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TREE-SIZE DIVERSITY AND TREE SPECIES DOMINANCE AS THE ELEMENTS OF MIXED BEACH SPATIAL STANDS STRUCTURE

Branko Stajic[1*], M.Vuckovic[1], M. Koprivica[2], S. Andrasev[3], B. Matovic[3], G.Vucetic[4]

[1]University of Belgrade, Faculty of Forestry, Belgrade, SERBIA
[2]Institute of Forestry, Belgrade, SERBIA
[3]Institute of Lowland Forestry and Environment, Novi Sad, SERBIA
[4]Public Company "Vojvodinasume", Forest holding "Banat" Pancevo, SERBIA

[*]*branko.stajic@sfb.bg.ac.rs*

ABSTRACT

A dataset of fifteen sample plots of mixed beech and valuable broadleaved forests in the northeast of Serbia was used in order to examine tree-size diversity and tree species dominance. For this purpose, structural index U (Hui *et al.* 1998) was applied. The results show that in this case the dominance of beech over valuable broadleaves is not so clearly expressed, as these relationships were analyzed through measures which are commonly used in forestry. It can be concluded that the applied index is very suitable for the evaluation of stand structure, tree-size diversity and the level of competition between trees.

Key words: beech and valuable broadleaved species, tree-size diversity, stand structure, dominance index

INTRODUCTION

Speaking about the necessity of applying new parameters for the characterization and description of the actual state and structure of the stands in forest management, Gadow (1993) underlines the importance of determining the degree of inequality – diversity of tree sizes in a stand. It is well known that tree size diversity within stands affects economical values in terms of relative profit of different management regimes and that large tree size diversity may ensure a wide range of habitats and a continuous supply of large dead trees, providing a high level of biodiversity in a forest ecosystem (Lexerød, Eid 2006). In these analyses, determination of tree diameter diversity is particularly emphasized because it is easy to define and it can be used for different purposes (Stajić, Vučković, 2006, Stajić 2011).

The basic information about the differences between the trees with regard to their diameter size can be obtained in different ways: by applying the diameter structure curves and statistical parameters that characterize these distributions, through so called degree of homogeneity (Kramer, Akça 1995, Banković, Medarević, 2003) or through the index of homogeneity (De Camino 1976). All these methodological approaches have one thing in common – their application does not provide detailed information about the "spatial" differences in the dimensions of trees and their nearest neighbours, which should be an important part of the database on spatial structure and diversity of forest stands.

The aim of this study is to analyze and quantify the tree size diversity and the tree species dominance in the mixed stands of beech and valuable broadleaved tree species and to review information on some characteristics of structure and biodiversity that are important for the nature-based management of these forests.

MATERIAL AND METHODS

The research of the stand structure and the tree size diversity in the mixed stands of beech and valuable broadleaved tree species was carried out in four series of sample plots (15 experimental plots in total) in the northeastern part of the Republic of Serbia, in the National Park ''Djerdap''(44°26'36" N, 22°09'45"). These four series represent four ecological units: A (SP1-SP4), B (SP5-SP8), C (SP9-SP12) and D (SP13-SP15). The average annual precipitation is 784 mm. The study stands, sized 0,25-0,45 ha (about 5 ha in total), are in the forest of beech and valuable broadleaves (Turkish hazel, Norway maple, wild cherry, sycamore, wild service tree, elm, lime, hornbeam and flowering ash).

The average number of trees per ha is: 621 (A), 401 (B), 309 (C) and 570 (D) and the average volume per ha (m^3) is: 453 (A), 431 (B), 494 (C) and 298 (D). The average quadratic mean diameter and the average quadratic mean diameter of dominant trees (cm) of two most represented tree species per ecological unit are: beech – 29,1 and 50,9, Turkish hazel – 26,9 and 36,9 (ecological unit A), beech – 38,4 and 56,2, Turkish hazel – 34,9 and 51,6 (ecological unit B), beech – 42,2 and 61,0, Norway maple – 29,7 and 43,2 (ecological unit C) and beech – 23,7 and 37,3, Turkish hazel – 29,4 and 45,2.

The diversity of the tree size (diameter differentiation) and the tree species dominance were calculated by *the measure of neighbourhood dimensions* or *dominance index*, i.e. structural index after Hui, *et al.* (1998):

$$U_i = \frac{1}{n}\sum_{i=1}^{n} k,$$

with: κ is a binary value (0 = neighbour is smaller then the reference tree *i,* 1 = otherwise)

The measure of the neighbourhood dimensions was based on the differentiation of the diameters of the reference tree and its three nearest neighbours. In general, this structural index quantifies the number of neighbouring trees that are larger than the reference tree and clearly illustrates the differences between the sizes of neighboring trees.

The average value of this index for all tree species together (stand level) and for two main tree species respectively was calculated as a mean value of all U_i values:

$$\overline{U} = \frac{1}{n}\sum_{i=1}^{n} U_i$$

RESULTS AND DISCUSSION

Table 1 presents the average values of the dominance index per diameter at stand level ($\overline{U}_{s\tan d}$), then per diameter of beech ($\overline{U}_{beech}$), Turkish hazel ($\overline{U}_{t.hazel}$) and Norway maple ($\overline{U}_{n.maple}$) trees. The values of dominance index $\overline{U}_{s\tan d}$ in all sample plots (except SP6) and averagely at the level of the ecological units are approximately the same and range from 0,44 to 0,49 (Table 1). The values of $\overline{U}_{s\tan d}$ index are quite different from the values of $\overline{U}_{t.hazel}$ and $\overline{U}_{n.maple}$ indices. The values of $\overline{U}_{beech}$, particularly within the stands of ecological unit A, are the closest to the average values of $\overline{U}_{s\tan d}$ index. This is due to the fact that beech trees outnumber other species in these stands. Therefore, the values of the beech tree dominance index have the greatest impact on the values of these indices at stand level.

A special importance of *U* index lies in the fact that its application provides results that can be used to determine the level of relative dominance of individual woody species in the stands. For this purpose, the average index of dominance was determined for two dominant tree species in each stand respectively. The average values of the index of dominance of beech (), Turkish hazel and Norway maple trees are also presented in Table 1.

Table 1. Values of $\overline{U}$ index-stand level, beech trees, Turkish hazel trees and Norway maple trees

		$\overline{U}_{s\tan d}$	$\overline{U}_{beech}$	$\overline{U}_{t.hasel}$	$\overline{U}_{n.maple}$
A	*SP 1*	0,47	0,47	0,48	-
	SP 2	0,49	0,50	0,18	-
	SP 3	0,45	0,46	0,52	-
	SP 4	0,48	0,50	0,42	-
	Average	*0,47*	*0,48*	*0,40*	-
B	*SP 5*	0,49	0,45	0,61	-
	SP 6	0,33	0,28	0,30	-
	SP 7	0,46	0,39	0,38	-
	SP 8	0,47	0,34	0,33	-
	Average	*0,44*	*0,37*	*0,41*	
C	*SP 9*	0,48	0,48	-	0,52
	SP 10	0,46	0,35	-	0,69
	SP 11	0,44	0,40	-	0,51
	SP 12	0,46	0,46	-	0,78
	Average	*0,46*	*0,42*		*0,63*
D	*SP 13*	0,47	0,54	0,23	-
	SP 14	0,47	0,48	0,33	-
	SP 15	0,49	0,55	0,39	-
	Average	*0,48*	*0,52*	*0,32*	

The results show that in the stands with beech and Turkish hazel as the most frequent species (stands of ecological units A, B and D), we cannot establish a uniform "pattern" of relative dominance of one species over another. In other words, in ecological units A and B, beech exhibits the greatest relative diameter dominance (SP1, SP3, SP5 and SP6) in one half of the stands, while Turkish hazel dominates in the other half of the stands (SP2, SP4, SP7 and SP8). On the other hand, all the stands of ecological unit D are characterized by a clear relative dominance of Turkish hazel over beech. There are two most frequent species in ecological unit C - beech and Norway maple. By comparing the obtained results it can be concluded that beech ($0{,}35 \leq \overline{U}_{beech} \leq 0{,}48$, averagely 0,42) has a significant relative dominance over Norway maple ($0{,}51 \leq \overline{U}_{n.maple} \leq 0{,}78$, averagely 0,63).

Even if the mean values are the same, data structure can be characterized by a quite different variability. Therefore, in order to make the picture of the actual stand structure and tree size diversity as clear as possible, the determined values of U_i index are classified according to the guidelines of Hui *et al.* (1998): "class 0" (all three nearest neighbouring trees have smaller diameters than the reference tree), "class 0.33" (two trees have smaller diameters than the reference tree), "class 0.67" (one tree has a smaller diameter than the reference tree) and "class 1" (none of the neighbouring trees have a smaller diameter than the reference tree).

The same species of trees with the same or approximately the same values of $\overline{U}$ index can have quite different distributions of individual values of U_i index, which means that they have different structural form as well (Graph 1). It can be clearly seen if we analyze for example distributions of individual U_i values for Turkish hazel trees in ecological unit A (Figure 1).

With approximately the same values of the average $\overline{U}$ index (0,48 and 0,52), classes "0" and "1" are the most frequent classes in SP1 and "0.67" in SP3. This value of U_i index ("0.67") is determined in about 10% of Turkish hazel trees in SP1, while the same value applies to 60% of the trees in SP3. It practically means that in SP1 only about 10% of Turkish hazel trees have 2 nearest neighbouring trees whose diameters are larger than the diameter of the observed tree, while in SP3, almost 60% of Turkish hazel trees are surrounded by two out of three neighbours with superior dimensions. U_i index of beech trees in this ecological unit has a more regular distribution of values in comparison to the distribution of the same index of Turkish hazel trees. The same can be said for the distribution of beech U_i index and Turkish hazel U_i index in ecological unit C. Anyway, in 14 out of 15 sample plots in total, U_i indices of individual beech trees are recorded in all four studied classes, which indicate a considerable regularity in the distribution of these values in all ecological units.

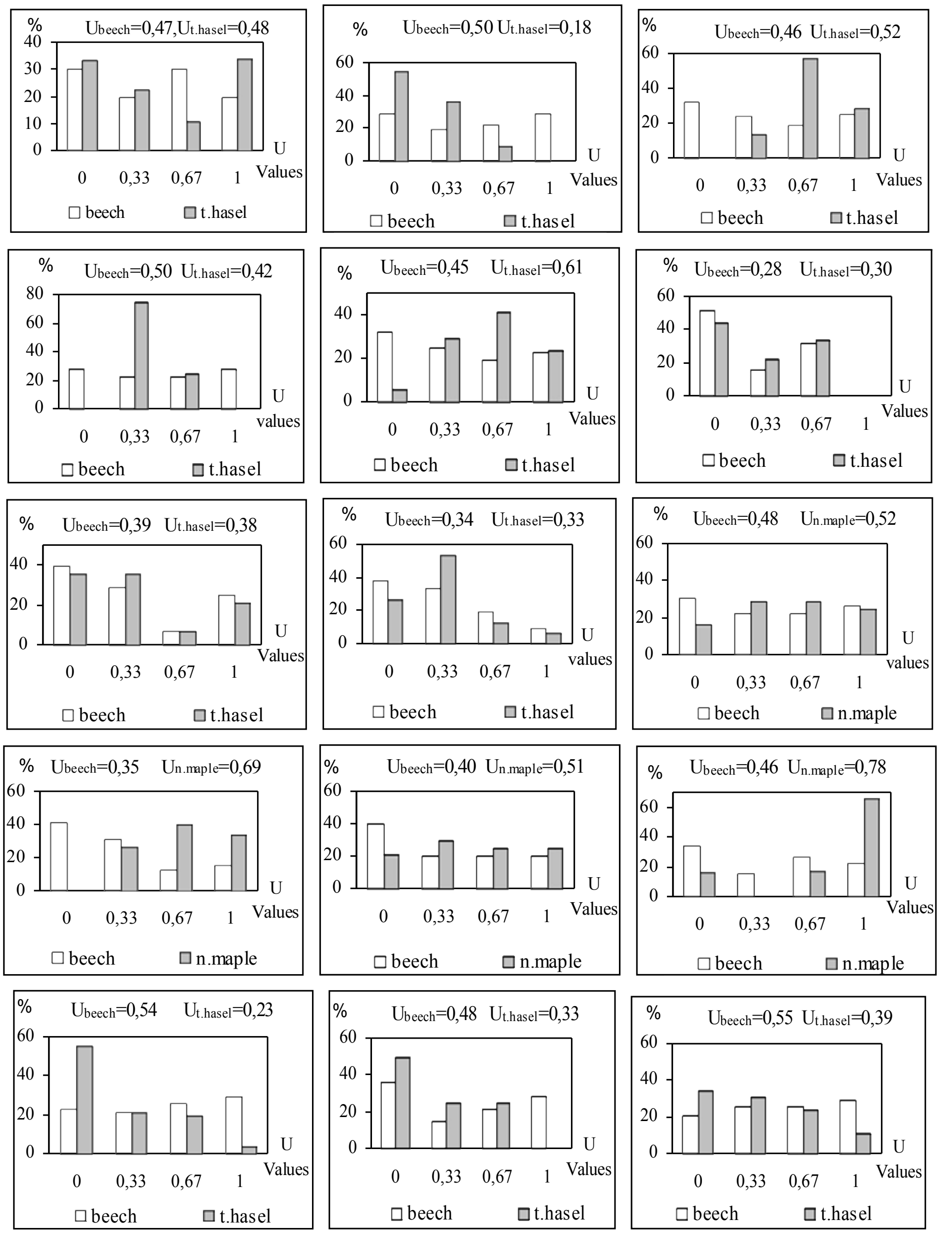

Figure 1. Values of $\overline{U}$ index- stand level, beech trees, turkish hasel trees and Norway maple trees according to classes (SP1-SP15)

The index of dominance is readily applicable in the assessment of the tree-size diversity and dominance, which can be proved by comparing the results obtained by applying *U* index with the results obtained by applying the parameters that are used to qualify diameter structure. Based on the values of quadratic mean diameter and average quadratic mean diameter of dominant trees, it is evident that the beech trees in ecological units A and B are characterized by larger diameters in comparison to the trees of Turkish hazel and this element of growth makes beech dominant over Turkish hazel. The results of the application of *U* index give a clearer picture of the actual dimensional relations between the trees of each individual species and their nearest neighbours. The smaller average value of the index determined for Turkish hazel in comparison to beech in ecological unit A shows that Turkish hazel has a relative dominance over beech in this ecological unit. Out of three analyzed dominant tree species, the smallest relative dominance is asserted by Norway maple, whose trees are usually surrounded by two rivals with larger and one with smaller dimension.

These results can be used to obtain basic information about the degree of tree competition in the stands. The basic assumption is that if the trees, which are in the immediate surroundings of the observed reference tree, have superior dimensions, they in most cases have better developed crowns and greater potential for competition in comparison to the reference tree.

With the beech trees, there is a kind of randomness in the distribution of the rivals with larger and smaller dimensions, which practically means that beech trees are partly surrounded by one rival with superior dimension and partly by two rivals with larger dimensions. The trees of Turkish hazel are in most cases trees with greater dimensions in comparison to the neighbouring trees, so their immediate neighbours are rivals whose diameters are about 40% smaller. The dimensions of Norway spruce trees are in most cases less superior in comparison to the neighbouring trees. Therefore, they are often under strong or extremely strong competition from the neighbouring trees.

CONCLUSIONS

Dimensional differences among the trees can be estimated by the curve which represents the number of trees per individual diameter degrees or by applying statistical parameters of diameter structure (for example, coefficient of variation). However, the stands of identical diameter structure and with the same values of coefficient of variation can differ considerably because the trees of different diameters can be spatially more or less mingled. In ecological unit A, relative dominance is exerted by beech in two stands and by Turkish hazel in the other two. On the average, it can be concluded that Turkish hazel has a greater relative dominance than beech in this ecological unit. The same applies to ecological unit B – two stands are dominated by beech and two by Turkish hazel. However, on average beech has a relative dominance over Turkish hazel at the level of this ecological unit. In ecological unit D, Turkish hazel can be described as a species with a greater relative dominance in comparison to beech. In ecological unit C, beech has considerably more dominant dimensions than Norway maple in relation to their nearest neighbours. On the average, each Norway maple tree is surrounded by two out of three nearest neighbours with larger diameters than the reference Norway maple tree.

At the end, we can say that in the commercial forests, as well as in the conserved ecosystems, the characteristics of structure and biodiversity are the key elements for the assessment of forest function, stability and hazards. For this reason, forest management and administration by the principles of sustainable development require permanent monitoring of different aspects of structure and diversity. In that context, spatial distribution of tree dimensions and tree species dominance are important parameters for the characterisation of the spatial stand structure and diversity.

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