Arch. Biol. Sci., Belgrade, 62 (4), 1119-1024, 2010 DOI:10.2298/ABS1004117S

CLASSIFICATION OF TREES AND TREE SPECIES IN OBRENOVAC "MALI PARK" BY THE ELEMENTS OF GROWTH, VITALITY AND ORNAMENTALNESS

N. STAVRETOVIĆ[1], M. VUČKOVIĆ[2] AND B. STAJIĆ[2]

[1]*Institute for Nature Conservation of Serbia,* 11000 Belgrade, Serbia
[2]*Faculty of Forestry, University of Belgrade,* 11000 Belgrade, Serbia

Abstract - The study was performed in Mali Park, in the town of Obrenovac. Our findings are based on the data obtained after direct measurments of elements of growth and the derived indicators of tree vitality and ornamentalness. Cluster analysis was applied to determine the relatively homogeneous groups of tree species. The results show that the group with the best functional characteristics includes *Platanus acerifolia*, *Tilia grandifolia* and *Fraxinus ornus,* and the group of species with inferior characteristics includes *Betula verrucosa*, *Juglans regia*, *Celtis australis*, *Acer platanoides*, *Cedrus atlantica* and *Acer negundo.*

Key words: Urban greenery, elements of growth, tree vitality and ornamentalness, cluster analysis

UDC 670.27(497.11)

INTRODUCTION

It is argued that urban trees provide numerous environmental and social benefits for the quality of life of our urbanized society (Ulrich, 1984; Xiao *et al.*, 1998; McPherson *et al.*, 1999; Chiesura, 2004; Nowak *et al.*, 2006; Arnberger, 2006). Urban greenery is especially significant in so-called industrial settlements like Obrenovac, where green spaces provide a healthy environment. The urban green spaces of Obrenovac, as a unique system of green spaces and tree rows, have the especially significant function of mitigating the adverse effects of the thermoelectric power station in the vicinity and numerous other polluters.

Due to the adverse effects of industrial pollution in such communities, urban green spaces "function" in specific conditions. The dynamics of plant growth and development, as well as the overall functionality and longevity, depend on the conditions in which the plant species grows (Stamenković, Vučković 1988, Anastasijević et al. 1997). The inventory and analysis of different elements characterizing plant material vitality, sanitation-hygienic and ornamental-aesthetic functionality enable the evaluation of individual woody plants, flower beds and lawns, as well as the soil in urban green spaces. Nevertheless, conducting a tree inventory is often the first step towards managing urban biodiversity (Alvey, 2006). After the evaluation of the state of green spaces and their components, their value and the extent of potential degradation can be determined by our and European standards and norms, which is especially significant in the vicinity of large industrial centers (Stavretović et al., 2008).

The research was based on the data of directly measured main elements of tree growth and the derived indicators of the vitality and ornamentalness of tree species found in Mali Park. The aim of this research was to answer the following questions:

- Can clearly differentiated groups of tree species be formed based on the available quantitative and qualitative indicators?
- Is there regularity in the case of grouping, or the relation to some of the known classifications of tree species (broadleaves-conifers, allochthonous-autochthonous species, etc.)?

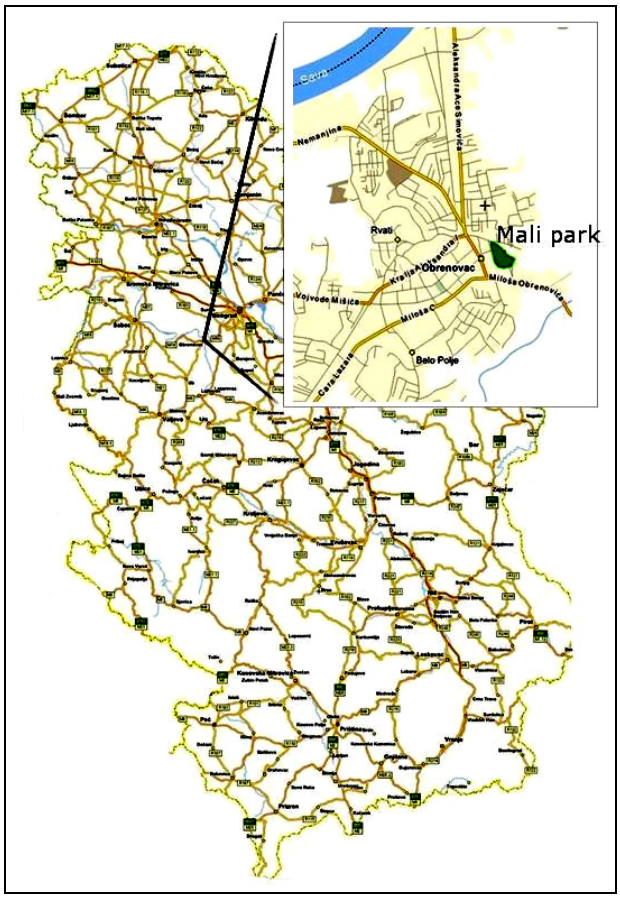

Fig. 1. The study area and location of Mali Park in Obrenovac

MATERIALS AND METHODS

The study area was Mali Park in Obrenovac. This municipality is near Belgrade and it is a part of the wider Belgrade area (Fig. 1). The evaluation of the growing conditions of the analysed tree species included data on the basic climate elements of the region (**http://www.obrenovac.org/obrenovac/klima/index.htm**). The mean annual air temperature was 11°C, the absolute fluctuation of air temperature was 67°C per year and the average temperature was 25°C, which is one of the indicators of a continental climate. The average annual mean daily relative humidity accounted for 74%. The annual range of relative humidity shows that it was high from November to February (80% - 85%), and in the other months it was lower (65% - 70%) or slightly higher (70% - 75%). The average annual precipitation was 662 mm. Annual precipitation indicates that May, June and July are the months with the highest percentages of total annual precipitation (11% - 12%).

Trees, as components of the Obrenovac urban greenery, can be divided into three major segments: tree rows, Mali Park and Central Park. Mali Park has 99 trees or 11% of the total number of trees in the urban core, with the following tree species present: silver fir (*Abies alba)*, black mulberry (*Morus nigra*), Aleppo pine (*Pinus halepensis*), Weymouth pine (*Pinus strobus*), small-leaved lime (*Tilia cordata*), large-leaved lime (*Tilia grandifolia*), birch (*Betula verrucosa*), common walnut (*Juglans regia*), European hackberry (*Celtis australis*), Norway maple (*Acer platanoides*), box elder (*Acer negundo*), Atlas cedar (*Cedrus atlantica*), European plane (*Platanus acerifolia*) and flowering ash (*Fraxinus ornus*).

The main characteristics of the tree species were assessed by direct measurement of growth elements: diameter at breast height (d), tree height (h), stem length (ld) and crown width (b), and also based on the derived complex indicators, such as the coefficient of vitality (VIT) and the coefficient of ornamentalness (DEK). The species were grouped based on the average values. The group stability was controlled by hierarchical and non-hierarchical grouping methods.

The main characteristics of trees were assessed in the following way:

- Tree diameters were measured at breast height (1.30 m) using a caliper, to the nearest 1 cm;
- Stem height and length (height to the point of crown spreading) of the study trees were measured using an electronic altimeter "Vertex";
- To analyze the vitality, further growth and development potential as well as the sanitation-hygienic and ornamental-aesthetic functions, two crown diameters of each tree in the Park were measured in the directions of the main cardinal points.

Table 1. Average values of the analysed characters of trees in Mali park

Tree species	N	d (cm)				h (m)				ld (m)				b (m)				Vitality (VIT)				Ornamentalness (DEK)			
	pcs	$\bar{x}$	$s_{\bar{x}}$	cv (%)	%	$\bar{x}$	$s_{\bar{x}}$	cv (%)	%	$\bar{x}$	$s_{\bar{x}}$	cv (%)	%	$\bar{x}$	$s_{\bar{x}}$	cv (%)	%	$\bar{x}$	$s_{\bar{x}}$	cv (%)	%	$\bar{x}$	$s_{\bar{x}}$	cv (%)	%
Betula verrucosa	3	21.7	2.2	17.5	50	11.4	1.1	16.2	70	2.1	0.4	35.8	88	6.6	0.4	11.3	62	3.70	0.7	31.5	110	4.00	0.4	19.9	125
Juglans regia	3	53.3	17.7	57.5	125	13.2	1.6	20.4	82	2.4	0.1	10.3	99	9.6	1.5	26.3	91	3.33	0.7	34.6	99	3.00	0.6	33.3	93
Celtis australis	4	42.0	4.4	20.8	98	16.4	1.0	10.8	101	2.1	0.4	32.9	88	13.3	1.2	18.3	126	3.25	0.5	29.5	97	2.75	0.6	45.8	86
Acer platanoides	8	37.5	3.2	23.9	88	16.6	0.9	13.4	103	1.9	0.3	45.6	80	9.8	0.5	13.2	92	2.63	0.3	30.1	78	2.90	0.3	25.2	90
Tilia grandifolia	8	51.9	6.5	35.6	121	17.4	1.2	19.6	108	2.1	0.2	27.5	85	11.4	0.6	16.2	107	3.37	0.4	31.4	101	3.25	0.4	30.9	101
Cedrus atlantica	10	29.3	2.2	23.5	68	16.2	1.1	21.4	100	2.2	0.2	22.1	91	6.6	0.3	15.3	62	3.83	0.4	30.0	114	3.45	0.4	36.6	107
Acer negundo	12	45.0	3.8	29.0	105	14.3	1.0	22.5	88	2.4	0.4	59.1	98	11.9	0.9	27.1	113	2.77	0.3	38.5	83	2.71	0.3	41.0	84
Platanus acerifolia	22	51.4	2.3	20.6	120	21.7	0.7	15.3	134	4.0	0.3	35.1	165	13.3	0.7	25.4	125	4.11	0.2	21.2	123	3.86	0.2	25.8	120
Fraxinus ornus	24	53.2	3.2	29.0	124	18.5	0.7	18.3	114	2.5	0.2	37.8	105	13.0	0.6	24.4	123	3.20	0.2	31.4	95	3.00	0.2	38.5	93
Average		42.8	5.06	28.6	100	16.2	1.03	17.5	100	2.4	0.28	34.0	100	10.6	0.74	19.7	100	3.35	0.41	30.9	100	3.21	0.38	33.0	100

- The vitality of the individual trees was assessed on the following principle:
  1. Severely diseased, damaged or dead tree;
  2. Diseased, damaged or decayed tree;
  3. Vital tree requiring regular tending to survive;
  4. Vital tree requiring periodical tending to maintain vitality;
  5. Exceptionally vital, healthy tree.
- The ornamentalness of the individual trees was assessed in the following way:
  1. Tree with no ornamental features;
  2. Tree with poor ornamental features;
  3. Tree of standard habitus with some defects;
  4. Tree of very good ornamental features, regular habitus with minor defects;
  5. Tree of excellent ornamental features, exceptionally well-developed, without visible defects in appearance.

RESULTS AND DISCUSSION

Mali Park comprises 99 trees and 14 tree species. The species with the highest percentage were *Fraxinus ornus* (24%), followed by *Platanus acerifolia* (22%), *Cedrus atlantica* (10%), *Acer negundo* (12%), *Tilia grandifolia* (8%) and *Acer platanoides* (8%) – Fig. 2. The percentage of other species was below 5%.

Table 1 presents the main characteristics of the tree species: stem diameter at breast height (d), tree height (h), stem length (ld) and crown width (b), and the derived complex indicators - the coefficient of vitality (VIT) and the coefficient of ornamentalness (DEK). The main characteristic of all tree species in Mali Park is the presence of some type of damage, caused by insufficient tending and the poor maintenance of the Park (Stavretović et al.,

Table 2. The means of the formed groups

Cluster	d cm	h m	ld m	b m	VIT	DEK
1	25.48	13.76	2.16	6.59	3.6	3.72
2	47.17	16.08	2.25	11.06	3.09	2.93
3	51.45	21.68	3.98	13.26	4.11	3.86

2007). In this respect, the species evaluation by vitality and ornamentalness is especially significant.

With the average mark of 4.11 for vitality and 3.96 for ornamentalness, *Platanus acerifolia* was assessed as the most vital and most ornamental species. This species was distinguished by the greatest average tree heights and crown sizes, and it was among the three most dominant species by tree diameter. Each individual tree was highly evaluated. Therefore, it can be stated that this species tolerates the environmental conditions very well.

The two indicators for *Betula verrucosa* also ranked very high (VIT = 3.70 and DEK = 4.0). Thanks to its numerous significant characteristics (ornamental value throughout the year, suitable for solitary planting, and also for grouping with conifers or broadleaves), this species is a generally used, representing a favorable tree in public green spaces. *Cedrus atlantica*, as a species in good condition and visual appearance (VIT = 3.83, DEK = 3.45) was also characterized by high vitality and ornamental value. However, although with high previous marks, *Betula verrucosa* and *Cedrus atlantica* were characterized by the lowest sizes of the main growth elements (tree diameter, tree height, crown width). The species with the lowest vitality and ornamental value were *Acer negundo, Acer platanoides* and *Fraxinus ornus,* with an average vitality of 2.77, 2.63 and 3.20 and ornamentalness, 2.71, 2.90 and 3.0, respectively. On the other hand, these species were among the most dominant species by tree diameter, height and crown size.

Cluster analysis was applied to determine the relatively homogeneous groups of tree species. Cluster analysis is used for the categorization, i.e. classification of similar, i.e. dissimilar objects according to some measured characteristics. The classification of tree species was based on a group of directly measured numerical indicators - elements of tree growth (d, h, ld, b), and estimated indicators (VIT and DEK).

The Dendrogram obtained by the so-called hierarchical classification is presented in Fig. 3 and it suggests the classification of tree species into three groups. The groups consist of the following tree species:

1. *Betula verrucosa, Cedrus atlantica*
2. *Juglans regia, Celtis australis, Acer negundo, Tilia grandifolia, Fraxinus ornus, Acer platanoides*
3. *Platanus acerifolia*

Table 2 presents the means of the formed groups. The data in the table show that the tree species in the first group are mainly characterized by the lowest values of growth elements and medium values of the coefficients of vitality and ornamentalness. The second group is characterized by substantially better growth, but somewhat poorer coefficients of vitality and ornamentalness, while the third group is characterized by the highest values of all indicators.

The clustering was controlled by the so-called *k-Means* method. The previously used methods showed the high differentiation between *Betula verrucosa* and *Platanus acerifolia*, i.e. the former had the lowest and the latter had the highest qualities. It is interesting to see the result of grouping when two clusters are created, using the abovementioned two species for the grouping. The result of grouping (Table 3) showed that the first group consisted of: *Betula verrucosa*, *Juglans regia*, *Celtis australis*, *Acer platanoides*, *Cedrus atlantica* and *Acer negundo*, and the second group consisted of *Tilia grandifolia*, *Platanus acerifolia* and *Fraxinus ornus*. It could be concluded that tree species in the second group were characterized by considerably

Table 3. Membership table: clustering method: k-means; distance metric: squared Euclidean

Row	Label	Cluster
1	Betula verrucosa	1
2	Juglans regia	1
3	Celtis australis	1
4	Acer platanoides	1
5	Tilia grandifolia	2
6	Cedrus atlantica	1
7	Acer negundo	1
8	Platanus acerifolia	2
9	Fraxinus ornus	2

better features regarding functionality expressed by the growth elements and the levels of vitality and ornamentalness.

CONCLUSION

Urban green spaces, especially the trees in parks, tree rows, small groups, and also solitary trees, significantly affect the town appearance (Barić et al., 2008). With the aim of increasing the functionality of such segments of urban greenery, it is necessary to assess their state, which is an initial step towards the rehabilitation and improvement of plant health and visual appearance.

The assessment of Mali Park in Obrenovac showed some types of damage on all tree species. The trees were of different sizes, vitality and ornamental value. *Platanus acerifolia* attained the highest average points for vitality and ornamental value. Some species (*Betula verrucosa, Cedrus atlantica*) had high points for vitality and ornamentalness, but simultaneously they had low diameters, heights and crown widths. On the other hand, *Acer negundo, Acer platanoides* and *Fraxinus ornus* had low points for vitality and ornamental value, but they had dominant sizes (also *Platanus acerifolia*).

Taking into account the different dimensions of tree growth elements (d, h, ld and b) and different vitality and ornamental value of the species, it was necessary to group (classify) the species. The classification was based on all measured indicators (exactly measured elements of tree growth and estimated indicators of vitality and ornamental value). The results of tree classification showed that clearly differentiated tree groups could be formed based on the available quantitative and qualitative indicators. The expected possibility of linking the classification to a well-known division of tree species (broad-leaves-conifers, allochthonous-autochthonous species, etc.) was not justified.

Based on the classification, it was concluded that *Betula verrucosa* and *Cedrus atlantica* had the poorest, and *Platanus acerifolia* the best characteristics. The classification performed at the level of two clusters to differentiate the species of inferior and superior functional characteristics shows that the first group consists of *Betula verrucosa*, *Juglans regia*, *Celtis australis*, *Acer platanoides*, *Cedrus atlantica* and *Acer negundo*, and the second group includes *Platanus acerifolia*, *Tilia grandifolia* and *Fraxinus ornus*.

REFERENCES

Alvey, A. A. (2006): Promoting and preserving biodiversity in the urban forest. *Urban Forestry & Urban Greening* 5, 195–201

Anastasijević, N., Vučković, M. and *V. Vratuša* (1997). Functionality of forest and ornamental trees in urban green spaces. *Eco-Conference: Environmental Protection in cities and suburban settlements*, 223-228, Novi Sad

Arnberger, A. (2006): Recreation use of urban forests: An inter-area comparison. *Urban Forestry & Urban Greening 4*, 135–144

Barić, L., Diminić, D., Glavaš, M, and *B. Hrašovec* (2008): Tree health in the town Pakrac with reference to diseases and leaf pests. Forestry Institute Jastrebarsko **43** (1), 59-70, Croatia

Chiesura, A. (2004): The role of urban parks for the sustainable city. *Landscape and Urban Planning* **68**, 129–138

McPherson, E G., Simpson, J. R., Peper, P. J. and *Q. Xiao* (1999): Benefit-cost analysis of Modesto's municipal urban forest. *Journal of Arboriculture* **25**, 235–248.

Nowak, D. J., Crane, D. C. and *J. C. Stevens* (2006): Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry & Urban Greening* **4**, 115–123.

Stamenković, V. and *M. Vučković* (1988): Increment and productivity of trees and forest stands. Faculty of Forestry, Belgrade, 368 p.

Stavretović, N., Stajić, B. and *S. Manjasek* (2007): Assessment of tree quality in "Mali Park" Obrenovac. Proceedings, *Scientific-Professional Conference "Ecological Truth"*, Sokobanja, Serbia.

Stavretović, N., Stajić, B., Manjasek, S. and *M. Vukin* (2008): Assessment of tree quality of the Central Square, Obrenovac. Proceedings, *Scientific-Professional Conference "Ecological Truth"*, 309-313, Sokobanja, Serbia

Urlich, R. S. (1984): View through a Window May Influence Recovery from Surgery. *Science*, Vol. **224**, No. 4647, 420-421

Xiao, Q. F., McPherson, E.G. and *J. R. Simpson* (1998): Rainfall interception by Sacramento's urban forest. *Journal of Arboriculture* **24**, 235–244.