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Natural Regeneration on Deadwood in the Primeval Forest Janj

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Abstract. The paper investigates the natural regeneration of downed deadwood in the Janj primeval forest. The old-growth forest is located in the southwestern part of the Republic of Srpska, which is dominated by dolomite geological base on which cambial soils were formed. The climate is perhumid and mountainous and the plantation belongs to the *Piceo-Abieti-Fagetum* community. The hectare contains 517 live trees with a total basal area of 53.0 m^2/ha and a volume of 876 m^3/ha. Twenty six downed deadwoods classified into three different degrees of decay were included in the study, where fir and spruce seedlings were found to be predominant and beech seedlings were rarely represented. The first degree of decay includes 7 (26.9 %), the second 8 (30.7 %), and the third 11 (42.3 %). The total volume of deadwood is 110.82 m^3/ha with an average volume per tree of 4.2 m^3/ha. The total number of seedlings on fallen dead trees is 836 seedlings (*Abies alba* – 89.59 %, *Picea abies* – 10.17 %, *Fagus silvatica* – 0.24 %). Fir seedlings are found on 25 fallen trees, spruce on 18 fallen trees, and beech on 2 fallen trees. Regarding quality, on average fir seedlings are better than spruce seedlings, but both species show a lot of senescence and very small size of current height increment. Most seedlings belong to the third quality class (fir – 46.2 %, spruce – 61.1 %), followed by second class (fir – 34.6 %, spruce – 22.2 %) and third class (fir – 19.2 %, spruce – 16.7 %). The total number of seedlings was found to have a statistically significant difference in the amount of downed deadwood depending on the degree of decay, and the number of seedlings depended on the degree of tree decay. The number of seedlings increased with increasing volume and length of rotten trees.
Keywords: downed deadwood, understory, seedlings, natural generation, primeval forests, old-growth forests, forest Janj, Republic of Srpska
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Научная статья

Естественное возобновление на валежной древесине в реликтовом лесу Янь Республики Сербской

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Аннотация. Исследовано естественное возобновление на стволах упавших деревьев в реликтовом лесу Янь в Республике Сербской (Босния и Герцеговина). Старовозрастные леса расположены в юго-западной части Республики, где преобладает доломитовая геологическая база, на которой сформировались камбиальные почвы. Климат – влажный горный, насаждение принадлежит сообществу *Piceo Abieti Fagetum*. Плотность произрастания деревьев – 517 живых дер./га, общая базальная площадь – 53 м^2/га, объем – 876 м^3/га. В исследование были включены 26 деревьев валежа, классифицированных по 3 различным степеням гниения. Установлено преобладание подроста пихты и ели, подрост бука представлен единично. К 1-й степени распада относится 7 (26,9 %), ко 2-й – 8 (30,7 %) и к 3-й – 11 (42,3 %) деревьев. Общий объем валежника составляет 110,82 м^3/га при среднем объеме одного дерева 4,2 м^3/га. Общее количество подроста на упавших деревьях – 836 шт. (*Abies alba* – 89,59 %, *Picea abies* – 10,17 %, *Fagus silvatica* – 0,24 %). Подрост пихты отмечен на 25 упавших деревьях, ели – на 18, бука – на 2. По качеству подрост пихты в среднем лучше, чем подрост ели, но у обоих видов наблюдается большое устаревание и очень маленький текущий прирост в высоту. Бóльшая часть подроста характеризуется как 3-й класс качества (пихта – 46,2 %, ель – 61,1 %), за ним по чис-

ленности следуют 2-й (пихта – 34,6 %, ель – 22,2 %) и 3-й (пихта – 19,2 %, ель – 16,7 %) классы. Обнаружено, что количество подроста имеет статистически значимые отличия от объема валежа в зависимости от степени гниения. Количество подроста увеличивается с повышением объема и длины гнилых деревьев.
Ключевые слова: валежник, подрост, саженцы, естественное возобновление, девственные леса, старовозрастные леса, лес Янь, Республика Сербская
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Introduction

The total area of forests and forest land of the Republic of Srpska is 1,282,412 ha or 51.7 % of the total area of the Republic. Within this area, protected forest areas of about 48,000 ha are of particular importance, in particular the primeval forest of Jan (295.0 ha), Lom (297.0 ha) and Perucica (1.291.0 ha). These primeval forests are classified as category Ia by the IUCN (International Union for Conservation of Nature). Primeval forests are ecologically protected forests with strong and dynamically balanced relations between climate, soil and organisms, and at the same time preserved from such anthropogenic influences that could change the laws of life processes and the structure of stands [14].

This is a forest that has remained completely stable and natural in terms of its plant structure, composition and climate [10]. The primeval forest in its centuries-long development, which in primeval beech, fir and spruce in the Dinarides lasts approximately 400–500 years, experiences initial, optimal and terminal development phases [15, 23].

The terminal phase is characterized by large amounts of dead, fallen wood, which is an important factor in the matter cycle and is a habitat for many plant and animal species and fungi. The terminal phase is characterized by the decomposition of living biomass, and includes an aging subphase and a decomposition subphase. The aging subphase occurs first and in it the growth of trees decreases, the stability of the stand is disturbed, and the vitality of the trees weakens, the shedding of conifers appears and the process of wood decomposition begins. In the decay subphase decomposition of the stand accelerates, and depending on the degree of decomposition, the trees fall under the blows of the wind, loads of snow or ice. The microhabitats associated with dead trees in primeval forests have a major impact on biodiversity and ecosystem services [18].

Dead wood that falls to the ground is exposed to various types of rot fungi such as beech *Armillaria mellea*, *Fomes fomentarius*, *Ganoderma applanatum*, *Pleurotus ostreatus*, *Polyporus squoamosus*, *Schizophyllum commune*, *Trametes gibbosa i dr*., na jeli *Armilaria ostoyae*, *Fomitopsis pinicola*, *Heterobasidion abietinum*, *Phellinus hartigii*, *Sparassis nemechii*, *Trichaptum abietinum* i na smrči *Armilaria ostoyae Fomitopsis pinicola*, *Gleophyllum sepiarium, Heterobasidium parviporum*, *Serpula lacrymans and others* [32].

Under such conditions of different degree of decay of dead wood, specific microhabitats are formed in which the process of natural regeneration begins. The dynamics of this process, growth and development of seedlings depend on the degree of decay, light regime, canopy cover, number of seeds, species of trees that are being renewed, etc.

However, there is not much research on the natural regeneration of dead lying wood in primeval forests, especially in the Dinarides. The study of old-growth regeneration can provide many answers to the questions of the forest development dynamics [19] and biogeochemical cycles in forests [17]. Until the beginning of the 21st century, not enough attention was paid to the amount of dead wood in the forest and the importance of these specific microhabitats.

Only about a decade ago, research on dead wood has intensified, mainly on biodiversity [21, 25]. Research on natural regeneration and dynamics of seedling development are very modest. The aim of this paper is to study the structure and natural regeneration of primeval forests in the terminal phase on rotten, fallen trees in different degrees of decay. Data on the degree of decay and seedlings allows us to define the null hypothesis: H_0 – there are no statistically significant differences in the number and height of seedlings developing on fallen dead trees of different degrees of decay.

Research objects and methods

The Janj primeval forest was singled out in 1954 as a research site, with a total area of 295 ha (57.92 ha of core and 237.80 ha buffer zone). In September 2021 it was declared a natural World Heritage Site by UNESCO. This natural asset on the territory of the municipality of Šipovo is protected under the highest category Ia, according to the classification of the IUCN. The Janj old-growth forest reserve is located on the Stolovaš mountain, between 44°07′ and 44°10′ north latitude and between 17°15′ and 17°17′ east longitude. The primeval forests are located at an altitude between 1.180 and 1.510 meters above sea level (Fig. 1). A dolomitic geological basement with a series of black, brown and illimerized soils prevails throughout the entire area of the reserve. The studied stand is extremely diverse and contains trees over 300 years old [7].

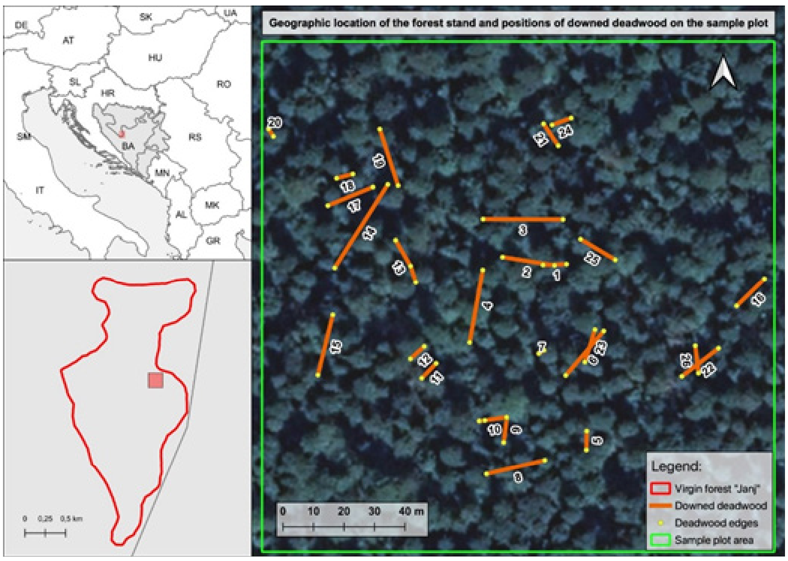

Fig. 1. Geographical position of the stand in the Janj old-growth forest and downed deadwood in the experimental area

The vegetation of this reserve is the result of habitat conditions and its historical development in the past. The vegetation of the reserve is divided into three groups: *Vaccinio – Piceion Br.* (spruce forest), *Fagion illiricum Ht.* (beech forest of the Illyrian area), *Pinion sylvestris* (white pine forest). The vegetation association of beech and fir with spruce in the "Janj" reserve occupies about 95 % of the area. Its important peculiarity is the high participation of fir and spruce, and almost complete absence of sycamore (*Acer pseudoplatanus*) in the tree layer, which is most likely due to the weaker mesophilicity of habitat conditions.

Subalpine beech forest, its lower underbelt, occupies a small area in the "Janj" reserve, only about 4 % of the total area. It is distributed on the northern and northeastern exposure, 1.470 m above sea level. It differs from the community of beech and fir with spruce, which is followed vertically not only by vegetation, but also by smaller overgrowth, volume, curvature of trees in the appendage, etc. The community of white pine and spruce represents the phase of vegetation succession to its final stage in this area. It occupies a very small area of only 1 %. The area of the reserve, which, according to the Ecological and Vegetation Regionalization of Bosnia and Herzegovina (BiH), is located in the territory of western Bosnia in inland Dinarides, is characterized by the conflict of continental and maritime air masses, which is a common characteristic of the climate of BiH [28].

According to the data from the meteorological station in Šipovo, which is located at 458 m above sea level, for the period 2003–2020, the average annual air temperature is 10.3 ^{o}C and the average annual precipitation is 981 mm. It can be estimated that the annual precipitation in the protected area is around 1.200 mm, with a maximum in June and a minimum in August. Judging by the estimated low precipitation amounts in September and October, the data indicate the continental type of precipitation regime.

For the preparation of this paper, data obtained in the core of an old-growth forest at an experimental site of 100×100 m were used. Tree diameters and height were measured above the taxation limit of 5.0 cm. 26 felled trees in different phases of decay were found on the experimental surface on which seedlings emerged. Each fallen tree was numbered, and its GPS coordinates were recorded with the corresponding spatial, attributive, and numerical data: tree species, diameters in the middle, thicker and thinner end (D, cm), length of the fallen tree (L, m), azimuth (^{o}), degree of decomposition (D_d). The degree of tree decay was estimated by the average penetration depth of a 50 cm long metal bar into the upper, middle and lower part of the lying dead wood [4]:

low degree up to 10 cm, less time than tree fall (1–10 years);

medium degree from 10 to 30 cm, medium time than tree fall (10–30 years);

high degree greater than 30 cm, long period of time since tree fall (over 30 years).

The degree of tree rot depends on the length of time the fallen tree has been on the ground. Data collection on seedlngs included determining the species, measuring the height of the seedlings (h, cm) and estimating the age of the seedlings based on the vertebrae of conifers (years). Seedling quality (1 – excellent; 2 – good; 3 – poor) was assessed in coniferous species based on obsolescence (ratio of length of apical and lateral shoots) and vitality. Data processing on the basic taxonomic elements of the stand as well as on dead, fallen trees were processed using dendrometric - statistical methods. The volume of downed deadwood trees was determined with the use of Huber's equation:

$$V = Lg_{1/2},$$

where V – volume, m^3; L – length, m; $g_{1/2}$ – basal area in the middle of the tree, m^2.

Data processing on seedlings and analysis of the dependence of the number of seedlings on the degree of decay of fallen trees was carried out using the analysis of variance, and testing the significance of differences in the number of seedlings was carried out using the F test. Statistical data processing was performed in the IBM SPSS Statistics 23.

Results and discussion

There are 517 trees with a total basal area of 53.0 m^2/ha and a volume of 876 m^3/ha in the stand on the hectare in standing condition. Based on previous research [7], it was estimated that the current volume increment is about a 8.0 m^3/ha (Fig. 2).

A small percentage of volume increment is a characteristic feature of old-growth forests [22]. Although all the three main tree species have very favorable conditions for growth and development, fir outperforms spruce and beech (Fig. 2).

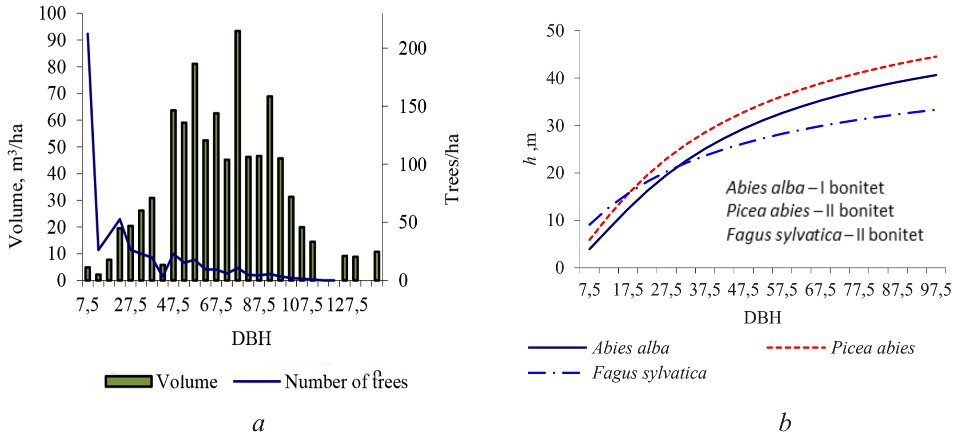

Fig. 2. Volume, number of trees (a) and hight curve and bonity (b)

Twenty six downed deadwood ("dead wood") in different degrees of decay were found in the experimental surface. The first degree of decay included 7 (26.9 %), the second 8 (30.7 %), and the third 11 (42.3 %) trees. The lowest value of dead lying wood volume was 0.41 m³, and the highest was 17.77 m³ (Table 1).

Table 1

Descriptive statistics for diameter, length and volume of downed deadwood

Values	N	Mean	Med.	Min	Max	Variance	St. dev	CV	Se	α_3	α_4
D (cm)	26	46.1	40.0	21.0	83.6	317.2	17.8	38.6	3.4	0.6	–0.5
L (m)		16.6	15.0	3.6	32.1	69.3	8.3	49.9	1.6	0.3	–0.9
V (m^3/ha)		4.2	3.0	0.4	17.7	17.6	4.2	98.6	0.8	1.7	3.2

The total volume of lying dead wood is 110.82 m^3/ha with an average volume of one tree 4.2 m^3/ha. The large variability of volume as an indicator is due to the large difference in the dimensions of fallen dead trees on the experimental surface. Thus, trees of larger size and volume fell to the ground due to physiological weakening and the action of wind and snow. Thinner trees, lower heights and volumes are mainly due to the fall of mature trees on them.Trees of the first degree of decay have a total volume of 41.40 m^3/ha (37.3 %), the second degree of decay 41.88 m^3/ha (37.8 %), and the third 27.54 m^3/ha (24.9 %). Depending on the degree of decay of the trees, there are differences in diameter and volume of fallen trees. Based on the obtained results using one ANOVA, it can be concluded that there is a statistically significant difference in volume values at different degrees of decomposition. This difference is particularly noticeable in the volume of trees belonging to the first and second degree of decay compared to trees belonging to the third degree of decay (Table 2).

Table 2

ANOVA for the volume of trees of different degrees of decay of "dead wood"

D_d	V (m^3)	N	V_s (m^3)	V_{min}(m^3)	V_{max} (m^3)	F	*p-value*	F_{crit}
1	41.40	7	5.91	0.51	17.77	–		
2	41.88	8	5.24	0.83	12.27			
3	27.54	11	2.50	0.41	6.45			
Total	110.82	26	4.26	–	–	6.20	0.02	4.03

The longitudinal cross-sectional area of fallen trees ($(D + d) / 2L$) is 206.30 m^2 and occupies an area of 2.0 % of the total experimental area and represents a potential "active" area for restoration on downed deadwood.

Characteristics of the seedlings. Beech, fir and spruce seedlings were found on 25 downed deadwood trees and only one tree had no seedlings observed (Table 3). The number of seedlings varies significantly depending on the degree of decay of the trees.

Table 3

Descriptive statistics for number, height and age of seedlings on downed deadwood

Parametres	Downed deadwood	N	Mean	Med.	Min	Max	Variance	St. dev.	CV	Se	α_3	α_4
Number of seedlings	*Fs*	2	1.0	1.0	1.0	1.0	–	–	–	–	–	–
	Aa	25	29.9	22.0	2.0	146.0	876.2	29.6	98.8	5.9	2.9	10.0
	Pa	18	4.7	4.0	1.0	21.0	19.8	4.4	94.3	1.0	3.1	11.4
High (cm)	*Fs*	2	14.0	14.0	10.0	18.0	32.0	5.6	40.4	4.0		
	Aa	25	5.8	4.1	2.1	11.9	9.7	3.1	52.8	0.6	0.7	–0.7
	Pa	18	13.2	3.2	1.0	85.0	448.4	21.1	160.2	4.9	2.6	7.7
Age (years)	*Fs*	2	3.0	2.5	2.0	3.0	0.5	0.7	28.2	0.5		
	Aa	25	3.0	2.4	1.0	7.0	1.7	1.3	48.3	0.2	2.2	5.5
	Pa	18	5.0	2.5	1.0	17.0	32.1	5.6	107.1	1.3	1.2	0.0

Note: *Fs* – *Fagus silvatica*; *Aa* – *Abies alba*; *Pa* – *Picea abies*; N – number of downed deadwood with seedlings.

Beech seedlings are least represented on fallen deadwood (26 trees) (2 individuals), followed by spruce (85 individuals), and fir seedlings are the most numerous (749 individuals). The total number of seedlings on fallen trees is 836 seedlings (*Abies alba* – 89.59 %, *Picea abies* – 10.17 %, *Fagus silvatica* – 0.24 %). Fir seedlings are found on 25 fallen trees, spruce on 18 fallen trees and beech on 2 fallen trees. No seedlings are found on one fallen tree. The Levene test was used to confirm the condition of homogeneity of dispersion of the total number of seedlings of tree groups with different degrees of decay and to ensure the possibility of applying the analysis of variance in further processing. The analysis of variance showed that there were no statistically significant differences in the total number of seedlings between the analyzed groups of trees of different decay degrees (Table 4).

Table 4

ANOVA for the total number of seedlings on trees of different degrees of decay of downed deadwood

	Sum of squares	*df*	Mean Square	*F*	Sig.
Between groups	3563.171	2	1781.585	2.332	.121
Within groups	16806.989	22	763.954	–	–
Total	20370.160	24	–	–	–

However, due to the small sample size, differences between the centers of the number of trees for different degrees of decay of fallen trees were tested using post-hoc analysis, i.e., subsequent comparisons of the numbers of offspring between groups of rotten trees were performed (Table 5). It was found that there is a statistically significant difference in the total number of seedlings between fallen trees between 1 and 3 degrees of tree decay, so the null hypothesis was rejected. Also, it was found that there are no statistically significant differences in the number of seedlings between 1 and 2 or 2 and 3 groups of fallen trees.

Table 5

Post-Hoc test of least significant difference (LSD) ANOVA comparison of the means of the total number of offspring between groups of lying trees

(I) Degree of decay	(J) Degree of decay	Mean Differ. (I–J)	Std. Error	Sig.	95 % Confidence Interval	
					Lower bound	Upper bound
1	2	–14.30357	14.30491	.328	–43.9701	15.3630
	3	–28.27500*	13.11067	.042	–55.4649	–1.0851
2	1	14.30357	14.30491	.328	–15.3630	43.9701
	3	–13.97143	13.62100	.316	–42.2197	14.2768
3	1	28.27500*	13.11067	.042	1.0851	55.4649
	2	13.97143	13.62100	.316	–14.2768	42.2197

* The mean difference is significant at the 0.05 level.

The dependence of the number of seedlings on the degree of decay of fallen trees is expressed by a straight line regression (Fig. 3, Table 6) and shows that the number of seedlings increases with increasing degree of decay, volume and length of downed deadwoods. When quality is considered, on average, fir seedlings are of better quality than spruce seedlings, but both species exhibit high obsolescence and very small size of current height increment. Fir, as a highly sciophilic species, tolerates heavy shade conditions better and has, on average, a taller apical shoot than spruce. The average length of the apex shoot of fir on felled deadwood is 2.2 cm, while that of spruce is 1.8 cm. The majority of seedlings are of third class quality (fir – 46.2 %, spruce – 61.1 %), followed by second (fir – 34.6 %, spruce – 22.2 %) and third (fir – 19.2 %, spruce – 16.7 %). The quality of beech seedlings was not assessed due to the small number of seedlings.

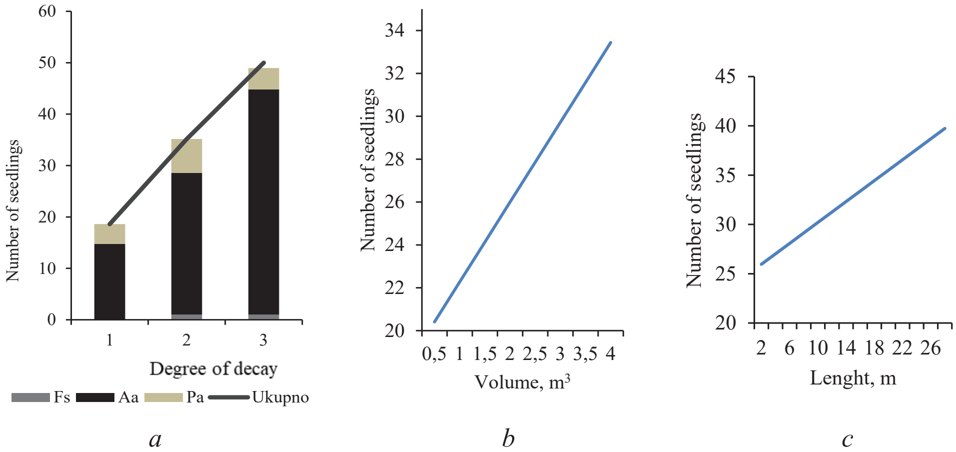

Fig. 3. Dependence of the total number of seedlings on the degree of decay (*a*), volume (*b*) and length (*c*) of downed deadwood

Table 6

Parameters of linear regression (dependent variable – number of trees)

Independent variable	$Y = a + bX$		R^2	F	p
	a	b			
Degree of decay	4.044	14.132	0.175	4.876	0.037
Volume decay of trees	18.545	3.724	0.129	2.658	0.120
Length of decaying trees	24.897	0.530	0.042	1.004	0.327

The amount of dead wood determined in this research is similar to the values determined in other natural reserves, which in Northeast America averages 121 m^3/ha in the forest *Tsuga canadensis* [30], then in an old oak and beech forest *Quercus–Fagus grandifolia* 82–132 m^3/ha [9]. The quantities of dead wood in northern Europe are much smaller and in white pine and spruce forests they range from 60 to 120 m^3/ha of dead wood [26]. The largest quantities were found in forests Douglas-fir-Hemlock – about 1.500 m^3/ha [9, 31], in the reserves of pure beech forests, an average of 113 m^3/ha is found [5].

The ratio of the volume of dead and living wood is otherwise very variable because it depends on the development phase, the composition of the species and the geographical location. In the studied stand, this ratio is 12.65 %, but similar research shows that it can be higher, especially in mixed forests with a large proportion of fir. In fact, fir is considered to be an endangered species due to climate change, especially due to drought [1], its vitality declines, trees dry up and fall to the ground, thus increasing the proportion of dead wood. The first records of forest degradation in Europe are related to the degradation of spruce. The common fir in Europe has been periodically dying out since about 1500 years [16], but recently, due to extreme occurrences, drought, bark beetle attacks and a chain of other pests and diseases, the resistance of fir has increased [10, 11, 20].

Dead wood is a temporary substrate for epixyl fungi as well as a starting substrate for seed germination and the emergence of seedlings. The substrate gradually decomposes and eventually turns into a lignohumus form, forming small elevations as a specific morphological form of relief. In the process of the growth, seedlings, passing to older developmental stages, become more and more firmly attached to the substrate, which is formed as a result of wood rotting. A feature of natural regeneration on rotten wood is that lignohumus has been playing a key role in the regeneration, growth and development of seedlings for several decades, unlike seedlings that do not grow on dead wood. Cryptogamous species such as lichens and mosses are also an integral part of dead wood microhabitats, affecting seed retention and creation of germination conditions [27].

A large number of seedlings do not appear on fallen trees until they reach the 2nd and 3rd stages of decay [24], and although they cover a relatively small area, a huge number of seedlings can be found on them [6], as was found in these studies. Despite the relatively low content of water-soluble nutrients in deadwood at late decomposition stages, seedlings develop successfully because they rely on mycorrhizal associations to acquire nitrides [29]. On dead wood, there is less snow retention, less competition from weeds, and the growing season lasts somewhat longer, so seedlings have relatively more favorable conditions for growth [3]. In addition, on very steep terrains, downed logs are important because they prevent erosion and landslides, which allows seedlings to develop successfully.

The number of seedlings depends on the morphological characteristics of tree species, such as: specific weight of seeds, seed germination and on the ecological conditions of the habitat, light, climatic conditions, soil. In addition, the number depends on the frequency and abundance of fruiting forest trees [12].

The microhabitats in which the seedlings appear are very diverse [conifers, trunk, cracks in the tree, moss). Fir and spruce seedlings are more numerous than beech seedlings due to the size of the seed and its characteristics. Beech seeds are much larger and heavier, so under the influence of gravity, they roll from the dead trees to the ground. Spruce seeds are the smallest and are easily retained in microcracks and on the moss of dead trees. The key factors for seed germination are humidity and heat. Humidity is higher in trees with a higher degree of decay, but the amount of heat also depends on the conditions of the stand assembly and light penetration. In the terminal phase of primeval forests development, openings within the stand occur as a result of extinction and decay of trees, and a larger amount of light and heat reaches the soil surface and fallen dead trees [8], thus creating favorable conditions for seed germination, especially on trees in ate stages of decay (degree 3).

The edaphic specificity of the primeval forests is in the creation of lignohumus as a kind of parahumus. Namely, dead trees falling to the ground form an irregular intertwined lattice horizontal texture and decay under the influence of fungi in the profile of which more than 50 % of wood is located and Myco-lignochemical humus is formed [13]. Partial and complete humification and mineralization is performed and lignohumus is formed as a specific form of humus in the creation of which wood participates the most [31]. It contains large amounts of humic and fulvic acids that strongly promote seed germination, root development and allow better use of water, improve mobilization and absorption of other nutrients and minerals.

The degree and speed of decay depends, among other things, on the type of trees and the duration of the decay process. Beech trees decay the fastest and create the most favorable conditions for the development of numerous species, as the humus is more basic, then fir, and finally spruce, which is the most acidic. The number of spruce seedlings is higher in less saturated soils and at $pH < 7$ [7].

Based on the number of seedlings, it can be stated that conditions for the emergence and development of seedlings on dead fallen trees are very favorable.

Namely, the determined number shows that in similar homogeneous conditions as on dead trees, the number of seedlings would be 40.423 seedlings/ha. Earlier research shows that under the conditions of the developmental phase in the transition from terminal to initial, the total number of seedlings in the Lom primeval forests in Republic of Srpska was 4.225 individuals per hectare and in the Janj primeval forest 6.600 individuals per hectare [7].

The experience of studying the importance and role of dead wood in old-growth forests is also important for managed forests, because in addition to natural regeneration, dead wood in forests allows reducing pest gradation and fires [2], which can be achieved by increasing the rotation duration of managed forests.

Conclusion

Natural spontaneous process of regeneration takes place in old-growth forests without human influence. Considering that the share of natural forests in the Republic of Srpska is large (over 90 %), it is clear that the knowledge of forestry science on natural regeneration in primeval forests is of great importance for forest management. Natural regeneration of commercial forests corresponds to the sub-phase of decay, which means that preparatory cuttings are performed in a way that mimics the process of degradation of the forest complex in primeval forests under the influence of various factors of living and non-living nature. However, the main difference is that in primeval forests during the destruction of dead wood it remains in the forest and natural regeneration occurs on it, and in managed forests wood is removed from the forest. Additionally, in old-growth forests there is a natural selection of trees that fall to the ground, and in managed forests the selection and cutting of trees are done by humans in accordance with management goals. Therefore, we understand the old-growth forest as a "school of nature" that provides knowledge about the natural life path of the forest from its origin to extinction, i.e., decay and re-emergence at the same time. In the old-growth forest we can find many different types and forms of regeneration process which is mainly caused by chance or the influence of natural disorders, windbreaks, diseases, pests, snowstorms, etc. and the process of physiological aging. The main conclusions that can be emphasized in this research are as follows:

the ratio of downed deadwood trees to live trees is 12.65 %, which corresponds to the average found in previous research;

the degree of decay in the initial stages has no statistically significant effect on the volume of lying trees, while in the later stages of decay this effect is pronounced;

beech seedlings are poorly represented (0.24 %) on downed deadwood, and fir seedlings dominate in quantity (almost 90 %);

fir seedlings are of slightly better quality and higher average age gain than spruce seedlings.

Research on the amount of dead wood in old-growth forests and commercial forests as well as the processes that take place on them in terms of natural regeneration and biodiversity in the Dinarides should be continued. Extensive research has been conducted in the primeval forests of Republic of Srpska in the past, but not enough attention has been paid to the natural processes that cause downed deadwood. Earlier research certainly indicates the stability of the Dinarides primeval forests and their good condition. By studying the dynamics of regeneration of primeval forests ecosystems in terms of changes caused by the natural elimination of dominant trees, their fall and rot, we gained insight into specific natural processes caused by microhabitats. This is still an open topic in Republik of Srpska, but in the future it will undoubtedly attract the attention of forestry researchers, as the importance of these micropopulated downed deadwoods for forest science is increasing.

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