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Original Article

Effect of Fungal Lesions on the Wood Density of Silver Fir (*Abies alba* L.) in Ukrainian Carpathians

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ABSTRACT

The research has covered the biological wood resistance in terms of reducing its wood density of Silver fir growing in the Ukrainian Carpathians. Six Silver fir stands were placed in the State Enterprise Perechyn Forestry, in which were cut 54 model trees with varying decay stages. All qualitative characteristics of Silver fir wood were diagnosed by the European norms. Altogether, 1620 wood samples were studied. The start of biological damage to wood was defined as the cessation of cambial activity and drying of the tree crown, as well as diagnosed fungal lesions. As a result, there were significant differences in wood density with a different timeframe of decay stages of wood. The basic density of healthy wood varied from 362 kg·m^{-3} to 457 kg·m^{-3} with an average value of 392 kg·m^{-3}, and the same figure for wood with significant damage ranged from 195 kg·m^{-3} to 283 kg·m^{-3} with an average value of 246 kg·m^{-3}. This should be associated with the biological destruction of the cell wall affected by fungi from division Basidiomycota. Four significant decay stages of Silver fir stemwood taking the lesioned time by the equal variances estimated through Scheffé's Method were set: (1) healthy wood without signs of biological damage by fungi; (2) initial wood damage caused by wood-staining fungi within up to 6 months; (3) medium wood damage caused by wood-destroying fungi within the timeframe from 0.5 to 2 years; and (4) substantial wood damage caused by wood-destroying fungi for more than 2 years.

Key words: Moldiness, natural resistance, wood biodegradation, wood density, wood-destroying fungi, wood-staining fungi

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Introduction

Global climate change affects forest ecosystems, which changes the physiological processes of growth and development of tree species and the speed of biophysical processes in the forest (Olesen et al., 2007; Thompson et al., 2009; Thurm et al., 2018). In this regard, the damage to the forest ecosystem should be associated with changes in its species composition, the structure of the ecosystem, and its main elements. Thus, the ability of the forest ecosystem to absorb various biological and ecological disturbances while maintaining its basic function and structure, as well as its identity, should be considered its biological resilience (Ibach, 2013; Verbist et al., 2019; Walker, 1995). At the same time, it is worth noting that the biological resilience of the forest ecosystem depends on the stability of dominant forest species or their structural components (Bari et al., 2020).

The process of wood decay should be related to the composition and richness of fungal communities for which wood is a potential source of food and causes the death of trees (Bässler et al., 2012; Ibach, 2013; Renvall, 1995). In carbohydrate polymers, namely in the cell wall, microorganisms with their enzyme system can hydrolyze these polymers to the digestible individual chemical components of hemicellulose, cellulose, and lignin (Kües et al., 2007; Tsyrulnyk & Shevchenko, 2008). Prolonged biodegradation of wood occurs in conditions of high absolute humidity. Biodegradation of stemwood is mainly due to wood-destroying fungi from the division Basidiomycota (Schwarze et al., 2000; Tsyrulnyk & Shevchenko, 2008).

Fungi decompose wood by the means of several types of rot, which could be sorted into three main types: white, brown, and soft rot. The white rot decomposes main woody components such as hemicelluloses and cellulose, while brown and soft rots decompose hemicelluloses and cellulose and cleave lignin (Pouska et al., 2010; Schwarze et al., 2000). Biological lesions to stemwood should be divided into damages of moldiness, wood-staining, and wood-destroying fungi. Moldiness of *Ceratocystis coeruleum* (Munch.) H. et Syd. and *Ceratocystis*

comatum Mill, et Cernz. damage the sapwood surface penetrating by about 1 mm. Favorable conditions for the development of superficial moldiness are the wood moisture content from 60% to 100% and a temperature of + 20–30°C. Moldiness is usually a white fungal plaque on the wood surface that causes oxidative fermentation and usually the destruction of parenchymal cells of sapwood. The formed intermediate products of the biochemical process of wood destruction are organic acids—gluconic, fumaric, tartaric, and so on. At the same time, fungi of the genera *Trichoderma* Pers., *Verticillium* Nees, *Repisillium*, *Trichothecium* Link, and *Mucor* Fresen. cause a change in the color range of wood to green, pink, gray, and olive; *Aspergillus* Micheli and *Alternaria* Nees cause black spots; *Aspergillus glaucus* Link. changes light green color of the wood; and *Repisillium roseum* Link. and *Repisillium purpurogenum* Flor. et Stoll. changes the color of wood to red (Tsyrulnyk & Shevchenko, 2008).

Superficial moldiness has much in common with wood-staining fungi, which are also primary saprophytic organisms. In coniferous wood, hyphae of wood-staining fungi penetrate deeply, which causes a change in the appearance of wood and a decrease in its quality class (EN 350, 2016; Sbirnyk, 2019). The diagnostic signs of coniferous wood damage by staining fungi are deeply penetrated gray-blue spots in stemwood. About 50 species of imperfect fungi mostly cause the above-mentioned wood discoloration, but the most common causative agents of gray-blue spots in the coniferous roundwood are species of Ascomycota: *C. coeruleum* (Munch.) H. et Syd., *C. comatum* Mill, et Cernz., *Ceratocystis piceae* (Munch.) H. et Syd., *Ceratocystis pini* (Munch.) H. et Syd., *Trichosporum tingens* Lag. et Mel., *Leptographium lundbergii* Lag. et Mell., *Cladosporium herbarum* Link., and *Disculapinicola* (Naum.) Petrak. (Schwarze et al., 2000; Tsyrulnyk & Shevchenko, 2008).

Fir species are economically valuable because of many features like timber, pulp and paper, oils, resins, and also ornamental purposes (Ayan et al., 2012). However, the natural resistance of wood against biological degradation such as fungal decay in the trunk is always of economic importance in forestry because of lowering the wood quality classes of round timber and attracts the scientific attention of many researchers (Bässler et al., 2012; Kutnik et al. 2017; Pouska et al., 2010; Schwarze et al., 2000). In this regard, Ayan et al. (2012) emphasize the importance of determining the target diameter of the selective forest in Trojan fir (*Abies nordmanniana* subsp. *equi-trojani* [Asch. & Sint. ex Boiss] Coode & Cullen) stands according to factors of the growing environment such as altitude, exposure, and site index. Otherwise, the low quality of wood caused by heart rots causes great economic losses. Özden Keleş et al. (2021) stated that *Melampsorella caryophyllacearum* is increasingly threatening for Trojan fir as a fungal pathogen affecting the growth and development of trees. Disease incidence tended to increase with decreasing altitude: trees that were grown at relatively low altitude (approx. 1400 m a.s.l.) showed greater disease incidence, compared with trees at higher altitude (approx. 1700 m a.s.l.). In this context, it should be noted that significant achievements in studying the issue of natural resistance of stemwood against wood decay have been insufficiently studied. The objective of this study was to investigate symptoms of biological degradation of stemwood in the context of reducing the volume mass of Silver fir in forest vegetation conditions of the Ukrainian Carpathians. To achieve this goal, the main objectives were to estimate (1) the impact of wood-staining and wood-destroying fungi on the wood density of Silver fir and (2) the timeframe of biological destruction of wood in terms of reducing its wood density.

Methods

The fieldwork was conducted between 2018 and 2020 in the Ukrainian Carpathians in part of Perechyn State Forestry Enterprise, in the Turytskiy and Turya-Remetivskyi forest districts (Figure 1), where 54 model trees with different degrees of biological damage by wood-staining and wood-destroying fungi and 18 model trees without any damages were selected.

Sampling plots of fir-beech stands were situated at the longitude 22˚45′ E, latitude 48°49′ N, and altitudes from 400 to 950 m a.s.l. Dominant Silver fir trees were located in the wet mixed forest stands by establishing six quadratic sampling plots on a 50 m × 50 m, where all silvicultural and dendrometrical characteristics were recorded. Forest types did not differ from each other in soil properties and the structure of the woody vegetation (Table 1).

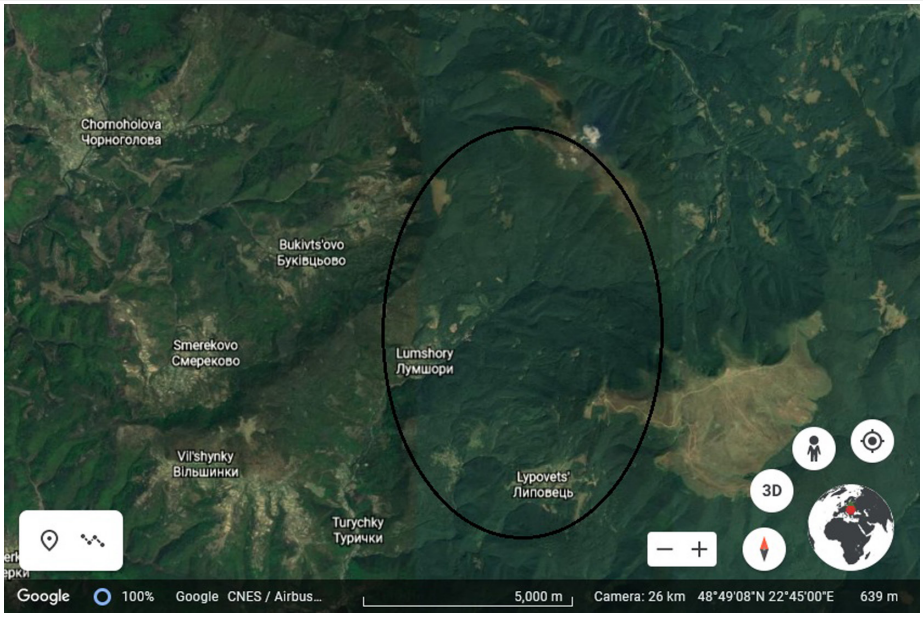

Figure 1.
The Location of the Investigated Area.

Table 1.
Forest and Estimated Features of Sampling Plots of Silver Fir Stands

Sampling Plots	Stand Composition	Age (Years)	Stand Quality/Stocking**	H (m)	D (cm)	M (m³)
1	*5ABA5FAS	170	I/0.45	33	52	350
2	5ABA5FAS	190	I/0.60	35	52	530
3	6ABA4FAS+ ACP	190	I/0.60	34	52	600
4	6ABA4FAS	85	IA/0.70	33	36	630
5	8ABA2FAS	89	IA/0.60	34	36	460
6	10ABA+FAS	115	IA/0.55	34	46	520

Note: *5 is defined as 50% of tree species occupying the stand composition; **calculated as a relationship between basal area of trees at the breast height and the total stand basal area per plot.
ABA = *Abies alba* L.; FAS = *Fagus sylvatica* L.; ACP = *Acer pseudoplatanus* L.; "+" defined as <5%; H = average tree height; D = average tree diameter at breast height; M = timber volume per hectare; IA and I = extra and very productive forest stand determined through the age and the height.

To study the effects of fungal lesions on the wood density of Silver fir, an equal number of lesioned trees in the timeframe of up to 6 months, from 0.5 to 2 years, and more than 2 years were examined. The beginning of the lesion of Silver fir was defined by the cessation of cambial activity (stop of sap flux) and the dieback of the tree crown as well as the diagnosis of fungal damages in the trunk, namely the presence of superficial moldiness: wood-staining and wood-destroying fungi. Twelve trunks of Silver fir at each sampling plot were studied and nine trunks were lesioned by wood-staining and wood-destroying fungi for the different time periods. On each sampling plot in the different decay stages 12 damaged Silver fir trees as well as 3 model trees with healthy stemwood were studied (Figure 1). All wood samples were collected in August. The total number of studied wood specimens (20 × 20 × 30 mm³) was 2160, which were selected using the generally accepted method of determining the physical properties of wood (Figure 2).

Different types of wood density were determined using the standard methods (Normen für Holz, 2009). Basic density (ρ_b) was determined as the ratio of the weight of the oven-dry wood (m_0) and the volume of green wood, whose moisture content was equal to the moisture content of growing trees. The dry basis moisture content of wood (W_a) was expressed as the ratio of the mass of water contained in the wood and the mass of the oven-dry wood on a percentage basis. The wood density by different moisture content such as green wood (ρ_g, $W_a \approx 100\%$), oven dry-wood (ρ_0, $W_a = 0\%$), and air-dry wood (ρ_{10}, $W_a = 10\%$) was

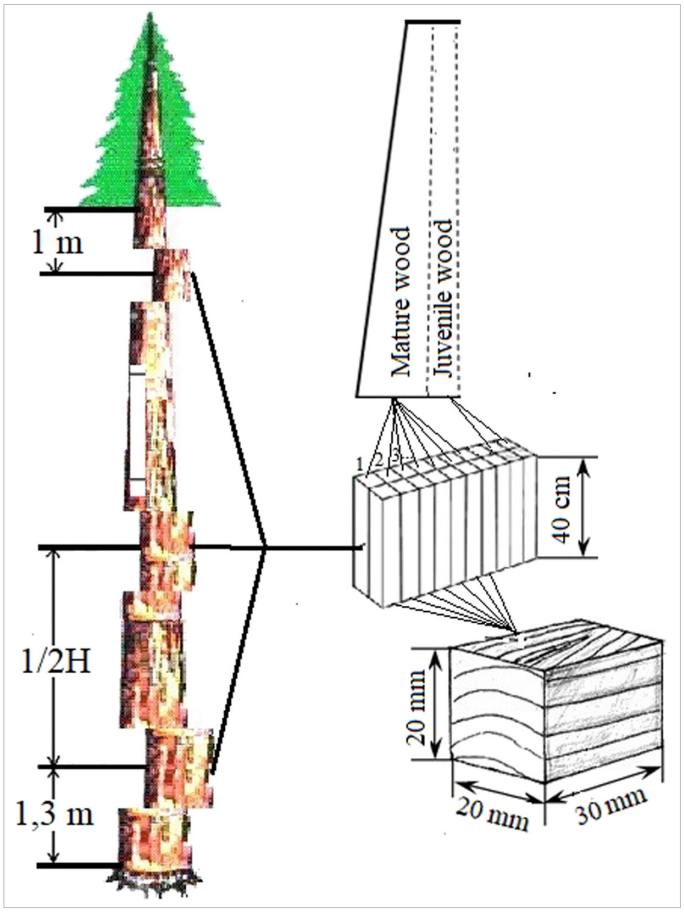

Figure 2.
Scheme of Selecting Wood Specimens from Model Trees.

Figure 3.
Biodegradation of Silver Fir Lesioned by Fomes fomentarius.

calculated as the ratio of the weight and the volume of wood respectively to moisture content. The natural (biological) wood resistance was interpreted as the ability of wood to resist fungal lesions in the context of wood decomposition, which reduces the wood quality and its energy value (EN 350, 2016; Kutnik et al., 2017).

The descriptive statistics were based on the procedure of Statistical Package of Social Sciences software package 17.0 and included number of samples, minimum and maximum value, mean value, and coefficient of variation. To determine the difference among the mean values of the wood density of healthy and lesioned stemwood caused by wood-staining and wood-destroying fungi, one-way analysis of variance (ANOVA) was used. Then, Duncan multiple tests were applied which looks at the difference in means of a continuous variable between groups. The null hypothesis has no difference in the mean values, and the alternative hypothesis has a difference in the mean values (significant at $<.05$).

Results and Discussion and Conclusion

The wood decomposition is a central ecosystem process and its rates depend on climatic conditions and differences in wood density (Oberle et al., 2020). Despite the importance of wood decomposition as an ecosystem process as well as for the forestry, for example wood quality assessment, many aspects regarding its effect on the stemwood density in standing trees remain unclear. In this study, cellulose-destroying fungi mostly cause the destruction of wood, which is a complex chemical process and it is not entirely clear how living microorganisms recognize carbohydrates and break them down in the trunks of Silver fir (Figure 3). The effect of fungal lesions on the wood density of Silver fir caused by wood-staining (*C. comatum* Mill. & Cernz., *C. coeruleum* (Munch.) H. et Syd.) and wood-destroying (*Fomes fomentarius* (L.) Fr., *Fomitopsis pinicola* (Swartz: Fr.) P. Karst.) fungi are given in Table 2.

The influence of superficial moldiness, wood-staining, and wood-destroying fungi on the wood density of Silver fir trunk showed significant differences in the values of basic, oven-dry, air-dry, and green wood density. The wide range of the value variation of the healthy wood density is needed to be associated with differences in macrostructural indicators. The basic density of healthy wood varied from 362 kg·m^{-3} to 457 kg·m^{-3} with a mean of 392 kg·m^{-3}. Simultaneously, the basic wood density with initial wood damages caused by wood-staining fungi (*Aspergillus* sp., *Penicillium* Link sp., *C. comatum* Mill. &

Table 2.
Wood Density of Healthy and Fungal Lesioned (kg·m^{-3})

Variables	Minimum	Mean	Maximum	Coefficient of Variation (%)	Accuracy Figure (%)
Healthy wood without any signs of fungal infection					
ρ_b	362	392	457	5.7	0.8
ρ_0	412	449	517	5.2	0.7
ρ_{10}	429	470	543	6.0	0.9
ρ_g	845	949	1099	5.9	0.8
W_a, %	121.0	134.7	148.3	6.3	0.9
Initial wood damage caused by wood-staining fungi (*Aspergillus* sp., *Penicillium* sp., *Ceratocystis comatum* Mill. & Cernz., *Ceratocystis coeruleum* (Munch.) H. et Syd.) within up to 6 months					
ρ_b	331	361	419	6.3	0.9
ρ_0	382	403	449	6.2	0.9
ρ_{10}	403	440	471	4.5	0.6
ρ_g	787	847	908	4.5	0.6
W_a, %	100.2	120.4	135.8	8.8	1.2
Medium wood damage caused by wood-destroying fungi (*Fomes fomentarius* (L.) Fr., *Fomitopsis pinicola* (Swartz: Fr.) P. Karst.) within the timeframe from 0.5 to 2 years					
ρ_b	249	283	309	5.7	0.8
ρ_0	281	321	368	5.2	0.7
ρ_{10}	300	343	389	7.7	1.1
ρ_g	503	610	678	6.1	0.9
W_a, %	92.5	109.6	118.8	5.5	0.8
Substantial wood damage caused by wood-destroying fungi (*Fomes fomentarius* (L.) Fr., *Fomitopsis pinicola* (Swartz: Fr.) P. Karst.) for more than 2 years					
ρ_b	195	246	283	7.0	1.0
ρ_0	232	279	335	6.3	0.9
ρ_{10}	268	318	347	6.0	0.9
ρ_g	513	560	619	4.5	0.6
W_a, %	90.4	96.1	103.0	3.2	0.4

ρ_b = basic density; ρ_0 = oven-dry wood density; ρ_{10} = wood density by the moisture content 10%; ρ_g = green wood density; W_a = dry basis moisture content of the wood.

Cernz., *C. coeruleum* (Munch.) H. et Syd.) within up to 6 months ranged from 331 kg·m^{-3} to 419 kg·m^{-3} with the mean of 361 kg·m^{-3}. The reduction of the density of lesioned wood was 7.9% compared to healthy wood, which could be considered insignificant. However, differences in basic wood density of medium and substantial wood damages caused by wood-destroying fungi (*F. fomentarius* (L.) Fr., *F. pinicola* (Swartz: Fr.) P. Karst.) within the timeframe from 0.5 to 2 years and for more than 2 years were characterized by a significant decrease. The basic wood density with medium wood damages varied from 249 kg·m^{-3} to 283 kg·m^{-3} with a mean value of 309 kg·m^{-3}, and a similar figure with substantial wood damages ranged from 195 kg·m^{-3} to 283 kg·m^{-3} with the mean value of 246 kg·m^{-3} (Table 2)

A similar tendency to decrease the wood density of stemwood as a result of its biodegradation was also characterized by the density of green wood, oven-dry wood, and air-dry wood. The density of healthy oven-dry wood varied from 412 kg·m^{-3} to 517 kg·m^{-3} with a mean value of 449 kg·m^{-3} and analogous variables of medium and substantial wood damages caused by wood-destroying fungi were significantly decreased. The mean value of density of oven-dry wood with medium and substantial wood damages caused by wood-destroying fungi was equal to 283 kg·m^{-3} and 279 kg·m^{-3}, respectively. In all experiments, the statistical indicators of the amplitude measurements were characterized by significant *p*-value ($p < .05$).

Analysis of the obtained results of the effect of fungal lesions on the wood density of Silver fir growing in Ukrainian Carpathians allowed us to statistically identify four stages (classes) of the trunk (stemwood) by natural (biological) wood resilience and their timeframe of wood decay, namely with (1) healthy wood without any signs of fungal infection in the trunk; (2) initial wood damages caused by wood-staining fungi (*Aspergillus* sp., *Penicillium* sp., *C. comatum* Mill. & Cernz., *C. coeruleum* (Munch.) H. et Syd.) within up to 6 months; (3) medium wood damages caused by wood-destroying fungi (*F. fomentarius* (L.) Fr., *F. pinicola* (Swartz: Fr.) P. Karst.) within the timeframe from 0.5 to 2 years; and (4) substantial wood damages caused by wood-destroying fungi

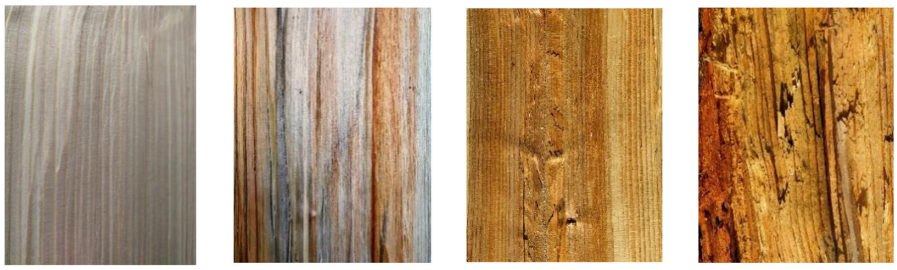

Figure 4.
Differences in the Appearance of Healthy and Lesioned by Fungi Wood.

Table 3.
Multiple Comparisons of the Wood Classes by Natural Wood Resilience through Basic Wood Density using Scheffe Test

					95% Confidence Interval	
I**	J**	Mean Difference (I-J)	Standard Error	Significance (*p*)	Lower Bound	Upper Bound
1	2	30.280*	3.969	.000	19.09	41.47
	3	108.740*	3.969	.000	97.55	119.93
	4	145.540*	3.969	.000	134.35	156.73
2	1	−30.280*	3.969	.000	−41.47	−19.09
	3	78.460*	3.969	.000	67.27	89.65
	4	115.260*	3.969	.000	104.07	126.45
3	1	−108.740*	3.969	.000	−119.93	−97.55
	2	−78.460*	3.969	.000	−89.65	−67.27
	4	36.800*	3.969	.000	25.61	47.99
4	1	−145.540*	3.969	.000	−156.73	−134.35
	2	−115.260*	3.969	.000	−126.45	−104.07
	3	−36.800*	3.969	.000	−47.99	−25.61

Note: 1—Healthy wood without any signs of fungal infection in the trunk; 2—Initial wood damages caused by wood-staining fungi within up to 6 months; 3—Medium wood damages caused by wood-destroying fungi within the timeframe from 0.5 to 2 years; 4—Substantial wood damages caused by wood-destroying fungi for more than 2 years.
*The mean difference is significant at the 0.05 level; **classes of stemwood by natural wood resilience.

Q2

(*F. fomentarius* (L.) Fr., *F. pinicola* (Swartz: Fr.) P. Karst.) for more than 2 years. Furthermore, the decay stage (classes) of the biological lesioned wood (stemwood) caused by wood-staining and wood-destroying fungi could be visually diagnosed in the forest practice (Figure 4). This approach is important for a better understanding of the consequences of fungal activity and the decomposition process in the technical perspective focused on construction timber. Thus, numerous mass timber buildings are already built and their performance will alter how engineers view wood as a raw construction material (Wang et al., 2018).

The procedure of one-way ANOVA was used to determine a statistically significant difference between the mean values of the wood density of healthy and lesioned stemwood caused by wood-staining and wood-destroying fungi (Table 3).

The statistical evaluation of the basic wood density testified the significant difference between classes of stemwood by natural wood resilience as demonstrated by one-way ANOVA and the *p*-value was less than the .05-alpha level. The similar tendency of the significant difference between classes of stemwood by natural wood resilience was characterized by the density of green wood, oven-dry wood, and air-dry wood as shown in Figure 5.

The variability of the different types of wood density displayed using the boxplots indicate the wide distribution of the data in the substantial stage of wood lesioned by fungi. The resulting *F*- and *p*-values are less than critical values which mean the obtained differences in wood density in the different stages of stemwood lesions are significant (Table 4). According to Duncan's multiple test results, in the four variables measured, healthy and initial stage stemwood formed the first homogeneous group, while the medium and substantial stages formed the second homogeneous group. They visually depict the natural tendency of the wood density decrease of Silver fir with different degrees of fungi lesion. Moreover, boxplots of the data showed significant distributions between stages of wood lesioned by fungi and their timeframe. The mean values especially differed from the median in four groups of wood samples with different degrees of fungal damage. Prolonged action of fungi (*F. fomentarius* (L.) Fr., *F. pinicola* (Swartz: Fr.) P. Karst.) for more than 2 years led to the decomposition of stemwood and caused the decrease of wood density by half. Simultaneously, the wood decay in the stage of initial wood damage caused by wood-staining fungi was characterized by the slight change in the wood density of Silver fir trunks. The mean value of the basic density with initial wood damages decreased by 8% compared to healthy wood. This deviation in wood density showed that the wood quality did not change, but there was a fungal lesion in

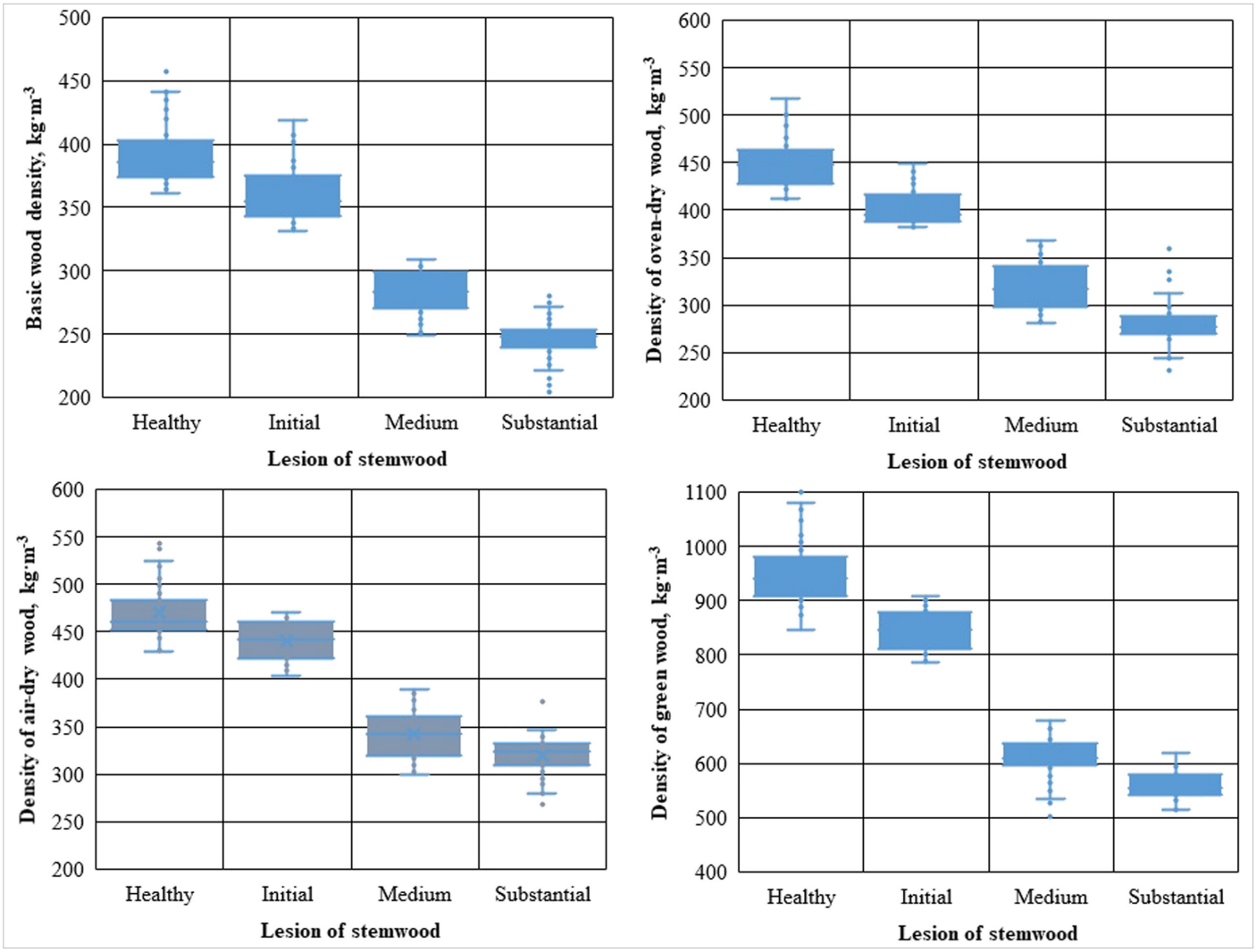

Figure 5.
Clustered Boxplots of the Wood Density by Natural Wood Resilience.

Table 4.
Homogeneous Groups and Results of One-way Variance Analysis for Lesioned Stemwood of Silver Fir

Lesion of Stemwood	Physical Wood Properties (kg/m³)			
	Basic Wood Density	Density of Oven-Dry Wood	Density of Air-Dry Wood	Density of Green Wood
Healthy	392a	449a	470a	949a
Initial	361a	403a	440a	847a
Medium	283b	321b	343b	610b
Substantial	246b	279b	318b	560b
F-value	3.7	4.4	3.4	7.4
p	.013	.005	.018	.000

Note: a, and b letters represent the homogeneous group formed by multiple test analysis.

stemwood causing the change of wood color. At the same time, the stemwood with medium and substantial damages caused by wood-destroying fungi (*F. fomentarius* (L.) Fr., *F. pinicolaTable 4.Homogeneous Groups and Results of One-way Variance Analysis for Lesioned Stemwood of Silver FirLesion of StemwoodPhysical Wood Properties (kg/m3)Basic Wood DensityDensity of Oven-Dry WoodDensity of Air-Dry WoodDensity of Green WoodHealthy392ahelp_outline449a470a949aInitial361a403a440a847aMedium283b321b343b610bSubstantial246b279b318b560bF-value3.74.43.47.4p.013.005.018.000Note: a, and b letters represent the homogeneous group formed by multiple test analysis.* (Swartz: Fr.) P. Karst.) within the timeframe from 0.5 to 2 years and for more than 2 years was characterized not only in the change of the wood appearance but also in the decrease of stemwood quality through significant decrease in the wood density caused by its decay. The basic density of the substantial damages in stemwood varies between 37% and 46% compared to the healthy stemwood, while this ratio is between 28% and 32% compared to the initial damages stage of the stemwoods. A similar trend was observed for other types of wood density indicating the biological degradation of stemwood of Silver fir, the start of which should be considered the time point of more than 6 months after the cessation of cambial activity and the fungal lesion of the trunk. In general, there is an important forestry issue that Silver fir timbers being affected by fungal lesions and not timely scheduled being harvested in Ukrainian Carpathians are fostering wood degradation and creating potential technical risks associated with the use of mass timber.

Biological developments of fungal damage to Silver fir at various stages of its decomposition have been revealed in a number of scientific works (Butin, 1996; Jahn, 1968; Kahl et al., 2017; Kriegelsteiner, 1991), but at the same time, no attention has been paid to changes in the wood density. The obtained results of the effect of fungal lesions on the wood density revealed the peculiarity of the biological resistance of wood cell over time and showed a significant decrease in the stemwood quality. In this context, timely diagnosis of fungal lesions of growing Silver fir trees is of economic value for most forestry enterprises of the Ukrainian Carpathians. Moreover, the established visual and qualitative differences in various stages of fungal lesions of Silver fir wood are a quantitative and qualitative tool during the monitoring of healthy stands regarding their biological damage. From the practical point of view, the established color shades of the wood are affected by fungal lesions and, accordingly, its density is a diagnostic criterion allowing to determine the quality class of Silver fir round timber. In the forestry sense, wood affected by fungi within 2 years has no commercial significance, but it provides food for thousands of invertebrates and homes for a wide array of wildlife (Gossner et al., 2016; Seibold et al., 2015).

Our research results showed that wood degradation in the initial stage by the fungus change wood in color and weight and still had a relatively good cohesion in its microscopic hierarchical structure. The investigation of Luthardt (2005) recommends to use the fungus to get velvety wood surfaces, which are technically used as polishing wood in the watch industry. Schmidt (2010) developed the industrial process for technical-mycological loosening of wood intending to improve the mechanical workability of European beech.

The results show that there is significant impact of fungal lesions on the wood quality. The wood density indicated significant differences at the stages of medium and substantial damages caused by wood-destroying fungi that linked with the crucial role of the time. Moreover, the effect of fungal lesions on the stemwood in the medium and substantial stages caused a reduction in the timber quality as a structural material, but in the initial stage, an increase in the decorative wood value was indicated. Hence, the established time frames of the different stages of biological destruction of stemwood is a valuable criteria in the planning and implementation of forestry activities directed at harvesting round timbers of proper quality.

In this study, the effect of biological lesions on stemwood caused by wood-staining and wood-destroying fungi indicated a significant decrease in the wood density of Silver fir growing in the Ukrainian Carpathians. There were statistically identified four classes of stemwood by the natural wood resilience and their timeframe of wood decay, namely (1) healthy wood without any signs of fungal infection in the trunk; (2) initial wood damages caused by wood-staining fungi (*Aspergillus* sp., *Penicillium* sp., *C. comatum* Mill. & Cernz., *C. coeruleum* (Munch.) H. et Syd.) within up to 6 months; (3) medium wood damages caused by wood-destroying fungi (*F. fomentarius* (L.) Fr., *F. pinicola* (Swartz: Fr.) P. Karst.) within the timeframe from 0.5 to 2 years; and (4) substantial wood damages caused by wood-destroying fungi (*F. fomentarius* (L.) Fr., *F. pinicola* (Swartz: Fr.) P. Karst.) for more than 2 years. The integral indicator of the wood quality such as the basic density of healthy stemwood varied from 362 kg·m^{-3} to 457 kg·m^{-3} with a mean value of 392 kg·m^{-3}, and trunks with substantial damage were characterized by the values from 195 kg·m^{-3} to 283 kg·m^{-3} with a mean value of 246 kg·m^{-3}. The mean value of the basic wood density of healthy trunks was 28% higher than in the trunks with medium fungal damages and 37% higher than in the trunks with substantial fungal damages. A similar trend in the decrease of stemwood density of the trunks was characterized by other types of wood density. Finally, the research results of the effect of fungal lesions on the wood density of Silver fir reveal the practical aspects of temporary destruction of affected wood in forest stands and reducing the timber quality as a structural material. At the same time, the change of color shades of stemwood in the time period of up to 6 months indicates an increase in its decorative features. This emerging situation also points to the importance of focusing on silvicultural techniques for how to reduce the destruction of stemwood in Silver fir-managed forests where damage is observed.

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