

*Jelena NINIĆ-TODOROVIĆ, Emina MLADENOVIĆ, Jelena ČUKANOVIĆ, Ivana SENTIĆ, Ana LAKIĆ, Dragan TODOROVIĆ, Ivan TODOROVIĆ*<sup>1</sup>

## BIO-ECOLOGICAL DENDROFLORA CHARACTERISTICS OF THE DISTRICT PARK IN NOVI SAD

### SUMMARY

This paper presents the results obtained in Futoški Park, in the city of Novi Sad. The work distinguishes the most longevous and valuable species that have adapted to the urban environment conditions. Based on the studied bio-ecological parameters, Bald cypress (*Taxodium distichum* (L.) Rich.) was singled out, as a representative of conifers, as well as London plane (*Platanus x acerifolia* (Ait.) Willd.), Pyramidal white poplar (*Populus bolleana* Lauche) and the association (*Ulmus effusa* Willd.), as representatives of deciduous species of significant vitality and decorative value. Individuals with high values of examined parameters can be used in further breeding work as mother plants in the production of planting material for horticulture and landscape architecture. Species grouped according to similar bio-ecological characteristics, isolated via cluster analysis, are recommended as a good arboreal material in future reconstructions of Futoški Park.

**Keywords:** district park, bio-ecological parameters, breeding.

### INTRODUCTION

Green spaces (garden, park and landscape compositions) are important elements of each city. As an essential part of the image of the city and its surroundings, they expand ecological diversity and essentially make cities and urban environments better suited for living. Where they exist, green areas provide numerous social, environmental, and economic services of measurable value to the cities (Escobedo et al., 2008; Conway and Urbani, 2007; McPherson et al., 2005).

Urban parks, as green spaces of an urban area, are providing a connection with nature, high comfort and ecological balance, while creating optimal urban environment for residential living. As a part of green spaces, they are important places for the conservation of biodiversity within cities; however, their vegetation is affected by a number of anthropogenic stressors (LaPaix, 2010). With the aim of increasing the functionality of urban greenery, it is necessary to

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<sup>1</sup> Jelena Ninić-Todorović (corresponding author: jelena@polj.uns.ac.rs), Emina Mladenović, Jelena Čukanović, Ivana Sentić, Ana Lakić, Dragan Todorović, University of Novi Sad, Faculty of Agriculture, Department of Pomology, Viticulture, Horticulture and Landscape Architecture, Trg Dositeja Obradovića 8, 21000 Novi Sad, Serbia, Ivan Todorović, Public enterprise The city greenery, Sutjeska 2, 21000 Novi Sad, Serbia.

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assess their condition, which is an initial step towards the rehabilitation and improvement of plant health and visual appearance (Stavretović *et al.*, 2010).

Among the numerous plant life forms, trees are the most useful and are irreplaceable in urban green spaces (Očokoljić *et al.*, 2010). By increasing the number of plant species, dendroflora diversity also increases, the potential for education of residents expands, while the microclimate and protective functions, as well as structural, visual and aesthetic components of the area, significantly improve. Vujković *et al.* (2003) indicated that the abundance of colors and the variety of forms make the green areas indispensable in the composition of urban spaces. The physical design of green areas is affected by both species' biological characteristics (e.g., habitat size and shape, branching pattern, color, as well as the mosaic formed by leaves, flowers, blossom and fruit), and environmental conditions, such as air, land, relief and water.

In Novi Sad, several categories of green spaces can be recognized, namely public green areas (comprising parks, squares and street greenery), protective zones within residential complexes and green areas for other purposes (education, sport, industry, etc.). The presence of parks and street greenery, on which cultivation and maintenance efforts are usually focused, serves as a measure of vegetation abundance. The most valuable city parks, which are also the most regularly maintained green spaces, are Dunavski, Futoški, and Limanski Park, as well as the Park of the Institute in Sremska Kamenica (Environmental protection study in the Novi Sad area, 2009).

The study presented here focused on Futoški Park that, because of the variety and high vitality and decorative value of dendroflora, represents an exceptional ecological, biological and environmental value in the urban structure of the city (Crnojački and Ninić-Todorović, 1989). Due to the exceptional tree specimens of considerable age, biodiversity, cultural and historical characteristics, with prominent pedological, hydrological and botanical features, this park is distinctive and unique, and is thus of great scientific, aesthetic, cultural and educational significance. Futoški Park is protected by the decision of the Novi Sad Assembly, as a natural resource of great importance, and is classified as Category III in terms of its protection status. In the protected area of this natural monument, Futoški Park, degree II and III protection regime was established (Management Plan Proposal SP "Futoški Park", 2012 - 2021). The area of 7 ha 11 a 39 m<sup>2</sup> is placed under level II regime of protection, while 1 ha 1 a 67 m<sup>2</sup> is under level III regime of protection (Ninić-Todorović *et al.*, 2010). On the park grounds, irrespective of the protection mode, modifying land use and undertaking works that could undermine the concept and style of the park, or endanger plant population, garden and architectural elements and fauna, is prohibited (Network of public green spaces in Novi Sad, 2004).

Park construction was completed in 1910 and the author of the conceptual design that was realized has thus far remained unknown (Korać, 2007). Since its opening, the park has undergone some changes in terms of architectural elements, as well as botanical composition (Ninić-Todorović *et al.*, 2008);

however, its boundaries have not been significantly altered (Ninić-Todorović et al., 2010). From its creation until the onset of World War II, the park underwent some changes, and the Iodine Spa buildings were damaged and many old trees were destroyed during the war (Crnojački and Ninić-Todorović, 1989). The last reconstruction was performed in 1964, based on the plans provided by the engineer Ratibor Dr. Djordjević. The stylistic features of free landscape composition were retained, with the intention to preserve healthy and vital tall trees. The floristic composition was enriched by introducing new allochthonous specimens (Ninić-Todorović et al., 2010).

The aim of this work is to, within the total dendroflora of Futoški Park, identify the most valuable species in terms of vitality, decorative value, old age and bio-ecological characteristics. The results yielded would serve as the foundation for selection of important species in future park landscape reconstruction endeavors. A further goal is to identify among the selected species individuals that are, based on the aforementioned qualitative and quantitative parameters, important for use in reproduction, i.e., as a source of generative and vegetative material for the production of planting material for horticulture and landscape architecture. Therefore, particular attention is devoted to the tree care and maintenance.

## MATERIAL AND METHODS

Futoški Park (Figure 1) covers an area of 12 ha, of which about 8.5 ha is under protection (Study of green and recreational areas, 2009). As a part of the urban space of Novi Sad, the park is in the region characterized by temperate continental to continental climate (Katić et al., 1979). It is located at 78 m altitude, with the mean annual temperature of 11.1°C and the mean annual total precipitation of 603.1 mm (Ninić-Todorović et al., 2010).

Based on the soil classification in article (Škorić et al., 1985), the soil in Futoški Park belongs to the hydromorphic order. Park dendroflora has an important function in phytoremediation of heavy metals in soil, with willow and poplar as dominant species. Chemical analysis revealed a low concentration of heavy metals (Ninić-Todorović et al., 2008). Several geothermal resources are also located within the perimeter of Futoški Park (Ninić-Todorović et al., 2010).

The wealth of the park comprises 108 species, varieties and forms of dendroflora that form small groups, massifs, alleys and solitaires (Crnojački and Ninić-Todorović, 1989). The information on the park's floristic composition from the time of its establishment and early development is scarce. Thus, the data on the most valuable and oldest trees analyzed in this paper, on the site of Futoški Park, was sourced from extant studies and gathered during the current research.

Twelve genotypes are considered the oldest and of the greatest biological value. Due to their exceptional biological, decorative and reproductive value, trees of Turkish hazel (*Corylus colurna* L.) were singled out, with a population of 54 individuals. According to Ninić-Todorović et al. (2008), the oldest specimens of Turkish hazel in the Novi Sad area are, indeed, located in the Futoški Park

area. In Futoški Park, individuals of Californian incense cedar (*Libocedrus decurrens* Torr.) were also singled out, owing to their high functional value and the ability to mass-reproduce seeds in biennial cycles (Ninić-Todorović *et al.*, 2008), as well as their approximate age of over 100 years (Ninić-Todorović and Ocokoljić, 2002).

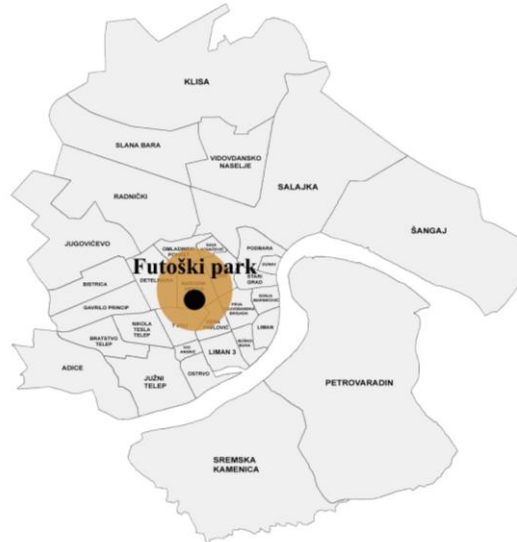


Figure 1: Position of Futoški Park within Novi Sad

Previous research (Ninić-Todorović and Ocokoljić, 2002) suggests that Bald cypress (*Taxodium distichum* (L.) Rich.) has also distinguished itself in the park area due to its favorable morpho-physiological characteristics, resistance to diseases and pathogens, as well as exceptional aesthetic value. In their work, Ninić-Todorović and Ocokoljić (1989) highlighted Austrian pine (*Pinus nigra* Arn), White pine (*Pinus sylvestris* L.), Pyramidal white poplar (*Populus bolleana* Lauche), Sliver-leaf poplar (*Tilia tomentosa* Decne), Small-leaved linden (*Tilia cordata* Mill), Black walnut (*Juglans nigra* L.), Grecian fir (*Abies cephalonica* Loudon), European wild elm (*Ulmus effusa* Willd.), as well as species characterized by particular biological and decorative traits. According to the same authors, the old London plane tree (*Platanus x acerifolia* (Ait.) Willd), included in the present study, is a further testimony to the park history and development.

Several analytical methods are applied in this paper, depending on the research phase. The study was predominantly qualitative, and included a review of available literature resources, which served as a source of general information about the historical development of the park and natural features of the area.

In the subsequent phase of this investigation, biological analysis was conducted, focusing on the most longevous and most representative species. The population size was also determined, and the health status assessed, and this data

was used to estimate vitality (VIT) and decorative value (ECD) on the scale from 1 to 5. Evaluation of the current conditions revealed twelve genotypes. Within these genotypes, individual trees were identified for a more detailed assessment, which included relevant indicators of biological and aesthetic value.

Three characteristics were evaluated as biological indicators and included tree height  $h$  (m), measured by Vertex laser altimeter. Tree height to the first branches  $ld$  (m) and crown width  $cw$  (m) were measured using geodesic ribbon. Standard geometry was used to determine the trunk diameter at the 1.30 m height (breast-height, or thoracic height). A detailed analysis of these indicators yielded the most valuable dendroflora specimens.

The data obtained was processed, interpreted and evaluated by employing the statistical software Statistica10 (StatSoft, OK, USA).

## RESULTS AND DISCUSSION

In Futoški Park, the 108 dendroflora representatives comprised 1611 trees in total. Conifers had 36 representatives, while 71 trees were deciduous. The twelve analyzed species, of which five were conifers and seven deciduous, were represented by 359 trees.

Species that are distinguished by the highest mean tree height values are *Populus bolleana* Lauche (23.90 m), *Taxodium distichum* Rich. (19.35 m) and *Platanus x acerifolia* (Ait.) Willd. (17.86 m). In addition to the tree height, these individuals stand out because of the high thoracic diameter value. Pyramidal white poplar (*Populus bolleana* Lauche) had the breast-height trunk diameter of 84.70 cm. It is followed by London plane (*Platanus x acerifolia* (Ait.) Willd.) with 74.46 cm and Bald cypress (*Taxodium distichum* Rich.) with 70.00 cm.

In addition to these species, Austrian pine (*Pinus nigra* Arn.), European wild elm (*Ulmus effusa* Willd.) and Turkish hazel (*Corylus avellana* L.) are also characterized by high values of breast-height trunk diameter, indicating their longevity. The coefficient of variation for this parameter ranged from 15.22% for Grecian fir (*Abies cephalonica* Loud.) to 50.67% for the Californian incense cedar (*Libocedrus decurrens* Torr.). In the tested specimens, crown width, as one of the most important parameters pertaining to maturity, ranged from 3.50 m (*Libocedrus decurrens* Torr.) to 16.17 m (*Platanus x acerifolia* (Ait.) Willd.). The greatest variation in the crown width was observed in Small-leaved linden (*Tilia cordata* Mill.). The coefficient of variation, which was 45.12% for this species, indicates its high variability, since it is present in street alleys, in groups, as well as solitary individuals within the park.

Analyzed species that had the highest values of the investigated quantitative characteristics are fully adapted to the site conditions. This representative habitus provides a valuable aesthetic dendroflora element to the examined area. Based on the high parameter values, the identified individuals can be considered the oldest trees planted in Futoški Park.

Evaluation of species by vitality and ornamentalness is especially significant. Pyramidal white poplar (*Populus bolleana* Lauche), Bald cypress

(*Taxodium distichum* Rich) and London plane (*Platanus x acerifolia* /Ait./ Willd.) were assessed as the most vital and the most ornamental species. In addition to these three species, based on their health condition and decorative value, *Ulmus effusa* Willd. (VIT and DEK = 4.14), *Juglans nigra* L. (VIT = 4.00 and DEK = 3.75) and *Corylus colurna* L. (VIT = 3.63 and DEK = 3.92) can also be distinguished.

Individuals with low to medium vitality and decorative values are White pine (*Pinus sylvestris* L.), with VIT = 2.51 and DEC = 2.48, and Austrian pine (*Pinus nigra* Arn.), with VIT = 2.68 and DEC = 2.35 (Table 1). Such low values can be attributed to dense planting and irregular maintenance, i.e., untimely tree pruning. Austrian pine is the most abundant conifer in Futoški Park, as a species of extraordinary phytoncide value. As the park borders the Iodine Spa, its original purpose was relaxation and rehabilitation of spa users, as evident in the number of Austrian pine specimens. Lučić et al. (2010) reported that many provenance tests in the world show that Austrian pine (*Pinus nigra* Arn.) populations from this region are characterized by their quality and are assessed as the best, the most resistant and with the highest genetic variability.

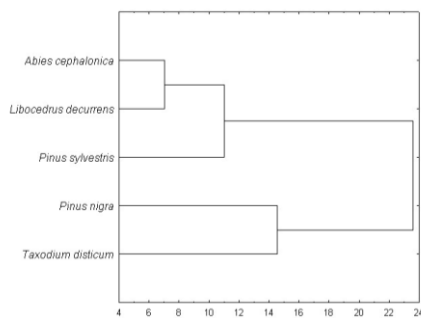


Figure 2: Cluster analysis of coniferous representatives

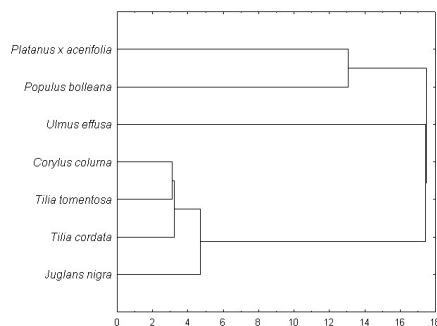


Figure 3: Cluster analysis of deciduous representatives

Cluster analyses of coniferous and deciduous representatives allowed grouping them into sub-clusters (Figure 2, Figure 3). Via hierarchical classification, conifers were segregated into two sub-clusters. The first comprised *Abies cephalonica* Loud., *Libocedrus decurrens* Torr. and *Pinus sylvestris* L., while *Pinus nigra* Arn. and *Taxodium distichum* Rich. formed the second.

Table 1. Bio-ecological, aesthetic and health characteristics of identified dendroflora representatives in Futoški Park

Tree species	h(m)		Id(m)		d(cm)		cw(m)		VIT		DEK	
	Mean	C <sub>v</sub> (%)	Mean	C <sub>v</sub> (%)	Mean	C <sub>v</sub> (%)	Mean	C <sub>v</sub> (%)	Mean	C <sub>v</sub> (%)	Mean	C <sub>v</sub> (%)
<i>Abies cephalonica</i>	13.60	4.16	1.43	12.58	40.17	15.22	4.05	1.74	3.25	10.88	3.25	10.88
<i>Pinus nigra</i>	6.84	25.13	2.49	52.34	60.30	35.57	4.72	22.04	2.68	27.91	2.35	37.24
<i>Pinus sylvestris</i>	10.75	23.34	3.76	34.45	30.22	34.45	6.80	25.66	2.51	53.23	2.48	56.30
<i>Taxodium distichum</i>	19.35	14.58	2.58	16.52	70.00	25.77	10.73	21.92	4.80	8.78	4.90	6.45
<i>Libocedrus decurrens</i>	7.61	50.62	1.36	81.55	43.80	50.67	3.50	39.37	3.04	43.87	2.80	44.78
<i>Platanus x acerifolia</i>	17.86	42.38	3.15	33.37	74.46	24.93	16.17	27.15	4.70	10.28	4.70	10.28
<i>Ulmus effusa</i>	16.96	34.59	3.17	46.15	57.10	44.77	14.54	37.46	4.14	25.80	4.14	25.80
<i>Corylus colurna</i>	12.28	39.92	3.02	43.24	40.00	49.24	8.49	39.11	3.64	34.40	3.92	28.84
<i>Juglans nigra</i>	15.45	41.41	3.56	40.17	36.10	30.12	12.36	31.89	4.00	23.14	3.75	23.64
<i>Populus bolleana</i>	23.90	/	5.00	/	84.7	/	11.10	/	5.00	/	5.00	/
<i>Tilia tomentosa</i>	14.44	26.54	2.93	39.34	40.30	30.29	10.67	28.58	3.70	21.01	3.79	23.32
<i>Tilia cordata</i>	10.90	28.35	2.65	44.71	38.4	49.37	10.87	45.12	3.75	28.74	3.75	27.92

Deciduous representatives were grouped into three sub-clusters, with *Platanus x acerifolia* (Ait.) Willd. and *Populus bolleana* Lauche in the first, *Ulmus effusa* Willd. in the second, and *Corylus colurna* L., *Tilia tomentosa* Moench., *Tilia cordata* Mill. and *Juglans nigra* L. in the third. The mean values of the formed sub-cluster groups are given in Table 2.

Table 2. Mean values of the analyzed bio-ecological characteristics pertaining to the identified clusters

Cluster	h (m)	ld (cm)	d (cm)	cw (m)	VIT	DEK
<i>Gymnospermae</i>						
1	10.65	2.18	38.06	4.78	2.93	2.84
2	13.09	2.53	68.65	7.72	3.74	3.62
<i>Angiospermae</i>						
1	20.88	4.07	79.58	13.63	4.85	4.85
2	16.96	3.70	57.10	14.54	4.14	4.14
3	13.27	3.04	38.7	10.59	3.77	3.80

The identified clusters reveal that the first deciduous sub-cluster is particularly important due to the high vitality and ornamentalness scores. The values of bio-ecological, health and decorative parameters for other deciduous species are also very high in comparison to the conifer representatives, which are not indigenous to the Futoški Park habitat. The park area belongs to the willow and poplar community, which suits the analyzed deciduous specimens in terms of the environmental conditions and the changed urban environment. Bald cypress (*Taxodium distichum* Rich.), with trees planted at the rim of the lake located in the front of the park, is also well adapted to the Futoški Park conditions.

Table 3. Values pertaining to the trees of the most significant age class

Species	h (m)	d (cm)	cw (m)	VIT	DEK
<i>Abies cephalonica</i> Loud.	13.60	40.17	4.05	3.25	3.25
<i>Pinus nigra</i> Arn.	15.80	43.45	9.50	3.70	3.70
<i>Pinus sylvestris</i> L.	12.88	36.80	7.90	2.63	2.63
<i>Taxodium distichum</i> Rich.	20.50	70.10	11.30	4.90	5.00
<i>Libocedrus decurrens</i> Torr.	9.70	59.50	4.40	3.50	3.30
<i>Platanus x acerifolia</i> (Ait.)Willd.	22.80	90.38	18.00	4.80	4.80
<i>Ulmus effusa</i> Willd.	20.70	63.80	14.50	4.50	4.50
<i>Corylus colurna</i> L.	17.02	43.44	10.76	3.85	4.15
<i>Juglans nigra</i> L.	19.30	57.86	16.80	3.70	3.30
<i>Populus bolleana</i> Lauche	23.90	84.70	11.10	5.00	5.00
<i>Tilia tomentosa</i> Moench.	17.41	42.52	12.06	3.73	3.96
<i>Tilia cordata</i> Mill.	13.70	48.93	14.39	4.00	4.00



Table 3 provides the values pertaining to the trees of the most significant age class. These trees were selected due to the high values of measured parameters. Three height, breast-height trunk diameter, and crown width indicate significant adaptability to the conditions of the examined area, as well as longevity of these individuals. Vitality and ornamentalness scores distinguish these trees from the remaining park dendroflora. Thus, these individuals represent a valuable source of reproductive material for nursery production.

## CONCLUSION

As a Category III natural resource, Futoški Park is an important green space in the urban core of Novi Sad. A particular contribution to its importance for the city is certainly provided by the rich dendroflora, consisting of the countless indigenous and non-indigenous species, varieties and forms, arranged in the form of small groups, massifs, alleys or solitaires.

The examined dendroflora representatives exhibited variable adaptability to environmental conditions typical of the urban environment. Based on longevity, high bio-ecological, health and aesthetic parameter scores, among conifers, Bald cypress (*Taxodium distichum* (L.) Rich.) could be singled out, while most notable deciduous species were Pyramidal white poplar (*Populus bolleana* Lauche) and London plane (*Platanus x acerifolia* (Ait.) Willd.).

In addition to these three species, based on their health condition and ornamentalness, European wild elm (*Ulmus effusa* Willd.) and Turkish hazel (*Corylus colurna* L.) trees could also be distinguished. Individuals characterized by high values of assessed parameters can thus serve in further breeding work, as mother plants in the production of planting material for horticulture and landscape architecture. Species grouped according to similar bio-ecological characteristics, isolated via cluster analysis, are recommended as a good arboreal material in future reconstructions of Futoški Park.

The significance of the research presented here stems from the identification of valuable trees (both autochthonous as well as allochthonous) that exhibit adaptability to the urban environment conditions. Similar studies can be conducted in other park areas, as well as protected natural resources (such as the Great War Island, Petrovaradin fortress, Kalemegdan, etc.), that serve as habitat for valuable and rare dendroflora samples. The lifespan of these species in urban areas, of which they are an integral part, can be extended by the necessary and adequate care and maintenance measures.

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