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Deadwood in piles or distributed: Does it make any difference to saproxylic beetles?

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Abstract

Piles of deadwood are often retained in forests after management to support the biodiversity of saproxylic organisms which depend on deadwood to survive. Any knowledge about the crucial role of piles as suitable habitat of saproxylic organisms compared to single distributed deadwood objects that are around the piles would help conservation actors to motivate more forest owners to support saproxylic organisms during their management. Therefore to give facts to this the saproxylic fauna of different pile positions (up and low) was studied and compared to distributed deadwood samples around each pile. Our study was focused on saproxylic beetles. Some other parameters such as diameter, deadwood volume, pile volume and decay stage were assessed to define any effect. Our study was done in a small part of urban forests in Uppsala. We collected pair-wise samples: one from pile consisting of two up and low sub-samples and one from distributed deadwood. Saproxylic beetles were reared indoors in rearing boxes for three months and determined. In total we recorded 106 individuals of 55 different species. The results showed that position, diameter and deadwood volume of the samples were not affecting species density or individual density of saproxylic beetles. However pile volume was positively related with individual density. Presence of the most decayed wood was positively related with species density. According to our results we concluded pile deadwood is useful for saproxylic beetles compared to distributed deadwood and saproxylic beetles are more frequent in bigger piles with presence of the most decayed wood.

Keywords: *Saproxylic beetles, Pile, position, Deadwood, Wood living, connectivity, volume, diameter, Quality, Distributed, Scattered, Accumulated, Stage of decay, Conservation, Biodiversity, Red-listed, Forest management, Boreo-nemoral forest, Sweden.*

Sammanfattning

Död ved i högar eller utspritt: Gör det någon skillnad för vedlevande skalbaggar?

En vanlig naturvårdsåtgärd för att gynna vedlevande organismer är att lämna högar av ved. Det är oftast klena stammar och grenar som blir över vid huggningar eller som av naturliga orsaker fallit och som ligger olämpligt i en parkmiljö eller betesmark som läggs i högar. Det finns dock i stort sett inga studier som undersökt i vilken grad dessa högar utnyttjas av de organismer som man vill gynna och om den höglagda vedens fauna skiljer sig från samma typ av ved om den ligger utspridd. För att ta reda på hur vedlevande skalbaggar förekommer i högarna samlade jag in prover från 11 dödvedshögar i tätortsnära skog i södra Uppsala. Prover togs från tre 'positioner' i eller vid varje hög: ytlagret (up) och bottenlagret (down) samt från utspridd ved i närheten (20-150m från högen). Enbart lövträdsved provtogs och vedens 'diameter' och 'röststadium' samt 'högstorlek' antecknades. Proverna togs genom att fylla 38.5*26*17 cm stora papplådor med buntar av ca 35 cm långa vedbitar som sågats in från högarna tidigt i maj. För varje provkategori togs två sådana buntar, ur vilka skalbaggar kläcktes fram inomhus. Totalt kläcktes 106 vedlevande skalbaggar tillhörande 55 olika arter fram. Fyra av dem var rödlistade. 'Position' och 'diameter' kunde inte påvisas ha någon effekt på artantal eller antal individer per prov. Däremot fann jag fler individer av vedskalbaggar per prov i stora högar. Det fanns också fler arter per prov där ved i de mest rötade successionsstadierna fanns. De positiva sambanden med högstorlek och rötad ved tyder på att stora högar som legat längre innehåller fler vedskalbaggar, kanske som en effekt av att högen successivt koloniseras av nya arter. Det höga artantalet, inte minst av rödlistade arter, visar att högarna utnyttjas och har positiv naturvårdsnytta, men att vedens nytta inte verkar påverkas av om veden ligger i högar eller är utspridd.

1. Introduction

World Wild Fund indicated deadwood importance in one sentence: Loss of deadwood means loss of life (Dudley et al., 2004). There are numerous roles of deadwood in forest ecosystem, providing food and shelter for many organisms such as many insects and these important roles make deadwood so exciting to study. Saproxylic beetles have an obligate association with deadwood habitats (Grove, 2002). These organisms were named as biological engineers because they participate in the early decay process that improve the soil physic and modulate the availability of resources for other organisms (Jones et al., 1994).

For thousand years agriculture in Europe has had a considerable disturbance on landscape and biodiversity (Samways, 1993; Warren and Key, 1989). More recently different intensive forest management methods for pulp and timber industry have started to cause fundamental changes in trees structure, succession and species composition (Emanuelsson, 2009).

The prevailing regeneration method in Fennoscandia is based on clear-cutting followed by planting and seed-tree cutting. This method leads to a disruption in availability of dead trees in different stages of decay. Dead, damaged and weakened trees are usually removed from the site. Nowadays less than 10 m^3/ha is generally found in managed forests compared to much higher amounts in natural forests characterized by repeatedly events of wind felling, fires and other disturbance (Nilsson and Cory, 2011).

The lack of suitable wood substrate of different tree species and in different decay stages are two of the most important factors causing lower species richness and lack of particular specialized, rare or threatened species in mature managed forests (Siitonen, 2001). As saproxylic organisms are dependent on deadwood removing all the wood substrate has a negative effect on saproxylic organisms and their associates (Ferris-Kaan et al., 1993).

Scandinavia is one of the frontiers in forest management. Although the amount of deadwood in Swedish productive forest has increased during the last years and is estimated to be an average of 8.1m^3/ hectare it is still far below the volume required to maintain all saproxylic organisms in the forest landscape (Siitonen, 2001). 875 beetles species are red listed in Sweden (Gärdenfors, 2010) and 42 percent of the total number of red-listed beetles were saproxylic in Red-list 1993 (Jonsell et al., 1998).

Although there are some evidence that diversity of the deadwood is more important than volume of the deadwood for saproxylic species richness**,** there is still no clear answer for how and where biodiversity benefit from deadwood increase in landscape level (Lassauce et al., 2011).

Concern that intense Scandinavian forest management has resulted in negative impacts on biodiversity lead to some conservation measures taken to improve the condition for saproxylic insects (Siitonen, 2001). These methods are based on the fact that the presence of wood substrate in areas after clear cutting would benefit saproxylic organisms.

Leaving piles of deadwood consisting of waste timbers and twigs is one such type of deadwood management commonly used in nature reserves or urban areas. Although these small fallen branches and twigs have generally less value to saproxylic insects than larger deadwood items, there are still many of species which prefer this kind of substrate (Ferris et al., 1993; Jonsell, 2008).

There has been a controversial debate between people involved in forest management on the amount of dead wood that should be left in the forests to support saproxylic beetles (Jonsson et al., 2005). Questions like: How much? Which tree species? Exposure? Concentrated or spread out? To give facts to this we should have more knowledge about how deadwood in different decay stages, in piles and spread out is utilized by specific saproxylic species and what substrate properties are the most important for the insects. By having more knowledge there will be more opportunities to inform and convince forest owners about the importance of deadwood in continuity of life in forests.

Although considering the whole deadwood community including insects, fungi, lichens and mosses is essential this study only focuses on saproxylic beetles. The aim was to study if there is a difference in the number of species or number of individuals in piles including different layers compared to distributed branches and twigs around the piles. Although I did not find any study on piles and their role in supporting biodiversity there have been several studies on the crucial role of other different types of deadwood such as logs, snags, coarse or fine deadwood (Kirby, 1992; Ferris-kaan et al., 1993; Schiegg, 2000; Jonsell, 2008). In these studies connectivity and site continuity are suggested to favor saproxylic organisms (Schiegg, 2000; Martikainen et al., 2003).

Based on mentioned studies I hypothesized that the species richness is higher in piles of wood than in distributed items dispersed on forest ground. We included some environmental parameters such as sun exposure and deadwood characteristics (deadwood volume and diameter, decay stage and pile volume) that are mentioned as key factors in saproxylic organisms' survival (Siitonen, 2001; Grove, 2002; Lindhe et al., 2005; Lemperiere and Marage, 2010; Hyvärinen and Kotiaho, 2008). Many saproxylic beetles are favored by sun exposure in the condition e.g. after a disturbance like wind felling creating gaps in the forests (Lindhe et al., 2005; Nilsson, 1997). Different decay stages favor beetles which are dependent on different successional stages (Siitonen, 2001; Grove, 2002). Larger diameter in deadwood objects contains more individuals according to larger mantle areas (Lindhe et al., 2005) and total volume of deadwood is correlated with the total number of saproxylic beetles but also highly inter-correlated with other ecological parameters (Martikainen et al., 2003). We also tested pile volume to define any correlation with species density or individual density.

The objective of my study was:

1- To study if the species density or individual density of saproxylic beetles in different piles is higher than in dispersed deadwood around the piles. Another aim was also to make the same comparison between different positions (up and low) in the same pile.
2- How different parameters such as stage of decay, diameter and volume, pile volume affect saproxylic beetles' species or individual density?

2. Materials and method

2.1. Study sites and sampling

The study was carried out in a boreo-nemoral forest located south of Uppsala. The geographic positions of all sites are mentioned in Appendix A. The forests were chosen from urban areas where piles were available and satisfied the definition of pile. Compared to dominant forests in the region that are dominated by dense pine and spruce, we chose our sites in urban areas were the forests were a mix of coniferous (*Pinus* sp., *Picea* sp., or both) and deciduous trees (*Betula* sp., *Salix*, *Ulmus* sp., *Populus* sp., *Fraxinus* sp., *Quercus* sp., etc) near agricultural lands. Almost all piles were in semi-shaded areas exposed to an open area from one side and to forest on other sides (Figure 1 and 2).

Fig. 1. A pile of deadwood in a forest in Uppsala.

Fig. 2. A big pile of deadwood in a forest in Uppsala.

Fig. 3. Pair samples of deadwood from different pile positions and distributed wood around the pile.

Fig. 4. Cutting pile deadwoods into pieces to fit into rearing boxes.

To be selected as a pile the following criteria were needed to be met:

1- The wood should be between stages 2 and 5 according to Siitonen and Saaristo (2000). That means that the wood should not be so much fresh or not so decayed and falling apart. Thus the wood samples were partly decayed with fungi development on tissues but not from those twigs that it was impossible to take pieces of wood from.
2- The piles should mainly consist of wood from deciduous trees. Coniferous wood was not included.
3- Piles should be situated at least 20 meters from another selected pile.
4- The piles had at least 2-3 meters length and 1 meter height (Figure 1 and 2).

In the first week of May 2011 in total eleven piles were selected for sampling. In each pile samples from three different positions were collected. The samples were considered as triplets. Samples from the pile were named 'up' and 'low'. Up sample was deadwood which we collected mostly from upper part of the piles specially exposed parts. Low sample was deadwood collected from inner part of the pile close to the ground. The third sample was from distributed woods around each pile (Figure 3 and 4).

To consider the distributed deadwood as independent samples the distance between scattered dead wood and each pile should be at least 20 meters. The maximum distance of distributed sample from a pile was set to 100-150 meters (Schiegg, 2000). Each pair (pile–distributed) had the same sunny or shady conditions and enough amount of deadwood to fill two rearing boxes of size 38.5*26*17 cm^3.

2.2. Data collection

For each sample I measured: decay stage (2-5), pile length and height (m), diameter (range of 2-7 (-10)cm), deadwood (=sample) volume, tree species of deadwood (*Betula* sp., *Salix*, *Ulmus* sp., *Populus* sp., *Fraxinus* sp., *Quercus* sp., *Sorbus* sp., *Prunus* sp., etc), sun exposure (shaded, semi-shaded and exposed), fungi (presence/ absence), a brief site description and coordinates (RT90 from a GPS) of each sample. Collected data is presented in Appendix A.

The decay stages of samples were based on Siitonen and Saaristo (2000). In this system, different stages of decay are defined as six different values considering how soft the wood is by testing with a sharp knife. Stage one indicates fresh one year old wood and stage 6 is used for dead wood which is mostly decomposed. As some of the samples of deadwood were in late stage of decay it was difficult to identify the tree species. In such cases the wood was just noted as a deciduous (Appendix A). Pile volume was calculated by considering all piles as rectangular to calculate their volume in cubic meter. Thus pile length and height were written down for later calculation. We determined tree species by looking at the bark and year rings. Sun exposure was categorized as shaded, semi-shaded or exposed. Almost all piles included in the study had semi-shaded (partially exposed) condition. In our study

Fig. 5. A rearing box containing of deadwood samples with a glass tube to attract the beetles to the light.

Fig. 6. The room in which rearing boxes were kept.

fungi was considered to be present in all samples due to the definition of pile (see criteria number 1 in study site and sampling section). Thus we did not include this presence/absence data in later analysis. I wrote a brief site description of surrounding tree species and any specific characteristic which made the site different from another. The coordinates of each pile were collected by using GPS. The diameter of twigs was measured before placing them in rearing boxes.

To calculate deadwood (sample) volume variable we multiplied the average diameter of deadwood in each rearing box by numbers of twigs in each box and then multiplied the achieved number by the length of rearing box which was 38.5 cm. Some data was discarded from the analysis due to difficulties in tree species determination and similarity in sun exposure. Fungi data was neither included.

2.3. Rearing

Each sample of wood was placed in two rearing boxes (Figure 5). Thus for each pile we had 6 boxes: two for up, two for low and two for distributed deadwood. In some piles, because of the size and conditions of decay stage, there was not enough sample wood to fill both boxes. In such cases we considered two boxes in our analysis even if one of them was not fully filled or was almost empty. To compensate this fact Deadwood (sample) volume was included in statistical analysis to minimize effects of differences between samples. A glass tube was inserted in each box to let the beetles pass through it to the light (Figure 5). After the rearing boxes were filled by samples, all boxes were kept in a room with constant humidity and a temperature of approximately 23-24 °C (Figure 6).

After three weeks the beetles started to emerge. The boxes were checked weekly to collect emerging insects. After almost one month the number of notifications started to decrease. I opened the boxes and shook all the deadwood on a white plain surface and collected remaining insects. The samples were then put back in rearing boxes to speed up the rearing process. The boxes were moved to a green house in which the temperature was higher than the first rearing room. After two months and a half the number of beetle emergence was zero and the rearing was stopped. All beetles were determined to species level using morphological characters. The species names are based on the Swedish catalogue (Lundberg and Gustafsson, 1995). Red-listed species were noted (Gärdenfors, 2010).

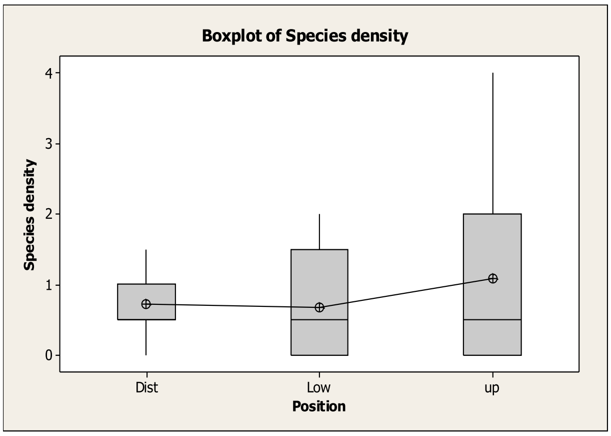

Fig. 7. Average number of species found in deadwood objects in piles and distributed.

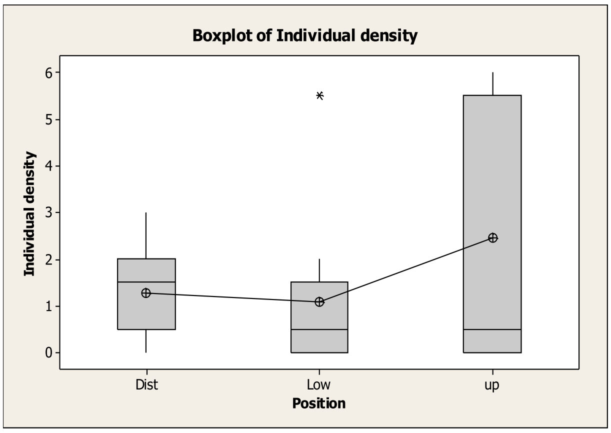

Fig. 8. Average number of individuals found in deadwood objects in piles and distributed.

2.4. Statistics

I calculated statistical probabilities for relationships between the response variables species density or individual density and position, the four decay stages, pile volume, deadwood volume (per sample) and diameter of deadwood (per sample) in Minitab version 16.

One-way ANOVA and General Linear Model were used for testing. Variables were chosen by forward selection (a step by step method) for different variables to see which variable could explain best the correlations with responses. First each response was tested with single variable (Table 1 and 3). Secondly we selected tests with two or more variables to see which shows significant relationship (Table 2 and 4). We used α– level of 0.05 as significance level in all models. At the end, all variables that had an explanatory power by themselves or combined with each other were determined. JMP was used to systematically define coefficients. We only retested variables with explanatory power to check Minitab results in JMP (Table 1- 4).The JMP results in Table 2 and 4 were the only designed models in which at least one parameter had the explanatory power to explain a relationship with species density or individual density.

3. Results

3.1. Description of the total material

In total 106 individuals of saproxylic beetles were reared, of which 54 were from upper and 24 from lower parts of the piles and 28 individuals from distributed deadwood objects (Appendix B). 32 species were collected from the samples.14 species in upper parts, 12 in lower and 14 in distributed deadwood around the piles. In piles *Latridius minutus* (Latridiidae) was the most numerous whereas *Leptura quadrifasciata* (Cerambycidae) was the most frequent one in distributed deadwood objects. Four red listed species were found. Three species in the category Near-Threatened (NT) species, *Obrium cantharinum* (Cerambycidae), *Microhagus lepidus* (Eucnemidae), *Magdalis armigera* (Curculionidae) and one vulnerable (VU): *Xyletinus ater* (Anobidae). All species are listed in Appendix B.

3.2. Position

The number of species in different positions was not so different from each other. No correlation was found between species density or individual density and different pile positions (up, low or distributed) (Figure 7 and 8).

3.3. Other parameters

When other parameters were tested individually decay stage 5 was the factor which had a significant relationship with species density (Table 1). In tests with two or more variables in which decay stage 5 was included results showed that this factor was able to explain the correlation and the correlation was positive (Figure 9-Table 2). In some tests of species density decay stage 2 showed a significant difference when it was tested with stage 5 (Table 2).

Table 1. JMP results, estimating the effects of species density on each parameter univariately.

Source of variation	Coef.	*P*	Source of variation	Coef.	*P*
Position (Dist)*	-0.106061	0.6386	Decay stage 5	0.663793	0.0038
Position (low)*	-0.151515	0.5030			
Decay stage 2	-0.275	0.3197	Pile volume	0.0123399	0.0771
Decay stage 3	0.260776	0.2834	Diameter	0.2889373	0.0566
Decay stage 4	0.202206	0.2010	Deadwood vol.	0.0006043	0.2914

Abbreviations of Table 1:
Coef., Coefficient; ***P**,* P-value; Deadwood vol., Deadwood volume.
*: In tests with position as parameter, up was the reference.

Table 2. JMP results, estimating the effects of species density on parameters combined in models by forward selection.

Source of variation	Coef.	*P*	Source of variation	Coef.	*P*
Decay stage 2	1.333333	0.0022	Deadwood vol.	0.0007897	0.1180
Decay stage 5	1.663793	0.0001	Decay stage 5	0.701419	0.0021
Decay stage 5	0.680556	0.0046	Deadwood vol.	0.000753	0.0845
Position (Dist)*	0.0589226	0.7755	Decay stage 2	1.315819	0.0019
Position (Low)*	-0.234007	0.2499	Decay stage 5	1.686536	0.0001
Diameter	0.1684774	0.2004			
Decay stage 2	1.375453	0.0016	Diameter	0.132097	0.3855
Decay stage 5	1.581733	0.0001	Decay stage 5	0.574685	0.0210

Abbreviations of Table 2:
Coef., Coefficient; ***P**,* P-value; Dist, Distributed wood; Deadwood vol., Deadwood volume.
*: In tests with position as parameter, up was the reference.

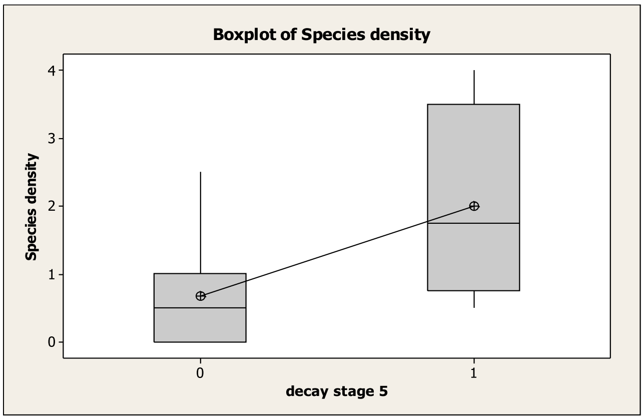

Fig. 9. Species density in piles with or without stage decay 5 (Table 1).

Pile volume had significant relationship with individual density and the correlation was positive (Table 3). Also in tests with multiple variables pile volume was the important variable explaining the correlation best (Table 4). In a multiple variable test with the presence of deadwood volume and decay 2 and absence of pile volume, when decay stage 5 was combined it became the important factor (Table 4). In two tests decay stage 2 had the explanatory power, too (Table 4).

Table 3. JMP results, estimating the effects of individual density on each parameter univariately.

Source of variation	Coef.	*P*	Source of variation	Coef.	*P*
Position (Dist)*	-0.333333	0.4786	Decay stage 5	0.4375	0.4033
Position (low)*	-0.515152	0.2763			
Decay stage 2	0.15	0.8017	Pile volume	0.0400232	0.0053
Decay stage 3	0.700431	0.1769	Diameter	0.466485	0.1568
Decay stage 4	0.011949	0.9723	Deadwood vol.	0.0012452	0.3111

Abbreviations of Table 3:
Coef., Coefficient; ***P***, P-value; Deadwood vol., Deadwood volume.
In test with pile volume as a parameter the distributed deadwood data was excluded.
*: In tests with position as parameter, up was the reference.

Table 4. JMP results, estimating the effects of individual density on parameters combined in models by forward selection.

Source of variation	Coef.	*P*	Source of variation	Coef.	*P*
Pile Volume	0.0400232	0.0039	Pile volume	0.0406172	0.0059
Position (low) *	- 0.681818	0.0949	Decay stage 4	-0.1939337	0.6492
Decay stage 2	2.083333	0.0611	Pile volume	0.0433074	0.0048
Decay stage 5	2.0	0.0423	Decay stage 5	-0.3417052	0.5472
			Position (low) *	- 0.681818	0.1010
Pile volume	0.0433074	0.0065			
Decay stage 5	- 0.3417052	0.5663	Diameter	0.4837031	0.1701
			Decay stage 2	2.204259	0.0460
Pile volume	0.0572661	0.0003	Decay stage 5	1.764403	0.0715
Decay stage 2	1.591098	0.0162			
			Deadwood vol.	0.001321	0.2669
Pile volume	0.0374664	0.0150	Decay stage 2	2.052607	0.0640
Decay stage 3	0.289048	0.6231	Decay stage 5	2.039898	0.0382

Abbreviations of Table 4:
Coef., Coefficient; ***P***, P-value; Deadwood vol., Deadwood volume.
*: In tests with position as parameter, up was the reference.
In tests with pile volume as a parameter the distributed deadwood data was excluded.

3.4. Summary results of the models

As a conclusion of all performed tests (Table 1- 4) the results are summarized as:
- Position was not important in species density or individual density.
- The presence of decay stage 5 had a strong influence on the number of species.
- Pile volume strongly influenced the number of individuals found.
- In some tests of individual density in the absence of pile volume, decay stage 5 was able to explain the correlation. Thus decay stage 5 was an important factor in both species density and individual density.
- In tests of individual density Decay stage 2 explained when it was added to pile volume or combined with decay 5 and diameter.
- Diameter or deadwood volume was not important in numbers of species or number of individuals.

4. Discussion

As a conclusion piles serve as suitable habitats for many saproxylic beetles by providing more diverse conditions compared to distributed wood. As expected this study showed that larger piles produce more individuals per object. Larger piles contain more individuals compared to smaller piles probably via providing larger suitable habitats with more continuity and less risks of extinction (Grove, 2002).

There was no difference of number of species or individuals between different positions. Pile would probably function as a more stable microclimate than disperse wood (Palm, 1959). Distributed wood decay faster than a pile wood because a dispersed wood piece is more prone to sun exposure or other environmental conditions and the wood objects connecting directly to the ground will dry out more rapidly compared to the wood within a pile (Sverdrup-Thygeson, 2002). Also there is a risk that beetles will encounter a continuity gap later in the areas if the distribution of deadwood objects are more scattered (Grove, 2002). This fact may push saproxylic beetles to search for more available bunch of deadwood such as piles rather than distributed wood. A fraction of some Near-Threatened (NT) species in our study showed that pile could be used as a habitat for saproxylic beetles and foremost the ones that are or would be in danger in future. An example is *Obrium cantharinum,* dependent on dead aspen wood may have disappeared from its few earlier localities in the west of Sweden. It has been predicted that this species will increase its abundance in south-eastern Sweden during the second half of the 20th century (Lindhe et al., 2010).This trend may probably be because of an increase of aspen and consequently dead aspen in the landscape due to re-growth in abandoned agricultural lands. The beetles in this situation still needs more care and support. To preserve saproxylic beetles and other related organisms, deadwood management would be of great importance. Leaving non-commercial deadwood designed as a pile after intensive management in forests has been suggested as a method to provide breeding habitat for some of saproxylic beetles (Kaila, 1997).

The results indicated that wood material in a more decayed stage influenced positively the density of saproxylic beetles species density (Table 1, 2 and 4). Some piles contained all decay stages and this diverse range of different dead wood in different decay stages favoured different beetles associated with different successional stages (Siitonen, 2001). The presence of other organisms such as different fungi and other invertebrates on which the saproxylic beetles depend is more frequent (Grove, 2002; Martikainen et al., 2003). As it was mentioned in some research, that dead wood with decay stage 5 is more colonized by species with limited dispersal capacity (Lemperiere and Marage, 2010), there is a higher probability that a pile consisting of different decay stages may favour a higher range of species. That means even the beetles with less dispersal capacity would be able to move from one decayed wood object to another without flight.

It would be wise to include the concept of adding piles of deadwood with more tree species to support these tiny creatures' life. It is also important not to destroy and remove piles during later operations and to add more wood to piles after cuttings in the site (Davies et al., 2008) as continuity of the site is a key factor in saproxylic organisms survival(Martikainen et al, 2003).

More actions should be done to inform forest owners to consider the saproxylic beetles as a part of the nature puzzle not a threat to public safety and to motivate them to leave more deadwood objects in the forests.

5. Future scopes

Many previous studies include similar variables as this one. Although we knew that saproxylic beetles have interactions with specific fungi (Jonsell et al., 2005; Lawrence, 1989; Reibnitz, 1999) and wood fungi are important food for many beetles (Palm, 1959) we skipped the correlation analysis because of time limitation and the complication of interactions. These interactions would be interesting for future studies.

Another factors influencing the beetles´ life cycle are history of the site and human intervention with a huge impact on population and distribution of different organisms such as saproxylic beetles which we were not able to follow as parameter (Warren and Key, 1989). The spatial pattern of the forests is also of importance. More knowledge about dispersal capacity and substrate demands in different species is necessary to better explain observation in this study (Forsse and Solbrek, 1985; Ranius, 2000).

Different aspects of wood quality such as tree species and decay stage are also of great importance in correlation with saproxylic beetles (Warren and Key, 1989). Late decay stages of samples made it almost impossible to use the data of different tree species in analysis. In our study we did not include tree species as a variable because there is a general pattern that with more advanced decay, saproxylic species are less dependent on specific tree species (Warren and Key, 1989) but the kind of decay. In future studies of piles with primary decay stages, new tree species determination methods such as biologically meaningful classifications would help to get more accurate data (Davies et al., 2008).

Because most beetles are dynamic in distribution (Jonsson et al., 2005) this general result will need further long term experimental studies in larger scales for assessing well the different parameters on landscape scale. After a while by designing long term regular experiments we will be able to build up a database which will help us to design modeling and provide more suitable piles with specific structures and characteristics. This long term studies will facilitate saproxylic beetles succession toward providing these organisms with the conditions to which they have become adapted over million years (Davies et al., 2008; Nilsson, 1997). As this study was done in a small part of Uppsala and most deadwood studies have been done in temperate and boreal forests more research is needed in for instance tropical forests or other regions.

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Appendix A. Summary table presenting some variables of the eleven studied samples

No	**position**	**GPS**	**Pile vol.(m^3)**	**Present tree species**	**Present decay stages**
1	pile	X.6636320 Y.1603779	81	Decid.,*Betu.,Ulmu.,Sorbu.,Sali.,Fraxi.*	3,4,5
	Dist.	X.6636352 Y.1603720	-	Decid.,*Sorbu.,Sali.,Fraxi.*	2,3
2	pile	X.6634457 Y.1603123	72	Decid.,*Betu.*	2,3,4,5
	Dist.	X.6634436 Y.1603043	-	Decid.,*Betu.,Ulmu.,Sorbu*	2,3,4
3	pile	X.6635777 Y.1602823	24	Decid.,*Betu.,Sorbu.,Sali.*	2,3,4,5
	Dist.	X.6635852 Y.1602828	-	Desid., *Betu.,Sali.,Popul.*	2,3,4
4	pile	X.6635844 Y.1602831	11.2	Desid., *Betu.,Sali.,Popu.*	2,3
	Dist.	X.6635675 Y.1602846	-	*Betu,.Sali.,Popu.*	2,3
5	pile	X.6635687 Y.1601196	12.6	*Betu.*	2,3
	Dist.	X.6635756 Y.1601134	-	Desid.*, Betu., Popu.*	2,3
6	pile	X.6636177 Y.1602608	4.5	Decid.*,Betu.,Sali.,Fraxi., Popu.*	2,3,4
	Dist.	X.6636156 Y.1602528	-	*Betu.*	2,3,4
7	pile	X.6636989 Y.1602327	63	Decid.*,Betu.,Fraxi., Popu.*	2,3
	Dist.	X.6636851 Y.1602401	-	Decid.*,Betu.,Sorbu.,Sali.,Popu.*	2,3
8	pile	X.6636861 Y.1602317	8	*Betu.,Sorbu.,Sali.,Fraxi.*	2
	Dist.	X.6636942 Y.1602255	-	*Betu.,Fraxi.,Prun.*	2,3,4
9	pile	X.6635889 Y.1603795	24	Decid.*,Betu.,Sorbu.,Sali.,Prun.*	2,3,4
	Dist.	X.6636026 Y.1603763	-	Decid.*,Betu.,Sali.,Popu.,Prun.*	2,3,4
10	pile	X.6637130 Y.1599346	96	Decid.*,Betu.,Sorbu.,Sali.,Prun.*	2,3
	Dist.	X.6637100 Y.1599358	-	Decid.*,Betu.,Sali.*	2,3,4
11	pile	X.6633405 Y.1601301	18	Decid.,*Ulmu.,Popu.*	2
	Dist.	X.6634173 Y.1601295	-	*Ulmu.,Popu.*	2,3,4

Abbreviations:

Dist.= Distributed; Pile vol.= Pile volume; *Betu.= Betula; Ulmu.= Ulmus; Sorbu.= Sorbus; Sali.= Salix; Fraxi.= Fraxinus; Popu.= Populus; Prun.= Prunus.*

The term pile in position column includes both up and low position.

Appendix B. Number of individuals of different species of saproxylic beetles found in different pile positions and distributed deadwoods
NT, a Near-Threatened species; VU, a vulnerable species

Species (red list category)	Family	Position Up	Low	Dist.	Total
Acrulia inflata	Staphilinidae	-	2	-	2
Anaspis thoracica	Scraptiidae	1	1	-	2
Anobium rufipes	Anobiidae	-	-	1	1
Chrysanthia nigricornis	Oedemeridae	-	-	1	1
Cis boleti	Ciidae	6	-	-	6
Cis alter	Ciidae	-	1	-	1
Clytus arietis	Cerambycidae	-	1	-	1
Dadobia immersa	Staphylinidae	1	-	-	1
Dasytes cyaneus	Melyridae	-	-	2	2
Dasytes plumbeus	Melyridae	1	-	-	1
Denticollis linearis	Elateridae	3	1	2	6
Dinaraea angustula	Staphilinidae	-	1	2	3
Microhagus pygmaeus	Eucnemidae	-	-	1	1
Microhagus lepidus (NT)	Eucnemidae	3	-	-	3
Latridius minutus	Latridiidae	20	12	2	34
Leptura quadrifasciata	Cerambycidae	-	-	7	7
Leptusa fumida	Staphylinidae	-	-	1	1
Magdalis armigera (NT)	Curculionidae	-	-	2	2
Mordella holomeleana	Mordellidae	1	-	-	1
Mordellochroa abdominalis	Moredellidae	-	1	-	1
Obrium cantharinum (NT)	Cerambycidae	-	1	-	1
Orthocis alni	Ciidae	1	-	-	1
Platycerus caraboides	Lucanidae	-	-	2	2
Platystomus albinus	Anthribidae	4	-	1	5
Pogonocherus hispidus	Cerambycidae	-	1	-	1
Ptilinus fuscus	Anobidae	-	-	3	3
Saperda scalaris	Cerambycidae	1	-	-	1
Schizotus pectinocornis	Pyrochoridae	3	1	-	4
Staphylinidae*	Staphylinidae*	1	-	-	1
Synchita humeralis	Colydiidae	-	1	-	1
Tomoxia bucephala	Mordellidae	8	-	-	8
Xyletinus ater (VU)	Anobidae	-	-	1	1
Grand Total	**-**	**54**	**24**	**28**	**106**

Abbreviation:
Dist, Distributed.
*: This beetle was only identified to family not to species because of some damages which made the determination impossible based on morphological characteristics.