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Visual Evaluation of Tree Health in Belgrade's Urban Forest: Čukarica Case Study

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Abstract. **A visual assessment of tree conditions is essential for public safety and health because urban trees increase attractiveness and provide other benefits, including reducing global warming and air filtration. Unhealthy or damaged trees pose a concern, emphasizing the importance of comprehensive inspections to identify hazards such as decay or dead branches. The assessment of the trees within the green infrastructure of the brownfield in Belgrade, Serbia, indicated that 35.1% of the examined trees failed to satisfy the basic preservation standards, emphasizing the necessity for proactive strategies for management.**

Urban trees are essential for enhancing urban environmental quality and offer numerous ecosystem benefits. These encompass climate regulation, air purification, noise reduction, wildlife habitat, soil stabilization, and visual enhancement of the landscape (Chiesura 2004; Lin and Lin 2010). Nonetheless, despite their numerous advantages, urban trees may also provide safety hazards, particularly as they mature or deteriorate. According to Koeser et al. (2016), the distribution of a tree's decay is a crucial component of its structural integrity and frequently has a bigger influence than the mere extent of decay. In response to these worries, visual tree assessment (VTA) has become a recognized approach for evaluating the stability and health of urban trees that has been verified by science. VTA integrates biomechanical principles with compliance with current arboricultural standards and regulations. The method comprises three main phases: 1) an initial visual inspection to detect symptoms of decay and assess the overall vitality of the tree; 2) a detailed examination of the structural defects identified; and 3) measurement, analysis, and evaluation of these defects to assess the residual load-bearing capacity and overall stability of the tree (Mattheck and Breloer 1994).

A VTA approach was used in 2022 to conduct a thorough evaluation of the green infrastructure in the municipality of Čukarica, Belgrade, Serbia. A total of 1340 trees were systematically evaluated, and the resulting data were thoroughly examined. This study, which focuses on the trees in the Čukarica urban landscape, emphasizes the critical significance that visual tree assessments have in the management of green infrastructure in urban areas.

Material and Methods

This study was conducted from May to Jul 2022 in the city of Belgrade—more precisely, in the city district Čukarica. Within the allocated study area, 1340 trees were found and examined. VTA technique was used to gather data. Measurements of height, length, and crown width were used to evaluate each tree's condition. The vitality of the trees was assessed using a 5-point scale: 1 = seriously diseased, damaged, or wilted tree; 2 = seriously diseased or decaying tree but still alive; 3 = vital tree requiring regular care to survive; 4 = healthy tree requiring occasional care to maintain vitality; and 5 = completely healthy tree with exceptional vitality. In addition, the aesthetic quality of the trees was assessed on a 4-point scale: 1 = tree with no aesthetic qualities; 2 = tree with poor aesthetic qualities; 3 = tree with a standard appearance with some defects; 4 = tree with very good aesthetic qualities; and 5 = tree with excellent aesthetic qualities, perfectly developed with no visible defects.

Comprehensive visual examination evaluated the overall condition of the trees, including the crowns and foliage, while considering potential phytopathological diseases, mechanical injuries, and entomological damage. Trees categorized as 1 or 2 in vitality and decorativeness (Semenyutina et al. 2022) were determined to be unacceptable for conservation and presented a possible hazard to site visitors. Furthermore, tree species designated as invasive in Serbia (Stojanović and Jovanović 2018) have been excluded from the conservation considerations for the purpose of biodiversity protection. Descriptive statistics have been used to determine the mean ($\bar{X}$), standard deviation ($\pm$ *SD*), and coefficient of variation (*CV*, %). Pearson correlation analysis was performed with statistical significance set at $P = 0.05$. An online statistics programs, DATA tab, was used for the statistical processing of this test (DATAtab E.U. Graz, Austria, https://datatab.net).

Results and Discussion

In the examined region, 405 out of 1340 tree individuals were identified as conifers, representing a diversity of 16 conifer species from a few genera: *Chamaecyparis* (1 species), *Hesperocyparis* (1), *Pseudotsuga* (1), *Taxus* (1), *Thuja* (3), and *Pinaceae* (9).

Within the coniferous category, the black pine (*Pinus nigra* J.F. Arnold) is the dominant species, with 196 trees, followed by the Arizona cypress [*Hesperocyparis arizonica* (Greene) Bartel.] with 135 trees.

The evaluated trees are primarily deciduous species, comprising 49 species from a number of genera: *Acer* (7 species), *Ailanthus* (1), *Betula* (1), *Castanea* (1), *Catalpa* (2), *Celtis* (1), *Cercis* (1), *Cornus* (1), *Corylus* (1), *Ficus* (1), *Fraxinus* (4), *Gleditsia* (1), *Juglans* (2), *Maclura* (1), *Magnolia* (1), *Malus* (1), *Morus* (1), *Platanus* (1), *Populus* (4), *Prunus* (6), *Pyrus* (1), *Quercus* (2), *Robinia* (1), *Sophora* (1), *Sorbus* (1), *Tilia* (2), and *Ulmus* (2). The dominant deciduous tree species are the silver lime (*Tilia tomentosa* Moench) with 100 individuals and the turkey oak (*Quercus cerris* L.) with 96 individuals. Furthermore, 170 invasive tree individuals were detected in the examined region, comprising 70 lacquer trees [*Ailanthus altissima* (Mill.) Swingle], 59 black locusts (*Robinia pseudoacacia* L.), and 41 box maples (*Acer negundo* L.). Despite their higher prevalence, the actual number of invasive

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Table 1. Descriptive statistics of the results obtained regarding vitality and decorativeness of the evaluated species.

		Frequency	Mean	*SD*	Variance	Min	Max	Mean ± *SD*
Vitality	Broadleaf	873	3.28	0.74	0.55	1	5	3.28 ± 0.74
	Conifer	405	3.07	0.75	0.56	1	5	3.07 ± 0.75
	Dead tree	62	1	0	0	1	1	1 ± 0
Decora-tiveness	Broadleaf	873	2.94	0.73	0.53	1	5	2.94 ± 0.73
	Conifer	405	2.83	0.7	0.5	1	5	2.83 ± 0.7
	Dead tree	62	1	0	0	1	1	1 ± 0

individuals of these species may be higher because limited access to certain areas has hindered their accurate positioning and detection. The presence of invasive woody species has significantly affected the vegetation dynamics in the studied area and its surroundings. Invasive plants pose a significant environmental problem and are considered the second greatest threat to global biodiversity after direct habitat destruction (Bell et al. 2003). In certain regions of the study area, invasive species dominate and pose a direct threat to both native and nonnative vegetation. In addition, 62 completely desiccated, dead trees were identified and positioned. On the basis of the assessment, ~35% (470 specimens) of the trees do not fulfill the minimum criteria to remain in the green area. This number also includes specimens of invasive species that should not be present in the area. The average vitality value of the trees among the specimens that fulfill the basic criterion for remaining in this green space is 3.45 (Supplemental Fig. 1). There were 873 observations of broadleaf trees, and the mean vitality rating was 3.28 with an *SD* of 0.73. Similarly, for conifer trees, there were 405 observations with a mean vitality rating of 3.07 and an *SD* of 0.76. For dead trees, there were 62 observations, all with a vitality rating of 1, resulting in a mean of 1 with no variability (*SD* of 0) (Supplemental Fig. 1, Table 1).

The result of the Pearson correlation showed that there was a very high, positive correlation between vitality and decorativeness. The correlation between vitality and decorativeness was statistically significant, r (1338) = 0.82, $P < 0.001$ (Supplemental Fig. 2). Regarding vitality, 17 deciduous species received a score of 1, and 85 species received a score of 2. In contrast, there were more species with a score of 1 (22) and fewer with a score of 2 (43) among the conifer species. Among the deciduous species, *Fraxinus excelsior* (5) had the most individuals with a score of 1, whereas among the coniferous species *Pinus nigra* had the most individuals with the lowest score (11) (Fig. 1). In terms of decorativeness, both scores were higher among deciduous species (1–39; 2–111), while the number was lower for coniferous species (1–28; 2–63).

A visual inspection of the condition of trees is essential for public safety and health in urban areas, where trees provide benefits such as shade, clean air, and wildlife habitat. However, diseased, damaged, or structurally compromised trees can pose risks. Through thorough visual inspections, arborists can identify hazards such as dead branches or rot. Proactive measures, such as pruning or tree removal, can then mitigate the risks and prevent accidents, ensuring a safe urban environment. Numerous studies indicate that trees with a healthy canopy help to reduce ground temperatures and contribute to cooler temperatures (Lin and Lin 2010). VTA plays a crucial role in this preliminary assessment of tree health, helping to assess risk and prioritize care (Li et al. 2022).

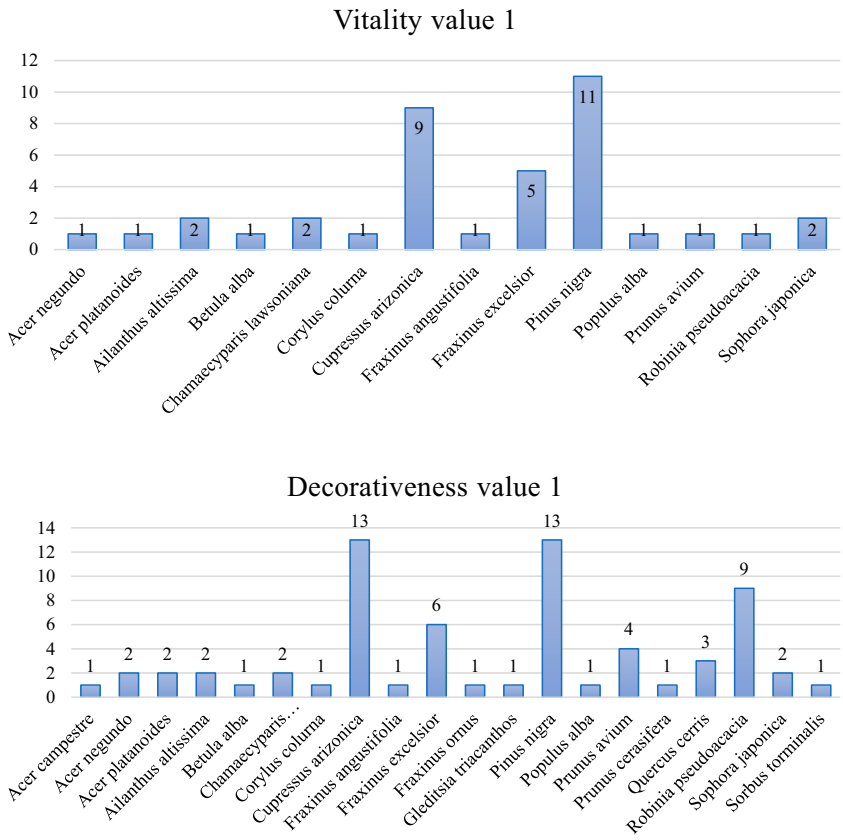

Fig. 1. Vitality of the evaluated trees with value 1 (above) and decorativeness of the evaluated trees with a value of 1 (below).

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