OLD PARK TREES: A HIGHLY DESIRABLE RESOURCE FOR BOTH HISTORY AND BEETLE DIVERSITY

By Mats Jonsell

Abstract. Many saproxylic beetles (those that live on dead wood) are confined to old trees. Because old trees have generally decreased drastically in number, many of these beetles are now red-listed, which means that they are on a list of species that are considered threatened by extinction from the area (often a country) that the list covers. Beetles dependent on old trees are found primarily in small remnants of semi-natural forests or on grazed land with old trees. However, parks around castles and manor houses also often contain old trees. This paper presents an inventory of saproxylic beetles in one such old, baroque park with an approximately 300-year-old avenue of lime (*Tilia cordata*) trees. The results are compared with a similar inventory of the most species-rich, old-tree site within the same region. It is a semi-natural forest, partly grazed, containing a number of old oaks. In the park, 18 red-listed beetle species were found—just a few less than the 22 found in the semi-natural forest. The results suggest that parks with old trees may be valuable sources of biodiversity. Because the number of old trees has decreased in the landscape generally, the remaining trees have become more important for the survival of the fauna associated with them. Cultural and biological values could be combined because both may be enhanced by retaining old trees.

Key Words. Old trees; biodiversity; park trees; saproxylic beetles.

Old trees have become much scarcer in the Swedish landscape during the past 200 years (Eliasson and Nilsson 2002). The cause of this increasing scarcity is twofold: trees are cut down, and others are outcompeted by younger trees when grazed land is abandoned to regrow. The situation is similar in other parts of Europe (Warren and Key 1991). Along with this decline, organisms associated with such trees have become red-listed (Berg et al. 1994), implying that they are at some risk of extinction in the region (IUCN 1994). The fauna in these trees are species-rich—the trees provide many different microhabitats such as rough bark, dead parts of the stem, dead branches, fungal fruiting bodies, and hollows, in which different kinds of animals can live (Warren and Key 1991). Such features generally start to appear on trees when they are about 100 to 200 years old, depending on the tree species and various other factors.

Beetles (Coleoptera) comprise one species-rich group of organisms that live in microhabitats in old trees (Jonsell et al. 1998). This is a diverse group; in all, approximately 1,000 Swedish beetle species live in various types of dead wood (Berg et al. 1994; Jonsell, et al. 1998) and are therefore termed "saproxylic" (Speight 1989). Old, hollow trees probably have the richest fauna of saproxylic beetles (Warren and Key 1991; Jonsell et al. 1998; Ranius and Jansson 2000).

Of the old-tree microhabitats listed above, only the hollows provide several niches such as the wood inside the hollow, bird nests, ant nests, and wood mold, for a wide range of specialized taxa. Wood mold is composed of loose bits of wood, leaves, and various other kinds of material that accumulate at the bottom of the hollow. A large hollow can contain hundreds of liters of wood mold. Species restricted to hollows in old trees may be more threatened than others because they have been suggested to have a poor ability to disperse to new sites (Nilsson and Baranowski 1997).

The old trees that remain in the Swedish landscape are clustered around manor houses and estates. This is mainly because the nobility that owned the estates kept their grounds wooded to provide good hunting grounds or for aesthetic reasons. The parks around the main buildings also usually have many old trees. Over the centuries, many old, hollow trees have been cut because they hindered agriculture (Eliasson and Nilsson 2002) or reduced the efficiency of wood production. A more recent threat is regrowth. As agriculture is modernized, many of the wooded meadows where old trees still exist are abandoned, allowing deciduous trees to sprout. After some decades, the old trees drown in a sea of regenerating young trees (Alexander et al. 1996; Read 2000; Nilsson and Baranowski 2003). They may survive among the regrowing trees for perhaps 50 years, but even during this period, the shading of the old trees has negative effects on some of the organisms that inhabit them (Ranius and Jansson 2000).

The decline of old trees means there now are fewer habitats for old-tree inhabitants than there were just 100 years ago, thereby increasing the risk of extinction. To develop guidelines for conserving these fauna, we need to identify kinds of trees that provide important habitats for these organisms. A number of authors have suggested that old trees in parks may be valuable in this respect (Gerell

2000; Ehnström and Axelsson 2002). To examine this hypothesis, I made an inventory of the beetle fauna in such trees and investigated their potential for preserving the fauna by comparing the results with a similar inventory taken in a semi-natural forest known to have a rich saproxylic beetle fauna. The specific questions addressed were

- Are many red-listed species inhabiting the old trees in the park?
- Is this number high compared to the numbers found using the same inventory method in one of the richest sites for wood-living beetles in the same region?

Figure 1. The lime tree (*Tilia cordata*) alley at Skokloster park, Sweden. It was originally planted in 1684 but as individual trees have become too old they have been continually replaced, which has been beneficial for the biodiversity of rare, wood-living beetles in the park.

MATERIAL AND METHODS

Study Sites

The inventoried park is situated at Skokloster in southeastern Sweden (N 59°40', E 17°40'), and the semi-natural, partly grazed wood of Biskops-Arnö is about 8 km (5 mi) southwest of the park. In the context of this study, the most interesting feature of the Skokloster park is an avenue of about 180 lime trees (*Tilia cordata*) around a baroque garden (Figure 1). The avenue was originally planted in 1684 (National Property Board 2001), and the oldest remaining trees today are probably from that time. However, trees have been continually replaced, so most of them are younger than that. The advanced age of the oldest trees is probably because the trees have been pollarded, which reduces their growth rates but prolongs their lifespan (Slotte 1993). The trees are about 7 m (23 ft) high. Most have hollows (Figure 2) in their trunks, ranging from small, newly formed ones to those so large that the trees have become chimney-shaped. The oldest trees have trunks that consist of a sector of the original circumference. All the trees are still vital and healthy enough to fulfill the purposes of the gardeners who planted them; that is, to form a pleasing avenue in the garden of the castle. Trees, or parts thereof, that are too badly deteriorated are removed. To promote biodiversity, such parts are left to decay in a particular location near the garden so that organisms (including the wood-living beetles) living in them can reproduce *in situ* (National Property Board 2001).

In other parts of the park are several large, deciduous trees, but they are not nearly as old as those along the lime avenue, so they have much less potential for hosting a diverse saproxylic fauna. However, some of these trees have started to develop hollows, and one horsechestnut (*Aesculus hippocastanum*) was investigated.

The site used for comparison was Biskops-Arnö, one of the richest sites for saproxylic beetles in southeast Sweden, in which 56 red-listed saproxylic beetle species have been

Figure 2. One of the old lime trees in the Skokloster park that has a large hollow with an opening about 2 m (6.6 ft) above ground.

recorded (Nilsson 2001; Jonsell, unpubl). It is an island with an area of about 2 km^2 (0.8 mi^2) in the lake Mälaren, supporting a mixture of arable land, old deciduous forest, and conifer plantations that are about 50 years old. The deciduous forest is rich in old, large, hollow trees, primarily oaks, but with all other species distributed in the region represented. The large trees grew in a fairly open, grazed forest, so they tend to have large crowns and stem diameters (Borgegård 1994). In addition to all the large, hollow trees are several dead and decaying trunks, which provide suitable habitats for saproxylic insects. Today, most of the land with large trees on the island is filling in with younger, deciduous trees (Figure 3), and only some parts are grazed.

Sampling Procedure

Beetles were sampled with window traps and pitfall traps (Ranius and Jansson 2002). The window traps each consisted of a transparent 30 × 60 cm (1 × 2 ft) large, plastic PVC window with a jar underneath, filled with water (plus a few drops of detergent) and propylene glycol, approximately 50:50 by volume. The windows were placed perpendicular to the trunk, near hollows 3 to 6 m (9 to 20 ft) above the ground. The pitfall traps each consisted of a small jar with an opening diameter of 7 cm (2.8 in.) placed in holes dug into the wood mold in the hollows so that its upper edge was level with the surface of the mold. The jar was three-quarters filled with the same liquid as the window traps.

Figure 3. An old, hollow oak typical of the regrowing sections of the semi-natural, deciduous forest site Biskops-Arnö.

Traps were set in three lime trees and one horsechestnut in the park at Skokloster, and in four large, hollow oaks at Biskops-Arnö. The traps were placed on May 18, 2001, and left *in situ* until August 30. During that time they were emptied three times. All beetles were sorted, and specimens that potentially belonged to saproxylic species were determined to the species level, according to the nomenclature of Lundberg and Gustafsson (1995). Excepted are the subfamily Aleocharine (within Staphylinidae). The beetles were classified as saproxylic, or not, by consulting Palm (1959) and Hansen (1964). These data sources, together with information about red-listed species on the Web (www.slu.se), were used to describe the substrate preferences for each species. Red-list categories are according to Gärdenfors (2000).

RESULTS

At Skokloster, 647 saproxylic beetles belonging to 67 species were caught (Table 1). In the semi-natural forest of Biskops-Arnö, the corresponding numbers were higher: 1,011 individuals representing 97 species. The number of beetles found in the lime trees in the avenue at Skokloster park (i.e., excluding those found in the horsechestnut tree) was 472, representing 57 saproxylic species, 17 of which were red-listed.

The two sites did not differ much in the frequency of red-listed species: 20 were found at Skokloster park and 24 in the semi-natural forest of Biskops-Arnö. The sum of red-listed species from both sites was 34, implying that ten red-listed species were found at both sites (Table 2).

All the red-listed species, except one found at Skokloster (*Monotoma testacea*) were saproxylic (Table 2). In total, 14 species—11 from Skokloster park and 12 from Biskops-Arnö's semi-natural forest—were associated with tree hollows (Table 2). All the other types of dead wood described in Table 2 can be found in old trees, although some of them may also occur in younger trees.

Table 1. Total number of saproxylic beetle species and individuals in the inventory.

	Skokloster	Biskops-Arnö
Number of saproxylic species	67	97
Number of saproxylic individuals	647	1,011
Number of red-listed species	20	24
Number of red-listed individuals	248	202

Table 2. The red-listed species found in Skokloster park and Biskops-Arnö's semi-natural forest. The red-list categories (Gärdenfors 2000) are NT = near-threatened, and VU = vulnerable. Species are listed in systematic order.

Species	Red-list category	Family	Microhabitat	Number of individuals	
				Skokloster	Biskops-Arnö
Plegaderus caesus (Herbst)	NT	Histeridae	White-rotten deciduous wood	1	0
Velleius dilatatus (Fabr.)	VU	Staphylinidae	Nests of *Vespa crabro* wasps*	0	2
Haploglossa gentilis (Märkel)	NT	Staphylinidae	Tree hollows with bird nests	2	2
Prionocyphon serricornis (Müll.)	NT	Scirtidae	Moist hollows on trees	2	0
Liocola marmorata (Fabr.)	VU	Scarabaeidae	Tree hollows	33	12
Calambus bipustulatus (L.)	VU	Elateridae	Bark on old deciduous trees	0	1
Procraerus tibialis (Lac.)	VU	Elateridae	Hollow trees, esp. white-rotten	1	3
Ampedus nigroflavus (Goeze)	NT	Elateridae	Hollow trees, esp. white-rotten	6	1
Ampedus hjorti (Rye)	NT	Elateridae	Brown-rotten, coarse wood, esp. oaks	0	2
Ampedus cardinalis (Schiödte)	VU	Elateridae	Brown-rotten wood in hollow oaks	0	1
Gastrallus immarginatus (Müll.)	NT	Anobiidae	Bark on old large trees, esp. oak	0	3
Xyletinus pectinatus (Fabr.)	NT	Anobiidae	Rotten, deciduous wood, esp. oak branches	0	2
Dorcatoma flavicornis (Fabr.)	NT	Anobiidae	Brown-rotten, deciduous wood	0	103
Lymexylon navale (L.)	VU	Lymexylidae	Oak wood, esp. sun-exposed	0	1
Grynocharis oblonga (L.)	VU	Trogossitidae	Coarse tree trunks	2	0
Trichoceble floralis (Ol.)	NT	Melyridae	white-rotten, deciduous wood	1	0
Trichoceble memnonia (Kiesenw.)	NT	Melyridae	white-rotten, deciduous wood	0	1
Epuraea guttata (Ol.)	NT	Nitidulidae	Sap flows	0	1
Cryptarcha undata (Ol.)	NT	Nitidulidae	Sap flows	1	1
Monotoma testacea (Motsch.)	NT	Monotomidae	Compost heaps	1	0
Laemophloeus monilis (Fabr.)	VU	Laemophloeidae	Dead lime wood	61	0
Cryptophagus confusus Bruce	NT	Cryptophagidae	Rotten, deciduous wood, hollows	1	1
Cryptophagus pallidus Sturm	NT	Cryptophagidae	Coarse, hollow, deciduous trees	1	1
Enicmus brevicornis (Mann.)	VU	Corticaridae	Dead lime wood	36	0
Diplocoelus fagi Guer.-Menev.	NT	Biphyllidae	Dead lime wood	3	0
Mycetophagus piceus (Fabr.)	NT	Mycetophagidae	Brown-rotten, deciduous wood	0	5
Euglenes oculatus (Payk.)	NT	Aderidae	Brown-rotten, deciduous wood	0	45
Allecula morio (Fabr.)	VU	Tenebrionidae	Tree hollows	0	1
Mycetochara axillaris (Payk.)	NT	Tenebrionidae	Tree hollows	68	1
Mycetochara humeralis (Fabr.)	NT	Tenebrionidae	Mainly in tree hollows	25	4
Scraptia fuscula Müll.	NT	Scraptiidae	Tree hollows	1	2
Leioderus kollari Redtenb.	NT	Cerambycidae	Recently dead maple (*Acer* spp.)	1	0
Phloeophagus turbatus Schönh.	NT	Curculionidae	Tree hollows	3	0
Dryocoetes villosus (Fabr.)	NT	Scolytinae	Recently dead oak	0	8

**Vespa crabro* is a large wasp that lives in tree hollows.

DISCUSSION

The high number of red-listed saproxylic species encountered in the park at Skokloster shows that the park's high cultural values are accompanied by high biodiversity values. The number of red-listed species was almost as high as the number found in Biskops-Arnö—a site that has long been known to be rich in saproxylic insects (Nilsson 2001; Palm 1959). This was despite the fact that the sample collected in the park (i.e., the number of saproxylic beetles trapped) was one-third smaller than the sample collected in the semi-natural forest. Thus, although the park may seem to be lacking in dead wood at first glance, it hosts a high number of red-listed saproxylic species, all of which live in its old trees.

The inventoried species are associated with a large variety of different microhabitats, some of which are found only in old trees. The manner in which trees develop old-tree microhabitats has not been studied in detail, but circumstantial observations indicate that they tend to be at least 100 years when such habitats first appear. Some of the beetles were associated with types of decaying wood, which may occur in younger trees but is more frequent in old trees. Two additional beetle species are associated with sap flow from the trunk, which may occur in younger trees but is more common in older ones. The single species associated with compost heaps (*Monotoma testacea*) may have been caught because it used the mold within the hollows, which is essentially a type of compost. There were no other compost habitats within at least 100 m (300 ft) of the trap. In conclusion, all the microhabitats listed in Table 2 can be found within an old tree population, but few are found in a young one.

Around Skokloster were larger areas containing old deciduous trees in previous times, as there were around most estates. Today, only small amounts of such land remain. Instead, there are numerous spruce plantations, many originating from converted deciduous land. Similar developments have occurred on Biskops-Arnö, where about half of the forested ground was planted with spruce 30 to 50 years ago (Borgegård 1994). Among the spruces, it is still possible to find large, struggling, old trees competing with the conifers, if they are not already dead. Thus, the abundance of suitable habitats for organisms that depend on old trees has declined considerably, and these organisms now have a greatly increased risk of extinction. The continued presence of old trees in the park is therefore probably more important these days for animals that are dependent on old trees.

The exceptional age of the trees has probably helped conserve high numbers of red-listed species in the park in two ways. First, because the avenue was planted as early as 1684, the trees had already reached an age of more than 100 years by the early 1800s—a time when the landscape was richer in old trees. At that time, the pool of species that was able to colonize such habitats was probably larger than it is today, and the avenue may have provided a refuge for a fauna that have declined or even disappeared in the surrounding landscape. Second, as trees age, the diversity of the microhabitats they provide tends to increase. The same is true for the avenue when considered as a whole. As the trees age, increasingly large variations in appearance between the tree individuals develop. Skokloster park contains trees with a wide spectrum of hollows, ranging from small, newly formed ones to those so large that only a sector of the original trunk remains.

The species of the investigated trees may have had some influence on the abundance and diversity of the beetle fauna, but it is unlikely to have been very strong. Lime is not one of the most highly ranked Swedish tree species in species-richness of the saproxylic fauna associated with it, although it does host a relatively high proportion of specialists (Palm 1959; Jonsell et al. 1998). In Skokloster park, three of the beetle species found are known to be specifically associated with lime (Table 2) and, more specifically, with a certain Ascomycetous fungus, *Biscogniauxia cineriolilacina*, which grows on lime trees (Palm 1956; Jonsell and Eriksson 2002). Oak, which was the most common tree on Biskops-Arnö, is the richest tree species for saproxylic beetle species in Sweden (Palm 1959). However, the effect of the tree species decreases as the wood decays (Jonsell et al. 1998), and the fauna become much more strongly influenced by the fungal flora. For insect species living in tree hollows, the structure and nature of the hollow are the most important factors. Although neither the fungal flora nor the characteristics of the hollows are independent of tree species, the old-tree structures in the park trees are much more important for maintaining high biodiversity than the species to which the trees belong.

MANAGEMENT IMPLICATIONS

From a biodiversity point of view, the most important and urgent task is to take care of the oldest trees and keep them alive as long as possible. Pollarding is likely to be beneficial in this context, for three main reasons. First, it is likely to preserve the old trunks, together with all the microhabitats described in Table 2. Second, the branches are unlikely to become too heavy and long for the old trunks to support, thus reducing the risk that their weight will eventually tear them apart. Third, the retarded growth associated with pollarding may increase the likelihood that the trees will grow old (Rackham 1976; Slotte 1993).

However, even if everything possible is done to prolong the life of the trees, they will eventually die. In parks, they will be replaced before their natural death, for either aesthetic or safety considerations. In such cases, it is important to remember that the various components of the fauna will continue to need appropriate habitats. Every summer the new generation of insects requires suitable sites to lay eggs and for the larvae to develop. Therefore, to replace all the old trees in a park in a single operation would be catastrophic for the park's biodiversity, especially because there are unlikely to be many recolonizations. In the surrounding landscape, which was presumably the source of the beetles that first colonized the park, the number of old trees has decreased drastically.

Therefore, the avenue must be replaced in a stepwise manner. So far, the alley at Skokloster park has been replaced tree by tree when individual trees have become too old (National Property Board 2001). There may, however, be problems with the establishment of newly planted trees if their roots have to compete with the root systems of older trees. If so, replacing sections of the avenue may be the best option, provided steps are taken to ensure that there is always a high number of trees with biodiversity-promoting structures. Because such structures are found on trees that are at least 100 years old, this replacement has to be a long-term project—as is the conservation of old cultural values.

CONCLUSIONS

This inventory shows that there are good opportunities for both cultural and biodiversity values to be maintained at high levels in parks. The high biodiversity value in Skokloster park is primarily attributable to management practices in the park that have preserved the large avenue of trees in such a way that many of the trees are now several hundred years old.

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Department of Entomology
Swedish University of Agricultural Sciences
Box 7044, SE-750 07 Uppsala, Sweden

Résumé. Plusieurs des coléoptères saproxyliques, c'est-à-dire ceux qui vivent dans le bois mort, sont confinés aux vieux arbres. Comme le nombre de vieux arbres a, de manière générale, diminué dramatiquement, plusieurs de ces insectes sont maintenant sur la liste rouge, ce qui signifie qu'ils sont sur la liste qui identifie les espèces qui sont plus ou moins menacées d'extinction d'une certaine région (souvent d'un pays) que la liste couvre. Les coléoptères dépendant des vieux arbres sont généralement retrouvés dans les petits résidus de forêts semi-naturelles ou dans les pâturages avec de vieux arbres. Néanmoins, les parcs autours des châteaux et des manoirs renferment eux aussi de vieux arbres. Cet article présente un inventaire des coléoptères saproxyliques dans un de ces vieux parcs baroques avec une longue allée de tilleuls (*Tilia cordata*) âgés (300 ans). Les résultats ont été comparés à un inventaire similaire fait dans le site le plus riche en espèces d'arbres âgés et localisé dans la même région. C'est une forêt semi-naturelle, partiellement en pâturage, contenant un lot de vieux chênes. Dans le parc, 18 espèces de coléoptères sur la liste rouge ont été découverts, c'est-à-dire juste un peu moins que les 22 observés dans la forêt semi-naturelle. Les résultats suggèrent que les parcs avec de vieux arbres peuvent fournir une source valable de biodiversité. Parce que le nombre de vieux arbres a généralement diminué dans le paysage, les arbres restants sont devenus d'autant importants pour la survie de la faune associée à ces derniers. Généralement, les valeurs culturelle et biologique pourraient être combinées, et pourraient peut-être même être accrue mutuellement par la conservation des vieux arbres.

Zusammenfassung. Viele saprophytisch lebende Käfer, d.h. die von Totholz leben, sind in ihrem Lebensraum auf alte Bäume beschränkt. Da alte Bäume allgemein in der Zahl drastisch reduziert sind, sind viele dieser Käfer auf der Roten Liste, die sie als von Aussterbung in der betreffenden Region bedroht sieht. Die Käfer, die abhängig von alten Bäumen sind, findet man hauptsächlich in kleinen Restbeständen natürlicher Wälder oder auf Weiden mit altem Baumbestand. Aber auch Parkanlagen um Schlösser und Landsitze enthalten oft alten Baumbestand. Diese Studie präsentiert eine Inventur der saprophytisch lebenden Käfer in einem alten Barockgarten mit einer 300 Jahre alten Lindenallee. Die Ergebnisse wurden verglichen mit einer ähnlichen Inventur eines artenreichen alten Baumbestandes in der gleichen Region. Es handelt sich um einen halbnatürlichen Wald, teilweise begrast, mit einer großen Anzahl alter Eichen. In dem Park wurden 18 der gelisteten Käfer gefunden, etwas weniger als die 22 Käferarten aus dem alten Mischwald. Die Ergebnisse weisen auf die große Biodiversität solcher alter Parkanlagen mit altem Baumbestand hin. Weil die Anzahl alter Bäume generell abnimmt, werden die verbleibenden Bäume immer wichtiger für das Überleben der assoziierten Fauna. Gewöhnlich können kulturelle und biologische Werte kombiniert werden, wenn beide für die Erhaltung alter Bäume geeignet sind.

Resumen. Muchos escarabajos saprofitos, lo que viven de la madera muerta, están confinados a árboles muertos. Como los árboles muertos generalmente han disminuido drásticamente en número, muchos de estos escarabajos están ahora en la lista roja, lo cual significa que están en la lista de especies bajo peligro de extinción del área o del país. Los escarabajos dependientes de árboles viejos están principalmente en pequeños remanentes de bosques semi-naturales, o pastizales con árboles viejos. Sin embargo, los parques alrededor de castillos y mansiones con frecuencia también contienen árboles viejos. Este reporte presenta un inventario de los escarabajos saprofitos en un viejo parque de 300 años con tilos (*Tilia cordata*). Los resultados son comparados con un inventario similar en otro sitio de árboles viejos en la misma región; es un bosque semi-natural, parcialmente cubierto de pastos que contiene un lote de viejos encinos. En el parque se encontraron 18 especies de la lista roja, pero poco menos de 22 en el bosque semi-natural. Los resultados sugieren que los parques con árboles viejos pueden proporcionar fuentes importantes de biodiversidad. Debido a que el número de árboles viejos ha disminuido, los árboles remanentes son importantes para la supervivencia de la fauna asociada con ellos. Usualmente los valores culturales y biológicos podrán ser combinados y valorados para mantener los árboles viejos.