

## Comparative analysis of dead wood in managed and virgin forests in the beech stands

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### Abstract

Dead wood is an indicator of forest biodiversity, forming key habitats for many species. In this study they were compared the quantities of dead wood from 4 sample plots from managed forest and 4 from virgin forest from beech stands in Semenic Mountains. Analysing the two types of forests revealed differences in the amount of dead wood. Therefore, in the sample plots from the virgin forest the mean quantity of fallen dead wood was 54.46 m<sup>3</sup> ha<sup>-1</sup>, while in the managed forest the mean quantity was much lower: 11.32 m<sup>3</sup> ha<sup>-1</sup>. Regarding the standing dead wood, the mean quantity in the virgin forest was 28.05 m<sup>3</sup> ha<sup>-1</sup>, while in the managed forest the quantity was much lower: 11.38 m<sup>3</sup> ha<sup>-1</sup>. As regards the distribution by decomposition classes, the absence of dead wood in a few classes was observed, in both types of forests. The largest proportion of standing dead wood in the sample plots from 1200 m altitude was in the second decomposition class in both forest types, while in the sample plots at 1350 m altitude it was in the third decomposition class both in the virgin and managed forest. In the case of the fallen dead wood, the largest proportion in the sample plots of 1350 m altitude was in the fourth decomposition class for both forest types, while at 1200 m altitude was in the second class for the managed forest and the third and fourth class for the virgin forest. The diversity of dead wood regarding the three categories of elements studied indicates, in general, higher values for the virgin forest.

**Keywords:** volume, decomposition classes, biodiversity indices

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### Introduction

Within the politics of forest management, dead wood is considered as an indicator of their sustainable management [2]. In the last decades, it was recorded a significative growth of scientific interest on dead wood and on its ecological role in the forest ecosystems [9].

Despite its enormous importance, dead wood is, now, at critical level (very low) in the forests of many European countries, especially due to inadequate management practices in the forests with production role and even in the protected areas. The removal of dead wood from the forest is one of the main threats on the survival of nearly one third of the species from the forest ecosystem and it is in direct connection with many threatened species which are included in the red list [6].

For example, the invertebrates, fungi, mosses, lichens, birds and mammals depend on or use the dead woos as food source or for shelter. Dead wood can influence the microclimate of the forest and can act as an important element of water storage during the drought periods. Also, it could provide proper conditions for stand regeneration in the forests from the cold temperate and boreal zones and in the subalpine forests. Dead wood also represents an important element for long term nutrient storage, also for the storage of important carbon quantities (related to the total quantity of carbon stored by the forest ecosystems) and ensures the process of humification, restoring in the soil important quantities of organic matter [4].

In contrast to North America and the boreal zone of Europe, where detailed evaluations of the amount of deadwood were made, for pure beech and mixed beech stands from the temperate zone of Europe, there were no such evaluations at the beginning of the 2000s. Due to the wide range of this species at the European level, in the following years there started to be an interest in the analysis and estimation of the volume of dead wood in such forests [4]. Beech is the most widespread species in Romania, occupying about 31% of the country's forested area. It has a very wide altitudinal range, constituting the upper limit of the forest in the Semenic Mountains [13].

The principle of sustainability (together with the principle of multi-functionality of forests) is a basic principle, which should be implemented in all the activities involved in the contemporary forest management.

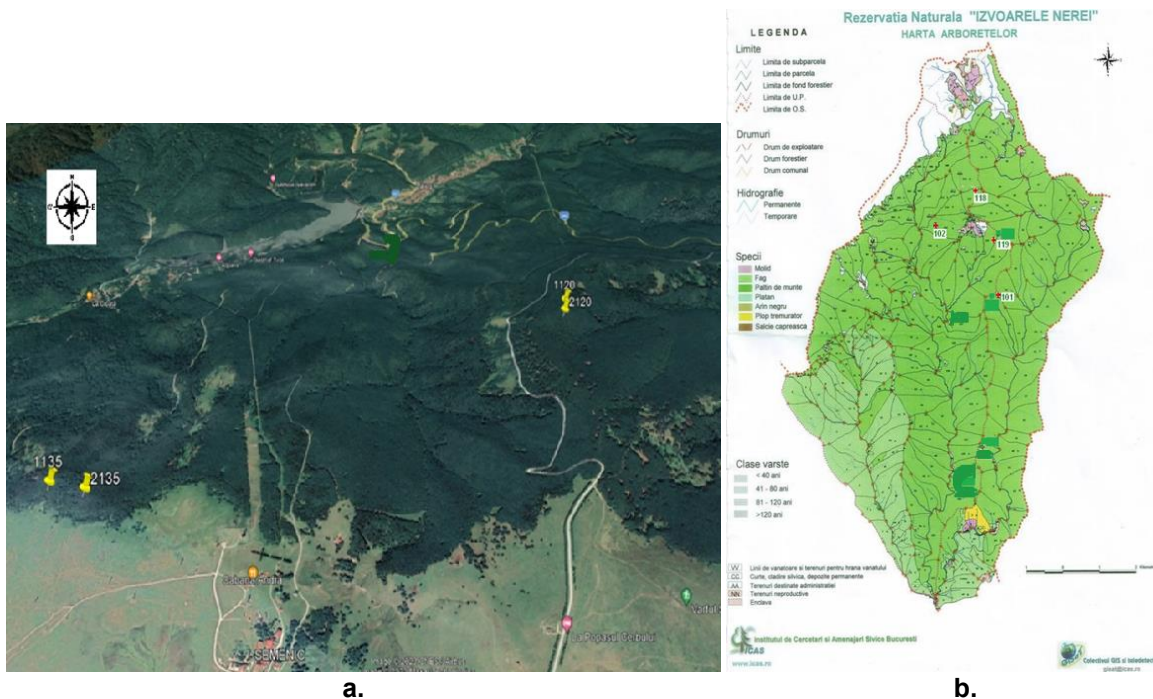
The implementation of the durability principle in forestry is closely related to the knowledge about growth and development processes of a forest ecosystem. Therefore, in the phases of aging and degradation of the forest in these ecosystems important quantities of dead wood accumulate if it is not removed by diverse silvicultural operations [5]. Unfortunately, the absence of the phases of aging and decomposition, rich in dead wood, is one of the main ecological deficiencies of the forests in the economic circuit [6].

Although it is frequently recommended the increase of the dead wood volumes, simple and feasible ways to fulfil this desiderate, together with specific operational approaches that could be implemented are rarely mentioned [17].

We started from the hypothesis that the dead wood volume is higher in the virgin forest and the diversity indices show higher values in this type of forest.

### Material and Method

The comparative study of the dead wood from a virgin forest and a forest with similar composition, subject to the management regime, was carried out based on the data collected in eight circular sample plots of 2500 m<sup>2</sup> each, installed at 1200 m (two in the virgin forest and two in the managed forest), respectively 1350 m altitude (two in the virgin forest and two in the managed forest). The sample plots are located in South-Western Romania, in the Semenice Massif, on the territory of Caraş-Severin County, within the Izvoarele Nerei Nature Reserve (Nera Forest District, subparcells: 113,123 and 12,14,115 from Production Units UP II and III), the stands having 180 years in age [20] and two managed forests from the vicinity, located in Văliug Forest District (subparcells 39B - UP XII and subparcells 17A and 21A - UP II), the stands having 100 years in age [19].



**Figure 1. The location of the sample plots in the managed forest (a) [21] and in the „Izvoarele Nerei” Nature Reserve (b) [14]**

The diameters of the dead wood pieces were measured using a forest calliper. In the case of the fallen dead wood pieces, they were measured only the ones having at least 15 cm at the thick end, and for the standing dead trees they were measured only the pieces having a minimal diameter of 6 cm. the heights were measured using the Vertex equipment and the lengths using a steel tape. They were inventoried the standing dead trees which had at least 1.3 m in height and the fallen dead wood pieces having the minimum length of 3 m.

For the determination of the decomposition class it was used a system of 5 classes of decomposition of dead wood, class A – fresh (green) dead wood, class B – hard dead wood (without sap, the knife enters very difficultly in the direction of the fibers), class C – softer dead wood, the knife enters easily in the direction of fibers but not in the direction perpendicular on the fibers, class D – soft dead wood, the knife enters easily

also on the direction perpendicular on the fibers and class E – very soft dead wood or dust which hardly stays together [8,12]. At the same time, each piece of dead wood was classified into one of the 7 types of dead wood (Fig. 2) [11].

It was calculated the diversity of dead wood using the Shannon index ( $H = -\sum_{i=1}^n p_i \ln p_i$ ) and using the Simpson index ( $D = \sum p_i^2$ ) for the decomposition classes ( $H_{CD}, D_{CD}$ ), type of dead wood ( $H_{TLM}, D_{TLM}$ ) and diameter categories ( $H_d, D_d$ ),  $p_i$  being the proportion of the species, of the decomposition class or of the type of dead wood  $i$ . They were defined three categories of diameters considering the thick end of the wood piece: <30 cm, 30-60 cm, >60 cm [10].  $H=0$  means lack of diversity and higher values of the Shannon index indicate a higher degree of diversity. In the case of the Simpson index, it has values between 0 (infinite diversity) and 1 (lack of diversity).

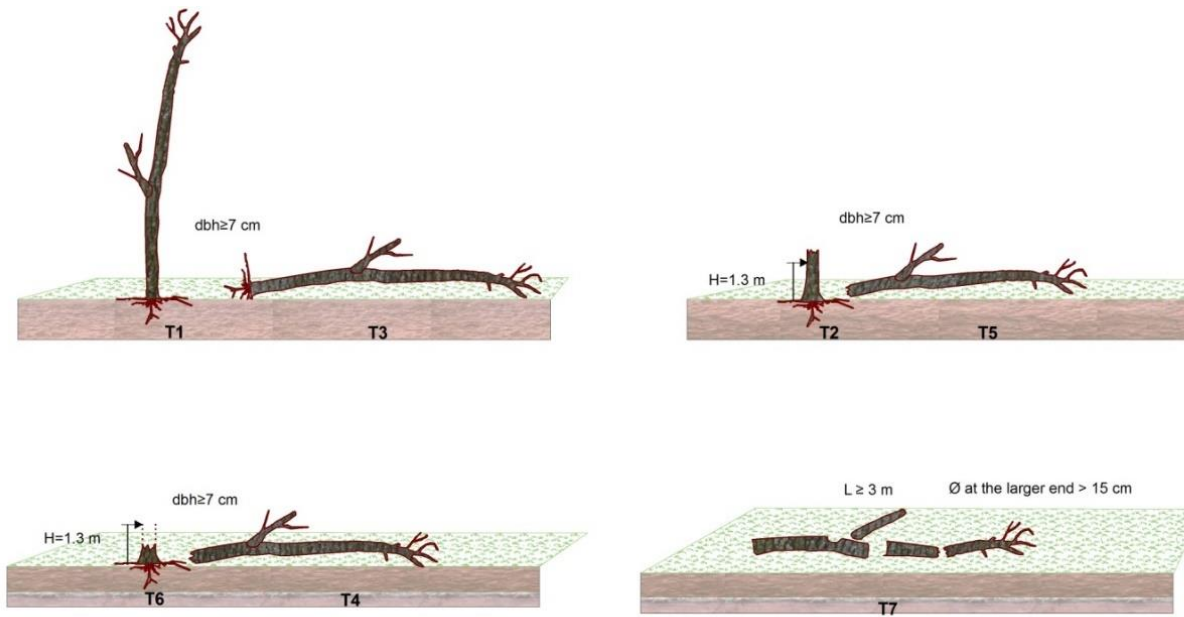


Figure 2. Types of dead wood [11,16]

### Results and Discussion

The density of standing dead trees varied between 112 and 152 ha<sup>-1</sup>, with an average of 132 trees per hectare for the sample plots located in the managed forest at the altitude of 1200 m. The managed forests located at the altitude 1350 m presented a smaller average number of standing dead trees (30 ha<sup>-1</sup>).

The density of standing dead trees in the virgin forest had close values between the two altitudinal levels, with an average of 22 trees for the sample plots at 1200 m altitude (101 and 102), respectively 26 trees for the sample plots from 1350 m altitude (118 and 119) (Table 1).

The largest number of fallen pieces of dead wood was recorded in the sample plot 2120 (184 pieces per hectare), in the sample plot 1120 being found 156 pieces per hectare. Therefore, it was found that in the sample plots located at 1200 m altitude, the number of fallen dead wood pieces (170 pieces per hectare) is significantly higher compared to the number of fallen dead wood pieces from the sample plots at 1350 m altitude (82 pieces per hectare) (Table 2).

Table 1. Distribution of the total number of standing dead wood per hectare on altitudinal levels in the sample plots from managed forest and virgin forest

Altitudinal level	Sample plot	Managed forest (number of trees)	Virgin forest (number of trees)
1200 m	1120	152	
	2120	112	
	101		16
	102		28
average		132	22

	1135	48	
	2135	12	
<b>1350 m</b>	118		28
	119		24
<b>average</b>		<b>30</b>	<b>26</b>

Regarding the virgin forest, by inventory it resulted a number of 78 pieces of fallen dead wood per hectare. Between the two altitudinal levels they are observed differences, in the sample plots from 1200 m altitude (101 and 102) being recorded 56 pieces per hectare, while in the sample plots at 1350 m altitude (118 and 119) being inventoried 100 pieces per hectare (Table 2).

**Table 2. Distribution of the total number of fallen dead wood per hectare on altitudinal levels in the sample plots from managed and virgin forest**

Altitudinal level	Sample plot	Managed forest (number of pieces)	Virgin forest (number of pieces)
<b>1200 m</b>	1120	156	
	2120	184	
	101		52
	102		60
<b>average</b>		<b>170</b>	<b>56</b>
<b>1350 m</b>	1135	108	
	2135	56	
	118		56
	119		144
<b>average</b>		<b>82</b>	<b>100</b>

The large number of pieces of dead wood, both fallen and standing, found in the sample plots from the managed forest at 1200 m altitude it is due to the dying of trees because of intraspecific competition and a high density of the stand, combined with the lack of silvicultural interventions during time. Analysing the past forest management plans it was found that in the subparcels where the sample plots were located, they were undertaken the following interventions: accidental harvesting in the decade 2012 – 2021 (26 m<sup>3</sup> –0.5% intensity) in the subparcels where the plots at 1200 m altitude were located, respectively in the subparcels with the plots at 1350 m altitude – thinnings (8 ha – 41% of the subparcel's area) and then normal harvesting (1293 m<sup>3</sup> – 11.7% intensity) in the decade 1993 - 2002, other harvesting (563 m<sup>3</sup> – 5.3% intensity), thinnings (25 m<sup>3</sup> – 0.25% intensity), accidental harvesting (78 m<sup>3</sup> – 0.8% intensity) and selective cutting transformation harvesting (1316 m<sup>3</sup> – 13.2% intensity) in the decade 2002 - 2012 and thinnings (12 m<sup>3</sup> – 0.16% intensity) and accidental harvesting (21 m<sup>3</sup> – 0.28% intensity) in the decade 2012 – 2021 [19].

After analysing the two forests they resulted significant differences regarding the quantity of dead wood. Therefore, in the sample plots from the virgin forest at 1200 m altitude, the fallen dead wood quantity was 51.84 m<sup>3</sup> ha<sup>-1</sup> (Table 3), and in the sample plots located at 1350 m altitude the quantity of dead wood was 57.09 m<sup>3</sup> ha<sup>-1</sup> (Table 4), while in the managed forest the dead wood quantity was a lot smaller: 10.42 m<sup>3</sup> ha<sup>-1</sup> fallen dead wood in the sample plots located at 1200 m altitude (Table 4) and 12.23 m<sup>3</sup> ha<sup>-1</sup> fallen dead wood in the sample plots at 1350 m altitude (Table 4).

**Table 3. Distribution of the volume of fallen dead wood per hectare by decomposition classes in the managed forest and the virgin forest in the sample plots at 1200 m altitude**

Decomposition class	Managed forest	%	Virgin forest	%
A	0.00	0	0.00	0
B	4,39	42	9,46	18
C	3,63	35	18,13	35
D	2,33	22	19,53	38
E	0,07	1	4,72	9
<b>Total</b>	<b>10,42</b>		<b>51,84</b>	
<b>%</b>	<b>17</b>		<b>83</b>	

**Table 4. Distribution of the volume of fallen dead wood per hectare by decomposition classes in the managed forest and the virgin forest in the sample plots at 1350 m altitude**

Decomposition class	Managed forest	%	Virgin forest	%
A	0.00	0	0.00	0
B	2.96	24	11,68	20
C	0,55	4	14,12	25
D	5,33	44	26,14	46
E	3,39	28	5,15	9
<b>Total</b>	<b>12,23</b>		<b>57,09</b>	
%	18		82	

In the sample plots at 1200 m altitude in the virgin forest and in the managed forest, the identified fallen dead wood in the sample plots from the virgin forest represented approx. 83 % from the total quantity of dead wood. At 1350 m altitude, the fallen dead wood from the virgin forest represents 82% from the total quantity of dead wood identified at this altitudinal level (in the sample plots from the virgin forest and the managed forest).

Regarding the standing dead wood, in the sample plots at 1200 m altitude, the total quantity of dead wood from the virgin forest was 36.09 m<sup>3</sup> ha<sup>-1</sup> (Table 5), and in the sample plots at 1350 m altitude it was 20.01 m<sup>3</sup> ha<sup>-1</sup> (Table 6), while in the managed forest the quantity of dead wood was smaller: 19.06 m<sup>3</sup> ha<sup>-1</sup> standing dead wood in the sample plots at 1200 m altitude (Table 5) and 3.71 m<sup>3</sup> ha<sup>-1</sup> standing dead wood in the sample plots at 1350 m altitude (Table 6).

**Table 5. Distribution of standing dead wood per hectare by decomposition classes in managed forest and virgin forest in the sample plots at 1200 m altitude**

Decomposition class	Managed forest	%	Virgin forest	%
A	0.00	0	0,28	1
B	17,09	89	32,68	90
C	0,91	5	3,13	9
D	1,06	6	0.00	0
E	0.00	0	0.00	0
<b>Total</b>	<b>19,06</b>		<b>36,09</b>	
%	35		65	

**Table 6. Distribution of standing dead wood per hectare by decomposition classes in managed forest and virgin forest in the sample plots at 1350 m altitude**

Decomposition class	Managed forest	%	Virgin forest	%
A	0.00	0	0.00	0
B	1,15	31	3.50	17
C	1,89	51	16.47	82
D	0,67	18	0.0.13	1
E	0.00	0	0.00	0
<b>Total</b>	<b>3,71</b>		<b>20.01</b>	
%	16		84	

Regarding the standing dead wood, 65% of its total amount was identified in the virgin forest in the sample plots at 1200 m altitude, and in the case of the plots at 1350 m altitude, the percentage reaches 84% from the total amount of dead wood at that altitudinal level.

In both virgin and managed forests, the dead wood was generated in an overwhelming proportion by beech, during the inventory being identified, in the managed forest, only two pieces of dead wood from other species (silver fir and spruce), which participate to the total volume with an insignificant quantity (0,88 m<sup>3</sup>).

In the managed forests from Western Europe the dead wood volume is very low. In France, for instance, 90% of the surfaces inventoried through the IFN (National Forest Inventory) show less than 5 m<sup>3</sup>/ha of dead wood [5]. In Europe, the average volume of dead wood, at regional and national level, exceeds 10 m<sup>3</sup>/ha only in Switzerland (Brassel si Brandli, 1999) and in Northern Sweden [7].

By inventorying the dead wood in 86 forest reserves in Europe, where beech is the dominant species, an important area with different climatic conditions was covered, from the oceanic climate in Southern England and Belgium to the cold climate (mountainous and continental) in Eastern Slovakia. The variation in volume of dead wood was large. The average amount of dead wood for all reserves was 130 m<sup>3</sup>/ha, this volume varying from almost insignificant values to 550 m<sup>3</sup>/ha. These quantities varied in the reserves, therefore in mountain reservations established over 50 years ago, the volume was 220 m<sup>3</sup>/ha, in the same category of reserves but in the submontane or hilly area the quantity was 131 m<sup>3</sup>/ha, and in the reserves established more recently, in the mountain area the volume was 116 m<sup>3</sup>/ha and in the submontane area the volume was 100 m<sup>3</sup>/ha [4].

Regarding the distribution by decomposition classes, the absence of dead wood was observed in several decomposition classes in both forests. The highest proportion of standing dead wood volume in the sample plots at 1200 m altitude was in the second decomposition class (90% in the virgin forest, 89% in the managed one), and in the sample plots at 1350 m altitude it was in the third decomposition class (82% in the virgin forest, 51% in the managed one) (Tables 5 and 6).

In the virgin forest, fallen dead wood has the highest proportion in the classes three and four (35%, respectively 38%) within the sample plots at 1200 m altitude, while in the managed forest, the highest proportion is in classes two and three (42%, respectively 35%). For the sample plots at 1350 m altitude, in the virgin forest the fallen dead wood has the highest proportion in the classes four and three (46%, respectively 25%), and in the managed forest in the classes four and five (44%, respectively 28%), (Tables 3 and 4).

**Table 7. Diversity of dead wood by decomposition classes, type of dead wood and diameter classes in the sample plots at 1200 m altitude**

Shannon index	Virgin forest (1200 m altitude)	Managed forest (1200 m altitude)
H <sub>CD</sub>	1,35	0,91
H <sub>TLM</sub>	1,54	1,50
H <sub>d</sub>	1,00	0,09
Simpson index	Virgin forest (1200 m altitude)	Managed forest (1200 m altitude)
D <sub>CD</sub>	0,29	0,47
D <sub>TLM</sub>	0,26	0,25
D <sub>d</sub>	0,39	0,96

The diversity of dead wood by the three categories of elements studied generally indicates higher values for virgin forest, regardless of whether we refer to the decomposition classes, the distribution by dead wood types or the dimensional characteristics. The only exception encountered occurs in the case of the distribution by dead wood types in the sample plots located at 1350 m altitude, where the indices show a slightly increased diversity in the managed forest. The highest discrepancy between the diversity in virgin forest and that in the managed forest is observed in the case of dimensional characteristics, in the managed forest being few pieces of dead wood in the 30–60 cm diameter category, and those above 60 cm are completely absent (Tables 7 and 8).

**Table 8. Diversity of dead wood by decomposition classes, type of dead wood and diameter classes in the sample plots at 1350 m altitude**

Shannon index	Virgin forest (1350 m altitude)	Managed forest (1350 m altitude)
H <sub>CD</sub>	1,30	1,17
H <sub>TLM</sub>	1,55	1,60
H <sub>d</sub>	0,95	0,37
Simpson index	Virgin forest (1350 m altitude)	Managed forest (1350 m altitude)
D <sub>CD</sub>	0,29	0,35
D <sub>TLM</sub>	0,27	0,24
D <sub>d</sub>	0,42	0,78

## Conclusions

Since the 1960s, the benefits of dead wood have been brought to light by researchers. However, it was not until the 1980s that the first monographs dedicated to this type of habitat were published, as well as the real inclusion of this component of the forest within management and conservation programs [15].

The quantities of dead wood are normally much lower in production forests than in virgin forests or those that are not in the productive cycle, because the large pieces of wood are extracted from the first category of forests. In the stands included in the productive cycle, usually only small branches and trees (dead as a result of the natural elimination process) and only scarce large logs are found. In managed forests, there is a positive correlation between the age of the stand, its volume and the quantity of dead wood. Also, the intensity of young stand care interventions and silvicultural harvesting interventions affects the quantity of dead wood.

According to the requirements of the FSC Certification Standard, after logging, a quantity of dead wood must be preserved. Therefore, maintaining enough dead wood is the guarantee of maintaining (or increasing) biodiversity in managed forests. Trees important for biodiversity can be spread evenly over the surface of a stand or in groups. When there is a possibility of preserving them as grouped, the manager may opt to preserve the so-called aging islands (groups of trees that are exempted from logging for an indefinite period, on areas of 0.1-0.2 ha). Trees with cavities are usually trees of low economic value, but with a special value for other animal species. As such, they will be mandatorily preserved, wherever they appear, when they shelter an active nest. Where it is not possible to manage dead wood in the form of aging islands or buffer zones for running waters (these two options will have priority given the biodiversity objectives), "standing" and/or fallen dead wood will be systematically preserved following the timber harvesting process. The dead or dying trees (standing or fallen) present in the stand will be preserved within the limit of at least 1-3 trees per hectare, starting with the first commercial thinnings. In the case of thinnings, standing softwood trees, with the diameter higher than 24 cm or larger trees from the pre-existing generation will be chosen. For older stands, fallen or dead trees, very old trees that have reached their physiological limit, and trees valuable in terms of biodiversity (with cracks, hollows, the presence of nests, food sources for birds, etc.) will be mainly chosen [18].

Another solution may be the artificial creation of dead wood by breaking trees, partial or total uprooting, producing of cavities in the trunk, as well as their drying using conventional forestry machines or various equipment (tractors with various accessories, barkers, chainsaws, etc.) [3]. In general, however, restoration methods are expensive and bring limited benefits [6].

In Romania, in most cases, the way forestry is applied is quite conservative, with strong links to traditional practices. This aspect can sometimes trigger conflicts of opinion with new management concepts.

Recent research on the adoption of new forest management practices has revealed that implementing innovative approaches can be challenging due to an increased reliance on technical norms with which forestry personnel have become familiar and due to a lack of agreement among forestry professionals regarding the selection of trees that should become deadwood [17].

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## References

- [1] Brassel, P., Brandli, U. (1999), *Inventariere forestier national suisse. Resultats du deuxieme inventaire 1993-1995*, Berne, Stuttgart, Viene
- [2] Bujoczek, L., Bujoczek, M., Zięba, S. (2021), *How much, why and where? Deadwood in forest ecosystems: The case of Poland*. Ecological Indicators. 121. 1-14.
- [3] Cavalli, R., Donini, F. (2003), *Possible management actions to increase the amount of dead and marcescent wood*, Proceeding of the International Symposium "Dead wood: a key to biodiversity", Mantova.
- [4] Christensen, M., Hahn, K., Mountford, E., Ódor, P., Standovár, T., & Roženbergar, D., Diaci, J., Wijdeven, S., Meyer, P., Winter, S., Vrška, T. (2005), *Dead wood in European beech (Fagus sylvatica) forest reserves*. Forest Ecology and Management. 210. 267-282.
- [5] Debeljak, M. (2006), *Coarse woody debris in virgin and managed forest*. Ecological indicators. , 2006, Vol. 6(4), p.733-742
- [6] Dudley, N., Vallauri, D. (2004), *Dead wood – living forests*, WWF Report
- [7] Fridman, J., Walheim, M. (2000), *Amount, structure and dynamics of dead wood on managed forestland in Sweden*, Forest Ecology and Management, 131
- [8] Keller, M. (Ed.). (2011), *Swiss National Forest Inventory. Manual of the Field Survey 2004–2007*. Swiss Federal Research Institute WSL, Birmensdorf, CH.

- [9] Keren, S., Diaci, J. (2018), *Comparing the Quantity and Structure of Deadwood in Selection Managed and Old-Growth Forests in South-East Europe*. Forests. 9.
- [10] Oettel, J., Lapin, K., Kindermann, G., Steiner, H., Schweinzer, K.M., Frank, G., Essl, F. (2020), *Patterns and drivers of deadwood volume and composition in different forest types of the Austrian natural forest reserves*. Forest Ecology and Management. 463
- [11] Oheimb, Gv., Westphal, Ch., Hardtle, W. (2007). *Diversity and spatiotemporal dynamics of dead wood in a temperate near-natural beech forest (Fagus sylvatica)*. European Journal Forest Research 126:359-370.
- [12] Petritan, I.C., Mihăilă, V.V., Yuste, J.C., Bouriaud, O. and Petritan, A.M. (2023), *Deadwood density, C stocks and their controlling factors in a beech-silver fir mixed virgin European forest*. Forest Ecology and Management, 539.
- [13] Stănescu, V., Șofletea, N., Popescu, O. (1997), *Romania's woody forest flora*. Editura Ceres, București.
- [14] Tomescu, R.; Târziu, D.; Gancz, V.; Petrila, M.; Teodosiu, M.; Turcu, D.O.; Brad, R.; Ștețca, I. (2004-2006), *Studiul factorilor de stabilitate in ecosistemele forestiere naturale. Evaluarea posibilităților de ameliorare a practicilor silvice în vederea gospodăririi durabile a pădurilor/A Study of the Stability Factors in Natural Forest Ecosystems. Evaluation of the Possibilities to Ameliorate the Silvicultural Practices for the Sustainable Management of the Forests*. Forest Research and Management Institute (ICAS) Bucharest, The Ministry of Agriculture, Forests and Rural Development, 3 volumes.
- [15] Vallauri, D. (2003), *Dead wood, a gap in French managed forests*, Proceeding of the International Symposium "Dead wood: a key to biodiversity", Mantova.
- [16] Vasile D., Petritan A.M., Tudose N.C., Toiu F.L., Scarlatescu V., Petritan I.C. (2017), *Structure and Spatial Distribution of Dead Wood in Two Temperate Old-Growth Mixed European Beech Forests*. Notulae Botanicae Horti Agrobotanici Cluj-Napoca 45(2): 639-645.
- [17] Vitkova, L., Bače, R., Svoboda, M. Kjucukov, P. (2018), *Deadwood management in Central European forests: Key considerations for practical implementation*. Forest Ecology and Management. 429.
- [18] xxx. (2019), *The FSC National Forest Stewardship Standard of Romania*
- [19] xxx. (2021), *Amenajamentul Ocolului Silvic Văliug – UP II, UP XII*
- [20] xxx. (2015), *Amenajamentul Ocolului Silvic Nera – UP II, UP III*
- [21] <https://earth.google.com/web/>