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Abstract

This study examined the effect of tree stump extraction on the diversity of saproxylic insects in Norway spruce *Picea abies* roots. I tested if the density of saproxylic beetles was the same in the interior layer of the stump storage piles as in the exterior layer. I also tested if the beetle density was as high or higher in piles as in remaining stumps at extraction clear-cuts and to test if they could be ecological traps. I tested if species at higher trophic level as well as red-listed species could be impacted negatively by stump extraction.

A total of 110 root wood samples were collected from 6 clear-cuts and 6 extraction clear-cuts and 4 different piles in central Sweden near Uppsala, Lindesberg and Fågelfors. The clear-cuts were dominated by Norway spruce and were sampled 1 to 2 years after clear felling. Norway spruce is the most common tree species used in tree stump extraction.

Insect were reared from the sampled roots in rearing boxes for 8 weeks. Insects were also sampled after the rearing box period by pealing the bark of the roots and putting the bark in Tullgren-funnels to sample the last insects inside the bark. The sampled Coleoptera were determined to species level.

A total of 1379 beetles of 35 species were collected from the roots. Higher species richness was found inside the piles (PIN) than on the outside of the piles (POUT). Hardly any difference was found between the clear-cut (C) and extraction clear-cut (EC) in species-richness per root-sample, but a significant difference was found between the pile habitats. Common saproxylic species, like *Dryocetes autographus* and *Hylastes cunicularius*, showed increased abundance in C and EC but a decrease in the storage piles. The pest species *Pityogenes chalcographus* was only reared in PIN.

Predatory species higher up in the trophic levels, like the staphylinid *Nudobius lentus*, were found in low abundance in C, EC and in POUT but not in PIN. This could mean that the piles can be an ecological trap to species at higher trophic levels as well as for some pest species. The results of this study indicates that tree stump extraction can cause a lower diversity of saproxylic insects in Norway spruce roots and a decreased species richness if the stump piles constitutes an ecological trap. As a consequence, this can decrease the diversity and species richness in the surrounding area.

1 Introduction

The Swedish government's goal is to decrease the emitted greenhouse gases in Sweden by 40% compared to the 1990-level. By 2020 fossil fuel will be partly phased out and half of the energy used should be created from renewable fuel sources such as solar energy, windpower, waterpower and bioenergy (Miljödepartementet 2010). This "greener" policy have led forest companies to exploit the potential resources such as the logging residues like tops and branches and other woody debries. This have also led to the implementation of stump extraction after clear-cutting (Skogsstyrelsen 2009). Over the last decades, the production of forest fuel have increased (Björheden 2006).

1.1 History of stump extraction in Sweden

During one period tree stumps were used in the production of wood-pulp. This took place between the end of the 1970's and into the 1980's and the period has been dubbed the Mackmyra period after the place situated west of Gävle, Sweden, where the stumps were processed. A total area of 9 220 ha was stump harvested during that period. However the raw-material for wood pulp mass needs to be pure to go into production, and there were too much contaminations from mineral soil in the stumps for it to be profitable. As a fuel source, wood chips from stumps were also unprofitable as it was too costly, this was because during this period wood chip from stumps were too expensive to use in energy purposes (Skogsstyrelsen 2009).

From 2005 and onward stumps have been extracted mainly as a source for bioenergy, mainly used in combined power and heating plants. With the environmental politics and Sweden becoming "greener", companies see possibilities to develop the extraction of stumps into a profitable business. The interest for stump extraction grew in association with the clean-up after the storm Gudrun in January 2005 (Skogsstyrelsen 2009).

1.2 Forests and climate of Sweden

About 66% of the Swedish landmass is covered by forests (FAO 2010). The central and southern parts of the country, where this study was performed, are classified as having a "continental warm summer hemi boreal climate, with moist, warm-to-cool summers in the southern parts and moist, cold winters which can be severe in the more central parts" (Ahrens 2008). This is part of the taiga and the Southern boreal zone is dominated by conifer forests (Ahrens 2008).

1.3 Forestry in Sweden and tree stump extraction

Forest fuel to production was 42 TWh in Sweden in the year 2011 (Skogsindustrierna 2012). Logging residues and stumps are profitable sources for bioenergy, although biofuel have become less profitable recently due to lower bioenergy prices. The energy demand of the Swedish forest industry is by 60% covered by the bio fuel created by the forest industry (Ericsson et al. 2004).

Stump harvest is mainly directed to Norway spruce *Picea abies*, and usually about 75% of the existing tree stump volume in a clear-cut is extracted, turning the site into an extraction clear-cut. It is not possible to extract more than 75% because of technical and environmental limitations, thereby a percentage is left to retain available habitats to species linked to these conifers (Skogsstyrelsen 2009).

1.4 Stump extraction and its effects on saproxylic insects

The decay of conifer wood in Scandinavian boreal forests can take over a hundred years. There are four recognized stages in the decomposition of dead conifer wood (Dajoz 1992, Ehnström & Axelsson 2002):

- Stage A. A short stage occurring from around when the tree died and until 2 years after deah. Species feeding under bark are related to this stage, such as cerambycids, curculionids and scotylids as well as their predators, parasites and their commensals.
- Stage B. Starts 2 years after death and ends around 10 years after death when the bark starts to peel off and the sapwood is affected. This stage comprises of sub-cortical and mycophagous species and those that feed in the outer layers of the wood. The fungus breaks down the wood and bark differently depending on species and therefore this

can have a great impact on the diversity of insects in this stage, and even in such a large scale it can differ between trees of the same species.

- Stage C. This stage spans over several decades. Species related to this stage live within the wood, and most species endangered and threatened by extinction in Scandinavian boreal forests can be found in this stage.
- Stage D. The longest stage. Species associated to this stage are soil-living and take shelter under the trunk, which start to fragment.

Long horned beetles and bark beetles were abundant and fungivore species were also found. These findings plus time since felling indicate that my samples were in the two first stages of decomposition of the dead wood.

Many saproxylic insect species, common ones as well as endangered and red-listed ones, use material like logging residues, logs and stumps as a substrate for reproduction (Abrahamsson & Lindbladh 2006, Hedgren, 2007) and can therefore be negatively impacted by stump extraction (Hjältén 2010, Jonsell 2008, Jonsell & Hansson 2011). Clear-felling have a big negative impact on saproxylic insects and with the removal of stumps it could lead to further deterioration of this habitat (Walmsley & Godbold 2010).

Stump-extraction cause a habitat loss for saproxylic beetles and stump storage piles become ecological traps for saproxylic beetles (Victorsson & Jonsell 2013). Newly cut trees releases ethanol and other semiochemicals (Jääskelä 1997, Moeck 1970, Schroeder 1988) that are detected by the sensitive chemosensory organs of saproxylic beetles (Byers 2004, Allison 2004). Aggregations of dead wood, like stump storage piles which often are stored 1 to 2 years in the forest as rain and further drying improves the quality of the stumps (Kärhä 2011). These aggregations release a lot of chemicals and they may attract insects and turning the piles into ecological traps if the attraction is stronger to this trap habitat then the natural habitat (Byers 2004). Saproxylic beetles are attracted by stump storage piles stored for 1 to 2 years, and if the attraction is stronger to the trap habitat than the natural habitat then the trap habitat constitutes a severe ecological trap (Robertson and Hutto 2006). When species prefer both habitat types equally it becomes an equal-preference-trap (Robertson and Hutto 2006).

Victorsson and Jonsell (2013) sampled only the outer layer of tree stump storage piles, and found that the piles were a severe ecological trap for four beetle species; the fungivorous latridiid *Corticaria rubripes* and three staphylinids; *Leptusa fumida*, *Dadobia immersa* and *Phloeocharis subtilissima*. The two first staphylinids are facultative predators and fungivores while the last species feeding habit is unknown (Victorsson & Jonsell 2013). Higher trophic level species, such as predators and fungivores often have small populations, therefore they probably are negatively impacted by stump storage piles (Victorsson & Jonsell 2013). Some predators (e.g. *Gabrius splendidulus* and *Nudobius lentus*) were found in higher numbers in clear-cuts than in stump storage piles and this created an ambiguous pattern since there were higher abundance of several predators and facultative predator/fungivores in clear-cuts than in storage piles (Victorsson & Jonsell 2013). But compared to the surrounding extraction clear-cuts, a lower community density of beetles was found in the storage piles of stumps, indicating that stump storage piles did not comprise a community-wide ecological trap (Victorsson & Jonsell 2013).

There is a lack of knowledge of saproxylic biodiversity in roots and we do not know how the root-living beetle fauna is affected by stump extraction. Actually, the diversity of saproxylic insects in roots is poorly known and amongst 482 Swedish saproxylic beetle species only 3 % of the species are associated with subterranean wood (Ehnström & Axelsson 2002). This low figure is undoubtedly due to too few studies done on root-living saproxylic insects. There are not many studies done on the beetle root fauna and most studies of root living beetles have focused on the pine weevils of the genus *Hylobius* and the bark beetles of the genus *Hylastes*. *Hylobius abietis* can locate roots by its olfactory use, burrow down for ovipositing or feeding (Nordlander et al. 1986), it also can lay eggs in the nearby soil (Nordlander et al. 1997, Bylund et al. 2004). It is a serious pest where clear-cutting with subsequent replanting is done because adult weevils will feed on the newly planted conifers seedlings (Björklund et al. 2005).

Since dead wood such as tree stumps is used as a substrate for reproduction by many saproxylic insects (Jonsell 2008), a similar fauna could be found in the roots of the stumps. Expanding this thought, I believe that stumps extraction of clear-cuts can reduce the available habitats needed for saproxylic insects. A difference in insect diversity can exist between clear-cuts and extraction clear-cuts, the latter recommended extracting 75-85% of the stumps and retaining the rest (Skogsstyrelsen 2009), with a decrease in species found in extraction clear-cuts.

Cerambycids can be found in tree stumps (Ehnström 2007) and the majority of them develop within dead wood like in the inner bark and the wood of the tree, and many species are facilitating each other through interactions such as coexistence (Victorsson 2012) and the succession of different animal communities until the woods nutrients are gone or all its important structures are no longer present (Ehnström 2007). Some species found in spruce are *Rhagium inquisitor*, *Tetropium fuscum*, and *Tetropium castaneum* (Ehnström & Axelsson 2002).The development time for longhorn beetles differ amongst species, with some taking several years to develop into a fully mature individual (Ehnström 2007). There are 47 longhorn beetle species at the Swedish red-list, 1 which is classified as critically endangered, 8 as endangered, 11 as vulnerable and 3 as data-deficient (Lindhe et al. 2010), therefore I believe some cerambycid species can be vulnerable to stump extraction, in particular if any red listed species are found during this study.

1.5 Aims of the study

The aim of this study was to analyze the effect of stump extraction on saproxylic insects in Norway spruce roots. My hypotheses were that: (1) stump storage piles can be ecological traps for saproxylic species; (2) the number of species per sample is lower in extraction clear-cuts than in ordinary clear-cuts; (3) the species composition differ between stump storage piles and clear-cuts; (5) the outer layer of the stump storage piles have a higher density of beetles than the interior of the piles.

2 Materials and method

2.1 Study site and study description

Samples were collected from 3 areas in central Sweden: Uppsala (Uppsala County), Lindesberg (Örebro County) and Fågelfors (Kalmar County). Four pairs of clear-cuts dominated by Norway spruce were sampled in each area. One to two years had passed since clear felling and a total of 110 samples (Table 1) were collected of which 50 were already harvested and put in piles. The four habitats sampled were clear cuts (C), extraction clear-cuts (EC), interior stump storage piles (PIN), and exterior of stump storage piles (POUT). The sampling was done in May 2 - 17 2012. The tree analyzed in this study was the Norway spruce *Picea abies*, since this tree species is the most commonly harvested in stump extraction.

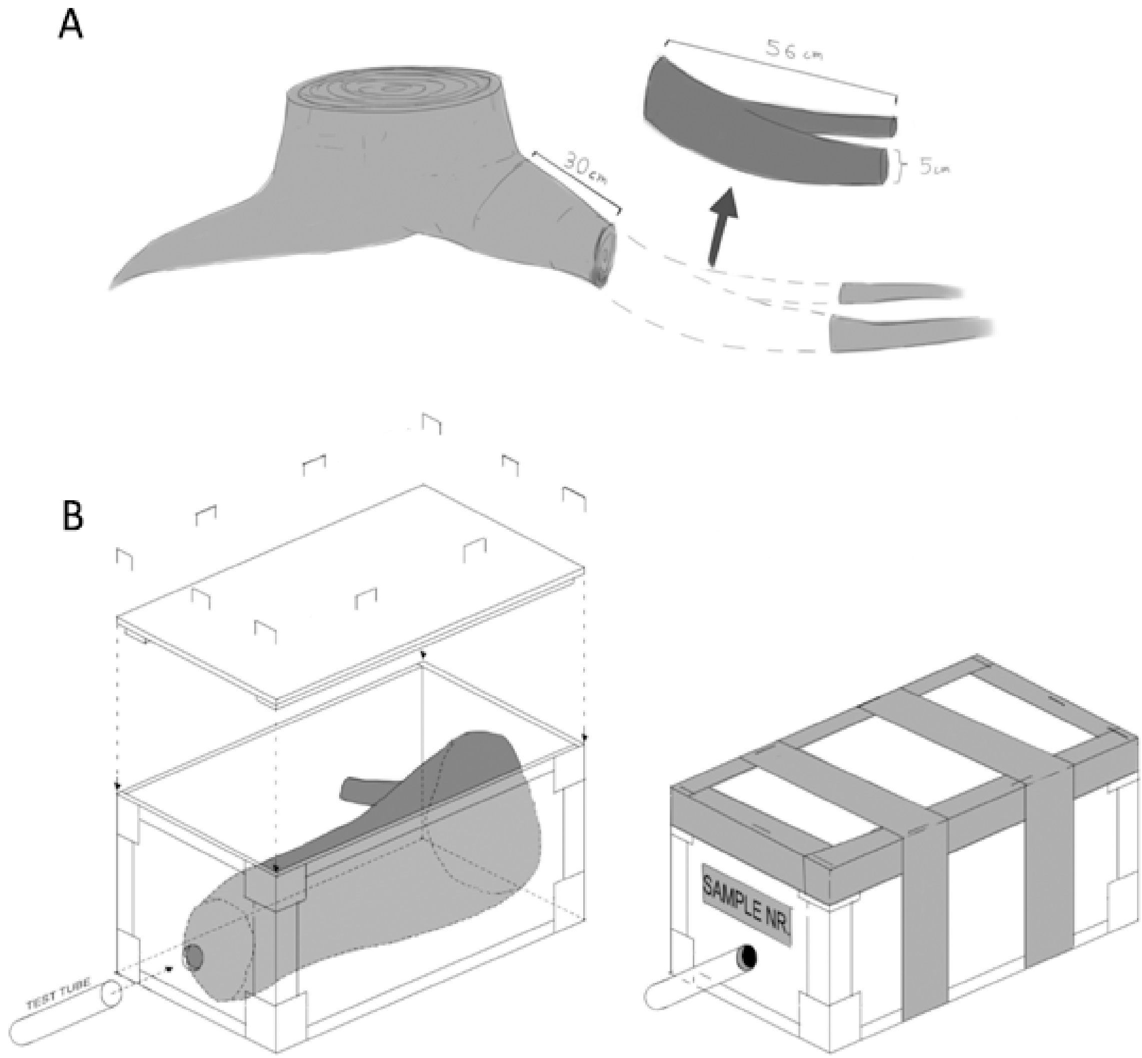
Landscape	Location	C	EC	PIN	POUT	Totalt
Uppsala	Norrunda		5	6	4	15
	Vikstaboda	5				5
	Nybygget		5		5	10
	Alsike	5				5
Lindesberg	Nedre Forsen	5				5
	Ängen		5		5	10
	Stora Vålen	5				5
	Kylnan		5	6	4	15
Fågelfors	Askeryd	5				5
	Dalen	5				5
	Fågelfors		5	5	5	15
	Rosdahl		5	5	5	15
	Totalt	**30**	**30**	**22**	**28**	**110**

Table 1. The distribution of root samples according to location. Abbreviations: C=Clear-cut, EC=Extraction clear-cut, POUT=Pile outside, PIN=Pile inside, P=Pile.

Root samples were taken from tree stumps in ordinary clear-cuts (30), extraction clear-cuts areas (30) and from stump storage piles, both from within (22) as well as from the outside (28) of the pile. Although in Ängen and Nybygget the only part that could be sampled was the exterior of the pile. Stumps with a diameter between 37-40 cm with at least 90 % retained bark on the above-ground part of the stump were used.

Sampling method

The root samples were taken approximately 30 cm from the stumps main trunk (Fig. 1a). This procedure was used for all samples taken from the piles as well as the clear-cuts and extraction clear-cuts, samples from the piles were removed with machinery and then sampled. The desired length of the root sample was 56cm in order to fit into the rearing boxes, if the root was found to be shorter than required at the tapering part, it was instead cut off when it reached minimum of 5 cm in width. The roots had intact bark and strips were used to secure the bark for transport, if the bark was brittle the sample was wrapped for transport.



2.2

Figure 1.

A) Root-sampling methodology, a max 56 cm long sample was taken from each stump.
B) Rearing box with test-tube for individual root samples.

2.3 Rearing method

The rearing was conducted in a greenhouse with temperatures of 15-20ºC with peaks of 30ºC on hot days). The volume of each wood sample was estimated by measuring sample length and the circumference in both ends, then calculating the volume of a tapering cylinder, if sample had branching roots then they were similarly measured and added to a total volume for the sample. Thereafter the wood samples were placed in tape-sealed rearing boxes for rearing (Fig. 1b) which all had a test tube placed in the side. During a period of 8 weeks the insects were regularly collected from the vials. At the end of rearing the boxes were opened and all dead or living insects inside the boxes were collected. In the next step the bark of the roots was peeled off, and visible insects were collected. Finally all bark and sub-cortical material were put in a Tullgren funnel for 48 hours.

2.4 Identification

All Coleoptera were determined to species, except *Crypturgus spp.* All species I found too difficult to determine to species were handed to Mats Jonsell and Åke Lindelöw for identification. I defined each species as saproxylic or not with literature (Lundberg et al,. Catalogus Coleopterorum Sueciae 1995) and by using a data file provided by Mats Jonsell, which was based on studies by Koch (1989–1992) Hansen (1964) and Palm 1959).

Beetle density and number of species per sample were analyzed with one-way mixed models ANOVAs using SAS 9.2. Clear-cut pairs were used as a blocking variable and sample volume was used as a covariate in the analysis of species number. Density (number of beetles per dm^3 wood) was already standardized regarding volume so the covariate was not needed.

Species composition was analyzed with CANOCO 4.5 software. The individual root-samples in each locality were pooled for this analysis. Also, the volume of the samples was pooled.

3 Results

A total of 1379 beetles of 35 species were collected from the roots, 26 of the species were saproxylic. 109 individual beetles, consisting of larvae, pupae and adults could only be determined to family or order. The most common species was *Dryocoetes autographus* (419 indivudials) followed by *Hylastes cunicularius* (269), *Silvanus bidentatus* (110), *Tetropium castaneum* (99) and *Hylobius abietis* (92). *Silvanus bidentatus* was red-listed in 2005 but not in 2010 and 100 of the 110 individuals were reared from the same root-sample.

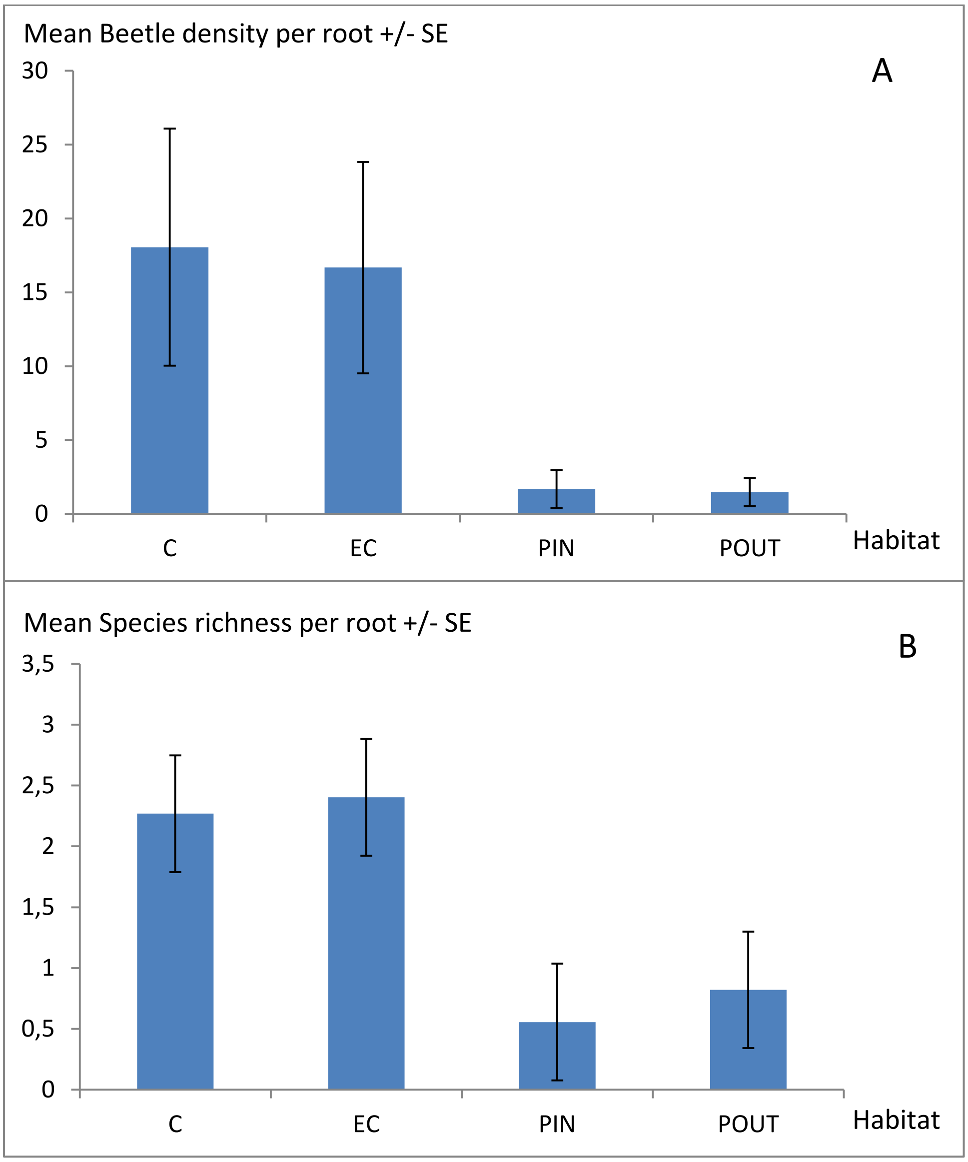


Figure 2. A) *The mean of beetle density (±SE) per root in each habitat sampled.* B) *The mean of species richness (±SE) per root in each habitat sampled.*

The abundance, individuals of insects per liter of wood per sample, did not differ between Piles Inside (PIN) and Piles Outside (POUT) (ANOVA; $F_{1,5.89}$=3.53; P=0.0983). However, although the two habitats did not differ in abundance as the P value was higher than the chosen significance level of 0.05 I decided to not combine the two substrate types in the final analysis. The abundance in stump roots differed between all habitat types (ANOVA: $F_{3,17}$ =5.81; P=0.0064) (Fig. 2a). There was also a significant effect of wood sample volume ($F_{1,81}$ =29.35; P<0.0001). The number of species per sample differed between the habitat types (ANCOVA: F $_{3,14}$=5.83; P=0.0084). The two clear-cut habitats were similar in species number but the stump storage piles had a lower species number (Fig. 2b).

There was a difference in species composition between the habitat types when all the habitats were then tested against each other (Canoco RDA with Total Volume/Sample as a covariable: F=2.336; P=0.0126) (Fig. 3), the two clear-cut types differed from each other (F =3.582; P=0.0020) and from the stump storage piles but the outer and inner part of the stump storage piles had the same species composition (F =3.026; P=0.0043) (Fig. 3). Common saproxylic species such as the bark beetles *D. autographus* and *H. cunicularius* had their center between Clear-cuts and Extraction Clear-cuts. This showed that the abundance of the two species increased towards Clear-cuts and Extraction Clear-cuts but decreased in the piles. *Dryocoetes autographus* had highest total abundance in extraction clear-cuts (N=238), followed by ordinary Clear-cuts (187), Piles Outside (2), and Piles Inside (1). The Hylastes sp. had highest total abundance in Clear-cuts (N=178), followed by Extraction Clear-cuts (91), Piles Outside (0), and Piles Inside (0).

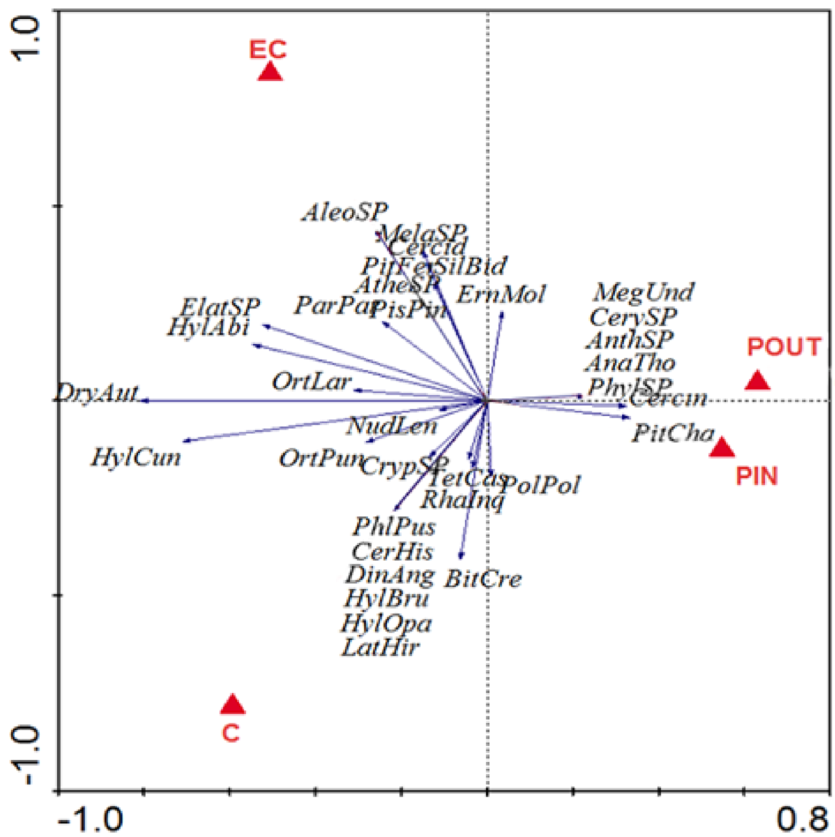


Figure 3. *CANOCO species composition.*

The cerambycids *Tetropium castaneum* and *Rhagium inquisitor* were situated close to each other in the ordination diagram (Fig. 3). *Tetropium castaneum* had the highest total abundance in Clear-cuts (N=80), followed by Extraction Clear-cuts (9), Piles Outside (8), and Piles

Inside (2). *Rhagium inquisitor* had highest total abundance in Clear-cuts (N=13), followed by Piles Outside (5), Extraction Clear-cuts (1), and Piles Inside (1).

Predators, such as *Nudobius lentus*, preferred Clear-cuts and Extraction Clear-cuts equally, with a slight preference for Clear-cuts (Fig.3). Other staphylinids, such as *Aleocharinae sp., Atheta sp., Dinaraea angustula* and *Phloeonomus pusillus*, were only found in root samples from stumps at the Clear-cut and Extraction Clear-cuts, seeming to prefer those habitats over the stump storage pile habitats.

4 Discussion

The inside and outside of the piles did not differ in community beetle density, indicating that the insects were evenly distributed throughout the pile (Table 2). Many species were found both inside and outside the piles. I expected stump storage piles to act as an ecological trap. However, there was a lower density of beetles in stump storage piles than in extraction clear-cuts so there was no community-wide ecological trap. This is in concordance with the study by Victorsson and Jonsell (2013). However, some individual species showed a pattern concurrent with an ecological trap. All 41 individuals of *Pityogenes chalcographus* were reared from the inside of the pile and found nowhere else. This suggests that the stump storage piles can indeed act as an ecological trap for some species, as previously shown (Victorsson & Jonsell 2013). *Pityogenes chalcographus* is one of Sweden's most common spruce-living beetles (Ehnström & Axelsson 2002) and considered a pest species that under certain conditions, such as drought stress, can attack and kill living Norway spruce. So even if *P. chalcographus* experience an ecological trap in stumps storage piles it is unlikely that stump extraction will pose a threat to this species. On the contrary, regarding pest species, a trapping effect might actually be beneficial since it could reduce the potential threat from these species.

Other species where most of the individuals were found in the stump storage piles were *Anaspis thoracica* (1), *Antherophagus sp.* (2), *Cerambycinae larva* (4), *Dienerella filum* (5), *Ernobius mollis* (2), *Megatoma undata* (1). The low abundance of these species makes all conclusions tentative but the stump storage piles could be an ecological trap for them. I reared six individuals of the predator *Nudobius lentus* and two individuals each were found in ordinary clear-cuts, extraction clear-cuts and stump storage piles. This suggests that the beetle can be as common on the outside of the piles as out in the clear-cut areas, and as such the outside of the piles could pose as an ecological trap to this species because of its roaming beneath the bark. Other higher trophic level staphylinid species reared, such as *Aleocharinae sp., Atheta sp., Dinaraea angustula* and *Phloeonomus pusillus,* seem to prefer the Clear-cut and Extraction Clear-cut habitats over the stump storage pile habitats. The piles seem not to be attractive to them. But since only one to two individuals of each species was reared, it is not possible to draw a firm conclusion. For all these species, further research to increase number of samples or rear a higher number of individuals of these species in the habitats investigated could lead to a firmer conclusion on if these species are subjected to ecological traps or not.

A pest species that was found in high abundance was the pine weevil *H. abietis* which was almost exclusively found in the clear-cut habitats. *Hylobius abietis* is able to locate roots when walking on the ground by its olfactory use and burrow down for ovipositing or feeding (Björklund et al. 2005, Nordlander 1986). It can lay eggs in the soil near roots or burrow down to chew recesses into the roots to lay eggs (Bylund et al. 2004). I found lower number of *H. abietis* in stump storage pile than in the clear-cuts, only 3 out of 92 reared individuals were found in the piles. The dry condition of and exposure of the uprooted stumps might be the cause as well as the surface area of the roots being more accessible to predators and parasites. It may also be due to that pine weevils after swarming mainly roam around at ground level in search for food and breeding sites and locate roots by olfactory use in order to oviposit in the nearby soil or in the roots themselves – this implies that the dry conditions and lack of soil on top of the piles of uprooted stumps are unattractive and not suitable as breeding and feeding substrate. This could also be a cause for other saproxylic species to reject stump storage piles. Since the same amount of adult *H. abietis* were found in the clear-cuts but none were found in the piles, and because the number of pine weevil larvae found in the clear-cuts exceeded those found in the piles, it could mean that the ones found in the piles could have originated in the clear-cuts habitats before the stumps were extracted. Reducing the problems with *H. abietis* by removing the stump storage piles from the area, will consequently not work according to my data which strongly suggests *H. abietis* doesn't thrive in or are attracted to storage piles.

In the ordination of the species composition the two clear-cut types differ from each other and from the stump storage piles whereas the outer and inner part of the stump storage piles have the same species composition. The abundance of the bark beetles *D. autographus* and *H. cunicularius* were higher in stump roots at the clear-cuts than in the piles. This shows that the piles were not an attractive substrate for these species, and it is likely that the piles cannot be an ecological trap for them. The cerambycids *T. castaneum* and *R. inquisitor* were found in greater numbers in clear-cuts than the other habitat types. This suggests that these cerambycids prefer clear-cuts over extraction clear-cuts. The cause for this could be the larger abundance of stumps available and how close they are to habitats in clear-cuts than in extraction clear-cuts. The large number of *H. abietis* found in Extraction clear-cuts (EC) could be because of that at this habitat they didn’t have as many available choices for selecting breeding substrate as in the Clear-cut habitats (C), since a large amount of the stumps have been extracted. They were not present inside of the piles. This might be because the inside of the pile does not receive enough sunlight and is not warm enough conditions for their reproduction cycle and therefore would actively avoid this habitat.

For *Silvanus bidentatus* 110 individuals were reared from the samples and 108 of them were found in one single root-sample in the extraction clear-cut at Norrunda and the rest found in the adjacent storage piles. This localized occurrence indicate that the Norrunda area could be important for the species.The species was red-listed in 2005 (Gärdenfors 2005) but not in 2010 (Gärdenfors 2010). Considering the status of the species and that so many individuals were found within one and the same root, it would be interesting to do a DNA-test too see if they’re all from the same egg-batch and related to each other or if they are all unrelated individuals gathered in the same root. If all individuals reared are related to each other then that shows that the roots of Norway spruce could be an important breeding-ground for this species, it could be even more important for the species if all individuals reared come from many egg batches layed by unrelated females. If the stumps are extracted then it could be damaging to the species reproduction and its local population if a whole genetically related batch or several unrelated batches are killed by tree-stump extraction. If all the individuals reared are unrelated, this behaviour where the individuals cluster together, maybe ovipositing females, could also be dangerous if the roots are extracted to be used as biofuel.

Conclusion

The common saproxylic species *D. autographus* and *H. cunicularius*, preferred the clear-cuts over the stump storage piles. For most species that were found in both clear-cuts and storage piles there was a higher abundance found in clear-cuts. The storage piles constituted an ecological trap for *P. chalcographus*. However, *P. chalcographus* is a very common species and will not become threatened by stump extraction, but the result for this species is important as proof of principle that the stump storage piles can be an ecological trap further supporting the finding by Victorsson & Jonsell (2013). It also suggests that piles can act as ecological traps for pest species such as *P. chalcographus*. While stump extraction can decrease the number of pest species, other and vulnerable species like predators and natural enemies or red-listed species can simultaneously be negatively impacted. The results of this study indicates that tree stump extraction can cause a lower diversity of saproxylic insects and a decreased species richness because of the ecological trap effect that piles cause and as a consequence can decrease the diversity and species richness in the whole surrounding area. It can be difficult knowing what is “natural” diversity and density when species like these ones are under limitations of available and suitable substrate for reproduction. The conventional clear-cut might not only favor *H. abietis*, but incidentally other saproxylic species found in stumps as well that would otherwise be dependent on dead or newly dead trees.

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Table 2. Species list, with information on total numbers and numbers reared from each sampling location.

Family	Species	C	EC	PIN	POUT	Total
Cerambycidae	Rhagium inquisitor - Larva	13	1	1	5	20
	Tetropium castaneum - Adult	35	8		2	45
	Tetropium castaneum - Larva	45	1	2	6	54
	Cerambycinae larva			1	3	4
	Cerambycidae undefined	2	8	1	6	17
Cerylonidae	Cerylon histeroides	1				1
	Cerylon sp.				3	3
Chrysomelidae	Phyllotreta sp.				1	1
Corylophidae	Orthoperus punctatus	27	5			32
	Orthoperus punctulatus	21	6		1	28
Cryptophagidae	Antherophagus sp.				2	2
Curculionidae	Crypturgus cinereus		1	2		3
	Crypturgus sp.	21	9	4	15	49
	Dryocoetes autographus	178	238	1	2	419
	Hylastes brunneus	1				1
	Hylastes cunicularius	178	91			269
	Hylastes opacus	1				1
	Hylobius abietis - Adult	12	16			28
	Hylobius abietis - Larva	4	57	1	2	64
	Orthotomicus laricis	3	3		1	7
	Pissodes pini		1			1
	Pityogenes chalcographus			41		41
	Pityophagus ferrugineus		1			1
	Polygraphus poligraphus	1			1	2
	Scolytidae pupa	1				1
	Unknown Scolytidae			1		1
Dermestidae	Megatoma undata				1	1
Elateridae	Dalopius marginatus - Larva	2	1			3
	Elateridae larva	11	16		1	28
	Melanotus sp. - Larva		7		1	8
Histeridae	Paromalus parallelopipedus	1	7			8
Latridiidae	Cartodere constricta	3	2			5
	Corticaria serrata	40	4	1	2	47
	Dienerella filum	1			5	6
	Latridius hirtus	1				1
	Unknown Lathridiinae	1				1
Ptinidae	Ernobius mollis			1	1	2
Scraptiidae	Anaspis thoracica				1	1

Silvanidae	Silvanus bidentatus		108		2	110
Staphylinidae	Aleocharinae sp.		2			2
	Atheta sp.		1			1
	Dinaraea angustula	1				1
	Nudobius lentus	2	2		2	6
	Phloeonomus pusillus	1				1
Zopheridae	Bitoma crenata	4		2	1	7
Unknown	Unknown Coleoptera	3		1		4
	Coleoptera larva	5	46	1	7	59
	Total	**620**	**642**	**61**	**74**	**1397**