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WOOD DENSITY VARIATION IN SERBIAN SPRUCE: A COMPARATIVE STUDY OF NATURAL STANDS AND PLANTATIONS

VARIRANJE GUSTINE DRVETA PANČIĆEVE OMORIKE: UPOREDNO ISTRAŽIVANJE PRIRODNIH SASTOJINA I KULTURA

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Abstract

Serbian spruce (*Picea omorika* Pančić/Purkyně) is a Tertiary relict and an endemic species of the Balkan Peninsula, whose limited distribution range and pronounced ecological specificity make the study of its physical properties particularly important. The objective of this research was to determine the differences in wood density between Serbian spruce originating from plantations and from natural stands, as well as to analyze the variation of density in both axial and radial directions. The research was carried out at five locations in Bosnia and Herzegovina (Dubrava, Srebrenica, Gostilja, Stolac 1, and Stolac 2), using a total of 3,117 specimens. Wood density was determined in the oven-dry, air-dry, and green states, as well as by its nominal value. The average oven-dry wood density was 0.421 g/cm³ in plantations and 0.487 g/cm³ in natural stands. An increase in density with tree height was observed in natural stands, which contrasts with the typical trend in spruce and suggests an adaptive mechanism of the trees to static and dynamic loads. Radially, the density increased from pith to bark, consistent with the higher proportion of latewood. Significant correlations were established between wood density, ring width, and the proportion of latewood. The obtained results indicate that Serbian spruce can represent a sustainable alternative to Norway spruce in technical and industrial applications.

Key words: natural stands, *Picea omorika*, physical properties of wood, plantations

1. INTRODUCTION / UVOD

Wood density represents one of the most important physical properties, as it determines a wide range of other wood characteristics and its utilization value. It is directly related to mechanical properties such as the modulus of elasticity, compression and bending strength and is therefore often used as an indirect indicator of wood quality and technical value (Siau, 1984; Kollmann & Côté, 1968). In addition, density affects other physical properties, including porosity, swelling and shrinkage, as well as the durability of wood under variable moisture conditions (Panshin & de Zeeuw, 1980).

From a technological standpoint, wood density determines the drying rate, impregnation capacity, adhesive penetration depth, and workability of wood. For these reasons, it is one of the fundamental criteria for the classification and grading of wood products (Zobel & van Buijtenen, 1989; Wagenführ, 2000). In the pulp and paper industry, wood of lower density provides fibers with more favorable characteristics for paper production, whereas in construction and furniture manufacturing, higher-density wood ensures greater load-bearing capacity (Dadswell & Watson, 2018; Glass & Zelinka, 2010).

From an energy perspective, wood density is closely related to the calorific value per unit volume, which is particularly important in biomass production and in the use of wood as a renewable energy source (Jenkins et al., 1998). Moreover, ecological studies have shown that variations in density may reflect a species' adaptation to specific site conditions and influence its resistance to biotic factors such as fungi and insects (Niklas, 1992).

Taking all these aspects into account, wood density is justifiably referred to as the "mother of wood properties" (Kollmann, 1951), since it forms the basis for understanding and predicting a wide spectrum of physical and mechanical characteristics. Consequently, it represents one of the key parameters in selecting wood for practical and industrial applications.

Given that Serbian spruce is a Tertiary relict with a narrow distribution range and pronounced ecological specificity, studying the density of its wood is essential both for understanding the species' adaptive mechanisms and for evaluating its potential for practical and industrial utilization.

2. MATERIAL AND METHODS / MATERIJAL I METOD RADA

The research was conducted at two plantation sites and three natural stand sites of Serbian spruce in the territory of Bosnia and Herzegovina.

Location Dubrava (DU) is plantation located near Banja Luka (064-61-754E, 049-56-083N), at an altitude of 300 m, on a pseudogley soil developed over flysch, the terrain is gently sloped (2–3°) with a southern exposure. Location Srebrenica (SR) is plantation situated near the town of Srebrenica (066-15-221E, 048-75-163N), at 860 m a.s.l., on a dystric cambisol developed over andesite, the terrain has a mild slope (5°) and a north-eastern exposure.

All three natural stand sites are located in the vicinity of Višegrad. Gostilja (GO) location (066-07-453E, 048-57-964N) is situated at 1000–1300 m a.s.l., on rendzina developed over limestone, with a slope of 30–35° and a north-eastern exposure. S1-Stolac 1 (066-03-458E, 048-65-199N) and S2-Stolac 2 (066-02-805E, 048-65-509N) locations are situated at 1000–1600 m a.s.l., on black soil formed over limestone, the average slope is 40–45° and the exposure is north-eastern.

From each site, three sample trees were selected — six from plantations and nine from natural stands. From each tree, 5 cm thick discs were taken at heights of 0.3 m, 1.3 m, and then every 2 m along the stem (a total of 158 discs).

For the purpose of examining the physical properties of wood, test specimens measuring 20 × 20 × 30 mm were prepared from air-dried discs (Figure 1). The analyses were carried out in accordance with the SRPS ISO 13061-2:2015 standard, ensuring the comparability of the obtained results with previous research. All specimens were labeled with five-digit identification codes, allowing precise determination of their position within each disc and tree. In total, 3,117 specimens were prepared and measured (Figure 2).

In the first phase, the dimensions of the specimens were measured in the axial, radial, and

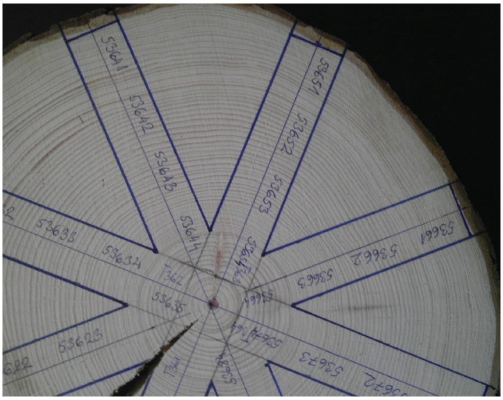


Figure 1. Labeled test specimens on a wood disc / **Slika 1**. Obilježeni testni primjerci na presjeku drvenog diska

Figure 2. Test specimens for examining the physical properties of wood / **Slika 2**. Testni primjerci za mjerenje fizičkih karakteristika drveta

tangential directions using a digital caliper with an accuracy of 0.01 mm, under air-dry moisture conditions. The masses were determined with an analytical balance accurate to 0.01 g. Subsequently, the cross sections of the specimens were scanned to measure the annual ring width and the proportion of earlywood and latewood. These parameters served as a basis for analyzing the relationships between physical properties, ring width, and latewood proportion.

In the next phase, the specimens were oven-dried in a laboratory dryer at a temperature of 103 ± 2 °C until reaching a constant mass, i.e., the oven-dry state. After cooling in a desiccator, the mass and dimensions were re-measured in all three directions, at the same positions as in the initial measurements. The specimens were then immersed in water until they reached the green moisture condition, after which the final measurements of mass and dimensions in the axial, radial, and tangential directions were performed.

Based on the obtained data, wood density was calculated for the oven-dry, air-dry, and green moisture conditions, as well as the nominal density.

3. RESULTS AND DISCUSSION / REZULTATI I DISKUSIJA

The results presented in Table 1 show the values of wood density in the oven-dry, air-dry, and green states, as well as the nominal wood density of Serbian spruce from plantations and natural stands.

In the oven-dry state, wood from plantations (PL) exhibited lower mean density values, averaging 0.421 g/cm³, whereas in natural stands (NS) the values were significantly higher, ranging from 0.477 to 0.502 g/cm³, with an average of 0.487 g/cm³. The average oven-dry density values obtained for natural stands are slightly higher than those reported by Lukić-Simonović (1955), who recorded mean densities of 0.432 g/cm³ (site A), 0.458 g/cm³ (site B), and 0.448 g/cm³ (site C). On the other hand, the data reported by Ugrenović (1950) for the oven-dry density of Serbian spruce wood (0.490 g/cm³) correspond well with the mean values obtained for the natural stand sites in the present study.

The application of the t-test in analyzing Serbian spruce wood density in the oven-dry state revealed a statistically significant difference between plantation-grown and naturally grown trees ($t = 44.10$; $p = 0.00$).

Table 1. Wood density of Serbian spruce / **Tabela 1**. Gustina drveta Pančićeve omorike

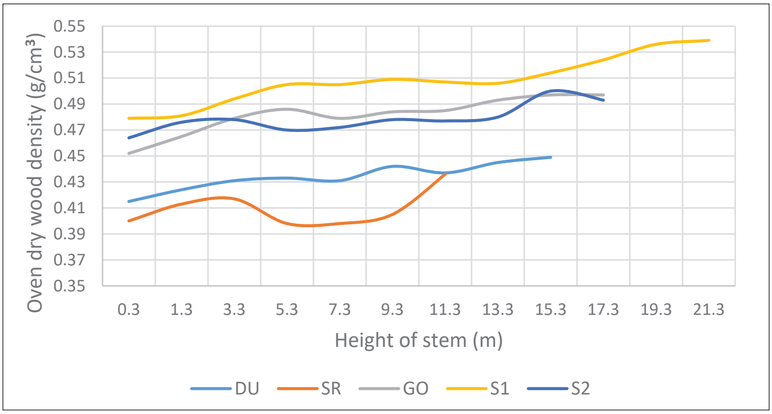
	Location	*N*	*As*	*Min*	*Max*	*SD*	*CV*
			g/cm^3				(%)
Oven-dry wood density	*DU*	553	0.429	0.342	0.563	0.036	8.46
	SR	301	0.407	0.342	0.564	0.037	9.03
	PL	**854**	**0.421**	**0.342**	**0.564**	**0.038**	**9.03**
	GO	664	0.477	0.368	0.604	0.03	6.22
	S1	859	0.502	0.405	0.601	0.04	7.90
	S2	740	0.477	0.403	0.599	0.031	6.46
	NS	**2263**	**0.487**	**0.403**	**0.604**	**0.036**	**7.46**
Air-dry wood density	*DU*	553	0.457	0.372	0.605	0.036	7.98
	SR	301	0.436	0.373	0.603	0.039	8.97
	PL	**854**	**0.450**	**0.372**	**0.605**	**0.039**	**8.6**
	GO	664	0.504	0.349	0.645	0.03	5.97
	S1	859	0.529	0.432	0.624	0.039	7.42
	S2	740	0.501	0.427	0.638	0.031	6.23
	NS	**2263**	**0.513**	**0.385**	**0.645**	**0.036**	**7.09**
Green wood density	*DU*	553	0.869	0.702	1.064	0.057	6.56
	SR	301	0.888	0.728	1.071	0.062	6.97
	PL	**854**	**0.875**	**0.702**	**1.071**	**0.059**	**6.79**
	GO	665	0.885	0.729	1.053	0.059	6.68
	S1	859	0.889	0.732	1.052	0.062	6.96
	S2	740	0.892	0.757	1.129	0.061	6.82
	NS	**2263**	**0.889**	**0.729**	**1.129**	**0.061**	**6.84**
Nominal wood density	*DU*	553	0.372	0.3	0.479	0.028	7.6
	SR	301	0.359	0.307	0.488	0.031	8.78
	PL	**851**	**0.367**	**0.3**	**0.488**	**0.03**	**8.19**
	GO	665	0.41	0.356	0.516	0.022	5.47
	S1	859	0.425	0.352	0.515	0.03	6.99
	S2	740	0.404	0.35	0.516	0.023	5.81
	NS	**2263**	**0.414**	**0.35**	**0.516**	**0.027**	**6.63**

The average moisture content of the specimens during the determination of air-dry density was as follows: Dubrava – 13.05%, Srebrenica – 13.27%, Gostilja – 13.08%, Stolac 1 – 13.03%, and Stolac 2 – 12.89%. The average air-dry wood density was 0.450 g/cm³ for the plantation and 0.513 g/cm³ for the natural stands. Lukić-Simonović (1955) reported an average wood density of 0.482 g/cm³ at 15% moisture content in natural stands of Serbian spruce, which is slightly lower than the values obtained in this study, despite the higher moisture content. Kommert (1993) examined the wood density of Serbian spruce in plantations in Germany at 12% moisture content and found an average value of 0.467 g/cm³, which is higher than the results obtained for the plantations in this study (0.450 g/cm³). Aanerød (2014) determined an average wood density of 0.450 g/cm³ at 12% moisture content for Norway spruce in Norway, with a coefficient of variation of 9.4%, indicating a high similarity with the results obtained for the Serbian spruce plantations in this research. In the study of Zeidler et al. (2020), the physical and mechanical properties of non-native species from the genus *Picea* were analyzed in comparison with the native *Picea abies*, in order to assess their potential as substitutes in industrial wood use. Among the examined species, Serbian spruce (*Picea omorika*) showed the highest mean density at 12% moisture content (0.525 g/cm³), compared to 0.517 g/cm³ for Norway spruce. These results confirm that, despite its endemic nature, Serbian spruce possesses physical properties that make it a competitive and sustainable alternative to Norway spruce for technical and structural applications.

The average moisture content of the specimens during the determination of wood density in the green state was as follows: Dubrava – 134.35%, Srebrenica – 148.48%, Gostilja – 116.35%, Stolac 1 – 109.30%, and Stolac 2 – 121.39%. The average wood density in the green state for trees from plantations was 0.875 g/cm³, while a slightly higher mean value of 0.889 g/cm³ was recorded for trees from natural stands. The average nominal wood density was 0.367 g/cm³ for plantations and 0.414 g/cm³ for natural stands.

Wood density shows significant variation along the axial direction, which is closely related to anatomical characteristics, the proportion of earlywood and latewood, as well as the physiological requirements of the tree under static and dynamic loads (Šoškić & Popović, 2002). In this study, wood density was measured at heights of 0.3 m and 1.3 m, and subsequently at every 2 meters along the stem. The analysis of results (Figure 3) indicates that oven-dry wood density (ρ_0) varies depending on both the site and the origin of the trees. In trees from plantations (Dubrava and Srebrenica), a somewhat irregular trend was observed — in Dubrava, density increased slightly with height, whereas in Srebrenica, a sudden decrease occurred at 5.3 m, followed by a gradual increase again. In contrast, trees from natural stands (Gostilja, Stolac 1, and Stolac 2) exhibited a consistent increase in density from the base toward the top of the stem. The most pronounced increase was recorded at the Stolac 1, where density reached its highest values in the upper stem sections.

These results are consistent with the findings of Lukić-Simonović (1970), who explained the increase in density in Serbian spruce as a consequence of the thickening of earlywood cell walls caused by the specific shape of branch whorls. The results of this study can also be interpreted in light of previous research on spruce wood density. Studies by Karahasanović (1962), Harvald & Olesen (1987), and Todorović (2006) demonstrated that coniferous species often exhibit axial density variations determined by the proportion of latewood and by structural adaptations of the tree. Unlike Norway spruce, in which wood density generally decreases with increasing height (Mäkinen et al., 2002; Mitchell & Denne, 1997), the results for Serbian spruce show an increase



Figures 3. Axial variation of oven-dry wood density along the stem height / **Slika 3**. Aksijalna varijacija gustine drveta u apsolutno suvom stanju duž visine stabla

in density along the stem height. This trend may be associated with the species' specific mechanical requirements and morphological characteristics. Ward (1975) also emphasized that in certain *Picea* species, density does not necessarily decrease with height but may remain constant or even increase. Furthermore, Gryc & Horáček (2007) pointed out that axial density variation is strongly influenced by the presence of reaction wood, which occurs more frequently in the upper parts of the crown as a response to mechanical stresses. Similarly, Horáček et al. (2018) showed that spruce wood density may be higher in the middle and upper stem sections compared to the base, interpreting this as an adaptive response to static and dynamic loading, such as wind or snow.

Based on Figures 4-8, it can be observed that the wood density of Serbian spruce varies both radially (from pith to bark) and axially (along the tree height), with the intensity of these changes differing among sites. This reflects the influence of site conditions and growth dynamics of the trees. In plantation Dubrava, density shows a moderate increase from the pith toward the bark, which represents a typical trend in conifers. At lower tree heights, density is slightly lower, while toward the upper parts of the stem, a slight increase can be noted. At plantation Srebrenica, a somewhat higher degree of variability is observed, with lower density values near the pith and a gradual increase toward the bark. In the upper stem sections, density tends to be slightly lower compared to the base, which may be a consequence of faster growth and wider annual rings. At Gostilja, wood density exhibits high radial and axial uniformity, with a slight increase both toward the bark and toward the top of the stem. The inner zones near the pith show somewhat lower density values due to a higher proportion of earlywood, while the outer zones, with a greater proportion of latewood, display a more compact structure. At Stolac 1, a consistent increase in density was observed both radially (from pith to bark) and axially (along the tree height). This pattern is typical of trees with stable, slower growth and a higher proportion of latewood. Trees from the Stolac 2 natural stand show a similar trend to those from Stolac 1 — a gradual increase in density from the pith toward the bark and along the stem height, confirming uniform growth and good physiological vitality. Similar tendencies were reported by Jyske et al. (2008), who emphasized that in spruce, density increases toward the periphery of the stem where the proportion of latewood rises, while axial variation may depend on growth conditions and the physiological status of the tree.

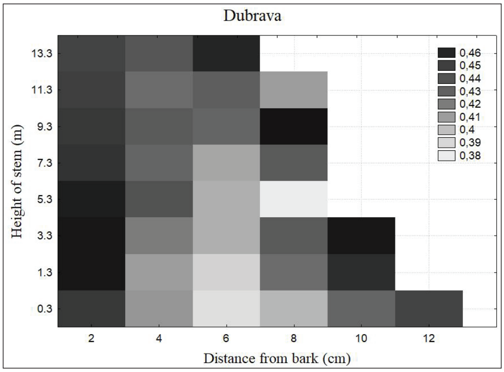


Figure 4. Variation of oven-dry wood density along the radius and stem height - Dubrava / **Slika 4**. Varijacija gustine drveta u apsolutno suvom stanju duž prečnika i visine stabla - Dubrava

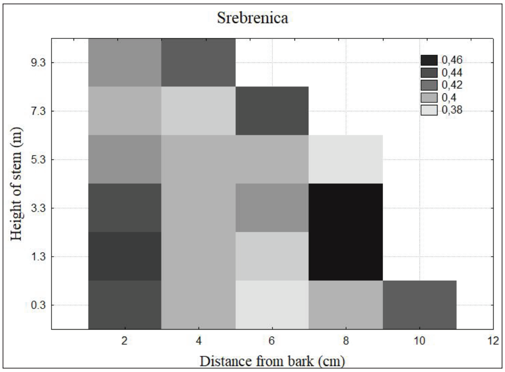


Figure 5. Variation of oven-dry wood density along the radius and stem height - Srebrenica / **Slika 5**. Varijacija gustine drveta u apsolutno suvom stanju duž prečnika i visine stabla - Srebrenica

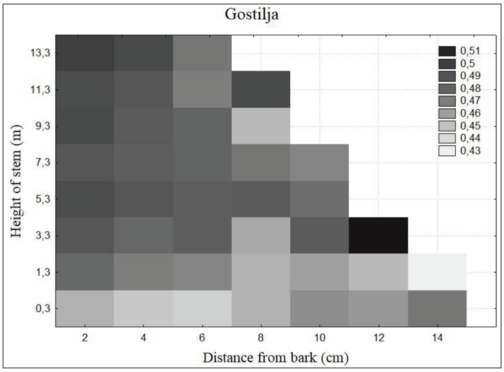


Figure 6. Variation of oven-dry wood density along the radius and stem height - Gostilja / **Slika 6**. Varijacija gustine drveta u apsolutno suvom stanju duž prečnika i visine stabla - Gostilja

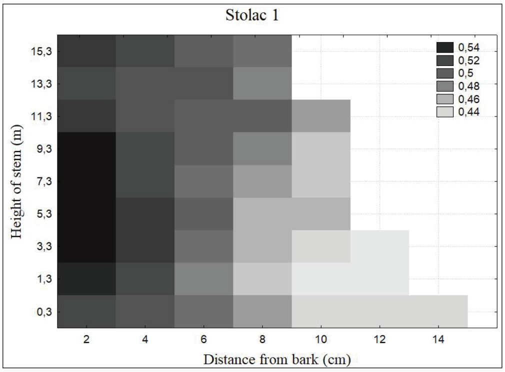


Figure 7. Variation of oven-dry wood density along the radius and stem height - Stolac 1 / **Slika 7**. Varijacija gustine drveta u apsolutno suvom stanju duž prečnika i visine stabla - Stolac 1

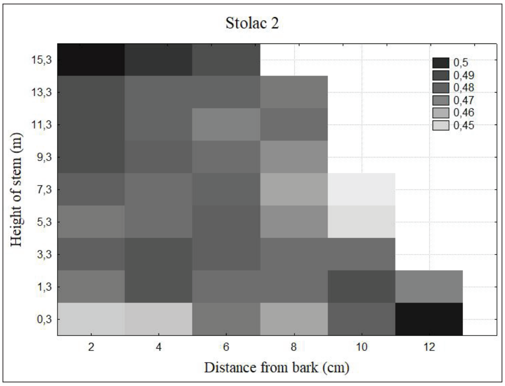
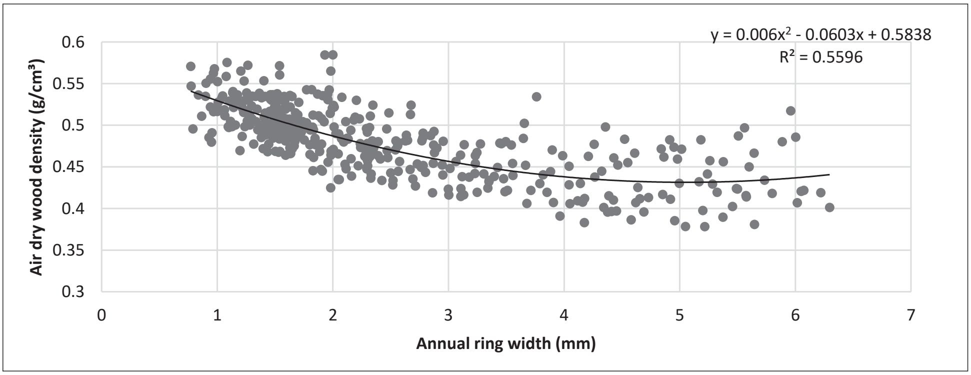


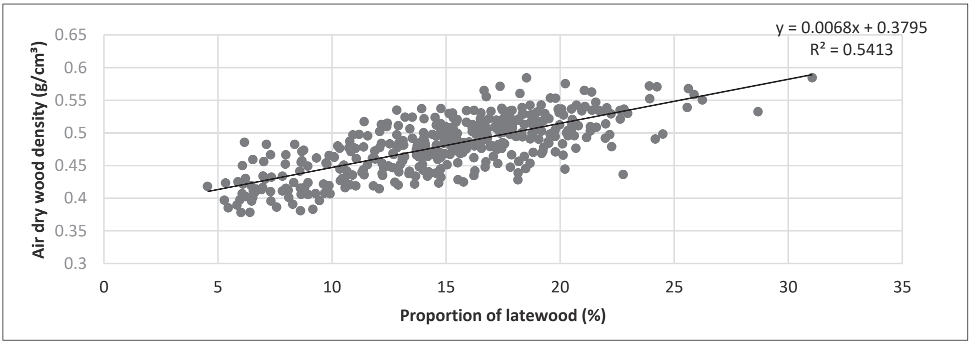
Figure 8. Variation of oven-dry wood density along the radius and stem height - Stolac 2 / **Slika 8**. Varijacija gustine drveta u apsolutno suvom stanju duž prečnika i visine stabla - Stolac 2

Figure 9 illustrates the relationship between wood density in the air-dry state and annual ring width. A strong negative correlation (R = 0.75) was established, indicating that wood density decreases as ring width increases. This trend is typical for coniferous species, where a higher growth rate leads to a greater proportion of earlywood, which has a lower density. The polynomial equation ($y = 0.006x^2 – 0.0603x + 0.5838$) shows that the decrease in density is non-linear—it is most pronounced in the range of narrow rings, while for wider rings, density values remain relatively stable. A similar trend was described by Harvald & Olesen (1987) for Norway spruce, emphasizing that density depends on the dynamics of annual growth and the proportion of latewood within the growth ring. Donaldson et al. (1995), Jyske et al. (2008) and Shchekalev et al. (2023) likewise confirmed that increased ring width leads to lower density, due to a higher proportion of earlywood with thinner cell walls and larger tracheid lumina.



Figures 9. Relationship between air-dry wood density and annual ring width / **Slika 9**. Zavisnost gustine drveta u prosušenom stanju od širine godova

Figure 10 illustrates the relationship between air-dry wood density and the proportion of latewood. A strong positive correlation (R = 0.73) was observed, indicating that an increase in the proportion of latewood has a significant effect on the rise in wood density. This relationship is consistent with well-established patterns observed in conifers (Panshin & de Zeeuw, 1980; Gryc & Horáček, 2007), as latewood is composed of cells with thicker walls, smaller lumina, and a higher amount of solid material per unit volume.



Figures 10. Relationship between air-dry wood density and the proportion of latewood / **Slika 10**. Zavisnost gustine drveta u prosušenom stanju od udjela kasnog drveta

4. CONCLUSIONS / ZAKLJUČCI

The results of this study show that the wood density of Serbian spruce varies depending on the origin of the trees, as well as on their radial position and height within the stem. Trees from natural stands exhibited higher density values and lower variability compared to those from plantations. The average density values in both the oven-dry and air-dry states were higher in natural stands, indicating the influence of natural site conditions and more stable growth dynamics.

Along the axial direction, an increase in density with tree height was observed, which deviates from the typical trend in most conifer species. This phenomenon can be interpreted as an adaptive response of trees to static and dynamic loading, particularly in the upper parts of the crown, where reaction wood develops and greater mechanical stability is required. The radial distribution of density shows a gradual increase from pith to bark, consistent with a higher proportion of latewood in the outer zones and a lower share of earlywood with thinner cell walls.

The analysis of the relationship between density and anatomical characteristics confirmed a strong dependence of density on ring width and latewood proportion. The obtained results demonstrate that the wood density of Serbian spruce is influenced by the internal growth ring structure and by the species' physiological adaptations to site conditions.

Higher density values in natural stands, together with the upward trend in density along the stem, indicate a high degree of adaptability of this species and its potential for technical, structural, and energy-related applications. Given its stable properties and favorable physical characteristics, Serbian spruce can be considered a species with considerable potential for practical and industrial use, particularly in the context of conserving native genetic resources and promoting the sustainable utilization of domestic wood materials.

References / Literatura

Aanerød, R. S. (2014). *Modeling density and mechanical properties in Norway spruce (Picea abies (L.) Karst) by forest inventory data* [Master's thesis]. Norwegian University of Life Sciences, Department of Ecology and Natural Resource Management.

Dadswell, H. E., & Watson, A. J. (1962). Influence of the morphology of woodpulp fibres on paper properties. In F. Bolam (Ed.), *The formation and structure of paper: Transactions of the II Fundamental Research Symposium, Oxford, 1961* (pp. 537–564). FRC.

Donaldson, L. A., Evans, R., Cown, D. J., & Lausberg, M. J. F. (1995). Clonal variation of wood density variables in *Pinus radiata*. *New Zealand Journal of Forestry Science, 25*(2), 175–188.

Glass, S. V., & Zelinka, S. L. (2010). Moisture relations and physical properties of wood. In *Wood handbook: Wood as an engineering material* (Centennial ed., chap. 4, pp. 4.1–4.19). U.S. Department of Agriculture, Forest Service, Forest Products Laboratory.

Gryc, V., & Horáček, P. (2007). Variability in density of spruce (*Picea abies* [L.] Karst.) wood with the presence of reaction wood. *Journal of Forest Science, 53*(3), 129–137. https://doi.org/10.17221/2146-JFS

Harvald, C., & Olesen, P. O. (1987). The variation of the basic density within the juvenile wood of Sitka spruce (*Picea sitchensis*). *Scandinavian Journal of Forest Research, 2*(4), 525–537. https://doi.org/10.1080/02827588709382488

Horáček, P., Fajstavr, M., & Stojanović, M. (2017). The variability of wood density and compression strength of Norway spruce (*Picea abies* /L./ Karst.) within the stem. *Beskydy, 10*(1–2), 17–26. https://doi.org/10.11118/beskyd201710010017

Institut za standardizaciju Srbije. (2015). *SRPS ISO 13061-2:2015: Fizička i mehanička svojstva drveta—Metode ispitivanja za male uzorke drveta bez grešaka—Deo 2: Određivanje zapreminske mase za fizička i mehanička ispitivanja.*

Jenkins, B. M., Baxter, L. L., Miles, T. R., & Miles, T. R. (1998). Combustion properties of biomass. *Fuel Processing Technology, 54*(1–3), 17–46. https://doi.org/10.1016/S0378-3820(97)00059-3

Jyske, T., Mäkinen, H., & Saranpää, P. (2008). Wood density within Norway spruce stems. *Silva Fennica, 42*(3), 439–455. https://doi.org/10.14214/sf.248

Karahasanović, A. (1962). Tehnička svojstva bosanske prašumske jelovine. *Radovi Šumarskog fakulteta i Instituta za šumarstvo i drvnu industriju u Sarajevu, 7*(7), 207–271. https://doi.org/10.54652/rsf.1962.v10.i7.423

Kollmann, F. F. P. (1951). *Technologie des Holzes und der Holzwerkstoffe* (2nd ed., Vols. 1–2). Springer.

Kollmann, F. F. P., & Côté, W. A. (1968). *Principles of wood science and technology: Part I. Solid wood*. Springer.

Kommert, R. (1993). Die Holzeigenschaften der serbischen Fichte aus Anbauten im Freistaat Sachsen. *Holz als Roh- und Werkstoff, 51*, 329–334. https://doi.org/10.1007/BF02663804

Lukić-Simonović, N. (1955). O osnovnim fizičkim svojstvima i njihovom međusobnom odnosu kod *Picea omorika* Pančić. *Glasnik Šumarskog fakulteta, 10*, 237–266.

Lukić-Simonović, N. (1970). *Uporedna istraživanja tehnoloških svojstava drveta Picea omorica Panč. i Picea excelsa Lin. u vezi sa uticajem staništa* [Unpublished Doctoral dissertation]. University of Belgrade.

Mäkinen, H., Saranpää, P., & Linder, S. (2002). Wood-density variation of Norway spruce in relation to nutrient optimization and fibre dimensions. *Canadian Journal of Forest Research, 32*(2), 185–194. https://doi.org/10.1139/x01-186

Mitchell, M. D., & Denne, M. P. (1997). Variation in density of *Picea sitchensis* in relation to within-tree trends in tracheid diameter and wall thickness. *Forestry, 70*(1), 47–60. https://doi.org/10.1093/forestry/70.1.47

Niklas, K. J. (1992). *Plant biomechanics: An engineering approach to plant form and function*. University of Chicago Press.

Panshin, A. J., & de Zeeuw, C. (1980). *Textbook of wood technology* (4th ed.). McGraw-Hill.

Shchekalev, R. V., Danilov, D. A., Zaytsev, D. A., Korchagov, S. A., & Melehov, V. I. (2023). Variation of physical and mechanical properties of *Pinus sylvestris* L. wood in the boreal zone of the European Northeast. *South-east European Forestry, 14*(2), 197–213. https://doi.org/10.15177/seefor.23-18

Siau, J. F. (1984). *Transport processes in wood*. Springer.

Šoškić, B., & Popović, Z. (2002). *Svojstva drveta*. University of Belgrade, Faculty of Forestry.

Todorović, N. (2006). *Aksijalno utezanje drveta bukve (Fagus moesiaca Č.), hrasta kitnjaka (Quercus sessiliflora S.) i smrče (Picea excelsa L.)* [Unpublished Master's thesis]. University of Belgrade, Faculty of Forestry.

Ugrenović, A. (1950). *Tehnologija drveta*.

Wagenführ, R. (2000). *Holzatlas* (5th ed.). Fachbuchverlag Leipzig.

Ward, D. (1975). *The influence of tree spacing upon tracheid length and density in Sitka spruce (Picea sitchensis (Bong.) Carr.)* [Master's thesis]. University College Dublin.

Zeidler, A., Borůvka, V., Brabec, P., Tomczak, K., Bedřich, J., Vacek, Z., Cukor, J., & Vacek, S. (2024). The possibility of using non-native spruces for Norway spruce wood replacement—A case study from the Czech Republic. *Forests, 15*(2), 255. https://doi.org/10.3390/f15020255

Zobel, B. J., & van Buijtenen, J. P. (1989). *Wood variation: Its causes and control*. Springer.

Sažetak

Pančićeva omorika (*Picea omorika* Pančić/Purkyně) predstavlja reliktnu i endemičnu vrstu ograničenog areala u istočnom dijelu Bosne i Hercegovine i zapadnoj Srbiji. Imajući u vidu njen izuzetan ekološki i genetički značaj, kao i potencijal za tehničku primjenu, poznavanje fizičkih svojstava, posebno gustine drveta, ima ključnu ulogu u procjeni adaptivnih sposobnosti i upotrebne vrijednosti ove vrste. Cilj ovog istraživanja bio je da se utvrdi varijacija gustine drveta

Pančićeve omorike u aksijalnom (po visini stabla) i radijalnom (od srži ka kori) pravcu, kao i da se analiziraju razlike između gustine drveta iz kultura i prirodnih sastojina.

Istraživanje je sprovedeno na pet lokaliteta u Bosni i Hercegovini: kulture Dubrava i Srebrenica, te prirodne sastojine Gostilja, Stolac 1 i Stolac 2. Ukupno je analizirano 3117 epruveta dimenzija 20 × 20 × 30 mm, dobijenih iz koturova stabala na različitim visinama (0,3 m, 1,3 m i dalje na svaka dva metra). Gustina drveta je određena u apsolutno suvom, prosušenom i sirovom stanju vlažnosti, kao i nominalna gustina.

Prosječna gustina drveta u apsolutno suvom stanju iznosila je 0,421 g/cm³ za kulture i 0,487 g/cm³ za prirodne sastojine, dok su u prosušenom stanju ove vrijednosti iznosile 0,450 g/cm³ i 0,513 g/cm³. Statistička analiza pokazala je da su stabla iz prirodnih sastojina imala manju varijabilnost i veću stabilnost svojstava. U aksijalnom pravcu utvrđen je trend povećanja gustine po visini stabla, što se može dovesti u vezu sa specifičnom morfologijom i mehaničkim zahtjevima vrste, kao i prisustvom reakcionog drveta u gornjim dijelovima krošnje. Radijalno, gustina raste od srži ka kori, što je u skladu sa povećanim udjelom kasnog drveta i smanjenim učešćem ranog drveta sa tanjim ćelijskim zidovima.

Korelaciona analiza pokazala je značajnu negativnu zavisnost između širine prstenova prirasta i gustine (R = 0,75), kao i pozitivnu zavisnost između udjela kasnog drveta i gustine (R = 0,73).

Dobijeni rezultati potvrđuju da Pančićeva omorika posjeduje stabilna fizička svojstva, koja je čine pogodnom za tehničku i industrijsku upotrebu, a ujedno ukazuju i na njen značaj kao autohtone vrste čije očuvanje i valorizacija mogu doprinijeti održivom upravljanju šumskim resursima regiona.

Ključne reči: fizička svojstva drveta, kulture, *Picea omorika*, prirodne sastojine