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i ämnet biologi

The effect of a natural forest fire on beetle assemblages in the boreal forest of Sweden

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Abstract

The aim of this study was to determine the effect of a large natural forest fire on the beetle community. Large, naturally-occurring forest fires rarely occur in north Sweden and the ecological effect on these events has therefore seldom been studied. It is, however, important to gain knowledge of natural forest fires to be able to mimic these events in conservation measures and fire management. I studied the changes in abundance, species richness and assemblage composition of beetles following the fire in 2007. I performed detailed analyses on four different groups of beetles: saproxylic beetles, beetles favoured or strongly favoured by fire, and cambium consuming beetles. In the latter group, many of the typical pest species are found. 18 traps where placed in the fire field and the same number of traps where placed in a control area close to the fire field. Data from this survey where later analysed with Wilcoxons rank sum test and PERMANOVA. The total number of species found was 335 consisting of 8586 individuals. In the fire field I caught 239 species consisting of 5507 individuals while I in the control area caught 221 species consisting of 3079 individuals. I found a significant increase in the abundance and changes in the species composition of beetles following fire. In contrast, I did not find clear evidence that the species richness was higher in the burned areas. However, my study, in agreement with earlier studies, showed that the forest fires have a strong effect on the species composition of beetles. Further research on the effects of large scale forest fire in landscapes with a long history of fire suppression is important for the development of sustainable management plans for species favoured by and adapted to fire.

Keywords: Beetles, boreal forest, forest fire, decaying wood, saproxylic species, forest management

Introduction

Fire is an important disturbance in the boreal forest landscape (Niklasson and Granström, 2000). A forest fire releases nutrients and creates large amounts of dead wood from dead and dying trees which is important substrate for many fungi and beetle species. The long term effects of fire are increased structural diversity and changes in tree species assemblage which is important for the long term survival of species adapted to early succession stages and dead wood continuity on the landscape level (Wikars and Ås, 1999). Additionally about 40 species of insects and approximately 50 species of fungi are directly dependent on scorched wood or ground, while another 100 species are favoured by fire (Swedish Environmental Protection Agency, 2005).

Structural diversity in the boreal forest landscape created by forest fires has been dramatically reduced due to intensive forest management focused on high production (Schimmel and Granström, 1991). Fire suppression has effectively reduced the number of fires (Lundberg, 1984; Wikars, 1992; Esseen et al., 1997; Swedish Environmental Protection Agency, 2006) and forestry measures like clear cutting, soil scarification, planting and thinning has replaced diverse natural forests with dense, even aged stands (Linder and Östlund 1998). Historically, a general decrease in forest fires can be seen from around 1870 (Niklasson and Granström, 2000). However, global warming is expected to result in increased frequency of forest fires in the near future because of a drier climate (IPPC, 2007). Today less than 0.016% of Sweden's forest area is burned annually, while approximately 1% (~200 000 hectares) was burned annually 150 years ago (Wikars, 1992; Swedish Environmental Protection Agency, 2005). Nordic countries are now facing a situation where areas with a natural fire regime are scarce (Esseen et al., 1997). Many organisms dependent on burned forest have decreased in population size and some species were close to extinction in the early 1980's (Lundberg, 1984).

Although it appears intuitively that clear cutting and forest fires gives similar ecological effects there are clear differences, e.g. biomass in the form of trees are taken away after clear cutting while forest fires leave most of the trees standing or lying down hence creating large amounts of substrate for saproxylic (wood-living) organisms (Wikars and Ås, 1999). Furthermore, because not all trees die at once, fire creates substrate over a long time (Wikars, 1997). Another difference is that fires generally increases structural heterogeneity while clear cutting generally decreases structural diversity and the amount of available substrate (Wikars and Ås, 1999). To reduce the negative impact from clear cutting it is possible to mimic the tree species assemblage among the remaining trees after clear cutting (Wikars and Ås, 1999) and also to leave and create dead wood in the managed forest has shown to be useful (Toivanen and Kotiaho, 2007). However, many effects from forest fires, e.g. reduction of the field layer and production of large amounts of dead wood creating opportunities for less competitive species to invade before opportunist species re-colonize the area, can not be completely mimicked by conservation oriented measures in clear cuts (Wikars and Ås, 1999). Another method for mimicking natural fires is prescribed burning where old growth forest as well as clear cuts can be used. During recent years an increased number of prescribed burnings has been performed to fulfil the certification demands (PEFC and FSC) in order to improve the situation for fire favoured and fire dependent species. Decreased forestry activity in naturally, fire damaged forest might also be a reason for this positive trend (Swedish Environmental Protection Agency, 2006).

To better understand the effects of fire on saproxylic insects assemblages it is important to study the assemblage composition and succession of insects after such a rare event as a large scale boreal forest fire. The large scale effect of naturally-occurring forest fires on beetles is, because of the scarcity of the event, poorly studied up until now. In this study I have had the opportunity to study the effects of such an event. Because it is well known that fire benefits various saproxylic and fire favoured species of beetles, I used the data to evaluate whether the abundance and species richness is in fact increased by natural fire. I also chose to analyse possible alterations in the assemblage composition of beetles. It is also well known that some pest species benefits and might mass reproduce during these occasions and I therefore analysed the same factors in this group of beetles.

I specifically asked the following questions:

1. What is the effect of fire on the abundance and species richness of saproxylic, fire favoured, strongly fire favoured and cambium consuming beetles?

2. What is the effect of fire on the assemblage composition of these four groups?

Material and methods

Study area and experimental design

The study area was situated in Bodträskfors, Boden municipality, in northern Sweden (approx. 66º 9’ N, 20º 49’ E) and constitutes a 1700 ha burned area which is a result of a natural forest fire in 2006. It is situated on and around Stora Klusåberget (Fig. 1). The fire was severe and most of the field layer was burned as well as higher parts with boulders and flat rocks. It has been decided that parts of the fire field owned by the Swedish forest company Sveaskog (approximately 250 hectares) will become a nature reserve.

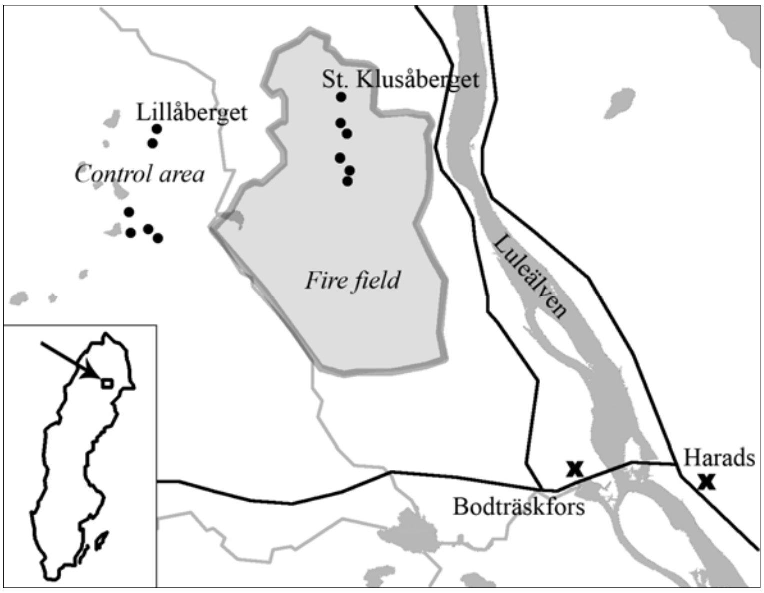

Fig. 1. Map showing study areas (black dots), location of the fire field and closest localities. Location of the section is presented in the inset (lover left corner).

The dominant tree species within the area was Scots pine although some stands contained considerable amounts of deciduous trees like goat willow, aspen and birch. I chose six areas within the fire field for sampling of insects. To the west of the fire field the same number of areas was chosen as controls. In each area I placed three window traps making up a total of 18 (6 x 3 traps) traps in each treatment. All stands included in the study were dominated by Scots pine with ages varying between 140-170 years. The controls were chosen to correspond to the circumstances in the burned area in terms of tree species composition, stand age, soil type, and direction of slope.

I collected insects between 31 May and 21 September 2007 by placing three IBL window traps in each of the twelve areas. IBL-traps were made out of a thin, semi transparent plastic sheet tightened between three thicker plastic parts, making a triangular, window-like flight intercept with a surface of approximately 0.35 m^2. The sides, made of thicker plastic fabric, constituted a channel for the trapped insects to slide down rather than falling to the ground. At the bottom a special, two level funnel collected the sliding insects. The funnel hade a special mechanism making rain water to go through a pipe on the side to prevent the jar from overflowing. The funnel was connected to a 725 cc collective jar by screw threads (Fig. 2).

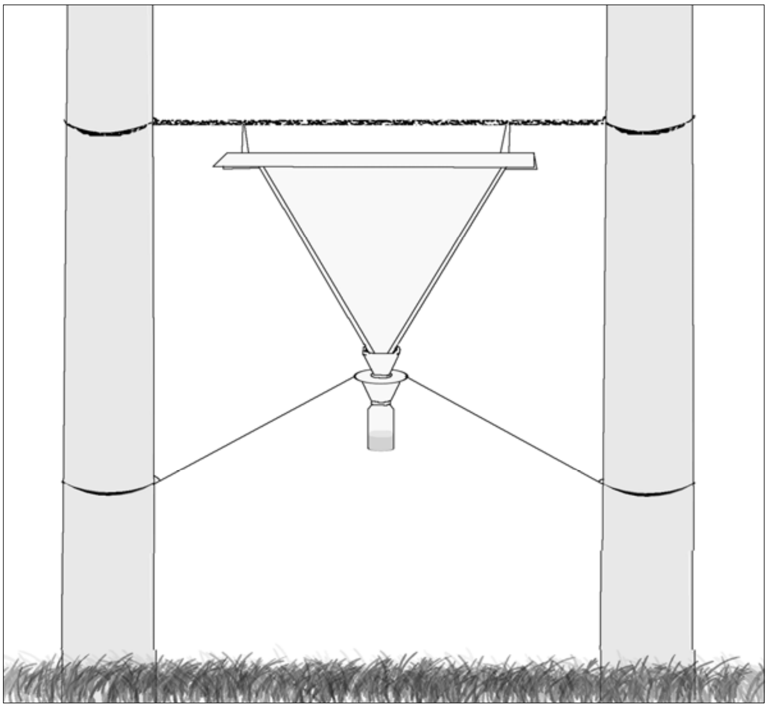

Fig. 2. The IBL-trap attached with threads between two trees. Funnels and collective jar is hanging under the triangular plastic sheet.

I tied the traps between appropriate trees with threads and placed them in a triangular pattern to cover different angels in the landscape. Collective jars were filled up to 1/3 with water, glycol and detergent to preserve the trapped insects.

Identification and classification of beetles

The entire material consisting of 8587 individuals was determined to species level during the winter 2007-2008 by S. Lundberg (Luleå, Sweden). Classification into functional groups was made using the wood decomposer database (Dahlberg and Stokland 2004), literature e.g. (Saalas 1923, Palm 1948) and gathered knowledge by R. Pettersson (Swedish University of Agricultural Sciences, Umeå, Sweden), J. Hilszczanski (Forest Research Institute, Warsaw, Poland) and S. Lundberg (Luleå, Sweden). I chose to include the following functional groups in the study: saproxylic beetles (species that are dependent or favoured by decaying wood meaning both obligate and facultative species), fire favoured (species favoured by fire through making suitable substrate available), strongly fire favoured (species strongly favoured by fire) and cambium consumers (phloem and cambium consumers and consumers of cortex on living trees). Overlap occurs between groups.

Statistical analysis

I analysed the effect of treatment (fire) on abundance and species richness in the different groups, saproxylic, fire favoured, fire dependent and cambium consuming beetles with Wilcoxon rank sum test in R version 2.6.0 (The R Foundation for Statistical Computing) because the data did not meet the assumptions of any parametric test method. Data from each area was pooled without transformation before analysis making 6 pooled samples for each treatment.

Species assemblage was analysed with Permutational Multivariate Analysis of Variance (PERMANOVA) (Anderson, 2003). In contrast to traditional MANOVA tests, permutation based tests requires no specific assumptions concerning correlation. Data might also contain a high number of zeroes due to the occurrence of rare species which is difficult to handle in traditional tests. In addition, the test requires no assumptions concerning correlation between the variables and the number of variables or their individual distributions (Anderson, 2001). In this case, the data did contain a large number of zeroes. I used 4999 permutations, the Bray-Curtis similarity index, and data was fourth-root transformed to reduce the impact of species with high abundance. Area was treated as a nested factor within the treatments. To present the species dissimilarities from the PERMANOVA analysis I plotted the data with non-metric multidimensional scaling (nMDS) (Clarke, 1993). To analyse which species had the greatest impact on the difference in species assemblages, I performed similarity percentages analysis (SIMPER). This is made by exploring how much the overall percentage contribution each species adds to the average dissimilarity between two groups. The species are then listed in decreasing order of importance (Clarke and Gorley, 2001) in distinguishing the two groups from the fire field and the control.

Results

Abundance and species richness

The total number of beetle species recorded was 335, consisting of 8586 individuals. The traps in the fire field caught 239 species consisting of 5507 individuals while the traps in the control caught 221 species consisting of 3079 individuals in total. The abundance was higher in the fire field than in the control area in all the examined groups (Wilcox, P = 0.002, 0.005, 0.026, 0.026 for the groups cambium consumers, strongly fire favoured, fire favoured and saproxylic beetles respectively, see Figure 3). The species mainly responsible for the difference in the abundance per group are presented in Figure 4.

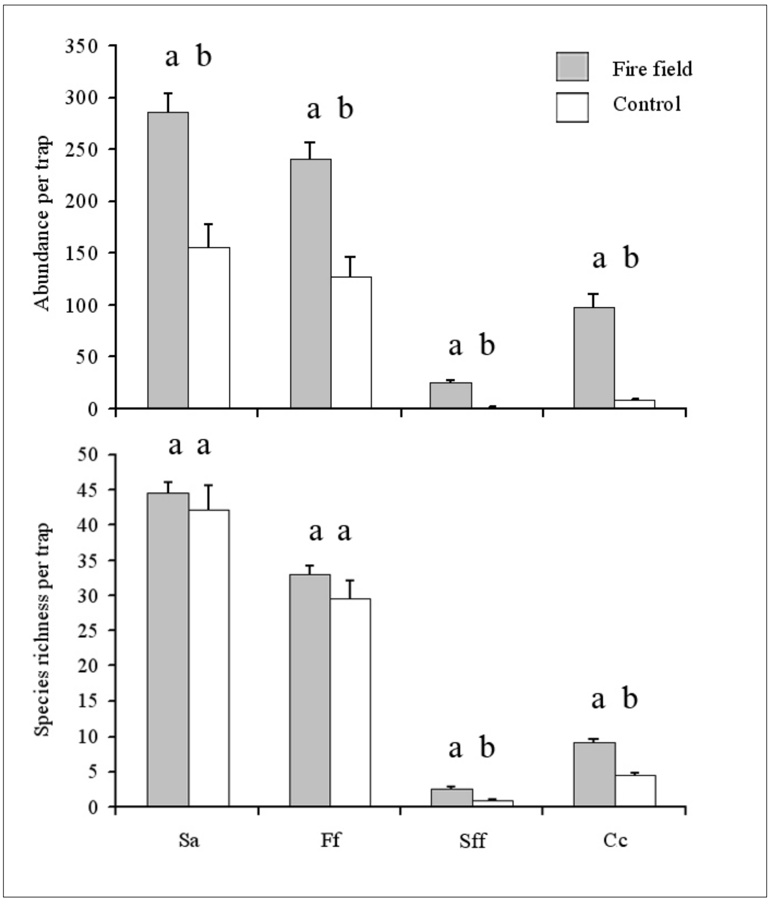

Fig. 3. The abundance and the number of species per trap in the four different categories saproxylic beetles (Sa), fire favoured (Ff), Strongly fire favoured (Sff) and Cambium consuming beetles (Cc) caught during the summer 2007. (mean ± SE, N=18) Overlaps occur between different groups.

Cambium consumers and strongly fire favoured beetles showed higher species richness in the fire field than in the control area (Wilcox, *P* = 0.009, 0.004 respectively) while the two remaining groups fire favoured and saproxylic beetles showed no significant difference in species richness (Wilcox, *P* = 0.688, 0.810 respectively). The total species richness in the group saproxylic beetles was actually slightly higher in the control area than in the fire field (see table 1) while the species richness per trap (mean value of all traps per treatment) was slightly higher in the fire field. This difference in the outcome of the test in comparison to the observed value is probably due to the highly elevated abundance in the fire field which causes the likelihood of trapping each species in each trap to be much higher in the fire field.

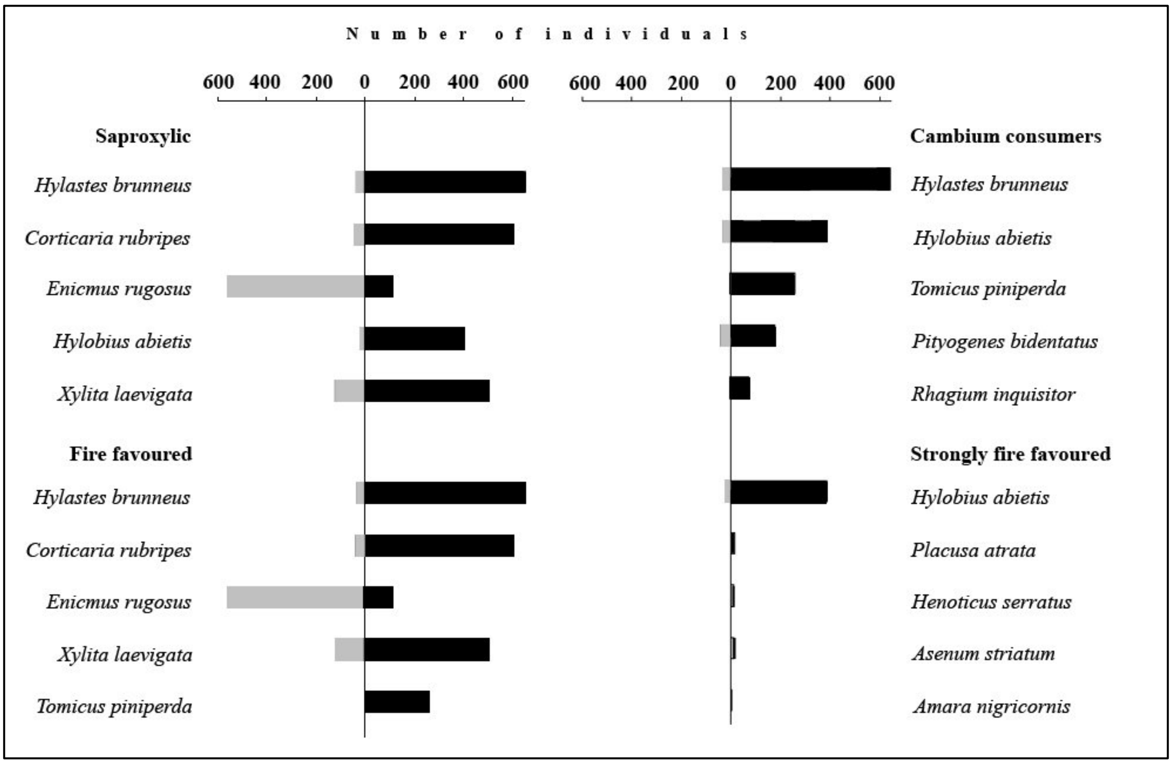

Fig. 4. The abundance per treatment for the five species with the biggest difference in abundance between the fire field and the control per group. Grey represents the control area and black the fire field.

Table. 1. Total species richness and abundance per treatment and group. To the right is shown the total species richness and abundance per group.

Group	Fire field		Control area		Total	
	Species	Abundance	Species	Abundance	Species	Abundance
Saproxylic	158	5148	162	2801	221	7949
Fire favoured	109	4343	109	2283	148	6626
Strongly fire favoured	9	450	5	22	11	472
Cambium consumers	24	1747	19	147	29	1894

Species assemblages

The assemblage composition of beetles differed significantly between the fire field and the control area in all the examined groups. No significant effect of area was recorded in the two group's cambium consumers and strongly fire favoured beetles indicating that the variation among the areas was low (table 2, Figure 5). The nMDS figure shows good grouping of all four groups and separated the fire field from the control. Fire favoured and saproxylic beetles showed very similar patterns which might have been an outcome of the strong species overlap. SIMPER analysis showed that the species mainly responsible for the difference in species assemblage between the fire field and the control was for the group cambium consumers *Tomicus piniperda* 14.38%, strongly fire favoured *Hylobius abietis*

Tab. 2. PERMANOVA shoving the effect of treatment (fire and control) on assemblage of saproxylic, fire favoured, fire dependent and cambium consuming beetles. Error degrees of freedom is 35 for all groups.

	df	MS	F	P
Saproxylic				
Treatment	1	17671.78	12.56	0.002
Area	5	1406.48	1.52	0.000
Fire favoured				
Treatment	1	18727.76	15.43	0.002
Area	5	1213.68	1.40	0.004
Cambium consumers				
Treatment	1	23250.21	14.72	0.002
Area	5	1579.01	1.36	0.089
Strongly fire favoured				
Treatment	1	17659.83	6.76	0.002
Area	5	2613.80	1.61	0.068

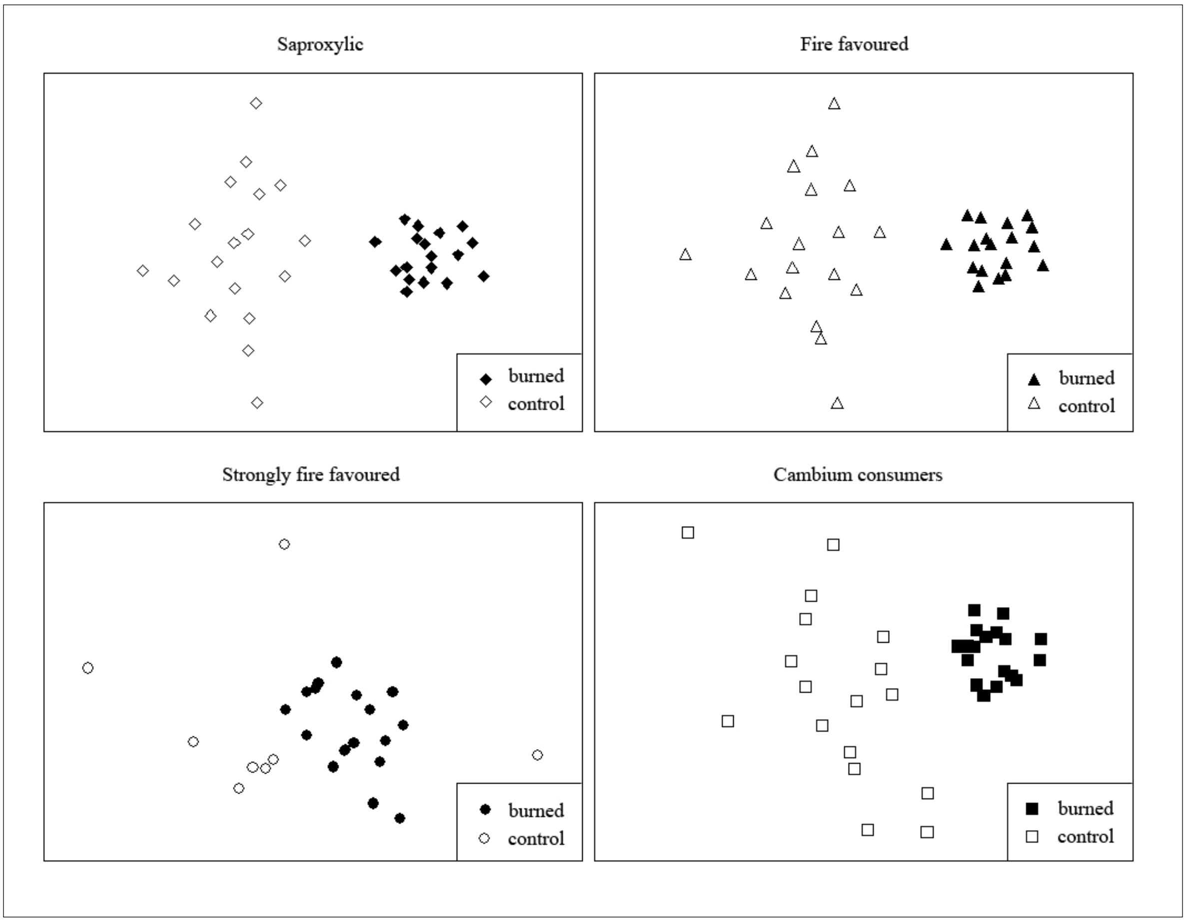

Fig. 5. Result from nMDS ordination. Stress values 0.15, 0.19, 0.09 and 0.15 for saproxylic, fire favoured, strongly fire favoured and cambium consuming beetles respectively

42.80%, fire favoured *T. piniperda* 3.59% and saproxylic beetles *T. piniperda* 2.65% (see table 3 below). Note that the fire favoured species *Scolytus ratzeburgi* was more abundant in the control area than in the fire field.

Tab. 3. The five most important species from the similarity percentages analysis (SIMPER) listed in decreasing order importance.

	Contribution in %	Comparisons
Saproxylic		
Tomicus piniperda	2.65	B > C
Hylobius abietis	2.20	B > C
Atomaria pulchra	2.13	B > C
Corticaria rubripes	2.08	B > C
Hylastes brunneus	1.92	B > C
Fire favoured		
Tomicus piniperda	3.59	B > C
Atomaria pulchra	2.89	B > C
Corticaria rubripes	2.82	B > C
Hylastes brunneus	2.59	B > C
Phloeonomus lapponicus	2.59	B > C
Strongly fire favoured		
Hylobius abietis	42.80	B > C
Henoticus serratus	16.62	B > C
Placusa atrata	12.52	B > C
Asenum striatum	11.77	B > C
Scolytus ratzeburgi	3.98	B < C
Cambium consumers		
Tomicus piniperda	14.38	B > C
Hylobius abietis	11.65	B > C
Rhagium inquisitor	9.86	B > C
Hylastes brunneus	9.48	B > C
Pityogenes bidentatus	8.99	B > C

Discussion

The fire had an enormous effect on the abundance and assemblage composition of beetles in all the examined groups. The total abundance was 79% higher in the fire field than in the control area and the species richness was 9% higher. I will first discuss the impact from the fire on abundance and species richness and later the impact on the assemblage composition of these different groups of beetles.

116 of the total 221 species of saproxylic beetles were more abundant in the unburned control area than in the fire field (see appendix) indicating that there are some saproxylic beetles that react negatively to fire. One reason for this might be that species inhabiting the area before the fire still have not re-colonized, another possible explanation is the fact that some saproxylic species who are also fungivores react negatively to forest fire. Species living on polypores and mushrooms are known to decline after forest fires and rapidly recover when their fungal host re-establish at the site (Muona and Rutanen, 1994). The two group's saproxylic beetles and fire favoured are as previously mentioned overlapping and similar results were expected. The great overlap might be due to a generous definition of fire favoured species where many species generally favoured by disturbance have fallen into the group fire favoured. Hyvärinen et al. (2005) studied the effects of controlled burning on beetle assemblages by using controlled burning. They used different levels of tree retention levels on burned or un-burned plots. In their study they noticed similar patterns as in this study i.e., slightly decreased species richness among saproxylic beetles in their un-harvested, burned plots.

My results are consistent with previous studies (Toivanen and Kotiaho, 2007) where the effects on beetle diversity were studied by using controlled burning and harvesting in combination with the creation of dead wood. Plots were also left un-harvested to mimic natural fire. They concluded was that the use of fire as a tool for conservation increases the overall abundance and species richness of not only pyrophilous (i.e., species strongly attracted to burning or newly burned areas, and species that have their main occurrence in burned forest 0-5 years after the fire (Wikars, 1992)) beetles but also beetle species in general. In the group strongly fire favoured beetles I found two red listed species, *Denticollis borealis* (NT) which thrives at later succession fire fields (Ehnström et al. 1995) and *Tropideres dorsalis* (NT), both species connected to birch (Lundberg, 1984). Although the examined area in the fire field was dominated by Scots pine, damp areas dominated by birch might constitute good habitat for these two species. In total six red listed species exclusive for the fire field was found. *D. borealis* and *T. dorsalis* were two among those. Both species richness and abundance of strongly fire favoured species was higher in fire field. After excluding the most abundant species, *H. abietis* making 89% of the total group abundance, the abundance was still approximately 9 times higher in the fire field. This confirms previous studies (Muona and Rutanen, 1994) showing that many groups including fire specialist's benefits from forest fire.

The results show that cambium consumers are strongly favoured by forest fire. The high numbers of individuals in the burned area was due to high abundance of the bark beetle *Hylastes brunneus*. However, after exclusion of this species the total abundance of cambium consumers was still approximately 5 times higher in the burned area compared with the control and only 6 species out of the total 29 was more abundant in the control area. Both species richness and the abundance were highly elevated in the fire field. Other studies (Johansson et al., 2007; Wikars, 2002) where logs have been treated with fire and later examined has shown that some fire favoured cambium consumers react negatively to burned wood because the cambium dries out during the fire, making it less appropriate as food for early succession bark beetles (Saint-Germain et al., 2004). The examined part of the fire field in Bodträskfors contained a high number of weakened, standing trees that constituted good substrate for these species, which might be one reason for the higher abundance of cambium consumers in the burned area compared with the control area. This indicates that mimicking or examining real fire fields is superior to direct treatment of substrate where much of the important, structural diversity created by natural fires is lost (Vanha-Majamaa et al., 2007).

As seen in Figure 4, a few species dominated the material in each group. These species were mainly *H. brunneus*, *Corticaria rubripes*, *H. abietis*, *T. piniperda* and *Enicmus rugosus* which all but *E. rugosus* had a highly elevated abundance in the fire field. In contrast, *E. rugosus* was more abundant in the control area. Similar results have previously been recorded by Toivanen and Kotiaho (2007). It is previously noted that *E. rugosus* is a species which appears later in the succession after fires (Wikars 1997) and might not have reached its peak in abundance in this study because I only sampled insects the first year after fire. 649 individuals of *H. abietis* were found in the traps at the fire field while 39 were found in the control area. *H. abietis* is considered to be one of the worst pest species in Swedish forests (Ehnström and Axelsson, 2002), a fact well worth thinking about while planning prescribed forest fires in boreal forests. However, the impact of pest bark beetle species may be reduced if the fire occurs after swarming (late June) and it has also been said that the problems with some pest species can be avoided or reduced by increasing the intensity of the fire (Wikars, 1992), something that can be achieved during prescribed fires. However these methods are not yet well tested.

The assemblage of beetle species was dramatically altered by the fire. All four groups experienced large changes in the composition of species. As seen in the nMDS ordination plots, there is a clear separation in the grouping of the beetle assemblages between the fire field and the control area (see Figure 5). The species mostly responsible for the difference in assemblage species composition in this study is also among the most abundant. All species tabulated (Table 2) but one, *S. ratzeburgi*, were more abundant in the fire field which might be surprising when at least parts of the fire field constituted good habitat for this species with high density of living or dying birch. However, only two 2 individuals were found in the control area which makes it difficult to draw any firm conclusions concerning their habitat preference. The occurrence in control areas might be due to random events.

Management and conservation of boreal forest

Sweden is committed under the Convention on Biological Diversity (CBD) to protect biodiversity and to use natural resources sustainably, but production is seemingly more important to the Swedish government than nature conservation. The government of Sweden is now preliminarily planning to increase production in the forest (Greenpeace, 2008), introducing new measures with unknown effects on biodiversity. It is thus more important than ever to develop methods to prevent further biodiversity loss in the forest landscape. One important measure is the creation of dead wood through prescribed burnings. Johansson et al. (2007) concluded that burning of logs was insufficient to create the variation needed to sustain the survival of pyrophilious species. I recommend that fires occurring on government property should be left burning under surveillance to produce larger areas with continuously burned forest. It is of course important to keep the threat from pest species in mind during these actions, but, as previously mentioned, forest fires after swarm time may reduce the risk for mass-outbreaks (Wikars, 1992). It is also an aid to preserve as much as possible of the forest damaged by natural occurring forest fires in the future by the creation of reserves. Prescribed fires as a conservation tool should be planned on large clear cuts where substantial amounts of retention trees are left to create sufficient volumes of substrate and a continuity of burned ground and substrate in the landscape. Although prescribed forest fires, should, as far as possible, be planned in reserves to reduce conflicting interests with forestry, it might be an aid to locate some fires in managed forest. Not all reserves may be suitable for prescribed forest fires, and it is also my conclusion that many reserves is located in the northern part of north Sweden and covering a small part of the forest land in Sweden which might create a geographic bias in the distribution of fire-damaged forest. Because the best response from fire favoured insects have been observed in northern parts of Sweden (Swedish Environmental Protection Agency, 2006) it might be wise to concentrate these actions to this area. To create new dead-wood and to preserve continuity of adequate substrate in the forest landscape, forest fires play a key role and it is therefore needed to further use and investigate the effects of naturally-occurring fires as well as prescribed fires. This study has given support to suggestions of the importance of natural occurring fires by showing a clear enhancement in the abundance and species richness of species strongly favoured by fire as well as a strong alteration in the assemblage composition of several functional groups of beetles. Further research on the effects of large scale forest fires in a landscape with a long history of fire suppression is important to better be able to develop sustainable management plans for species favoured by and adapted to fire.

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Appendix 1. All species caught in the fire field and the control area.

SxO: obligate saproxylic, SxF: facultative saproxylic, NS: non-saproxylic, FF: fire favoured, SFF: strongly fire favoured, PF: pyrophilous, Ca: cambium consumer, D: detritivore, F: Fungivore, P: predator, W: wood borer, NT: near threatened, VU: vulnerable, DD: data deficient. Species written in bold letters where more common in the fire field.

Species name	Saproxylic group	Fire cathegory	Functional group	Redlist cathegory	Burned	Control
Abdera affinis	SxO	FF	F			3
Abdera triguttata	SxO	FF	F		2	
Absidia schoenherri	SxO		P		3	6
Acanthocinus aedilis		FF			4	
Acrotona pusilla	Unknown	Unknown	Unknown	Unknown	1	
Acrotrichis insularis			F			9
Acrotrichis intermedia			F		1	
Acrulia inflata	SxF		?F			1
Agathidium arcticum	SxF		F			1
Agathidium mandibulare	SxF		F	NT	1	2
Agathidium pallidum	SxF		F	NT	1	
Agathidium pisanum	SxO	FF	F			8
Agathidium rotundatum	SxF	FF	F		3	7
Agathidium seminulum	SxF		F		78	45
Aleochara fumata			?P		1	2
Aleochara moerens			?P			3
Aleochara sparsa	Unknown	Unknown	Unknown	Unknown	2	
Aleochara stichai	SxF		?P		1	
Aloconota planifrons			?P			1
Altica longicollis			H		8	
Amara familiaris	NS				1	
Amara nigricornis		SFF	H,P		2	
Amischa analis			?P		3	
Ampedus balteatus	SxO	FF	P,W		13	22
Ampedus nigrinus	SxO	FF	P,W		10	48
Ampedus tristis	SxO	FF	P,W		68	5
Anaspis bohemica	SxO		P		1	
Anaspis rufilabris	SxO		P			4
Anisotoma axillaris	SxO	FF	F		3	3
Anisotoma castanea	SxO	FF	F		1	3
Anisotoma glabra	SxO	FF	F		18	12
Anisotoma humeralis	SxO	FF	F			2
Anomognathus cuspidatus	SxO	FF	D,P			3
Anoplodera reyi	SxO		W		1	1
Anotylus clavatus			?P			1
Aphodius ater			D		4	1
Aphodius depressus			D			4

Species name	Saproxylic group	Fire cathegory	Functional group	Redlist cathegory	Burned	Control
Aphodius lapponum			D		10	12
Aphodius nemoralis			D		20	10
Aphodius rufipes			D		13	30
Arpidiphorus orbiculatus	SxF	FF	F			6
Asemum striatum	SxO	SFF	C,W		10	1
Atheta aquatica	Unknown	Unknown	Unknown	Unknown	1	
Atheta crassicornis	Unknown	Unknown	Unknown	Unknown		5
Atheta euryptera	SxF				4	
Atheta nigricornis	SxF				5	
Atheta pilicornis	SxF				1	
Atheta procera	Unknown	Unknown	Unknown	Unknown		2
Athous subfuscus	SxF		P		5	3
Atomaria alpina	SxO		F	NT		12
Atomaria atrata		FF	F		9	
Atomaria bella	SxO	FF	F		16	32
Atomaria fuscata	SxF		F		1	
Atomaria lewisi			F		1	
Atomaria nitidula	Unknown	Unknown	Unknown	Unknown		1
Atomaria ornata	SxF		F			3
Atomaria peltata	SxF		F		1	
Atomaria procerula	SxF	FF	F		1	
Atomaria pulchra	SxF	FF	F		187	9
Atomaria rubella			F			1
Atomaria umbrina	SxO	FF	F			2
Atrecus affinis	SxO		P			11
Atrecus longiceps	SxO		?P		1	6
Atrecus pilicornis	SxO	FF	?P		2	
Batrisodes hubenthali		FF		VU	1	
Bembidion grapii			P		1	
Bembidion lampros			P		1	
Bibloporus bicolor	SxO	FF	P		1	13
Bibloporus minutus	SxO	FF	P		1	3
Bolitochara pulchra	SxF		?F		2	
Bolitophagus reticulatus	SxO	FF	F		2	
Boreophila eremita	Unknown	Unknown	Unknown	Unknown	1	
Bradycellus caucasicus			?P		1	
Bryoporus cernuus	SxF		?P			1
Byrrhus pilula			H		4	1
Caenoscelis ferruginea	SxF	FF	F		13	
Calitys scabra		FF		VU	1	
Cantharis paludosa			?P		1	
Cardiophorus ruficollis	SxO		D,W		1	
Cartodere constricta	SxF		F		21	
Catops alpinus			D			2
Catops coracinus			D			4

Species name	**Saproxylic group**	**Fire cathegory**	**Functional group**	**Redlist cathegory**	**Burned**	**Control**
Cerylon deplanatum		FF	F			2
Cerylon ferrugineum	SxO	FF	F			14
Cerylon histeroides	SxO	FF	F		289	138
Chilocorus renipustulatus	NS				1	
Cis bidentatus	SxO	FF	F		3	13
Cis boleti	SxO		F		45	56
Cis comptus	SxO	FF	F		6	17
Cis dentatus	SxO	FF	F	NT		3
Cis hispidus	SxO		F		7	30
Cis jacquemartii	SxO		F			1
Cis lineatocribratus	SxO		F		3	14
Cis punctulatus	SxO	FF	F		2	49
Coccinella trifasciata			P			1
Coccinula quadriguttatus	NS				3	
Coccinula quattuordecimpustulata			P		3	
Corticaria abietorum	SxF	FF	F		1	
Corticaria fennica	SxO		F	DD		1
Corticaria ferruginea	SxF	FF	F		56	1
Corticaria interstitialis	SxF		F		1	6
Corticaria lapponica	SxO	FF	F		1	
Corticaria orbicollis	SxO	FF	F		5	6
Corticaria rubripes	SxF	FF	F		607	40
Corticaria saginata			F		1	
Corticarina fuscula	SxF	FF	F		11	
Cortinicara gibbosa	SxF	FF	F		1	
Cryptophagus confertus	?		F		1	
Cryptophagus confusus	SxO	FF	F			3
Cryptophagus dentatus	SxF		F		12	14
Cryptophagus dorsalis	SxF	FF	F		2	8
Cryptophagus lapponicus	SxF	FF	F		15	96
Cryptophagus lysholmi	SxO	FF	F	VU	3	
Cryptophagus saginatus	Unknown	Unknown	Unknown	Unknown	1	
Cryptophagus subdepressus	Unknown	Unknown	Unknown	Unknown	6	
Crypturgus cinereus	SxO	FF	C		2	
Crypturgus pusillus	SxO	FF	C		1	4
Curtimorda maculosa	SxO	FF	F		1	
Cyphon coarctatus			H		2	
Cyphon padi			D,H		7	1
Cyphon pubescens			D,H		35	4
Cytilus sericeus			H		1	
Dacne bipustulata	SxO	FF	F		353	311
Dasytes obscurus	SxO		?P			2
Dendrophagus crenatus	SxO	FF	F		1	3
Dendrophilus pygmaeus	SxF		P		2	
Denticollis borealis	SxO	SFF	P,W	NT	1	

Species name	Saproxylic group	Fire cathegory	Functional group	Redlist cathegory	Burned	Control
Dictyoptera aurora	SxO	FF	P		2	7
Dinaraea aequata	SxO	FF	?F		2	1
Dinaraea linearis	SxO	FF	?F		1	4
Dorcatoma robusta	SxO	FF	F			2
Dromius agilis	SxF	FF	P			7
Dryocoetes autographus	SxO		C		20	3
Dryocoetes hectographus	SxO		C		32	17
Eanus costalis			?		23	91
Enicmus fungicola	SxO	FF	F		3	4
Enicmus planipennis	SxO		F		1	3
Enicmus rugosus	SxO	FF	F		113	560
Ennearthron cornutum		FF				2
Ennearthron laricinum	SxO	FF	F	NT		2
Enochrus affinis	Unknown	Unknown	Unknown	Unknown		2
Episernus angulicollis	SxO	FF	W		2	6
Epuraea aestiva	SxF		F			1
Epuraea angustula	SxO	FF	F,P			1
Epuraea biguttata	SxO	FF	F		2	
Epuraea boreella	SxO	FF	F,P		5	3
Epuraea contractula	SxO	FF	F		8	
Epuraea marseuli	SxO	FF	D,F		13	1
Epuraea pygmaea	SxO	FF	D,F		5	4
Epuraea rufomarginata	SxF	FF	F		6	
Epuraea silacea	SxO		F		4	31
Epuraea variegata	SxO	FF	F		1	
Euaesthetus ruficapillus	NS				1	
Euconnus maeklinii	SxF					1
Eudectus giraudi	SxO	FF	?F			3
Euplectus piceus	SxF		P		2	1
Euplectus punctatus	SxO		P		12	40
Euryusa castanoptera	SxO	FF	?F		4	4
Gabrius expectatus	SxF	FF	P		8	44
Glischrochilus quadripunctatus	SxO	FF	F,P		46	1
Globicornis emarginata	SxO	FF	D		1	1
Gyrophaena affinis	SxF		F		1	
Gyrophaena boleti	SxO		F			1
Hadrobregmus confusus		FF		VU		2
Hadrobregmus pertinax	SxO	FF	W		9	19
Hallomenus binotatus	SxO		F			2
Hapalaraea clavigera	SxO	FF	?P	NT	3	1
Hapalaraea linearis	SxO	FF	?P		1	
Haploglossa marginalis	SxF		?F		1	
Haploglossa nidicola	Unknown	Unknown	Unknown	Unknown		1
Haploglossa villosula	SxF		?F		32	60
Henoticus serratus	SxF	SFF	F		12	

Species name	Saproxylic group	Fire cathegory	Functional group	Redlist cathegory	Burned	Control
Holobus apicatus		FF				1
Homalota plana	SxO	FF	?F		1	
Hydroporus nigrita			P		1	
Hylastes brunneus	SxO	FF	C		649	39
Hylastes cunicularius	SxO	FF	C		56	1
Hylastes opacus	SxO		C		6	
Hylecoetus dermestoides	SxO	FF	W,F		1	10
Hylobius abietis	SxO	SFF	C,W		404	17
Hylurgops glabratus	SxO		C		1	1
Ischnoglossa elegantula	SxF		?F			2
Judolia sexmaculata	SxO		C,W			1
Lacon conspersus	SxO	FF	P	NT		3
Lacon fasciatus	SxO	FF	P		3	
Latridius consimilis	SxF	FF	F		2	5
Latridius hirtus	SxO	FF	F		1	8
Latridius minutus	SxF	FF	F		1	
Latridius nidicola	SxF		F			1
Leiodes rhaetica	NS				1	
Leptusa fumida	SxO	FF	?F		1	8
Leptusa pulchella	SxO	FF	?F			4
Limonius aeneoniger			?		2	
Longitarsus holsaticus	NS				1	
Lordithon lunulatus	SxF		P			5
Lordithon speciosus	SxO		P			1
Lordithon thoracicus	SxF		P			1
Lythraria salicariae			H		1	
Magdalis phlegmatica	SxO				1	
Magdalis violacea	SxO		C		3	
Malthinus biguttatus	SxO		?P			1
Malthodes fuscus	SxO		?P		2	5
Malthodes guttifer	SxO		?P		3	5
Megasternum obscurum			P		1	1
Melandrya dubia		FF		VU		1
Melanotus castanipes	SxO	FF	P,W		4	17
Microdota subtilis	Unknown	Unknown	Unknown	Unknown		1
Molorchus minor	SxO		C,W		1	1
Mycetochara flavipes	SxO	FF	?			1
Mycetochara obscura	SxO	FF	?	NT	2	102
Mycetophagus fulvicollis	SxO		F	NT	2	
Mycetophagus multipunctatus	SxO					1
Mycetophagus populi	SxO					7
Mycetoporus lepidus			P		14	11
Myrmetes paykulli			P		4	
Myzia oblongoguttata			P			3
Nepachys cardiacae	SxO	FF	P		1	

Species name	Saproxylic group	Fire cathegory	Functional group	Redlist cathegory	Burned	Control
Nephus bisignatus			P		2	
Nevraphes coronatus	SxF		P			1
Notiophilus aquaticus			P			1
Notiophilus biguttatus			P		21	4
Notothecta flavipes	Unknown	Unknown	Unknown	Unknown	1	
Nudobius lentus	SxO	FF	P		2	
Omalium caesum	SxF		?P		3	
Orchesia fasciata	SxO		F	NT	1	1
Orchesia micans	SxO	FF	F		2	15
Orchesia minor	SxO		F	NT		1
Orithales serraticornis			?		6	
Orthocis alni	SxO	FF	F			7
Orthocis linearis	SxO	FF	F		1	
Orthomicus suturalis	SxO				2	
Orthoperus atomus	SxF	FF	F			1
Ostoma ferruginea	SxO	FF	F		2	3
Oxymirus cursor	SxO	FF	W			3
Oxypoda elongatula			?F		1	
Oxypoda skalitzkyi	SxF		?F		2	1
Oxypoda spectabilis	SxF		?F			1
Oxypoda umbrata	Unknown	Unknown	Unknown	Unknown	1	
Philonthus sordidus	Unknown	Unknown	Unknown	Unknown	1	
Phloeonomus lapponicus	SxO	FF	P		87	
Phloeonomus planus	SxO	FF	?P		49	1
Phloeonomus pusillus	SxO	FF	P		2	2
Phloeonomus sjoebergi	SxO	FF	?P			1
Phloeopora concolor		FF			1	1
Phloeopora corticalis	SxO	FF	?P		1	4
Phloeopora testacea	SxO	FF	?P		1	
Phloeotribus spinulosus	SxO		C		1	1
Phyllodrepa melanocephala	SxF	FF				5
Pissodes gyllenhalii	SxO		C		2	
Pissodes pini	SxO	FF	C		6	
Pityogenes bidentatus	SxO	FF	C		198	20
Pityogenes chalcographus	SxO	FF	C		3	
Pityogenes quadridens	SxO	FF	C		10	
Pityophagus ferrugineus	SxO	FF	P		51	
Placusa atrata	SxO	SFF	?P		17	1
Placusa depressa	SxO	FF	?P		1	
Platycerus caprea	SxO	FF	W		2	4
Platydracus fulvipes	Unknown	Unknown	Unknown	Unknown		1
Plegaderus vulneratus	SxO	FF	P			1
Podabrus alpinus			?P		1	1
Pogonocherus decoratus	SxO		C,W		1	
Pogonocherus fasciculatus	SxO	FF	C,W			1

Species name	Saproxylic group	Fire cathegory	Functional group	Redlist cathegory	Burned	Control
Polygraphus punctifrons	SxO	FF	C			2
Polygraphus subopacus	SxO	FF	C		2	1
Porrhodites fenestralis	Unknown	Unknown	Unknown	Unknown	33	
Potosia cuprea spp metallica	SxF					2
Prosternon tessellatum	Unknown	Unknown	Unknown	Unknown	2	6
Pseudomedon obscurellus	Unknown	Unknown	Unknown	Unknown	1	
Pterostichus adstrictus		FF	P		1	
Pterostichus oblongopunctatus		FF	P		1	
Pteryx suturalis	SxO	FF	F			1
Pytho depressus	SxO	FF	C		3	
Quedius plagiatus	SxO	FF	P			6
Quedius tenellus	SxF		?P			2
Rhagium inquisitor	SxO	FF	C,W		76	3
Rhagonycha atra	?		?P		2	4
Rhagonycha elongata	?		?P		4	1
Rhizophagus bipustulatus		FF				3
Rhizophagus dispar	SxF	FF	P			2
Rhizophagus ferrugineus	SxO	FF	P		35	15
Rhizophagus nitidulus	SxO	FF	P			5
Rhizophagus parvulus	SxO	FF	P		193	32
Rhyncolus sculpturatus	SxO	FF	W		4	10
Ropalodontus strandi	(tom)				1	4
Salpingus ruficollis	SxO	FF	P			4
Scaphisoma agaricinum	SxF	FF	?F		71	113
Sciodrepoides fumatus	NS					2
Sciodrepoides watsoni			?P		1	1
Scolytus ratzeburgi	SxO	SFF	C			2
Scymnus limbatus	NS				1	
Selatosomus aeneus			?		1	1
Selatosomus impressus	SxF		P		5	18
Selatosomus melancholicus			?		16	
Sepedophilus testaceus	SxF		F			10
Sericoda quadripunctata		PF			1	
Sericus brunneus			?		23	8
Sogda suturalis	Unknown	Unknown	Unknown	Unknown	1	
Soronia grisea	SxO		D			2
Sphindus dubius	SxF	FF	F		2	4
Stenichnus bicolor	SxF	FF	P			4
Stenotrachelus aeneus	SxO	SFF	C,W		2	
Stenus clavicornis			P		1	
Stenus europaeus	Unknown	Unknown	Unknown	Unknown	1	
Stenus strandi	Unknown	Unknown	Unknown	Unknown	1	
Stephanopachys linearis		PF		VU	1	
Stephostethus pandellei	SxF	FF	F			2
Stephostethus rugicollis	SxF		F		1	1

Species name	Saproxylic group	Fire cathegory	Functional group	Redlist cathegory	Burned	Control
Strophosoma capitatum		FF	H		9	2
Sulcacis affinis	SxO	FF	F		2	1
Synchita humeralis		SFF				1
Syneta betulae			H			1
Tachinus atripes			?F,?P			1
Tachinus basalis				DD		1
Tachinus elongates	NS				1	1
Tachinus pallipes			?F,?P			2
Tachinus proximus			?F,?P		1	1
Tachyta nana	SxO	SFF	P		1	
Tanasimus formicarius	SxO				2	
Tetratoma ancora	SxO	FF	F			4
Thalycra fervida	Unknown	Unknown	Unknown	Unknown	5	2
Thanasimus formicarius	SxO	FF	P		23	1
Thyasophila angulata			?P		1	
Thyasophila canaliculata	Unknown	Unknown	Unknown	Unknown		1
Tomicus piniperda	SxO	FF	C		258	2
Triplax aenea	SxO	FF	F		1	6
Triplax russica	SxO	FF	F		12	49
Triplax scutellaris	SxO	FF	F		6	40
Tropideres dorsalis		SFF		NT	1	
Trypodendron lineatum	SxO	FF	F		37	13
Trypodendron proximum	SxO				44	35
Tyrus mucronatus	SxF	FF	?F		8	
Xenota myrmecobia	Unknown	Unknown	Unknown	Unknown	10	6
Xylechinus pilosus	SxO		C			30
Xylita laevigata	SxO	FF	F		506	122
Zilora ferruginea	SxO	FF	F	NT	1	
Total abundance					5507	3079
Total species richness					239	221