Forest management and snag characteristics in Northern Iran lowland forests

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ABSTRACT: Some snag characteristics were studied in three different Hyrcanian lowland forests. The highest snag density (38.4 stem·ha^{-1}) was found in fully protected forests, and it was significantly higher than in selectively logged (23.7 stem·ha^{-1}) and open access forests (8.8 stem·ha^{-1}). The snag volume, diameter and height were also significantly higher in the fully protected forests. The number of snag species was recorded in fully protected (9), selectively logged (5) and open access forests (4). The snags were more evenly distributed among diameter, height and decay classes in the fully protected forest. The larger diameter snags (> 90 cm) and snags higher than 15 m in height were not found in the open access forest. The snags of decay class 5 had a density of 6.8 stem·ha^{-1} in the fully protected forest, while they had a low density (1.5 stem·ha^{-1}) in the selectively logged forest and they were not found in the open access forest. Target values of snags for managed lowland forests in Iran were defined in relation to management influences.

Keywords: biodiversity; broadleaved forests; Caspian forests; dead wood; Hyrcanian forest

Deadwood has a wide range of ecological values in forest ecosystems, offering habitats for many living organisms (Bursell 2002, Humphrey et al. 2002; Britzke et al. 2003, Lonsdale et al. 2008; Lučan et al. 2009; Hanberry et al. 2012), providing carbon sequestration (Allard, Park 2013; Matsuzaki et al. 2013) and forest productivity preservation and also contributing to soil development and to nutrient cycles (Laiho, Prescott 1999; Kim et al. 2006; Strukelj et al. 2013). Decaying logs retain moisture and nutrients and play an important role for forest regeneration and for the maintenance of microhabitats (Szewczyk, Szwagrzyk 1996). Logs also store energy and fix nitrogen (Brunner, Kimmins 2003; Yatskov et al. 2003; Creed et al. 2004). Furthermore, deadwood could reduce soil erosion in slope areas. The research indicates that many forest insects are kept at low levels by insectivorous birds and small mammals that eat insects during all or part of their life cycle (Rafferty et al. 1996). Deadwood is also considered an important indicator, becoming relevant in the National Forest Inventories, in forest certification schemes and in some forest management plans (MCPFE 2007; Rondeux, Sanchez 2010). The best practice guidelines for sustainable management often encourage the retention of a higher volume of deadwood in managed forests (Böhl, Brändli 2007).

Snags are the standing trees dead for a natural process. They are an important environmental element and are essential for maintaining biodiversity in forest ecosystems (Ferris, Humphrey 1999). Snags are originated by any possible factor that contributes to tree mortality, such as lightning, storm breakage, fire, disease, insects, drought, flooding, forestry practices, and so on (Rafferty et al. 1996; Wolf et al. 2004; Bendix, Cowell 2010). Snags are not only the base of a food-chain but also they provide microhabitats for many living organisms, including fungi, epixylic lichens, bryophytes, invertebrates, birds, mammals, reptiles, and amphibians (Russell et al. 2006; Wisdom, Bate 2008; Larrieu, Cabannettes 2012; Nascimbene et al. 2013).

Wildlife use snags and downed logs for nesting, roosting, foraging, perching, or territorial displays (Rabe et al. 1998; Wisdom, Bate 2008; Lučan et al. 2009). Cavities in trees and snags provide suitable nesting sites for birds, bats and other wildlife species. In forest areas, an adequate and continuous availability should be ensured for preservation purposes (Fan et al. 2003; Tremblay et al. 2010; Russo et al. 2011; Ulyshen 2011; Ghadiri Khanaposhtani et al. 2013; Regnery et al 2013; Rost et al. 2013). Snags also contribute to ecological processes and decay dynamics (Lindenmayer et al. 1997; Ganey, Vojta 2005; Strukelj et al. 2013). Numerous wildlife functions are attributed to decaying wood as a source of food, nutrients, and cover for organisms at diverse trophic levels (Spies et al. 1988; Nascimbene et al. 2013).

The potential benefits to wildlife from deadwood are dependent on several factors, size, species, level of decay, and location. Increasingly, snags have been studied in managed forests to determine snag dynamics (Chambers, Mast 2005; Russel, Weiskittel 2012), snag abundance and snag recruitment (Bull et al. 1990; Ganey 1999; Harris 1999; Stephens 2004; Moroni, Harris 2010), effects of orography (Gale 2000; Clark et al. 2002) and effects of shelterwood cut (Kenefic, Nyland 2007). Snag and deadwood size and abundance are highly variable among regions and are dependent on forest type, successional stage, climate and forest management regimes (Fan et al. 2003, 2004; Böhl, Brändli 2007; Nagaike 2009). Different management regimes affect snag richness (Pedlar et al. 2002; Ganey, Vojta 2005; Stephens, Moghaddas 2005; Kenefic, Nyland 2007). Forest management, timber harvest and human access can have substantial effects on snag density (Wisdom, Bate 2008; Larrieu et al. 2012; Perry, Thill 2013). The snags have become a major conservation issue in managed forest ecosystems. Managing for quality saw timber with the single tree selection system often reduces the number of cavity trees and snags, because they are removed under an intensive timber management regime (Larrieu et al. 2012,; Perry, Till 2013).

The total forest area of Iran is approximately 12.4 mil. ha, which makes only 7.3% of the total national surface (FAO 2005). The Hyrcanian forests of Iran (also known as Caspian forests) are located in the north of Iran and on the south coast of the Caspian Sea (Fig. 1). These forests cover

Fig. 1. The study area

2 mil. ha of land area and are broadleaf forests while the Iranian part is only commercial forests (FAO 2005). Approximately 60% of these forests are used for commercial purposes and the rest of them are more or less degraded (Marvie Mohadjer 2006). These are the most valuable forests in Iran, both in commercial and in natural terms. The Hyrcanian forests are generally managed by selection cutting, with different logging methodologies. Data on existing densities and composition of snag populations are scarce for the Iranian lowland forests. The purpose of this study was to determine the density, size, level of decay and species of snags in different managing scenarios and the effect of forest management method on snag characteristics in the Hyrcanian lowland forests. The species, the volume, the distribution of species and diameter of snags in relatively undisturbed forests could provide a valuable baseline for sustainable management goals in managed forests and constitute a reference for restoring degraded woodland.

MATERIAL AND METHODS

Study area. This study was carried out in the Hyrcanian lowland forest in Guilan province in the north of Iran. The study area is located between 37°37'0" to 37°39'0"N and 49°0'10" to 49°0'40"E and the altitude ranges between –20 to 50 m a.s.l. (Fig. 1). The climate is temperate based on the Demarton classification and it is very wet, with the mean annual temperature of 15.7°C and mean annual precipitation of 1,306 mm. Three forest stands with different

Table 1. Management characteristics of the study area

Characteristics	Fully protected	Selectively logged	Open access
Surface	52 ha	44 ha	53 ha
Management	no cutting no hunting no grassing no tourism no rural use for firewood, fuel protected by barbed wire	selection cutting (in each 10-year period – about 7–10% of stand volume – ground-based logging – skid trails) low grazing low rural use for firewood protected by barbed wire	no cutting (because stand volume is low and area is degraded) a lot of grassing tourism rural use for firewood (fuel) protected by barbed wire (but many parts are open)

management methods (Table 1) were selected: (1) fully protected forest (the Forest Management Plans were prepared for these forests in 1963, from that year up to now no timber harvesting has been performed), (2) selectively logged forest, where selective harvest is allowed, the woodland was and it is protected from grazing, trampling and other forms of disturbance and (3) open access forest, where people have unrestricted access to forest resources.

Data collection. Data were collected by a systematic sampling design (Stephens 2004; Kenefic, Nyland 2007; Hessburg et al. 2010). In each of the three managed forest areas (treatments) 30 circular plots (replicate) with a surface of 1,000 m^2 were taken at regular distances (100 m) from each other.

The number and the diameter at breast height (DBH) of all living trees and standing dead trees (snags) were recorded. The height of two living trees was measured selecting the nearest to the centre of the plot and the maximum DBH of the tree.

All snags ≥ 10 cm diameter at breast height and ≥ 2 m in height within plot boundaries were sampled. For all snags sampled, species, DBH, height, volume, percent bark cover, and decay class were recorded. The species of a snag was determined from bark characteristics. The DBH was recorded to the nearest centimetre using a DBH tape. Height was estimated to the nearest meter using a Suunto clinometer. Volume was calculated by Huber's Equation (1):

$$V = A_m H \tag{1}$$

where:
V – volume (m^3),
A_m – mid-point cross-sectional area (m^2)
H – height (m).

Bark coverage was visually estimated to the nearest 5%.

Decay class of snag was determined in 5 classes (Holloway et al. 2007; Corace et al. 2010):

DC1 – recently dead tree with intact tops and the majority of fine branching present;

DC2 – trees with loose bark, intact tops, and most of the fine branches;

DC3 – trees with < 50% of coarse branches and < 50% bark;

DC4 – trees with broken tops and few or no coarse branches;

DC5 – trees with broken tops and no coarse branches.

Data analysis. After checking for the normality (Kolmogorov-Smirnov test) and homogeneity of variance (Levene's test), distribution of tree species in the studied forests was compared using the Kruskal-Wallis test, which was also applied for the distribution of tree snag species; the averages of stand structure variables (DBH and height) were compared using a two-way ANOVA to test differences between the plots within each forest stand and differences between the three forest stands with different management methods (treatments); the averages of snag density and snag characteristics (volume, DBH and height) were compared using a two-way ANOVA to test differences between the plots within each forest stand and differences between the three forest stands with different management methods (treatments). Multiple comparisons were made by Duncan's test considered for this data typology as one of the most powerful tests (Day, Quinn 1989) (significance at $\alpha < 0.05$). Correspondence analysis was done considering the distribution of snags by DBH classes, height classes and decay classes for the three forest stand management. SPSS 19.0 software (IBM, New York, USA) was used for statistical analysis; also the results of the analysis were presented using descriptive statistics.

RESULTS

The presence of boxwood (*Buxus hyrcana*) live trees is relevant only in the fully protected forest (Table 2), while it is absent in the open access forest. *Alnus glutinosa* is the most frequent species followed by *Parrotia persica* and *Quercus castaneifolia* both in selectively logged and in open access forest.

The species number decreases if disturbances increase. There are 18 species in the fully protected forest, 14 in the selected logged area and 11 in the open access forest (Table 2). The main dendrometric characteristics of the three treatments (DBH and height) were analyzed to differences between the plots of every single treatment and between the three treatments. The ANOVA test shows any difference between the plots for each treatment ($P > 0.05$, df = 2.27) and significant differences between the three treatments ($P < 0.05$, df = 2.27) (Table 3). The same trend was observed in tree density, seedling density and canopy cover (Table 3). In the selectively logged forest, basal area and height are greater.

The species richness of the snags mirrored those of living trees in the different forests. The number of snag species in the fully protected, selectively logged and open access forest was 9, 5

Table 2. Distribution of tree species in the studied forests. From the Kruskal-Wallis test between the three areas there are significant differences in the distribution ($P < 0.05$)

	Fully protected		Selectively logged		Open access	
	(indd·ha^{-1})	(%)	(indd·ha^{-1})	(%)	(indd·ha^{-1})	(%)
Tree species						
Buxus hyrcana Pojark.	91.6	47.9	6.4	3.8	0	0
Parrotia persica C.A. Meyer	27.9	14.6	31.5	18.6	22.4	18.5
Quercus castaneifolia Gled.	26.3	13.7	31.4	18.5	21.4	17.7
Alnus glutinosa L.	21.1	11.0	36.0	21.2	30.7	25.3
Pterocarya fraxinifolia Lam.	7.0	3.7	12.1	7.1	14.1	11.6
Carpinus betulus L.	5.2	2.7	22.5	13.3	14.8	12.2
Acer insigne Boiss.	2.2	1.2	14.0	8.3	12.1	10.0
Acer cappadocicum Gled.	2.2	1.2	7.6	4.5	0	0
Zelkova caprinifolia (Pall.) Dipp.	2.1	1.1	6.1	3.6	0	0
Mespilus germanica L.	2.0	1.0	0.5	0.3	2.4	2.0
Diospyrus lotus L.	1.1	0.6	0.5	0.3	0	0
Ulmus minor Miller.	0.7	0.4	0.4	0.2	0	0
Gleditsia caspica Desf.	0.6	0.3	0	0	1.6	1.3
Albizzia julibrissin Durazz.	0.5	0.3	0	0	1.1	0.9
Prunus avium L.	0.3	0.2	0.2	0.1	0.6	0.5
Populus nigra L.	0.2	0.1	0	0	0	0
Fraxinus excelsior L.	0.2	0.1	0.2	0.1	0	0
Ficus carica L.	0.1	0.1	0	0	0.5	0.4
Snag species						
Buxus hyrcana Pojark.	17.8	46.3	–	–	–	–
Quercus castaneifolia Gled.	7.1	18.5	3.6	15.2	–	–
Carpinus betulus L.	4.1	10.7	10.8	45.6	–	–
Alnus glutinosa L.	3.0	7.8	3.0	12.7	1.5	17.0
Acer insigne Boiss.	2.7	7.0	–	–	–	–
Parrotia persica C.A. Meyer	1.8	4.7	4.5	18.9	2.0	22.7
Pterocarya fraxinifolia (Lam.	1.0	2.6	–	–	–	–
Mespilus germanica L.	0.8	2.1	1.8	7.6	2.6	29.6
Gleditsia caspica Desf.	0.1	0.3	–	–	2.7	30.7

Table 3. Stand structure variables (mean ± standard deviation)

Stand characteristics	Fully protected	Selectively logged	Open access
Stand basal area ($m^2 \cdot ha^{-1}$)	13.3 ± 4.2	17.9 ± 2.9	12.5 ± 3.2
Tree density ($stem \cdot ha^{-1}$)	191.3 ± 22.2	169.4 ± 8.7	121.1 ± 16.2
Seedling density ($stem \cdot ha^{-1}$)	447.1 ± 32.7	322.3 ± 38.1	86.5 ± 19.5
Tree height (m)	16.1 ± 4.1	21.2 ± 4.2	15.5 ± 5.4
Canopy cover (%)	83.1 ± 8.4	78.0 ± 7.9	59.9 ± 6.9

and 4, respectively (Table 2). *Buxus hyrcana* had the highest snag density (17.8 $stem \cdot ha^{-1}$) in the fully protected forest, where it is the most representative species, while it was not found in the selectively logged and open access forest, where boxwood was sporadic or absent among the living trees. Three species (*Buxus hyrcana*, *Quercus castaneifolia* and *Carpinus betulus*) had the greater spread representing 75.5% of snags; these species also accounted for nearly 65% of living trees in the fully protected forest. In particular boxwood showed the same frequency both in the living trees and in snags.

Carpinus betulus had the highest snag density (10.8 $stem \cdot ha^{-1}$) in the selectively logged forest. This species represents 45.6% of the snags while only 13.3% of the living trees. *Gleditsia caspica* had the highest snag density (2.7 $stem \cdot ha^{-1}$) in the open access forest although the frequency in living trees was only 1.3%.

The density of snags was 38.4, 23.7 and 8.8 $stem \cdot ha^{-1}$ in the fully protected, selectively logged and open access forest, respectively (Table 4). The snags represented 20, 14 and 7% of the living trees, respectively. The average volume of snags in the fully protected, selectively logged and open access forest was found to be 17.3, 9.4 and 1.1 $m^3 \cdot ha^{-1}$ (Table 4). The ANOVA and Duncan's test showed that the snag density and the snag volume are significantly higher in fully protected forest than in selectively logged forest ($P < 0.01$), and they are significantly higher in selectively logged forest than in open access forest ($P < 0.01$).

The snag diameter in fully protected forest (37.7 ± 9.9 cm) was significantly higher than in selectively logged (22.2 ± 6.0 cm) and in open access (13.5 ± 3.2 cm) forests (Table 4 and Fig. 2). Moreover diameter, snag height and snag volume in fully protected forest were significantly higher than in selectively logged and open access forests (Table 4 and Fig. 2). The mean of snag height in fully protected, selectively logged and open access forests measured 14.5, 10.1 and 6.3 m, respectively (Table 4). The average volume of snag in fully protected, selectively logged and open access forests measured 0.47, 0.36 and 0.09 m^3 (Table 4).

The distribution of snags by diameter classes is shown in Table 5. The results indicated that the snags were more evenly distributed among diameter classes in the fully protected forest than in the selectively logged and open access forests (Fig. 2). The large and very large diameter snags (DBH > 60 cm) had the highest density (15.9 $stem \cdot ha^{-1}$) in fully protected forest, 2.3 $stem \cdot ha^{-1}$ in selectively logged forest and were not observed in open access forest (Table 5 and Fig. 2). Small snags (DBH < 30 cm) had the higher frequency (82.9%) in the open access forest (Fig. 2). Even in selectively logged forest the small snags were more abundant than the other diameter classes. Snags < 30 cm DBH are less valuable as wildlife habitats than larger snags. The very large diameter snags (DBH > 90 cm) were not found

Table 4. Density, volume and average parameters of snags (mean ± standard deviation) in the studied forests (different letters indicate statistically significant differences by Duncan's test at $\alpha = 0.05$)

	Fully protected	Selectively logged	Open access
Snag parameters			
Density ($stem \cdot ha^{-1}$)	38.4 ± 7.2^a	23.7 ± 5.6^b	8.8 ± 2.5^c
Volume ($m^3 \cdot ha^{-1}$)	17.3 ± 5.1^a	9.4 ± 2.9^b	1.1 ± 0.3^c
Snag average parameters			
Diameter (cm)	37.7 ± 9.9^a	22.2 ± 6.0^b	13.5 ± 3.2^c
Height (m)	14.5 ± 3.4^a	10.1 ± 2.2^b	6.3 ± 1.3^c
Volume (m^3)	0.47 ± 0.13^a	0.36 ± 0.10^b	0.09 ± 0.02^c

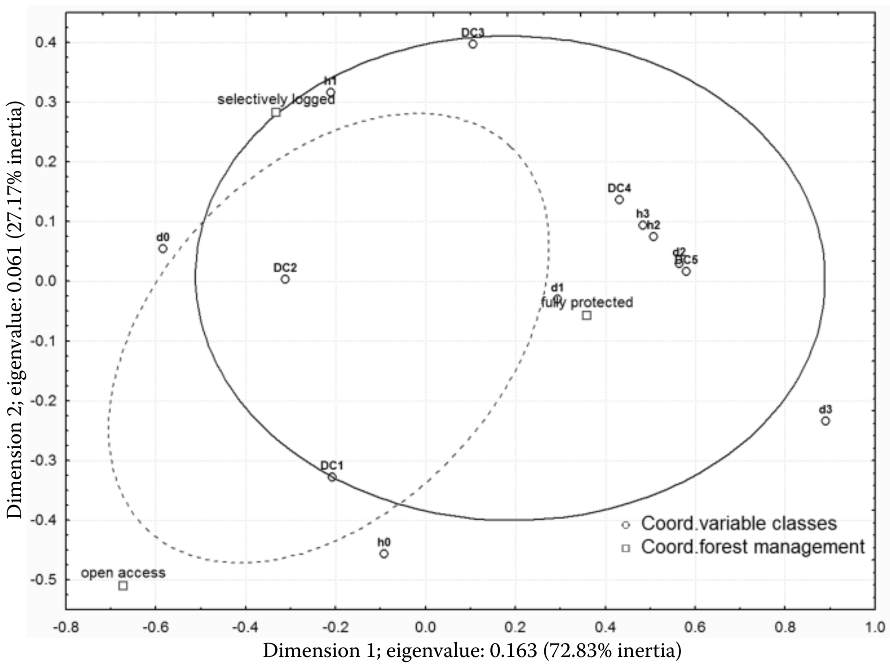

Fig. 2. Correspondence analysis considering the distribution of snags by DBH classes (d), height classes (h) and decay classes (DC) (solid line) for the three types of forest management (dotted line)

in selectively logged and open access forests, while these snags had the density of 6.1 stem·ha^{-1} in the fully protected forest (Fig. 2).

The distribution of snags by height classes is shown in Table 5 and Fig. 2. The snag height was more evenly distributed among classes in the fully protected forest than in the selectively logged and open access forests. The snags higher than 15 m had the highest density (4.5 stem·ha^{-1}) in the fully protected forest (Fig. 2). The snags higher than 10 m were not found in the open access forest where the shorter class showed a frequency of more than 70%.

The higher snags (height > 10 m) were found in fully protected and selectively logged forests. The density was 13.2 and 3.9 stem·ha^{-1} in fully protected and selectively logged forest, respectively, but with relevant difference in frequency (Fig. 2). It was about double in the fully protected forest.

The distribution of snags by decay classes is shown in Table 6 and Fig. 2. The level of snag decay

Table 5. Distribution of snags by parameters in the studied forests

	Fully protected		Selectively logged		Open access	
	(indd·ha^{-1})	(%)	(indd·ha^{-1})	(%)	(indd·ha^{-1})	(%)
Snag diameter (cm)						
< 30 (d_0)	8.0	20.8	16.3	68.8	7.3	82.9
31 – 60 (d_1)	14.5	37.8	5.1	21.5	1.5	17.1
61 – 90 (d_2)	9.8	25.5	2.3	9.7	–	–
> 91 (d_3)	6.1	15.9	–	–	–	–
Snag height (m)						
< 5 (h_0)	13.2	34.4	4.4	18.6	6.2	70.4
5 – 10 (h_1)	12.0	31.2	15.4	65.0	2.6	29.6
10 – 15 (h_2)	8.7	22.7	2.5	10.5	–	–
> 15 (h_3)	4.5	11.7	1.4	5.9	–	–
Snag decay class						
DC1	9.8	25.5	5.4	22.8	5.1	57.9
DC2	7.7	20.1	8.3	35.0	3.7	42.1
DC3	7.0	18.2	5.9	24.9	–	–
DC4	7.1	18.5	2.6	11.0	–	–
DC5	6.8	17.7	1.5	6.3	–	–

is another important factor to consider in management decisions. Snags were more evenly distributed among the decay classes in the fully protected and in the selectively logged forests than in the open access forest.

Snag decay classes DC3, DC4 and DC5 were not found in the open access forest, while these classes had 20.9 and 10.0 stem·ha^{-1} in the fully protected and in the selectively logged forest (Fig. 2). The snags in decay class DC5 (very decayed snags) had a density of 6.8 stem·ha^{-1} in the fully protected forest, while their density in the selectively logged forest was 1.5 stem·ha^{-1} (Fig. 2).

DISCUSSION

Dead wood and snags particularly may be considered a proxy of biodiversity although the knowledge acquired on the abundance and attributes of snags is not directly transferable to other forest contexts for the well-known differences due to climate, site, forest types and history. Forest managers need biodiversity indicators that are easy to use. The effect of forest management was surveyed focusing on snags. The snag attributes (species, density, size, and level of decay) were studied in three different forests (fully protected, selectively logged and open access) in the Hyrcanian lowland forests. Forest management has caused changes in stand composition, tree density, basal area, height, seedling density, and canopy cover. Forest management has also influenced the attributes of snags. Snags were more diffused in fully protected forest than in forests managed in another way (Sefidi et al. 2009). The reduction of snag density was higher in the open access forest, where cutting of snags is allowed. Generally, snags were removed by rural people for fuelwood. The removal of snags can negatively impact wildlife populations that are dependent on them as essential habitat components. In addition, our results on the snag density and human access are similar to those of Wisdom and Bate (2008) on pine and larch in the Rocky Mountains and to those of Bate et al. (2007) obtained in the Northeast Oregon. Russell et al. (2012) found that snag density was lower in intensively managed stands and that height and DBH were greater in unmanaged stands. The results indicated that the range of snag species depends on the specific composition of the stand, although the frequency does not. Sefidi and Marvie Mohadjer (2009) found similar results in a beech stand in Caspian forest in the north of Iran. The snag density, especially of large-size snags, was significantly higher in the fully protected forest than in the selectively logged and open access forests. Russel and Weiskittel (2012) found that the probability of snag survival was dependent on species and DBH. Lõhmus et al. (2013) noted that snags of deciduous trees had a higher probability of trunk breakage during the time, particularly the higher and the thinner ones, with the consequence of decay acceleration due to the ground contact. From an ecological point of view, snags of larger diameter are particularly important, due to the richness of microhabitats per tree (Regnery et al. 2013). In addition, the diameter at breast height and height of snags determine which species will use the snag for nesting (Thomas et al. 1979). Ghadiri Khanaposhtani et al. (2012) underlined that high volumes of coarse woody debris, especially large snags, and dense canopy cover are habitat requirements of the black woodpecker, *Dryocopus martius*, in Hyrcanian Forests.

The level of snag decay is another important factor driving management decisions (Jonsson et al. 2005; Nascimbene et al. 2013). Suitable density and different stages of decay of snags are critical to the preservation of biodiversity and the constant functionality of forest ecosystems (De Long et al. 2008). For example, soft snags are most often used for nesting whereas hard snags are most often used for foraging (Fan et al. 2003). In order to maximize the wildlife benefits, a variety of decay snag classes is necessary: snags from harder trees newly died still with bark and old decayed snags debarked.

Defects and indicators of wood decay are considered when trees are selected for cutting, due to the maximization of the future value of forest (Trimble et al. 1974). Standing dead or dying trees are usually harvested to avoid pest problems and fire hazards and to maximize the commercial value of the harvest. Intensively managed forest or productive forests are subjected to disturbances caused by logging operations. Damage to residual trees may increase the stand mortality both during the selection cutting operations (Tavankar et al. 2011, 2013) and during thinning (Picchio et al. 2011, 2012; Marchi et al. 2014) with a consequent increase of dying or standing dead trees, which take on the configuration of snags during time.

Snags are a significant structural component of forest ecosystems. They preserve biodiversity, as many dead wood dependent organisms are confined to snags during their life cycle (Nilsson et al. 2002). Although density or volume thresholds of snags are not yet established for Iranian forest types, some authors have addressed this issue. Marvie Mohadjer et al. (2009) found a density of 19.3 snags (DBH ≥ 7.5cm) per hectare for a selectively logged stand in the northern forests of Iran. It is important to provide snags of various sizes. A selectively logged stand had a density of 2.1 to 2.5 snag·ha^{-1} (DBH ≥ 50 cm) in the Hyrcanian forests (Sefidi et al. 2009). In Caspian Hyrcanian mixed forest within the Alborz mountains Ghadiri Khanaposhtani et al. (2013), studying the effect of forest logging on avian communities, found 6.66 (+ 0.37 SD) snag·ha^{-1} in a never harvested area and 4.32 (+ 0.42 SD) snag·ha^{-1} in a logged area. In Mazandaran Province, Sefidi and Marvie Mohadjer (2010) examined the amount of dead wood in mixed beech forests in late, middle and early successional stages. The late successional forest had a larger amount of logs, snags and stumps than the other two forests. The snag volume differed between the late (15.62 m^3·ha^{-1}) and middle successional forest (0.48 m^3·ha^{-1}), and it was 16.60 m^3·ha^{-1} in the early successional stand.

The results of this study showed that the characteristics of snags were affected by forest management, these results were confirmed by Kenefic and Nyland (2007) and by Wisdom and Bate (2008). Timber harvest and human access can have substantial effects on snag density (Wisdom, Bate 2008). It is now widely accepted that forests should be managed in an ecologically sustainable manner (Kohm, Franklin 1997). For the first time this study contributes to the definition of the target values of snags for managed lowland forests in Iran and highlights the management influences on snag density, species frequency and distribution in decay classes. The fully protected forest could represent a guide for snag management in selectively logged and open access forests, in the lowland Hyrcanian forest.

CONCLUSION

Today, the Hyrcanian lowland forests of Iran are depleting rapidly due to the population growth and associated socio-economic problems, industrial development and urbanism (Poorzady, Bakhtiari 2009). Consequently, the reduction in snag density would likely decrease the biodiversity in forest ecosystems. Snags provide habitats for foraging, nesting, resting or cover for many species of wildlife, as well as a source of coarse woody debris important in forest succession. Characteristics of snags, including the stage of decay, density, size, and species influence their use by wildlife. A reduction in the density of snags in selectively logged and open access forests may have negative consequences for wildlife. A continuous supply of snags and downed logs must be preserved to sustain wildlife populations that depend on these resources. Recommendations for "management of snags" include long rotations of forest stands and retaining of dying trees, dead standing trees and snags during harvest.

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