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Bedömning av naturvärde hos enskilda lövträd baserad på vedlevande insekter

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Examensarbete i ämnet biologi

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Abstract

AHA is a Swedish abbreviation of "reveal threatened park and avenue trees" and is a method to assess the conservation value of individual trees, mainly in the park environments but also in natural stands. This method has previously only been practiced in southern Sweden (Sörensson 2008). To see if this method could provide satisfactory results in northern Sweden, I have studied it in areas around the Umeå River. This was done by studying the relationship between trees with different classifications of conservation value (as classed by the AHA method) and their content of species (species richness and abundance). Insects were collected using trunk window traps in a period of 13 weeks during the summer of 2014. The tree species included in my analysis was aspen, birch, grey alder and goat willow and I looked primarily at the wood-dwelling species for the analysis.

There was a total of 3015 saproxylic beetles (Coleoptera), 166 true flies (Diptera) and 234 wasps (Hymenoptera) determined to species level. These 3415 individuals were included in the ANOVA analysis and box plots. The result from the data analysis showed a higher species richness and abundance between the highest class of conservation value and the four lower classes for all tree species ($p = 0.000$) except for the abundance of insects on goat willow ($p = 0.086$). There was also a high number of special species found, some were new to Västerbotten and two were even new to Sweden.

My result shows that deciduous trees in northern Sweden harbour a significantly higher abundance and species richness of saproxylic species in the AHA-class with higher conservation value. Through this study, I show that the AHA methodology also works well in deciduous habitats in northern Sweden. The high species richness found also demonstrates how important it is to preserve these substrates treated in the AHA-method in order to conserve biodiversity.

Sammanfattning

AHA-metoden är en förkortning av ”Avslöja Hotade park- och Allé-träd” och är en metod för att utvärdera bevarandevärdet för enskilda träd främst i parkmiljöer men även i naturliga bestånd (Sörensson 2008). Denna metod har tidigare endast praktiserats i södra Sverige. För att se om denna metod skulle kunna ge fullgoda resultat även i norra Sverige har jag studerat denna metod i områden runt Umeälven. Detta har jag gjort genom att analysera sambandet mellan träd med olika naturvärden (enligt klassificeringen i AHA-metoden) och innehållet av arter (artrikedom och abundans). Insekter samlades in med trädfönsterfällor i en period på 13 veckor under sommaren 2014. De trädslag som ingick i min analys var Asp, Björk, Gråal och Sälg och jag tittade främst på de vedlevande arterna.

Totalt artbestämdes 3015 vedlevande skalbaggar (Coleoptera), 166 tvåvingar (Diptera) och 234 steklar (Hymenoptera), dessa ingick i ANOVA-analysen. ANOVAN visade på en högre artrikedom och abundans av insekter mellan den högsta klassen av bevarandevärde och de fyra lägre klasserna för alla trädslag (p=0,000) utom abundansen av insekter för sälg (p=0,086).

Mina resultat visar att lövträd i norra Sverige hyser en betydligt högre förekomst och artrikedom av vedlevande arter i AHA-klassen med högre naturvärden. Genom denna studie visar jag att AHA metodiken fungerar bra även i lövträdsmiljöer i norra Sverige. Den höga artrikedomen visar hur viktigt det är att bevara dessa substrat som behandlas i AHA-metoden och på så sätt bevara den biologiska mångfalden.

Introduction

Dead or dying trees are key features in the conservation of biodiversity since they create favorable substrates for many wood-living insects (Andersson & Östlund 2004). The properties of older trees, like the presence of decaying wood (mould), rot, sap flows, wood fungi, exposed wood and tree hollows are among those favorable substrates (Sörensson 2000). Several of these properties provide cover for specialized insects (Ranius 2002) The loss of habitat and saproxylic species is of great concern in present conservation biology (Miller 2005, Stokland *et al.* 2012). As of 2010, 875 species of beetles are on the Swedish red-list, the majority of them are wood-dwelling (Gärdenfors 2010). Therefore, it is problematic when substrates that are required by these species, e. g. snags, old trees, downed logs etc. is becoming scarcer in our forests.

The amount of important substrates (old, dead or dying trees) has decreased since the development of modern forestry (Dahlberg & Stokland 2004, Kaila *et al.* 1997, Wikars 2008). The reason for the drastic reduction is the forestry exploitation and loss of natural disturbance regimes (like forest fires and damages by storms and floods (Kaila *et al.* 1997). The commercial forestry's main impact is the reduction of deciduous forest made in favor of larger acreage of coniferous stands (Martikainen *et al.* 1998), and the reduction in the amount- and diversity of dead wood (Martikainen *et al.* 1998, Siitonen 2001, Mikusinski *et al.* 2003, Similä *et al.* 2003, Wikars 2008, Lassauce *et al.* 2011). This is mainly done through standard management practices such as thinning and clear-cutting (Jonsell *et al.* 1998).

According to Berg *et al.* (1994) up to 95 % of the Swedish forests are being commercially used. The result of changing the structure, succession and composition of tree species is uniform stands that are evenly aged and homogenous (Lindhe *et al.* 2005, Gibb *et al.* 2006). However, since the 1990s, the forest industry has started to move towards a more conservation-oriented management, yet the majority of the forest landscape will remain uniform for many years to come (Jonsell *et al.* 1998).

The definition of saproxylic species

A saproxylic organism is a species "depending on dying or dead wood, during some part of their life cycle" (Speight 1989). These organisms can either be directly linked to dead wood or they can live on other saproxylic organisms (Dahlberg & Stokland 2004, Wikars et al. 2005). The term saproxylic does not only include wood-feeders but also those who feed on bark, wood-decomposing fungi and waste products from other saproxylics (detritivores), as well as those who live in close association to others like the saproxylic species of predators, parasitoids and other commensals (Grove 2002). There is a division between two different types of saproxylics, obligate saproxylic organisms that are totally dependent on dead wood during some part of their life cycles and facultative saproxylic organisms that are linked to dead wood but are only partially dependent on it for survival (Dahlberg & Stokland 2004, Gibb et al. 2006).

Healthy trees are also important substrate to saproxylic species according to Alexander (2008). The definition of a healthy tree is in most cases not consistent with that of a natural trees life cycle. The forestry tends to see the trees as mature at their peak value for forestry exploitation. This is long before the onset of decaying heartwood that would lower the value in timber. We have a tendency to get caught up in the concept of a healthy tree developed by forestry. Developing decaying, dead or dying branches or decaying heartwood is normal as the tree ages. These factors do not affect the health of the tree and it may in turn create habitats for saproxylic species (Alexander 2008). Therefore Alexander (2008) proposes a modification in the definition of saproxylic species to include the healthy trees with dead branches and internal decay as well as species attracted to sap-runs. Since the insect fauna in natural forest largely consist of saproxylics (Grove 2002, McGeoch *et al.* 2007), they are a component of the forest with functional importance (Grove 2002), with an essential contribution to the species richness (Kaila et al 1997).

Biodiversity assessment

Finding the total biodiversity in a landscape is nearly impossible. Therefore methods have been developed to evaluate it with the help of indicator structures (like dead wood or coarse ancient trees), or species that are presumed to represent the overall biodiversity (Nilsson *et al.* 2001). Environmental indicators are habitats and/or substrates that can be used as proxies for biodiversity because of the richness of species they attract (Jonsson & Jonsell 1999, Lassauce *et al* 2011). Using the deadwood volume as an indicator of saproxylic diversity might not be sufficient because of the variation of specific requirements between species. Instead, a finer resolution, like the type of deadwood, i.e. tree species or volume and/or decay stage, should be included in the monitoring (Lassauce *et al*. 2011). Deadwood diversity is therefore proposed as a better biodiversity indicator (Dahlberg & Stokland 2004, Brin *et al.* 2009).

Microhabitats – Attributes and tree traits important to saproxylic invertebrates

A tree has many different communities, each community is a different microhabitat and they harbor different assemblies of species (Stokland *et al.* 2012). In 1989, Speight coined a term for this, Arboreal Megalopolis. The definition of a megalopolis is the merging of many cities or communities into one geographic area. The direct translation from the Greek word “Megalópolis” is “great city” (Encyclopedia Britannica 2013). One tree does not constitute only one habitat but a diversity of habitats (Speight 1989).

The habitats on dead trees differ substantially from each other, for example the chemical and nutritional difference between the bark and the wood (Speight 1989), but the regional climate (altering the temperature and humidity of the microhabitats) (Stokland *et al.* 2012) and the tree species (with varied bark and wood morphology and chemistry components) (Dahlberg & Stokland 2004) also has its effect on the species composition (Speight 1989, Stokland *et al.* 2012). The various stages of tree decomposition may also have different sets of saproxylic species as the decaying tree goes through both chemical and physical changes (Stokland *et al.* 2012).

With the aging of a tree comes diseases or damages, for example; dead branches or stem wounds (creating stems with exposed wood or rot-holes); these will provide a habitat the saproxylic organisms need to colonize (Speight 1989). Some of these wounds (e.g. created by mechanical damage or wood-boring activities) (Speight 1989, Stokland *et al.* 2012) may result in sap-runs which in turn can attract insects (Stokland *et al.* 2012). Cavities and hollows are an important feature on living, dead or dying trees. They create different kinds of climates depending on their moisture level for example. Cavities also harbor predators (who prey upon other saproxylics) and organisms that live in the microhabitats that are created by an accumulation of debris (Speight 1989, Stokland *et al.* 2012).

The mould in cavities is stable dead wood microhabitats that can last a long time in some tree species. The tendency of dispersal is lower for those species in long-lived substrates like tree mould in contrast to substrates like snags and logs (Ranius & Hedin 2001, Stokland *et al.* 2012). These species have therefore been reported to be more vulnerable than others saproxylic species (Jonsell 2004a). Many rare species also benefit from the old trees affected by decaying fungi (Sörensson 2000). The saproxylic fungi are important as both a food source (spore-, fruiting body- and mycelium feeders) and for creating substrate for detritivores (those who feed on dead plant material created by decomposing fungi) (Speight 1989, Stokland *et al.* 2012).

Dead branches are a natural part of all trees. There is a distinction between different dead branches, those that are still attached to the tree and those that have fallen to the ground. The varying exposure to sun light between the different branch types determines the moisture level (desiccation) and temperature which in turn affects the inhabiting fauna (Stokland *et al.* 2012). The dead branches that have fallen from the tree have often already been inhabited by fungi and insects before hitting the ground. However the species composition will change due to the difference in microclimatic conditions between the canopy and the ground (Stokland *et al.* 2012).

The AHA-method as an assessment of conservation value

The AHA-method by Sörensson (2008) is a system for environmental assessment in southern Sweden. "AHA" is a Swedish abbreviation of "Avslöja Hotade park- och Allé-träd" and translates to "unveil threatened park and avenue trees" (Sörensson 2008). The method evaluates the conservation priority of individual deciduous trees from a saproxylic entomological point of view.

The method is built on a classification system of different tree attributes and qualities, both structural and ecological that has emerged as important to saproxylic insects (Sörensson 2008). The deciduous trees are divided into five different classes based on these attributes and qualities. The attributes are: tree hollows with wood mould, water-filled branch holes, stem or branches with exposed wood, sap flow and tree fungi as well as traits like larger tree dimensions and snags (table 1 & appendix 1) (Sörensson 2008). If a tree has more of these attributes the probability of hosting red-listed species increases, it ranges from very high in the highest conservation class to very low in in the lowest conservation class. The fourth class includes trees with no conservation value and the fifth class (also called class R) is an addition to the other classes and include trees that are set to evolve into the first three classes and develop wood entomological characteristics within a couple of decades. The fifth class is important for the future conservation work (Sörensson 2008).

The method is adapted for parks and urban settings in southern Sweden (nemoral and boreonemoral zone) but even if the main use is for cultural settings the method also works in natural tree environments. The AHA-method is not locked to a particular season but may be applied any time of the year (Sörensson 2008).

Objectives

The aim of this study was to investigate if the AHA-method could be used with satisfactory results in the north boreal zone. The study was done by examining the relation between the AHA-classes and the abundance and species richness of saproxylic insects. I address the following questions:

1. Is there a relation between trees with higher conservation value and the species content (species richness and abundance) of saproxylic species?
2. What interesting/special species (Red-listed or species new to the area, county and new to Sweden) are found in the study area?

Materiel and Method

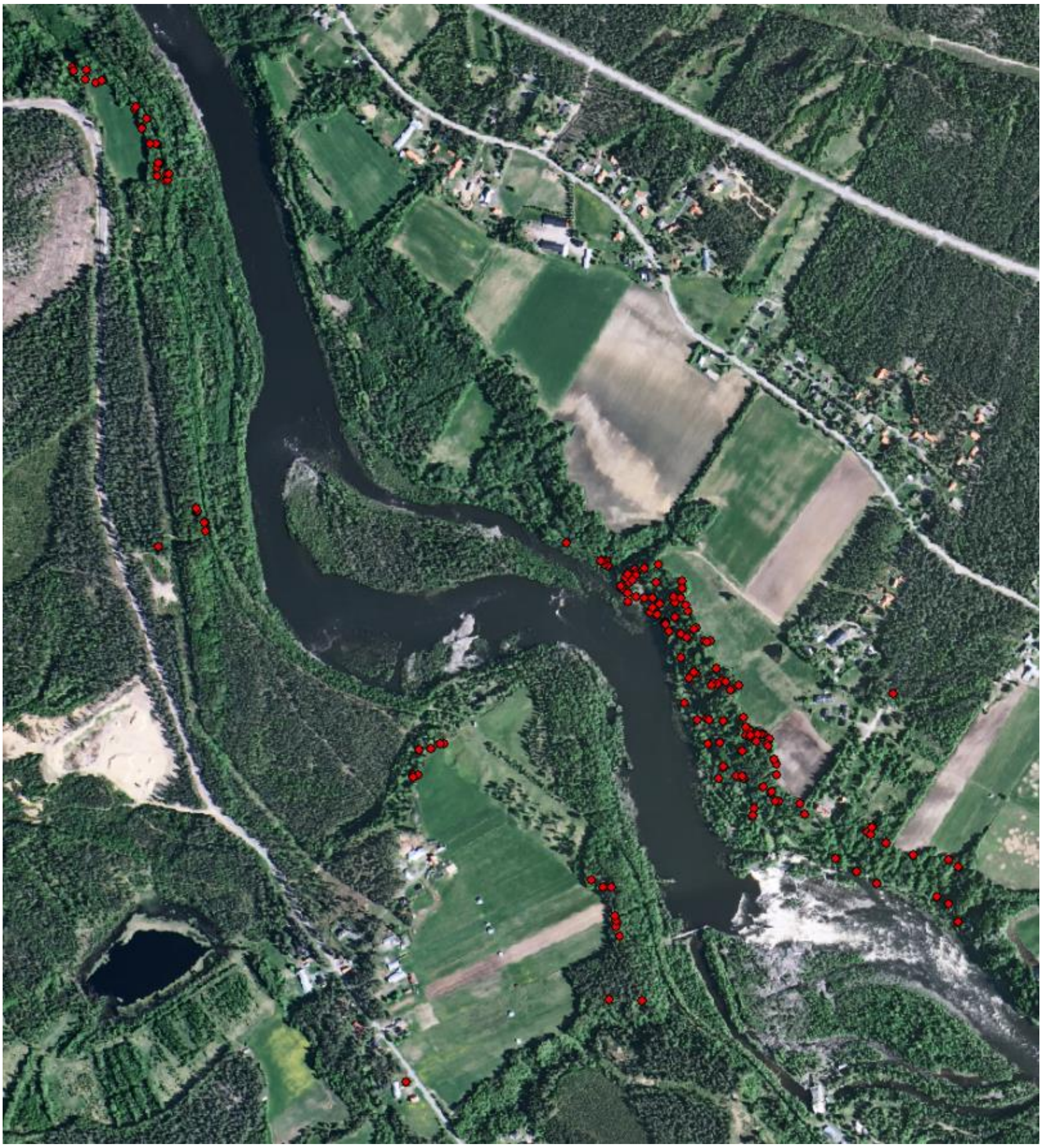

Figure 1 - Study areas in Baggböle and Klabböle, Umeå, Sweden, with each dot representing one tree with a window trap and each cluster of points is a study area. The study areas was approximately 1.4 km apart

Study area

This study was conducted 8 km outside of Umeå in the province of Västerbotten, Sweden (app. 63°50'N. 20°6'E.), in five different but closely located subareas close to the Umeå River (figure 1). Arboretum Norr in Baggböle is one of the subareas. It is a 17 ha recreational forest that stretches along the northern side of the Umeå River. The arboretum has a high diversity of planted tree species from the northern hemisphere that grow side by side with naturally occurring trees. Planting of exotic species has been done since the 1980s (Hagner 2011). The area also contains a high amount of dead wood in various stages of decay as the trees felled for new plantations are left. Parts of the area have also been set aside for free development. The arboretum is an area with very productive soils relative to the north boreal zone (Pers.comm Johnny Schimmel, 2014). Three of the subareas in Klabböle on the southern side of Umeå River are natural deciduous forest and categorized as key biotopes or objects with natural values (Enetjärn & Granér 1997). These areas comprises approximately 3,8 ha and are dominated by grey alder (*Alnus incana*), birch (*Betula sp*.) and aspen (*Pupulus tremula*) and contains high abundance of dead wood (Enetjärn & Granér 1997). The fifth subarea in this trial, located in Klabböle, is an enclosed pasture for sheep that contained several old birches (figure 1).

Sampling

In this study I investigated the AHA-method by Sörensson (2008) in northern Sweden. Therefore the criteria from this method were used when selecting the sampling trees (table 1) however they were adapted for northern Sweden. The changes of the criteria included the dimensions of snags and "giant trees". This was done due to the lack of dimensions in the category of "giant trees" (1 meter in diameter at breast height (Höjer & Hultengren 2004) (Nilsson & Cory 2014). The sample trees are treated individually and can therefore be compared to one another (Sörensson 2008).

Table 1 – The criteria for the five classes (1-4 and R) of the AHA-method by Sörensson (2008). For a tree to be in class 1 it has to have at least two of the criteria listed for class 2. A class 2 tree may have one of the criteria listed for class 2 or at least 4 of the criteria listed for class 3. To be put in class 3 the tree must have at least 2 of the criteria listed for this class. Healthy trees >30 cm in diameter at breast height were categorized in class R while all healthy trees <30 cm were put in class 4. The difference between class four and class R is that the latter is considered mature trees. For a more detailed description see Appendix 1.

Class	AHA-criteria
1	***At least 2 of class 2 below***
2	Have a large or medium sized trunk cavity with wood mould
2	Have one or more major, deep, branch holes filled with water or wood mould
2	Have a large external or internal sap flow(about 10 cm long or longer)
2	Have several polypore and/or larger wood fungi or extensive fungi fouling
2	Have a larger area with exposed wood on the trunk (about 3 dm^2 or more)
2	Is a coarse, rotting snag (more than 30 cm in diameter)
2	***At least 4 of class 3 below***
3	Is a coarse tree. Have an exceptional diameter (>0,5 meters in breast height)
3	Have one or more, shallow, often smaller, branch holes
3	Have a smaller sap flow (<10cm long)
3	Have a small fungi fouling or few polypore
3	Have a small, shallow, incipient trunk cavity
3	Have a smaller area with exposed wood (<3dm^2) on trunk or branch
4	Healthy, unharmed trees (<30 cm in breast height)
R	Older, often coarse and unharmed, living trees or snags (>30 cm in breast height)

To search for the sample trees in Arboretum Norr I followed the paths in the park and actively searched for trees around the edge zones to match the criteria for the AHA-method. In order to have sufficient replicates I looked for sample trees on both sides of the river. The same method of searching for trees as the one used in the arboretum was used in Klabböle, except the areas on this side of the river lacked trails. Therefore, I walked around randomly in these stands. However, the majority of the trees were found in Arboretum Norr (figure 1). There were no distance limits between the sampling trees. In total I sampled 165 trees (table 2) but not all samples were used. I removed one trap on aspen in class 2 from the analysis due missing values; the trap did not contain any data due to a faulty trap. Traps placed in cavities with mould were also excluded from the study. For the data analysis the catch from 163 traps were used. Tree species included in this study were: grey alder (*Alnus incana*), birch (*Betula sp.*), aspen (*Populus tremula*) and goat willow (*Salix caprea*).

Each tree was determined to species level and cross-measured at breast height (1,2 meters off the ground) with a caliper, larger trees were measured with a diameter tape. The diameter was not measured for trees with multiple stems at breast height. After measuring the trees were categorized in one of the five classes of the AHA-method and mapped with a GPS. Trees were classified into one of the five classes based on the list of attributes (table 1).

Table 2 – Number of traps used for my analysis, in each category of the AHA classes and for each tree species. 165 trees had traps, 163 of these were used for the data analysis.

AHA class	***A.incana***	***Betula sp.***	***P.tremula***	***S. caprea***
1	8	8	8	8
2	7	9	8	9
3	8	8	9	8
4	8	8	8	8
R	8	9	8	8
Total # traps	**39**	**42**	**41**	**41**

Trunk window traps (flight interception) was mounted to sample saproxylic beetles. Each trap was attached in a southern direction and if possible in connection to the tree attributes and qualities of the AHA-method. This meant that some traps were mounted on a higher elevation (and some lower) to be close to the existing attribute, but the average height of the trunk window traps were in breast height (1,2 m). The trunk window traps were made of a transparent plastic sheet (app. 10 by 20 cm) which was placed perpendicular to the stem with an aluminum tray (could hold 4 dl of fluids) placed directly under (figure 2). The tray was filled with propylene glycol as a preservative for the insects and water (50:50), as well as a small amount of odor- and colorless detergent to reduce the surface tension. The sampling period lasted between the 5th of June and the 5th of September, 2014. The traps was checked and refilled with the propylene glycol, water (50:50) and detergent mixture once in mid- July (traps that required a ladder was not refilled).

Once the traps had been collected the saproxylic beetles (Coleoptera) and some of the saproxylic true flies and mosquitos (Diptera) as well as some of the saproxylic wasps (Hymenoptera) were determined to species level by experts, with respectively 166, 14 and 26 species for the orders (table 3). All species included in the data analysis of this study are shown in appendix 3 and 5. The subfamily Aleocharinae and parts of the genera Euplectus of the family Staphylinidae were excluded because they were difficult to determine on a species level. Because of the short timeframe for this study I also excluded the families Cryptophagidae, Latridiidae and Ptiliidae. Excluded were also species only associated to coniferous trees that may have ended up in the traps as so called tourists (appendix 4).

In addition to the previous 14 species of Diptera, a large number (app. 200 species of both saproxylic and non-saproxylic species) were species determined at a later stage and were therefore not included in the data analysis. The red-listed species and those new to the area from this data-set are listed in table 5 and appendix 2 respectively. Listed here are also the red-listed species and other interesting species (such as species new to the area, county and new to Sweden) of the non-saproxylic Coleoptera and the species found in the mould traps. The nomenclature and taxonomy follows Silfverberg (2010), the species were divided into obligate and facultative saproxylics (R.B. Pettersson and J. Hilszczański, unpubl. Biocore database SX).

Table 3 – The number of species found on each tree species of the total for each order.

Number of Species			
	Coleoptera	**Diptera**	**Hymenoptera**
Total	166	14	26
Birch	124	7	19
Aspen	108	9	11
Grey Alder	98	4	18
Goat Willow	84	3	13

Figure 2 - Window trap mounted adjacent to the attribute, in this case tree fungi (*Phellinus igniarius*).

Data- and statistical analysis
To answer my first question regarding the species richness and abundance I used an ANOVA procedure. However, since the data was not normally distributed and strongly skewed to the left, with many low values, I used a generalized linear model (GLM). When data are in counts a negative binomial model is often used to account for i.e. correlated error structure. I therefore used glm.nb in the R package [MASS] (Venables & Ripley 2002). When a significant main effect of class was found I used pairwise multiple comparisons to investigate which individual classes were significantly different from the other. The pairwise comparisons were conducted in the R package multcomp (Hothorn et al. 2008). To visualize the results I made box plots (figure 4). The analyses and the boxplots were done in the statistical computer software R (R Development Core Team 2013).

In appendix 3 I present the saproxylic species included in the statistical analysis. A part of this list is presented as ranked abundance (table 4). This was done for each tree species and category to see which beetle species were the most abundant. The four tree species was compared to each other to see if there was a difference in the most abundant species. I also present a ranked abundance-list for the red-listed species in table 5. A rank-abundance list is a compilation of the species that are the most numerous of the captured species in the samples. The species with the highest number of individuals will stand at the top of the list and vice versa.

Result

There were a total number of 3015 saproxylic Coleoptera, 166 Diptera and 234 Hymenoptera determined from 206 species and 50 families (table 3). There was 128 different species collected on aspen, 150 on birch, 100 on goat willow and 120 on grey alder. Aside from the 206 species found there were 12 species that were categorized as coniferous and therefore tourists on deciduous trees, they are documented in appendix 4. For almost half the species the number of individuals recorded was between 2 to 10 (figure 3).

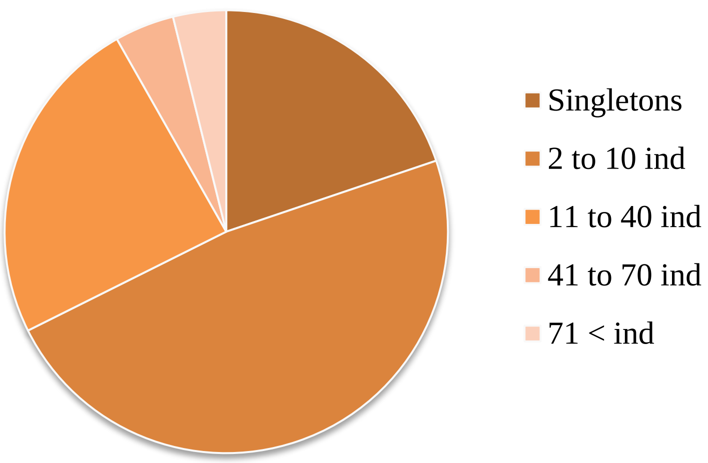

Figure 3 – The percentage of species divided into categories of how many individuals of each species were recorded.

Abundance and species richness

The most abundant saproxylic species is presented as a ranked abundance (table 4). *Carpophilus marginellus, Glischrochilus hortensis* and *Protaetia cuprea metallica* were the three most abundant species in the total dataset. A ranked abundance list is also presented for the red-listed species found in the study (Table 5). The red-listed species were mainly found in trees with higher AHA-classes, however some were found in the lower classes as well.

Table 4 – The five most abundant saproxylic species in the five different AHA-classes for all tree species merged. No. stand for the number of individuals (abundance) encountered in each class.

Total Class 1.	**No.**	**Total Class 2.**	**No.**
Cerylon ferrugineum	71	*Glischrochilus hortensis*	89
Anisotoma humeralis	70	*Carpophilus marginellus*	59
Glischrochilus hortensis	57	*Rhizophagus dispar*	32
Protaetia cuprea metallica	52	*Cerylon ferrugineum*	31
Carpophilus marginellus	44	*Anisotoma humeralis*	28
Total Class 3.	**No.**	**Total Class 4.**	**No.**
Glischrochilus hortensis	83	*Carpophilus marginellus*	212
Carpophilus marginellus	53	*Protaetia cuprea metallica*	81
Protaetia cuprea metallica	34	*Glischrochilus hortensis*	59
Xylophagus ater	22	*Xylophagus ater*	21
Cerylon ferrugineum	18	*Anaspis frontalis*	20
Total Class R.	**No.**		
Glischrochilus hortensis	85		
Carpophilus marginellus	42		
Cerylon ferrugineum	28		
Anaspis frontalis	17		
Protaetia cuprea metallica	17		
Xylophagus ater	17		

Table 5 – The red-listed species found in the study, in a ranked abundance-list with a column for in which AHA-class they were found and on which tree species with A = aspen, B = birch, G = grey alder and S = goat willow. The red-listed species were ranked by level of extinction risk in the following classes from Gärdenfors (2010); Data Deficient (DD), Near threatened (NT), Vulnerable (VU), Endangered (EN), Critically endangered (CR) and Regionally extinct (RE).

Red-listed species	**No.**	**Red-list category**	**AHA-class**	**Tree species**
Pseudanidorus pentatomus	18	VU	1	A,B,S
Orchesia fasciata	8	NT	All	A, B, G, S
Amiota alboguttata	5	NT	1,2,4	A, B, S
Hendelia beckeri	5	NT	1,3,4,R	A, B, G, S
Neurigona abdominalis	4	DD	2,R	A, G, S
Cis quadridens	3	NT	1	A, B
Necydalis major	3	NT	2,3,5	B, G, S
Dolichocis laricinus	2	NT	1	B
Harminius undulatus	2	NT	1,5	B
Mycetophagus fulvicollis	2	NT	1	B, S
Hyperoscelis eximia	2	DD	1	G
Cerylon deplanatum	1	NT	5	B
Hallomenus axillaris	1	NT	1	A
Neoalticomerus formosus	1	VU	2	G
Sphecomyia vespiformis	1	VU	3	A
#S	**58**			

The abundance for each tree species indicated a higher number of individuals (for class 1) in Aspen and Birch, than in Goat willow and Grey alder. The median for the two former species was around 40 individuals while the latter was around 20 individuals. A similar pattern can be seen for the species richness, with more species found in aspen and birch (figure 4). For all tree species, except the abundance of insects on grey alder, a significant difference was detected between the highest AHA-class and remaining classes (table 6).

Table 6 – The result from the statistical analysis of species richness and abundance between the AHA-classes on the four different tree species as well as the result from all tree species combined. α was set to 0.05 in all tests. All numerator *df* were 4 and the total number of sampled trees were 163, with 41 *P. tremula*, 42 *Betula sp*., 41 *S. caprea* and 39 *A. incana*. Tukey's test was used for multiple comparisons. The post-hoc test demonstrates between which classes there are a significant difference, classes that have demonstrated as significant difference from the others are shown as X> followed by the other classes (with X being the class that show significant different and the following classes that X is significant different to).

Source of variation	**Chi^2**	**P-value**	**post-hoc test**
Abundance			
Total	66.490	**0.000**	1>2,3,4,5
Birch.	55.554	**0.000**	1,4>2,3,5
Aspen	69.221	**0.000**	1>2,3,4,5
Goat willow	8.166	0.086	-
Grey alder	19.709	**0.000**	1>3,4;2>4
Species richness			
Total	70.599	**0.000**	1>2,3,4,5
Birch	46.975	**0.000**	1>2,3,4,5
Aspen	37.630	**0.000**	1>2,3,4,5
Goat willow	23.389	**0.000**	1>3,4;2>4
Grey alder	18.883	**0.000**	1,2>4

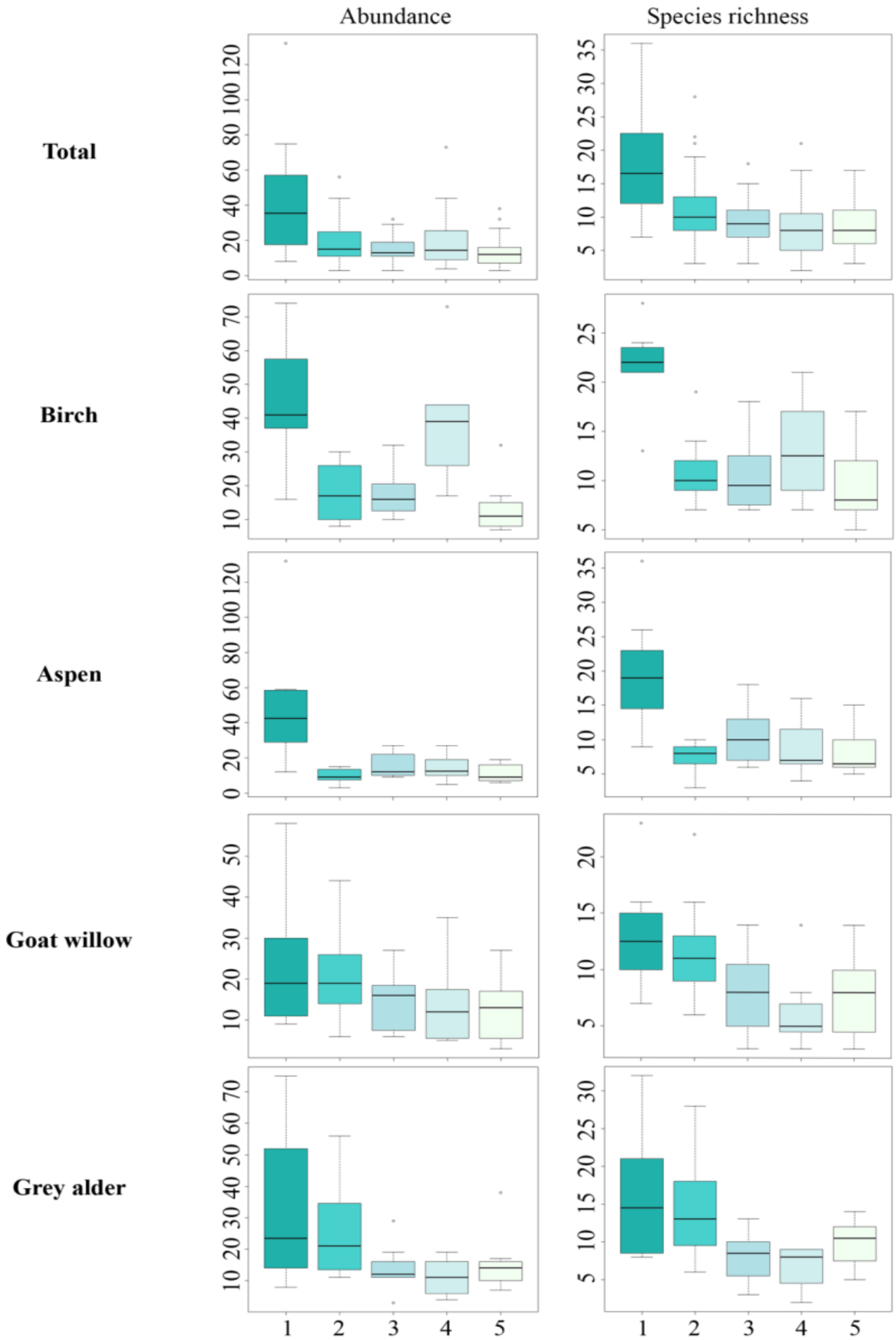

Figure 4 – Box plots over species richness and abundance for each tree species as well as for all tree species together, with median value, the 1st and 3rd quantile, whiskers (min and max values) and possible outliers (above and below 3/2 of the 3rd and 1st quantile resp.). The line inside the boxes represents the median and the whole box (the interquartile range) consist of 50 % of the values, alas the upper quartile mark 75 % and the lower quartile 25 %. The x-axis represents the 5 different AHA-classes (with class 5 being class R) and the y-axis shows us the abundance respectively the species richness.

Discussion

Conservation value

In this study I found that the abundance and species richness of saproxylic insects was significantly higher in the highest AHA-class (class one) for all tree species ($p = 0.000$) except for the insect abundance of grey alder ($p = 0,086$) (table 6). The result is in agreement with the assumptions behind the AHA-method by Sörensson (2008), which is that trees with higher conservation value harbour more species. The result of high species richness is frequent in trees with similar attributes and qualities as those discussed in the AHA-method (see Jonsell 2004b, Jonsell 2008).

I found that aspen and birch differed from the other two tree species. They had both higher species richness and a higher abundance than goat willow and grey alder (figure 4 & table 6). This corresponds with a study by Jonsell *et al.* (1998) which showed that aspen and birch have a richer insect fauna than grey alder and goat willow. In their study the tree species appear in the order of birch, aspen, grey alder and goat willow, with the most species associated to birch. This pattern is also seen in my study. However, Jonsell *et al.* (1998) merge grey alder and common alder as one while I in my study only include grey alder because of the scarcity of common alder in the northern Sweden. Aspen have been reported as important to other organisms as well beside the insect fauna, for example many lichens and epiphytic bryophytes (Esseen *et al.* 1997). Birch and aspen was reported to harbour a large amount of wood living fungi-species (Dahlberg & Stokland 2004), but here the alder are also in the same level of species richness. Dahlberg & Stokland (2004) study shows the importance of these tree species for other organism beside for the insect fauna.

For many of the tree species there was no significant difference between any of the classes below class one for either abundance or species richness (table 6). One explanation to this result can be the overlapping and diffuse criteria of the AHA-method (Sörensson 2008). There are no distinct limits between them and it is up to the inventory taker to determine the limits. It can be difficult to determine in which class the tree belongs. I had, for example, some problems with finding trees in class two based on the criteria, because the tree attributes and qualities from the criteria for class two often came in pairs. So if a tree had larger areas with exposed wood it also had several or larger wood fungi, therefore being classified as the highest conservation value (class one). It was rare that a tree only presented one of the attributes in the criteria list. I suggest that if more than one person is doing the inventory they should agree on the basis for each criterion before conducting the inventory, for example the definition of "a few polypores" or "a small fungi fouling" (appendix 1).

Evaluation of the AHA-method

I think this study shows the possibilities with the AHA-method and its use in the northern parts of Sweden. However, two of the criteria for the AHA-method were altered for this study. This included the minimum diameter of stems in the category of giant trees and snags (from 1 meter in diameter at breast height (d b h) to 50 cm for giant trees and 50 cm in dbh to 30 cm for snags). This decision was taken because of the lower numbers of coarse trees (>45 cm) in northern Sweden (app. two per hectare, in contrast to six per hectare in southern Sweden) (Nilsson & Cory 2014). Only one tree in my study would be considered a "giant tree", if the criteria had not been changed. The tree in question had a dbh of 1,2 meters.

The AHA-method is easy to use and very time- and cost efficient in contrast to other methods of conservation valuation. We can compare the AHA-method to a similar method of conservation assessment called the “five aces”-method by Rundlöf & Nilsson (1995). This is an inventory method used to track forests worth to preserve in southern Sweden. The two methods are somewhat alike as they both assess biodiversity but they use different systems. AHA method uses a classification system of tree attributes and qualities in order to assess the likelihood that the tree harbour red-listed species, and through this evaluate the conservation value of individual trees. The “five aces”-method uses indicators species (birds, vascular plants, lichens and insects) together with environmental indicators, such as large trees with cavities, “giant trees” and forest continuity to assess if an area should be conserved. The difference between the two methods is that the former are easy to use for everyone, even those without prior education. You do not need the knowledge of any special species and you only need a short introduction to the classification system used for this method. However, the “five aces”-method, have a higher difficulty level and require some prior knowledge of certain species used as indicators; this will of course increase the costs as educated personnel are needed.

It is important to remember that the AHA-method only shows the potential of a single tree harbouring red-listed species and that the probability increases in the higher AHA-classes (Sörensson 2008). If one would want to know for certainty which species there are in the area, an insect inventory should be done.

There are some factors that were not measured in my study, mostly because of the limited timeframe, that have been reported as important to species richness. Sverdrup-Thygeson *et al.* (2010) writes about the main factors that affected their study, they were breast height diameter (dbh), the proportion of tree species (%) in the area and the proportion of coarse woody debris (CWD). All of them affect the species richness significantly. Only dbh was measured in my study. The sun exposures of stems are another factor not measured for this study. Sun exposed stems are important to certain species that are favoured by disturbances in the landscape (Wikars 2008).

None of the factors, like sun-exposure, CWD or the proportion of tree species in the landscape are a part of the methodology of AHA. It may be because the AHA-method is developed for urban areas where these factors are not of concern. However, I propose that for future studies with the AHA-method one should take notice of this result from Sverdrup-Thygeson *et al.* (2010) and include more measurements of the surrounding environment to eliminate possible errors. It may also improve the assessment of biodiversity in natural forests and perhaps improving the AHA-method as a biodiversity assessment in northern Sweden.

Abiotic conditions can also affect the study. In this case the summer of 2014 was very warm and dry for the most part of it, this meant that some traps in the more open areas was subjected to desiccation. I do not know the extent of this as the week before gathering the traps the weather was very much the opposite of dry and a large amount of rain fell across the Umeå area. This is a possible source of error as some insects may have fallen out of the traps both during the dry season (blown out by wind) and during the week of intense raining (overflowing traps). In addition, a large number of insects were never determined to species level. This meant that they were not included in the data analysis and my results may have looked different if they had been included.

Insect species in Arboretum Norr and Klabböle

Out of the 206 saproxylic insect species the most abundant were *Carpophilus marginellus, Glischrochilus hortensis* and *Protaetia cuprea metallica* (table 4). This was overall persistent for all tree species, with some variation. These are all common species in the Swedish deciduous forest and therefore not an unexpected result (see for example Garpebring & Nilsson-Örtman 2010). The *Carpophilus marginellus* and *Glischrochilus hortensis* are also generalists, (i.e. living on several tree species), according to The Saproxylic Database, which may have a contributory effect to their abundance in my traps.

Throughout this study many special species have been found, for example, 15 red-listed species (table 5) and two species of flies, new to Sweden (appendix 2). The most abundant of the red-listed species in my study was the beetle *Pseudanidorus pentatomus*, with 18 individuals recorded. The majority of these (14 individuals) were recorded on the same tree. This three in question, a birch, had both tree fungi as well as a substantial part with exposed wood; it was therefore classed as the highest conservation priority according to the AHA-method. The beetle is classed as vulnerable (VU) according to Gärdenfors (2010) and has only been documented in Västerbotten once before (Pettersson & Fors 2014a).

Two very interesting species of flies (Syrphidae) were also found in my study. The first, *Sphecomyia vespiformi* (VU), was found in the arboretum on an aspen with dried exposed wood. The second, *Xylota sylvarum*, was new to Västerbotten and found in one of the subareas of Klabböle on a coarse birch with *Phellinus igniarius* (Pettersson & Fors 2014b). One of the more special species found in Arboretum Norr was the mosquito, *Hyperoscelis eximia*. Only five individuals have been reported in Artportalen for Sweden since the first finding in 1856. The biggest threat to the species is the decreasing amount of dead wood in forests (Pettersson & Fors 2014a). The beetle *Ahasverus advena* is another interesting species found. This species had previously only been linked to composts and the Arboretum Norr is probably the first ever location in Scandinavia where the species have been found outside of this environment (Pettersson & Fors 2014a).

The red-listed beetles were mainly found in trees with higher conservation value, this result agrees with the previous study by Sörensson (2008) which showed that red-listed species were more present in two higher AHA-classes. However some red-listed specis in my study were also recorded in the lower classes as well. One explanation for this may be the location of the sample trees. I did not use any minimum distances when searching for trees to sample. Therefore some trees could be located adjacent to each other while others could be isolated. There is a possibility that species ended up in the trap placed on the lower class tree while being attracted to the tree adjacent to it with a higher AHA-class. However, the high richness of special species in these areas shows the importance of the substrates that are processed in the AHA-method. The species richness also demonstrates how important it is to preserve these substrates in order to conserve the biodiversity in the river landscape.

Conclusions

My result shows that deciduous trees in northern Sweden harbour a significantly higher abundance and species richness of saproxylic species in the AHA-class with higher conservation value. My findings suggest that it is possible to practise this method in northern Sweden as well. With the AHA-method you can easily and quickly evaluate an area and assess its conservation value for richness of saproxylic insects.

I think my findings of the many special species also fulfil my second goal with this study. The Arboretum Norr and the river landscape around Umeå River are important areas to preserve in order to protect the biodiversity as they have a high species richness of forest insects. When managing these areas one should consider preserving as many of the trees in the higher AHA-classes as possible, as they have shown to harbour more species than those trees with lower conservation values. But in cases when this cannot be done one should try to preserve the tree species which have the higher species richness, in this case birch and aspen. I also suggest preserving trees in the R-class as well as they have a future of developing attributes associated to the higher AHA-classes.

Hopefully this study will work in the future to help Arboretum North when designing new park action to preserve the trees with higher AHA-classes. The Arboretum north should takes advantage of the opportunity with its rich fauna of insects when developing the park.

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Appendix 1.
Criterion for AHA method used for this study, the original criterion can be found in Sörensson (2008).

Class 1 – trees with the highest priority of conservation. They are rare and absent in many Swedish forests and broadleaved stands. Today they are likely to exclusively occur in cultural environments such as parkways, churches, farm and city parks, but also in national parks, nature reserves and areas with natural values. Have a combination of at least two of the attributes listed below class 2.

Class 2 – trees with a high priority of conservation. They are quite rare tree individuals that only occurs in single or few specimen in a stand (except for some parkways, churches, farm and city parks where the percentage can be quite high). Have at least four of the listed properties/attributes listed under class 3, or one of the following characteristic:

4 Have a large or medium sized trunk cavity with wood mould
4 Have one or more major, deep, branch holes filled with water and/wood mold
4 Have a large external or internal sap flow(about 10 cm long or longer)
4 Have several polypore and/or larger wood fungi or extensive fungi fouling
4 Have a larger area with exposed wood on the trunk (about 3 dm^2 or more)
4 Is a coarse, rotting snag (more than 30 cm in diameter)

Class 3 – some priority of conservation. Occurs in most deciduous stands and contains both younger and older, for the most part, healthy trees. Trees have two or more of the following characteristic (if four or more exists, the overall quality of each attribute of the tree determines if the tree should be sorted into class 2.

4 Is a so-called giant tree. Have an exceptional diameter (>0,5 meters in breast height)
4 Have one or more, shallow, often smaller, branch holes.
4 Have a smaller sap flow (<10cm long)
4 Have a small fungi fouling or few polypore
4 Have a small, shallow, incipient trunk cavity
4 Have a smaller area with exposed wood ($<3dm^2$) on trunk or branch

Class 4 – no priority of conservation. They are young, healthy and unharmed trees (<30 cm in diameter at breast height).

Class R – varying conservation priority. Resource trees are older, mostly broader (> 30 cm in diameter) and for the most part, healthy deciduous trees or living snags, with few or no injuries, which within a period of 20-100 years is expected to replace the current tree in class 1-3 in a particular stand.

Appendix 2 - Interesting species (new to the area, county and new to Sweden)

A number of interesting species of both saproxylic and non-saproxylic Diptera (mainly flies but also mosquitoes) and non-saproxylic Coleoptera, was found. The following species (table 7) are interesting for the area. Interesting species are former red-listed species and uncommon species with only few records. In some cases they are new to Västerbotten and even some are new to Sweden.

Table 7 – Interesting species documented in the study areas of Klabböle (K) and Baggböle (B). They were species determined after the data analysis had been done; therefore they were excluded from that moment.

Interesting species:
Lauxania albomaculata (New to Sweden)
Lonchaea carpathica (New to Sweden)
Xylota sylvarum (New to Västerbotten)
Curculio betulae
Nemadus colonoides
Xyletinus planicollis
Fannia difficilis
Berkshiria hungarica (Stratiomyidae)
Neopachygaster meromelas (Stratiomyidae)
Lonchaea (Lonchaeidae)
Dasiops (Lonchaeidae)
Periscelis nigra (Periscelidae)
Myodris annulata (Periscelidae)
Aulacigaster pappi (Aulacigastridae)
Euphranta toxoneura (Tephritidae)
Rhamphomyia physoprocta (Empididae)
Oedalea spp. (Hybotidae)
Systenus bipartitus (Dolichopodidae)
Systenus pallipes (Dolichopodidae)
Odinia ornata
Odiniaboletina
Gymnochiromyia inermis (Chyromyidae)
Leiomyza dudai
Leiomyza scatophagina (Asteiidae)
Clusiodes spp. (Clusidae)
Medetera spp. (Dolichopodidae)
Drosophilidae

Appendix 3

Table 1 **–** The saproxylic beetles (Coleoptera) included in the data analysis. The Sx category shows the saproxylic category for each species, SxO stand for obligate saproxylic and SxF for facultative saproxylic. The column for tree species shows on what tree species the saproxylic beetles were found, with B standing for Birch, A for Aspen, G for Grey alder and S for Goat willow and the column for tree type shows the division into polyphagus species (P), deciduous species (D) and coniferous species (C). The red-listed species were ranked by level of extinction risk in the following classes from Gärdenfors (2010); Data Deficient (DD), Near threatened (NT), Vulnerable (VU), Endangered (EN), Critically endangered (CR) and Regionally extinct (RE). *Microhabitat: C = cambium, e.g. in and under bark; D = detritus, e.g. decaying twigs, litter of leaves, sap flow, dung & dead animals; F = fungi, e.g. sporocarps and mycelia in wood; H = green plant tissues, e.g. living needles and leaves; W = wood, e.g. dead sapwood & wood mould cavities; A - ant nests. **Nutrition: C = cambium consumer, incl. phloem and consumers of cortex on living trees; D = detrivore, incl. necrophagous saproxylics; F = fungivore, i.e. mycetophag; H = herbivore, incl. bryophagous; P = predator, incl. Ectoparasitoids; W = wood-boring in dead wood, e.g. xylophagous, incl. dead terminal shoots; ? = insufficient knowledge nutrional ecology.

Family	Species	Sx category	Microhabitat*	Nutrition**	Red-list	Tree type	Preference	Tree species	Source
Carabidae	Dromius agilis	SxF	C,H	P		P	Conifer	A,B,S	Palm 51, Palm 59
	Dromius fenestratus	SxF	C	P		P	Conifer	A,B,G,S	Palm 51, Palm 59
	Dromius schneideri	SxF	H	P		P	Conifer	B	Palm 51, Palm 59
	Philorhizus sigma	SxF	D	P		P		B	Palm 51, Palm 59
Histeridae	Carcinops pumilio	SxF	D	D		P		B	Palm 51, Palm 59
	Gnathoncus buyssoni	SxF	D	P		P		S,A,B	Palm 51, Palm 59
Leiodidae	Agathidium badium	SxF	F,D	F		P		S,G	Palm 51, Palm 59
	Agathidium confusum	SxF	C,D,W	F		P		G	Palm 51, Palm 59
	Agathidium pisanum (bicolor)	SxO	C,W	F		P	Aspen	S,A	Palm 51, Palm 59
	Agathidium rotundatum	SxF	D,W	F		P		A,B	Palm 51, Palm 59
	Agathidium seminulum	SxF	C,D,W	F		P	Aspen	S,G,B	Palm 51, Palm 59
	Agathidium varians	SxF				P		S,G	Palm 51, Palm 59
	Anisotoma axillaris	SxO	C,D,F,W	F		P		S,G	Palm 51, Palm 59
	Anisotoma castanea	SxO	C,D,F,W	F		P		G,A	Palm 51, Palm 59
	Anisotoma glabra	SxO	C,D,F,W	F		P		S	Palm 51, Palm 59
	Anisotoma humeralis	SxO	C,D,F,W	F		P		S,G,A,B	Palm 51, Palm 59
Scydmaenidae	Eutheia linearis	SxF	C,D,W,A	P		D		S,G,A,B	Palm 51, Palm 59
	Microscydmus minimus	SxO	W,A	P		D		G	Saproxylic.org
	Nevraphes coronatus	SxF	C,D	P		P		G,A,B	Palm 51
	Stenichnus bicolor	SxF	C,D,W,A	P		P		S,G,A,B	Palm 51, Palm 59
	Stenichnus collaris	SxF	D,W	P		P		S,G,A,B	Koch 1: 197
Staphylinidae	Acrulia inflata	SxF	C,D,F,W	?F		P		S,B	Palm 51, Palm 59

	Anthobium atrocephalum	SxF	D	?P		P		G	Saproxylic.org, Koch 1: 229
	Atrecus longiceps	SxO	C,W	P		P	Conifer	A	Palm 51, Palm 59
	Bibloporus bicolor	SxO	C,D,W	P		P	Alder	S,G,A,B	Palm 51, Palm 59
	Bibloporus minutus	SxO	C,W	P		P		A,B	Palm 51, Palm 59
	Bisnius subuliformis	SxF	D	P		P		A,B	Palm 51, Palm 59
	Gabrius splendidulus	SxF	C,D,W	P		P		G,A,B	Palm 51, Palm 59
	Lordithon lunulatus	SxF	F	P		P		S,G,A,B	Palm 51, Palm 59
	Lordithon speciosus	SxO	F	P		P		A,B	Palm 51, Palm 59
	Lordithon trimaculatus	SxO	F	P		P	Birch	S,A,B	Palm 51, Palm 59
	Nudobius lentus	SxO	C	P		P	Conifer	A	Palm 51, Palm 59
	Philonthus decorus	SxF	D,F	?P		P		B	Koch 1: 299
	Phloeostiba lapponica	SxO	C	P		P	Conifer	G,A	Palm 51, Palm 59
	Phyllodrepa linearis	SxO	C,F,W	?F,?P		P	Conifer	G,A,B	Palm 51, Palm 59
	Phyllodrepa melanocephala	SxO	C,D,F,W	?F,?P		D		S,A,B	Palm 51, Palm 59
	Quedius brevicornis	SxO	D	P		P		A	Palm 51, Palm 59
	Quedius cruentus	SxF	D,F	?P		D	Elm	S,G,A,B	Palm 59
	Quedius maurus	SxO	C,D,F	?P		P		S,G,A,B	Palm 51, Palm 59
	Quedius mesomelinus	SxF	C,D,F	?P		D		S,G,A,B	Palm 59
	Quedius plagiatus	SxO	C,D,F	P		P		S,G,A,B	Saproxylic.org
	Quedius xanthopus	SxF	C,D,F	?P		P	Conifer	S,G,A,B	Palm 51, Palm 59
	Scaphisoma agaricinum	SxF	C,D,F	?F		P		S,A,B	Palm 51, Palm 59
	Scaphisoma boreale	SxF	C,D,F	?F		D		A	Palm 59
	Sepedophilus littoreus	SxF	C,D	F		P		A	Palm 51, Palm 59
	Sepedophilus marshami	SxF	C,D,F	F		P		S,A,B	Koch 1: 335
Trogidae	Trox scaber	SxF	D	D		P		A	Palm 51, Palm 59
Scarabaeidae	Protaetia cuprea metallica	SxF	W,A	D		P		S,G,A,B	Koch 2: 379
Clambidae	Clambus punctulum	SxF				P		S,G,A	Saproxylic.org
Elateridae	Ampedus balteatus	SxO	C,W	P,W		P	Conifer	B	Palm 51, Palm 59
	Ampedus nigrinus	SxO	C,W	P,W		P		G, A, B	Palm 51, Palm 59
	Ampedus pomorum	SxO	C,W	P,W		P	Alder	G, A, B	Palm 51
	Denticollis linearis	SxO	C,W	P,W		P	Alder	G, B	Palm 51, Palm 59
	Harminius undulatus	SxO	C,W	P,W	NT	P	Conifer	B	Palm 51, Palm 59
	Melanotus castanipes	SxO	C,W	P,W		P	Conifer	S, G, A, B	Palm 51
Lycidae	Dictyoptera aurora	SxO	C	P		P	Conifer	G	Palm 59

Cantharidae	Absidia schoenherri	SxO			P	Conifer	G, A	Palm 51
	Malthinus biguttatus	SxO	H,W	H,P	P		S, G	Koch 2: 38
	Malthodes brevicollis	SxO	H,W	H,P	D	Birch	G, A, B	Palm 59, Koch 2: 42
	Malthodes flavoguttatus	SxO	H,W	P	D		G, B	Saproxylic.org, Koch 2: 39
	Malthodes fuscus	SxO	H,W	P	P		S	Saproxylic.org
	Malthodes marginatus	SxO	H,W	P	P		S, G, A, B	Palm 59, Koch 2: 40
	Malthodes maurus	SxO	H,W	H,P	D		A	Koch 2: 40
	Malthodes mysticus/guttifer	SxO	H,W	P	P		S, G, A, B	Palm 59, Koch 2: 40
	Malthodes pumilus	SxO	H,W	H,P	P		A, B	Saproxylic.org, Koch 2: 41
	Podistra rufotestacea	SxO	C	?P	P		S, G, A, B	Saproxylic.org, Koch 2: 35
Dermestidae	Anthrenus museorum	SxF	W	D	D		S, G, A, B	Palm 51, Palm 59
	Attagenus pellio	SxF			P		G, B	Palm 59, Koch 2: 127
	Dermestes lardarius	SxF	D	D	D		B	Palm 59: 254
	Megatoma undata	SxF	C	P	P		S, G, A, B	Palm 51, Palm 59
Anobiidae	Anobium rufipes	SxO	W	W	D	Alder	S, G, B	Palm 51, Palm 59
	Dorcatoma dresdensis	SxO	F	F	P		S, G, A, B	Palm 51, Palm 59
	Hadrobregmus pertinax	SxO	W	W	P	Conifer	B	Palm 51, Palm 59
	Ptinus villiger	SxF	C	?C	D		A	Saproxylic.org, Koch 2: 282
Dasytidae	Dasytes niger	SxO	C	P	P		G, A, B	Palm 51, Palm 59
Malachiidae	Malachius bipustulatus	SxO	C	P	P		B	Palm 51, Palm 59
Sphindidae	Aspidiphorus orbiculatus	SxF	C,F	F	P	Conifer	S, G, A	Palm 51, Palm 59
	Sphindus dubius	SxF	C,F	F	P	Conifer	A	Palm 51, Palm 59
Nitidulidae	Carpophilus marginellus	SxF	C,D	D	P		S, G, A, B	Saproxylic.org
	Cychramus variegatus	SxF	F	F	P		S, G, A	Palm 51, Palm 59
	Epuraea aestiva	SxF	D,F	F	P		S, G, A, B	Saproxylic.org
	Epuraea angustula	SxO	C,F,W	F,P	P		G, B	Palm 51, Palm 59
	Epuraea biguttata	SxO	D,F	F	P		G, A	Palm 51, Palm 59
	Epuraea longiclavis	SxO	C,W	D,F	D		G, A, B	Palm 51, saproxylic.org
	Epuraea longipennis	SxO	C,W	D,F	P	Conifer	A	Palm 51, saproxylic.org
	Epuraea oblonga	SxO	C,W	D,F	P	Conifer	S, G, A, B	Höjer 2011, saproxylic.org
	Epuraea rufomarginata	SxF	C,D,F,W	F	P		B	Palm 51, Palm 59
	Epuraea silacea	SxO	C,D,F	F	D			Palm 51, Palm 59
	Epuraea unicolor	SxF	C,D,F,W	D,F	D		S, G, A, B	Palm 51, Palm 59
	Glischrochilus hortensis	SxF	C,D,F	D,F	D		S, G, A, B	Palm 51, Palm 59

	Glischrochilus quadripunctatus	SxO	C	P		P		B	Palm 51, Palm 59
	Pityophagus ferrugineus	SxO	C	P		C		B	Saproxylic.org
	Soronia grisea	SxO	C,D,W	D		D		S, G, A, B	Palm 51, Palm 59
	Soronia punctatissima	SxO	C,D,W	D,F		D		S, A, B	Palm 51, Palm 59
Monotomidae	Rhizophagus bipustulatus	SxO	C	P,F		P		G	Palm 51, Palm 59
	Rhizophagus cribratus	SxO	C,D,F	P		D		B,A	Palm 51, Palm 59
	Rhizophagus dispar	SxF	C,F	P		P		S,G,A,B	Palm 51, Palm 59
	Rhizophagus nitidulus	SxO	C,F	P		P		B, A, G	Palm 51, Palm 59
	Rhizophagus parallelocollis	SxO				D		G	Palm 59, saproxylic.org
	Rhizophagus parvulus	SxO	C,F	P		P	Birch	A, B	Palm 51, Palm 59
Erotylidae	Dacne bipustulata	SxO	F	F		P		S, G, A, B	Palm 51, Palm 59
	Triplax aenea	SxO	F	F		D		S, G, A, B	Palm 51, Palm 59
	Triplax russica	SxO	F	F		D		B	Palm 51, Palm 59
	Triplax scutellaris	SxO	F	F		D		G, B, A	Palm 51, Palm 59
Cerylonidae	Cerylon deplanatum	SxO	C	F	NT	D	Aspen	B	Palm 51, Palm 59
	Cerylon ferrugineum	SxO	C	F		P		S, G, A, B	Palm 51, Palm 59
	Cerylon histeroides	SxO	C	F		P		S, G, A, B	Palm 51, Palm 59
Endomychidae	Endomychus coccineus	SxO	C	F		D	Aspen	S, G, A, B	Palm 51, Palm 59
Corylophidae	Orthoperus atomus	SxF	C,D,W	F		P		A, G	Palm 51, Palm 59
	Orthoperus punctatus	SxF	C,D	F		P		A, G, B	Palm 51, Palm 59
Mycetophagidae	Litargus connexus	SxO	C	F		P		B	Palm 51, Palm 59
	Mycetophagus fulvicollis	SxO	C,W	F	NT	P	Aspen, Spruce	S, B	Palm 51, Palm 59
	Mycetophagus multipunctatus	SxO	C,F,W	F		D		A, B	Palm 51, Palm 59
	Mycetophagus populi	SxO	W	F		D		B	Palm 51, Palm 59
Ciidae	Cis alter	SxO	F	F		P		G	Palm 51, Palm 59
	Cis bidentatus	SxO	F	F		P		S, G, A, B	Palm 51, Palm 59
	Cis boleti	SxO	F	F		D		S, G, A, B	Palm 51, Palm 59
	Cis comptus	SxO	F	F		P	Birch	B, A, S	Palm 51, Palm 59
	Cis festivus	SxO	F	F		D		B, A, S	Palm 51, Palm 59
	Cis hispidus	SxO	F	F		D		B, G	Palm 51, Palm 59
	Cis jacquemartii	SxO	F	F		P		S, G, A, B	Palm 51, Palm 59
	Cis lineatocribratus	SxO	F	F		P		S	Palm 51, Palm 59
	Cis quadridens	SxO	F	F	NT	P	Conifer	B, A	Palm 51, Palm 59
	Dolichocis laricinus	SxO	F	F	NT	P	Birch, Conifer	B	Palm 59

	Ennearthron cornutum	SxO	F	F		P		G, S	Palm 51, Palm 59
	Hadreule elongatula	SxO	F	F		P		A	Koch 2: 261
	Orthocis alni	SxO	F	F		P		S, G, A, B	Palm 51, Palm 59
	Ropalodontus strandi	SxO	F	F		D		B	Saproxylic.org
Tetratomidae	Tetratoma ancora	SxO	C,D,F	F		P	Pine, deciduous	S, G, A, B	Palm 51, Palm 59, Pettersson 2013
Melandryidae	Abdera affinis	SxO	C	F		D		G, B, S	Palm 51, Palm 59
	Abdera flexuosa	SxO	C	F		P		S, G, A, B	Palm 51, Palm 59
	Hallomenus axillaris	SxO	C	F	NT	P		A	Palm 51, Palm 59
	Hallomenus binotatus	SxO	C	F		P		S, G, A, B	Palm 51, Palm 59
	Orchesia fasciata	SxO	C	F	NT	P	Conifer	S, G, A, B	Palm 51, Palm 59
	Orchesia micans	SxO	C	F		D		S, G, A, B	Palm 51, Palm 59
	Orchesia minor	SxO	C	F		P		A	Palm 51, Palm 59
Mordellidae	Mordella holomelaena	SxO	W	F		D		G, B	Saproxylic.org
	Mordellochroa abdominalis	SxO				D		B	Saproxylic.org
	Tomoxia bucephala	SxO	W	W		P	birch	S, G, A, B	Palm 51, Palm 59
Zopheridae	Synchita humeralis	SxO	D,F	D,F		D	Alder	S, G, A, B	Palm 51, Palm 59
Salpingidae	Rabocerus foveolatus	SxO	C	P		D		B	Palm 51, Palm 59
	Rabocerus gabrieli	SxO	C	P		D	Alder	G	Palm 51, Palm 59
	Salpingus planirostris	SxO	C	P		D		S, G, A, B	Palm 51, Palm 59
	Salpingus ruficollis	SxO	C	P		P		S, G, B	Palm 51, Palm 59
Aderidae	Pseudanidorus pentatomus	SxO			NT	D	Aspen	A, S, B	Palm 51, Palm 59
Scraptiidae	Anaspis arctica	SxO	C	P		P		S, G, A, B	Palm 51
	Anaspis frontalis	SxO	C	P		P		S, G, A, B	Saproxylic.org
	Anaspis rufilabris	SxO	C,W	P		P		S, G, A, B	Palm 51, Palm 59
Cerambycidae	Anoplodera maculicornis	SxO	W	D,W		P		B	Palm 51, Palm 59
	Aromia moschata	SxO	C,W	C,W		D	Goat willow	B, S	Palm 51, Palm 59
	Leptura melanura	SxO	W	W		P		A	Saproxylic.org, Palm 59
	Leptura quadrifasciata	SxO	W	W		D	Alder	S, G, A, B	Palm 51, Palm 59
	Necydalis major	SxO			NT	P		G, B, S	Palm 51, Palm 59, Ehnström 2007
	Rhagium mordax	SxO	C	C		D		B	Palm 51, Palm 59
	Saperda carcharias	SxO				D	Aspen	A	Palm 51, Palm 59
	Saperda scalaris	SxO	C,W	C,W		D		B, G	Palm 51, Palm 59
	Tetrops praeusta	SxO				D		B, S	Palm 51, Palm 59
	Xylotrechus rusticus	SxO	C,W	C,W		D	Aspen	A	Palm 51, Palm 59

Anthribidae	Platystomos albinus	SxO	W	W	D		B, S	Palm 51, Palm 59
Curculionidae	Cryptorhynchus lapathi	SxO	C,W	C,W	D		S, G	Palm 51, Palm 59
	Dryocoetes alni	SxO	C	C	D	Alder	S, G, B	Palm 51, Palm 59
	Magdalis ruficornis	SxO	C	C	D		G, A, B	Palm 59, saproxylic.org
	Rhyncolus ater	SxO	W	W	P	Conifer	B	Palm 51, Palm 59
	Scolytus ratzeburgii	SxO	C	C	D	Birch	B	Palm 51, Palm 59
	Trypodendron domesticum	SxO	W	F	D		B, G, A	Palm 51, Palm 59
	Trypodendron signatum	SxO	W	F	D		A, B	Palm 51, Palm 59

Appendix 4.

Table X – Coniferous species of saproxylic beetles (Coleoptera). The Sx category shows the saproxylic category for each species, SxO stand for obligate saproxylic and SxF for facultative saproxylic. The column for tree species shows on what tree species the saproxylic beetles were found, with B standing for Birch, A for Aspen, G for Grey alder and S for Goat willow. The red-listed species were ranked by level of extinction risk in the following classes from Gärdenfors (2010); Data Deficient (DD), Near threatened (NT), Vulnerable (VU), Endangered (EN), Critically endangered (CR) and Regionally extinct (RE). *Microhabitat: C = cambium, e.g. in and under bark; W = wood, e.g. dead sapwood & wood mould cavities. **Nutrition: C = cambium consumer, incl. phloem and consumers of cortex on living trees; P = predator, incl. Ectoparasitoids; W = wood-boring in dead wood, e.g. xylophagous, incl. dead terminal shoots.

Family	Species	Sx category	Microhabitat*	Nutrition**	Red-list	Tree type	Tree species	Source
Buprestidae	Anthaxia quadripunctata	SxO	C	C		C	B	saproxylic.org
Anobiidae	Microbregma emarginatum	SxO	C	C		C	A	saproxylic.org
Nitidulidae	Pityophagus ferrugineus	SxO	C	P		C	B	saproxylic.org
Cerambycidae	Anoplodera sanguinolenta	SxO	W	W		C	B	saproxylic.org
	Molorchus minor	SxO	C,W	C,W		C	A,B,G,S	saproxylic.org
	Pogonocherus decoratus	SxO	C,W	C,W	NT	C	B	saproxylic.org
Curculionidae	Hylastes cunicularius	SxO	C	C		C	G,A	saproxylic.org
	Hylobius abietis	SxO	C,W	C,W		C	G	saproxylic.org
	Hylurgops palliatus	SxO	C	C		C	S	saproxylic.org
	Ips typographus	SxO	C	C		C	G	saproxylic.org
	Pityogenes bidentatus	SxO	C	C		C	B	saproxylic.org
	Pityogenes chalcographus	SxO	C	C		C	A,B,G,S	saproxylic.org

Appendix 5.

Table 2 - Saproxylic species of Diptera and Hymenoptera. The column for tree species shows on what tree species the saproxylic beetles were found, with B standing for Birch, A for Aspen, G for Grey alder and S for Goat willow. *Microhabitat: C = cambium, e.g. in and under bark; V = wood living; V(P) = parasitism on wood living Aculeata; W=dead wood; P = predators in wood; S = resin flow; D = disintegrators.

Family	Species	Order	Microhabitat*	Tree species	Preference	Source
Bethylidae	Cephalonomia formiciformis	Hymenoptera	V(P)	G		Pers comm. Sven Hellquist 2014
Chrysididae	Chrysis angustula	Hymenoptera	V(P)	S, B, A, G		Pers comm. Sven Hellquist 2014
	Chrysis ignita-gruppen sp.	Hymenoptera	V(P)	S, B, A, G		Pers comm. Sven Hellquist 2014
	Trichrysis cyanea	Hymenoptera	V(P)	G		Pers comm. Sven Hellquist 2014
Colletidae	Hylaeus annulatus	Hymenoptera	V	A, B, G		Pers comm. Sven Hellquist 2014
Crabronidae	Crossocerus annulipes	Hymenoptera	V	B, G, S		Pers comm. Sven Hellquist 2014
	Crossocerus barbipes	Hymenoptera	V	S		Pers comm. Sven Hellquist 2014
	Crossocerus cetratus	Hymenoptera	V	S, B, A, G		Pers comm. Sven Hellquist 2014
	Crossocerus dimidiatus	Hymenoptera	V	G		Pers comm. Sven Hellquist 2014
	Crossocerus megacephalus	Hymenoptera	V	S, B, A, G		Pers comm. Sven Hellquist 2014
	Crossocerus nigritus	Hymenoptera	V	B		Pers comm. Sven Hellquist 2014
	Crossocerus subulatus	Hymenoptera	V	S, B, A, G		Pers comm. Sven Hellquist 2014
	Crossocerus walkeri	Hymenoptera	V	B		Pers comm. Sven Hellquist 2014
	Ectemnius borealis	Hymenoptera	V	S		Pers comm. Sven Hellquist 2014
	Ectemnius cavifrons	Hymenoptera	V	S, B, A, G		Pers comm. Sven Hellquist 2014
	Ectemnius ruficornis	Hymenoptera	V	B		Pers comm. Sven Hellquist 2014
	Passaloecus eremita	Hymenoptera	V	B		Pers comm. Sven Hellquist 2014
	Passaloecus monilicornis	Hymenoptera	V	B, G		Pers comm. Sven Hellquist 2014
	Pemphredon flavistigma	Hymenoptera	V	B, S		Pers comm. Sven Hellquist 2014
	Pemphredon lugubris	Hymenoptera	V	S, B, A, G		Pers comm. Sven Hellquist 2014
	Pemphredon morio	Hymenoptera	V	S, B, A, G		Pers comm. Sven Hellquist 2014
	Spilomena differens	Hymenoptera	V	A, B, G		Pers comm. Sven Hellquist 2014
	Trypoxylon minus	Hymenoptera	V	G		Pers comm. Sven Hellquist 2014
Drosophilidae	Stegana mehadiae	Diptera	W	B	Deciduous	Pers comm. Sven Hellquist 2014

Hybotidae	Tachydromia umbrarum	Diptera	P	A, B		Pers comm. Sven Hellquist 2014
	Tachypeza nubila	Diptera	P	A		Pers comm. Sven Hellquist 2014
Lonchaeidae	Lonchaea affinis	Diptera	C	A	Conifer	Pers comm. Sven Hellquist 2014
Megachilidae	Chelostoma campanularum	Hymenoptera	V	B		Pers comm. Sven Hellquist 2014
Pompilidae	Dipogon bifasciatus	Hymenoptera	V	S, B, A, G		Pers comm. Sven Hellquist 2014
Psilidae	Chyliza annulipes	Diptera	S	A	Spruce	Pers comm. Sven Hellquist 2014
Stratiomyidae	Neopachygaster meromelas	Diptera	C	A	Deciduous	Pers comm. Sven Hellquist 2014
Syrphidae	Brachyopa testacea	Diptera	W	A	Spruce	Pers comm. Sven Hellquist 2014
	Chalcosyrphus nemorum	Diptera	C	B, G	Deciduous	Pers comm. Sven Hellquist 2014
	Sphecomyia vespiformis	Diptera	W	A	Deciduous	Pers comm. Sven Hellquist 2014
	Xylota segnis	Diptera	W	S, B	Deciduous, Conifer	Pers comm. Sven Hellquist 2014
	Xylota sylvarum	Diptera	W	B	Deciduous, Conifer	Pers comm. Sven Hellquist 2014
Tipulidae	Dictenidia bimaculata	Diptera	D	S, B, A, G	Deciduous	Pers comm. Roger Pettersson 2014
	Tanyptera atrata	Diptera	D	S	Deciduous	Pers comm. Roger Pettersson 2014
Vespidae: Eumeninae	Discoelius dufourii	Hymenoptera	V	G		Pers comm. Sven Hellquist 2014
Xylophagidae	Xylophagus ater	Diptera	C	S, B, A, G	Deciduous	Pers comm. Sven Hellquist 2014

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2014:8	Full Circle: Upstream and downstream migration of Atlantic salmon (*Salmo salar*) in the northern Swedish river Vindelälven. Författare: Raven Grandy-Rashap
2014:9	Nyckeltal för älg och fodertillgång på tall Pinus sylvestris och rönn Sorbus aucuparia. Författare: Mikael Åkerblom Andersson
2014:10	Rissepareringens effekter på viltets nyttjandegrad av GROT. Författare: David Rehmberg
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2014:15	The Secret Role of Elephants - Mediators of habitat scale and within-habitat scale predation risk Författare: Urza Flezar
2014:16	Movement ecology of Golden eagles (Aquila crysaetos) and risks associated with wind farm development Författare: Rebecka Hedfors
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2015:2	The repulsive shrub – Impact of an invasive shrub on habitat selection by African large herbivores Författare: David Rozen-Rechels
2015:3	Suitability analysis of a reintroduction of the great bustard (Otis tarda) to Sweden Författare: Karl Fritzson

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