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URBAN STRESS TOLERANCE OF EVERGREEN TREES ON GREEN AREAS OF NOVI SAD CITY

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Summary: The Novi Sad area belongs to hygrophilic, mesophilic and xerophilic forest habitats. This environment is unsuitable for coniferous species. In the studied area, longitudinal monitoring has indicated a significant reduction in life expectancy of many species, especially of the representatives of conifers. Among the introduced representatives, *Cupressus arizonica* Green, *Taxodium distichum* (L.) Rich, *Tsuga canadensis* Carr. and *Cedrus atlantica* G.Don have demonstrated exceptional adaptability, condition and vitality in the urban Novi Sad environment.

Keywords: conifers, ecological conditions, urban stress, adaptability, monitoring.

INTRODUCTION

According to Craul (1999) and Unger et al. (2001), urban environment is characterized by increased air temperature, greater concentration of exhaust gasses and unbalanced groundwater regimen. The findings of numerous studies in this field (Kramer and Kozłowski, 1979; Kabata-Pendias and Pendias, 1986; Bargagli, 1998; Rajšić et al., 2008; Kastori and Milošević, 2011) confirm that deposition of pollutants from the air adversely affects physiological processes in plants. Moreover, Chen (2004) and Ninić-Todorović et al. (2010) noted that green areas are essential for the urban life quality, as they make living conditions more humane. In this context, Gerhold and Porter (2007) favor the species with strong trunk and developed canopy, due to their better adaptation to the stresses induced by negative environmental factors, as well as better resistance to pests and illnesses and minimal maintenance requirements.

Airborne pollutants, according to Hinrichsen (1987), can have both synergic and antagonistic effect on plant growth. They typically disrupt the nutrient transport mechanism from the roots to the tree trunk. Heliotis (1988)

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further noted that pollutant deposition on conifers could cause their extinction. In a more recent study, Donovan et al. (2005) determined that presence of *Pinus nigra* Arn. in urban environments significantly improved air quality. According to the findings reported by Kastori and Milošević (2011), increased occurrence of acid rains during the 20th century contributed to the greater quantity of soluble matter and gasses in the atmosphere.

Findings of the study conducted by Očokoljić and Ninić-Todorović (2007) indicate that *Cupressus arizonica* Greene is highly adaptable to the Novi Sad urban conditions. These results were subsequently confirmed by Todorović (2012), who also highlights the resistance of *Cupressus arizonica* Green to the stress induced by climatic and edaphic factors commonly affecting the green areas in Novi Sad.

Swamp cypress (*Taxodium distichum* [L.] Rich.) was first introduced to Europe around 1640 from southeastern and flooded areas of the US. In Novi Sad, it is grown as an ornamental and resistant species in public parks, and is used within the reforestation initiatives (Ninić-Todorović and Očokoljić, 2001).

MATERIALS AND METHODS

Novi Sad is located on a plain, at an average altitude of 72 to 80 m asl. Its climate is temperate continental to modified continental. The mean annual temperature and precipitation are 11.1 °C and 603.1 mm, respectively. The soil is mostly under anthropogenic influence, of the urbisol type (Očokoljić and Ninić-Todorović, 2002). The methodology adopted in this study included longitudinal monitoring of the existing genotypes and studying their adaptability. Eco-physiological adaptability was assessed at the individual level by observing and analyzing autochthonic and introduced trees. Using the methodology described by Anastasijević (2012), for the creation of Futoški Park cadastre (Ninić-Todorović et al., 2010), as well as that pertaining to the conifers in the Novi Sad district Bistrica (Žugić, 2013), biometric parameters for the conifers present in these green areas were obtained.

RESULTS

More extensive and detailed studies of exogenous tree species in Serbia commenced in the mid-20th century and have, thus far, yielded numerous important findings and conclusions (Ninić, 1981; Vidaković, 1982; Vukićević, 1996; Jovanović, 2000). In the last 35 years, at the Faculty of Agriculture, University in Novi Sad, the work on monitoring autochthonic and introduced dendroflora within urban cenoses has been conducted. Green areas in Novi Sad abound with a wide spectrum of autochthonic dendroflora, with *Cupressus arizonica* Greene as one of its representatives. The species has been introduced into this area, and is currently grown for its highly decorative value across different green space categories. The analysis of *Cupressus arizonica* Greene trees, cultivated in the park of the Institute for cardiovascular diseases in Sremska Kamenica (Ninić-Todorović and Očokoljić, 2007; Očokoljić et al., 2005; Todorović, 2012) revealed that they possess exceptional eco-physiological characteristics. These favorable traits are exhibited through overall appearance, resistance to illnesses and pests, general functionality and visual and esthetic value. Their longitudinal monitoring has indicated that these trees periodically produce abundant yield, thus manifesting their reproductive function, significant for the production of seed material that can be used in horticulture and landscape architecture.

By analyzing *Tsuga canadensis* Carr. growth and productivity, significant productivity within the area of the Novi Sad City cemetery was noted, at the habitat of the maple and ash association. According to the statistical parameters of the analyzed trees, their height ranged from 8.50 m to 11.50 m, and the chest-level trunk diameter from 22.20 cm to 30.20 cm, while crown volume ranged from 9.42 m to 13.50 m. For a more detailed knowledge about adaptability of decorative evergreen species it was performed a comparative analysis of climate similar sites in the city of Belgrade, at localities Kalemegdan and Arboretum of Faculty of Forestry. Quantitative measurements of *Tsuga canadensis* Carr. adult trees were carried out on the former habitat of *Quercetum farnetto-cerris* Rud. in Belgrade. The height of these trees ranged from 7.56 m to 8.90 m, the chest-level trunk diameter from 9.39 cm to 12.80 cm, and the crown volume from 16.48 m to 21.20 m. In both habitats, cones were also analyzed and revealed significant variability with respect to the studied parameters (Table 1). In Belgrade, the cone length ranged from 13.58 mm to 16.87 mm, while it measured 17.68 mm to 20.46 mm in Novi Sad. The mean cone width for the trees grown in Belgrade was 6.59 mm to 7.76 mm, while those in Novi Sad measured 7.99 mm to 9.26 mm in width.

The data obtained indicate variability between the cones of *Tsuga canadensis* Carr. parent trees located in Belgrade and Novi Sad. Given the adaptability of the *Tsuga canadensis* Carr. species in both habitats, it is possible to improve their yields in the later stages of tree growth, with the aim of applying the obtained reproductive material in horticulture and landscape architecture (Očokoljić et al., 2005).

In the parks within the Novi Sad area, *Taxodium distichum* /L./Rich. is of particular ecological value. For the purpose of this study, 10 trees grown in Futoški park and 18 located in Dunavski park were selected. These

individuals possess exceptional eco-physiological characteristics, as evident in their overall appearance, resistance to pests and illnesses, and visual and esthetic qualities. The distance among the chosen trees is about 5 meters. In both parks, the soil belongs to the hydromorph order, fluvial and fluvial-gley class, fluvial meadow soil - humofluvisol (Ninić-Todorović and Ocokoljić, 2001).

Table 1. Statistical parameters pertaining to the *Tsuga canadensis* Carr. cone quantitative characteristics

Characteristics	Tree	X±S _x	S±S _s	V±S _v
Belgrade				
Cone length (mm)	1	16.87-0.17	1.79-0.12	10.63-0.72
Cone width (mm)		7.08-0.07	0.77-0.05	10.86-0.74
Cone length (mm)	2	15.85-0.14	1.64-0.09	10.32-0.63
Cone width (mm)		7.76-0.07	0.82-0.05	10.62-0.64
Cone length (mm)	3	13.58-2.20	1.72-0.14	12.64-1.06
Cone width (mm)		6.59-0.08	0.74-0.06	11.30-0.94
Novi Sad				
Cone length (mm)	4	20.46-0.10	1.21-0.03	5.91-0.35
Cone width (mm)		9.26-0.04	0.48-0.02	5.17-0.36
Cone length (mm)	5	18.27-0.08	1.03-0.06	5.62-0.34
Cone width (mm)		8.35-0.03	0.39-0.02	4.76-0.29
Cone length (mm)	6	17.68-0.19	2.24-0.13	12.66-0.77
Cone width (mm)		7.99-0.04	0.50-0.01	6.28-0.38
Cone length (mm)	7	19.06-0.09	1.09-0.06	5.70-0.34
Cone width (mm)		9.04-0.02	0.29-0.01	3.23-0.20

The mean tree height among the *Taxodium distichum* /L./Rich. individuals located in Futoški park is 17.6 m, and the chest-level trunk diameter is 56.22 cm (Table 2). In Dunavski park, the mean tree height of 22.55 m and the chest-level trunk diameter of 59.72 cm were measured. At both locations, the tree crown was well developed, with mean height and width of 14.72 m and 8.05 m, respectively, measured in Futoški park, with slightly higher values of 19.63 m and 9.67 m for the meant tree crown height and width for individuals in Dunavski park. The coefficient of variation values satisfactorily reflect the hereditary potential.

Table 2. Statistical parameters for five characteristics of 28 *Taxodium distichum* /L./Rich trees grown in Novi Sad

FUTOŠKI PARK			
Boundary values Min.-max.	X±S _x	S±S _s	V±S _v
Tree height(m)			
16-21	17.6±1.05	1.84±0.75	10.44±4.26
Trunk diameter at 1.30 m height (cm)/ Prečnik debla na 1,30m			
36-90	56.22±10.11	17.69±7.22	31.47±12.85
Trunk height below the crown (m)			
2-4.5	2.88±0.45	0.78±0.32	27.13±11.07
Crown height (m)			
13-17.5	14.72±0.87	1.53±0.62	10.39±4.24
Crown diameter (m)			
4.5-10	8.05±1.27	2.21±0.90	27.54±11.24
DUNAVSKI PARK			
Tree height (m)			
18-28	22.55±1.71	2.99±1.22	13.28±5.42
Trunk diameter at 1.30 m height (cm)			
38-79	59.72±6.22	10.89±4.44	18.23±7.44
Trunk height below the crown (m)			
1.8-5	2.95±0.65	1.15±0.47	38.90±15.88
Crown height (m)			
6-14	9.67±1.41	2.47±1.00	25.59±10.44
Crown diameter (m)			
16-26	19.63±1.61	2.82±1.15	14.38±5.87

Field studies conducted over the last two decades in the Novo Naselje, Slobodana Jovanovića Boulevard (GUP Novog Sada, 2000), revealed magnificent changes in the number of conifer species. Namely, there was a significant reduction of conifer species in the street profiles (Figure 1). It was identified that 64.52% of the existing conifer trees are exotic. As a part of the development of the Novi Sad General Urban Plan (GUP), during 1994, conifer cadastre for the Novo Naselje district (Bistrica area) was created. It revealed that most abundant genotype representatives in 1994 were *Pinus nigra* Arn. with 32%, *Cedrus atlantica* G.Don with 16% and *Sequoiadendron giganteum* Lindl. with 12% participation in the total conifer number. A more recent field study, conducted in 2013, revealed some important changes in the conifer structure and number. Currently, *Picea abies* Karst. is most abundant, with 19.27%, followed by *Thuja orientalis* L. with 17.35% and *Pinus nigra* Arn., the percentage of which declined in comparison with the earlier study findings (Graph 1). *Picea abies* Karst. has become more numerous in the Novo Naselje district as a result of the initiative, whereby this species is planted with the roots following the New Year’s celebrations.

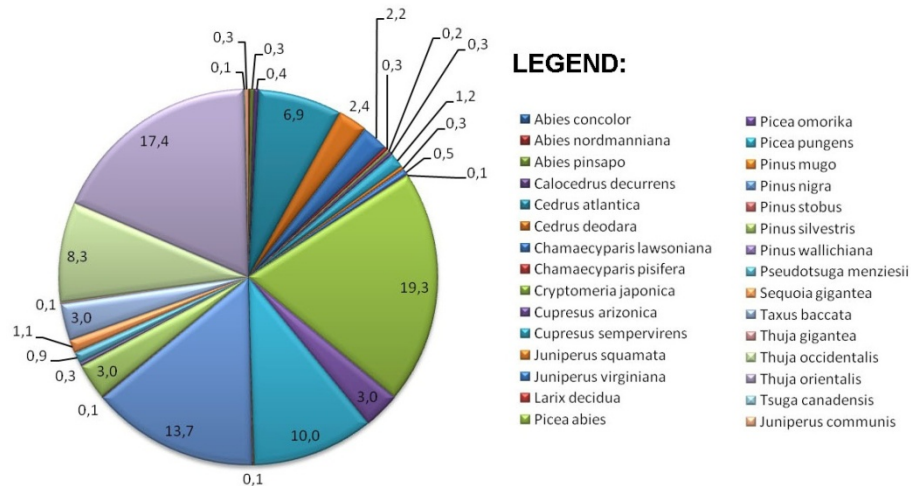


Figure 1. Prevalence of various coniferous species in the Novi Sad district Novo Naselje in 2013.

Significant reduction in the number of *Sequoiadendron giganteum* Lindl. trees occurred between 1994 and 2013, as presently only 21 individuals remain, corresponding to 34.37% of the total conifer number (Figure 2). In addition, within the residential green spaces, *Abies concolor* Lindl. et Gord suffered severe degradation with 62.96% of total. Due to the stress caused by a wide amplitude of absolute extremes and inadequate maintenance measures, nine *Picea omorika* /Panč/Purkyne were uprooted in the Dušana Danilovića street. The best adaptability was noted for *Cedrus atlantica* G. Don and *Pinus nigra* Arn.



Image 1. Slobodana Jovanovića Boulevard in the Novi Sad district Novo Naselje



Figure 2. Dried-out *Sequoiadendron giganteum* Lindl. Trees at the corner of Slobodana Jovanovića Boulevard and Raše Radujkova

DISCUSSION

The Novi Sad area belongs to hygrophilic, mesophilic and xerophilic forest habitats and is subjected to the steppe vegetation effects. In the city green spaces, reproductive material obtained from tree nurseries aimed at reforestation is commonly used. In addition, the reproductive material is also sourced from horticultural nurseries, where the ecological conditions significantly differ from those within the Novi Sad area. These factors, compounded by the minimal maintenance measures, due to financial constraints, have resulted in a significantly diminished conifer function in the Novi Sad area. Terrain configuration, edaphic and microclimate factors, in interaction with environmental conditions and genotype, have exhibited weaker or stronger reaction levels among the individuals tolerant of stress induced by urban cenoses.

CONCLUSION

In the Novi Sad district Novo Naselje, conifer genotypes of European, American and Asian origin are mostly cultivated, with the exception of *Cedrus atlantica* G. Don, which originates from the northern parts of Africa, and has adapted to the ecological conditions prevalent in the city. Longitudinal monitoring of physiological and ecological characteristics of gymnosperm and angiosperm genotypes within the Novi Sad green areas enables reaching some conclusions regarding the cultivation and longevity potential of these species. Based on the analysis of growth and productivity of *Tsuga canadensis* in Belgrade and Novi Sad, trees are characterized by rapid and stable growth, and it can be concluded that the terms of the former habitat of oak and ash (Novi Sad) are more conducive to this species than habitat of *Quercetum farnetto-cerris* Rud. (Belgrade). These findings are valuable for the conservation of sanitary, hygienic and visual authenticity of the city environment. Owing to the methodology adopted in this study for the development of the green areas cadastre, whereby a pilot study was conducted for the Futoški park, the direction for the use of GIS—a software tool for data collection and analysis—was defined with the aim of better management of the green spaces in Novi Sad.

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TOLERANCIJA ZIMZELENOG DRVEĆA NA GRADSKI STRES NA ZELENIM POVRŠINAMA U GRADU NOVOM SADU

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Izvod: Područje grada Novog Sada pripada staništima higrofilnih, mezofilnih i kserofilnih šuma. Kao takvo nije pogodno za gajenje četinara. Značajna je sanitarna i higijenska funkcija koju četinari ostvaruju u gradu i vizuelni efekat na zelenim prostorima. Dugogodišnji monitoring ukazao je na značajno smanjenje dužine života, posebno predstavnika konifera, na osmatranom prostoru. Od introdukovanih predstavnika *Cupressus arizonica* Green, *Taxodium distichum* [L.] Rich, *Tsuga canadensis* Carr., *Cedrus atlantica* G. Don pokazali su izuzetnu adaptivnost, kondiciju i vitalnost u urbanim uslovima Novog Sada.

Ključne reči: konifere, ekološki uslovi, urbani stres, adaptivnost, monitoring.

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