Threatened Beetles in White-Backed Woodpecker Habitats

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Abstract: *We explored the importance of habitats preferred by the endangered White-backed Woodpecker (*Dendrocopos leucotos*) for threatened, saproxylic beetles (Coleoptera). We sampled 16 potential breeding forests of the White-backed Woodpecker in Finland and Russian Karelia. Our surveys yielded 16 threatened species from a total of 39,485 identified beetle individuals. All 16 species and the woodpecker are dependent on the same resource, decaying wood, and at least some of the beetles even prefer successional deciduous habitats, as does the woodpecker. Based on 6 years of data, we conclude that the number of threatened beetle species in each of these forests is considerable (6 or more), although samples from one season included only 0–4 such species. These inconspicuous threatened species might be protected through use of the White-backed Woodpecker as an umbrella species to define suitable habitats. The woodpeckers require approximately 50–100 ha of suitable habitat for breeding, suggesting that every woodpecker territory may include local populations of a number of threatened beetle species. If the White-backed Woodpecker can be saved in Finland, a suite of threatened saproxylic beetles will most likely be saved as well. We also need more information on the minimum requirements of the threatened beetles, which can be obtained only by continued study of the beetles themselves.*

Escarabajos Amenazados en Hábitats del Pájaro Carpintro de Espalda Blanca

Resumen: *Exploramos la importancia de los hábitats preferidos por el pájaro carpintero de espalda blanca, en peligro de extinción (*Dendrocopos leucotos*) para los escarabajos saproxilicos (Coleoptera) amenazados. Muestreamos 16 bosques con potencial para la reproducción del pájaro carpintero en Finlandia y la Karelia Rusa. Nuestros muestreos arrojaron 16 especies amenazadas de un total de 39,485 individous de coleopteros identificados. Las 16 especies y el pájaro carpintero dependen del mismo recurso, madera en descomposición y al menos algunos de los escarabajos prefieren hábitats deciduos sucesionales al igualque el pájaro carpintero. Basados en 6 años de datos, concluimos que el número de especies de escarabajos amenazadas en cada uno de estos bosques es considerable (6 o mas), aunque las muestras de una estación incluyeron solo 0–4 de estas especies. Estas especies amenazadas inconspicuas pueden ser protegidas utilizando al pájaro carpintero como especie sombrilla para definir hábitats aptos. El pájaro carpintero requiere de aproximadamente 50–100 ha de hábitat adecuado para reproducción, sugiriendo que cada territorio de pájaro carpintero podría incluir problaciones locales de un número de especies de escarabajo amenazados. Si el pájaro carpintero de espalda blanca pudiera ser salvado en Finlandia, un espacio para los escarabajos saproxílicos amenazados sería salvado también. Sin embargo, necesitamos aún mas información sobre los requerimientos mínimos de los escarabajos amenazados, los cuales pueden ser solo obtenidos mediante la continuación de estudios específicos sobre los escarabajos.*

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Introduction

Populations of the White-backed Woodpecker (*Dendrocopos leucotos*) have declined in many European countries (e.g., Håland & Ugelvik 1990; Scherzinger 1990; Wesołowski 1995). In Finland and Sweden the situation is critical: the White-backed Woodpecker is one of the most endangered bird species in both countries (Aulén 1988; Rassi et al. 1992). The population size in Finland has decreased about 95% from 1950 to the 1990s, and the woodpecker may disappear from Finland as a breeding species within decades (Virkkala et al. 1993*a*). Today, the Finnish population is divided into two main breeding areas (Fig. 1), both of which host approximately 15 pairs (Virkkala et al. 1993*a*, 1993*b*; R. Virkkala personal communication). A conservation plan to protect the most important remaining breeding habitats for the woodpecker in Finland was completed in 1992 by World Wide Fund for Nature Finland and included 199 forest areas, for a total of about 50 km^2 (Valkoselkätikkatyöryhmä 1992).

Angelstam and Mikusiński (1994) classified the White-backed Woodpecker together with the Lesser-spotted (*D. minor*) and the Middle-spotted Woodpecker (*D. medius*) as the group of most sensitive northern European woodpecker species in relation to changes in forest structure and composition. This is because these species feed mainly on insects living in deadwood from deciduous trees. According to Virkkala et al. (1993*a*), the nesting woods of the White-backed Woodpecker in Finland are usually dominated by birches (*Betula pubescens* and *B. pendula*) and other deciduous trees, the proportion of coniferous trees being less than 10%. The mean number of standing and fallen dead trees is 140 per hectare, which corresponds to 15% of the number of living trees. Formerly, suitable habitats for the White-backed Woodpecker were created by succession after forest fires and slash-and-burn agriculture, at a stage when pioneering deciduous trees started to die, slowly giving way to shade-tolerant Norway spruce (*Picea abies*). In addition, deciduous forests along lake and sea shores were important. Field edges and abandoned farmlands are now also significant habitats.

The population contraction of the White-backed Woodpecker in Finland is mainly due to suppression of forest fires and to intensive forestry, which together have reduced both the proportion of deciduous forests and the amount of decaying wood (for more detailed data see Virkkala et al. 1993*a*). These factors, as well as other consequences of forest management, are the primary causes of the species being threatened in Finland (Rassi et al. 1992). Of the 1692 threatened animal, fungus, and plant species in Finland, 43% (727 spp.) live in forests. Furthermore, 54% of the threatened forest species are confined to deciduous forests with rich grass-herb vegetation, the same habitat type preferred by the White-backed Woodpecker.

We explored the importance of typical White-backed Woodpecker habitat for other threatened forest species, using beetles as an example. If these habitats turn out to be important for threatened Coleoptera as well, initiatives to protect woodpecker habitats could gain additional support. Beetles are well suited for this kind of study because about 80% of all threatened forest beetle species in Finland are saproxylic, depending on dead wood for some aspect of their life cycle (Speight 1989).

We compiled data from extensive surveys of the beetle fauna of deciduous forests that we conducted in southeastern Finland and Russian Karelia from 1990 to 1995. Most of the sampling sites were within the home ranges of White-backed Woodpeckers. We focused mainly on beetle families containing species living on dead or dying trees.

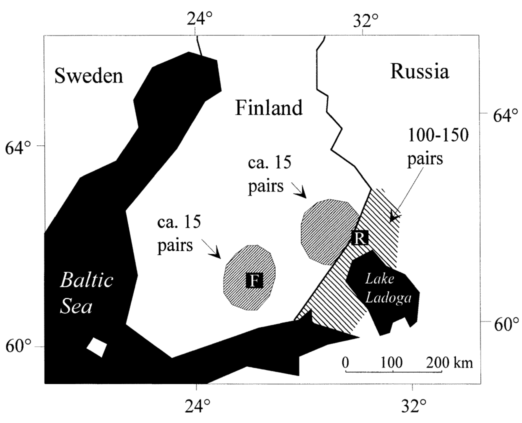

*Figure 1. The locations of the main breeding areas of the White-backed Woodpecker in Finland and Russian Karelia (modified from Virkkala et al. 1993*a*) with population size estimates (data from Virkkala et al. 1993*a*, 1993*b*, R. Virkkala, personal communication). The* F *indicates the location of the forests F1–F6 and* R *that of the forests R1–R10.*

Methods

We sampled beetles in 16 forests in Finland and Russian Karelia. Six of the forests (F1–F6) were situated in the western main breeding area of the White-backed Woodpecker in southern Finland, and the remaining 10 forests (R1–R10) in Russian Karelia, 10–15 km from the Finnish border (Fig. 1). The eastern main breeding area in Finland is actually continuous with the larger population in Russian Karelia. The size of the population in Russian Karelia near the Finnish border has been estimated to be roughly 100–150 pairs (Virkkala et al. 1993*b*).

The original selection of the study sites was based on habitat features: we searched for mature deciduous forests with plenty of decaying birch snags. These were potential nesting sites of the White-backed Woodpecker because they were situated in its breeding areas. The occurrence of woodpeckers in these areas was further verified by woodpecker records and by the presence of their typical foraging signs in our study sites. Furthermore, stand characteristics (Table 1) corresponded well with those of the nesting woods of the woodpecker, the only remarkable difference being a higher proportion of conifers in some of the study sites. The abundance of coniferous trees—spruces in particular—may prevent breeding in otherwise suitable forests, yet it does not make the forests unsuitable for feeding; these are included in the home range of the White-backed Woodpecker (Aulén 1988). The selection of the forests for the conservation plan of the woodpecker was based on these characteristics (Valkoselkätikkatyöryhmä 1992), so it is justified to assume that the forests in this study represent suitable habitats for the woodpecker.

All of the forests were dominated by birches, with varying proportions of other tree species (Table 1). Standing dead trees made up 7–21% of the total basal area, corresponding to approximately 20-50 m^3/ha. These forests were of anthropogenic origin as abandoned fields, old forest pastures, or former slash-and-burn cultivation areas, but none had been managed during the last few decades. The forests typically had a rich grass-herb undergrowth.

We used trunk window traps (Kaila 1993) to sample insect assemblages. The trap consisted of a 20 × 30 cm transparent plastic window, with a plastic funnel under the window leading to a 1-L container. The traps were attached to trunks of dead trees, usually close to fruiting bodies of polypores, which attract many saproxylic beetles. The trap captures both flying beetles and beetles walking on the trunk. The substrate (i.e., tree and fungus species) on which the trap is attached has been shown to affect the species composition of the catch (Kaila et al. 1994). For the purpose of this study we combined samples from several years and from different sampling designs, so the numbers of traps on different tree and polypore species varied greatly (Appendix). In each forest, however, at least 10 traps were attached to dead birches with *Fomes fomentarius*, the single exception being R10 with only 8 traps on such trunks. The rest of the traps were placed close to other polypores (*Fomitopsis pinicola*, *Phellinus igniarius* coll., and *Inonotus obliquus*) or on dead trunks without visible polypores near the trap. Because of differences in these trapping effects, it is not possible to compare directly the samples from different forests, but neither is this necessary to assess the possible association of rare beetles with the White-backed Woodpecker.

Samples from Russian Karelia were collected in 1991, and those from Finland during the years 1990–1995. Sampling started between 13 April and 22 May and ended between 3 September and 4 October. The total numbers of trapping days per site are presented in Appendix 1. In two of the Finnish forests (F1 and F2) we continued trapping for 6 years. These data can be used to indicate the shape of the species-accumulation curve when sampling is continued in the same sites over several years (Williams 1964). This is particularly important in estimating the number of threatened and uncommon species at particular sites because all such species will not be included in the sample of a single year.

All individuals were identified to species level, except for some families excluded because of identification problems (Table 2). The Finnish classification of threatened species (Rassi et al. 1992) was used to designate beetles as threatened in all samples, including those from Russian Karelia. We have also listed species with

Table 1. Total basal area of standing trees (including living and dead trees) and proportion of different tree species and dead trees of the total basal area in each forest stand.

Forest stand	*Total basal area m^2/ha*	*Birch (%)*	*Other deciduous (%)*	*Spruce (%)*	*Pine (%)*	*Dead trees (%)*
R1	31.7	67	5	13	1	14
R2	29.3	59	0	15	8	18
R3	41.7	83	3	2	1	10
R4	41.3	65	2	10	15	9
R5	28.3	55	14	12	1	18
R6	31.7	83	4	2	0	11
R7	28.3	65	16	1	0	18
R8	33.3	65	10	14	0	11
R9	21.0	54	5	21	3	17
R10	38.7	62	15	3	0	21
F1	27.5	61	28	0	3	9
F2	18.7	56	2	4	23	15
F3	not measured					
F4	not measured					
F5	not measured					
F6	27.5	47	0	2	44	7

Table 2. The identified families of Coleoptera, observed threatened and uncommon species belonging to these families, categories of threatened species, and frequency scores of the uncommon species.

Identified families / *Observed threatened and uncommon species*[a]	*Category*[b]	*Frequency score*[c]
Leiodidae		
Amphicyllis globiformis (Sahlberg)	—	40
Agathidium pallidium (Gyllenhal)	Mr	100
Agathidium nigrinum Sturm	—	60
Agathidium discoideum Erichson	—	40
Staphylinidae[d]		
Philonthus subuliformis (Gravenhorst)	—	40
Carphacis striatus (Olivier)	Mr	80
Lordithon pulchellus (Mannerheim)	—	60
Sepedophilus bipunctatus (Gravenhorst)	—	40
Aleochara sparsa Heer	—	40
Aleochara stichai Likovský	—	40
Oxypoda vittata Märkel	—	40
Ischnoglossa prolixa (Gravenhorst)	—	80
Atheta pallidicornis (Thomson)	—	40
Sphaeritidae		
Lucanidae		
Lampyridae		
Elateridae		
Denticollis borealis (Paykull)	—	40
Eucnemidae		
Microrhagus lepidus Rosenhauer	Mp	60
Hylis procerulus (Mannerheim)	—	40
Hylis foveicollis (Thomson)	—	60
Buprestidae		
Dermestidae		
Anobiidae		
Dorcatoma substriata Hummel	Mr	80
Lymexylidae		
Trogossitidae		
Peltis grossa (Linnaeus)	Md	30
Nitidulidae[e]		
Sphindidae		
Rhizophagidae		
Rhizophagus parallelocollis Gyllenhal	—	40
Monotomidae		
Cucujidae		
Erotylidae		
Tritoma bipustulata Fabricius	—	40
Triplax rufipes (Fabricius)	Mr	40
Endomychidae		
Cisidae		
Cis fissicornis Mellié	Mp[f]	100
Hadreule elongatula (Gyllenhal)	—	60
Sulcacis fronticornis (Panzer)	Mp	60
Colydiidae		
Mycetophagidae		
Mycetophagus quadripustulatus (Linnaeus)	Md	40
Mycetophagus fulvicollis Fabricius	—	40
Mycetophagus populi Fabricius	—	40
Pythidae		
Pyrochroidae		
Salpingidae		
Aderidae		
Phytobaenus amabilis F. Sahlberg	Mr	60
Anthicidae		
Stenotrachelidae		
Scotodes annulatus Eschscholtz	V	60

Table 2. Continued.

Identified families Observed threatened and uncommon species[a]	Category[b]	Freqency score[c]
Tenebrionidae		
Corticeus bicolor (Olivier)	—	40
Mordellidae		
Tomoxia bucephala Costa	Md	40
Hoshihananomia perlata (Sulzer)	—	40
Rhipiphoridae		
Pelecotoma fennica (Paykull)	Mr	60
Tetratomidae		
Melandryidae		
Orchesia minor Walker	—	40
Dircaea quadriguttata (Paykull)	V	80
Melandrya dubia (Schaller)	Md	40
Phryganophilus ruficollis (Fabricius)	E	80
Cerambycidae		
Acanthoderes clavipes (Schrank)	—	40
Anthribidae		

[a] *Nomenclature follows Silfverberg (1992).*
[b] *Categories of threatened species: endangered, E; vulnerable, V; in need of monitoring, M, which is divided further into declining (Md), rare (Mr), and poorly known (Mp) (according to Rassi et al. 1992). For definition of the categories see Rassi and Väisänen (1987).*
[c] *Frequency scores were obtained from Rassi (1993). Score 100 corresponds to 1–3 known occurrences (10 × 10 km[2] each) in Finland after 1960, score 80 to 4–6, 60 to 7–12, and 40 to 13–25.*
[d] *All Staphylinids were identified in 1990. Since then, only genera* Lordithon *and* Carphacis *were identified in samples F1, F2, and F6.*
[e] *Genera* Epuraea *and* Meligethes *excluded.*
[f] Cis fissicornis *was found in Finland after the latest version of the Finnish list of threatened species was published. Class Mp will be suggested for this species in the next update.*

less than 26 known occurrences in Finland since 1960 (frequency score of 40 or more, according to Rassi 1993), although they are not classified as threatened (called "uncommon" below).

Results

A total of 39,485 individual beetles, representing 300 species, were identified in the samples included in this study (Appendix). The total number of threatened and uncommon species was 16 and 23, respectively (Table 2 and Appendix). All of the threatened species depend on decaying deciduous trees, except for *Phryganophilus ruficollis* and *Peltis grossa*, which can also develop on dead coniferous trees if the decay type is suitable. Most of the uncommon species also depend on decaying deciduous trees, and all of them are at least facultatively saproxylic. Threatened and uncommon species had stricter microhabitat requirements (e.g., polypore or tree species associations) than other species, and some of the other species do not require decaying wood at all—for example, many species in the family Staphylinidae.

The number of threatened species per site and year varied between 0 and 4 (mean 2.4), and the number of uncommon species between 1 and 8 (mean 3.2). The number of individuals per trapping day varied greatly (0.34–1.64 individuals per trapping day). The main sources of the variation were probably differences between years, forests, sampling periods, and tree-polypore combinations used as the substrate. The number of threatened species caught in one forest during one season varied rather independently of the numbers of trapping days or total catch (Spearman rank correlation, $r_s = 0.16$ and $r_s = 0.12$, respectively, neither significant, $n = 26$). The correlations were stronger in uncommon species ($r_s = 0.40$ and $r_s = 0.39$, $p < 0.05$, $n = 26$). Only 0.67% of the individual beetles belonged to threatened species and 1.5% to uncommon species.

The mean number of threatened species captured per year was 2.25 in sites F1 and F2, but new species were found in both sites in a majority of the years, and the total number over 6 years was 7 in both sites. A similar trend was observed in uncommon species (Fig. 2).

Discussion

Number of Threatened Beetle Species

Our results show that the number of threatened species actually present at a particular site is likely to be considerably higher than can be detected by reasonable sampling effort in a single year. At both sites F1 and F2 the cumulative number of both threatened and uncommon species continued to grow throughout the 6 years, after more than 10,000 trapping days (Fig. 2). The pattern,

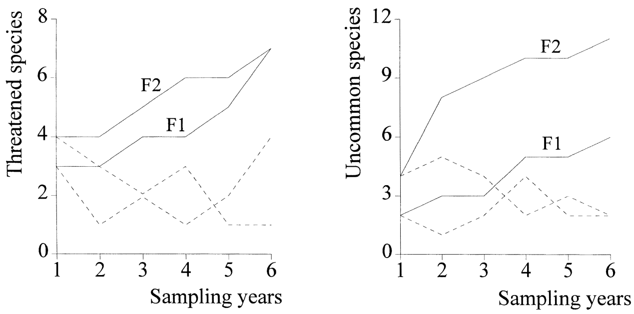

Figure 2. Numbers of threatened and uncommon species caught each year (dashed line) and accumulation of threatened and uncommon species (solid line) in the forests F1 and F2. Staphylinids not belonging to genera Carphacis *and* Lordithon *were excluded (from the year 1990) to make the analyzed groups identical for each year.*

with an increasing number of scarce species included in a sample of increasing size, is expected from sampling theory alone, as pointed out in the classic works of Fisher et al. (1943), Preston (1948), and Williams (1964). In addition, three potential ecological mechanisms may increase year-to-year stochastic variation in catching threatened and uncommon invertebrates.

First, the species have strict microhabitat requirements and may inhabit only a few dead trees at one time within a forest. Thus, the probability of catching a particular species probably varies with the location of the traps. For example, *Phytobaenus amabilis* was caught for the first time on site F1 in 1995. We caught 41 individuals in a single trap that was presumably attached to the very tree where this species was breeding; only one individual was caught in the other 14 traps within the same forest in that year.

Second, it is possible that some of the species comprise true metapopulations in the forests where we took our samples, with local reproducing units going extinct every now and then from some localities but simultaneously colonizing new ones (Levins 1969; Gilpin & Hanski 1991). Such a dynamic would increase variability at any single site.

Third, some of the species can be occasional visitors ("tourists") that do not typically reproduce in this kind of forest. This alternative is not likely to be important in this case because most of the uncommon and threatened species were encountered in more than one location.

Our data do not allow conclusions as to the relative significance of these factors. In focused surveys of threatened species it would be preferable to use a combination of different sampling methods, including direct searching for specimens by experienced collectors. But, general survey methods such as the one we have used are sufficient to demonstrate that a considerable number of threatened and uncommon invertebrates do live in the habitats favored by the White-backed Woodpecker. Because of stochastic variation in the location of local reproducing subpopulations of the threatened species and continuous successional change in microhabitats within the forest, a "true total number" of threatened species per site is an abstraction. We can nevertheless assume that the total number of threatened beetles present at our sampling sites might at any point in time be on the order of six or more (Fig. 2).

Significance of Woodpecker Habitats to Threatened Beetles

Because we did not include any controls in our sampling scheme, we cannot exclude the possibility that certain threatened and uncommon species also occur outside woodpecker habitats. This is, however, irrelevant in this context. Controls are not needed to confirm the observation that many threatened and uncommon species were frequently encountered in the woodpecker habitats.

There is evidence suggesting that post-fire successional deciduous forests, such as our sampling sites, are important for a whole suite of species. According to Esseen et al. (1992) such fire-related species are found in almost all plant and animal groups. Wikars (1992) gives an example of 20 such beetle species, most of which were also found in the present study. Effective elimination of fire during this century in the Nordic countries has led to a scarcity of natural successional deciduous forests (Esseen et al. 1992). Species dependent on such habitats, the White-backed Woodpecker among them, have been forced to shift into other successional habitats, mainly anthropogenic in origin.

According to the Finnish Red Data Book (Rassi et al. 1992), the main reason for the population decline of all but one of the threatened species included in our data is reduction in the amount of decaying wood in forests. Most of these species have also suffered from the decreasing proportion of deciduous trees in the forests. Only one third of the species have been assumed to suffer from changes in the age structure of forests. This suggests that threatened beetles inhabiting the same forests as the White-backed Woodpecker do not necessarily require old forests, but rather successional deciduous forests with plenty of decaying deciduous wood.

We conclude that the same basic processes cause the decline of both the beetles and the White-backed Woodpecker. There is, however, a difference in characteristic scale between the beetles and the woodpecker. According to Swedish and German estimates, a pair of White-backed Woodpeckers requires at least 50–100 ha of suitable habitat to survive (Aulén 1988; Scherzinger 1990). The home ranges of the Finnish woodpecker pairs usually include several separated forest stands, each of which might be large enough to support a reproducing population of a threatened beetle species. So the decline in deciduous forests with an abundance of decaying trees on the scale of southern Finland would affect the population of the woodpeckers through a declining number of good nesting sites and increasing mortality during juvenile dispersal (Virkkala et al. 1993*a*, 1993*b*), but local populations of the threatened beetle species would probably still remain in these areas.

White-Backed Woodpecker as an Umbrella Species

We found that many threatened beetle species inhabit the same habitat as the White-backed Woodpecker. The difficulty of monitoring threatened beetles poses major problems to the conservation of these species because even adequate mapping of their occurrence is practically impossible. One possibility for protecting threatened species living in the same habitats as the White-backed Woodpecker might be to use the woodpecker as an umbrella species—employing this popular and conspicuous species in planning and implementing conservation measures to preserve the beetles. Such a status would not only support efforts to protect the woodpecker itself but would also give some measure of protection to the habitats of less conspicuous and less popular species that are also threatened.

The idea of using umbrella species in the conservation of other target species has gained currency, for instance, in discussions about the protection of the Northern Spotted Owl in the United States (Wilcove 1994). Originally, the idea seems to have been derived from the protection of large mammals that require large areas to support them. The argument is that preserves established to protect large mammals would, as a side effect, give protection to a large number of other species as well (Heywood & Watson 1995; Wallis de Vries 1995). As another example, Launer and Murphy (1994) investigated the possibility of using the threatened Bay checkerspot butterfly (*Euphydryas editha bayensis*) as an umbrella species for native Californian grassland plants.

For the concept of umbrella species to be rigorously applied, the similarity between the umbrella species and the target species should be ecological and not merely statistical. The latter seems to be the case with the idea that large mammals are good umbrella species because of their large area requirements. This argument reduces to the idea that a large area provides habitats for a larger number of species than a small area, which is correct for statistical reasons alone without there necessarily being any similarity in the ecological requirements of the mammals and the assumed targets. The use of the Bay checkerspot butterfly as an umbrella for grassland plants is problematic for another reason (as recognized by Launer and Murphy [1994]), namely, that the factors influencing the distribution patterns of butterflies and plants differ. Although the spatial scale of habitat units relevant for the butterfly and the plants are similar—a few hectares or tens of hectares—the plants are distributed across the area according to their species-specific site requirements, which have no direct relevance for the butterflies. In the case of the White-backed Woodpecker and threatened saproxylic beetles, however, there is a common key property affecting the occurrence of the species: decaying deciduous wood within successional deciduous forests.

Although the use of the White-backed Woodpecker as an umbrella species for threatened beetles is attractive, there may be some problems involved that should be considered. First, it is possible that some beetle species require the same habitat type as the woodpecker but are even more sensitive to changes in habitat quality than the White-backed Woodpecker. These species may include specialists of transient habitats such as newly dead large aspens (e.g. *Hololepta plana, Rhizophagus puncticollis*, and *Cucujus cinnaberinus*) or special kinds of decay (e.g., *Hylochares cruentatus, Phryganophilus ruficollis*, and *Melandrya barbata*), which are usually sparse even within a good forest stand (Siitonen & Martikainen 1994). For such species, even a relatively small increase in stand isolation or decrease in forest quality may lead to sudden extinction (Hanski et al. 1995); consequently, they may become extinct before the White-backed Woodpecker.

Second, the status of the White-backed Woodpecker is already critical in Finland. If the woodpecker went extinct, this would not mean that the woods where it lives at present could be legitimately reclaimed for economic use because many of the threatened beetles would still survive. It is therefore important to continue focused studies on the minimum requirements of the beetles themselves.

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Literature Cited

Angelstam, P., and G. Mikusiński. 1994. Woodpecker assemblages in natural and managed boreal and hemiboreal forest—a review. Annales Zoologici Fennici **31:**157–172.

Aulén, G. 1988. Ecology and distribution history of the White-backed Woodpecker *Dendrocopos leucotos* in Sweden. Ph.D. thesis. Swedish University of Agricultural Sciences, Uppsala.

Esseen, P.-A., B. Ehnström, L. Ericson, and K. Sjöberg. 1992. Boreal forests: the focal habitats of Fennoscandia. Pages 252–325 in L. Hansson, editor. Ecological principles of nature conservation. Elsevier, London.

Fisher, R. A., A. S. Corbet, and C. B. Williams. 1943. The relation between the number of species and the number of individuals in a random sample from an animal population. Journal of Animal Ecology **12:**42–58.

Gilpin, M., and I. Hanski, editors. 1991. Metapopulation dynamics: empirical and theoretical investigations. Academic Press, London.

Håland, A., and M. Ugelvik. 1990. The status and management of the White-backed Woodpecker *Dendrocopos leucotos* (L.) in Norway. Pages 29–35 in A. Carlson and G. Aulén, editors. Conservation and management of woodpecker populations. Report 17. Swedish University of Agricultural Sciences, Uppsala.

Hanski, I., J. Pöyry, T. Pakkala, and M. Kuussaari. 1995. Multiple equilibria in metapopulation dynamics. Nature **377:**618–621.

Heywood, V. H., and R. T. Watson, editors. 1995. Global biodiversity assessment. Cambridge University Press, Cambridge.

Kaila, L. 1993. A new method for collecting quantitative samples of insects associated with decaying wood or wood fungi. Entomologica Fennica **4:**21–23.

Kaila, L., P. Martikainen, P. Punttila, and E. Yakovlev. 1994. Saproxylic beetles (Coleoptera) on dead birch trunks decayed by different polypore species. Annales Zoologici Fennici **31:**91–107.

Launer, A. E., and D. D. Murphy. 1994. Umbrella species and the conservation of habitat fragments: a case of a threatened butterfly and a vanishing grassland ecosystem. Biological Conservation **69:**145–153.

Levins, R. 1969. Some demographic and genetic consequences of environmental heterogeneity for biological control. Bulletin of the Entomological Society of America **15:**237–240.

Preston, F. W. 1948. The commonness and rarity of species. Ecology **29:**254–283.

Rassi, P. editor. 1993. Frequency score of Coleoptera in Finland 1.1.1960–1.1.1990. Report no. 6. World Wide Fund for Nature Finland, Helsinki.

Rassi, P., and R. Väisänen, editors. 1987. Threatened animals and plants in Finland. (English summary.) Committee for the Conservation of Threatened Animals and Plants in Finland, Helsinki.

Rassi, P., H. Kaipiainen, I. Mannerkoski, and G. Ståhls, editors. 1992. Uhanalaisten eläinten ja kasvien seurantatoimikunnan mietintö [in Finnish]. Komiteanmietintö **1991:**30.

Scherzinger, W. 1990. Is competition by the Great-spotted Woodpecker the cause for White-backed Woodpeckers rarity in Bavarian Forest National Park? Pages 81–91 in A. Carlson and G. Aulén, editors. Conservation and management of woodpecker populations. Report 17. Department of Wildlife Ecology, Swedish University of Agricultural Sciences, Uppsala.

Siitonen, J., and P. Martikainen. 1994. Occurrence of rare and threatened insects living on decaying *Populus tremula*: a comparison between Finnish and Russian Karelia. Scandinavian Journal of Forest Research **9:**185–191.

Silfverberg, H. 1992. Enumeratio Coleopterorum Fennoscandiae, Daniae et Baltiae. Helsingin Hyönteisvaihtoyhdistys, Helsinki.

Speight, M. C. D. 1989. Saproxylic invertebrates and their conservation. Council of Europe, Strasbourg.

Valkoselkätikkatyöryhmä. 1992. Valkoselkätikan suojeluohjelma II osa [in Finnish]. World Wide Fund for Nature, Finland, Helsinki.

Virkkala, R., T. Alanko, T. Laine, and J. Tiainen. 1993*a*. Population contraction of the White-backed Woodpecker *Dendrocopos leucotos* in Finland as a consequence of habitat alteration. Biological Conservation **66:**47–53.

Virkkala, R., T. Alanko, and T. Laine. 1993*b*. The White-backed Woodpecker in Finland in 1992 [in Finnish with English summary]. Linnut **28:**16–19.

Wallis de Vries, M. F. 1995. Large herbivores and the design of large-scale nature reserves in Western Europe. Conservation Biology **9:** 25–33.

Wesołowski, T. 1995. Value of Bialowieza forest for the conservation of White-backed Woodpecker *Dendrocopos leucotos* in Poland. Biological Conservation **71:**69–75.

Wikars, L.-O. 1992. Forest fires and insects [in Swedish with English summary]. Entomologisk Tidskrift **113:**1–11.

Wilcove, D. S. 1994. Turning conservation goals into tangible results: the case of the spotted owl and old-growth forests. Pages 313–329 in P. J. Edwards, R. M. May, and N. R. Webb, editors. Large-scale ecology and conservation biology. Blackwell Scientific, Oxford, United Kindom.

Williams, C. B. 1964. Patterns in the balance of nature. Academic Press, London.

Appendix

Sampling effort and observed threatened and uncommon beetle species, including numbers of individuals, in each forest stand.*

Forest/ year	*Number of traps on birch/other*	*Trapping days*	*Identified individuals*	*Threatened species*	*Uncommon species*
R1/1991	10/0	1420	949	1 agpa, 13 myqu, 1 tobu	36 agdi, 1 agni
R2/1991	10/0	1420	1370	2 agpa, 3 cifi, 10 myqu, 2 trru	72 agdi, 1 agni
R3/1991	10/0	1420	511	2 agpa, 5 myqu	1 mypo
R4/1991	10/0	1420	1010	1 agpa, 4 myqu, 1 tobu	12 agdi, 1 myfu, 2 mypo, 1 ormi
R5/1991	10/0	1420	1505	10 myqu	44 agdi, 1 agni, 1 mypo
R6/1991	10/0	1420	1522	1 agpa, 7 myqu	49 agdi, 2 mypo, 1 ormi
R7/1991	10/0	1420	1106	1 cifi, 3 myqu, 1 trru	8 agdi, 2 ormi
R8/1991	10/0	1420	1218	1 agpa, 1 myqu	40 agdi, 1 ormi
R9/1991	10/0	1420	2335	5 medu, 11 myqu, 1 phru	177 agdi, 1 agni
R10/1991	8/2 alder	1420	984	1 agpa, 5 myqu, 1 pegr, 1 trru	57 agdi, 1 ormi
F1/1990	17/3 aspen	2640	2977	13 **dosu**, 1 **myqu**, 3 **trru**	3 **alsp**, 2 **alst**, 1 **atpa**, 1 **ispr**, 5 **lopu**, 1 **mypo**, 2 **sebi**
F1/1991	20/0	3100	1868	25 dosu	1 **rhpa**
F1/1992	10/0	1100	1455	1 **cast**, 1 dosu	1 lopu, 1 mypo
F1/1993	10/0	1520	2045	2 cast	1 **agni**, 1 **debo**, 1 lopu, 2 mypo
F1/1994	11/1 sallow	1800	2014	1 cast, 1 **sufr**	1 lopu, 1 mypo
F1/1995	10/5 aspen	2025	1982	7 dosu, 3 **pefe**, 42 **pham**, 3 sufr	2 **hyfo**, 4 mypo
F2/1990	20/0	2640	1753	1 **diqu**, 1 **myqu**, 10 **tobu**, 1 **trru**	4 **accl**, 1 **alst**, 5 **cobi**, 3 **debo**, 1 **hope**, 1 **oxvi**, 1 **phsu**
F2/1991	18/0	2790	1589	1 diqu, 1 myqu, 1 tobu	1 cobi, 1 **hael**, 1 **myfu**, 2 **mypo**, 1 **trbi**
F2/1992	10/0	1100	1097	1 **cast**, 15 tobu	3 cobi, 3 debo, 1 hael, 1 **hyfo**
F2/1993	10/0	1520	1029	3 myqu, 1 **pegr**, 4 tobu	4 debo, 1 **hypr**
F2/1994	10/0	1500	517	2 tobu	1 cobi, 3 debo, 1 hyfo
F2/1995	10/0	1350	739	1 **pham**	1 mypo, 1 **ormi**
F3/1990	14/0	1848	1441	—	1 alsp, 1 alst, 1 debo, 1 mypo, 2 sebi
F4/1990	19/1 sallow	2640	2241	1 mile, 1 myqu, 2 pham	1 amgl, 1 atpa, 1 ispr, 2 sebi
F5/1990	20/0	2640	3170	2 cast, 4 myqu, 1 pegr	1 accl, 1 amgl, 1 cobi, 3 debo, 1 hyfo, 2 mypo, 1 phsu, 2 sebi
F6/1993	10/0	1520	1058	9 myqu, 1 scan, 1 trru	1 amgl, 1 lopu, 1 trbi
Total	317/12	45933	39485	263 individuals and 16 species	611 individuals and 23 species

**The species are abbreviated as the first two letters of their generic and specific names. For more information on the species, see Table 2. In F1 and F2 sampling continued for 6 years. There, the first observation of a given species is expressed by boldface. Note that all staphylinids were identified only in 1990. Later, only genera* Carphacis *and* Lordithon *were identified in samples F1, F2, and F6 only.*