

UDK: 712.253(497.11)=111

DOI: 10.5937/SustFor2693037M

Original scientific paper

VISUAL ASSESSMENT OF TREE CONDITION AS A BASIS FOR URBAN GREEN SPACE MANAGEMENT: A CASE STUDY OF GAVRILO PRINCIP PARK IN BELGRADE

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Abstract: Urban green areas are essential for improvement of ecosystem services, biodiversity, and well-being of people, but their sustainability depends on the long-term vitality and aesthetic quality of the trees. In this paper, the goal was to present the results of the research of health and aesthetic condition of trees in Gavriilo Princip Park in Belgrade. Vitality and ornamental marks were evaluated on a 1 to 5 scale using Visual Tree Assessment (VTA) method. 172 trees were recorded on the researched location with an area of 1.92 ha. A total of 39 taxonomic categories were identified, of which 8 within Gymnosperms and 31 from Angiosperms. The most dominant taxa in the park are *Pinus nigra* J.F. Arnold (within Gymnosperms) and *Tilia cordata* Mill. (within Angiosperms). The average vitality mark of all trees in the park is 3.01 and ornamental mark is 3.19. These research studies as a part of regular monitoring of urban green areas should contribute to the preservation and proper management of urban spaces green infrastructure.

Keywords: VTA method, vitality, ornamental, green infrastructure, Gavriilo Princip Park.

VIZUELNA PROCENA STANJA DRVEĆA KAO OSNOVA ZA UPRAVLJANJE URBANIM ZELENIM POVRŠINAMA NA PRIMERU PARKA GAVRILA PRINCIPA U BEOGRADU

Sažetak: Urbane zelene površine su od suštinskog značaja za unapređenje ekosistemskih usluga, biodiverziteta i dobrobiti ljudi, ali njihova održivost zavisi od dugoročne vitalnosti i estetskog kvaliteta drveća. U ovom radu cilj je bio da se prikažu rezultati istraživanja zdravstvenog i estetskog stanja drveća u parku Gavrila Principa u Beogradu. Ocene vitalnosti i dekorativnosti vrednovane su skalom od 1 do 5 korišćenjem metode vizuelne procene stabala (VTA). Na istraživanoj lokaciji, površine od 1.92 ha, zabeleženo je 172 stabla. Ukupno je identifikovano 39 taksonomskih kategorija, od čega 8 u okviru golosemenica i 31 u okviru skrivenosemenica. Najdominantniji taksoni u parku su *Pinus nigra* J.F. Arnold (u okviru golosemenica) i *Tilia cordata* Mill. (u okviru skrivenosemenica). Prosečna ocena vitalnosti svih stabala u parku iznosi 3.01 a dekorativnosti 3.19. Ova istraživanja kao deo redovnog monitoringa urbanih zelenih

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površina treba da doprinose očuvanju i pravilnom upravljanju zelenom infrastrukturu urbanih prostora.

Ključne reči: VTA metoda, vitalnost, dekorativnost, zelena infrastruktura, park Gavril Principa.

1. INTRODUCTION

A city park as an object of green infrastructure is of great importance in improving the quality of life in a city (Biddulph, 1999; Ćirković-Mitrović et al., 2016; Galečić et al., 2016). In conditions of intensive urbanization, where plants are exposed to the influence of various biotic and abiotic factors, such as air pollution, limited space for root system development and changed microclimatic conditions, it is necessary to carry out regular and systematic assessments of their condition in order to identify potential risks and define adequate care and protection measures (Nowak et al., 2004; Roloff, 2001; Anastasijević, 2011).

Effective management of urban greenery implies continuous monitoring of the condition of trees, as well as the assessment of their mechanical stability, especially in densely populated areas where potential risks can have serious consequences for users and the surrounding infrastructure (Konijnendijk et al., 2005). For this reason, in this study the method of visual assessment – VTA (Visual Tree Assessment) was applied to determine the mark of the condition of the trees. The method represents an effective and widely applied approach in arboriculture, because it enables the provision of guidelines aimed at safe use of public areas, but also the improvement of ecosystem services provided by urban trees (Mattheck & Breloer, 1994; Mitrović et al., 2025).

Considering that a city park should provide conditions to meet the needs of users such as recreation, relaxation, play and social activities, while the ecological and aesthetic function of the park should not be neglected, the objective of this paper is to present the value, health and aesthetic condition of dendroflora in Gavril Princip Park, as necessary factors in the management of urban green infrastructure.

Gavril Princip Park has significant cultural and historical heritage and ecological value. It was founded in 1836 as the garden of Prince Miloš's residence, while it was opened to visitors in 1864, which earned it the title of the first public city park in Belgrade. It is located in the central part of Belgrade in the territory of the city municipality of Savski Venac. The park has changed names throughout history, and these are: Soviet Park, Council Park and Financial Park. The park was originally designed in the English style and was reconstructed in 2004. The most recent reconstruction was completed in 2011.

2. MATERIAL AND METHOD

The study area is Gavril Princip Park (44°49'14"N, 20°27'44"E), located in the inner-city core of Belgrade. The boundaries of the researched part of the green infrastructure are Admirala Geprata Street in the north, Balkanska Street in the west, Nemanjina Street in the south and Kneza Miloša Boulevard in the east (Figure 1). The park covers an area of 1.92 ha. Field research was conducted in April 2024.

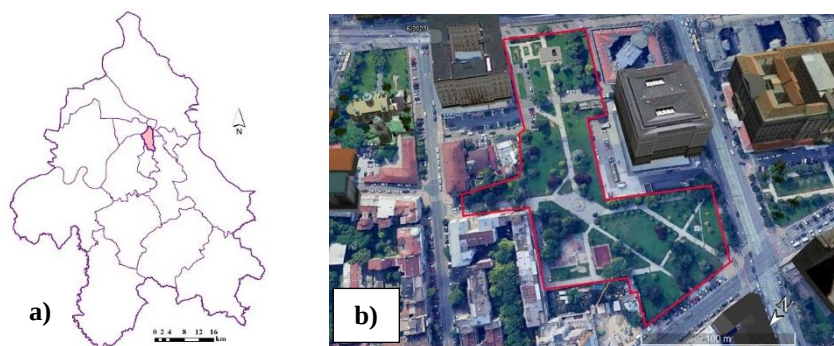


Figure 1. a) Position of the city municipality of Savski Venac on the territory of Belgrade, b) Study area

The paper analyzes the connection between the marks of vitality and ornamentality of trees, as well as the difference between Gymnosperms and Angiosperms. The data were collected using the basic method of visual tree assessment – VTA. The sample included 172 trees, of which 31 trees belonged to Gymnosperms and 141 individuals belonged to Angiosperms. The marks of vitality and ornamentality are expressed on an ordinal scale from 1 to 5 (Table 1) and they are obtained using visual assessment by the researcher.

The mark of vitality is based on basic measurements, such as tree height, diameter at breast height, height of the stem without branches, crown width, but also on visual assessment of the existence of broken and dry branches in the crown, top dieback, mechanical and entomological damages, as well as phytopathological diseases.

Tree ornamentality basically represents the aesthetic value of trees. This parameter is based on the subjective assessment of the researcher whereby, habitus form, symmetry, leaf mass density and coloration are considered. The ornamentality rating is also affected by the potential presence of mechanical damage, insects and fungi.

Table 1. *The scale for evaluating tree vitality and ornamentality*
(Stojanović et al. 2013)

Mark	Parameters for evaluating tree vitality	Parameters for evaluating tree ornamentality
1	Dead tree. Wry or sick tree. A tree on the verge of decay. Broken or mechanically significantly damaged tree in any way. A tree that has no possibility of further recovery.	Visually unbalanced tree without symmetry. A tree that spoils the impression in the overall impression of space. Without pronounced color, changeability, dynamism, without clearly defined mass and area.
2	Still vital tree, mechanically damaged or sick in any way. A tree with part of its crown missing. A severely damaged tree that may still survive.	A tree with an inharmonious silhouette and a disproportionate and insufficiently clearly delineated habitus. Poor color ratio. Poor ratio of mass and area.
3	A tree with damages that can be revitalized with care measures. A Crown with clearly defined form. A tree with medium intensity of occurrence of phytopathological diseases and mechanical damages.	Crown with clearly defined form. Coloristically uniform, monotonous. Trees inappropriately fit into the given space, out of proportion.
4	Vital tree with small intensity of phytopathological diseases or entomological damages. A tree with minor defects that can be corrected with appropriate care measures.	A tree in a visually balanced form, with less pronounced asymmetry. Recognizable ratio of colors, area and mass.
5	A completely healthy and undamaged tree. A tree of exceptional vitality, well adapted to environmental conditions.	Visually imposing and aesthetically extremely valuable tree. A tree of clear proportions and symmetry in accordance with the characteristics of the taxon. Coloristically emphasized tree. A tree that positively stands out in any way in space, by its build, figure, shape.

The descriptive analysis includes basic statistical indicators, including the arithmetic mean, standard deviation, median, and minimum and maximum values. Since the variables were ordinal, the association between the observed variables was examined using Spearman's correlation coefficient and Kendall's τ coefficient. The difference in vitality and ornamentality between Gymnosperms and Angiosperms was examined using the Mann–Whitney U test for two independent samples. Statistical significance was set at $p < 0.05$. Statistical data processing was performed in the IBM SPSS Statistics software.

3. RESULTS

In Gavriilo Princip Park, 39 tree taxa with 172 individuals were identified. The trees from Gymnosperms are dominant with 31 taxa that include 141 individuals, i.e. 81.98% compared to the total number of trees. Gymnosperms are represented by 8 species and a total of 31 trees in a percentage of 18.02 of the total number of trees.

Within Gymnosperms the most abundant species is *Pinus nigra* J.F. Arnold (15 individuals), followed by species *Platycladus orientalis* L. and *Taxus baccata* L. with 4 trees each, while other species within this group were represented by 3 or fewer individuals.

Among Angiosperms, the most abundant taxon is *Tilia cordata* Mill. (20 individuals), followed by *Acer pseudoplatanus* L. (16), *Robinia pseudoacacia* 'Umbraculifera' (13), *Fraxinus excelsior* 'Globosa' (9), *Prunus cerasifera*

'Atropurpurea' (9), *Acer platanoides* L. (8), *Tilia platyphyllos* Scop. (7) and *Betula pendula* Roth (7). Other taxa from Angiosperms are represented by 5 or fewer individuals.

The average mark of tree vitality (collectively for Gymnosperms and Angiosperms) amounts to 3.01, while the average mark for ornamentality is 3.19.

Taxa of Gymnosperms which showed the greatest vitality and ornamentality include the following: *Taxus baccata* L. (mark 4.5), *Picea pungens* Engelm. and *Platycladus orientalis* L. (mark 4). These taxa are represented in the field by 1-4 individuals, so the most numerous taxon from this group should not be ignored - *Pinus nigra* J.F. Arnold (15 individuals), whose average vitality mark is 3.0, and average ornamentality mark is 3.3. The lowest vitality and ornamentality mark was given to the species *Abies alba* Mill. (mark 2), which was considering the ecological requirements of the species (Ocokoljić and Petrov, 2022).

Deciduous species that showed the highest vitality are *Cercis siliquastrum* L., *Fraxinus angustifolia* Vahl. with an average mark of 5, while the lowest average vitality mark was given to taxa *Acer negundo* L., *Catalpa bignonioides* Walter, *Salix babylonica* var. *matsudana* 'Tortuosa' and *Scandosorbus intermedia* Pers. (mark 2).

Taxa of Angiosperms that showed the highest ornamentality are the following: *Cercis siliquastrum* L., *Fraxinus angustifolia* Vahl., *Liquidambar styraciflua* L., *Magnolia x soulangeana* Soul.-Bod., *Platanus x hispanica* Mill. ex Münch., *Quercus robur* L., *Quercus robur* 'Fastigiata' with an average mark 5; then *Prunus cerasifera* 'Atropurpurea' (mark 4.2). The most abundant species in the park within Angiosperms is *Tilia cordata* Mill., whose average vitality mark is 2.65, and average ornamentality mark is 2.70.

Descriptive statistical analysis (Table 2) indicates that average values of vitality and ornamentality mark are higher in gymnosperms, compared to angiosperms. The average vitality mark for trees from *Pinophyta* subdivision is 3.32 ± 0.70 , while for *Magnoliophyta* subdivision it is 2.94 ± 0.99 . The average ornamentality mark showed a similar trend, whereby average value in gymnosperms was 3.48 ± 0.72 , while in angiosperms it was 3.12 ± 0.99 . The median value was 3 in all cases.

Table 2. Descriptive statistics for the value of vitality and ornamentality

	Phylogenomics	Frequency	Mean $\pm$ Std. Dev.	Median	Min	Max
Vitality	Gymnosperms	31	3.32 ± 0.70	3	2	5
	Angiosperms	141	2.94 ± 0.99	3	1	5
	Both	172	3.01 ± 0.95	3	1	5
Ornamentality	Gymnosperms	31	3.48 ± 0.72	3	2	5
	Angiosperms	141	3.12 ± 0.99	3	1	5
	Both	172	3.19 ± 0.95	3	1	5

The results of Mann–Whitney U test (Table 3) show statistically significant differences between Gymnosperms and Angiosperms, both in vitality ($U = 1618.50$; $Z = -2.38$; $p = 0.017$), and in ornamentality ($U = 1656.00$; $Z = -2.23$; $p = 0.026$). Higher mean rank values in Gymnosperms indicate that these taxa are evaluated as more vital and decorative on average compared to taxa from Angiosperms.

Table 3. Results of the Man –Whitney U Test for differences in vitality and ornamentality values between Gymnosperms and Angiosperms

	Phylogenomics	N	Mean Rank		Mann – Whitney U	Z	p - value
			Gymnosperms	Angiosperms			
Vitality	Gymnosperms	31	104.79	89.48	1618.50	-2.38	0.017
	Angiosperms	141					
	Both	172					
Ornamentality	Gymnosperms	31	103.58	82.74	1656.00	-2.23	0.026
	Angiosperms	141					
	Both	172					

The analysis of correlation between vitality and ornamentality (Table 4) showed a statistically significant positive correlation in all the observed groups. For the entire sample, Spearman's correlation coefficient was 0.906 ($p < 0,001$), which indicates a very strong correlation between the observed variables. Similar results were obtained within individual groups, whereby the correlation is somewhat weaker in conifers ($\rho = 0.812$), while in deciduous trees it is nearly identical to the total sample ($\rho = 0.906$). The Kendall's τ coefficient additionally confirms the results of the correlation analysis.

Table 4. Correlation between vitality and ornamentality

Phylogenomics	N	Spearman ρ	Kendall τ	p - value
Gymnosperms	31	0.812	0.804	<0.001
Angiosperms	141	0.906	0.875	<0.001
Both	172	0.906	0.874	<0.001

4. DISCUSSION

The obtained results support previous research (Vratuša and Anastasijević, 1998) and indicate that the vitality and ornamentality of plants are significantly influenced by the characteristics of the site, the plant species selection, the microclimatic characteristics of the space and the level of exposure to adverse urban conditions. Although the ecological conditions of the site have changed, some taxa have adapted well to them (*Taxus baccata* L., *Platanus × hispanica* Mill. ex Münch., *Prunus cerasifera* 'Atropurpurea', *Quercus robur* L., *Quercus robur* 'Fastigiata', *Tilia platyphyllos* Scop., *Tilia tomentosa* Moench).

Species sensitive to urban conditions have been identified in the park (*Abies alba* Mill.). Therefore, poor marks of vitality and ornamentality were expected for them.

The poor vitality of the trees reduces their ornamental value in green spaces, but also the ability of these taxa to provide ecological benefits (Mitrović et al., 2025). 42 trees which are considered potentially dangerous for the users of a city park, but also provide favorable conditions for the development of pathogens and insects, got mark 1 or 2, therefore, their removal is recommended.

In addition to its important role in preserving and improving the urban biodiversity environmental quality (Maričić, 2007), the value of Gavriilo Princip Park

is also reflected in the positive effects of dendroflora in air purification from pollutants and dust, reduction of solar radiation, and lowering the air temperature in the urban core of Belgrade during the summer months.

5. CONCLUSION

In this research, 39 taxa of trees with a total of 172 individuals were analyzed. Using a five-point rating scale, the average tree vitality mark was 3.01, and the average ornamentality mark was 3.19. The taxa with high average marks of vitality are *Taxus baccata* L., *Cercis siliquastrum* L., *Fraxinus angustifolia* Vahl. and *Prunus cerasifera* 'Atropurpurea'. The taxa with the highest average mark of ornamentality are *Cercis siliquastrum* L., *Fraxinus angustifolia* Vahl., *Liquidambar styraciflua* L., *Liriodendron tulipifera* L., *Magnolia* × *soulangeana* Soul.-Bod., *Platanus* × *hispanica* Mill. ex Münch., *Prunus cerasifera* 'Atropurpurea', *Quercus robur* L., and *Quercus robur* 'Fastigiata'.

Abies alba Mill., *Acer negundo* L., *Catalpa bignonioides* Walter, *Salix babylonica* var. *matsudana* 'Tortuosa' and *Scandosorbus intermedia* Pers received the lowest marks for vitality and ornamentality. Significant differences in vitality and ornamentality marks at the taxonomic level indicate that it is necessary to develop separate management strategies adjusted to different taxa with the aimed of preserving the aesthetic and ecological value of urban greenery. Also, such research is useful in the selection of species both for the reconstruction and restoration of flora elements of already existing green spaces, and in the design of new ones under altered ecological conditions of urban environments.

The trees identified in the field are taxonomically and biogeographically very diverse which indicates the high ability of these taxa to acclimatize in the conditions of the urban environment.

Visual assessment of dendroflora plays a significant role in preservation and management of urban green infrastructure. In this way, potential risks of endangering user safety are minimized, but also further spread of pathogens and insects is prevented by giving adequate guidelines for measures of care and recovery of plants.

Acknowledgement: *This research was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract No. 451-03-33/2026-03/200027, dated February 5, 2026).*

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Summary

The focus of this study is the identification and analysis of vitality and ornamental parameters of the trees in Gavriilo Princip Park, as an object of cultural-historical, sociological and ecological importance for the green infrastructure of Belgrade. The objective of the paper is to present the importance of regular monitoring of green areas in management of urban green spaces. On the researched location, a total of 172 trees within 39 taxa (Gymnosperms 8 taxa and Angiosperms 31 taxa) were identified and analyzed. The assessment of trees was conducted using the method of Visual Tree Assessment (VTA). The attributes based on which the analysis was carried out are vitality and ornamental marks expressed according to the established five-point scale.

The taxa within the Angiosperms dominate in the park with 141 trees, and the most frequently recorded species is *Tilia cordata* Mill. with 20 individuals. As for Gymnosperms 31 trees were identified, whereby Austrian pine is the most frequent with 15 trees. According to the vitality assessment the highest ranked species are *Taxus baccata* L., *Cercis siliquastrum* L., *Fraxinus angustifolia* Vahl. and *Prunus cerasifera* 'Atropurpurea', while *Cercis siliquastrum* L., *Fraxinus angustifolia* Vahl., *Liquidambar styraciflua* L., *Liriodendron tulipifera* L., *Magnolia × soulangeana* Soul.-Bod., *Platanus × hispanica* Mill. ex Münch., *Quercus robur* L., *Quercus robur* 'Fastigiata' were rated as the most decorative species. The taxa *Abies alba* Mill., *Acer negundo* L., *Catalpa bignonioides* Walter, *Salix babylonica* var. *matsudana* 'Tortuosa' and *Scandosorbus intermedia* Pers. had the lowest marks for both analyzed parameters.

Descriptive statistical analysis showed that the average marks of vitality and ornamental in Gymnosperms (3.32; 3.48) were higher than in Angiosperms (2.94; 3.12). The results of the Mann–Whitney U test show that there are statistically significant differences between gymnosperms and angiosperms, both in vitality ($U = 1618.50$; $Z = -2.38$; $p = 0.017$), and ornamental ($U = 1656.00$; $Z = -2.23$; $p = 0.026$). For the entire sample, Spearman's correlation coefficient was 0.906 ($p < 0.001$), which indicates a very strong correlation between vitality and ornamental. The Kendall's τ coefficient further confirmed the correlation analysis.

This paper indicates the crucial importance of early visual assessment of dendroflora in urban areas in order to apply care and protection measures adequately and in a timely manner. In this way, potential risks for users of public green areas would be prevented, but also possible centers of occurrence of phytopathological diseases, entomological damage and chains of damage.

VIZUELNA PROCENA STANJA DRVEĆA KAO OSNOVA ZA UPRAVLJANJE URBANIM ZELENIH POVRŠINAMA NA PRIMERU PARKA GAVRILA PRINCIPA U BEOGRADU

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Rezime

Fokus ove studije je identifikacija i analiza parametara vitalnosti i dekorativnosti drveća u parku Gavril Principa, kao objekta od kulturno-istorijskog, sociološkog i ekološkog značaja za zelenu infrastrukturu Beograda. Cilj rada je prikazati značaj redovnog monitoringa zelenih površina pri upravljanju zelenilom urbanih prostora. Na istraživanoj lokaciji ukupno je identifikovano i analizirano 172 stabla, u okviru 39 taksona (golosemenice 8 taksona i skrivenosemenice 31 takson). Procena stabala rađena je primenom metode vizuelne procene drveća (VTA). Atributi na osnovu kojih je rađena analiza su ocene vitalnosti i dekorativnosti izražene prema ustaljenoj petostepenoj skali.

U parku dominiraju taksoni u okviru skrivenosemenica sa 141 stablom, a najčešće zabeležena vrsta je *Tilia cordata* Mill. sa 20 jedinki. Što se tiče golosemenica, identifikovano je 31 stablo, pri čemu je najčešći crni bor sa 15 stabala. Prema oceni vitalnosti najviše su rangirane vrste *Taxus baccata* L., *Cercis siliquastrum* L., *Fraxinus angustifolia* Vahl. i *Prunus cerasifera* 'Atropurpurea', dok su najboljom dekorativnošću ocenjeni *Cercis siliquastrum* L., *Fraxinus angustifolia* Vahl., *Liquidambar styraciflua* L., *Liriodendron tulipifera* L., *Magnolia* × *soulangeana* Soul.-Bod., *Platanus* × *hispanica* Mill. ex Münch., *Quercus robur* L., *Quercus robur* 'Fastigiata'. Taksoni *Abies alba* Mill., *Acer negundo* L., *Catalpa bignonioides* Walter, *Salix babylonica* var. *matsudana* 'Tortuosa' i *Scandosorbus intermedia* Pers. najniže su ocenjeni po oba analizirana parametra.

Deskriptivnom statističkom analizom utvrđeno je da su prosečne ocene vitalnosti i dekorativnosti kod golosemenica (3.32; 3.48) više nego kod skrivenosemenica (2.94; 3.12). Rezultati Mann–Whitney U testa pokazuju da postoje statistički značajne razlike između golosemenica i skrivenosemenica, kako vitalnosti ($U = 1618.50$; $Z = -2.38$; $p = 0.017$), tako i dekorativnosti ($U = 1656.00$; $Z = -2.23$; $p = 0.026$). Na nivou celokupnog uzorka, Spearmanov koeficijent korelacije iznosi 0.906 ($p < 0.001$), što ukazuje na veoma jaku povezanost vitalnosti i dekorativnosti. Kendallovim τ koeficijentom dodatno je potvrđena sprovedena korelaciona analiza.

Ovim radom ukazuje se na krucijalnu važnost rane vizuelne procene dendroflora u urbanim područjima kako bi se blagovremeno i adekvatno primenjivale mere nege i zaštite. Na taj način, bili bi sprečeni potencijalni rizici po korisnike javnih zelenih površina, ali i moguća žarišta nastanka fitopatoloških oboljenja, entomoloških oštećenja i ulančavanja šteta.