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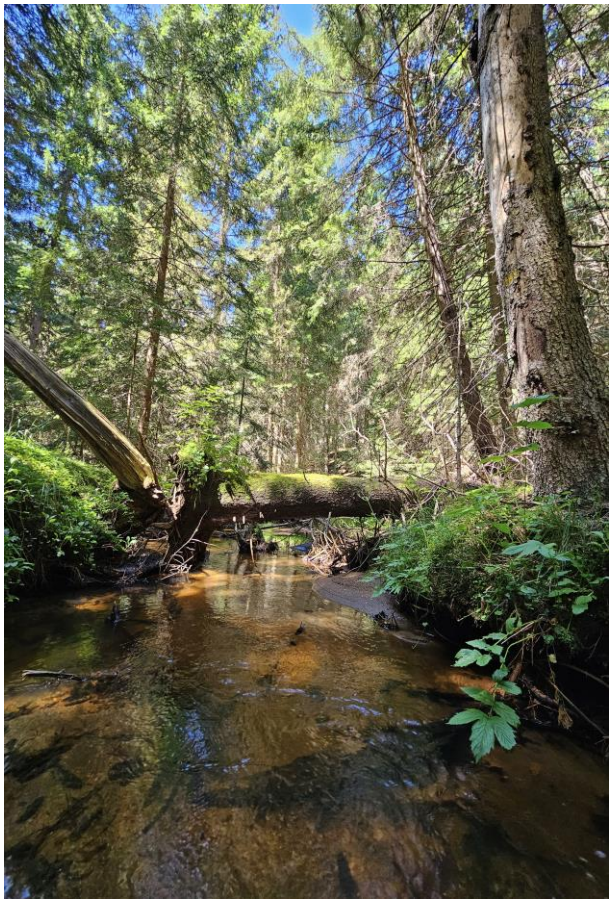

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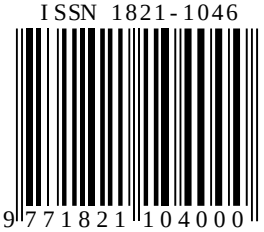

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CONDITION OF DOUGLAS FIR TREES IN THE URBAN AREA OF BELGRADE (SERBIA)

Filip JOVANOVIĆ[1], Ivana ŽIVANOVIĆ[1], Nenad ŠURJANAC[1]*
Đorđe FILIPOVIĆ[2], Đorđe JOVIĆ[1], Aleksandar LUČIĆ[1]

Abstract: *A total of 179 Douglas fir trees (Pseudotsuga menziesii /Mirb./ Franco) were examined in the municipality of Savski Venac, Belgrade, to assess the condition of this non-native species in Serbia and its adaptability to urban environments. Tree measurements (trunk diameter, tree height and crown diameter) were taken, and the trees were rated for vitality and decorativeness. The trees were found to be in a very good condition, with 89.05% of them showing no visible signs of disease. The average vitality rating was 3.94, and the average rating of decorativeness was 3.57. The results for vitality and some physical measurements exceeded values reported in the literature, suggesting that Douglas fir has adapted well to the urban environment of Belgrade. Although further research is needed, it can be concluded that Douglas fir is a suitable species for landscape planting in urban areas of Serbia.*

Keywords: *Pseudotsuga menziesii* (Mirb.) Franco, vitality, decorativeness, tree measurements, species adaptability, Belgrade.

STANJE STABALA DUGLAZIJE U GRADSKOJ SREDINI BEOGRADA (SRBIJA)

Sažetak: *Ispitano je 179 stabala duglazije (Pseudotsuga menziesii /Mirb./ Franco) na teritoriji GO Savski venac u Beogradu, radi utvrđivanja stanja ove alohtone vrste u Srbiji i njene sposobnosti prilagođavanja urbanim sredinama. Stablima su izmerene dimenzije i ocenjena je njihova vitalnost i dekorativnost. Analizirana stabla su u vrlo dobrom stanju, pri čemu 89,05% stabala nije pokazivalo vidljive znake bolesti. Prosečna ocena vitalnosti je 3,94, a prosečna ocena dekorativnosti – 3,57. Dobijene vrednosti za vitalnost i pojedine dimenzije stabala su veće od onih navedenih u literaturi, što sugeriše da se duglazija dobro prilagodila urbanoj sredini Beograda. Premda su neophodna dalja istraživanja, na osnovu ovih rezultata, duglazija se smatra pogodnom vrstom za sadnju u urbanim sredinama Srbije.*

Ključne reči: *Pseudotsuga menziesii* (Mirb.) Franco, vitalnost, dekorativnost, dimenzije stabala, adaptibilnost vrste, Beograd.

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1. INTRODUCTION

Urban green areas regulate the microclimate of city districts, reduce air pollution, mitigate wind blows and control soil erosion, reduce the negative effects of precipitation, and reduce the noise level in cities (Prpić, 1992; Vuletić et al., 2010).

In Belgrade, the capital of the Republic of Serbia, urban green areas cover around 2,907 ha, including parks and squares, greenery of residential areas, green areas of roads, urban forests, coasts and shores, protective areas and other categories of greenery (Milanović, 2006). The dendroflora of the area was gradually enriched by man. In addition to native species of coniferous trees, there is also a large number of species brought from other climates. According to literature (Maksimović et al., 1979), among the domestic conifer species – Austrian pine (*Pinus nigra* J.F.Arnold) and Norway spruce (*Picea abies* /L./ Karst.) are the most common. As for the introduced genera and species of conifers, the most represented are silver fir (*Abies alba* Mill.), cedar (*Cedrus* spp.), yew (*Taxus baccata* L.), junipers (*Juniperus* spp.), etc.

The selection of plant species for planting should maximally correspond to the targeted environmental conditions. The selected species should have fast growth and productivity, and decorative properties. Hence, when selecting plant species for urban green areas, species that are extremely sensitive to air pollution should be avoided (Anastasijević, 2011).

Douglas fir [*Pseudotsuga menziesii* (Mirb.) Franco, Pinaceae] is a conifer species native to North America. Under optimal conditions, this species reaches a height of over 100 m, a diameter of 4 m, and an age of 1,300 years or more (Hermann & Lavender, 1990). It is notable for its adaptability and has been successfully introduced to Europe, where it thrives in diverse climates, including urban areas (Castaldi et al., 2020).

The health and stability of urban trees are increasingly important due to environmental stressors, such as pollution and limited root space. In this paper, Douglas fir trees growing in the area of Belgrade city were examined to assess their condition and adaptability to urban environments. The results of this study can guide future efforts to maintain and expand urban greenery, ensuring that green spaces of Belgrade city continue to offer vital ecological, social and aesthetic benefits to its residents.

2. MATERIAL AND METHODS

2.1. Study area

In the present study, Douglas fir trees were examined in the municipality of Savski Venac (Figure 1). This is one of the oldest and most significant municipalities in the city of Belgrade, serving as a major traffic, tourist and business center. Home to about 40,000 residents, and twice as many workers, this area highlights the need for thoughtful urban green space management (Beogradska opština Savski venac, 2022). The municipality covers an area of 15.8 km², with its northernmost point located at 44°48'54" N and its southernmost at 44°45'15" N. The westernmost point is at 20°25'29" E and the easternmost at 20°28'26" E. The municipality stretches 6.91

km from south to north and 5.20 km from west to east (Vojnogeografski institut, 1990). Geographically, the highest elevation in Savski Venac is found at the Royal Complex (210 m), while the lowest point is at the confluence of the Topčider River with the Sava River (75 m). The geological substrate of the area comprises Holocene-age sediments and the alluvial plain of the Sava River, while the soils are mostly anthropogenically modified. The climate of Savski Venac is temperate and continental, characterized by long, hot summers and cold winters. Due to the high density of residential areas and heavy traffic, the municipality experiences a localized increase in temperatures, contributing to an urban heat island effect. However, the abundant green spaces help counteract this effect (Gradski zavod za javno zdravlje Beograd, 2022). The flora in Savski Venac is diverse, with deciduous trees, such as oak, birch, maple, cherry plum, apple, and poplar being common, alongside conifers like pines and spruces (Gradski zavod za javno zdravlje Beograd, 2022).

2.2. Data and methodology

A total of 179 Douglas fir trees were sampled in the yards of public institutions of Savski Venac municipality. The investigation included measuring tree parameters – trunk diameter (at breast height), tree height and crown diameter – as well as assessing the vitality and decorativeness of the trees.

Trunk diameter was measured using a diameter tape (Bandmass 10 m, Weiss, Germany). Tree height was measured with a height measuring instrument (Vertex 4, Haglöf, Sweden). Crown diameter was determined by projecting the crown edges to the ground and measuring along one axis with a measuring tape (Fast Winder Frame 30 m, Weiss, Germany). The vitality and decorativeness of the trees were assessed using the Visual Tree Assessment (VTA) method (Mattheck & Breloer, 1994), according to predefined scales, as shown in Table 1. Vitality was evaluated based on tree health, including signs of disease or physical damage, while decorativeness was based on the aesthetic value and structural form of trees.

Table 1. *Rating scales for vitality and decorativeness of trees*

Grade	Vitality	Decorativeness
5	Excellent, healthy and strong trees, with no visible insect damage or indication of disease and no mechanical wounds.	Visually imposing and aesthetically valuable trees.
4	Trees in good condition, healthy, with only slight signs of injury, disease or physiological weakness.	Trees with a visually balanced form.
3	Trees with some mechanical, phyto-pathological or entomological damage.	Trees that have a clearly outlined crown in silhouette.
2	Trees with clearly visible mechanical damage from insects and/or diseases.	Trees of a disharmonious and disproportionate silhouette with insufficiently clearly delineated habitus.
1	Dead or nearly dead trees.	Trees without aesthetic value.

The collected data was processed using descriptive statistical procedures. The statistical analysis included the following basic statistical parameters: minimum

value, maximum value, variation range, mean value, standard deviation and coefficient of variation. The statistical analysis was performed using Statgraphics Centurion software (ver. XVI.I, 2009, Statpoint Technologies, Inc., Warrenton, VA).

Figure 1. *Locations of the analyzed Douglas fir trees in Savski Venac municipality, Belgrade, Serbia*

3. RESULTS AND DISCUSSION

The descriptive statistics for Douglas fir trees in Belgrade revealed high variability in their physical measurements (Table 2; Figure 2). The trunk diameter varied from 12.50 cm to 65.00 cm, with a mean value of 30.98 cm, and a coefficient of variation of 35.29%. The crown diameter measurements ranged from 1.25 m to 13.50 m, with a mean value of 6.70 m, and a coefficient of variation of 35.47%. The height of the trees ranged from 4.50 m to 20.00 m, with a mean value of 13.84 m, and a coefficient of variation of 29.89%. The obtained results suggest that the sample included trees of various ages.

Table 2. *Descriptive statistics for the vitality, decorativeness and physical measurements of Douglas fir trees in the urban area of Belgrade*

Property	Mean value	Standard deviation	Coeff. of variation (%)	Minimum value	Maximum value	Variation range
Vitality (1–5)	3.94	1.07	27.07%	1.00	5.00	4.00
Decorativeness (1–5)	3.57	1.02	28.63%	1.00	5.00	4.00
Trunk diameter (cm)	30.98	1.09	35.29%	12.50	65.00	52.50
Crown diameter (m)	6.70	2.38	35.47%	1.25	13.50	12.25
Tree height (m)	13.84	4.14	29.89%	4.50	20.00	15.50

On the other hand, the vitality and decorativeness were somewhat less variable traits of the analyzed Douglas fir trees (coefficients of variation 27.07% and 28.63%, respectively). The vitality ranged from grade 1 to grade 5, with a mean value of 3.94, whereas the grades of decorativeness ranged from 1 to 5, with a mean value of 3.57 (Table 2). In addition, it was found that the analyzed trees are in very good condition based on their health status, considering that most of them (89.95%) had no visible indication of disease.

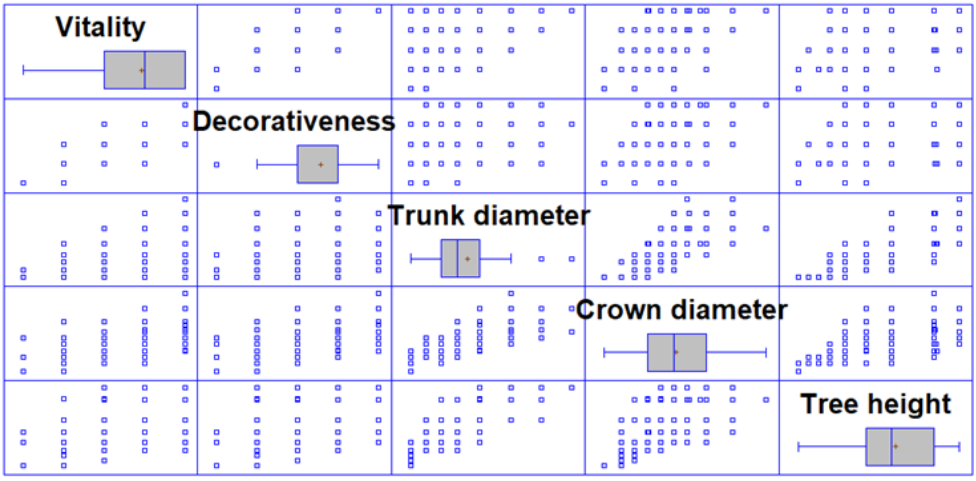

Figure 2. *Box-and-Whisker plot of basic parameters of vitality, decorativeness and physical measurements of Douglas fir trees in the urban area of Belgrade. Legend: middle sign = mean, middle line = median, box = lower and upper quartile, whisker = variation range*

In comparison with literature data, the mean trunk diameter of the analyzed Douglas fir trees, which was 30.98 cm, exceeded the mean value reported by Ratknić and Rakonjac (2010) for Douglas fir plantations on various sites in Serbia. For trees aged 15 to 30 years, they reported an average trunk diameter of 23.60 cm. Similarly, Rais et al. (2013) studied 133 Douglas fir trees and found an average trunk diameter ranging between 22.30 cm and 23.40 cm. In contrast, Smolnikar et al. (2018) studied 1,061 Douglas fir trees in Slovenia and reported slightly higher mean trunk diameter of 31.2 cm. In addition, Pretzsch et al. (2015) analyzed 1,613 Douglas fir trees and calculated a mean trunk diameter of 32.7 cm.

As for the crown diameter, the mean value in our study was 6.70 m, which is notably larger than the 3.10 m mean crown diameter reported by Pretzsch et al. (2015). On the other hand, the mean tree height observed in our study was lower than the average values reported by Pretzsch et al. (2015) (21.29–22.70 m), but higher than the value found by Smolnikar et al. (2018) (6.05 m).

Assessing the vitality of park species and identifying the biotic and abiotic factors that directly or indirectly threaten their condition is crucial to applying appropriate care and protection measures (Mladenović et al., 2020). This process ensures that targeted interventions can be implemented to promote the health and longevity of park vegetation, preserving both ecological balance and aesthetic value. The vitality of the sampled trees of Douglas fir in this study was in average 3.94 on a scale 1–5, which is higher than the mean value reported by Smolnikar et al. (2018) for 1061 trees of Douglas fir in Slovenia (2.21 on a scale 1–3). Given that the trees have been sampled in yards of public institutions, the observed high tree vitality is probably a result of tending measures applied in these areas.

For the successful establishment of functional green areas in urban environments, it is essential to use healthy planting stock and carefully selected plant species. This should be coupled with proper tending and protection measures, including the replacement of sensitive species with more resilient ones (Mladenović et al., 2018). Although further research is needed, based on the results of this study, and by comparison with literature data, it can be argued that the Douglas fir has adapted well to the urban environment of Belgrade, displaying very good health and proper physical characteristics. As a result, this species, which to date has not shown invasive behavior in Serbia, can be recommended for planting in the urban areas of Serbia as a landscape tree.

4. CONCLUSION

Based on the obtained results for the vitality, decorativeness, and physical measurements of Douglas fir trees in the urban area of Belgrade, the following conclusions can be drawn:

- the physical measurements of Douglas fir trees in Belgrade (trunk diameter, tree height, and crown diameter) are highly variable, indicating that the sampled trees represent a wide range of ages;
- vitality and decorativeness are variable traits of the Douglas fir trees in the area;
- the analyzed Douglas fir trees are in very good health, with 89.05% of the trees showing no visible signs of disease. The mean vitality rating

is 3.94, and the mean rating of decorativeness is 3.57, both on a scale of 1 to 5.

- the observed values for vitality and some physical measurements, such as crown diameter and in some cases trunk diameter, were greater than those reported in the literature for the same species in similar environments.

Although further research is needed, Douglas fir has demonstrated good adaptation to the urban environment of Belgrade and should be considered a suitable species for landscape planting in urban areas of Serbia.

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CONDITION OF DOUGLAS FIR TREES IN THE URBAN AREA OF BELGRADE (SERBIA)

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Summary

In the present paper, Douglas fir trees (*Pseudotsuga menziesii* /Mirb./ Franco) were examined in the urban area of Belgrade to assess the condition of this non-native species in Serbia and its adaptability to urban environments.

A total of 179 trees of Douglas fir were examined in the area of the municipality of Savski Venac (Figure 1). The trunk diameter, tree height and crown diameter of the sampled trees were measured using adequate tools and instruments (Weiss Bandmass 10 m; Haglöf Vertex 4; Weiss Fast Winder Frame 30 m). The vitality and decorativeness of the trees were assessed according to the VTA method (Visual Tree Assessment) (Mattheck & Breloer, 1994) using the rating scales given in Table 1. The obtained data was processed employing descriptive statistical procedures.

The results show that the trunk diameter of the analyzed trees has a range of values 12.5–65.00 cm and a mean value of 30.98 cm; the crown diameter ranged from 1.25 m to 13.5 m, with a mean value of 6.70 m, and the tree height ranged from 4.50 m to 20.00 m,

with a mean value of 13.84 m, indicating a wide range of age of the sampled trees. On the other hand, the vitality and decorativeness were less variable features. The mean rating of vitality is 3.94, and the mean rating of decorativeness is 3.57 (Table 2). In addition, the analyzed trees are in very good condition based on their health status (89.05% of trees are with no visible indication of disease). In comparison with the literature data (Pretzsch et al., 2015; Rais et al., 2013; Ratknić & Rakonjac, 2010; Smolnikar et al., 2018), the obtained values for the vitality and physical measurements (crown diameter and, in some cases, trunk diameter) of the sampled trees were greater than those stated for the same species in similar environments.

Although further research is needed, it can be concluded that Douglas fir has adapted well to the urban environment of Belgrade and it should be considered a suitable landscape tree species for planting in urban areas of Serbia.

STANJE STABALA DUGLAZIJE U GRADSKOJ SREDINI BEOGRADA (SRBIJA)

Filip JOVANOVIĆ, Ivana ŽIVANOVIĆ, Nenad ŠURJANAC
Đorđe FILIPOVIĆ, Đorđe JOVIĆ, Aleksandar LUČIĆ

Rezime

U radu se analiziraju stabla duglazije (*Pseudotsuga menziesii* /Mirb./ Franco) u urbanom području grada Beograda, kako bi se procenilo stanje ove alohtone vrste u Srbiji i njena adaptabilnost na urbane uslove.

Ispitano je 179 stabala na području GO Savski Venac (slika 1). Prečnik debla, visina stabala i prečnik krošnje mereni su korišćenjem odgovarajućih alata i instrumenata (Weiss Bandmass 10 m; Haglöf Vertex 4; Weiss Fast Winder Frame 30 m). Vitalnost i dekorativnost stabala procenjeni su prema VTA metodi (Mattheck & Breloer, 1994) na skali 1–5 (tabela 1). Podaci su obrađeni u skladu sa deskriptivnim statističkim metodama.

Rezultati pokazuju da prečnik debla analiziranih stabala varira od 12,5 cm do 65,00 cm, s prosečnom vrednošću 30,98 cm; prečnik krošnje varira od 1,25 m do 13,5 m, s prosečnom vrednošću 6,70 m, dok visina stabala varira od 4,50 m do 20,00 m, s prosečnom vrednošću 13,84 m, što ukazuje na širok raspon starosti uzorkovanih stabala. S druge strane, vitalnost i dekorativnost su manje promenljive karakteristike stabala. Prosečna vrednost vitalnosti iznosi 3,94, a prosečna vrednost dekorativnosti je 3,57 (tabela 2). Analizirana stabla su u vrlo dobrom stanju na osnovu procene zdravstvenog stanja (89,05% stabala nema vidljivih znakova bolesti). U poređenju sa literaturnim podacima (Pretzsch et al., 2015; Rais et al., 2013; Ratknić & Rakonjac, 2010; Smolnikar et al., 2018), dobijene vrednosti za vitalnost i pojedine dimenzije (prečnik krošnje i, u nekim slučajevima, prečnik debla) uzorkovanih stabala su veće od onih navedenih za istu vrstu u sličnim okruženjima.

Premda su neophodna dalja istraživanja, na osnovu ovih rezultata se može zaključiti da je duglazija dobro prilagođena vrsta gradskoj sredini Beograda i da se može preporučiti za sadnju u urbanim područjima Srbije.

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