Anadolu Orman Araştırmaları Dergisi
Anatolian Journal of Forest Research

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The effect of elevation and exposure on stability index and quantity of snags in pure Oriental beech (*Fagus orientalis* Lipsky.) managed forests

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ARTICLE INFO
Received: 11/04/2022
Accepted : 26/04/2022
https://doi.org/10.53516/ajfr.1101788
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ABSTRACT **Research Article**

Snags are a major structural and functional component in oriental beech (*Fagus orientalis* Lipsky.) because of their high degree of naturalness in northern Anatolia forests. This research, as a case study, was conducted in the even-aged and pure oriental beech managed forest in Bartın. In this research where the effect of exposure and elevation, zone factors on stability index, the number and volume of snags (standing coarse deadwood: CDW_{snags}) were examined. It was found that exposure did not affect the stability index, number and volume of CDW_{snags}. However, there is a significant difference among the elevation zone on the number of CDW_{snags}, their volume and stability index (*P≤0.000*). It was found that there is an average volume of 8.87 m^3/ha of CDW_{snags}. The diameter of the snags is distributed between 32 and 72 cm. In addition, a strong positive correlation was determined between the number of CDW_{snags} and the stability index (r= 0.95), height and breast diameter of CDW_{snags} (r = 0.98). These results may be an important tool to be used to improve management interventions in the management of high value forests.

Key Words: Managed forest, oriental beech, stability index, standing deadwood, sustainable forestry

Saf Doğu Kayını (*Fagus orientalis* Lipsky.) işletme ormanlarında yükselti ve bakının dikili ölü ağaç sayısı ve stabilite indeksine etkisi

ÖZ

Ölü ağaçlar, yüksek doğallık dereceleri nedeniyle kuzey Anadolu doğu kayını doğu ormanlarının önemli bir yapısal ve fonksiyonel bileşendir. Örnek olay olark bu araştırma, Bartın'da aynı yaşlı ve saf doğu kayını işletme ormanında yürütülmüştür. Bu araştırmada, bakı ve yükselti faktörlerinin birey stabilite indeksi, dikili ölü ağaç (CDW_{snags}) sayısı ve hacmi üzerine etkisi incelenmiştir. Dikili ölü ağaç (CDW_{snags}) hacmi, sayısı ve stabilitesi üzerine bakı faktörünün etkisi tespit edilmemiştir. Ancak, yükselti zonları arasında dikili ölü ağaç (CDW_{snags}) sayısı, hacmi ve stabilitesi üzerinde önemli farklılık bulunmuştur (*P≤0,000*). Hektardaki dikili ölü ağaç hacmi ortalaması 8.87 m^3 olarak bulunmuştur. Dikili ölü ağaçların çapları 32 ile 72 cm arasında dağılım göstermiştir. Ayrıca, dikili ölü ağaçların (CDW_{snags}) sayısı ile stabilite indeksi (r= 0,95) ve boy ile göğüs çapı (r = 0,98) arasında güçlü pozitif korelasyon belirlenmiştir. Bu sonuçlar, yüksek değerli ormanların yönetiminde yönetim müdahalelerini iyileştirmek için kullanılacak önemli bir araç olabilir.

Anahtar Kelimeler: İşletme ormanı, doğu kayını, stabilite indeksi, ayakta ölü ağaç, sürdürülebilir ormancılık

Citing this article:
Özel, H.B., Ayan, S., Varol, T., 2022. The effect of elevation and exposure on stability index and quantity of snags in pure Oriental beech (*Fagus orientalis* Lipsky.) managed forests. Anatolian Journal of Forest Research, 8(1), 43-50.

1. Introduction

Structural components such as living trees, dead trees, and forest gaps perform an influential role in determining the dynamic phases of forest ecosystems (Parhizkar et al., 2018, Etemad et al., 2019). Deadwoods (DW) are a major component that supports the ecosystem and ensures its sustain, both for managed forests and for non-managed forests (urban forest, green belt, and so) especially in temperate and boreal forest ecosystems (Varol et al., 2019). DW, which consists of both standing deadwood and fallen dead wood, is a dynamic resource in forest ecosystems (Mark et al., 2006). DW, can be evaluated in two parts, as coarse deadwood (CDW) and fine dead wood (FDW). FDW mainly consists of small twigs and is much less important in ecological function compared with CDW (Lipan et al., 2008). In practice, CDW is generally classified as snags (standing deadwood: CDW_{snags}) and logs (fallen dead wood: CDW_{logs}) (von Oheimb et al., 2005). The coarse woody debris can be considered as an adequate and indispensable indicator both in the nutrient cycle, long-term carbon storage, forest regeneration, production and sustainability, and forest biodiversity assessment of forest ecosystems, as well as in reducing the negative effects of production on forest soil (Etemad et al. 2019). Sefidi and Marvie Mohadjer (2010) suggest that the removal of deadwood materials from early- and mid-successional forests leads to a sharp drop in total deadwood biomass. Reductions in the volume of the coarse woody debris in young- and intermediate successional forests, which may occur from other causes such as wildfires, can have negative consequences for populations of endemic, understory bird species that commonly nest in cavities located in or under logs on the forest floor (Ertugrul et al., 2017). In short, in other words; CDW is recognized as having great importance for wildlife and ecological processes in forest ecosystems (Harmon et al., 1986; Jonsson et al., 2005). Fallen dead wood and stumps provide nurse logs for regeneration in cool temperate, boreal and submontane-subalpine forest types (Christensen et al., 2005). Deadwood is increasingly regarded as a major component of, and a useful indicator of, biodiversity in forests (Colak, 2002; Hahn and Christensen, 2005; Marage and Lemperiere, 2005). For this reason, it was adopted as an indicator for sustainable forest management by the Ministerial Conference on the protection of forests in Europe (MCPFE, 2003; Butler and Schlaeper, 2004).

The quantity, quality, and dynamics of dead wood resources are able to effect on silvicultural and timber harvesting activities such as natural and artificial regeneration (Saniga and Schütz, 2001). In addition, the amount of deadwood in forests is attracting attention to biodiversity within forests managed by forest managers (Kirby et al., 1998). Its quantities are normally much lower in managed forests than in unmanaged old-growth forests. In recent years, in the interests of sustainable forestry and biodiversity conservation, efforts are being made to increase dead wood levels in managed forests (Marage and Lemperiere, 2005). In Europe, the volume of standing and fallen deadwood is one of nine pan-European indicators for sustainable forest management (Christensen et al., 2005).

Although research on the amount of deadwood in managed and protected forests in Europe has been conducted intensively, there are very few studies on this issue in Turkey. The recognition of the importance of management for dead wood is vital if its nature conservation objectives and obligations are to be met. The aim of this research as a case study was to investigate the change in the amount of standing deadwood in the oriental beech (*Fagus orientalis* L.) forest, which has its main distribution in Northern Anatolia in Turkey, according to the physiographic characteristics.

2. Material and Method

2.1 Material

The research was carried out in pure oriental beech forests in the Western Black Sea, Sub-Oksin sub-forest belt in Turkey. The hypothesis of this research is to test how the amount of CDW_{snags} varies depending on the exposure and elevation in pure and managed oriental beech forests. These forests typically occur on acid clay soils (Colak and Rotherham, 2006) in areas with cool winters, and humid to sub-humid summers. The best sites, along most of northern Anatolia and a narrow strip of the Black Sea coast in European Turkey, are characterized by a wet climate, particularly in the east where there is heavy precipitation throughout the year and mists are frequent. Mean annual precipitation in oriental beech forests ranges from 700 mm to 2300 mm (Atici, 1998). They are mainly found in sites up to 500-1200 m altitude, but a few were as high as 1560 m (Ertekin et al., 2015).

The study area is the plan unit forests belonging to Kumluca Forest District Chief located between 32° 23′ 46″ - 32° 33′ 44″ east longitudes and 41° 30′ 16″ - 41° 20′ 27″ north latitudes under Ulus Forest Management Directorate in Bartın, Turkey (Figure 1). The mean annual temperature in the research area is 17.3 ºC and the mean annual precipitation is 796 mm. In the province where the vegetation period is six months, early and late frosts are encountered from time to time. The mean annual snow-covered period in the region is 4 months. The average crown closure of the oriental beech stand in the research area is 0.6-0.7, the average density is 0.5-0.6, and the site index is III. The pure oriental beech stands in the area is the even-aged (age class is IV) and one layer. In Kumluca pure oriental beech forests, the soil texture is sandy-clayey-loam, the structure is granular. In terms of soil depth, deep soil conditions prevail. The amount of organic matter is high. In general, the land slopes vary between 35.3 and 72.7% (Anonymous, 2021).

2.2 Method

Within the scope of the research, the standing deadwood available in pure managed oriental beech were determined according to three different elevation zones and different exposure conditions. In the study, trees with a breast diameter of more than 6-7 cm that were broken from the top or trunk were considered dead trees (von Oheimb et al., 2005) and were included in the evaluations (Figure 1).

All measured trees were assigned to one of the four diameter classes: *small* (DBH ≤ 32.5 cm; snags number: 0), *medium* (32.5 cm < DBH ≤ 52.5 cm; snags numbers:32), *large* (52.5 cm < DBH ≤ 72.5 cm; snags numbers:40), and *extra-large* (DBH > 72.5 cm; snags numbers:0) and a more detailed classification is given in Figure 3 (Akhavan et al. 2012; Zenner et al. 2015).

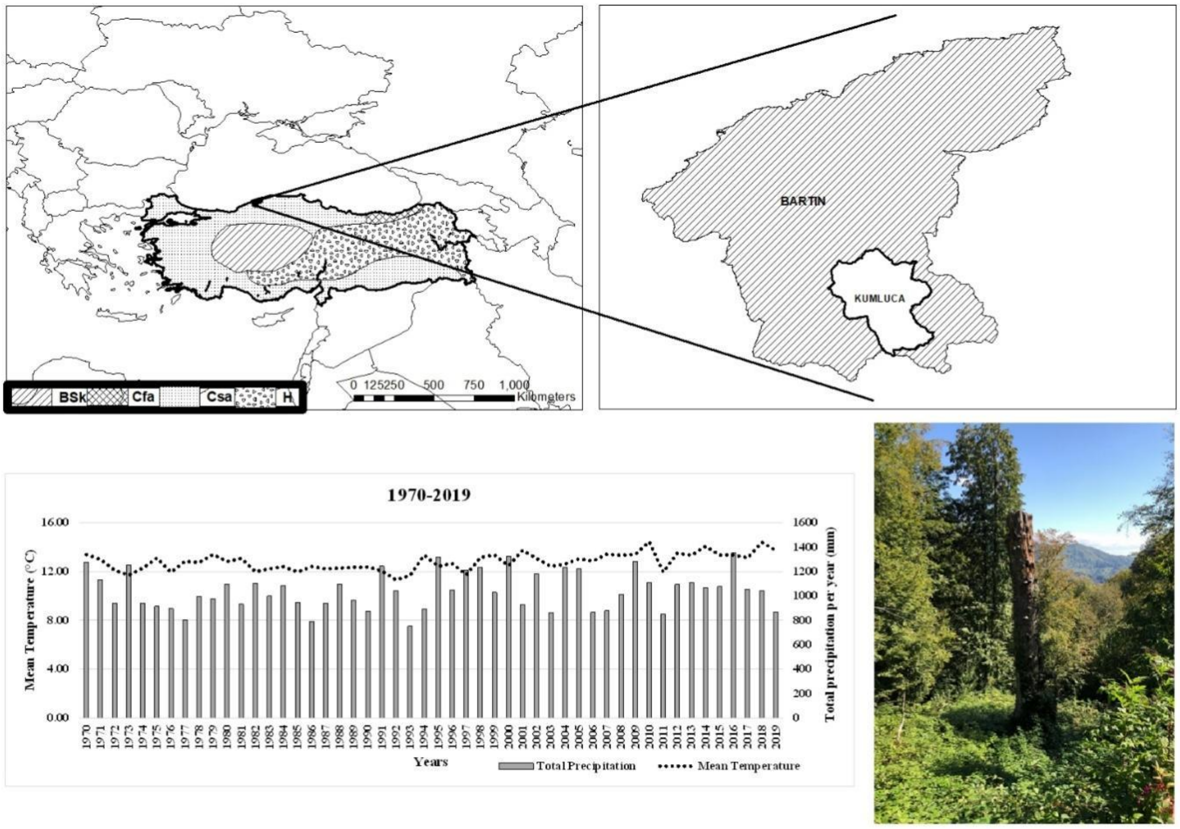

Fig. 1. Location and meteorological data of the study area and an example of standing deadwood belonging to the oriental beech stand (BSk: Semiarid-cold, Cfa: No dry season-hot summer, Csa: Dry summer-hot summer, H: Unclassified highlands)

This research, conducted snags at three different elevation zones in Kumluca Forest Planning Directorate, was designed to a random blocks trial design. All measurements and determinations were carried out in samples areas of 2000 m^2 (20 x 100 m) in size and rectangular shape. Digital diameter and height meters were used to measure breast diameters and heights of the snags. Using these height and diameter values, the volumes of the snags were calculated by using double-entry beech volume tables. In addition, the stability of the snags was also calculated at all exposures and three elevation zones (Table 1) (Oheimb et al., 2007; Lombardi et al., 2008; Jakoby et al., 2010; Larrieu et al., 2012).

Table 1. Index values according to the degree of stability (Van der Valk, 2009)

Degree of stability	h/d
Very weak	> 100
Weak	80-100
Stable	45-80
Very stable	< 45

2.3 Statistical analysis

The main descriptive statistics were determined for the number of standing deadwoods, their volume, breast diameter, and height, as well as the stability index variables, determined in the study. In addition, logarithmic transformations were performed to bring the measured variables closer to the normal distribution. Variance analysis was applied to evaluate the effects of different exposure and elevation zone factors, and after determining the significant difference, homogeneous groups were determined using the Duncan multiple tests. All data IBM SPSS Statistics (ver.23) the package has been analyzed through the program. Furthermore, the relationship between the stability index and the number of snags was tried to be revealed by correlation analysis for the factors of elevation zone and exposures.

3. Results

Descriptive statistics of the stability index, the number and volume of snags in the pure-managed oriental beech forest are given in table 2 according to the exposure factor and in table 3 according to the elevation zones. It was found that there was no significant statistical effect on the variables in which the exposures were determined (Table 2, Figure 2). In all exposures, almost all of the trees had "*Weak*" stability index.

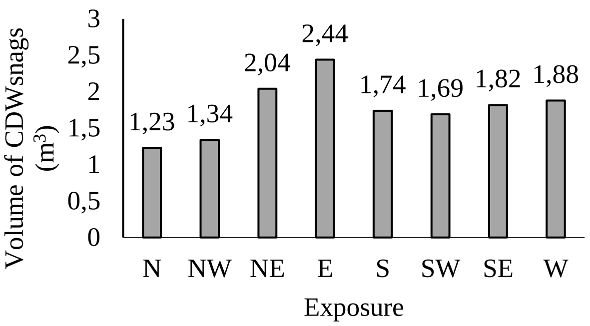

Fig. 2. The volume of snags according to the exposure

Other significant traits of deadwood are a distribution of its diameter classes. It has been determined that the diameter classes of the snags are distributed between 32 cm and 72 cm. 44.4% of the existing snags were in the medium and 56.6% were in the large diameter class (Figure 3). The absence of individuals in the thicker diameter classes, or in other words, the presence of snags in the lower diameter classes, is due to the fact that it has been a managed forest for a long time and the individuals have a sprout originated.

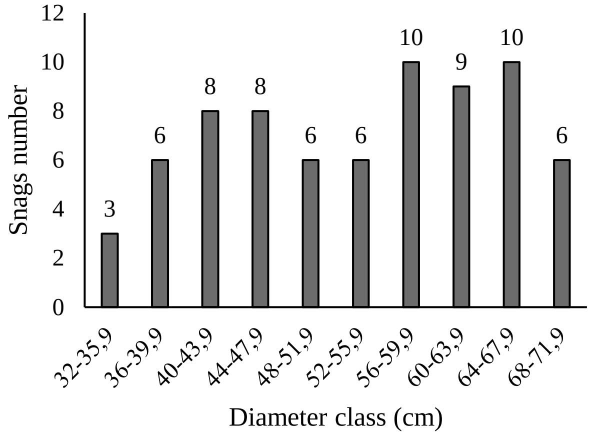

Fig. 3. Distribution of snags at diameter classes

Table 2. Descriptive statistics of the stability index, the number and volume of standing deadwood according to the exposure

Exposure	**Stability Index**				
	Mean	**Std. Deviation**	**Std. Error**	**Minimum**	**Maximum**
North	99.1111	27.26465	9.08822	63.00	123.00
Northwest	95.0000	17.40690	5.80230	72.00	112.00
Northeast	93.6667	25.70992	8.56997	66.00	126.00
East	78.3333	20.51219	6.83740	51.00	102.00
South	84.8889	22.67402	7.55801	54.00	108.00
Southwest	79.2222	14.14901	4.71634	59.00	93.00
Southeast	83.6667	28.18688	9.39563	47.00	114.00
West	76.5556	20.57979	6.85993	48.00	97.00
Mean	86.3056	22.85511	2.69350	47.00	126.00
F Value – P Level			*1.296 ns*		

Exposure	**Number of Standing Deadwood***				
	Mean	**Std. Deviation**	**Std. Error**	**Minimum**	**Maximum**
North	32.3333	12.58968	4.19656	17.00	48.00
Northwest	32.3333	10.93161	3.64387	18.00	45.00
Northeast	30.3333	11.85327	3.95109	17.00	46.00
East	22.6667	9.77241	3.25747	12.00	36.00
South	26.0000	9.16515	3.05505	15.00	38.00
Southwest	23.6667	7.85812	2.61937	14.00	34.00
Southeast	25.6667	11.46734	3.82245	13.00	41.00
West	24.0000	9.68246	3.22749	13.00	37.00
Mean	27.1250	10.65851	1.25612	12.00	48.00
F Value – P Level			*1.273 ns*		

Exposure	**Volume of Standing Deadwood (m^3)***				
	Mean	**Std. Deviation**	**Std. Error**	**Minimum**	**Maximum**
North	1.2267	0.80609	0.26870	0.37	2.76
Northwest	1.3422	0.77383	0.25794	0.41	2.43
Northeast	2.0389	1.02299	0.34100	0.48	3.35
East	2.4422	1.00322	0.33441	1.04	3.77
South	1.7400	1.03256	0.34419	0.68	3.40
Southwest	1.6978	0.86333	0.28778	0.47	2.86
Southeast	1.8200	1.08578	0.36193	0.60	3.44
West	1.8789	0.95005	0.31668	0.47	2.95
Mean	1.7733	0.96969	0.11428	0.37	3.77
F Value – P Level			*1.462 ns*		

* The values belong to sample areas with a size of 2000 m^2.
*P significance level; ns: non-significant, * P < 0.05: ** P < 0.01; *** P < 0.001*

The elevation zone factor had a significant statistical effect on the stability index, the number and the volume of snags. At the elevation zone 1200-1600 m, the stability index (108,083) is very weak and therefore a high number of snags was determined, however, the lowest volume of snags was detected at this elevation step. At 400-800 m, which is the lowest elevation step, it was determined that the stand individuals were stable (58,833) and as a natural result, the number of snags was low, while the volume of snags was the highest at this elevation.

Table 3. Descriptive statistics of stability index, number, and volume of snags according to elevation zones

Elevation Zone (m)	**Stability Index**				
	Mean	**Std. Deviation**	**Std. Error**	**Minimum**	**Maximum**
400-800	58.833a	8.15431	1.66449	47.00	75.00
800-1200	92.000b	9.36227	1.91107	80.00	114.00
1200-1600	108.083c	11.91972	2.43310	90.00	126.00
Mean	86.3056	22.85511	2.69350	47.00	126.00
F Value – P Level					153.300***
Elevation Zone (m)	**Number of Standing Deadwood***				
	Mean	**Std. Deviation**	**Std. Error**	**Minimum**	**Maximum**
400-800	15,875a	2.29010	0.46747	12.00	20.00
800-1200	25,875b	4.84824	0.98964	19.00	35.00
1200-1600	39,625c	5.02007	1.02472	32.00	48.00
Mean	27,1250	10.65851	1.25612	12.00	48.00
F Value – P Level					189,755***
Elevation Zone (m)	**Volume of Standing Deadwood (m^3)***				
	Mean	**Std. Deviation**	**Std. Error**	**Minimum**	**Maximum**
400-800	2.7883c	0.54809	0.11188	1.85	3.77
800-1200	1.7738b	0.59796	0.12206	0.80	2.94
1200-1600	0.7579a	0.30627	0.06252	0.37	1.48
Mean	1.773	0.96969	0.11428	0.37	3.77
F Value – P Level					98.711***

* The values belong to sample areas with a size of 2000 m2.
P significance level; ns: non-significant, * P < 0.05: ** P < 0.01; *** P < 0.001

To the elevation zones and exposures data obtained from the research, a strong positive relationship was found between the number of snags and the stability indices. The relationship was best expressed by a polynomial equation (Figure 4).

The correlation coefficients were determined as r = 0.899 at the 400-800 m, r = 0.877 at the 800-1200 m, and r = 0.933 at the 1200-1600 m in the correlation analyses applied separately for each elevation zone. The relationship between the number of snags on all elevation steps and the stability index is best expressed by the polynomial equation (Figure 5).

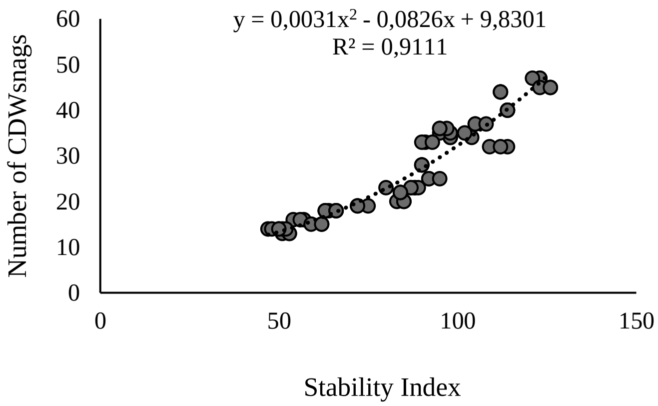

Fig. 4. The relationship between the stability index and the number of snags at different elevations and exposure

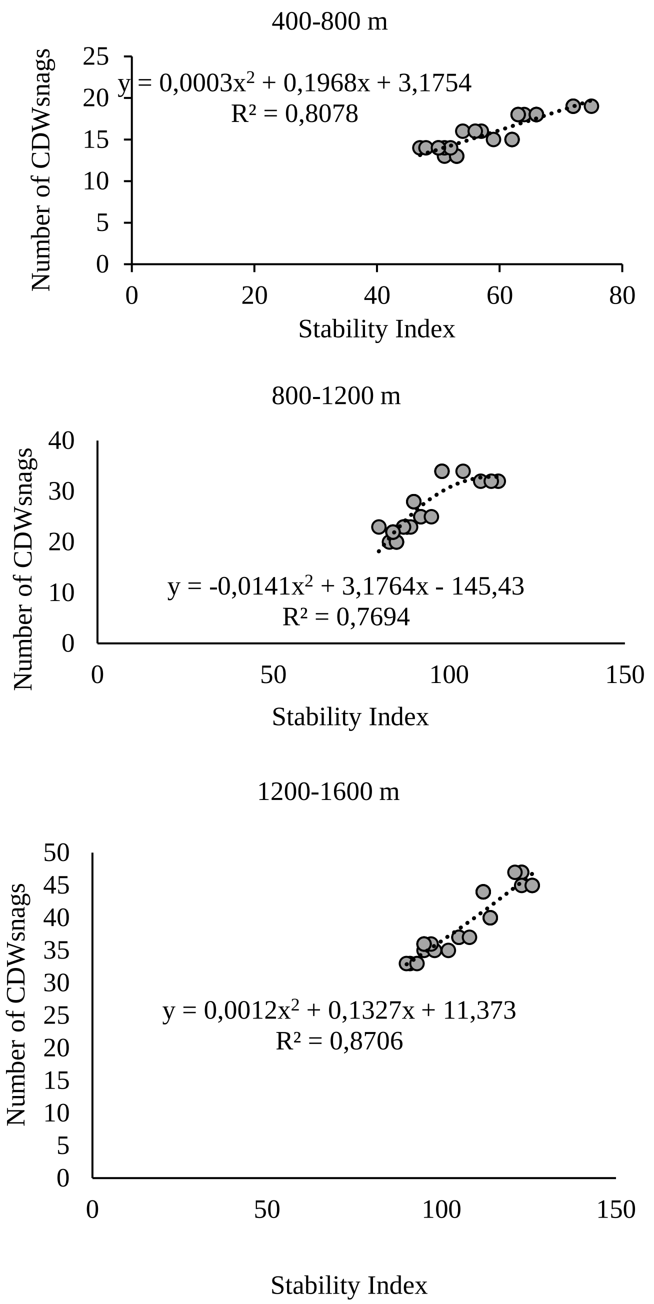

Fig. 5. The relationship of the stability index with the number of snags as different elevation zones

4. Discussion and Conclusion

The deadwood as one of the most notable structural components of forest stands performs an effective part in the separation of forest dynamic phases simultaneously with other features (Etemad et al. 2019). However, there are no determined standards for definitions and inventory format for deadwood sampling (e.g., decay classification, minimum diameter, volume functions, and sampling methods) (Debeljak, 2006). In this research; the shortest height and thinnest diameter snags were determined as 6.8 m and 34 cm in the northern exposure at 1200-1600 m; the highest height and thickest diameter snags were determined as 16.2 m and 70.8 cm in the eastern exposure at 400-800 m elevation.

In terms of the distribution of dead trees into diameter classes, which is an important treat, it was found that the distribution of snags in this study was observed in diameter class of 32-72 cm, and the maximum diameter was 70.8 cm. Kazempour Larsary et al. (2018) used the criterion of “proportion of dead trees in diameter classes” as one of the criteria used to define development periods in their studies. In our research, the fact that snags are largely in the medium and large diameter class shows that they are at the optimal stage in terms of development. With a similar result, Tavankar et al. (2014) emphasized that they could not determine snags with a diameter of more than 90 cm in open access forests in Northern Iran lowland. Wisdom and Bate (2008) stated that timber harvest and human access can have substantial effects on snag density.

In our research, while the exposure did not affect a statistically significant difference in the number and volume of snags, and the stability index (Table 2). Wheras, according to Topacoğlu et al. (2017) stated that elevation and exposure were not effective on the snags volume in their study conducted on Trojan fir forest. However, the factor of elevation has a significant difference in these measured variables (Table 3). It was already expected result that there will be more snags number at high altitudes in the research. As a result of the ecological difficulties in the high altitudes, more deadwood are left in the forests where regeneration difficulties are also experienced in these zones, where the cohorts can form more intensively and strongly.

Colak et al. (2009) described the state of coarse dead wood (CDW) in the managed forest of northern conifer-broadleaved mixed forest. The results of their research showed mean total CDW volumes 9.31±2.84 m^3/ha in the managed forest. In this research, an average of 8.87 m^3/ha of CDW was detected in the even-aged pure oriental beech managed forest. However, in different studies conducted, there are quite different values related to the amount of deadwood. The amount is generally from 40 to 220 m^3/ha in the less intensively and more natural forests of Middle and Eastern Europe (Vallauri et al., 2003; Hahn and Christensen, 2005), with a maximum of 400 m^3/ha (Colak, 2002). Deadwood at this level is considered important in the forest ecosystem for soil improvement, water economy, micro-climate, nutrient cycling, and energy flow. Etemad et al. (2019) in their study conducted in oriental beech forests in northern Iran an average volume of the dead tree was 41.5 m^3/ha, and they emphasized that this ratio was higher than in other studies in northern Iran. The main reason for this is due to the lack of traditional and commercial harvesting. However, in managed forests, it may be reduced to only 1-5 m^3/ha (Albrecht, 1991) with an average for example, of only 2.2 m^3/ha in France (Vallauri et al., 2003). Utschik (1991) states that it is important for levels to be at least 3 m^3/ha in a managed forest. According to Scherzinger (1996), very low values (for instance 1 m^3/ha) are probably too low to have any nature conservation value. Ammer (1991) claimed that the volume of deadwood to be around 1-2% of the whole forest yield. Möller (1994) advocates keeping 5% of the yield in managed forests to generate dead wood, and Jedicke (1995) proposes 5–10% dead wood per compartment. wood per compartment. However, Harmon et al. (1986) emphasized that generally, the amount of deadwood is lower in managed forests than in unmanaged forests. Our findings confirm this determination.

In the research conducted by Atici et al. (2008) in the main distribution area of oriental beech in Turkey; the stands have 22.87 ± 4.34 m^3/ha coarse deadwood. In demonstrating total deadwood volumes at this level, the research indicates that this resource is above the critical desired levels. Schmitt (1992) compared the deadwood in European beech forest reserves and managed forests and found 104.7 m^3 and 4.2 m^3/ha, respectively.

The use of coarse woody debris is a particularly important tool in determining and distinguishing the dynamic phases. Dynamic phases can also be used to study the dynamics of oriental beech forests of Northern Turkey in the long-term. It is also to be used to improve management interventions in the management of valuable forests. Our results are important in being to base the management work concerning coarse dead wood in oriental beech forests for places where the ecological conditions of the area where the research is conducted are represented. Further and much more detailed work is needed on the assessment of the deadwood resource in unmanaged and managed beech forests in the present study region. It would also be informative to then undertake detailed assessments of critical indicators of deadwood and its quality for key species for biological diversity. This research may support this process.

References

Akhavan, R., Sagheb-Talebi, K., Zenner, E.K., Safavimanesh, F., 2012. Spatial patterns in different forest development stages of an intact old-growth oriental beech forest in the Caspian region of Iran. European Journal of Forest Research, 131, 1355–1366.

Albrecht, L., 1991. Die Bedeutung des toten Holzes im Wald. Forstwissenschaftliches Centralblatt, 110, 106-113.

Ammer, U., 1991. Konsequenzen aus den Ergebnissen der Totholzforschung für die forstliche Praxis. Forstwissenschaftliches Centralblatt 110, 149-157.

Anonymous, 2021. Kumluca Orman İşletme Şefliği Detay Silvikültür Planı, Bartın.

Atici, E., 1998. Increment and growth in uneven-aged forest stands of Oriental beech (*Fagus orientalis* Lipsky) Forests. PhD thesis, Istanbul University, Istanbul.

Atici, E., Colak, A.H., Rotherham, I.D., 2008. Coarse dead wood volume of managed Oriental beech (*Fagus orientalis* Lipsky) Stands in Turkey. Investigación Agraria: Sistemas y Recursos Forestales, 17(3), 216-227.

Butler, R., Schlaepfer, R., 2004. Dead wood in managed forests: how much is enough? Schweizerische Zeitschrift für Forstwesen, 155(2), 31-37.

Christensen, M., Hahn, K., Mountford, E.P., Ódor, P., Standovár, T., Rozenbergar, D., Diaci, J., Wijdeven, S., Meyer, P., Winter, S., Vrska, T., 2005. Dead wood in European beech (*Fagus sylvatica*) forest reserves. Forest Ecology and Management, 210(1-3), 267-282.

Colak, A.H., 2002. Dead wood and its role in nature conservation and forestry: a Turkish perspective. The Journal of Practical Ecology and Conservation, 5(1), 37-49.

Colak, A.H., Rotherham, I.D., 2006. A review of the Forest Vegetation of Turkey: its status past and present and its future conservation. Royal Irish Academy, Journal of Biology and the Environment, 106B(3), 343-355.

Colak, A.H, Tokcan, M., Rotherham, I.D., Atici, E., 2009. The amount of coarse dead wood and associated decay rates in forest reserves and managed forests, northwest Turkey. Investigación Agraria: Sistemas y Recursos Forestales, 18(3), 350-359.

Debeljak, M., 2006. Coarse woody debris in virgin and managed forest, Ecological Indicators, 6, 733-742.

Ertekin, M., Kirdar, E., Ayan, S., 2015. Effects of tree ages, exposures and elevations on some seed characteristics of Oriental beech *(Fagus orientalis* Lipsky.). SEEFOR - South-east European Forestry, 6(1) 15-23.

Ertugrul, M., Varol, T., Kaygin, A.T., Ozel, H.B., 2017. The relationship between climate change and forest disturbance in Turkey. Fresenius Environmental Bulletin, 26, 4064-4074.

Etemad, V., Javanmiri, Pour, M., Foolady, Z., 2019. The importance of coarse woody debris in dynamic phases exposure in the beech (*Fagus orientalis* L.) stands of Hyrcanian forests. J. For. Sci., 65, 408–422.

Hahn, K., Christensen, M., 2005. Dead wood in European forest reserves - A reference for forest management. In: Marchetti M. (Ed.): Monitoring and Indicators of Forest Biodiversity in Europe - From Ideas to Operationality. European Forest Institute Proceedings, Florence, 51, 181- 191.

Harmon, M.E., Franklin, J.F., Swanson, F.J., Sollins, P., Gregory, S.V., Lattin, J.D., Anderson, N.H., Cline, S.P., Aumen, N.G., Sedell, J.R., Lienkaemper. G.W., Cromack, K.J.R., Cummins, K.W., 1986. Ecology of coarse woody debris in temperate ecosystem. In: Advances in Ecological Research. Academic Press, New York, 15: 133-302.

Jakoby, O., Rademacher, C.H., Grimm, V., 2010. Modelling dead wood islands in European beech forests: how much and how reliably would they provide dead wood? Europaean Journal of Forest Research, 129, 659–668.

Jedicke, E., 1995. Anregungen zu einer Neuauflage des Altholzinsel- Programms in Hessen. Allgemeine Forstzeitung, 10, 522-524.

Jonsson B.G., Kruys N., Ranius T., 2005. Ecology of species living on dead wood - Lessons for dead wood management. Silva Fennica, 39(2), 289-309.

Kazempour Larsary, M., Taheri Abkenar, K., Pourbabaei, H., Pothier, D., Amanzadeh, B., 2018. Spatial patterns of trees from different development stages in mixed temperate forest in the Hyrcanian region of Iran. J. For. Sci., 64, 260–270.

Kirby, K.J., Reid, C.M., Thomas, R.C., Goldsmith, F.B., 1998. Preliminary estimates of fallen dead wood and standing dead trees in managed and unmanaged forests in Britain. Journal of Applied Ecology, 35, 148–155.

Larrieu, L., Cabanettes, A., Delarue, A., 2012. Impact of silviculture on dead wood and on the distribution and frequency of tree microhabitats in montane beech-fir forests of the Pyrenees. European Journal of Forest Research, 131, 773–786.

Lipan, Y., Wenyao, L., Wenzhang, M., 2008. Woody debris stocks in different secondary and primary forests in the subtropical Ailao Mountains, southwest China. Ecol Res., 23, 805-812.

Lombardi, F., Lasserre, B., Tognetti, R., Marchetti, M., 2008. Deadwood in Relation to Stand Management and Forest Type in Central Apennines (Molise, Italy). Ecosystems, 11, 882–894.

Marage, D., Lemperiere, G., 2005. The management of snags: A comparison in managed and unmanaged ancient forests of the Southern French Alps. Annals of Forest Science, 62(2), 135-142.

Mark, C.V., Malcolm, J.R., Smith, S.M., 2006. An integrated model for snag and downed woody debris decay class transitions. Forest Ecology and Management, 234(1- 3), 48-59.

MCPFE (Ministerial Conference on the Protection of Forests in Europe), 2003. Vienna declaration and Vienna resolutions. Adopted at the fourth ministerial conference on the protection of forests in Europe, 28–30 April 2003, Vienna, Austria.

Möller, G., 1994. Alt- und Totholzlebensräume. Ökologie, Gefährdungssituation, Schutzmaßnahmen. Beiträge Forstwirtschaft und Landschaftsökologie, 28(1), 7-15.

Oheimb, G., Westphal, C.H., Härdtle, W., 2007. Diversity and spatio-temporal dynamics of dead wood in a temperate near-natural beech forest (*Fagus sylvatica*). European Journal of Forest Research, 126, 359–370.

Parhizkar, P., Hassani, M., Sadeghzadeh Hallaj M.H., 2018. Gap characteristics under oriental beech forest development stages in Kelardasht forests, northern Iran. J. For. Sci., 64, 59–65.

Saniga, M., Schütz, J.P., 2001. Dynamics of changes in dead wood share in selected beech virgin forests in Slovakia within their development cycle. J. For. Sci., 47, 557–565.

Scherzinger, W., 1996. Naturschutz im Wald. Qualitätsziele einer dynamischen Waldentwicklung. Praktischer Naturschutz. Verlag Eugen Ulmer, Stuttgart.

Schmitt, M., 1992. Buchen-Totholz als Lebensraum für Xylobionte Käfer-Untersuchungen im Naturwaldreservat "Waldhaus" und zwei Vergleichsflächen im Wirtschaftswald (Forstamt Ebrach, Steigerwald). Waldhygiene, 19, 97-191.

Sefidi, K., Marvie Mohadjer, M.R., 2010. Characteristics of coarse woody debris in successional stages of natural beech (*Fagus orientalis*) forests of Northern Iran. J. For. Sci., 56, (1), 7–17.

Tavankar, F., Picchio, R., Lo Monaco, A., Bonyad, A.E., 2014. Forest management and snag characteristics in Northern Iran lowland forests, J. For. Sci., 60(10), 431–441.

Topacoğlu, O., Kara, F., Yer, E.N., Savci, M., 2017. Determination of deadwood volume and the affecting factors in Trojan Fir Forests. Austrian Journal of Forest Science, Heft 3, 245-260.

Utschick, H., 1991. Beziehungen zwischen Totholzreichtum und Vogelwelt in Wirtschaftswäldern. Forstwissenschaftliches. Centralblatt, 110(2), 135-148.

Vallauri, D., Andre, J., Blondel, J., 2003. Dead wood - a typical shortcoming of managed forests. Revue Forestiere Francaise, 55(2), 99-112.

Van der Valk, A.G., 2009. Forest Ecology (Recent Advances in Plant Ecology), Springer Science+Business Media B.V., 361s.

Varol, T., Gormus, S., Cengiz, S., Ozel, H.B., Cetin, M., 2019. Determining potential planting areas in urban regions. Environmental monitoring and assessment, 191(3), 1-14.

Von Oheimb, G., Westphal, C., Tempel, H., Härdtle, W., 2005. Structural pattern of a near-natural beech (*Fagus sylvatica*) forest (Serrahn, northeast Germany). Forest Ecology and Management, 212(1-3), 23-263.

Wisdom, M.J., Bate, L.J., 2008. Snag density varies with intensity of timber harvest and human access. Forest Ecology and Management, 255, 2085–2093.

Zenner, E.K., Sagheb-Talebi, K., Akhavan, R., Peck, J.L.E., 2015. Integration of small-scale canopy dynamics smoothes live-tree structural complexity across development stages in old-growth Oriental beech (*Fagus orientalis* Lipsky) forests at the multi-gap scale. Forest Ecology and Management, 335, 26–36.