest tending selected. Proper selection of tree species during afforestation ensures the improvement of biological diversity, while preserving endangered and rare plant species. Therefore, the aim of this study was to determine site conditions in the investigated forest community of sessile oak-hornbeam (*Querco petraeae-Carpinetum betuli* Rudski 1949 s.l.) in the area of Kosmaj in Serbia, from species composition.

MATERIAL AND METHODS

The research was conducted in the protected area of Kosmaj Mountain (Serbia). The research of site conditions and floristic composition was performed by means of series of trials, conducted in mixed sessile oak-hornebam forest. Field surveys were conducted in 2016 and 2017. Floristic sampling was done on a floristically homogeneous surface area with a plot size of 900 m^2 (30 x 30 m). In each plot, a complete floristic list of all vascular plants (tree, shrub, and herb layers separately) was recorded using the Braun-Blanquet scale (Braun-Blanquet, 1964). Plant species were determined based on the following literature sources: Flora of Serbia I-X (Josifović et al., 1972-1977; Sarić et al., 1986; 1992; Stevanović et al., 2012;).The indicator values of plants and ecological optimums were determined using the Method of Kojić *et al.* (1997).

RESULTS AND DISCUSSION

The sessile oak and common hornbeam forests in Serbia are conditioned by orographic and edaphic factors, i.e., they occur as extrazonal vegetation and cover significantly smaller areas than in the Illyrian province (Tomić and Rakonjac, 2013). Sessile oak-hornbeam community represents a climate-regional type of forest growing on silicate rocks of small mountain massifs of northern Serbia, on the edge of the Pannonian Basin, at altitudes ranging from 300 to 600 m (Dinić 1978; 1997; Cvjetićanin et al., 2013). The community of sessile oak and hornbeam (*Querco petraeae-Carpinetum betuli* Rudski 1949 s.l.) in the area of Kosmaj is found only in fragments, relevés were taken at altitudes ranging from 339 to 410 m, eastern to northeastern aspects, and the slope of 15-23° (Stajic et al., 2021).

The floristic structure of this forest phytocoenoses is characterized by biodiversity consisting of 30 families, 53 genera, and 66 plant species, of which two species are protected species – *Lilium martagon* and *Crataegus nigra* (Table 1). Most of the plant species belong to the following families: *Rosaceae* (17%), *Fagaceae* (6%), *Lamiaceae* (6%), *Poaceae* (6%) *Asparagaceae* (5%), *Asteraceae* (5%), *Cyperaceae* (5%) and *Rubiaceae* (5%). The Rosaceae family is also the most numerous with seven genera: *Crategus*, *Rubus*, *Prunus*, *Pyrus*, *Rosa*, *Fragaria* and *Geum.*

The mesophilic character of this community can easily be recognized by the characteristic set of species, most often found in the sessile oak-hornbeam forests of Serbia, which is determined by a combination of site factors. This is also indicated by the abundant presence of plants of the subatlantic-submediterranean floral element, such as *Ruscus aculeatus* L., *Euphorbia amygdaloides* L., *Hedera helix* L. and *Tamus communis* L. A distinctive feature of this sessile oak-hornbeam forest is the presence *Ruscus aculeatus*, a submediterranean species that is found in Serbia only in the warmest Pontic-Pannonian part (Stajic et al., 2020).

Table1. Floristic composition of *Querco petraeae-Carpinetum betuli* phytocenosis

Family/species	Ecological indices				
	F	R	N	L	T
ACERACEAE					
Acer campestre L.	3	4	3	3	4
APIACEAE					
Chaerophyllum temulum L.	3	3	4	3	3
ARALIACEAE					
Hedera helix L.	3	3	3	2	4
ASPARAGACEAE					
Asparagus tenuifolius Lam.	1	3	2	3	5
Polygonatum odoratum (Mill.) Druce	2	3	2	3	3
Ruscus aculeatus L.	3	3	3	2	5
ASTERACEAE					
Doronicum columnae Ten.	4	4	4	3	2
Lapsana communis L.	3	3	4	2	3
Mycelis muralis (L.) Dumort.	3	3	3	2	3
BRASSICACEAE					
Cardamine bulbifera (L.) Crantz	3	4	3	2	3
CAMPANULACEAE					
Campanula patula L.	3	3	2	4	3
Campanula persicifolia L.	2	4	2	3	4
CAPRIFOLIACEAE					
Lonicera caprifolium L.	3	4	2	3	4
Sambucus nigra L.	3	3	4	3	4
CARYOPHYLLACEAE					
Moehringia trinervia (L.) Clairv.	3	2	4	2	2
Silene viridiflora L.	3	3	2	4	4
CORNACEAE					
Cornus mas L.	3	4	3	3	4
Cornus sanguinea L.	3	4	3	3	3
CORYLACEAE					
Carpinus betulus	3	3	3	2	
CYPERACEAE					
Carex divulsa Stokes	3	3	2	3	4
Carex pilosa Scop.	3	2	3	2	3

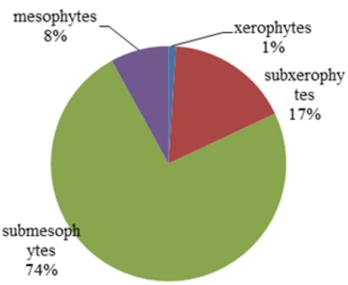
Carex sylvatica Huds.	3	3	3	1	3
Dioscoreaceae					
Tamus communis L.	3	4	3	3	4
EUPHORBIACEAE					
Euphorbia amygdaloides L.	3	4	3	2	3
FABACEAE					
Lathyrus venetus (Miller) Wohlf.	2	3	2	2	4
Lathyrus vernus (L.) Bernh.	3	4	3	2	3
FAGACEAE					
Fagus sylvatica L.	4	3	3	2	3
Quercus cerris L.	2	3	2	4	4
*Quercus farnetto*Ten.	2	4	2	4	4
Quercus petraea (Matt.) Liebl.	3	3	2	3	3
GERANIACEAE					
Geranium robertianum L.	3	3	4	2	3
HYPERICACEAE					
Hypericum hirsutum L.	3	4	3	3	3
LAMIACEAE					
Ajuga reptans L.	3	3	3	3	3
Clinopodium vulgare L.	3	4	2	4	3
Glechoma hirsuta Waldst. & Kit.	3	3	3	3	5
Lamium maculatum L.	3	3	3	3	3
LILIACEAE					
Lilium martagon L.	3	4	3	3	3
OENOTHERACEAE					
Circaea lutetiana L.	4	3	4	2	4
OLEACEAE					
Fraxinus ornus L.	2	4	2	3	4
Ligustrum vulgare L.	3	4	2	3	4
SCROPHULACEAE					
Veronica officialis L.	3	2	2	3	2
Scrophularia nodosa L.	3	3	3	2	3
POACEAE					
Brachypodium silvaticum (Hudson) Beauv.	2	4	3	3	3
Dactylis glomerata L.	3	3	4	3	3
Festuca ovina L.	2	2	2	4	3
Poa nemoralis L.	3	3	2	2	3
POLYGONACEAE					
Fallopia convolvulus (L.) A. Löve	3	3	3	3	3
Rumex sanguineus L.	4	3	4	3	3
RANUNCULACEAE					
Clematis vitalba L.	3	4	3	3	3
Helleborus odorus Waldst. & Kit.	3	1	2	3	4
ROSACEAE					
Crataegus monogyna Jacq.	3	4	2	4	3
Crataegus nigra Waldst.& Kit.	3	3	3	3	3

Fragaria vesca L.	3	3	3	3	3
Geum urbanum L.	3	3	4	2	3
Prunus avium L.	3	4	3	3	4
Prunus spinosa L.	2	4	3	4	4
Pyrus pyraster Burgsd.	3	4	3	3	4
Rosa arvensis Huds.	3	4	3	3	4
Rosa canina L.	3	3	2	3	3
Rubus canescens DC.	2	3	3	4	4
Rubus hirtus Waldst. & Kit.	4	3	2	3	3
RUBIACEAE					
Galium odoratum (L.) Scop.	3	4	3	2	3
Galium aparine L.	3	3	5	3	4
Galium schultesii Vest	3	4	2	3	3
ULMACEAE					
Ulmus minor Mill.	3	4	3	4	3
VIOLACEAE					
Viola hirta L.	2	4	1	3	3

Legend: F- soil humidity;R-soil reaction;N-nitrogen;L-light availability;T-temperature.

Regeneration of oaks is a crucial issue in forest management, and it is often observed that in unmanaged oak forests, shade-tolerant species regenerate instead of oaks (Saniga et al., 2014). In order to determine the ecological conditions in investigated forest community, we assigned to each species the respective indicator values following Kojić et al. (1997): soil humidity, soil reaction, nitrogen, light availability and temperature. Also, we used plant ecological indicator values averaged at the community level.

According to soil humidity (Figure 1) the plant community of sessile oak and hornbeam is mostly mesophilous, because the share of mesophilous and submesophilous species is 82%, while the share of mostly xerophylous species is 18% . This is conditioned by a set of habitat factors: shaded positions, relatively high humidity of the air and soil, as well as deep ilimerized soils where this plant community occurs.



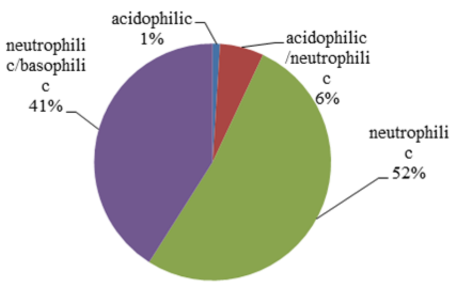
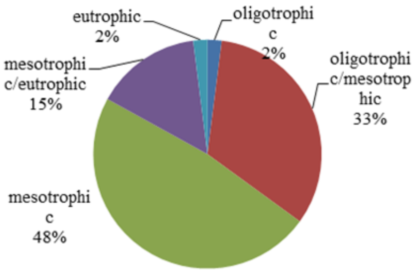


Figure 1 and 2. Share of plants according to ecological indicator values for F and R

Soil pH affects the general nutrient status and the available amounts of other elements in the soil. According to soil reaction (Figure 2), these forests have neutrophilic to neutrophilic-basophilic character, as neutrophilic plants are present with 52%, and neutrophyle-basiphyle with 41%.

Within terrestrial ecosystems, one of the most important macro-nutrients to plant growth is nitrogen. According to soil nitrogen supply (Figure 3) these forests have mezotrophic character (N – 2,82), with presence of this plant groups of 48%, with increased participation of plants tending towards oligotrophic (35%). In terms of light requirements (Figure 4), semi-sciophytes (56%) and plants transitional to heliophytes (27%) are dominant, whereas plants transitional to semisciophytes (15%) and sciophytes are represented with 2%. The mean ecological indicator values for light (L) is 2.85.



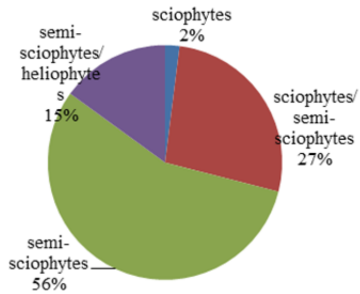


Figure 3 and 4. Share of plants according to ecological indicator values for N and L

Temperature, as one of the most important environmental factors, is closely related to light, because with increased light intensity, the temperature usually increases, and therefore transpiration. In relation to temperature, mesothermic plants (56%) and ones in transition to thermophilic species (35%) are dominant, while species transitional between frigoriphilic and mesothermic plants (4%) and thermophilic species (5%) are less well represented (Figure 5). The mean ecological indicator values for temperature (T) is 3.39.

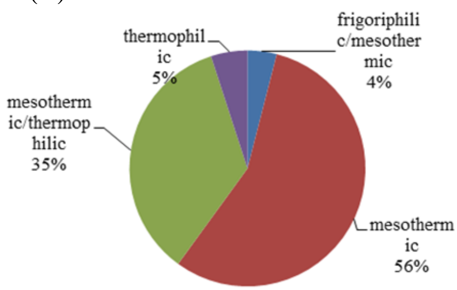


Figure 5. Share of plants according to ecological indicator values for T

CONCLUSIONS

The floristic structure of *Querco petraeae-Carpinetum betuli* community is characterized by biodiversity consisting of 30 families, 53 genera, and 66 plant species. Most of the plant species belong to the following families: *Rosaceae* (17%), *Fagaceae* (6%), *Lamiaceae* (6%), *Poaceae* (6%) *Asparagaceae* (5%), *Asteraceae* (5%), *Cyperaceae* (5%) and *Rubiaceae* (5%). According to the indicator values of plants, the community of sessile oak and hornbeam is mesophilic in terms of humidity (F– 2.88), neutrophilic-basophilic (R–3,32) in terms of acidity, mesotrophic in terms of soil nitrogen supply (N – 2,82), semisciophilic regarding light (L – 2,85), and mesothermal in terms of heat (T – 3,39). It can be concluded that mixed communities of sessile oak and hornbeam in the area of Kosmaj occur in wet site conditions, with little light and in moderately warm conditions. The soils are neutral to slightly alkaline, moderately supplied with minerals.

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