Restoration of nemoboreal deciduous forests - how could we optimise food availability for white backed wood pecker?

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Abstract

Introduction

Scandinavian forestry has for a long time intensively used the wood for timber and pulp and strongly favored coniferous tree species on the cost of deciduous. This has resulted in forests with low amounts of dead trees and especially low amount of dead deciduous trees, which has resulted in that many species associated with this habitat has declined (Berg et al. 1994). A flagship species among those is the white backed wood pecker (*Dendrocopus leucotos* (Bechstein, 1802)), which in the beginning of the 1900's used to be wide-spread all over Scandinavia, but now is extinct from most of that area (Mild and Stighäll 2005). Several actions are made to improve the status of the forest for those threatened species, and this study focuses on stands that have been restored for the white backed woodpecker.

Dead deciduous trees is the key element for white backed wood pecker as it depend on those for foraging (Stighäll et al. 2011). The food is mainly saproxylic (=wood living) insect larvae which it excavates in deciduous wood (Aulén 1986; Aulén 1991). Also in mixed stands it strongly prefers to forage on the deciduous trees even though coniferous trees are abundant in the same stand (Stenberg and Hogstad 2004). As the wood pecker requires high amounts of dead deciduous wood in its´ habitat, many other threatened species with similar habitat requirements thrive in the same areas (Martikainen et al. 1998; Roberge et al. 2008).

To improve the conditions for white backed wood pecker and associated species, forest stands are actively being restored (Figure 1). Stands with a mixture of spruce and deciduous tree species are usually chosen and the spruces are thinned to get a stand dominated by deciduous trees. In some restorations individual trees are also actively killed, by felling, by girdling or by cutting it as a high stump, in order to provide dead wood within a short time. Such artificially killed trees are used by many saproxylic insects (Aulén 1991; Lindhe and Lindelöw 2004), although the species composition between stumps (beta diversity) is more homogenous than for naturally died stumps (Jonsell et al. 2004).

The supply of food is regarded a limiting factor for the white backed woodpecker (Stighäll 2015). A key factor for the restorations to be successful is hence that the amount of food for the wood-pecker is increased. The food, i.e. saproxylic insect species, discriminate strongly between different types of dead wood, and factors as sun-exposure, tree species and diameter are important (Jonsell et al. 1998; Köhler 2000; Stokland et al. 2012), and all three factors can be affected by how trees are selected at cuttings. By definition a cutting will open up the stand and Bell et al (2015) reported that more saproxylic beetles were found in window traps in restored stands than in unrestored stands. It is also often assumed that more opened conditions favor the density of prey for the wood pecker (e.g. Stighäll 2015). Oak and birch are among the most species rich tree species in Scandinavia (Palm 1959; Jonsell et al. 1998) and aspen is usually regarded as an important key element for biodiversity in the boreal forest (Esseen et al. 1997; Niemelä 1997). Age of the trees, which is strongly correlated with diameter, is sometimes also suggested as important to the wood pecker (Andersson and Hamilton 1972). However, in analyses of landscape characteristics in an area where white backed wood peckers occur, stand age ≥ 60 years did not fall out as a significantly explaining variable (Stighäll et al. 2011). Still, in even aged stands, rather small amounts of dead wood are produced before approximately 50-70 years as the selfthinning process has not started (Ekbom et al. 2006). The restoration cuttings are designed after such general knowledge on how saproxylic species respond to the environment, but the actual effect on prey density in the wood has not been evaluated.

Our aim with this study was therefore to do such an evaluation, and in a field inventory we analysed which tree and stand variables are important to produce high densities of saproxylic insects. We analysed density of insect galleries with regard to variables on tree scale and on stand scale and hypothesized that:
- Trees standing more openly should produce more food for white-backed wood-pecker than shaded trees. However, our study could not find support for that.
- Aspen, birch and oak provide high density of wood pecker food. This was true especially for birch.
- Increasing diameter and stand age are positive for the density of prey species for the white backed wood pecker. This was supported by our results.
- Artificially killed trees produce as high density of prey as naturally died trees. This was not supported for young trees.

Material and methods
The study was made in Sweden in the province of Uppland in the boreonemoral zone (Ahti et al. 1968). In this area we selected 13 sites which are defined as good habitat for the white backed woodpecker (Fig. 1). Those areas are defined …. Beskrivning av hur de områdena definierats

Nine of the sites were restored (REFERENS), which means that most of the coniferous trees are removed in a thinning, leaving deciduous trees in the stand. In some of the stands a share of the deciduous trees were also felled, most often retained in the stand in order to provide more dead-wood habitat, and in order to promote the diameter growth of the remaining stand. There are also stands where some trees were girdled or cut as high stumps to increase the dead wood supply in the short term. The restored sites varied in age and tree species composition. Four of the sites were not restored, thereby having a considerable share of coniferous trees (mainly spruce) among the deciduous. The age was given in the land owners´ stand data for some of the stands and was estimated ocularly from stand characteristics for the other stands, in classes of young (40 yrs), middle (70 yrs) and old (100 yrs). Tree species composition was given by our own inventory (described below).

On each site we defined a 10 m wide transect chosen so that the length of it was maximised according to the geometry of the stand. In the transects all deciduous dead trees were measured and all insect galleries on them were surveyed. The transects were walked for one working day, meaning that length was somewhat different at different sites and much related to the density of dead wood, as the more dead wood the slower was the speed along the transect.

For each dead wood object we noted seven variables that were used in the analyses (Table 2) and also length, which was used to estimate the mantle area of bark on each trunk. Tree species were assigned to seven categories: the species aspen (*Populus tremuloides*), oak (*Quercus robur*), rowan (*Sorbus aucuparia*), the pooled species within a genus (Alder: *Alnus incana* and *glutinosa*., Birch: *Betula pubescens* and *pendula* and *Salix* spp. (most often *caprea*) and ”Other southern deciduous” which was the pooled southern deciduous tree species with few observations (Ash *Fraxinus excelsior*, Lime *Tilia cordata*, Hazel *Corylus avellana*, Maple *Acer platanoides*). Death mode was categorized as Naturally dead or Artificially dead. The latter category consisted of felled, girdled trees and cut high stumps. Sun exposure was ocularly estimated as Open, Half-open or Shaded with a main focus on the east, west and southern directions where from where warming sunshine comes. Proportion of bark remaining in the trunk was ocularly estimated in 10% classes. Diameter was measured at breast height for standing trees, and as middle diameter for laying. Decay stage was defined after the scale of Siitonen & Saaristo (2000), where stage 1 = wood hard, phloem still fresh or currently used by primary scolytids, at most 1 year old; stage 2 = wood hard, but more than 1 year old; in stage 3 to 5 a knife can be pushed into the trunk to different depths: in stage 3: 0.5-2 cm; in stage 4: 2-4 cm and stage 5 ≥5 cm. Length were measured for laying trunks and ocularly estimated for standing trees.

All visible insect galleries were noted and identified to species or higher taxa after Ehnström and Axelsson (2002) added with our own experience. The number of rearing holes and/or larval galleries was noted for each taxa, except for bark beetles where the number of gallery systems were counted for species ≥ 3 mm. The insect species were categorised into 18 groups defined after size and feeding mode of the larvae (Table 3). This was both due to that the wood-pecker probably not discriminate much between species as long as they are of similar size and feed in the same part of the wood and successional stage of wood. Similarly it is not always easy for researchers to discriminate and therefore determinations of some species are approximate into those categories. The categories were defined after three properties of the wood-pecker prey: size of (fullgrown) larvae, part of wood (cambium, interior of wood, polypore fruiting bodies) and decay stage (living trees/fresh wood/rotten wood. Bark beetles categorised after size and ambrosia beetles were their own categories, as well as three species with distinct feeding mode: Wood wasps, *Hylocoetes dermestoides* and *Scardia boletella*.

Analyses

Density of insect galleries in the wood was estimated according to mantle area of bark. We chose mantle area as measure of substrate amount (ín favor of volume) as most of the insects in early succession (bark beetles and many cerambycids) have their development in the cambium (Ehnström and Axelsson 2002). Mantle area was calculated by assuming trees have the shape of a cone, giving the mantle area = diameter * height / 2. The height of the trees was estimated from the breast height diameter by a function for the 20 % tallest trees in each cm-class giving the function Height = -2,717376 + 4,3541656 * Sqrt(Diameter) (Rsquare=0.74). For broken (snapped) trees the upper, lost, part of the cone was subtracted. For pieces of logs the mantle area was estimated as a cylinder based on length of the trunk and middle diameter.

The total biomass of insects that had reared out from a trunk was estimated by a function of Rogers et al. (1976), that relate length of insects (listed in Table 3) to their dry weight.

The density of beetles and the biomass of insects were analyzed with mixed models assuming normal distribution and identity link. The fixed factors were the variables measured in the field (Table 2) and Site was random factor. The variables that explained a significant ($p<0.05$) amount of the variation was defined by both forward and backward stepwise regression. In forward regression the most explanatory variable (as measured by its' p-value) was added until none of the remaining variables could add any significant explanation, and vice versa for the backward elimination. The analyses were made with the software JMP Pro 16.0.0 for Mac.

Whether the total density of insect galleries per stand could be explained by stand variables (Restoration, Stand age and proportion of tree species) was tested in a Standard least square model (assuming normal distribution and identity link). Which variables that could explain significant amount of the variation was tested in Forward and Backward section procedure as explained for the tree-wise models above. However, the variables describing proportion of various tree species were only included one at the time since they are strongly correlated with each other. The software JMP Pro 16.0.0 for Mac was used.

Results

On each of the 13 sites 17 to 78 dead deciduous trees were surveyed, making up a total sum of 522 trees for all sites. Birch was the most frequent tree species with 276 measured trunks, followed by aspen (106), willow (46) and oak (35). More trees were laying (330) than standing (192). On 10 of the sites a total of 162 trees were killed, thus also in one of the not restored sites. Most of the artificially killed trees were laying, i.e. just felled and retained (126), while 36 were standing either as girdled trunks (15) or high stumps (21).

The most common category of wood feeding larvae was ”Larvae large in cambium” which occurred in 214 trunks. On 130 trunks we did not find any trace of wood feeding insects. On one trunk there were galleries of six different categories.

The density of larvae per mantle area bark was related to Tree species, Diameter and Position (Table 4a). Birch and Alder had higher density of insects than Aspen. The diameter was positively related to density and Standing trees had higher density than Laying.

The interaction Death mode * Diameter was significant (Table 4b), as low diameter trees of artificially created trunks had less dense insects galleries than naturally dead trees (Fig. 3a). Similarly, the interaction Position * Death mode was significant (Fig 3b), whereas Position * Diameter was not significant. This shows that the laying artificially killed trees of low diameter was sparsely colonized compared to other types of trees. For standing trees we could not find any difference between artificially and naturally dead trees.

The biomass of larvae was also explained by Tree species and Diameter, but here Death mode entered as a third variable (Table 4d). Almost the same tree species affected biomass significantly, except for that Other Southern deciduous was associated with lower biomass. Diameter was a positive factor and naturally created wood had higher biomass than artificially created.

Also in models where only naturally created wood was analysed the diameter was still a positive factor both for total larval density and total biomass.

Models of the stand characteristics (Restoration, Stand age and proportion of different tree species) could in most cases not explain any significantly explain the variation in gallery density or total produced biomass. However, in one model with Proportion of oak and Age both variables were significant (Table 5a). The youngest stands had low densities of insect larvae, whereas the intermediately old stands in most cases had higher density, but the oldest stand had a very large variation in density (Fig. 2).

When gallery density was analysed only for the artificially created wood a model with Stand age as a positive factor and Proportion of aspen as a negative factor was significant (Table 5b).

Discussion

Tree species (birch and alder) and coarse diameter were the two most important variables in this study and they were positively related to densities of saproxylic insects. Standing trunks and naturally died trunks were also positive factors for the densities of insects in some of the models. On stand level the age of the stand was positively related to gallery density, especially when only the artificially created wood was considered.

Low density of galleries was a general trend for aspen in all analyses. This is surprising as aspen usually is regarded as positive for biodiversity in general (Niemelä 1997) and for the the white backed wood pecker in particular (Stenberg and Hogstad 2004). In our study it was instead birch and alder that had the highest density of saproxylic insects, and Stenberg and Hogstad (2004) also found those tree species to be preferred by the wood pecker. One main difference between birch and aspen is that many birch trunks are densely colonized by the bark beetle *Scolytus ratzeburgi* the first year after they died, whereas aspen has no similar bark beetle species. Another fact is that our inventories focused on dead trees, as few saproxylic insects are found in trees when they are alive. By this we missed presences of one important prey-species living in aspen:

Saperda carcharias which is a large longhorn beetle with large larvae tunneling the centre of the basis of young live aspen trunks (Nourteva et al. 1981). Still, aspen hosted many saproxylic beetle larvae, and is therefore a positive contribution to the food supply for the woodpecker.

Similarly oak had lower gallery density than the average tree species, and especially fell out as negatively related on stands scale (Table 5a). This is also somewhat surprising as oak in general a rich tree species for saproxylic insects with many specialists (Palm 1959), but in north Uppland it is on the northern limit of its distribution. Therefore many of the associated beetle species are absent or probably somewhat rare compared to south Sweden. However, one of the most common species *Saperda scalaris* was similarly frequent on birch and oak logging residues (Jonsell 2008). Thus the low density of galleries on oak is somewhat surprising.

Many authors have suggested that older stands are more valuable for the white-backed woodpecker than younger (Andersson and Hamilton 1972; ArtDatabanken 2022). However, the relationship seem hard to show in systematic studies, and stand age > 60 years was not among the stand characteristics that explained the occurrence of the species in west Sweden (Stighäll et al. 2011). Still, in this study we found support for increasing stand age to be a positive factor at least for prey density on the stand scale. Diameter was moreover the most explanatory variable in our analyses on tree level and as diameter and age are strongly correlated this also supports that tree age is a positive factor. Thus, within the age span we investigated, from around 40 to 100 years, older stands seem to have a better basis to provide good habitat for the wood pecker within short time frames as they provide high densities of prey.

Our analyses show that the large quantities of felled young (40-50 yrs) trees present in some of the stands were only sparsely colonized by saproxylic insects. Low diameter, artificially created wood and laying trunks were all factors that were negatively correlated with density (Table 4). The three restored young sites were also in the bottom in gallery density per area of bark (Fig. 2). Thus, the retention of many young felled trees on a site seem not to contribute to the food supply for white backed wood pecker. However, on a longer term it is likely that the thinning will have positive effects, as share of conifers is lower and as fewer trees per ground area implies faster development of diameters on the deciduous trees.

The reason to why so few insects that colonise the young felled trees is unclear. We have two hypothesises that we think are more likely than others: a) that the substrate qualities does not suit the beetles, and b) that there are too few colonizing individuals in the stand. At least two quality factors of the substrate might be important for the insects: diameter and the high vigor of the trees when they die. Usually, all diameters of wood are used by saproxylic insects (Jonsell et al. 2007; Foit 2010; Brin et al. 2011), but if the total density of insects are different between diameters is hard to find facts on as it is usually not reported in studies. The vigor if the wood at death might also be important, as a fastly growing tree that is suddenly killed might have other properties for a colonizing insect than trees that have died slowly (Ehnström 2001; Manak and Jonsell 2017; Runnel et al. 2021). Whether fast growing deciduous trees that are suddenly killed are more sparsely colonized than trees with slower growth is something that needs to be investigated in the future. However, results from spruce indicate the opposite (Runnel et al. 2021) but results seem to be different for different tree species (Aulén 1991). The second hypothesis is based on that a restoration event in a young forest results in a very sudden increase in habitat supply. Young forests generally have low quantities of dead trees since the self thinning process has not started yet (Ekbom et al. 2006), and a sudden felling of a rather high share of the trees will be a very drastic increase in habitat supply. Therefore, there might be too few insect individuals present in the area to densely colonise the wood.

Standing trunks were found to have higher density of saproxylic insects than laying. This was true also if the artificially dead trees were excluded from the analyses, showing that the effect is not only due to that the artificially killed felled young wood was sparsely colonized in our material.

Standing trunks are also suggested as better food-resource for the wood pecker as they will not be snow covered during winter when the food is most limited for the woodpecker (Aulén 1991).

Sun-exposure did not explain insect density to any degree. It should be noted that openly standing trees were scarce in our material, and therefore the value of the most sun exposed positions were not so well evaluated. However, shaded trees performed as good as the intermediate category which suggest that trees within closed stands provide good habitat for the white backed wood pecker. This might seem contradictory to that most saproxylic beetle species are associated with sunny conditions (Jonsell et al. 1998; Lindhe et al. 2005). However, it is important to distinguish between number of species and abundance. Usually the value of various tree properties are described by the number of species that use them, and especially red-listed and rare species are counted. For the white backed wood pecker it is the density of larvae that is important and it will feed also on a not so diverse menu of common and generalistic species. Such species might thrive in wood of many different types as the commonness is usually related to generalistic substrate requirements.

The good performance of shaded trees might also seem contradictory to the high catches of beetles reported by Bell et al (2015) in open, recently restored stands. However, trap catches of flying beetles might not reflect beetles density in wood that well. Higher catches might be because beetles are attracted to semiochemicals emitted from the wood killed in the cutting operation, and which indicate breeding substrates for the insects (Moeck 1970; Schroeder 1988). Open conditions might also increase the activity of the flying beetles and thereby increase the trap catches (Williams 1961). Moreover, the wood-pecker is associated to wetland habitats (Stighäll et al. 2011) which often are rather dense. Thus, our results suggest that shaded trunks provide as dense food supply as more openly standing trunks.

The good performance of shaded trunks deviate from what was suggested about white-backed woodpecker habitat (Stighäll 2015). But this is the first time it is quantified in surveys of the wood, and we think these results give a stronger evidence than previous studies and suggestions. However, food density in different stands might be disconnected with other important factors for a good woodpecker habitat. Predation risk might be such a factor, and if so, habitat quality needs to be evaluated from other aspects as well. Presently, we do not know.

The practical advice we can give for restorations based on our study is that older stands (above 60 years) give better food density in the short term. Also shaded wood is highly beneficial for the food supply for the wood pecker. Standing trunks generally provide more food supply for the woodpecker than laying trunks, and this is especially true if there is a think snow cover. All these results are short term effects of restorations… How restorations of young stands pay off on a longer term needs to be evaluated in future studies.

We found the artifically created wood to be rich in insects with one important exception. The young felled birches that we investigated in some restored stands had low densities of galleries. For these trees it would probably be more valuable to retain them and wait for their natural death when self thinning process accelerate. As we have shown shaded trees to have as dense galleries as the semi shaded, the openness of the stand is not important for the production of woodpecker food.

That also shaded wood have high prey density, and such wood should thus also be highly beneficial for the wood pecker, Our results support that standing trees are more valuable than laying also when it comes to prey density. The restoration of young stands (40 years) is not highly beneficial for the wood pecker as regards prey density in the short term, and it can be questioned whether the retention of many felled young trees really is useful. However, restorations of young stands will probably pay off when the forest is some decades older as the share of deciduous trees will be high when trees start to self thin to a higher degree.

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Table 1. The investigated sites. Numbers refers to Fig. 2.

Site	Stand type	Age	Dominating tree species	Transect length
1. Kungsgårdsholmarna	Restaurerad	70	mixed decid	274
2. Pellesberget north	Not restored	70	mixed decid	306
3. Pellesberget south	Restaurerad	70	mixed decid	539
4. Söderfors north	Restaurerad	45	birch	309
5. Söderfors south	Restaurerad	100	mixed decid	311
6. Untra not rest	Orestaurerad	100	mixed decid	331
7. Untra rest	Restaurerad	100	mixed decid	331
8. Persbo	Restaurerad	45	birch	177
9. Lockelsbo	Restaurerad	70	birch	68
10. Åängsån	Orestaurerad	100	birch, aspen	397
11. Bennbo	Restaurerad	47	birch	221
12. Koludden	Orestaurerad	73	birch	348
13. Hasselhorn	Restaurerad	45	aspen, mixed decid	191

Table 2. Variables collected in the field survey.

Variable	Unit/Categories
Tree variables	
Tree species	Alnus, Aspen, Birch, Oak, Other southern deciduous, Rowan, Salix spp.
Death mode	Naturally dead, Artificially dead
Sun exposure	Open exposed, half shaded, Shaded
Proportion bark	% of the bark that remain on the trunk.
Position	Laying, Standing
Diameter	cm
Decay stage	1, 2, 3, 4, 5 according the the scale of Siitonen & Saaristo (2000).
Stand variables	
Restoration	Restored(Not restored
Stand age	Years - either from data on the stand or ocularly estimated
Proportion of Alder	
Proportion of Aspen	
Proportion of Birch	
Proportion of Oak	
Proportion of OS deciduous	
Proportion of Rowan	
Proportion of Salix	

Table 3. Categories of wood feeding larvae, with the estimated length of the larvae, and the species which belonged to the respective category.

Category	*Species*
Ambrosia beetles, 4mm	*Trypodendron* spp., *Anisandrus dispar*
Bark beetle <2 mm, 2mm	*Ernoporus tiliae*
Bark beetle 2 mm, 3 mm	*Pityogenes chalcographus*, *Polygraphus poligraphus*, *Dryocoetes alni*, *Trypophloeus* spp
Bark beetle 3-4 mm, 4mm	*Ips typographus, Xyleborus cryptographus, Hylurgops palliatus, Hylesinus fraxinii, H. crenatus, Scolytus intricatus, Hylurgops glabratus, Scolytus rugulosus, Tomicus piniperda*
Bark beetle 5 mm, 5 mm	Scolytus ratzeburgi
Hylocoetes, 14 mm	*Hylecoetes dermestoides*
Larvae in polypore fruiting bodies, 5 mm	*Dorcatoma* spp., *Bolitophagus reticulatus, Diaperis boleti*
Larvae large (> 2 cm) in living wood, 22 mm	*Aromia moschata*, *Saperda similis, Saperda carcharias, Zeuzera pyrina*
Larvae, large (> 1 cm) cambium, 15 mm	*Saperda scalaris, Rhagium mordax*, *Saperda perforata*, *Plagionotus arcuatus*, *Xylotrechus rusticus*, *Phymatodes testaceus*, *Clytus arietis*, *Chrysobotris* spp.
Larvae, large (> 1 cm), rotten wood, 15 mm	*Strangalia quadrifasciata*, *Necydalis major*, *Sinodendron cylindricum*, *Peltis grossa*, *Trichius fasciatus*, *Oxymirus cursor*, Scarabaeide spp
Larvae, medium (0,5-1 cm) cambium, 7,5 mm	*Leiopus* spp., *Agrilus* spp., *Obrium cantharinum, Magdalis carbonaria, Pogonochaerus hispidus*, *Anthaxia* spp.
Larvae, medium (0,5-1 cm) rotten wood, 7,5 mm	*Alosterna tabacicolor*, *Leptura sanguinolenta*
Larvae, small (> 0.5 cm) cambium, 4 mm	*Synchita humorless*
Larvae, small (< 0.5 cm) rotten wood, 4 mm	*Ptilinus fuscus*, *Anobium rufipes, Anobium thomsoni, Tropideres* spp*., Tomoxia bucephala, Anobium nitidum, Ernobius mollis, Hadrobregmus pertinax, Ptinus subpilosus?, Eremotes/Rhyncolus*
Scardia boletella, 25 mm	*Scardia boletella*
Small Tineidae, 10 mm	Tineidae spp.
Tipulidae, 20 mm	Tipulidae spp.
Wood wasp (and similar), 20 mm	*Xiphydria camelus*, *Anthribus albinus*

Table 4. Results from models explaining variation in insect density on tree scale. The variables that could significantly explain the a) density; b) total biomass of insect larvae reared out from the wood. Output from a mixed model selected in a stepwise procedure.

Term	Estimate	Prob>|t|
a) Density of insect galleries		
Intercept	0,6908625	<,0001
Tree sp. [Alder]	0,3376218	0,0225
Tree sp. [Aspen]	-0,229812	0,003
Tree sp. [Birch]	0,2734909	<,0001
Tree sp. [Oak]	-0,190666	0,0842
Tree sp. [OSdecid]	-0,087613	0,4731
Tree sp. [Rowan]	0,1610355	0,2924
Diameter	0,0150615	<,0001
Position [Laying]	-0,10362	0,0011
b) Density of insect galleries with interaction Death mode * Diameter		
Intercept	0,4834176	0,0012
Tree sp. [Alder]	0,3459445	0,0188
Tree sp. [Aspen]	-0,235285	0,0022
Tree sp. [Birch]	0,2846798	<,0001
Tree sp. [Oak]	-0,198344	0,0719
Tree sp. [OSdecid]	-0,09584	0,4317
Tree sp. [Rowan]	0,1693992	0,2668
Death mode [Natural]	0,0656539	0,1047
Diameter	0,0256906	<,0001
Position[Laying]	-0,096586	0,0023
Death mode [Natural]*Diameter	-0,012455	0,0161
c) Density of insect galleries in Naturally created dead wood		
Intercept	0,7975596	<,0001
Position [Laying]	-0,074369	0,042
Diameter	0,0133029	0,0012
Tree sp. [Alder]	0,3605651	0,0201
Trsl sammanslagna[Asp]	-0,243733	0,0057
Trsl sammanslagna[Björk]	0,2720844	0,0004
Trsl sammanslagna[Ek]	-0,222234	0,0572
Trsl sammanslagna[OSdecid]	-0,093259	0,4942
Trsl sammanslagna[Rönn]	0,2111983	0,1965
d) Total biomass		
Intercept	1,313455	<,0001
Tree sp. [Alder]	0,4136499	0,0696
Tree sp. [Aspen]	-0,455933	0,0001
Tree sp. [Birch]	0,2996895	0,0033
Tree sp. [Oak]	0,0157168	0,9265

Tree sp. [OSdecid]	-0,753812	<,0001
Tree sp. [Rowan]	0,36389	0,1229
Diameter	0,0206606	0,0004
Death mode [Natural]	0,1388833	0,0269

Table 5. Standard least square models on stand scale. Response variable is the density of galleries summarized for the whole stand.

Term	Estimate	Prob>|t|
a) All wood		
Intercept	2,2415814	0,0178
Restoration [Not rest]	-0,287915	0,2112
Age	0,0261194	0,041
Proportion of oak	-0,037008	0,0742
b) Artificially created wood		
Intercept	0,903823	0,4067
Age	0,0481302	0,0141

Figure 1. The border of a restored stand (between stand 2 and 3 in Fig. 2). The original stand to the left has a high proportion of spruce, which at restoration is removed leaving an almost entirely deciduous stand.

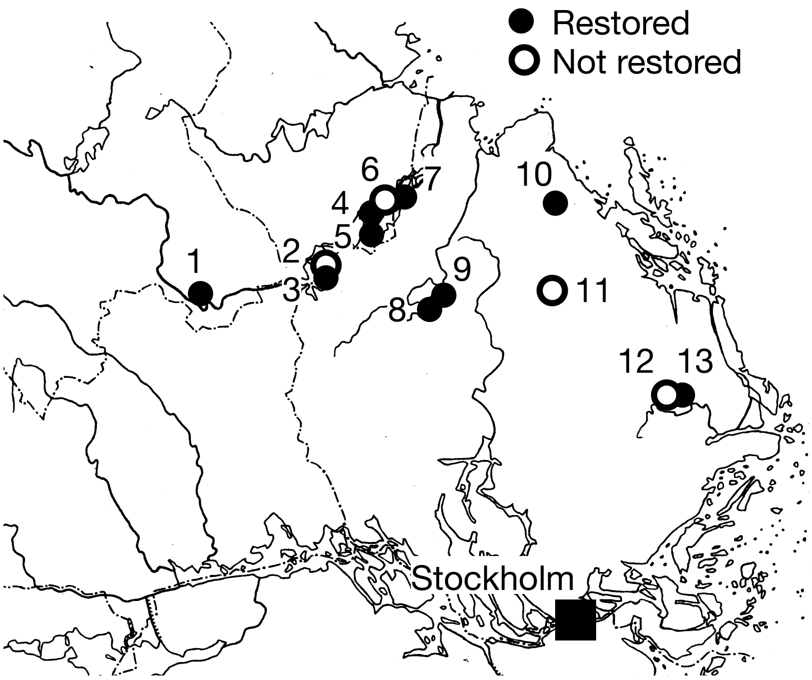

Figure 2. Position of the 13 stands that were investigated.

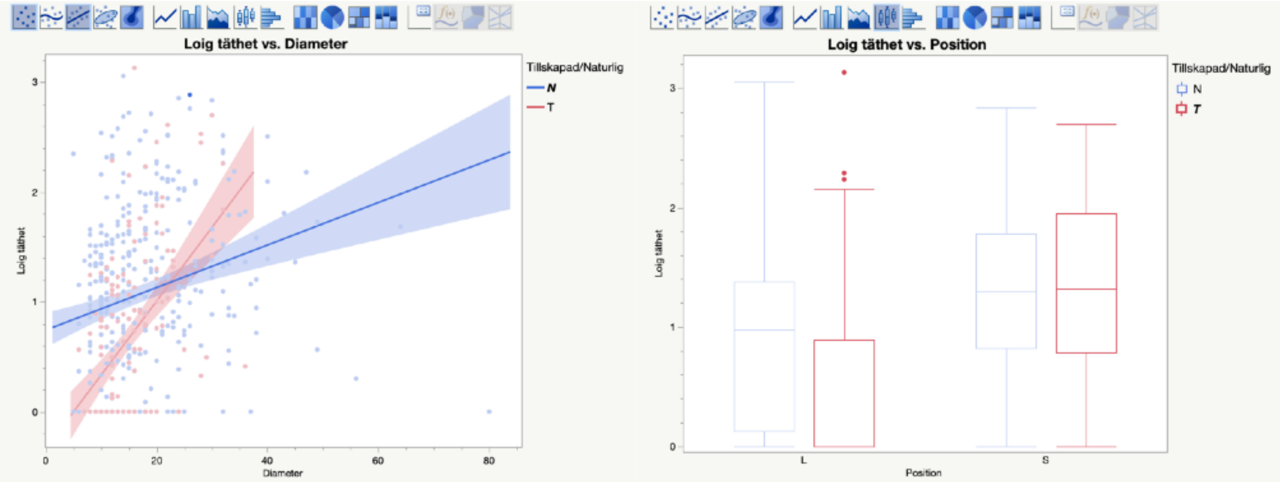

Figure 3. The density of insect galleries for artificially and naturally dead wood in relation to a) diameter; b) position.

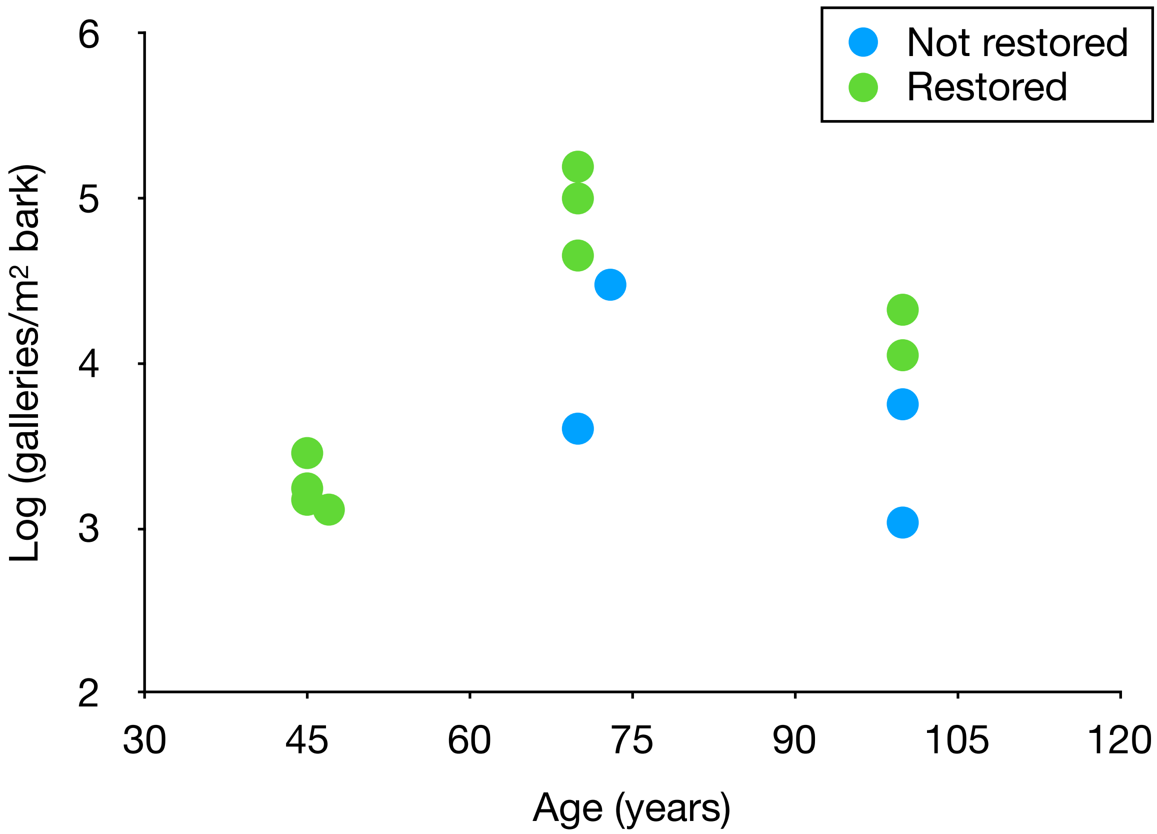

Figure 4. The larval density per stand in relation to Stand age. Restored and not restored sites are plotted with different colours. No stand variable could explain any significant variation for the stands.