



Examensarbete i ämnet biologi

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

Jon Andersson



Handledare: Therese Johansson & Joakim Hjältén

15 Poäng, C-nivå



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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 were placed in the fire field and the same number of traps were placed in a control area close to the fire field. Data from this survey were later analysed with Wilcoxon's 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 in the control area I 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 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 recolonize 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. 66° 9' N, 20° 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.

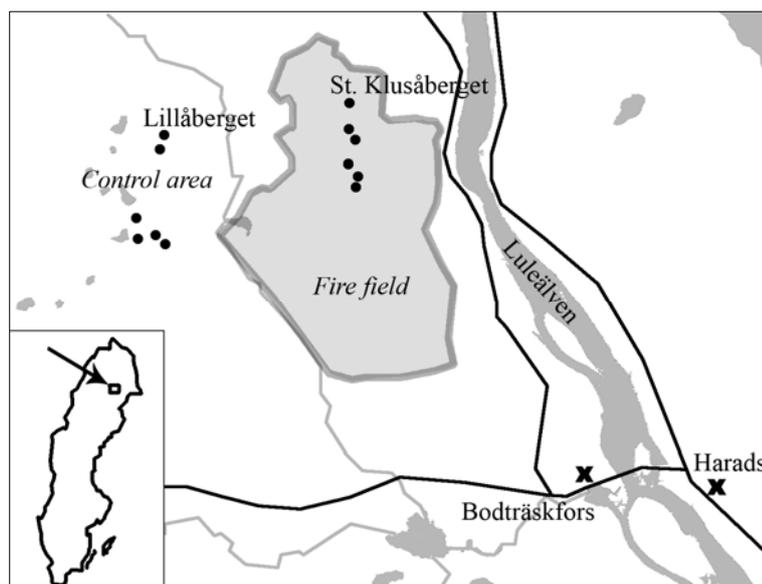


Fig. 1. Map showing study areas (black dots), location of the fire field and closest localities. Location of the section is presented in the inset (lower left corner).

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 m². 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 had 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).

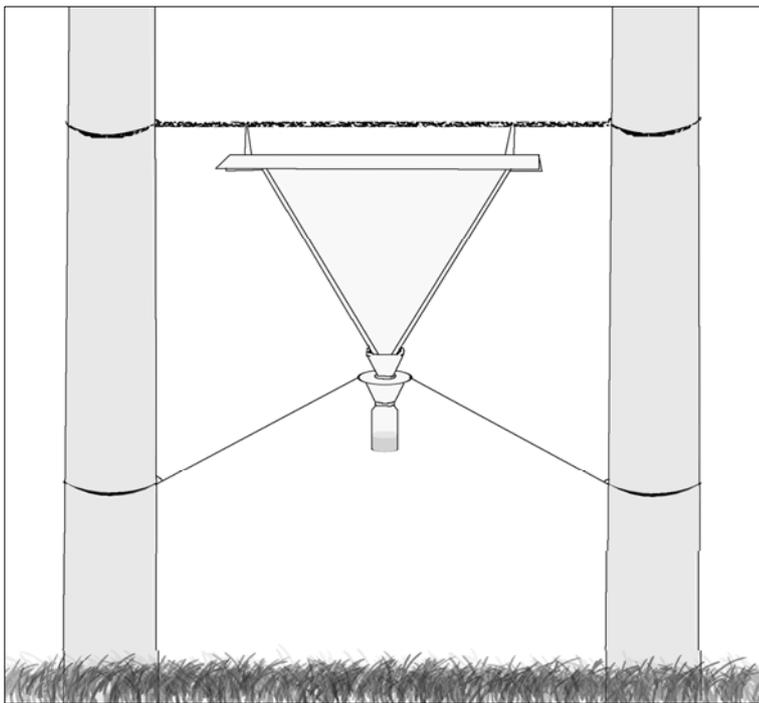


Fig. 2. The IBL-trap attached with threads between two trees. Funnels and collective jar is hanging under the triangular plastic sheet.

I tied the traps between appropriate trees with threads and placed them in a triangular pattern to cover different angles 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.

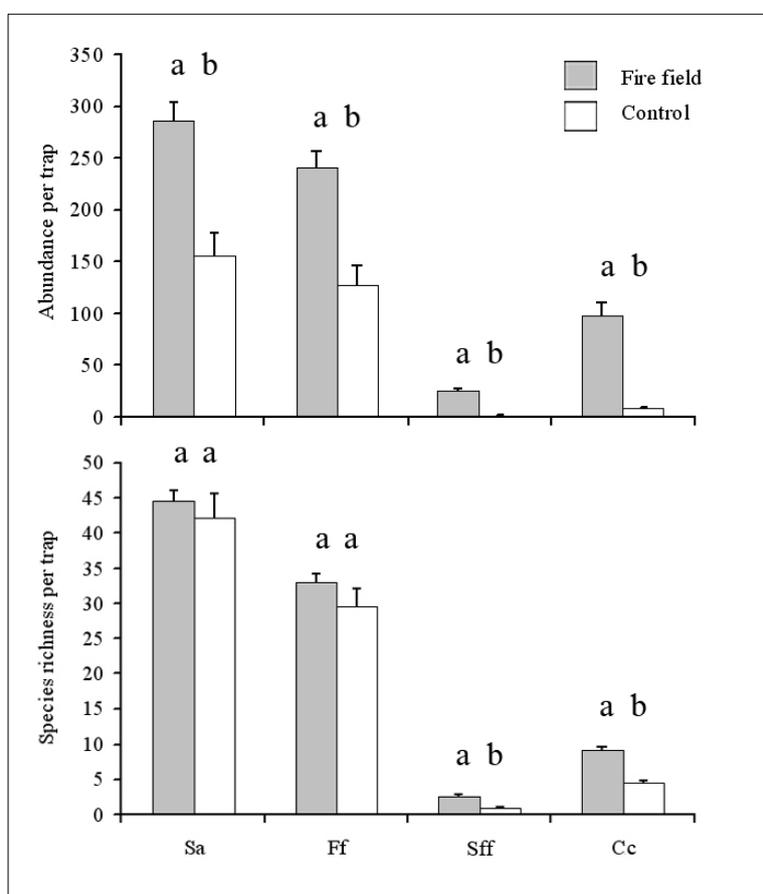


Fig. 3. The abundance and the number of species per trap in the four different categories saproxylic beetles (Sa), fire favoured (Ff), Strongly fire favoured (Sff) and Cambium consuming beetles (Cc) caught during the summer 2007. (mean \pm SE, N=18) Overlaps occur between different groups.

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.

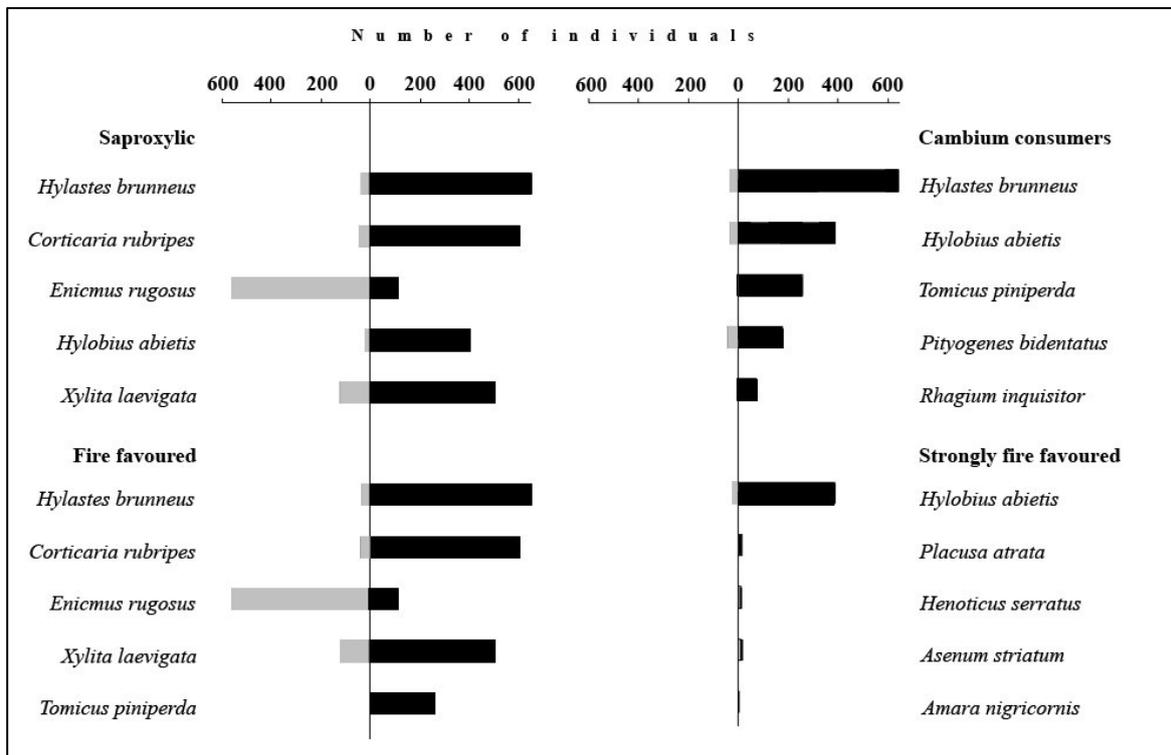


Fig. 4. The abundance per treatment for the five species with the biggest difference in abundance between the fire field and the control per group. Grey represents the control area and black the fire field.

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
Saproxyltic	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 saproxyltic 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 showing the effect of treatment (fire and control) on assemblage of saproxyltic, fire favoured, fire dependent and cambium consuming beetles. Error degrees of freedom is 35 for all groups.

	df	MS	F	P
Saproxyltic				
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

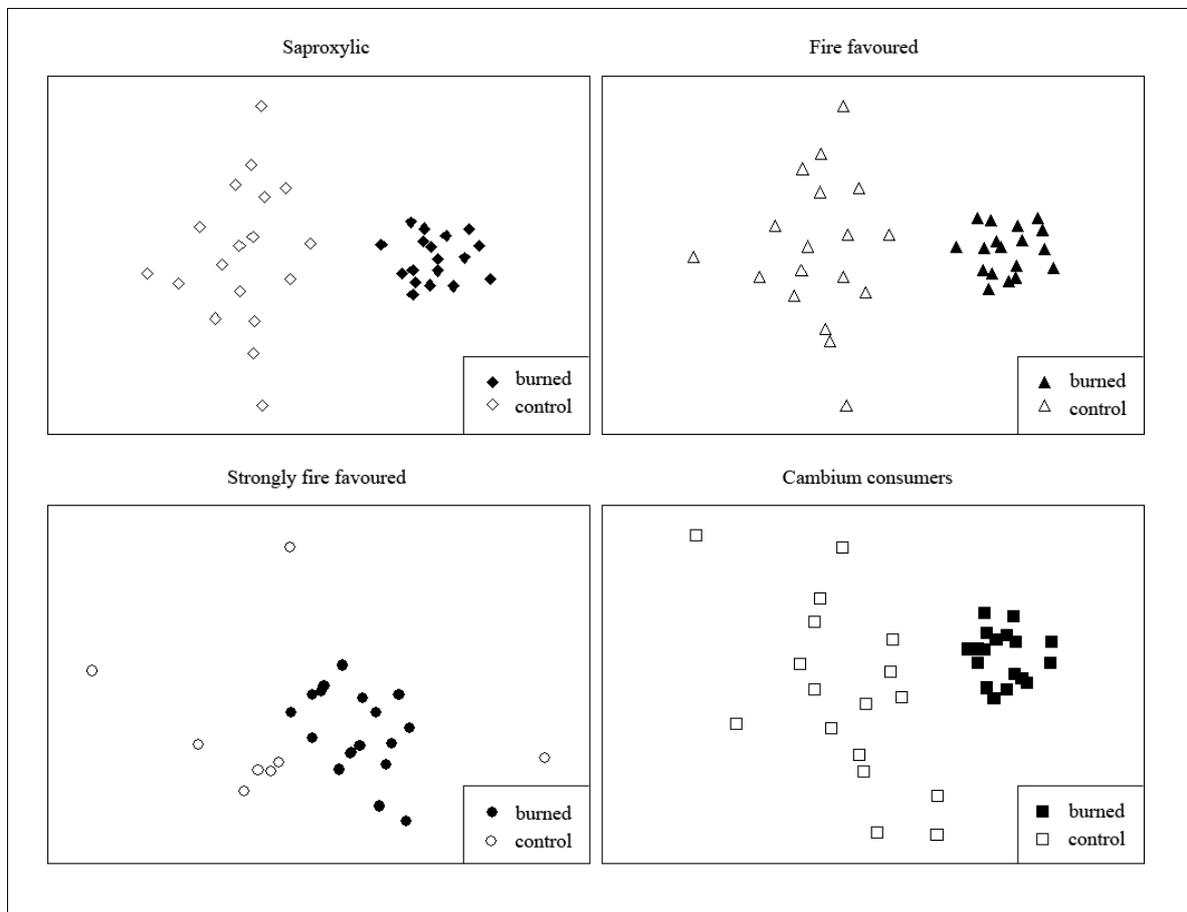


Fig. 5. Result from nMDS ordination. Stress values 0.15, 0.19, 0.09 and 0.15 for saproxylic, fire favoured, strongly fire favoured and cambium consuming beetles respectively

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		
<i>Tomicus piniperda</i>	2.65	B > C
<i>Hylobius abietis</i>	2.20	B > C
<i>Atomaria pulchra</i>	2.13	B > C
<i>Corticaria rubripes</i>	2.08	B > C
<i>Hylastes brunneus</i>	1.92	B > C
Fire favoured		
<i>Tomicus piniperda</i>	3.59	B > C
<i>Atomaria pulchra</i>	2.89	B > C
<i>Corticaria rubripes</i>	2.82	B > C
<i>Hylastes brunneus</i>	2.59	B > C
<i>Phloeonomus lapponicus</i>	2.59	B > C
Strongly fire favoured		
<i>Hylobius abietis</i>	42.80	B > C
<i>Henoticus serratus</i>	16.62	B > C
<i>Placusa atrata</i>	12.52	B > C
<i>Asenum striatum</i>	11.77	B > C
<i>Scolytus ratzeburgi</i>	3.98	B < C
Cambium consumers		
<i>Tomicus piniperda</i>	14.38	B > C
<i>Hylobius abietis</i>	11.65	B > C
<i>Rhagium inquisitor</i>	9.86	B > C
<i>Hylastes brunneus</i>	9.48	B > C
<i>Pityogenes bidentatus</i>	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 groups of 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 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, Car: 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 category	Functional group	Redlist category	Burned	Control
<i>Abdera affinis</i>	SXO	FF	F		2	3
<i>Abdera triguttata</i>	SXO	FF	F		3	6
<i>Absidia schoenherri</i>	SXO	FF	P		4	
<i>Acartthocius aedilis</i>		FF			1	9
<i>Acrotoma pusilla</i>	Unknown	Unknown	Unknown	Unknown	1	
<i>Acrotichis insularis</i>			F		1	
<i>Acrotichis intermedia</i>			F		2P	1
<i>Acrulia inflata</i>	SXF		2F			1
<i>Agathidium arcticum</i>	SXF		F			1
<i>Agathidium mandibulare</i>	SXF		F	NT	1	2
<i>Agathidium pallidum</i>	SXF		F	NT	1	
<i>Agathidium pisanum</i>	SXO	FF	F		3	8
<i>Agathidium rotundatum</i>	SXF	FF	F		78	45
<i>Agathidium seminulum</i>	SXF		F		2P	2
<i>Aleochara fumata</i>			2P			3
<i>Aleochara moerens</i>			2P			
<i>Aleochara sparsa</i>	Unknown	Unknown	Unknown	Unknown	2	
<i>Aleochara stichal</i>	SXF		2P		1	1
<i>Aloconota planifrons</i>			2P		8	
<i>Altica longicollis</i>			H		1	
<i>Amara familiaris</i>	NS		H,P		2	
<i>Amara nigricornis</i>		SFF	2P		3	
<i>Amischa analis</i>			2P		13	22
<i>Ampeplus balteatus</i>	SXO	FF	P,W		10	48
<i>Ampeplus nigrinus</i>	SXO	FF	P,W		68	5
<i>Ampeplus tristis</i>	SXO	FF	P,W		1	4
<i>Anaspis bohemica</i>	SXO		P		3	3
<i>Anaspis rufilabris</i>	SXO		F		1	3
<i>Anisotoma axillaris</i>	SXO	FF	F		1	3
<i>Anisotoma castanea</i>	SXO	FF	F		18	12
<i>Anisotoma glabra</i>	SXO	FF	F		2	2
<i>Anisotoma humeralis</i>	SXO	FF	F		D,P	3
<i>Anomognathus cuspidatus</i>	SXO		W		1	1
<i>Anoplodera reyi</i>	SXO		2P		4	1
<i>Anoxylius clavatus</i>			D		1	1
<i>Aphodius ater</i>			D		4	4
<i>Aphodius depressus</i>			D			

Species name	Saproxyllic group	Fire category	Functional group	Redlist category	Burned	Control
<i>Aphodius lapponum</i>			D		10	12
<i>Aphodius nemoralis</i>			D		20	10
<i>Aphodius rufipes</i>			D		13	30
<i>Asenum striatum</i>	SxF	FF	F		6	
	SxO	SFF	C,W		10	1
<i>Atheta aquatica</i>	Unknown	Unknown	Unknown	Unknown	1	
<i>Atheta crassicornis</i>	Unknown	Unknown	Unknown	Unknown		5
<i>Atheta euryptera</i>	SxF				4	
<i>Atheta nigricornis</i>	SxF				5	
<i>Atheta pilicornis</i>	SxF				1	
<i>Atheta procerata</i>	Unknown	Unknown	Unknown	Unknown		2
<i>Atthous subfuscus</i>	SxF		P		5	3
<i>Atomaria alpina</i>	SxO		F			12
<i>Atomaria atrata</i>				NT		
	SxO	FF	F		9	
	SxO	FF	F		16	32
<i>Atomaria bella</i>			F		1	
<i>Atomaria fuscata</i>	SxF		F		1	
<i>Atomaria lewisi</i>			F		1	
<i>Atomaria nitidula</i>	Unknown	Unknown	Unknown	Unknown		1
<i>Atomaria ornata</i>	SxF		F			3
<i>Atomaria pelata</i>	SxF		F		1	
<i>Atomaria procerula</i>	SxF	FF	F		1	
<i>Atomaria pulchra</i>	SxF	FF	F		187	9
<i>Atomaria rubella</i>			F		1	
<i>Atomaria umbrina</i>	SxO	FF	F		2	
<i>Atomaria umbrina</i>	SxO		P			11
<i>Atreous affinis</i>	SxO		P			
<i>Atreous longiceps</i>	SxO		?P		1	6
<i>Atreous pilicornis</i>	SxO	FF	?P		2	
<i>Batrissodes hubenthalii</i>		FF		VU	1	
<i>Bembidion grapti</i>			P		1	
<i>Bembidion lampros</i>			P		1	
<i>Biblioporus bicolor</i>	SxO	FF	P		1	13
<i>Biblioporus minutus</i>	SxO	FF	P		1	3
<i>Bolitochara pulchra</i>	SxF		?F		2	
<i>Bolitochagus reticulatus</i>	SxO	FF	F		2	
<i>Boreophila ereinita</i>	Unknown	Unknown	Unknown	Unknown	1	
<i>Bradycellus caucasicus</i>	SxF		?P		1	
<i>Bryoporus cernuus</i>			?P			1
<i>Byrrhus pilula</i>			H		4	1
<i>Caenoscelis ferruginea</i>	SxF	FF	F		13	
<i>Callys scabra</i>		FF		VU	1	
<i>Cantharis paludosa</i>			?P		1	
<i>Cardiophorus ruficollis</i>	SxO		D,W		1	
<i>Cardodere constricta</i>	SxF		F		21	
<i>Catops alpinus</i>			D			2
<i>Catops coracinus</i>			D			4

Species name	Saproxyllic group	Fire category	Functional group	Redlist category	Burned	Control
<i>Cerylon deplanatum</i>		FF	F			2
<i>Cerylon ferrugineum</i>	SxO	FF	F			14
<i>Cerylon histeroides</i>	SxO	FF	F		289	138
<i>Chilocorus renipustulatus</i>	NS					
<i>Cis bidentatus</i>	SxO	FF	F		1	13
<i>Cis boleti</i>	SxO		F		3	13
<i>Cis compus</i>	SxO	FF	F		45	56
<i>Cis dentatus</i>	SxO	FF	F		6	17
<i>Cis hispidus</i>	SxO	FF	F	NT		
<i>Cis jacquemartii</i>	SxO		F		7	30
<i>Cis lineatorioratus</i>	SxO		F		3	1
<i>Cis punctulatus</i>	SxO	FF	F		3	14
<i>Coccinella trifasciata</i>			F		2	49
<i>Coccinella quadrigutatus</i>	NS		P			1
<i>Coccinula quattuordecimpustulata</i>			P		3	
<i>Corticaria abietorum</i>	SxF	FF	F		3	
<i>Corticaria fenica</i>	SxO		F		1	1
<i>Corticaria ferruginea</i>	SxF	FF	F	DD	56	1
<i>Corticaria interstitialis</i>	SxF		F		1	6
<i>Corticaria lapponica</i>	SxO	FF	F		1	
<i>Corticaria orbicollis</i>	SxO	FF	F		5	6
<i>Corticaria rubripes</i>	SxF	FF	F		607	40
<i>Corticaria saginata</i>			F		1	
<i>Corticaria fuscata</i>	SxF	FF	F		11	
<i>Corticaria gibbosa</i>	SxF	FF	F		1	
<i>Cryptophagus confertus</i>	?		F		1	
<i>Cryptophagus confusus</i>	SxO	FF	F			3
<i>Cryptophagus dentatus</i>	SxF		F		12	14
<i>Cryptophagus dor-salis</i>	SxF	FF	F		2	8
<i>Cryptophagus lapponicus</i>	SxF	FF	F		15	96
<i>Cryptophagus lysholmi</i>	SxO	FF	F	VU	3	
<i>Cryptophagus saginatus</i>	Unknown	Unknown	Unknown	Unknown	1	
<i>Cryptophagus subdepressus</i>	Unknown	Unknown	Unknown	Unknown	6	
<i>Crypturgus chinereus</i>	SxO	FF	C		2	
<i>Curtimorda pusillus</i>	SxO	FF	C		1	4
<i>Curtimorda maculosa</i>	SxO	FF	F		1	
<i>Cyphon coarctatus</i>			H		2	
<i>Cyphon padi</i>			H			
<i>Cyphon pubescens</i>			D,H		7	1
<i>Cytilus sericeus</i>			D,H		35	4
<i>Dacne bipustulata</i>	SxO	FF	F		1	
<i>Dasytes obscurus</i>	SxO		?P		353	311
<i>Dendrophagus crenatus</i>	SxO	FF	F		1	2
<i>Dendrophilus pygmaeus</i>	SxF		P		1	3
<i>Denticollis borealis</i>	SxO	SFF	P,W	NT	1	

Species name	Saproxyllic group	Fire category	Functional group	Redlist category	Burned	Control
<i>Diclyptera aurora</i>	SxO	FF	P		2	7
<i>Dinaraea aequata</i>	SxO	FF	?F		2	1
<i>Dinaraea linearis</i>	SxO	FF	?F		1	4
<i>Dorcatoma robusta</i>	SxO	FF	F			2
<i>Dromius agilis</i>	SxF	FF	P		7	
<i>Dryocoetes autographus</i>	SxO		C		20	3
<i>Dryocoetes hectographus</i>	SxO		C		32	17
<i>Earnus costalis</i>	SxO		?		23	91
<i>Enicmus fungicola</i>	SxO	FF	F		3	4
<i>Enicmus planipennis</i>	SxO	FF	F		1	3
<i>Enicmus rugosus</i>	SxO	FF	F		113	560
<i>Ennearthron cornutum</i>	SxO	FF	F	NT		2
<i>Ennearthron laticinnum</i>	Unknown	FF	F	Unknown		2
<i>Enochrus affinis</i>	Unknown	Unknown	Unknown	Unknown		2
<i>Episerenus angulicollis</i>	SxO	FF	W		2	6
<i>Eपुरaea aestiva</i>	SxF		F			1
<i>Eपुरaea angustula</i>	SxO	FF	F,P			1
<i>Eपुरaea biguttata</i>	SxO	FF	F		2	
<i>Eपुरaea boreella</i>	SxO	FF	F,P		5	3
<i>Eपुरaea contractula</i>	SxO	FF	F		8	
<i>Eपुरaea marsuili</i>	SxO	FF	D,F		13	1
<i>Eपुरaea pygmaea</i>	SxO	FF	D,F		5	4
<i>Eपुरaea rufomarginata</i>	SxF	FF	F		6	
<i>Eपुरaea silacea</i>	SxO		F		4	31
<i>Eपुरaea variegata</i>	SxO	FF	F		1	
<i>Euaesthetus ruficapillus</i>	NS				1	
<i>Eucomnus maeklinii</i>	SxF		?F			1
<i>Eudectus graudi</i>	SxO	FF	P			3
<i>Euplectus piceus</i>	SxF		P		2	1
<i>Euplectus punctatus</i>	SxO		P		12	40
<i>Euryusa castanoptera</i>	SxO	FF	?F		4	4
<i>Gabrius expectatus</i>	SxF	FF	P		8	44
<i>Glischrochilus quadripunctatus</i>	SxO	FF	F,P		46	1
<i>Globicornis emarginata</i>	SxO	FF	D		1	1
<i>Gyrophana affinis</i>	SxF		F		1	
<i>Gyrophana boleti</i>	SxO		F			1
<i>Hadröbrignus confusus</i>		FF		VU		2
<i>Hadröbrignus pertinax</i>	SxO	FF	W		9	19
<i>Hailomenus binotatus</i>	SxO		F			2
<i>Hapalaraea clavigera</i>	SxO	FF	?P	NT	3	1
<i>Hapalaraea linearis</i>	SxO	FF	?P		1	
<i>Haploglossa marginalis</i>	SxF		?F		1	
<i>Haploglossa nidicola</i>	Unknown	Unknown	Unknown	Unknown		1
<i>Haploglossa villosula</i>	SxF		?F		32	60
<i>Henödus serratus</i>	SxF	SFF	F		12	

Species name	Saprophytic group	Fire category	Functional group	Redlist category	Burned	Control
<i>Holdbus apiceus</i>	SXO	FF	?F		1	1
<i>Homalota plana</i>	SXO	FF	P		1	
<i>Hydroporus nigrita</i>	SXO	FF	C		649	39
<i>Hylastes brunneus</i>	SXO	FF	C		56	1
<i>Hylastes curvilaris</i>	SXO	FF	C		6	
<i>Hylastes opacus</i>	SXO	FF	W/F		1	10
<i>Hylecoetus dermestoides</i>	SXO	SFF	C;W		404	17
<i>Hylobius abietis</i>	SXO	SXO	C		1	1
<i>Hylogops glabratus</i>	SXF		?F		2	
<i>Ischnoglossa elegantula</i>	SXO		C;W		1	
<i>Judolia sexmaculata</i>	SXO	FF	P	NT		3
<i>Laeon conspersus</i>	SXO	FF	P		3	
<i>Laeon fasciatus</i>	SXF	FF	F		2	5
<i>Latridius consimilis</i>	SXO	FF	F		1	8
<i>Latridius hirtus</i>	SXF	FF	F		1	
<i>Latridius minutus</i>	SXF	FF	F		1	1
<i>Latridius nidicola</i>	SXF		F		1	
<i>Leiodes rhaetica</i>	NS				1	8
<i>Leptusa fulvicollis</i>	SXO	FF	?F		1	4
<i>Limonius aeneoniger</i>	NS		?F		2	
<i>Longiarisus holsaticus</i>	NS		?F		1	5
<i>Lordithon lunulatus</i>	SXF		P			1
<i>Lordithon speciosus</i>	SXO		P			1
<i>Lordithon thoracicus</i>	SXF		P			1
<i>Lythraria salicariae</i>	SXO		H		1	
<i>Magdalis phlegmatica</i>	SXO		C		3	1
<i>Magdalis violacea</i>	SXO		?P		2	5
<i>Malthinus biguttatus</i>	SXO		?P		3	5
<i>Malthodes fuscus</i>	SXO		?P		1	1
<i>Malthodes guttifer</i>	SXO		P		4	17
<i>Megasternum obscurum</i>	SXO	FF	P;W	VU	4	
<i>Melandrya dubia</i>	SXO	FF	Unknown	Unknown	1	
<i>Melanotus castanipes</i>	Unknown	Unknown	Unknown	Unknown	1	
<i>Meloechus minor</i>	SXO	FF	?F		1	1
<i>Mycetochara flavipes</i>	SXO	FF	?F		2	102
<i>Mycetochara obscura</i>	SXO	FF	?F	NT	2	
<i>Mycetophagus fulvicollis</i>	SXO		F	NT	2	1
<i>Mycetophagus multipunctatus</i>	SXO				14	7
<i>Mycetophagus populi</i>	SXO				4	11
<i>Mycetoporus lepidus</i>	SXO				4	
<i>Myrmex paykulli</i>	SXO	FF	P		3	
<i>Myzia oblongoguttata</i>	SXO	FF	P			
<i>Nepachys cardiaca</i>	SXO	FF	P		1	

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

Species name	Saproxyllic group	Fire category	Functional group	Redlist category	Burned	Control
<i>Polygraphus punctifrons</i>	SxO	FF	C		2	2
<i>Polygraphus subopacus</i>	SxO	FF	C		2	1
<i>Portodites fenestralis</i>	Unknown	Unknown	Unknown	Unknown	33	
<i>Potosia cuprea</i> spp. <i>metallica</i>	SxF	Unknown	Unknown	Unknown	2	2
<i>Prosternon tessellatum</i>	Unknown	Unknown	Unknown	Unknown	1	6
<i>Pseudomodon obscurillus</i>	Unknown	FF	P		1	
<i>Pterostichus adstrictus</i>		FF	P		1	
<i>Pterostichus oblongopunctatus</i>		FF	P		1	
<i>Pteryx suturalis</i>	SxO	FF	F		1	1
<i>Pytho depressus</i>	SxO	FF	C		3	
<i>Quedius plagiatus</i>	SxO	FF	P		6	6
<i>Quedius tenellus</i>	SxF	FF	?P		2	2
<i>Rhagium inquistor</i>	SxO	FF	C/W		76	3
<i>Rhagonycha atra</i>	?		?P		2	4
<i>Rhagonycha elongata</i>	?		?P		4	1
<i>Rhizophagus bipustulatus</i>		FF			3	
<i>Rhizophagus dispar</i>	SxF	FF	P		2	2
<i>Rhizophagus ferrugineus</i>	SxO	FF	P		35	15
<i>Rhizophagus nitidulus</i>	SxO	FF	P		5	5
<i>Rhizophagus parvulus</i>	SxO	FF	P		193	32
<i>Rhyncolus sculpuratus</i>	SxO	FF	W		4	10
<i>Ropalodontus strandi</i>	(tom)				1	4
<i>Salpingus ruficollis</i>	SxO	FF	P		4	4
<i>Scaphisoma agaricinum</i>	SxF	FF	?F		71	113
<i>Scolodreporides fumatus</i>	NS				2	
<i>Scolodreporides watsoni</i>			?P		1	1
<i>Scolytus ratzeburgi</i>	SxO	SFF	C		1	2
<i>Scymnus limbatus</i>	NS				1	
<i>Selatosomus aeneus</i>			??		1	1
<i>Selatosomus impressus</i>	SxF		P		5	18
<i>Selatosomus melanchoilicus</i>			??		16	
<i>Sepedophilus testaceus</i>	SxF		F		10	
<i>Sericoda quadripunctata</i>		PF			1	
<i>Sericus brunneus</i>			??		23	8
<i>Sogda suturalis</i>	Unknown	Unknown	Unknown	Unknown	1	
<i>Soronia grisea</i>	SxO		D		2	2
<i>Spirindus dubius</i>	SxF	FF	F		2	4
<i>Stenichnus bicolor</i>	SxF	FF	P		4	4
<i>Stenotrachelus aeneus</i>	SxO	SFF	C/W		2	
<i>Stenus clavicornis</i>			P		1	
<i>Stenus eutropaeus</i>	Unknown	Unknown	Unknown	Unknown	1	1
<i>Stenus strandi</i>	Unknown	Unknown	Unknown	Unknown	1	
<i>Stephanopachys linearis</i>		PF		VU	1	
<i>Stephostethus pandellei</i>	SxF	FF	F		1	2
<i>Stephostethus rugicollis</i>	SxF		F		1	1

Species name	Saproxyllic group	Fire category	Functional group	Redlist category	Burned	Control
<i>Strophosoma caplatum</i>		FF	H		9	2
<i>Sulcicis affinis</i>	SxO	FF	F		2	1
<i>Synchlita humeralis</i>		SFF				1
<i>Syneta betulae</i>			H			1
<i>Tachinus atripes</i>			?F, ?P			1
<i>Tachinus basalis</i>				DD		1
<i>Tachinus elongates</i>	NS		?F, ?P		1	1
<i>Tachinus pallipes</i>			?F, ?P			2
<i>Tachinus proximus</i>			?F, ?P		1	1
<i>Tachyta nana</i>	SxO	SFF	P		1	1
<i>Tanasius formicarius</i>	SxO		P		2	
<i>Tetartona ancora</i>	SxO	FF	F			4
<i>Thalycra fervida</i>	Unknown	Unknown	Unknown	Unknown	5	2
<i>Thanasius formicarius</i>	SxO	FF	P		23	1
<i>Thyasophila angulata</i>			?P		1	
<i>Thyasophila canaliculata</i>	Unknown	Unknown	Unknown	Unknown		1
<i>Tomticus pithiporda</i>	SxO	FF	C		258	2
<i>Triplax aenea</i>	SxO	FF	F		1	6
<i>Triplax russica</i>	SxO	FF	F		12	49
<i>Triplax scutellaris</i>	SxO	FF	F		6	40
<i>Tropideres dor-salis</i>		SFF		NT	1	
<i>Trypodendron lineatum</i>	SxO	FF	F		37	13
<i>Trypodendron proximum</i>	SxO				44	35
<i>Tyrus mucronatus</i>	SxF	FF	?F		8	
<i>Xenota myrmecobia</i>	Unknown	Unknown	Unknown	Unknown	10	6
<i>Xylechinus pilosus</i>	SxO		C			30
<i>Xylita laevigata</i>	SxO	FF	F		506	122
<i>Zilora ferruginea</i>	SxO	FF	F	NT	1	
Total abundance					5507	3079
Total species richness					239	221