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Ecological characteristics of six important submediterranean tree species in Serbia

Abstract

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Through a study of the submediterranean woodland communities of Mt Maljen in C. Serbia, the distribution of six dominant tree species *(Carpinus orientalis, Pinus nigra, Quercus frainetto, Q. cerris, Fraxinus ornus,* and *Ostrya carpinifolia)* along gradients for four ecological parameters (light, moisture, soil acidity, and nitrogen concentration) was assessed by means of the method of weighted averaging, and the respective optima and tolerance ranges were obtained for each species. Integer values for the estimated optima were compared with Ellenberg's indicator values for the corresponding species, and such differences as were found are discussed. The results are apt to illustrate the ecological requirements of the various species and therefore show promise as an instrument to better plan their reintroduction in disturbed and deforested areas

Introduction

Ellenberg (1965, 1979, 1986) described the ecological characteristics of some submediterranean plant species by assigning them indicator values that correspond to their optimum requirements for light, temperature, continentality, moisture, soil reaction, and nitrogen availability. Ideally, descriptions of the ecological characteristics of a species should include information on both its optimum and tolerance range for various environmental factors. Due to interactions between species, response curves may differ in shape (Austin 1976; 1985, 1987; Minchin 1987). In many cases, however, the distribution of a species along an environmental gradient can be properly described by a Gaussian function (Whittaker 1970; Gauch & Whittaker 1972; Gauch 1982; Braak & Gremmen 1987). The Gaussian (normal) function has three parameters: the mode, the maximum value, and the dispersion measured in units of standard deviation. Dispersion and mode of a response curve correspond, respectively, to the ecological tolerance and ecological optimum of the species in question.

This paper aims (1) to relate the distribution of the six most important submediterranean tree species in Serbia to gradients of light, moisture, soil acidity and nitrogen richness of the soil, (2) to calculate ecological optima for these species and to compare them with those of Ellenberg's indicator values, and (3) to estimate the ecological tolerance of these species with respect to the same environmental gradients.

Material and methods

The area studied were the xerophilous forests (associations *Quercetum confertae cerris* Rud. 1949; *Quercetum montanum* Čer & Jovanović 1949; *Fraxino orni-Ostryetum carpinifoliae* Gajić & al. 1956, and *Pinetum nigrae sylvestris* Z. Pavletić 1951) growing on Mt Maljen.

Mt Maljen is situated in the western part of central Serbia. In a biogeographical sense, it belongs to an intermediate zone connecting the Illyric and Moesic phytogeographical provinces (Horvat & al. 1974; Stevanović 1992). The northern slopes of the mountain are exposed to the influence of the Pannonian climate. Due to its transitional position and to the heterogeneity of the landscape, soil, and bedrock the entire Mt Maljen area may be considered as a large ecotone with numerous community types.

Environmental conditions within each of investigated communities were quantified using the "calibration" procedure (Braak 1987), based on the method of weighted averaging. This method has been used frequently for direct gradient analysis (Cottam & al. 1973). In weighted averaging, ecological groups (species grouped on the basis of distributional similarity) are used to arrange community samples along environmental gradients. The samples thus arranged constitute a basis for the study of species distributions. Due to this kind of circular reasoning, the weighted averaging method has been criticized in the literature (Austin 1985). Nevertheless, as Whittaker (1973) pointed out, the circularity does not invalidate the method when it is based on correctly observed ecological groups and gradient relations.

In this paper we used ecological groups as defined by Ellenberg (1979). Average environmental values within each of the analysed communities, or characteristic indicator values (CIV) sensu Persson (1981), were estimated as:

$$CIV_{(i,j)} = \sum_{h=1}^{n} X_{(h,i)}\, E_{(h,j)} \,/ \sum_{h=1}^{n} X_{(h,i)}; \quad X_{(h,i)} \neq 0$$

where $CIV_{(i,j)}$ is the characteristic indicator value the of j-th environmental factor within the i-th community, $X_{(h,i)}$ represents abundance of species h in community i, and $E_{(h,j)}$ denotes Ellenberg's index of species h for the j-th environmental factor. Species abundances were determined according to the modified scale of Braun-Blanquet (Westhoff & Maarel 1973).

Species optima and tolerances were detected by Gaussian regression (Braak & Looman 1986).

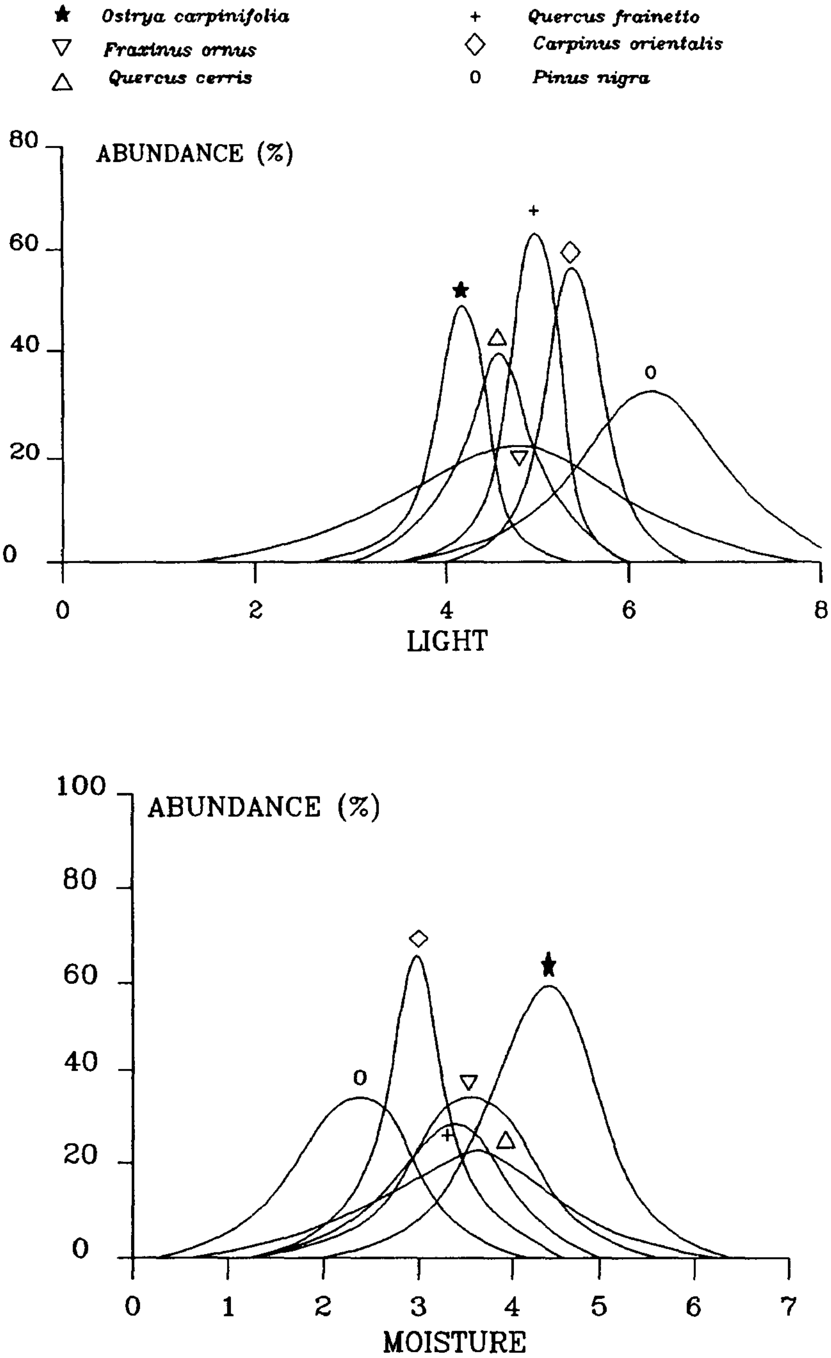

Fig. 1. Curves showing the response of the species analysed to light and moisture gradients.

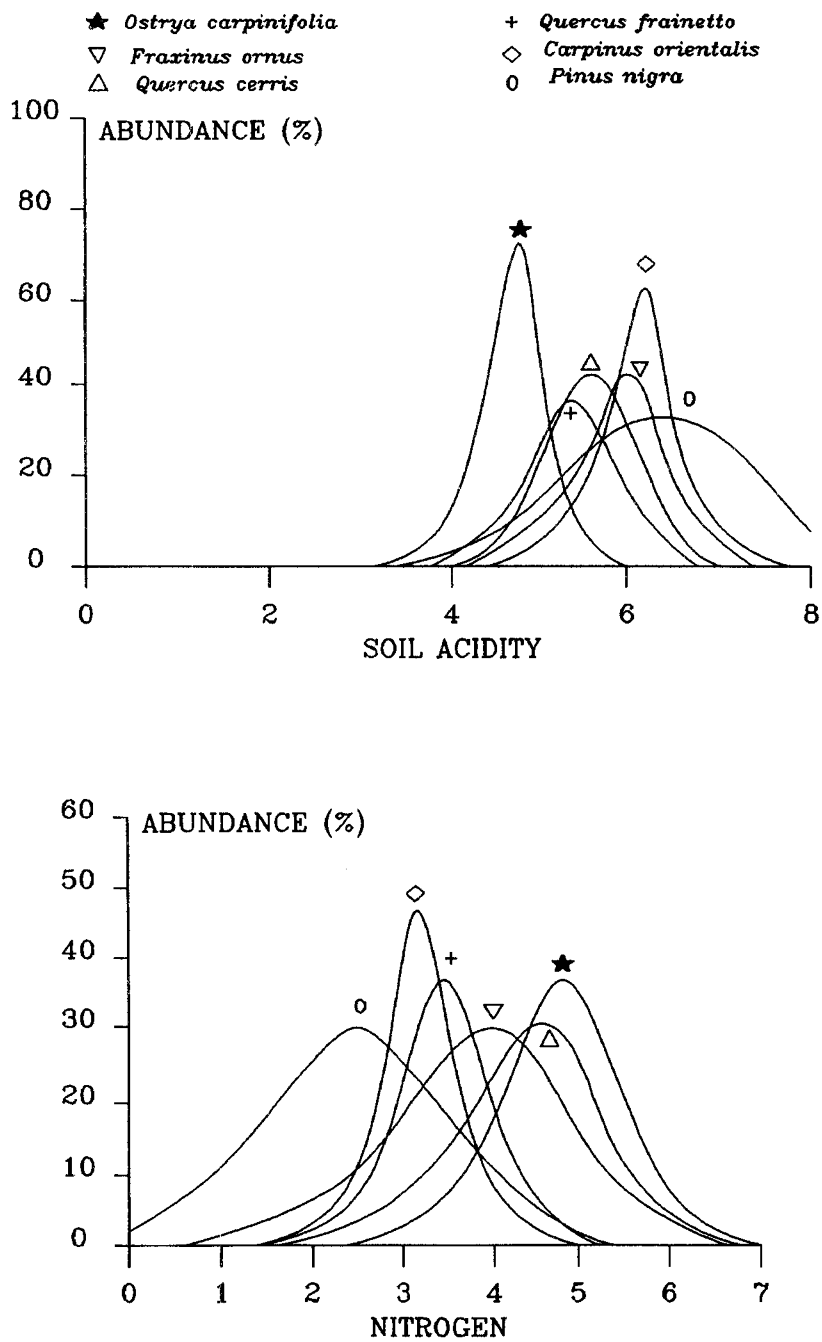

Fig. 2. Curves showing the response of the species analysed to soil acidity and nitrogen supply in the soil.

Results

In this study we analysed ecological features of *Carpinus orientalis* Mill., *Pinus nigra* Arnold, *Quercus frainetto* Ten., *Q. cerris* L., *Fraxinus ornus* L. and *Ostrya carpinifolia* Scop. These species dominate in xerothermic forests that are widespread in lowland and mountain areas of the Balkan Peninsula.

Response curves of analysed trees with respect to light and moisture gradients are given in Fig. 1. *Pinus nigra* and *Carpinus orientalis* are "half-light" species in the sense of Ellenberg (1979). Oaks *(Quercus frainetto* and *Q. cerris)* as well as *Fraxinus ornus* are adapted to more shaded conditions. *Ostrya carpinifolia* is the most shade-tolerant species among those considered; its estimated optimum for light indicates that it is adapted to "half-shadow" conditions.

Fraxinus ornus and *Pinus nigra* have the widest ecological amplitudes for light. The narrowest amplitudes with respect to light conditions are those of *Quercus frainetto* and *Carpinus orientalis.*

Pinus nigra and *Carpinus orientalis,* which are adapted to high light intensity, have their optimum near the xeric end of the moisture gradient. The position of the response curve of *Quercus frainetto* indicates that it, too, is suited to withstand extremely dry conditions. *Ostrya carpinifolia* is the most mesic among the analysed trees. *Fraxinus ornus* and *Quercus cerris* have an intermediate position with respect to the moisture gradient. *Quercus cerris* has the widest ecological amplitude with respect to soil moisture, whereas *Carpinus orientalis* and *Ostrya carpinifolia* have much narrower tolerance limits.

Response curves of the analysed trees with respect to soil acidity and nitrogen supply in the soil are given in Fig. 2.

Pinus nigra is adapted to basic soils. The ecological optima of *Carpinus orientalis* and *Fraxinus ornus* indicate that these species occur mostly on neutral soils. *Quercus cerris* and *Q. frainetto* are adapted to weakly acid soils. *Ostrya carpinifolia* is, relatively, the most acidophilous species.

Our analyses have shown that *Pinus nigra* is the most tolerant species with respect to soil acidity. *Carpinus orientalis* and *Ostrya carpinifolia* have the narrowest ecological amplitudes.

The greatest diversity among the analysed species was observed with respect to nitrogen supply in soils. *Pinus nigra* is adapted to soils that are extremely poor in nitrogen. Oligotrophism is less pronounced in *Carpinus orientalis* whose optimum value indicates, however, that it is also adapted to poor soils. *Ostrya carpinifolia* occurs on much richer soils, whereas *Quercus cerris, Fraxinus ornus,* and *Q. frainetto* hold an intermediate position. *Carpinus orientalis, Ostrya carpinifolia,* and *Quercus frainetto* have much narrower ecological amplitudes than *Q. cerris, Fraxinus ornus,* and *Pinus nigra.*

Discussion and conclusions

One of the aims of our paper was to detect whether or not the estimated ecological optima of the analysed species were in agreement with Ellenberg's indicator values. Our

Table 1. The indicator values expected (E) and obtained (O) for the analysed species.

Species	Light		Moisture		Soil acidity		Nitrogen	
	E	O	E	O	E	O	E	O
Carpinus orientalis	–	6	–	3	–	6	–	3
Pinus nigra	(7)	6	2	2	9	7	2	2
Quercus frainetto	–	5	–	3	–	6	–	4
Quercus cerris	(6)	5	4	4	X	6	X	5
Fraxinus ornus	(5)	5	3	4	8	6	3	4
Ostrya carpinifolia	(4)	4	4	4	X	5	5	5

estimated ecological optima, when transformed into integer values, are comparable with Ellenberg's indicator values which are also integers. Expected (Ellenberg's) and obtained (estimated) indicator values for all species except *Ostrya carpinifolia* differ significantly (Table 1).

The greatest difference concerns soil acidity. The soil acidity indicator value for *Pinus nigra* was significantly underestimated, which may be explained by the floristic composition of the forests studied, belonging to the association *Pinetum nigrae-sylvestris*. All these forests stock on ultrabasic serpentine bedrock. According to Ellenberg's indicator values, many species that occur in these communities belong to "acidophilic" category. In actual fact, these species are indifferent with respect to soil acidity but are adapted to soils which are poor in calcium and nitrogen. Most important among these "pseudoacidophilic", oligotrophic calcifuge species are *Vaccinium myrtillus* L., *Juniperus communis* L., *Potentilla erecta* (L.) Raeusch., and *Chamaespartium sagittale* (L.) P. E. Gibbs. Their presence in the analysed communities considerably lowered the obtained indicator value for soil acidity of *Pinus nigra*.

Some differences between obtained and expected indicator values can be attributed to specific floristic features of the analysed communities. Relevés included in our investigations include numerous (sub)illyric, scardo-pindic and (sub)moesic species. Most important among these endemic plants are *Alyssum markgrafii* Schultz, *Cerastium decalvans* Schloss. & Vuk., *Erythronium dens-canis* L., *Corydalis acaulis* (Wulfen) Pers., *Athamanta haynaldii* Borbás & Uechtr., *Campanula lingulata* Waldst. & Kit. and *Crocus veluchensis* Herb. These species, as well as some others, are not considered by Ellenberg and did not therefore contribute to our estimate of environmental factors within the respective relevés. Consequently, the correctness of the indicator values obtained for the analysed species is questionable. The obtained indicator values are, however, far less important than the relative position of the analysed species along the environmental gradients. The gradient interrelations among the analysed submediterranean species that we detected by our study are confirmed in numerous papers (Jovanović 1967; Janković 1973; Trinajstić & Cerovečki 1978; Popović & al. 1984; Popović & Karadžić 1992; Vidaković 1982).

The results presented in this paper should be regarded as preliminary. The knowledge of ecological requirements of the analysed trees is extremely valuable when the (re)introduction of the species in disturbed and deforested areas is envisaged. Further analyses of gradient relationships among submediterranean plant species in Serbia should be conducted over a larger area.

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