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The amount and quality of dead trees in a mixed beech forest with different management histories in northern Iran

KIOMARS SEFIDI♥, VAHID ETEMAD
[1]Faculty of Agriculture Technology and Natural Resources, University of Mohaghegh Ardabili, Ardabil, Iran. Tel: +98-451-5512081;
Fax.: +98-4515512081; ♥email: kiomarssefidi@gmail.com.
[2]Department of Forestry, Faculty of Natural Resources, University of Tehran, Tehran, Iran.

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ABSTRACT

Sefidi K, Etemad V. 2014. The amount and quality of dead trees in a mixed beech forest with different management histories in northern Iran. Biodiversitas 15: 162-168. Dead tree (fallen logs and snags), is regarded as an important ecological component of forests on which many forest dwelling species depend, yet its relation to management history in Caspian forest has gone unreported. The aim of research aim was to compare the amounts of dead tree in the forests with historically different intensities of management, including: forests with the long term implication of management (Patom), the short term implication of management (Namekhaneh) which were compared with semi virgin forest (Gorazbon). The number of 215 individual dead trees were recorded and measured at 79 sampling locations. ANOVA revealed volume of dead tree in the form and decay classes significantly differ within sites and dead volume in the semi virgin forest significantly higher than managed sites. Comparing the amount of dead tree in three sites showed that, dead tree volume related with management history and significantly differ in three study sites. Reaching their highest in virgin site and their lowest in the site with the long term implication of management, it was concluded that forest management cause reduction of the amount of dead tree. Forest management history affect the forest's ability to generate dead tree specially in a large size, thus managing this forest according to ecological sustainable principles require a commitment to maintaining stand structure that allow, continued generation of dead tree in a full range of size.

Key words: Forest biodiversity, snag, sustainable management, *Fagus orientalis*, Iran.

INTRODUCTION

An important feature of natural forests is that they possess high amounts of dead tree in all stages of decay and also high proportions of old, living trees with dead parts (Harmon and Sexton 1996; Kraigher et al. 2002; Debeljak 2006). Dead tree has been denoted as the most important, manageable habitat for biodiversity in forests (e.g. McComb 2003), supporting a wide diversity of organisms, including birds, mammals, insects, mites, collembolans, nematodes, bryophytes, lichens, fungi and bacteria. As the most important agent of wood decay, fungal diversity can be regarded as a crucial indicator of dead tree biodiversity.

Fallen dead tree and stumps provide nurse logs for regeneration in temperate, boreal and submontane-subalpine forest types (Ott et al. 1997; Christensen et al. 2005). Dead trees are usually divided into coarse and fine woody debris, although the minimum threshold diameter value varies a lot (Müller and Bartsch 2009). All type of dead tree play different role in the forest ecosystems. Dead tree is increasingly regarded as a major component of forest structure, and a useful indicator of biodiversity in forests (Colak 2002; Norden et al. 2004; Christensen et al. 2005; Hahn and Christensen 2004; Rahman et al. 2008). For this reason it was adopted as an indicator for sustainable forest management by the Ministerial Conference on the protection of forests in Europe (Butler and Schlaeper 2004). The nature of the dead tree resource and the implications of this for nature conservation are well-established issues and concerns.

Dead tree offers rooting substrate for plants (Schuck et al. 2004), provides wildlife habitat facilitates nutrient cycle and energy flows and maintains hydrology and soil retention capacities (Hafner and Groffman 2005). In terms of animal habitat, a diversity of dead tree conditions helps ensure a diversity of organisms including fungi, bryophytes, lichens, invertebrates, amphibians, cavity nesting birds, and small mammals (Bobiec et al. 2005). In the temperate European beech (*Fagus sylvatica*) forests, the death of individuals or small groups of trees is the primary natural disturbance that provides for a continuous presence of dead tree of different sizes and decay status (Laarmann et al. 2009). Forest fragmentation has imposed additional difficulties for dispersal of dead tree dependent forest organisms between remaining old-growth stands (Edman et al. 2004).

Lassauce et al. (2011) showed that the correlation between dead wood volume and species richness of saproxylic organisms was moderately significant, and that it varied only slightly between logs and snags or between decay stages.

However, there has been little consideration of the extent or role of dead tree in Caspian forests, or of the effects that management might have on it, and no such regulatory frameworks exist. The dead tree's volume varies with successional stage in the Caspian forests. Early successional forests have an average of 37 m^3 ha^{-1}; mid-successional forests have an average of 26 m^3 ha^{-1}; and late successional forests have an average of 51 m^3 ha^{-1} (Sefidi and Marvie-Mohadjer 2010). Oriental beech stands managed for timber production had the lowest volume of coarse woody debris with an average of 23 m^3 ha^{-1}(Atici et al. 2008). In the north of Iran, Amanzadeh et al. (2013) showed the total dead tree ranged from 1 to 27 m^3 ha^{-1}. In the other research on amount of coarse and fine woody debris, results showed coarse woody debris had an average volume of 15 m^3 ha^{-1} and fine woody debris had an average of 10 m^3 ha^{-1}.Within the oriental beech forest the most common form of coarse woody debris was logs and the most frequent species was Oriental beech (Sefidi et al. 2013).

To date, no comprehensive studies have dealt with the amount of dead tree in the area with different management history in the Caspian beech forests of northern Iran. Forests in the north of Iran managed based on ecological concepts and in close to the nature way, so the recognition of the importance of management of the dead tree is vital if its nature conservation objectives and obligations are to be met. Thus, the goal of this study was to quantify the extent and composition of the dead tree resource in an area of deciduous forests in Hyrcanian forests and to assess to what extent historically different intensities of management have affected this relationship and the dead tree resource.

MATERIALS AND METHODS

Study area

The study was conducted within the Kheiyroud Experimental Forest in northern Iran which is owned and managed by the University of Tehran, Iran for education, research, and conservation (Figure 1, Table1). The forest covers a total area of 8,000 ha and ranges in latitude from 36°27'N to 36°40'N and in longitude from 51°32'E to 51°43'E (Nosrati et al. 2005).

The climate is sub-Mediterranean with a mean annual temperature of 9°C and total annual precipitation of 1380 mm (Figure 2, Table1). Selected forest communities occupy plateaus or moderately inclined slopes which are dominated by moderately acidic to alkaline brown forest soils with deep, organic A-horizons, limestone bedrock, and a surface largely free of rocks (Dewan and Famouri 1961).

Forests occupy plateaus on moderately inclined slopes, largely free of rocks with limestone bedrock. Caspian forests occupy an approximate area of 2,000,000 ha being dominated by oriental beech (*Fagus orientalis* Lipsky). These forests are characterized by natural uneven aged structures with gap dynamics typical of old-growth forests (Marvie-Mohadjer 2001). Forests at middle and upper evaluations are primarily composed of beech followed by hornbeam (*C. betulus*), alder (*T. begonifoia*), and maple (*A. velutinum*) (Sagheb-Talebi et al. 2013). Beech (*F. orientalis*) is the most productive timber species in Caspian forests occupying 17.6 percent of the total land area and representing 30 percent of the standing tree volume. Beech in this area can grow taller than 40 m and exceed diameters than 1.5 m measured at breast height (Resaneh et al. 2001).

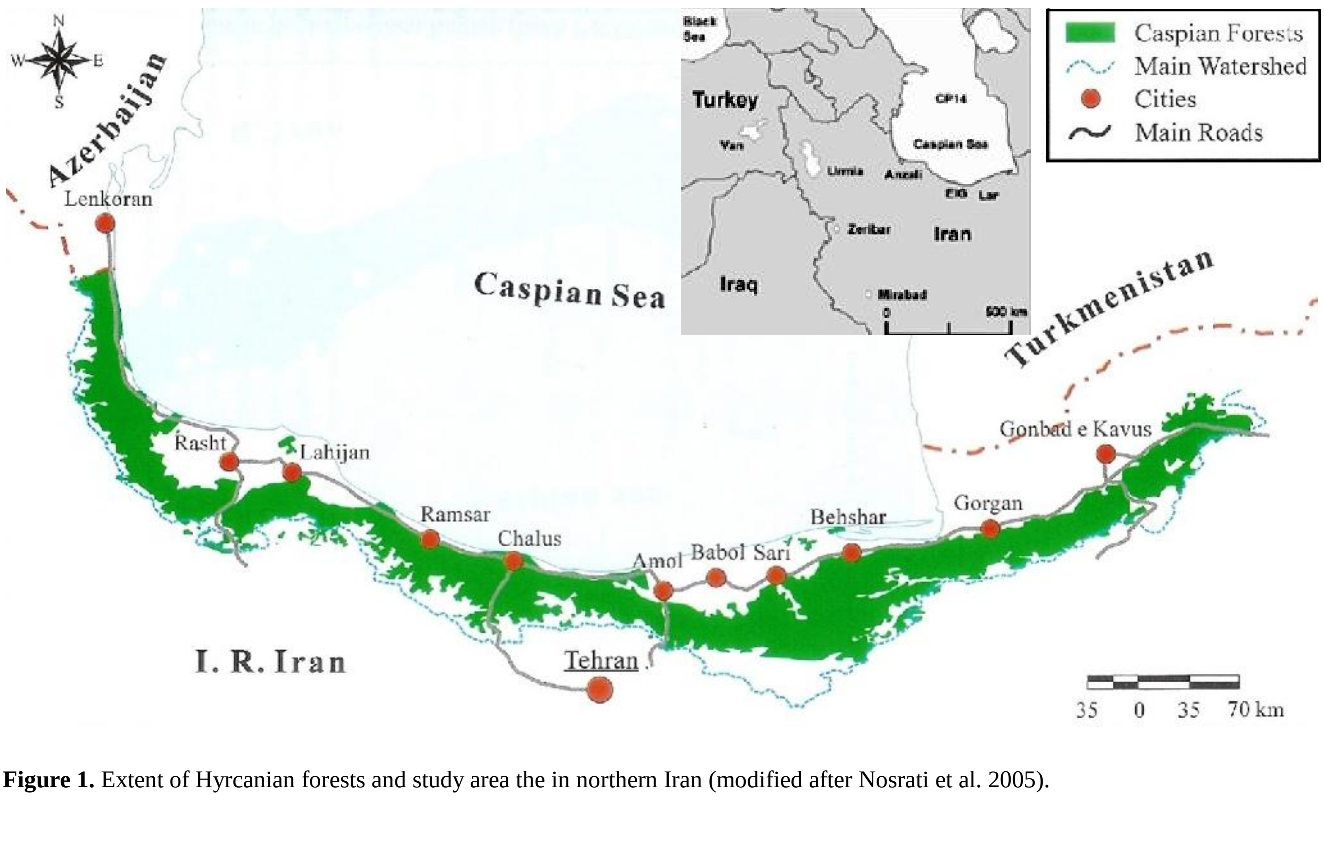

Figure 1. Extent of Hyrcanian forests and study area the in northern Iran (modified after Nosrati et al. 2005).

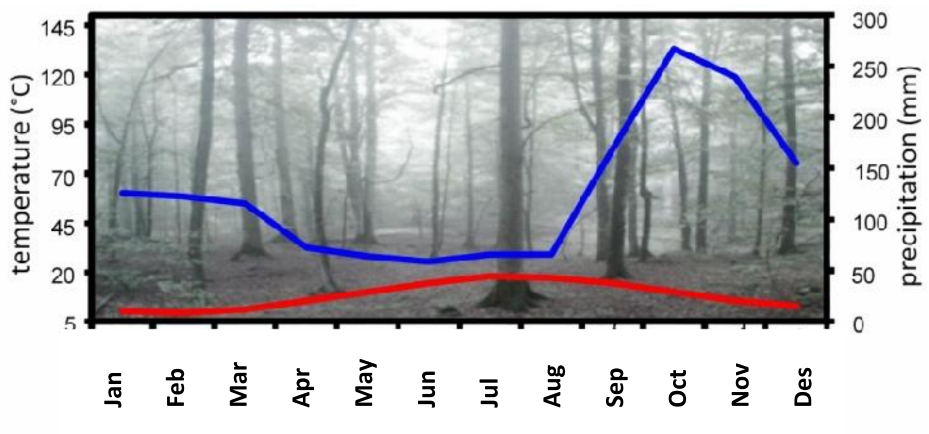

Figure 2. Climate diagram of Kheyrud Experimental Forest in Northern Iran on 1500 m a.s.l., the red curve shows the temperature development, the blue one the precipitation (modified according to the Azarian 2012).

Table 1. Description of study site indicating management history and other structural characteristics(Azarian 2012).

Study Area	Site code	Area (ha)	Associated tree species	Management history	Regeneration	Elevation(m)
Patom	PS	59	*Acer capadocicum, Carpinus betulus*	60 yr<	Natural	480-630
Namkhaneh	NS	39	*Acer velutinum, Carpinus betulus*	20 yr<	Natural	950-1110
Gorazbon	GS	75	*Acer velutinum, Carpinus betulus*	Unmanaged	Natural	850-1220

The Caspian forests of Iran are largely natural temperate broad leaved with minimal active management during the last four decades, *F. orientalis* stands in the Caspian region have been managed chiefly using shelter wood system, but now the all of beech forests managed using selection method (Sefidi et al. 2014). In this research three study sites had selected based on different management history. Patom (PS) site has long-term management period, Namkhaneh (NS) is in the intermediate state and short-term management period and Gorazob (GS) as third study sites that was unmanaged and semi virgin area without any logging operation (Table 1, Azarian 2012).

Dead tree selection and description

Dead tree comes in many forms (Sefidi et al 2013; Müller and Bartsch 2009), but above ground two tend to predominate dead trees on the forest floor (logs), and standing dead trees (snags) and these are the two on which the present study focuses. All of dead trees including: fallen logs and snags had measured within the study sites using the full callipering method. For each piece of coarse woody debris, we recorded species, total length, form (log, snag or stump), diameter at both ends, diameter at the midpoint, and decay class. Lengths and diameters were taken at the edge of the plot boundary if the log extended outside of the plot. Diameters of logs and snags were measured using calipers; however, for taller snags, top diameters were estimated visually. For snags taller than 4 m, height was measured with a clinometer. Dead trees standing at an angle of less than 45° from the vertical were classified as snags and those at a greater that 45° from the vertical were classified as logs. Decay classes were defined according to Albrecht (1990) as Class 1 (recently dead), Class 2 (bark loose with some decay in the sapwood), Class 3 (decay obvious throughout the secondary xylem) and Class 4 (woody debris mixing with soil, little structural integrity).

Most dead trees displayed a mixture of different decay stages along their total length; therefore the dominant decay stage class was used during the analysis. Diameter at breath height was measured on dead trees in the early stages of decay. In order to investigate the species composition around large dead trees, according to the Zobeiri (2008) the 0.1 ha circle plots established around dead trees having diameter larger than 50 centimeters.

Data analysis

To calculate the volume of dead trees, Newton's formula was used (Harmon and Sexton 1996) for snag and log volume:

$$V = \frac{L\,(A_b + 4A_m}{6}$$

where, V = volume in m^3, L = length, and A_b, A_m and A_t = the cross-sectional area at the base, middle, and top, respectively. The volume for stumps was calculated by:

$$V = Am \times L$$

where, V = volume in m^3, A_m = cross-sectional area at the middle of the stump, and L = length.

To determine whether the volume of CWD of different types, decay classes and size classes differed among these three forests, different management histories was considered as a fixed factor and volume of CWD was analyzed as a response variable using one-way analysis of variance (ANOVA). If there was a significant effect of different management history, the least squares mean separation with Tukey's correction was used to test for differences among sites. Normality and homogeneity of variance of the residuals were tested and data were log-transformed if the homogeneity of variance was not met. All statistical tests were considered significant at the p< 0.05 level (Zar 1999).

RESULTS AND DISCUSSION

Totally 215 individual dead trees were recorded and measured at 79 sampling locations. GS as a semi virgin forest generally contained greater volume of dead tree. The results showed that the stocking volume of alive and dead trees was 352m^3 ha^{-1}and 3.2 m^3 ha^{-1}in PS and 531m^3 ha^{-1}and 5.17 m^3 ha^{-1}in NS, respectively.

The 32% of all dead trees in PS were snag and 68% belonged to log forms. This amount in NS calculated 36 and 64 %, respectively (Figure 2). We found the same results in the GS. In this site 70% of dead tree was logs. Stocking volume also calculated 685 m^3 ha^{-1} in the GS. High amount of logs in contrast snags showed rapidly decomposing of material in these forests. Results of ANOVA indicate significantly different among three study sites. Volume of dead tree significantly higher in unmanaged forests (GS) in comparing with two other sites (F =14.25; P < 0.001).

In order to investigate the species composition around large dead trees, the dead trees with diameter higher than 50 centimeters were considered being the fixed area sampling plots (0.1 ha). The results showed beech constitute the highest amount of live trees in PS, whereas the most of dead trees in the given site was hornbeam. The same results obtained in the other sites. *F. orientalis* is the dominant tree species in the study area and showing the greatest standing volume. In the PS 57, 31.4 and 11.8 % of live trees that allocated around large dead trees were *F. orientalis, C. betulus* and other species, respectively. In the NS this amount calculated 49.5, 30 and 19.5 %, respectively (Table 2). Moreover according to the full callipering inventory of dead trees in study sites, the highest amount of dead volume recorded in the GS as un-managed sites and the lowest was in the PS with the long term of management implication.

Quality of dead trees was measured in this research. Figure four illustrates the distribution of dead trees in different decay classes. Results showed that the highest amount of dead trees in this forest belonged to decay class III with 30.7 % of all dead trees. Also more than 40% of all dead trees belonged to decaying stage III and IV. Analysis revealed the amount of dead volume in decay classes significantly differ in three study sites (Table 3).In this study the most of dead trees were in advance decay class.

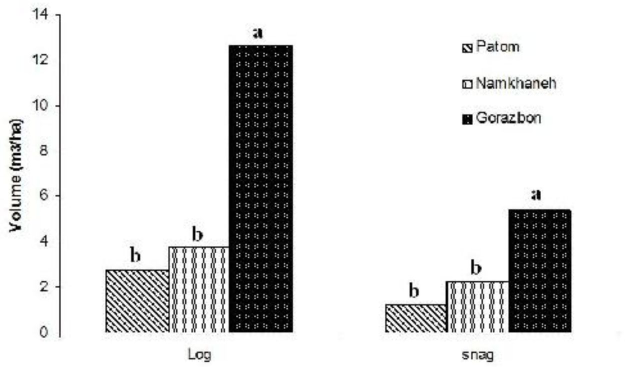

Figure 3. Dead tree volume in different study sites

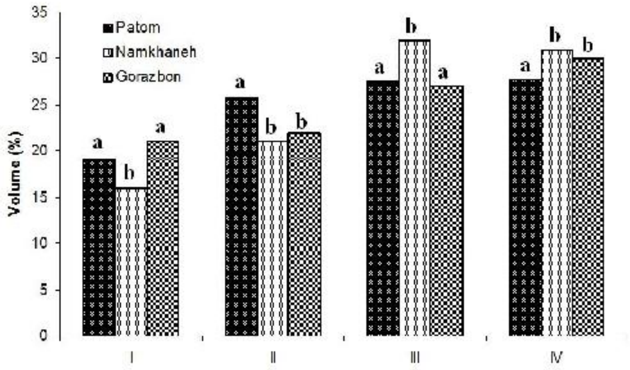

Figure 4. Distribution of dead trees in different decaying classes. Different letters used to showing the significant statistical differences.

Table 2. Total dead tree volume and living tree volume of oriental beech forests at stand level

Species tree	Live trees(m^3 ha$^{-1)}$			Dead trees(m^3 ha^{-1})		
	PS	NS	GS	PS	NS	GS
Fagus orientalis	156.3	278.4	397	0.99	2.30	15.91
Carpinus betulus	131.5	165.5	75	1.81	22.2	1.62
Parrotia persica	15.68	-	-	0.28	-	-
Other species	49.57	9.02	213	0.08	0.73	1.30
Total	352.33	531.3	685	3.16	5.1	18.85

Table 3. Results of one-way ANOVA's of different types and decay classes of CWD in three forests with different management history, deciduous broad-leaved forest of Northern Iran

characteristics of CWD		df	Volume	
			F	P
Tree species	*F. orientalis*	2	30.45	< 0.001
	C. betulus	2	28.12	< 0.011
	Other species	2	37.45	< 0.001
Types	Logs	2	37.45	< 0.001
	Snags	2	41.12	< 0.001
Decay class				
	I	2	39.95	< 0.001
	II	2	51.38	< 0.001
	III	2	13.26	< 0.001
	IV	2	62.76	< 0.001
Total			14.25	< 0.001

Note: The F-Value and P-value are presented for effect of management history.

Discussion

The range of the dead tree volume in this study was different to that reported in other studies (e.g. 16.5 m^3 ha^{-1} for dead trees in Chelir Forest; Zolfaghari 2004). Dead tree volumes were at or below the lower end of the range reported in the some studies. Harmon and Sexton (1996) reported dead volumes for tropical forests ranging from 33 to 126 m^3 ha^{-1}, with most of the higher values referring to forests recently disturbed by fire and/or hurricane.

Some other forest types such as tropical mangrove forests had dead tree volumes ranging from 35.1 to 104.2 m^3 ha^{-1} (Allen et al. 2000). Obtained amount of dead tree in Iran is lower than tropical forest. In general, the values reported for other forests tend to be slightly greater than those for temperate deciduous forest, but much less than those in temperate or boreal evergreen/coniferous forest. The main reason of low amount of dead tree in study areas can be management of this forest in the past decade. The amount of dead tree varied in different developmental stage and phases, and Sefidi and Marvie-Mohadjer (2010) showed the highest amount of dead tree in the late-successional stage. Also, genecological differences among tree species and structural differences of forest stands led to different dead tree input rates. Susceptibility to storm damage (Bruederle and Stearns 1985), successional status (Sefidi and Marvie-Mohadjer 2010; Sefidi 2012; Saniga and Shutz 2002), and susceptibility to pathogens (McCarthy et al. 2001) is different among species and stands which impact accumulation of dead volume. Our findings demonstrate amount of dead tree can be influenced also by management regimes. Patom forest (PS) is a managed forest with a long term period of management and some fresh dead trees extracting, in forestry plans in the past decades and have no chance to inter in the dead tree pool. Meanwhile nearing this site to rural community and consuming dead trees for fuel and charcoal making in the past can be one of reason for decreasing the dead tree volume in this forest. Namkhaneh Forest (NS) is younger than Patom with a short management history, for this reason the high amount of fallen tree had the opportunity for decaying in forest floor and creating dead tree. Volume of dead tree in NS was higher than the PS. In the NS forest far from rural communities and indicate a low impact of natural disturbance and short term implication of management. Studies in European managed beech forest showed that the amount of dead tree was 1-5 m^3 ha^{-1} (Christensen et al. 2005) that is similar to the results of this research in the Caspian beech forest in northern Iran. Gorazbon (GS) forests developed far from human implication and are in the natural condition. Large dead trees immediately inter to the dead trees pool after falling and have opportunity for decaying. In the late successional stage stands in the study sites Sefidi and Marvie-Mohadjer (2010) report a high amount of dead trees. Also possessing of large dead trees within stand structure is future of old growth forests.

In terms of total amounts of dead tree, there are two feasible models for responses to logging. The amount of dead tree in logged forest might reasonably be expected to be higher than in an old - growth forest if it largely comprises logging residue. Such a situation was reported for snags in the Bornean rainforest (Cannon et al. 1994). On the other hand, it might be expected to be lower than old-growth forest if the logging residue has already decayed, and there is a deficit of newly generated dead trees due to removal of some of the larger-diameter trees that would otherwise have died in situ. This is the long-term prognosis for managing forest predicted by many researchers (e.g. Meyer and Schmidt 2011), particularly if mean dead tree diameters decrease, since smaller diameter pieces would be expected to decay more rapidly than larger ones (Fasth et al. 2011). In this study, whilst old-growth forest had dead volume on average than logged forest, and the volume contributed by larger-diameter dead tree was significantly higher, there was considerable variation at the sites and plot level. Comparing amount of dead tree in three sites showed dead tree volume related with management history. Reaching their highest in virgin site and their lowest in a region with long term implication of management, it was identified that forest management cause reduction of amount of dead tree on our study region and affect the forest ability to generate dead tree specially in a large size, thus managing this forest according to ecologically sustainable principles require a commitment to maintaining stand structure that allow, continued generation of dead tree in a full range of size.

The most common form dead tree found in the Oriental beech-dominated forests of northern Iran was logs. Density (number of occurrences of a status class) is perhaps more useful to compare status of dead tree than volume because, in general logs and snags inherently have a larger volume than stumps (Sefidi et al. 2013). The high proportion of logs vs. stumps implies that stumps decompose faster than logs or that individual stems divide into multiple logs as they decompose because originally the log to stump ratio would have been 1:1; whereas the current ratio is 16:1.

The gross pattern of decay shown by dead tree across all study sites, in which most is in a late stage of decomposition, suggests that residence times in each decay class are not equal. A bell-shaped distribution would suggest a geometric increase in residence times with successive decay stages. In PS forest according to shown high amount of dead trees in high decaying class; we can state that this forest is in developed stage of succession, but in NS Forest high amount of dead trees belonged to low stage of decaying that sowed this forest is in developing stage toward late successional stages.

Figure 5. Management effect on decreasing trend of dead trees

Figure 5 illustrates the influence of management on decreasing trend of dead trees amount in three sites with historical differences. PS is an oldest forest with the long term implication of management and get a high impact of human activity and other disturbances, NS is a younger forest with the low impact of human activity and middle state, in contrast GS had located in un-managed and near virgin forest, so the highest amount of dead tree observes in this area. Increasing management period caused to falling down amount of dead volume within forests.

CONCLUSION

A tightly controlled selection silviculture system using reduced-impact logging techniques to remove just a few highly valued timbers would impinge on dead tree volumes or size-distributions to a far lower extent than more extensive and more poorly controlled systems. Nevertheless, any system whose long-term effect is to reduce the proportion of basal area contributed by larger-diameter trees, even if the aim is to maintain a “reverse J” shaped distribution of size-classes in the equilibrium state (Sefidi 2012) risks ultimately reducing overall dead tree volumes in general, and volumes in the larger size-classes in particular. Given the known dependence of many organisms on this resource in temperate forests, ample consideration should be given to the dead tree and stand structure when formulating policies, silvicultural systems and criteria and indicators for ecologically sustainable forest management.

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