INSTITUTE OF FORESTRY • BELGRADE
INSTITUT ZA ŠUMARSTVO • BEOGRAD
SUSTAINABLE FORESTRY COLLECTION 91, 2025
ODRŽIVO ŠUMARSTVO ZBORNIK RADOVA 91, 2025

DOI: 10.5937/SustFor2591069D
UDK: 630*111:582.477(497.11Beograd)
Original scientific paper

CLIMATE CHARACTERISTICS AND DIAMETER INCREMENT OF INCENSE-CEDAR: POTENTIAL USE IN AFFORESTATION IN BELGRADE AREA (REPUBLIC OF SERBIA)

Tatjana DIMITRIJEVIC[1], Mihailo RATKNIC[1] Sasa EREMIJA[1], Sabahudin HADROVIĆ[1], Violeta DJORDJEVIĆ[2], Snežana KONATAR[3]*

Abstract: *The paper presents the results of research dealing with the influence of climatic factors on the size of earlywood and latewood and the total diameter increment of incense-cedar* (*Calocedrus* decurrens (Torr.) Florin*). Samples taken from 30 trees at a height of 1.3 m were used in the analysis. The values were correlated with the mean monthly air temperature and precipitation sums (from April to September). In addition, the tree age expressed in years was included as an important factor. The analysed parameters explained 64.8% of the current diameter increment, 64.8% of the latewood, and 55.8% of the earlywood share.*

Keywords: *Calocedrus decurrens*, climate change, REG_IN model, early wood, late wood, total growth

КЛИМАТСКЕ КАРАКТЕРИСТИКЕ И ДЕБЉИНСКИ ПРИРАСТ ЛИБОКЕДРА:ПОТЕНЦИЈАЛНА УПОТРЕБА У ПОШУМЉАВАЊУ НА ПОДРУЧЈУ БЕОГРАДА (РЕПУБЛИКА СРБИЈА)

Извод: *У раду су приказани резултати истраживања утицаја климатских фактора на величину раног и касног дрвета и укупан прираст Calocedrus decurrens (Torr.) Florin). У анализи су коришћени узорци узети са 30 стабала на висини од 1,3 м. Вредности су у корелацији са средњом месечном температуром ваздуха и сумом падавина (од априла до септембра). Поред тога, као важан фактор укључена је старост дрвета изражена у годинама. Анализирани параметри објаснили су 64,8% укупног дебљинског прираста, 64,8% касног дрвета и 55,8% раног дрвета.*

Ključne reči: *Calocedrus decurrens*, климатске промене, REG-IN модел, рано дрво, касно дрво, укупни прираст

[1] Institute of Forestry, Kneza Viseslava 3, 11030 Belgrade, Serbia
[2] Ministry of Environmental Protection, Omladinskih brigada 1, 11070 Belgrade, Serbia
[3] Bio Save d.o.o, Tolstojeva 24, 11040 Belgrade, Serbia
*Corresponding author. E-mail: tatjanaratknic@yahoo.com

1. INTRODUCTION

According to the ND-GAIN index, Serbia ranks 76th out of 182 countries in terms of vulnerability to climate change and global challenges, as well as its readiness to improve resilience. The purpose of this index is to assist governments, businesses, and communities in prioritizing investments that will effectively address the immediate global challenges ahead (Notre Dame Global Adaptation Initiative, 2023). These changes will significantly impact forest ecosystems. Human activities have destroyed numerous habitats, which are often fragmented or damaged due to long-term pollution from various sources (Ratknić et al., 2019b). In the Belgrade area, existing and future vegetation will experience increased temperatures compared to current conditions. The isotherms of the average annual air temperature have shifted approximately 160 km north, and by the end of the 21st century, this shift is expected to exceed the tolerances of many tree species, potentially leading to their extinction in regions where they are currently found (Barnes, 2009; Iverson et al., 2008; Kirschbaum and Fischlin, 1996; Joyce and Rehfeldt, 2012). Climate change will result in significant alterations to the forest ecosystems of Belgrade as they will struggle to adapt to the new climatic conditions (Dimitrijević and Ratknić, 2023).

Climate change presents challenges for choosing the most effective methods of forest management. The rapid pace of climate change hinders the timely adaptation of forest ecosystems, jeopardizing their sustainable use. One potential solution to these challenges lies in understanding climatic niches (Joyce and Rehfeldt, 2013). Utilizing climate characteristics to describe species niches forms the foundation of "much ecological thinking and theory" (Pulliam, 2000, as cited in Joyce and Rehfeldt, 2013). The relationship between growth and environmental factors, such as climate, is crucial for defining species niches and selecting suitable habitats as climate conditions evolve (Dimitrijević and Ratknić, 2023). According to Pearson (2007, as cited in Joyce and Rehfeldt, 2013), "the central premise of this approach is that the currently realized niche of a species provides the best available metric for projecting the future distribution of suitable habitat." Research based on climate models and changes in forest ecosystems (Ratknić et al., 2019a) suggests that most native tree species may struggle to adapt to future climate conditions. This could prompt the introduction of non-native species in the urban forests of Belgrade that are better suited to future climates, potentially increasing the overall number of species in the area. So far, the impact of climatic factors on species such as Douglas fir (Ratknić et al., 2019), Cedar (Dimitrijević et al., 2022), Red oak (Dimitrijević et al., 2023), and eastern white pine (Dimitrijević et al., 2024) has been identified in Belgrade's urban forests.

Incense-cedar is a species commonly found in the mixed forests of the Sierra Nevada, where it typically grows either alone or in small groups. Its range spans about 15° of latitude and a variety of climates from the southern slope of Mount Hood in Oregon, southward through the Siskiyou, Klamath, and Warner Mountains, Cascade and Coast Ranges, and Sierra Nevada to the dry Hanson Laguna and Sierra de San Pedro Martir Ranges in Baja California (Grifin and Critchfield, 1972). Incense-cedar grows from the coastal fog belt eastward to the desert fringes. It can be found in the Washoe Mountains of west-central Nevada

(McDonald) (Map 1). Incense cedar grows at altitudes ranging from 50 to 2010 m in the limits and from 910 to 2960 m in the southern limits of its range. In the Sierra Nevada, it can be found at altitudes from 610 to 2100 m.

Incense cedar is a good competitor on hot, dry sites and commonly shares an upper canopy position on southwestern slopes. On cooler, moister aspects, it is usually subdominant to other species.

"Incense-cedar grows on many kinds of soils developed from a wide variety of parent rocks- rhyolite, pumice, andesite, diorite, sandstone, shale, basalt, peridotite, serpentinite, limestone, and granitic or metamorphic: equivalents. It is particularly adept at extracting soil phosphorus and calcium and excluding surplus magnesium. Incense-cedar grows on many kinds of soil developed from a wide variety of parent rocks- rhyolite, pumice, andesite, diorite, sandstone, shale, basalt, peridotite, serpentinite, limestone, and granitic or metamorphic equivalents. It is particularly adept at extracting soil phosphorus and calcium, and excluding surplus magnesium" (Powers and Oliver).

Map 1. *Distribution of Lybocedra in Natural Habitats Across the USA.*

2. MATERIAL AND METHODS

The research was conducted in an artificially raised stand of Libocerus located at Šuplja Stena. The coordinates of the sample site are X = 7463396, Y = 49448501, and the altitude is Z = 278 meters. The studied stand is 60 years old, well-preserved, and fully assembled, situated at an altitude of 278 meters with a 50-degree slope and western exposure. The study examined the relationship between the current increase in diameter and the width of early and late wood in relation to climatic factors. These factors include the total monthly precipitation and the average monthly air temperature during the growing season, which spans from April to September.

The independent variables assessed were:

- age
- Total precipitation in April (AP_P), May (MA_P), June (JU_P), July (JL_P), August (AV_P), and September (SE_P)
- Average air temperature in April (AP_T), May (MA_T), June (JU_T), July (JL_T), August (AV_T) and September (SE_T).

3. RESULTS

3.1. Pedological Characteristics

Soil Type: Eutric Cambisol , Soil Profile Structure: A (0-4 cm) - (B) (4-60 cm)

Based on its texture, the soil is classified as clay loam, which is poorly permeable to water and poorly aerated. The reaction of the soil solution is moderately acidic, and the degree of saturation with base cations is high. The surface layer (0-20 cm) is adequately supplied with nutrients, while the deeper layers contain low levels of humus. The soil is well-supplied with total nitrogen. However, the availability of easily accessible phosphorus for plants is low, and the levels of accessible potassium are at the lower end of the medium range. The chemical properties of the soil in this experimental field are detailed in Table 1, while the physical properties are outlined in Table 2.

Table 1. *Chemical Properties of Soil*

Depth	pH		Adsorption complex.					Total		Accessible	
	H_2O	KCl	T	S	T-S	V	Y1	hummus	N	P_2O_5	K_2O
cm			cmol/kg			%	cm^3	%	%	mg/100g	
0-20	6.42	5.49	27.37	22.17	5.20	81.01	7.99	3.77	0.22	1.90	13.00
20-40	6.10	4.73	26.06	19.19	6.87	73.64	10.57	1.87	0.11	2.31	11.90
40-60	5.84	4.28	26.88	18.86	8.02	70.15	12.34	1.36	0.08	6.44	11.40

Source: *Miletić, Z. and Eremija, S., 2019*

Table 2. *Physical properties of soil*

Depth	Coarse Sand	Fine Sand	Dust	Clay	Total Sand	Total Clay	Texture Class
cm	%	%	%	%	%	%	
0-20	0.90	39.10	31.30	28.70	40.00	60.00	Clayey loam
20-40	0.40	34.40	32.00	33.20	34.80	65.20	Clayey loam
40-60	0.30	34.40	29.80	35.50	34.70	65.30	Clayey loam

Source: *Miletić, Z. and Eremija, S., 2019*

3.2 Phytocenological characteristics

Habitat belongs to the forest community of Italian oak and Turkey oak with a broom, a variant of hornbeam (Ass. *Quercetum farnetto-cerris Rud. aculeatetosum* Job.). The following species are recorded in the stand (Stajić, S., 2019):

- **Tree layers**: Canopy (0.9) Calocedrus decurrens (4.2); Quercus cerris (1.1).
- **Shrub layer**: Canopy: (0.6); mean height 2 m Rosa canina (2.2); Crataegus monogyna (2.1); Fraxinus ornus (2.1); Ulmus carpinifolia (1.2); Lonicera caprifolium (1.2); Cornus mas (1.2); Acer campestre (1.2); Acer tataricum (1.2); Carpinus betulus (1.2); Acer pseudoplatanus (1.1); Prunus avium (1.1); Quercus frainetto (1.1); Tilia argentea (1.1); Calocedrus decurrens (+.1).
- **Ground flora layer**: Coverage (0.6) Lonicera caprifolium (3.2); Galium aparine (3.2); Quercus cerris (3.1); Ruscus aculeatus (3.3); Geranium robertianum (2.3); Ligustrum vulgare (2.3); Hedera helix (2.2); Alliaria petiolata (2.2); Rubus hirtus (2.2); Cardamine bulbifera (2.1); Fragaria vesca (1.2); Carex sylvatica (1.2); Crataegys monogyna (1.2); Clematis vitalba (1.2); Bilderdykia convolvulus (1.1); 188 Tilia argentea (1.1); Acer campestre (1.1); Tamus communis (1.1); Fraxinus ornus (1.1); Viola silvestris (1.1); Brachypodium sylvaticum (+.2); Ulmus carpinifolia (+.1); Polygonatum odoratum (+.1).

3.3 Stand Characteristics

The studied stand is located at an altitude of 278 meters, on a slope of 50 degrees, with a western exposure. The stand is 60 years old, well-preserved, and fully intact. There are a total of 1,007 trees per hectare. The highest number of trees is found in the thickness grade of 37.5 cm, accounting for 34.6% of the total. The average diameter of the stand, based on the logs, is 31.1 cm, while the arithmetic mean diameter is 32.5 cm.

Table 3. *Statistical indicators of diameter (D), height (H), and Volume Distributions (V).*

Size	Xsr	Min.	Max	Quartile		σ	V	sd	Distribution coefficient	
				Q1	Q3		%		α_3	α_4
D (cm)	32.5	21.7	43.8	29.0	37.7	5.85	17.99	1.07	-0.125	-0.824
H (m)	17.2	11.7	20.9	16.2	18.6	4.76	2.18	0.41	-0.760	0.863
V (m^3)	0.5	0.0	1.0	0.3	0.7	0.05	0.23	0.04	0.039	-0.495

Source: *Original*

The stand has distribution lines of trees and volume by diameter classes typical of even-aged stands. The total basal area is 76,94 m^2ha^{-1}, while the total wood volume amounts to 519,9 m^3ha^{-1}. The maximum volume is in the diameter class of 37.5 cm._Data regarding the mean stand diameter, along with basic statistical information, is presented in Tables 3 and 4.

Table 4. Basic Data on Incense-cedar Stand

Diameter degree (cm)	N		H	G	V	
	per ha	%	(m)	m^2/ha	m^3/ha	%
22,5	104	10,3	13,2	4,13	27,9	5,4
27,5	243	24,1	16,48	14,43	97,5	18,8
32,5	243	24,1	17,72	20,16	136,2	26,2
37,5	348	34,6	18,94	28,43	192,1	37,0
42,5	69	6,9	19,3	9,79	66,2	12,7
Σ	1007	100,0		76,94	519,9	100,0

Source: *Original*

3.3 The Influence of Climatic Factors on Current Diameter Increase

Using the correlation method for estimating weights, we constructed a model to analyze how age and various climatic factors influence the current increase in diameter, as well as the sizes of late wood (Ka) and early wood (Ra). The parameters of these models are detailed in Table 4.

The size of early wood is negatively influenced by several factors, including age (AGE), total precipitation in April (AP_P), as well as mean air temperatures in April (AP_T) and August (AU_T), a positive impact on early wood size was observed with the amount of precipitation in May (MA_P), June (JU_P), July (JL_P), August (AP_P) and September (SE_P), along with mean air temperatures in May (MA_T), June (JU_T), July (JL_T) and Septembar (SE_T). The correlation coefficient for this model is 0.3457, indicating that 55,31% of the variation in early wood size is explained by these factors. The F-test value suggests a significant level of 3.90.

For late wood, the size is negatively influenced by age (AGE), total precipitation in May (MA_P), August (AU_P), and September (SE_P), as well as the mean monthly air temperature in April (AP_P), May (MA_P), June and September (SE_T). However, a positive influence is noted from precipitation in April (AP_P), June (JU_P), and July (JU_P), along with mean air temperatures in July (JL_T) and August (AU_T). The regression coefficient for late wood size is

1.5408, explaining 49.89% of the variation. The F-test value indicates a significant level of 3.14.

Overall, the total current diameter increase is negatively influenced by age (AGE), total precipitation in April (AP_P), August (AU_P), and September (SE_P), as well as mean temperatures in April (AP_T), May (MA_T), June (JU_T) and September (SE_T). Positive influences are associated with total precipitation in May (MA_P), June (JU_P), and July (JL_P), along with mean air temperatures in July (JL_T) and August (AU_T). The results of the analysis are presented in Tables 5 and 6.

Table 5. The influence of age and analysed climatic factors on current diameter increment (Zi), share of latewood (Ka), and share of earlywood (Ra)

Independent variable	Dependent variable					
	Ra		Ka		Zi	
	Parameters	Error	Parameters	Error	Parameters	Error
Constant	-2.2269	1.4135	3.5293	6.2989	1.3023	6.9469
AGE	-0.0226	0.0048	-0.0859	0.0214	-0.1086	0.0237
AP_P	-0.0018	0.0021	0.0015	0.0096	-0.0003	0.0106
MA_P	0.0016	0.0013	-0.0001	0.0058	0.0014	0.0064
JU_P	0.0021	0.0012	0.0043	0.0055	0.0064	0.0061
JL_P	0.0013	0.0011	0.0084	0.0051	0.0098	0.0056
AU_P	0.0008	0.0017	-0.0049	0.0075	-0.0041	0.0083
SE_P	0.0022	0.0015	-0.0161	0.0075	-0.0139	0.0078
AP_T	-0.0333	0.0337	-0.0494	0.1503	-0.0827	0.1657
MA_T	0.1320	0.0404	-0.2041	0.1798	-0.0721	0.1984
JU_T	0.0176	0.0455	-0.0578	0.2029	-0.0402	0.2237
JL_T	0.0666	0.0523	0.4176	0.2334	0.4842	0.2574
AU_T	-0.0328	0.0429	0.2067	0.1911	0.1738	0.2108
SE_T	0.0027	0.355	-0.4068	0.1582	-0.4041	0.1745
R						
R^2	55.31		49.89		52.14	
Standard error	0.3457		1.5408		1.6993	
F-test	3.90		3.14		3.44	

Source: Original

4. DISCUSSION

Natural habitats are characterized by dry summers, typically receiving less than 25 mm of precipitation per month, and experiencing extreme annual temperatures ranging from -34°C to +48°C. The total annual precipitation can vary from 510 mm to 2030 mm, though amounts around 380 mm per year are not uncommon, especially on the eastern side of the Cascades and in the Warner Mountains in Oregon and California (Schubert, 1965). During the notably dry period from 2012 to 2016, there was a relatively low level of drying observed (Fettig et al., 2018), yet a high degree of survival following forest fires was noted, just behind that of redwood trees (Stephens and Finney, 2002). Overall, it can be concluded that this species is adaptable to climate change and holds significant potential. It is important to note that its commercial wood value is high (Powers and Oliver, 1990). In habitats with high production rates, this species tends to grow more slowly, while it plays a dominant role on dry, warm slopes compared to other tree species (Powers and Oliver, 1990). The root system is well-developed, featuring pronounced lateral roots. Arbuscular mycorrhizae are present on the roots, allowing for increased drought tolerance compared to other species (Auge, 2001). In summary, sycamore trees are shade-tolerant, drought-tolerant, and host relatively few harmful insects and pathogenic organisms (Powers and Oliver, 1990).

Table 6. Type of Effect on the Size of Earlywood (Ra), Latewood (Ka), and Total Current Volume Increment (Zi)

Effect	Size		
	Earlywood (Ra)	Latewood (Ka)	Total current diameter increment (Zi)
Positive	• Precipitation in May • Precipitation in June • Precipitation in July • Precipitation in August • Precipitation in September • Temperature in May • Temperature in June • Temperature in July • Temperature in September	• Precipitation in April • Precipitation in June • Precipitation in July • Temperature in July • Temperature in August	• AGE • Precipitation in May • Precipitation in June • Precipitation in July • Temperature in July • Temperature in August
Negative	• AGE • Precipitation in April • Temperature in April • Temperature in August	• AGE • Precipitation in May • Precipitation in August • Precipitation in September • Temperature in April • Temperature in May • Temperature in June • Temperature in September	• AGE • Precipitation in April • Precipitation in August • Precipitation in September • Temperature in April • Temperature in May • Temperature in June • Temperature in September

Source: Original

Current climate change projections for Serbia indicate a trend of increasing temperatures under both the A1B and A2 scenarios for three observed periods: 2011-2040, 2041-2070, and 2071-2100 (MPZŽS, 2015).

The expected temperature changes for these periods are as follows:

1. 2011-2040: Temperature increase of 0.5-0.9°C for the A1B scenario and 0.3-0.7°C for the A2 scenario.
2. 2041-2070: Temperature increase of 1.8-2.2°C for the A1B scenario and 1.6-2.0°C for the A2 scenario.
3. 2071-2100: Temperature increase of 3.6-4.0°C for the A1B scenario and 3.2-3.6°C for the A2 scenario.

The most significant warming, exceeding 4.0°C by the end of the century, is anticipated during the summer and autumn seasons (MPZŽS, 2015). Serbia is expected to experience a greater increase in air temperature compared to the global average, along with a higher prevalence of severe droughts and intense precipitation events. Summer temperatures in the Balkans and western Turkey may rise by 5-6°C during the period of 2071-2100 under the A2 scenario (Giorgi, F. et al., 2009). The ICTP-RegCM3 model predicts a temperature increase of 7.0°C over the Balkan countries, including Serbia, for the same period and scenario (Önol & Semazzi, 2009). When comparing these projections to the average air temperature and total precipitation in the Belgrade area (according to the REG_IN model) for the period from 2021 to 2100, it becomes evident that these projections fall within the ecological limits for all measured parameters (Table 7.).

Table 7. *Values of climatic parameters for the analyzed periods obtained based on the REG -IN model*

Size by REG-IN model	Periods (year)	Months					
		April	May	June	July	August	September
Average air temperature (^{0}C)	2021-2050	14,6	20,0	23,0	24,0	24,6	19,0
	2051-2080	15,0	20,6	23,4	24,2	25,1	19,2
	2081-2100	15,4	21,1	23,9	24,5	25,6	19,5
Average maximum air temperatures (^{0}C)	2021-2050	19,3	24,1	27,6	29,7	30,1	24,3
	2051-2080	20,3	24,8	28,5	30,9	31,4	24,4
	2081-2100	21,5	25,5	29,7	32,3	33,1	24,5
Average minimum air temperatures (^{0}C)	2021-2050	10,5	14,8	17,8	18,7	18,1	13,3
	2051-2080	12,4	16,7	19,3	19,8	18,6	12,8
	2081-2100	14,4	18,6	20,9	20,8	19,0	12,3
Absolute maximum air temperatures (^{0}C)	2021-2050	26.6	30.5	33.0	35.6	35.4	31.6
	2051-2080	26.8	30.6	33.0	35.6	35.3	31.5
	2081-2100	26.9	30.7	32.9	35.7	35.2	31.4
Absolute minimum air temperatures (^{0}C)	2021-2050	2.8	7.0	10.3	12.9	12.0	8.1
	2051-2080	3.5	7.5	10.5	13.3	12.3	8.6
	2081-2100	4.2	8.1	10.7	13.7	12.6	9.0
Average precipitation (mm)	2021-2050	55.7	90.1	83.9	74.3	55.7	69.4
	2051-2080	52.7	85.3	79.5	70.4	52.7	65.7
	2081-2100	49.8	80.6	75.1	66.5	49.8	62.1
Lowest precipitation (mm)	2021-2050	28.8	39.8	32.8	18.1	27.8	7.4
	2051-2080	27.3	37.7	31.1	17.2	26.4	7.0
	2081-2100	25.8	35.6	29.3	16.2	24.9	6.6

Source: Dimitrijevic and Ratknic, 2019

These parameters indicate that Incense – cedar can survive in the newly opened conditions of climate change, which is why it's more excellent representation in the urban forests of Belgrade should be enabled.

5. CONCLUSION

To sustain forest ecosystems in a given area, it is crucial to develop strategies that mitigate future risks, even amid uncertainties in precise forecasting (Millar et al., 2007). One effective approach is to manage specific tree species that can fulfill some of the functions that non-adapted species can no longer provide. By actively replanting after stand-replacing disturbances or proactively transitioning to new species compositions, we can potentially lessen the impacts of climate change (Nagel et al., 2017).

The evidence presented in this paper indicates that incense-cedar may be a species of the future, as its ecological niche aligns well with the conditions generated by climate change, particularly concerning air temperature and precipitation.

These parameters suggest that Incrense - cedar has the potential to thrive under the new conditions created by climate change. Therefore, it is essential to promote its increased presence in the urban forests of Belgrade.

Acknowledgement: *The authors are grateful to the Ministry of Science, Technological Development and Innovation of the Republic of Serbia for financial support (**451-03-136/2025-03/ 200027)***

REFERENCES

Barns, B.V. (2009). Tree response to ecosystem change at the landscape level in eastern North America. Forstarchiv 80 (3), 76–89
https://www.semanticscholar.org/paper/Tree-response-to-ecosystem-change-at-the-landscape-Barnes/4ad56abf687d60d0e0e5d5e00f581e1dbace65e5

Dimitrijević, T. & Ratknić, M. (2022). Strategija uticaja klimatskih promena na interakciju ekosistemskih usluga u korišćenju i upravljanju šumskim resursima Beograda, Projekat Instituta za šumarstvo, Beograd.

Ratknić, T., Šekularac, G., Ratknić, M., Poduška, Z. & Aksić, M. (2022). Effects of climate characteristics on the diameter increment of cedar in the city of Belgrade (Serbia), EcoTER'22, 21-24 June 2022, Hotel Sunce, Sokobanja, Serbia, pp 446-451

Dimitrijevic, T., Ratknic, M. & Hadrovic, S. (2023): Climate characteristics and diameter increment of eastern white pine: potential use in afforestation in the Belgrade area (Republic of Serbia), SUSTAINABLE FORESTRY COLLECTION 87-88, 99-113
DOI: 10.5937/SustFor2388099D UDK: 630*232.1:582.475(497.11Beograd)

Dimitrijević, T., Šekularac, G., Ratknić, M. & Aksić, M. (2023). Effects of climate characteristics on the diameter increment of red oak in the city of Belgrade (Serbia), EcoTER'23, 20-23 June 2023, Serbia, pp 555-560

Giorgi, F., Jones, C. & Asrar, G. (2009). Addressing climate information need at the regional level: the CORDEX framework, World Meteorological Organization Bulletin 58 (3) – July 2009, 175-183
http://wcrp.ipsl.jussieu.fr/cordex/documents/CORDEX_giorgi_WMO.pdf

Global adaptation index - ND-GAIN, https://gain.nd.edu/our-work/country-index/downloaddata/

IPCC (2023). Sections. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115, DOI: 10.59327/IPCC/AR6-9789291691647

Iverson, L.R., Prasad, A.M. & Mathews, S. (2008). Modelling potential climate change impacts on the trees of northeastern United States. Mitig. Adapt. Strat. Glob. Change 13, 487–516.

Joyce, D. & Rehfeldt, G. (2013). Climatic niche, ecological genetics, and impact of climate change on eastern white pine (Pinus strobus L.): Guidelines for land managers, Forest Ecology and Management, Volume 295, 1 May 2013, Pages 173-192
https://doi.org/10.1016/j.foreco.2012.12.024

Kirschbaum, M. & Fischlin, A. (1996). Climate change impacts on forests. In: Watson, R., Zinyowera, M.C., Moss, R.H. (Eds.), Climate Change 1995 – Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analysis. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel of Climate Change (IPCC). Cambridge University Press, Cambridge, pp. 95–129.

Miletić, Z. & Eremija, S. (2019). Fizičke i hemijske osobine zemljšta u kulturi borovca na području Šuplje stene, rukopis.

Önol, B. & Semazzi, F. (2009). Regionalization of climate change simulations over the eastern Mediterranean. *Journal of Climate* 22: 1944–1961, DOI: https://doi.org/10.1175/2008JCLI1807.1

Ratknić, T., Ratknić, M., Poduska, Z., Zivanovic, I., Lazarevic, N. & Hadrovic, S. (2019a). The Effects of Climate Characteristics on the Diameter Increment of Douglas-Fir in the City of Belgrade (Serbia), Proceedings of the X International Scientific Agricultural Symposium “Agrosym 2019”, Jahorina, October 03-06, 2019, pp. 1953-1958

Ratknić, T., Ratknic, M. & Vukadinovic, L. (2019b). The Regional Climate Model (REG-IN) for Forecasting the Adaptivity of Forest Ecosystem in Belgrade, Sustainable Forestry, Collection 79-80, Institute of Forestry, UDK 630*180:551.581 (497.11 Belgrade).

Stajić S. (2019). Fitocenološke karakteristike u kulturi borovca na području Šuplje stene, Rukopis

University of Notre Dame, Notre Dame Global Adaptation Initiative, 721 Flanner Hall, Notre Dame, IN 46556 USAPhone 574-631-9103 ndgain@nd.edu, Accessibility Information

Griffin, R. & Critchfield, W. (1972): The distribution of forest trees in California. USDA Forest Service, Research Paper PSW-82 (reprinted with supplement, 1976). Pacific Southwest Forest and Range Experiment Station, Berkeley, CA. 114p. https://www.fs.usda.gov/psw/publications/documents/psw_rp082/psw_rp082.pdf

McDonald, P. 1973. Incense-cedar... an American wood. USDA Forest Service, FS-226. Washington, DC.: 7 https://dn790000.ca.archive.org/0/items/incensecedaramer226mcdo/incensecedaramer226mcdo_bw.pdf

Schubert, H. (1965): Incense-cedar *(Libocedrus decurrens* Torr.). *In Silvics* of forest trees of the United States. H. A. Fowells, comp. U.S. Department of Agriculture, Agriculture Handbook 271. Washington, DC.: 243-247.
https://www.fs.usda.gov/psw/publications/documents/cfres_series/cfres_tp018.pdf

Powers F. & Oliver WW.(1990): Libocedrus decurrens Torr. Incense-cedar. In: Burns RM, Honkala BH, tech coords. Silvics of North America. Volume l, Conifers. Agric. Handbk. 654. Washington, DC: USDA Forest Service: 173B180.

Fetting, C., Mortenson, L., Bulaon, B. & Foulk, P. (2019): Tree mortality following drought in the central and southern Sierra Nevada, California, U.S.Forest Ecology and Management 432: 164-178 DOI:https://doi.org/10.1016/j.foreco.2018.09.006

Stephens, S. & Finney, M. (2002): Prescribed fire mortality of Sierra Nevada mixed conifer tree species, Forest Ecology and Management 162(2):261-271
DOI:10.1016/S0378-1127(01)00521-7

Augé, R. (2001): Water relations, drought and vesicular-arbuscular mycorrhizal symbiosis. *Mycorrhiza* **11**, 3–42. https://doi.org/10.1007/s005720100097

Powers and Oliver
https://www.srs.fs.usda.gov/pubs/misc/ag_654/volume_1/libocedrus/decurrens.htm

Millar, I., Stephenson, N. & Scott L.(2007): Climate Change and Forests of the Future: Managing in the Face of Uncertainty.” Ecological Applications 17, no. 8 (2007): 2145–51. https://doi.org/10.1890/06-1715.1

Linda M. Nagel, Brian J. Palik, Michael A. Battaglia, Anthony W. D’Amato, James M. Guldin, Christopher W. Swanston, Maria K. Janowiak, Matthew P. Powers, Linda A. Joyce, Constance I. Millar, David L. Peterson, Lisa M. Ganio, Chad Kirschbaum, and Molly R. Roske (2017): Adaptive Silviculture for Climate Change: A National Experiment in Manager-Scientist Partnerships to Apply an Adaptation Framework, *ournal of Forestry*, Volume 115, Issue 3, May 2017, Pages 167–178, https://doi.org/10.5849/jof.16-039

CLIMATE CHARACTERISTICS AND DIAMETER INCREMENT OF INCENSE-CEDAR: POTENTIAL USE IN AFFORESTATION IN BELGRADE AREA (REPUBLIC OF SERBIA)

Tatjana DIMITRIJEVIĆ, Mihailo RATKNIC, Sasa EREMIJA, Sabahudin HADROVIĆ, Violeta DJORDJEVIĆ, Snežana KONATAR

Summary

The paper investigates how climate influences the early, late, and total tree growth of Calocedrus decurrens in the Belgrade area. It compares data on habitat changes with habitat characteristics found in natural localities across North America. Early tree size is negatively impacted by several factors, including age (AGE) and precipitation in May (MA_P), June (JU_P), and July (JL_P), as well as average air temperatures in April (AP_T), May (SE_P), and July (OK_T). Conversely, there is a positive correlation with the total sum of precipitation in April (AP_P), August (AU_P), and September (SE_P). The correlation coefficient for early growth is 0.8054, indicating that 64.87% of the variation in early tree size can be attributed to these factors. The F-test value shows a significance level of 3.56.In contrast, late tree size is negatively influenced by age (AGE), as well as precipitation in April (AP_P), May (MA_P), and June (JU_P). Additionally, the average air temperature in September (SE_T) has a detrimental effect. Positive influences are associated with the total sum of precipitation in July (JL_P), August (AV_P), and September (SE_P), as well as the average air temperatures in April (AP_T), May (MA_T), June (JU_T), July (JL_T), and August (AV_T). The regression coefficient for late tree growth is 0.7471, explaining 55.81% of the variation in late tree size. The F-test value indicates a significance level of 2.44. Moreover, the total growth of tree thickness is negatively affected by age (AGE), the total sum of precipitation in May (MA_P) and June (JU_P), as well as temperatures in April (AP_T), May (MA_T) and September (SE_T). Positive influences are noted with precipitation in July (JL_P), August (AU_P), and September (SE_P), along with average air temperatures in June (JU_T) and July (JL_T). According to the REG_IN climate model, these findings suggest that the habitat conditions in Belgrade's urban forests are becoming favorable for the successful establishment of new plantations.

KLIMATSKE KARAKTERISTIKE I DEBLJINSKI PRIRAST LIBOKEDRA:POTENCIJALNA UPOTREBA U POŠUMLJAVANJU NA PODRUČJU BEOGRADA (REPUBLIKA SRBIJA)

Tatjana DIMITRIJEVIĆ, Mihailo RATKNIC, Sasa EREMIJA, Sabahudin HADROVIĆ, Violeta DJORDJEVIĆ, Snežana KONATAR

Rezime

U radu je vršeno istraživanje na koji način klima utiče na veličinu ranog, kasnog drveta i ukupnog tekućeg prirasta stabala Calocedrus decurrens na području Beograda. Podaci promene staništa poređeni su sa karakteristikama staništa na prirodnim nalazištima na području Severno Američkog kontinenta. Veličina ranog drveta je pod negativnim uticajem starosti (AGE), sume padavina u maju (MA_P), sume padavina u junu (JU_P), sume padavina u julu (JL_P), kao i srednje temperature vazduha u aprilu (AP_T), maju (MA_T), avgustu (AU_U), septembru (SE_T) i oktobru (OK_T). Pozitivan uticaj je konstatovan sa sumom padavina u aprilu (AP_P), avgustu (AU_P), septembru (SE_P).

Koeficijent korelacije iznosi 0,8054 i objašnjeno je 64.87% vrednosti ranog drveta. Vrednost F-testa ukazuje na nivou značajnosti od 3.56. Veličina kasnog drveta je pod negativnim uticajem starosti (AGE), sumom padavina u aprilu (AP_P), maju (MA_P), junu (JU_P) kao i sa srednjom mesečnom temperaturom vazduha u septembrom (SE_T). Pozitivan uticaj utvrđen je sa sumom padavina u julu (JL_P), avgustu (AV_P), septembru (SE_P) i sa srednjom temperaturom vazduha u aprilu (AP_T), maju (MA_T),junu (JU_T), julu (JL_T) i avgustu (AV_T). Koeficijent regresije iznosi 0,7471 i objašnjeno je 55.81% vrednosti kasnog drveta. Vrednost F testa ukazuje na nivo značajnosti 2.44. Veličina ukupnog tekućeg debljinskog prirasta pod negativnim uticajem je starosti (AGE), sume padavina u maju (MA_P), junu (JU_P) kao i temperature aprilu (AP_T), maju (MA_T), septembru (SE_T) i oktobru (OK_T). Pozitivan uticaj konstatovan je sa sumom padavina u julu (JL_P), avgustu (AU_P) i septembru (SE_P) i sa srednjom temperaturom vazduha u junu (JU_T), julu (JL_T). Na osnovu klimatskog modela REG_IN ukazuje se da se stvaraju stanišni uslovi koji omogućavaju uspešno podizanje novih plantaža u urbanim šumama grada Beograda.