Saproxylic species in Fennoscandian forests - gathering ecological knowledge for applied use

3rd Nordic Saproxylic Network meeting

Lammi Biological Station, 7th – 9th December, 2005

Abstracts

invited papers, voluntary papers and posters

Edited by Juha Siitonen

Organizing committee: Anders Dahlberg, Sanna Laaka-Lindberg, Reijo Penttilä, Juha Siitonen, Jogeir Stokland

Programme

Day 1, Wednesday 7th Dec, Invited papers

Time	Speaker	Title
8:00–10:00		*Registration, coffee*
10:00–10:10	Sanna Laaka-Lindberg/ Jogeir Stokland	*Seminar opening*
10:10–10:40	Bengt-Gunnar Jonsson	Effects of alternative forest management regimes on the amount of dead wood and saproxylic organisms
10:40–11:10	Atte Moilanen	Connectivity and quantitative methods for large-scale reserve planning
11:10–11:40	Anders Dahlberg	Potential effects of energy-wood harvesting on saproxylic communities
11:40–12:10	Mats Jonsell	Impact of forest management on saproxylic insects in wood-decaying fungi
12:10–13:00		*Lunch*
13:00–13:30	Petri Heinonen	Consideration of dead wood and saproxylic species in Finnish state forests
13:30–14:00	Lauri Saaristo	Consideration of dead wood and saproxylic species in Finnish private forests
14:00–14:30	Timo Lehesvirta	Consideration of dead wood and saproxylic species in UPM company forests
14:30–15:00		*Coffee*
15:00–15:30	Jari Kouki	Predicting the future of saproxylic species: prospects and pitfalls in combining forest planning with ecological knowledge
15:30–16:00	Jogeir Stokland	The Nordic Saproxylic Database – usefulness for forest management and other applications
16:00–16:30		*Discussion: developing the saproxylic knowledge base for forest management*
17:30–18:30		*Dinner*
18:30–20:00		*Poster session*
20:00–		*Sauna, free discussion, evening tea, Slide show from Canada*

Day 2, Thursday 8th Dec, Invited & voluntary papers

Time	Sessions/ Speaker	Title
8:00–9:00		*Breakfast*
9:00–9:30	Tord Snäll	The importance of patch dynamics on the dynamics of epiphyte metapopulations
	Voluntary papers	
9:30–10:30	**Session I: Population biology and dispersal of saproxylic organisms**	
9:30–9:50	Shawn Fraver	Temporal and spatial variability in deadwood formation: evidence from old-growth forests
9:50–10:10	Göran Thor	A comparison between the lichen flora on wooden barns and snags in Dalarna, Sweden

10:10–10:30	Atte Komonen	Experimental study on the colonization ability of fungivorous beetles
10:30–10:50		*Coffee*
10:50–12:30	**Session II: Restoration**	
10:50–11:10	Esko Hyvärinen	Controlled burning and tree retention in conservation of saproxylic beetles (Coleoptera) - focus on red-listed and rare species
11:10–11:30	Tero Toivanen	Mimicking natural disturbances of boreal forests: the effects of controlled burning and creating dead wood on beetle diversity
11:30–11:50	Pekka Punttila	Landscape effects on species recovery in forest restoration
11:50–12:10	Anne-Maarit Ollila	Impact of forest restoration on saproxylic beetles - Green Belt as an example
12:10–12:30	Riitta Ryömä	First steps of recolonization of epixylic bryophytes on burnt logs
12:30–13:30		*Lunch*
13:30–14:50	**Session III: Effects of (biodiversity-oriented) forest management on saproxylic species**	
13:30–13:50	Kaisa Junninen	Are woodland key habitats hotspots for polypores?
13:50–14:10	Jenni Hottola	Polypores in brook-side key habitats and ordinary managed forests in southern Finland
14:10–14:30	Anna-Liisa Sippola	The role of retention trees and woodland key habitats in preserving lichen and polypore diversity in managed boreal forests
14:30–14:50	Anne Sverdrup-Thygeson	The effect of retention trees and CWD in the surroundings on red-listed beetles in Norwegian boreal forest
15:00–15:30		*Coffee*
15:30–16:50	**Session III: Management (continued)** **Session IV: Biology of threatened and poorly-kown saproxylic groups**	
15:30–15:50	Panu Halme	Relationship between species richness of perennial and annual polyporous fungi
15:50–16:10	Dmitry Sciegel	Beetles in polypores: hunting after rarities
16:10–16:30	Lars Lundqvist	Mites associated with wood - dead or alive
16:30–16:50		
16:50–17:00		*Break*
17:00–18:00	Jogeir Stokland	Introduction to the saproxylic database: information content, table structure, practical demonstration
18:00–18:30		*Discussion: possibilities for coordinated Nordic research projects*
19:00–20:30		*Special dinner*
20:30–		*Sauna, free discussion, evening tea*

I Invited papers

(abstracts are arranged in alphabetical order according to the first author)

Potential effects of energy-wood harvesting on saproxylic communities

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Forest management have resulted in drastically decreased amounts of dead wood, i.e. particularly coarse woody debris (CWD) in Fennoscandia. Thus, slash or fine woody debris (FWD) and stumps left from forest operations may be increasingly important for saproxylic organisms in managed forests landscapes. Increasing energy prices and environmental concern for rising CO2 levels is enhancing the use of bio-fuels and clear cut slash is already removed and used for energy production from 50 % of clear cut areas in southern Sweden. Results will be presented from a study where we studied the relative importance for different types of dead wood in general, and for slash in particular, for saproxylic lichens, beetles and fungi in Norway spruce forests during a forest generation. The analysis is based on an analysis of individual species from revised and updated data from the a saproxylic network database.

Results will also be presented from a modelling of the relative availability of CWD, FWD and other plant litter types, i.e from the tree-, field- and bottom layer above- and belowground, in Norway spruce forests.

Dead wood and saproxylic species in Finnish state forests

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Metsähallitus is a state enterprise responsible for management of all state forests of Finland, whether protected or commercial. Protected state forests consist of all statutory conservation areas of Finland, i.e. national parks, protected peatlands, old-growth forests, etc. Commercial state forests are managed for wood production. The Natural Heritage Services unit of Metsähallitus is responsible for management of protected areas and Forestry Business unit of Metsähallitus is responsible for management of commercial forests.

Metsähallitus has created an ecological network approach for the management of natural resources. At the landscape level, an ecological network consists of what are called cores, ecological connections and enhancement areas, as well as regular managed forests (Figure 1).

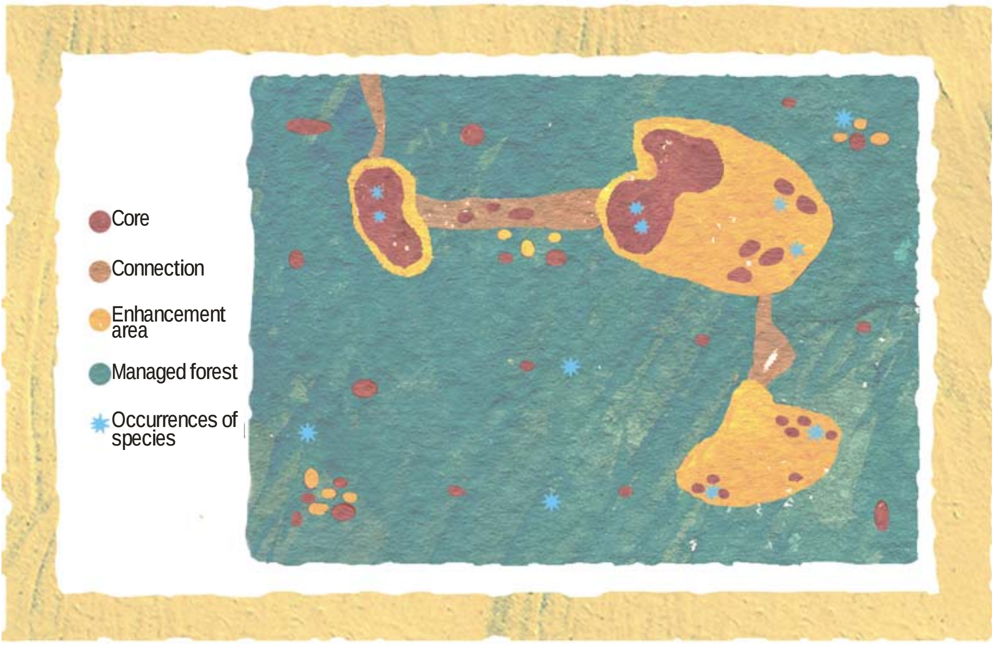

Figure 1. Simplified example of an ecological network on the landscape level.

In practice, the core habitats are generally excluded from forestry measures. This group comprises the majority of statutory conservation areas, valuable habitats in managed forests identified in the landscape ecological planning and some occurrences of species. In connection with the landscape-ecological survey of forestry, ecological links have been established in managed forests. The ecological network is complemented by a buffer zone consisting of environmentally valuable forests and biodiversity enhancement areas, as well as protective and transitional zones.

Metsähallitus' regular managed forests also play a crucially important role in ensuring biodiversity. The retention trees in the managed forests, small-scale valuable habitats, transitional zones, protective zones of watercourses and logging residue create living environments for many species which are already rare or declining.

The environmental needs of the majority of forest species can be ensured in managed forests, provided the needs of different species are taken into consideration in silvicultural measures. One of the central factors impacting the survival of species is the quantity of decaying wood in forest habitats. Metsähallitus has set clear long-term objectives in order to increase the quantities of decaying wood, depending on the land-use class and ecological potential of each site. The land-use, its theoretical proportion and respective primary goals as well as the set target for the volume of coarse woody debris is illustrated in the figure 2.

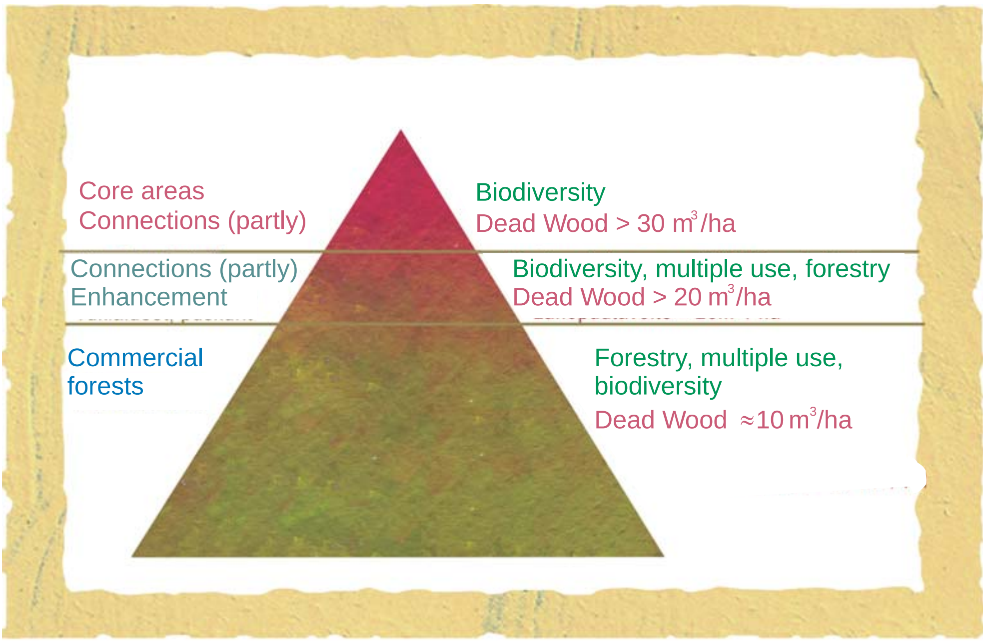

Figure 2. Theoretical illustration on the degree of protection of biodiversity and the respective operational targets.

In ecological connections, buffer zones and managed forests, the saving of retention trees and natural succession are the means employed to reach target volumes of decaying wood. The goal is reached gradually as retention trees from regeneration cutting die naturally within decades, or one or two rotation cycles.

In order to ensure a continuum of decaying wood, decayed stock must be preserved as carefully as possible at all stages of development. Additionally, some living stock must be left to die and decay in the woods. It is preferable to plan groups of retention trees early on, when the stand is at the sapling stage.

As a consequence of earlier forest management operations, there is a particular shortage of sturdy decaying broadleaves, i.e. aspen, goat willow and birch; sturdy decaying conifers are also valuable. It is important to leave a sufficient number of sturdy retention trees at final felling sites.

In final cuttings, 5–20 living retention trees reaching the diameters given in the table 1 are left standing per hectare. In addition to living retention trees, in regeneration cutting, all standing dead broadleaves are spared, together with decaying wood lying on the ground at various stages of decay. Dead spruce and pine trees are primarily also spared. In normally treated managed forests the amount of stock spared during regeneration cuttings should be approximately 5–10 m^3/ha. In intermediate cuttings, the number of trees left standing should be about the same, using the same principles, but without diameter limits and volume targets.

Region	**Pine**	**Spruce**	**Birch**	**Other broad leaved**
Southern Finland	20 cm	20 cm	20 cm	10 cm
Ostrobothnia – Kainuu	20 cm	20 cm	15 cm	10 cm
Lapland	20 cm	10 cm	10 cm	10 cm

Table 1. Size of retention trees (diameter).

Broadleaves, especially sturdy aspen (*Populus tremula*) and goat willows (*Salix caprea*), are ideal retention trees. Sturdy retention spruces and pine trees are also significant from the standpoint of the species thriving on decaying trees, and sometimes, they also serve as possible nesting trees for large birds of prey. It is especially important to spare all hollow trunks. In addition, all trees from an earlier generation of each species must be spared as well during felling. In valuable landscapes, the largest and finest individual trees of the dominant species, such as pine, spruce or birch, are also to be left standing.

In intermediate cuttings, particularly in first thinnings, the aforementioned diameter limits cannot be presupposed. Instead, smaller trees are left as retention trees.

The location of retention trees in both final and intermediate cuttings is determined primarily on ecological grounds. Suitable locations include, among others, wet depressions, small-scale paludified areas, bedrock outcrops and transitional zones.

In order to assist the survival of species dependent on decaying wood, it is more efficient to keep concentrations of retention trees rather than scattering them. For the visual landscape, too, it is more favourable to leave retention trees primarily in groups consisting of several tree species and layers of different top heights.

Saproxylic insects in Scandinavian forests – lessons from the assemblage living on polypore fruiting bodies

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Fruiting bodies of wood decaying fungi constitute a conspicuous and well defined part of the decaying wood, to which many organisms are specialised. The insects are more or less specialised on certain host-fungi, and which host they use seem related to the phylogenetic relatedness of their hosts. Fruiting bodies of the most common fungi is a trivial dead-wood microhabitat. That means that even though they occur much denser in old-growth forests they are distributed on nearly all forest ground in Scandinavia. Despite that, some species using this trivial resource are restricted to natural or old-growth forests. The reason for this is probably not that the restricted species have a more specific requirement on their microhabitat. Instead, studies have given support that there are differences in dispersal strategy between different species. The widespread tenebrionid *Bolitophaguis reticulatus* has more individuals that disperse long distances than its more restricted relative *Oplocephala haemorrhoidalis*. On the other hand, the latter species has larger eggs, indicating a better capacity to compete in the habitat patches when in place.

Effects of alternative forest management regimes on the amount of dead wood and saproxylic organisms

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Dead wood is a dynamic substrate. Tree mortality and decay rates govern the availability of dead wood over time. Both these factors may be influenced by forestry operations and especially the extraction of wood resources limits the total volumes of potential dead wood considerably. To be able to make prediction on future dead wood volumes we need models and empirical data on wood decay. Simple logarithmic models may be used to broadly approach dead wood dynamics:

$$Y_t = Y_0 e^{-kt}$$

where Y_t is the volume or (biomass) at time t, Y_0 the initial volume and *k* the decay rate constant. A range of estimates for conifers is available and suggests *k*-values between 0.02–0.05, corresponding to a “half life” of the biomass between 15–35 years.

However, in order to follow the composition of dead wood (e.g. size- and decay classes) more mechanistic models are required and application of matrix models to follow the transitions over decay classes is one approach. Given knowledge on the input of trees in different diameter classes these models provide much needed details on dead wood quality relevant for associated species.

According to the Swedish environmental a first goal is to increase the volume of hard dead wood by 40% until 2010. The consequences for dead wood inputs have been recently analysed. Up to 2010 the goal require only marginal addition to current background levels, but to further increase the volume by additionally 40 % during coming decades will provide challenges to forest management. This analysis does not address management options that would provide this increase, pointing at a field where additional research is needed.
In an attempt to explore the consequences of changed management an analysis of the dynamics in dead wood given FSC-based forestry in spruce forests have been done. These analyses show that an increase in dead wood is feasible, providing a range from about 5 m^3ha^{-1} at mid-succession to more than 15 m^3ha^{-1} at harvesting age. Although this indicate an improvement over the current situation the volumes does not reach values indicated as needed for biodiversity maintenance.

Setting quantitative targets to dead wood volumes is an important step to improve the situation for saproxylic species. The task is however complex and it is likely to be unwise to use a single “magic number”. Such a number would hide the importance of providing the full range of different types of dead wood substrates. It will also set focus on an average rather than considering the need to distribute available dead wood differently across the landscape. At some successional stages, forest types or landscapes the value of dead wood may be much higher.

Predicting the future of saproxylic species: prospects and pitfalls in combining forest planning with ecological knowledge

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Saproxylic species constitute numerically the largest forest-dwelling species group currently threatened in Fennoscandia. Their future survival obviously requires that amount of dead wood is increased in forest landscapes.

Any actions targeted at conservation of saproxylics are, however, complicated for two ecological reasons: (1) Despite the fact that species are associated to dead wood there are profound differences in the (micro)habitat requirements among the red-listed saproxylic species, and it would be a confounding error to consider them as a homogenous group; and (2) their habitat is highly dynamic, almost ephemeral in some cases. Successful conservation of saproxylic species requires that detailed habitat associations of different species and the dynamic characteristics of their habitats are taken into account. Clearly, suitable habitats can occur in protected and/or managed forests, depending on the exact habitat requirements of a particular species.

We analysed current and future availability of suitable habitat for saproxylics in landscape area of about 12 000 ha in size, including protected (10 %) and managed (90 %) forests. The area is located in eastern Finland in the middle boreal zone. Forests are pine-dominated. All the threatened and NT species that potentially occur in the study area were first assessed and classified according to their habitat requirements. 27 species type groups were formed, each group contained typically 3-6 species that shared common habitat requirements. The long-term availability of habitat for each group were next analysed with stand-level forest simulator. The time-frame in the analyses was 60 years.

Forests in the study area have experienced very intensive management during the past decades and their current suitability for the species is rather poor. Quite expectedly, habitat availability for many species groups will improve within the next decades. The future, however, will be heavily dependent on species group: groups that can breed only in the large-diameter trunks with advanced decay are likely to remain at low levels or become extinct. Further, species associated with pine and, to lesser extent, birch are predicted to face a brighter future than species associated with spruce or aspen.

In general, the conservation of species can be improved with only slight economic losses: by reducing the value of timber production with ca. 6 %, there is a long-term possibility for ca. 40 % increase in habitat availability for the species. Not all the species, however, will be saved with these investments.

In conclusion, (1) combining the simultaneous and long-term contribution of managed and protected areas to species conservation and (2) assessing the economical consequences of conservation actions is likely to provide cost-efficient and novel solutions for the conservation planning. These approaches require application of forest growth simulators, and the reliability of the models used in these simulators is critical in this process. The models currently used in the forest simulators may still contain biases that need further refinements.

Consideration of dead wood and saproxylic species in UPM company forests

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UPM is one of the world's leading forest products companies. The company's businesses focus on magazine papers, newsprint, fine and speciality papers, converting materials and wood products. UPM Forest is the Group's Forest division that is responsible for supplying UPM's Finnish mills with wood. Forest division also manages 920 000 hectares of land owned by the Group in Finland.

UPM launched a biodiversity program for its own forests in Finland in 1998. The aim is to enhance biodiversity as part of commercial forest management. The Biodiversity program included a comparison of UPM's own commercial forests with forests in their natural state. A gap analysis was carried out based on the results.

The gap analysis identified seven main areas of difference (Fig. 1).

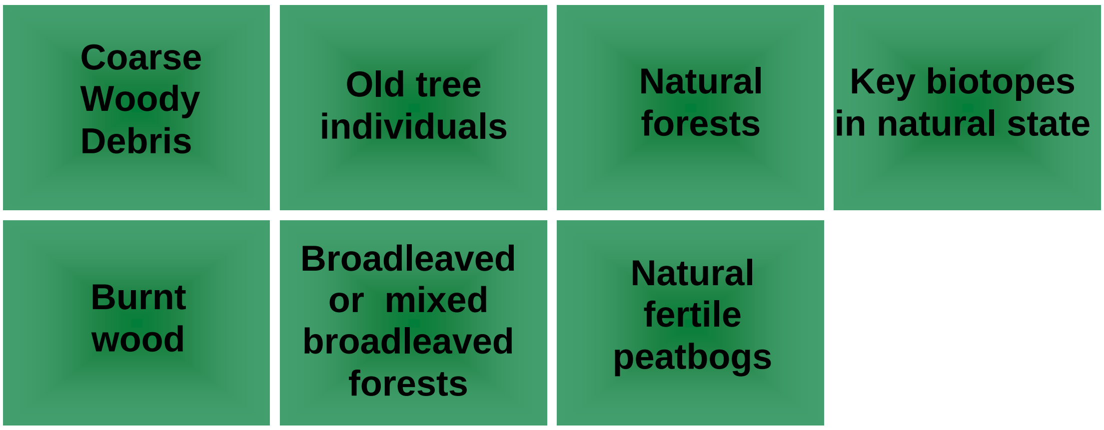

Figure. 1. Main differences between UPM owned commercial forests and natural forests based on the gap analysis.

Biodiversity can be enhanced in two ways:

1. Maintaining existing biodiversity values
2. Creating new elements for biodiversity.

The latter point can be further divided into long and short term targets.

UPM's biodiversity program includes an action plan to lessen the differences identified in the gap analysis (Fig. 2).

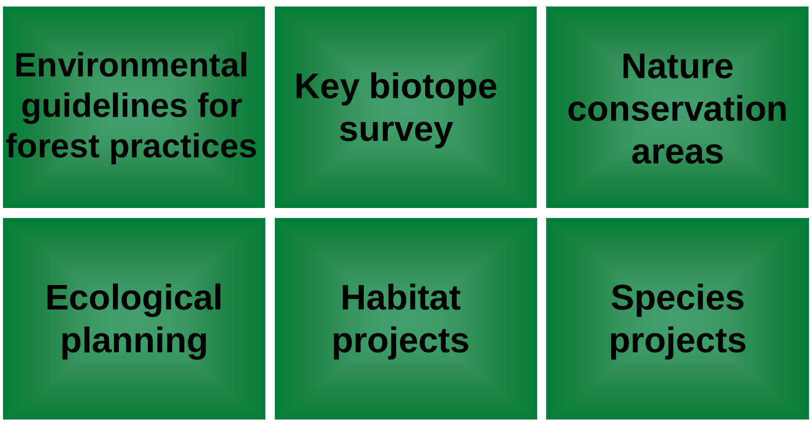

Figure 2. UPM's Biodiversity program's action plan to enhance natural-state forest's characters into UPM's commercial forests.

Different methods and their objectives have different time scales (Fig. 3). It is not possible to obtain all the benefits in the short term, some advantages will only be achieved after a longer time period. So far, it has only been possible to study the short term effects of different methods. UPM's man-made stump project is one example of a study where the short term effects have been assessed in an effective way. The aim of the project was to monitor the occurrence of beetle species over time as the stumps decay. More than 400 different beetle species have been observed so far, including a number of threatened species. More information about the project can be found from our poster.

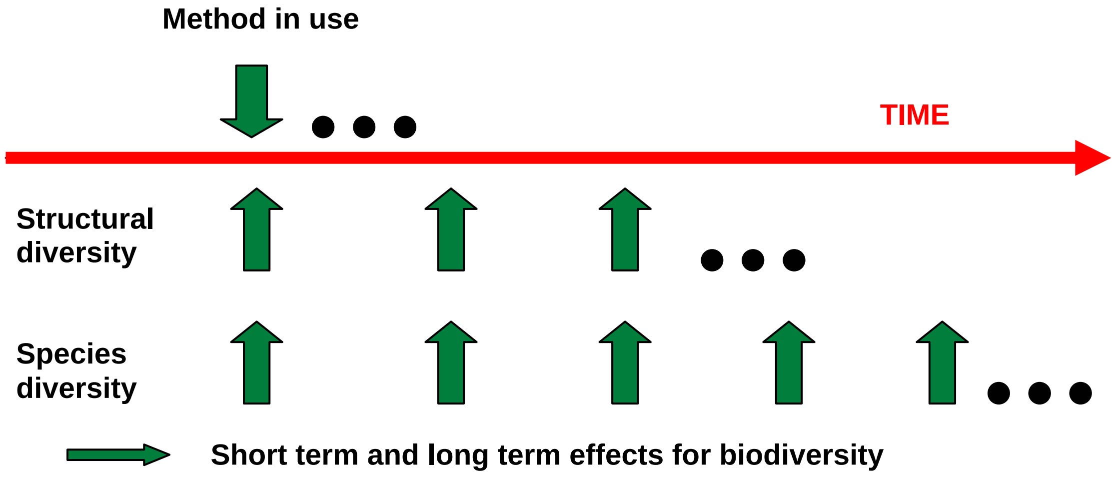

Figure 3. Time scale for operations maintaining and enhancing biodiversity dependent on deadwood.

UPM has carried out a key biotope survey in all of its forests as part of a 5-year project since 1997. As a result, 22 000 key biotopes were identified and protected. These sites are left outside forestry operations.

The quantity of dead wood in key biotopes was low because of their previous history of use (Fig. 4). It is expected that the volume of coarse wood debris will increase over time due to the current protection of these habitats from forestry operations. The effect will be that key biotopes will be agglomerations of dead wood after a period of time. A large share of the key biotopes has special microclimatic conditions, and it is believed that this will have a positive effect on saproxylic species.

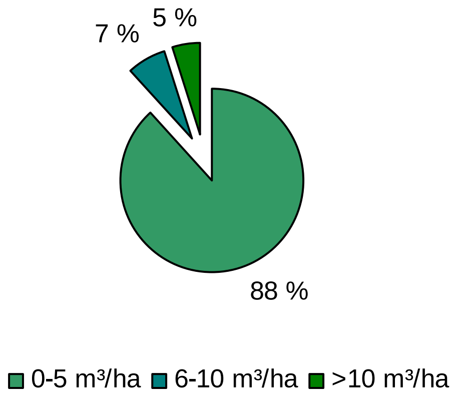

Figure 4. Amount of dead wood in protected key biotopes on UPM land.

UPM has inventoried dead wood quality classes in Harjula, a UPM owned forest in southern Finland (Table 1). The results show that the quantity of dead wood is over 30 m³ per hectare. Despite the enormous amount of dead wood, it is not at the optimum for different saproxylic species and does not indicate the diversity of dead wood. It is important to give weight must be given to different tree species and to different quality classes.

UPM develops deadwood on the basis of tree species and quality classes.

Table 1. Quantity of dead ground wood in UPM’s forest estate Harjula in Southern Finland.

	Hard	**Quite hard**	**Quite soft**	**Soft**	**Almost decomposed**	**m³/ha**
Pine	0,00	0,33	0,18	0,00	0,00	0,51
Spruce	0,01	8,96	4,62	0,46	0,00	14,05
Birch	0,00	0,73	0,43	0,12	0,00	1,28
Aspen	0,00	0,09	0,02	0,00	0,00	0,11
Other	0,00	0,36	0,23	0,30	0,00	0,89

Energy wood harvesting is intensifying the utilization of wood by concentrating on different parts of trees e.g. branches, tops and stumps. Energy wood is collected according to UPM's Energy wood harvesting guidelines. These guidelines are being continually updated according to new information. Energy wood harvesting is implemented only on specific nutrient rich forest sites. To minimize the possible negative effects of energy wood harvesting, 30 % of logging waste and 5 % of stumps are left on site.

UPM is developing energy wood harvesting methods and continues to study its possible impacts.

Connectivity and quantitative methods for large-scale reserve planning

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I briefly summarize some emerging methods and ongoing developments in large-scale reserve planning methods, including the ZONATION algorithm for identifying important conservation landscapes, uncertainty analysis for reserve planning, and reserve selection based on benefit functions.

ZONATION. The Zonation algorithm produces a hierarchy of conservation priority throughout the landscape. It starts from the full landscape and iteratively removes the ”least important” cell from the edge of the landscape. During removal, when a part of the distribution of a species is removed, the ”value” of the remaining part increases, which guarantees that core areas of all species are retained late into cell removal. The order of removal is recorded to produce the hierarchy – most important areas are retained until last. Zonation includes species weights, site costs etc., and it is suitable for many species and very large landscapes. *Distribution smoothing* and the *boundary quality penalty* are two techniques that can be used in the context of Zonation to produce reserve plans that are spatially aggregated at scales relevant for the species in the analysis. Zonation operates on species distribution grid maps, which can, for example, be produced via habitat modeling/GIS.

Uncertainty analysis. In most countries reserve planning is necessarily based on very uncertain information about species distributions. Uncertainty analysis provides tools for understanding effects of uncertainty on conservation decisions. Simplifying, potential conservation areas can be divided into four kinds: (i) Areas that are certain to have high biological value are the most important ones for conservation. (ii) Areas that are certain to have low biological value should be avoided. (iii) So-called robustness analysis applies to areas that have high estimated value, but this value is uncertain. These areas have potential for negative surprises for conservation. (iv) The fourth category includes areas that have low value, but we are unsure of this. These areas have potential for positive surprises, which can be understood via uncertainty analysis and the concept of opportunity. Uncertainty analysis can be implemented in the context of Zonation via so-called *distribution discounting*.

Perhaps of relevance for Finland is that all quantitative conservation planning methods that include modeled effects of connectivity suggest, that optimal conservation areas should consist of rather large and well connected habitat fragments. This contradicts the practice of protection of key-habitats (small creeks etc.) with only narrow habitat buffers around them.

Recent references:

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Moilanen, A., and B. A. Wintle. 2006. Uncertainty analysis favours the selection spatially aggregated reserve networks. Biological Conservation, in press.

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Consideration of dead wood and saproxylic species in Finnish private forests

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Private individuals and families own slightly over half of the forestry land in Finland. Dead wood in private forests is considered in the Forest Act, forest certification criteria and forest management recommendations. The main tools for dead wood consideration are the securing of the valuable habitats, retention tree groups and leaving dead wood in the forest. Forest level considerations are done within the cutting and thinning operations based on the forest management plans. Governmental funding is available for securing the valuable habitats and for nature management projects. The METSO-programme includes new funding instruments like the voluntary conservation through natural values trading. In addition to the funding, the possibilities to increase the amount of dead wood in Finnish private forests is very much depending on the objects of the forest owner but also on the knowledge and attitude of the forest professionals. Research is needed to produce data and information from the saproxylic species living in the managed forests, to give examples for the planning of dead wood management projects and to help in creating information materials of the dead wood and saproxylic species.

The importance of patch dynamics on the dynamics of epiphyte metapopulations

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Metapopulation dynamics have received much attention in population biology and conservation. Most studies have dealt with species whose population turnover rate is much higher than the rate of patch turnover. Models of the dynamics in such systems have assumed a static patch landscape. The dynamics of many species is, however, likely to be significantly affected by the dynamics of their patches. I will talk about a test of the relative importance of local conditions, connectivity and dynamics of host tree patches on the metapopulation dynamics of a red-listed epiphytic moss, *Neckera pennata*. Repeated surveys of the species and its host trees were conducted at three sites over a period of six years. There was a positive effect of connectivity, and colonizations mainly occurred in the vicinity of occupied trees. Colonizations were also less likely on strongly leaning trees. Local extinctions sometimes occurred from small trees with low local abundances, but were most often caused by tree fall. Based on simulations of the future (100 yrs) dynamics of the system, I will show that the metapopulation size will be overestimated unless the increased local extinction rate imposed by the dynamics of the trees is accounted for. I will also show that local extinctions from standing trees may be disregarded in dynamic models for this species.

The Nordic saproxylic database – usefulness for forest management and other applications

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The biodiversity associated to decaying wood is tremendously rich and rather well documented within the Nordic countries. Enumeration of known wood-decaying species and expert assessments of less known species groups suggest that we have 6000-7000 species that depend upon dead wood for fulfilling their life cycle. This corresponds to roughly 25 % of all forest species in the region.

In 2004 a Swedish-Norwegian initiative was taken to establish a Nordic network of experts on wood-inhabiting species and to develop a common database on the ecology of all wood-inhabiting species in Denmark, Finland, Norway and Sweden. This was considered as quite natural as the countries share these species to a large extent as a common species pool. At present the database contains species-specific information for roughly 4500 species, primarily fungi, beetles and gnats/flies (Diptera). The ecological information includes occurrence and preference for alternative host trees, decay classes, dimension classes, microhabitats (subsection of a dead wood unit or an individual tree), type of wood (snag, log, stump, logging residual), mortality factor, and surrounding environment. The information content is primarily from the Nordic countries but information from neighbouring countries is also included.

The database is potentially useful for various uses including forest management, nature conservation, scientific research and learning among the interested public. The presentation will emphasize potential use in forest management using three examples. In the first example the number of species associated to alternative host trees is shown to indicate that conservation measures should not be distributed proportional to the frequency of various key habitat types. Instead one should over-represent measures allocated to key habitats dominated by broad-leaved forest. The second set of examples shows how species-specific information can be used to develop fine-tuned conservation measures on known localities of identified red-listed species. The third set of examples uses the umbrella species approach and shows how a careful selection of saproxylic umbrella species can be chosen to give a face to the large biodiversity in dead wood and simultaneously be tools for developing conservation measures in forest management planning.

Finally, the presentation will highlight some topics where experts on species diversity in dead wood need assistance from the forestry sector to develop the usefulness of their knowledge.

II Contributed papers

Temporal and spatial variability in deadwood formation: Evidence from old-growth forests

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The typical model for deadwood accumulation shows a U-shaped pattern, with (1) a high-abundance period immediately following a catastrophic disturbance, (2) a gradual decrease as this post-disturbance deadwood decays, then (3) an increase over time as the trees in the recovering stand begin to die. This model, however, does not apply to many old-growth forest types where gap dynamics or small-scale disturbances dominate. Such forests are often considered to be in a state of relative equilibrium, implying a somewhat constant input of CWD. However, reconstructed disturbance histories from old-growth spruce-dominated forests clearly show peaks of moderate-severity disturbance (i.e. high input of deadwood), with intervening periods – sometimes lasting for decades – without disturbance (little or no input). Further, in a case study conducted in a 2000-ha old-growth landscape, these disturbance peaks were rather synchronous throughout the landscape. Combined, these results suggest that deadwood abundance in old-growth spruce forests shows an irregular wave-form that includes a high degree of temporal and spatial variability. The effect of these fluctuations on the population dynamics of saproxylic organisms remains unknown.

Developing polypore indicators in assessing the conservation value of boreal forests

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Polypores are often used to assess the conservation value of forest stands. Many polypores are specialized in their requirements for substrate and environment. Thus polypores have been suggested to indicate for example the continuity of coarse woody debris or forest canopy. The use of polypores as indicators is restricted by the limited appearance of annual fruitbodies, which mainly occur from August to November. Furthermore, the present indicator lists do not take into account regional variation and human influence on the species composition. Our project aims at determining new indicator groups and species on basis of large datasets from several researchers and institutions. The goals of our project are to determine (1) whether perennial polypores can be used as surrogates for overall polypore diversity, (2) whether the occurrence of currently used indicator species or some other species indicate overall species richness or richness of threatened species, and (3) how the list of indicators should be developed in order to take into account regional differences in species composition.

Currently our data includes 1338 separate sample plots, study areas and inventory areas, ranging from southern to northern boreal zone in Finland. Results on the goal (1) show that in large scale (the whole country) the perennial species richness explains about 70 % of the variation in the species richness of annual species. Moreover, about 65 % of the species richness of annual threatened species was explained by perennial species richness. We also determined the minimum sample size of occurrences of perennial fruiting bodies that allow reliable prediction of the annual species richness from the perennial species richness. To do this, we analysed the strength of the correlation between the perennial and annual species richness among sample plots with varying sample size of perennial polypore occurrences. Somewhat surprinsingly, a relatively small number of occurrences (15-20) was needed for making relatively reliable conclusions on overall annual species richness. The effects of forest type, stand age and biogeographical area on the correlation between annual and perennial species richness are also discussed.

Polypores in brook-side key habitats and ordinary managed forests in southern Finland

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Preservation of small woodland key habitats has become an integral part of biodiversity-oriented forest management in the Nordic countries. Brook-side key habitats, formed by the immediate surroundings of brooks with moist microclimate and often rich soil, constitute the most important key habitat type in terms of area and timber volume. One of the species groups that have suffered the most from modern forestry is polypores. 37% of polypores in Finland are classified as threatened or near threatened, and the main reasons for the decline are decrease in suitable substrates and changes in the forest landscape composition. Our aim was to find out if there are red-listed polypore species in brook-side key habitats in private forests as assumed, and to examine if species composition in key habitats differ from that in ordinary managed forests. Furthermore, our objective was to assess the importance of structural features of the stand on the diversity of polypores, and to explore the variation in different parts of southern Finland. Altogether 70 brook-side key habitats and 70 ordinary managed forests were inventoried in seven separate study areas in southern Finland. Over 12,000 studied dead trees hosted 3,518 occurrences of 106 species. Brook-side key habitats had been less intensively managed and had, on average, larger volume of more diverse dead wood than ordinary managed forests. Accordingly, key habitats hosted more polypore species than ordinary managed forests, but there was no clear difference in the number of threatened or near threatened species between the two forest categories. Both the volume and, particularly, diversity of dead wood explained significantly the number of polypore species per site. When diversity of dead wood was included as a covariate in a factorial covariance model, the species richness of polypores did not differ between key habitats and managed forests, nor between the different study areas. Our conclusion is that the total volume and diversity of dead wood, which are both connected to the size of the habitat, are the main factors explaining the number of polypore species in a forest stand.

Controlled Burning and Tree Retention in Conservation of Saproxylic Beetles (Coleoptera) – Focus on Red-listed and Rare Species

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Habitat loss, fragmentation and declining habitat quality have greatly affected the biota of boreal forests. By deliberately improving the availability of dead-wood resources in managed areas outside reserves species for which unsuitable habitats do not so easily constitute dispersal barriers, such as many insects, might benefit. We studied the effects of green-tree retention and controlled burning on forest-dwelling beetles in a large-scale field experiment in eastern Finland. Here we focus on red-listed and rare saproxylic species. The factorial study design included 24 Scots pine dominated sites with three levels of tree retention, 0, 10 and 50 m^3/ha, and uncut controls. Twelve of the 24 sites were burned in 2001. Beetles were sampled with ten flight-intercept traps on each site during the years 2000–2002, i.e. in one pre-treatment and two post-treatment years. A total sample of 153 449 individuals representing 1160 beetle species yielded 2107 specimens of 84 red-listed or rare saproxylic species. The richness of red-listed and rare saproxylic species was higher on the burned than on the unburned sites, and higher tree retention levels promoted species richness, but there were clear differences between the years. The richness of red-listed and rare saproxylic species increased in the first post-treatment year, evidently due to the treatments, and continued to increase on the burned sites in the second post-treatment year but decreased on the unburned sites. The results show that the living conditions of many red-listed and rare saproxylic species can be significantly improved with rather simple alterations to forest management methods. Controlled burning with high tree retention levels is highly applicable for creating resources for many saproxylic species, but increasing the levels of green-tree retention in unburned areas can also be beneficial.

Woodland key habitats in Finland and their importance for polypores

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In Fennoscandia, the concept of woodland key habitats has become one of the key concepts when defining hotspots for forest biodiversity. There is a serious lack of studies, however, where the diversity value of the assumed key habitats had been assessed for any groups of organisms. The aim of this study was to investigate whether the woodland key habitats as defined in the Finnish Forest Act can be advocated as diversity hotspots for polypores, a group of wood-decaying fungi including several red-listed species and species used as indicators for conservation value of forests. The study area was situated in eastern Finland, southern boreal zone. A total of 72 woodland key habitat sites representing six different habitat types, and 12 production forest sites as controls were investigated for their polypore assemblages. A total of 2,077 records of 93 species were made in the key habitat sites; of these, only 17 records of nine species were red-listed. On average, key habitats hosted more species than control forests, but of the six habitat types, only fresh and mesic-moist herb-rich forests differed significantly from the control forests. Compared to control forests, key habitats can maintain rich polypore flora but are of little help in conservation of threatened polypores.

Experimental study on the colonization ability of fungivorous beetles

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Direct studies (e.g. mark-release-recapture) on the dispersal ability of saproxylic insects are difficult, due to the concealed life-style of most species. Thus, dispersal ability is often evaluated indirectly relating the presence or absence of species on a given resource patch to the spatial arrangement of occupied patches in the surrounding landscape. This approach has one obvious pitfall: it is impossible to determine the origin of the individuals in a given resource, i.e. to estimate the *distance* traveled. In this study, I used a field experiment to study the dispersal distance of the fungivorous insects *Sulcacis affinis*, *Cis hispidus*, *Cis boleti* and *Octotemnus glabriculus* (Coleoptera: Ciidae). Fruiting bodies of the wood-decaying fungus *Trametes ochracea* (Aphyllophorales: Polyporaceae) were grown on pieces of birch wood in laboratory. The fruiting bodies were taken to the islets (n = 24), as wells as larger islands and surrounding forests (controls; n = 19) of the Lake Koitere in eastern Finland, June-September 2004. *Sulcacis affinis* colonized 8% of the fruiting bodies on the islets, *C. hispidus* 80%, *C. boleti* 21% and *O. glabriculus* 13%. These results suggest that the colonization ability of the fungivorous ciid beetles is rather good (up to 1.5 km), but there are considerable differences between species.

Mites associated with wood - dead or alive

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The Acari, or mites and ticks, are small to very small Arachnids. The length measurement varies from 0.09 to 1.5 mm (maximum 16 mm, not counting ticks which can be several centimetres). They play very important roles in many ecosystems, and take an essential part in the decomposing processes in forests. I will give a brief account of the group, or possibly “groups”, and present some of the acrid participants in the process of breaking down dead wood.

Impact of forest restoration on saproxylic beetles – green belt as an example

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Green belt is an extensive network of old-growth forests, aapamires, boreal hills and arctic fells at the border of Finland, Russia and Norway. Two large restoration projects (Malahvia project and Green Belt Life) were established in the green belt to improve the conservation status of areas formerly influenced by commercial forestry. The purpose of both projects is to investigate how restoration practices work to re-establish forests to their original state and function, and how different forest-dwelling species respond to restoration practices. The variables investigated are plant species, wood-decaying fungi and lichens and saproxylic beetle species assemblages and tree stand structure. The natural succession will be generated by controlled burnings, simulated storms and creating gaps by cutting and felling trees.

This study is a subproject of the two restoration projects. In order to investigate how saproxylic beetles respond to 1) fire in different fire intensity levels and 2) increased amounts of dead wood, we have established study sites in three regions during 2002-2005: Elimyssalo (Kuhmo), Pahamaailma (Suomussalmi) and Malahvia (Suomussalmi). Pahamaailma and Elimyssalo belong to the GreenBelt Life project. Species depending upon dead and charred wood are expected to increase after restoration practices and to spread into new areas.

The research was started in Malahvia in 2002 and in Elimyssalo and Pahamaailma in 2005 by investigating the species composition before restoration. In Malahvia there are four replicates of five treatments in both pine-dominated and spruce-dominated forests: pristine control, control under commercial management, burning, storm-simulation and thinning. Burning, storm simulation and thinning will increase dead wood to the study sites. In Elimyssalo and Pahamaailma the treatments include two kinds of burning and pristine control. Each treatment has three replicates. Beetles have been collected using window-traps attached to trees, 54 traps per area. Restoration will be conducted during the summer 2006.

In the sample plots in Malahvia the tree stand structure is well documented. All living and dead trees are counted and individually numbered. The decay stage and size of all trees in a sample plot (10 x 100m) are measured and the species of fungi growing on them are investigated. Since no restoration practices are conducted yet, the results include three years data of the investigated species assemblages before treatments. Preliminary results of species composition of wood-decaying fungi and saproxylic beetles are given. Changes in composition of coarse woody debris after clear-cutting and soil preparation are reported.

In Pahamaailma and Elimyssalo the tree stand structure, plants and polyporous fungi have been investigated.

Landscape effects on species recovery in forest restoration

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The proportion of seminatural old forests has declined to about 1% of forest land in southern (hemi-south-mid boreal) Finland, and young natural forests are practically lacking today. This indicates a considerable extinction debt of species depending on natural forests. Only 36% of the seminatural forests are located in the reserve network indicating further decline of these forests. Reserves cover 1.6% of forest land in southern Finland, but most the forests in reserves have been managed previously. An extensive restoration program has been launched to increase the quality of reserves to enhance the recovery of red-listed and other declining species.

Species recovery is expected to be enhanced if restoration effort is (1) concentrated on smaller areas instead of being thinly spread over larger areas, (2) located close to existing high-quality areas instead of regions with poor connectivity, and (3) started immediately instead of later.

We explored these predictions with data on stand structure, polypores and saproxylic beetles from three managed forest landscapes with varying degree of spatio-temporal continuity and connectivity of seminatural forests in southern Finland. In each landscape we examined three types of forests: (1) seminatural old-growth, (2) stands treated with prescribed burning, and (3) stands with abundant windthrow. The two latter types were analogous to the present restoration practices in managed forests.

Polypores were collected on 0.5 ha sample plots in each stand (n=76), with additional sampling for large logs. Beetles were sampled with two types of window-flight traps (n=10 for each stand, n=88 stands). In addition, polypore succession was followed for 13 yrs in three burned stands.

Landscape quality appeared to determine the success of restoration. Several threatened species were observed in abundance in the landscape which become most recently exploited by modern forestry, and which had the largest amount of high-quality forests and coarse woody debris. Only few threatened species were found in the other landscapes with lower spatio-temporal continuity. However, near-threatened species were observed in the restored stands in all the landscapes indicating that restoration may prevent further species becoming threatened. The follow-up study showed the importance of large trees and tree-species diversity for the recovery of red-listed species.

We conclude that the restoration efforts should be concentrated close to high-quality core areas to enhance the colonization of the most demanding species, and to increase the effective size of the core areas and the population sizes. The sooner the restoration is started the less species have become too rare to be able to take full advantage of restoration.

Changes in the diversity and coverage of epixylic bryophytes after restoration with logging and prescribed burning

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Bryophyte communities growing on dead wood are natural elements of the boreal forest. Many bryophyte species growing on decaying wood, especially hepatics (*Marchantiophyta*), have declined because of intensive forestry and lack of suitable substrates. There is a need for research to increase the knowledge on the vulnerability, population ecology and dispersal ability of these species, results of which can then be applied to the modern restoration ecology. The objectives of this study were to investigate the effects of restoration loggings and burning on the diversity and coverage of the epixylic bryophytes. The study was carried out in mature Norway spruce (*Picea abies*) forest stands with a management history in Southern Finland. All stands included upland and paludified biotope. The restoration loggings were carried out in the winter 2001-2002, and half of the stands were burnt in the summer 2002. Control stands with no treatments were also included. We established permanent sample plots (10 x 20 cm) on the logs before the treatments, and estimated the coverage of the epixylic bryophytes on the plots during the field seasons 2001-2004. The immediate effects of restoration loggings and fire on the species were severe, especially in upland biotopes. So far the effects of restoration treatments on the diversity of the bryophyte species have been only negative, and we have found no evidence on the 'fire-prone' epixylic bryophytes. On the other hand, the paludified biotopes inside the burnt areas were burnt more weakly and may act as refugia, and subsequent dispersal sources for the species.

Beetles in polypores: hunting after rarities

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In 1992 I started compiling a database on polypore – insect interactions for the goal of preparation of the two student theses. This *MYCETINA* database was designed to contain data on the polypore-associated Coleoptera of Northern and Eastern Europe. Data on beetles of polypores of Moscow region were later revised and published by Nikitsky & Schigel (2004), and data from East European plain and Crimea by Schigel (2002). From year 2002 the work continued in Finland with the support of the Ministry of Environment. The majority of the Finnish data was collected in Lapland, North Karelia, Central Finland, southern and south-western Finland and the Åland Islands.

At present the *MYCETINA* database has a multi-tabular structure with referentially integrated and constantly updated data. Field collections plus observations of polypores total 12031 records, the number exceeding 15000 in the near future. Taxonomical tables include 452 species of fungi, including all the Finnish polypore species and 5404 species of Coleoptera, a complete list of Nordic species, plus selected eastern beetles.

All records are geographically labeled, often with precise GPS coordinates of 1 × 1 kilometre grid or more accurate. The data is planned to be used as a starting point for mapping Finnish

Aphyllophorales. Altitude above sea level is given for montane forests. Sixteen researchers from Finland, Sweden, France and Russia contributed with their collections.

Ecological information is organized according to the Nordic Saproxylic Network framework and includes forest biotopes (with compartment codes of the Finnish Forest and Park Service), trees (61 species), trunk dimensions and decay classes, bark cover, mortality factor, fire impact and trunk state. For the collections of fungi soil details, exposure to light, number of fruit bodies, hyphal system, moisture of the basidiocarp, anamorphic fungi cover, decay class of the fungus, fruit body size and shape, consistency and altitude above ground are indicated. The insect specimens are sorted with life stages, genders, and insect localization in the fungus fruit body.

The literature data will be digitized starting from year 2006 in a way that will allow customizing and excluding from the analysis the references predating the certain year, or using the full set of records, or only selected ones. A regularly revised literature table contains 664 titles, with a portion linked to PDF files.

The *MYCETINA* database includes valuable data on interactions among the rare and red-listed species. Many of such fungi were probably never surveyed for their insect mates before, e.g. *Albatrellus citrinus*, *Tyromyces canadensis,* and *Perenniporia medulla-panis*. At the moment the unpublished data are closed to external access because of the preparation of my PhD thesis. The published data are open to be given to the Nordic Saproxylic Database.

Retention trees and key habitats in preserving lichen diversity in managed boreal forests

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The role of retention trees and woodland key habitats (WKHs) in preserving diversity of old-growth forest lichens was studied in north boreal spruce forests in Finland. We compared (1) 10-12 years old clear-cuts, logged with old methods without retention trees, (2) 7-8 old clear-cuts with retention trees (new logging methods), (3) WKHs (0.05-0.42 ha) left within new clear-cuts and (4) old-growth spruce forests. There were five replicates in each category . The occurrence of 14 old-growth forest indicator lichens was studied on five circular plots (radius 10 m) per site and on 30 deciduous trees and snags along transects on each site except in WKHs.

The species richness of indicator lichens was significantly higher in old-growth forest sites (altogether 10 species, 76 records) than in clear-cuts, despite whether they were logged with old (3 species, 12 records) or new (2 species, 22 records) methods. Preliminary results also indicate that the species richness in WKHs was higher than in both types of clear-cuts (altogether 6 species, 16 records in 25 circular plots). Most of the species found in clear-cuts (one *Leptogium* and two *Nephroma* species), were growing on aspens left as retention trees, whereas most of the species found in old-growth sites were growing either on birch or goat willow. The old-growth forest indicator lichens on birch (e.g., all *Chaenotheca* species) were completely lacking from clear-cuts.

The results indicate that the ability of retention trees to maintain lichen diversity in clear-cuts is limited, especially species, which prefer closed canopy and steady microclimate. Woodland key habitats, on the contrary, could much better maintain lichen diversity. The survival of species in the clear-cuts and small woodland key habitats in the long run still needs to be studied.

The effect of retention trees and CWD in the surroundings on red-listed beetles in Norwegian boreal forest

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The aim of the study was evaluate the effect of the forest management action of retaining aspens (*Populus tremula*) in clear cuts, with focus on red-listed beetles. Also, it was an aim to investigate the effect of Coarse Woody Debris (CWD) density on different scales on the beetle diversity.

Two landscapes with similar natural conditions and management history, north and east of Oslo in South Eastern Norway, were chosen for the study. In each landscape, 15 aspens in closed forest and 15 retained aspens in clear cuts were chosen in a stratified random way. On each tree, large window traps were operating one summer (2001). In the fall of 2001, the trees were turned into high stumps using explosives and followed for 3 more years. In addition, 30 free-hanging traps were mounted in one of the landscapes, within the same stands. Density of living and dead aspens were mapped on several scales.

31 075 specimen were collected, representing 719 beetle species, of which 399 species were saproxylic. 392 specimen of 51 red-listed saproxylic species were collected, including several specimen of the globally vulnerable species *Cucujus cinnaberinus*.

Red-listed species are attracted to the retained aspens, and traps mounted on the retention trees caught more red-listed beetles than freely hanging window traps in the same forest stand. Aspens that had cavities or were hollow while living had the highest number of redlisted species. The amount of CWD on a scale of 30-100 meters radius around the traps could not explain the differences in number of redlisted species.

The landscape where aspen was frequent had more saproxylic beetles, more red-listed beetles and more endangered species than the landscape with less aspen. This may indicate that a landscape level threshold of dead wood is necessary for some of the uncommon beetle species, although it is not possible to conclude on the basis of only two studied landscapes.

High stumps from retained aspens attract substantial numbers of red-listed beetles and it is reasonable to assume that retained trees improve the viability of the saproxylic beetle fauna in the boreal forest. CWD on a small scale does not seem to matter so much for the number of redlisted beetles, but the results indicate a deprivation of redlisted species in the landscape with low levels of CWD, which is a trend that urgently needs more focus.

A comparison between the lichen flora on wooden barns and snags in Dalarna, Sweden

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In Sweden, old wooden barns often host a diverse and threatened lichen flora including eight red-listed species, but this kind of barn has declined over the past 100 years. The barns have traditionally been made out of *Pinus sylvestris,* and it could be hypothesized that pine snags are the natural habitat for many lichens occurring on anthropogenic wood. We compared the lichen flora on old wooden barns in the village of Gärdsjö, Dalarna with that on snags of *P. sylvestris*. At alfa level, both species richness and lichen abundance were highest on snags, and for both substrates the north aspects had more species and higher abundance than E, S and W aspects. Overall species richness was similar on the substrates, with a slight tendency for higher gamma-level diversity on barns. NMS ordination showed clear compositional differences between barns and snags, and also indicated a more heterogeneous vegetation on barns. Implications for conservation measures will be discussed.

Mimicking natural disturbances of boreal forest: the effect of controlled burning and creating dead wood on beetle diversity

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The young successional stages of boreal forests are an important habitat for many saproxylic species. These habitats are formed by disturbances like forest fires and they are characterized by large volumes of dead wood and sun-exposed conditions. Today, young successional stages of natural origin are very rare in Fennoscandia and restoration of these habitats is required. Here, we present results of two studies in which we have explored the importance of burnt areas and restored habitats for beetle diversity.

In the first study, we tested whether silvicultural burnings have been important in maintaining the populations of rare and threatened beetle species. We sampled beetles from 20 silvicultural burnings of 1 to 16 years of age and 20 seed-tree cuts of the corresponding ages. The abundance of beetles did not differ between burnt areas and seed-tree cuts but burnt areas had more species. In particular, the numbers of rare and threatened species were greater at burnt areas up to ten years of age. Also the beetle assemblages of younger burnt areas differed from seed-tree cuts. We conclude that silvicultural burnings are likely to have been effective in preserving the populations of disturbance-adapted species. However, they remain a suitable habitat for a limited time only and a continuum of these habitats should be ensured.

In the second study, we constructed a large-scale field experiment in which we studied the effects on beetle diversity of two restoration practices, controlled burning and harvesting with creating different volumes of dead wood. The species richness and abundance of beetles were increased by both burning and harvesting. Also rare species, especially saproxylic ones, preferred burnt sites and a similar trend was observed among threatened species. The effect of harvesting was due to harvested sites differing from unharvested controls but the volume of

dead wood left on harvested sites had no short-term effect on species richness. Burning and harvesting also resulted in different species assemblages and there were some additional differences according to the volume of dead wood.

In conclusion, fire can be successfully used in restoration of managed boreal forests to increase species diversity and to create habitats for specialized species. When dead wood is created without fire, the build-up of the beetle communities may take a longer time and long-term monitoring is therefore needed to clarify the effects of the restoration actions.

II Posters

A new rearing method for revealing larval microhabitats of saproxylic Diptera

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Rearing records of larvae living in decaying wood, wood-growing fungi, slime moulds and other media associated with wood-decomposing system cover only a small part of the whole species pool of saproxylic Diptera known in Europe. Even in relatively well-studied group of fungus gnats (Diptera: Mycetophilidae s.l.), the host fungi of ca. 80 % of the species are yet unknown in spite of the extensive rearing (Jakovlev 1994).

Most of the published rearing records were obtained with traditional methods based on isolating fruit bodies with larvae into rearing boxes. During more than hundred years, hundreds of fungus species with generally large fruiting bodies were studied, and at the moment this method can produce only little new information. The main difficulty is the high mortality of larvae after placing fruit bodies into rearing boxes. Rearing from samples of dead wood kept in the original locality enables to increase the set of species obtained. Økland (1999) used emergence traps and discovered 100 species in ten families of Diptera, of these for 54 species the biology was unknown before.

In 2005 I experimented with a series of twenty emergence traps in southern Finland exposed during the whole season since 24 April to 27 September). The trap consists of a pyramidal aluminum framework (1 x 1 m in base) covered with black cotton cloth. At the top of the trap a transparent flexible channel-pipe (50 cm long, 5 cm diameter) was connected to a collecting bottle mounted outside (Fig. 1). Ethylene-glycol with a small amount of detergent was used as a preservative.

Fig. 1. The emergence trap used mounted on a decaying spruce log.

Traps were set up in three forest stands (old-growth forests in Vesijako and Kotinen Nature Reserves, and herb-rich forest near Lammi research station) and in two burnt clear-cuts with retention trees in Evo area. Each trap covered a piece of decaying fallen trunk, ca 70–80 cm in length (15 traps), or a whole stump (5 traps) in which living fungus-gnat-like larvae were found. Traps were checked three to four times during the season. Around midsummer (26-27 July) new sections of decaying wood from the same trunk were added into ten traps. Other five traps mounted on fallen logs were set in another places while the five traps mounted on stumps were left in place.

Tree species sampled included *Picea abies* (12 traps), *Betula* sp. (5), *Populus tremula* (3), *Pinus sylvestris* (2), *Alnus glutinosa* (1), *A. incana* (1) and *Salix caprea* (1). The decay classes varied from 2 to 4. Fungal fruit bodies were collected and described in fresh state in each case, but the final identification is not completed yet.

The trapping (a total of 63 samples, of which 25 have been treated so far) yielded a large insect material. The amount of individuals collected varied from tens to hundreds between traps. Only fungus gnats s.l. (Bolitophilidae, Ditomyiidae, Diadocidiidae, Keroplatidae, Mycetophilidae), making on average ca. 10% of the catches, and Heleomyzidae have been picked out for further species identification. So far a total of 37 species of fungus gnats for which the biology was unknown before have been discovered.

Other groups of Diptera (among which Limoniidae, Sciaridae, Cecidomyiidae s.l., Bibionidae, Anisopodidae, Rhagionidae, Empididae, Phoridae, Anthomyiidae and Muscidae seem the most abundant ones) and Hymenoptera are available to taxonomists interested in discovering potentially new larval microhabitats to their groups.

Saproxylic species in Sciaroidea (Diptera, Nematocera) within Fennoscandia

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Saproxylic species occur in most families in the insect order Diptera. Saproxylics can constitute whole families or only include single species within families or genera mainly consisting of non-saproxylic species.

The superfamily Sciaroidea is one of the most species-rich groups of Diptera and contains a large proportion of saproxylic species. In Europe Sciaroidea includes the families Bolitophilidae, Diadocidiidae, Ditomyiidae, Keroplatidae, Mycetophilidae (collectively called as fungus gnats or Mycetophilidae *sensu lato*), Sciaridae and, according to some recent taxonomic work, also Cecidomyiidae. Fungus gnats and two sub-families of Cecidomyiidae, Porricondylinae and Lestremiinae, are typical forest dwellers and share at large similar biology. Most species live in fruit bodies or mycelium of either terrestrial or wood-decomposing fungi. However, the exact habitat requirements, including the saproxylic status, of large part of species are still completely unknown.

Here we present an estimate for the proportion and total number of saproxylic species belonging to the different groups of Sciaroidea within the Fennoscandian area (table 1). We calculated the proportions of saproxylic species in each family and subfamily based on all available literature records and, in addition, to our own unpublished rearing records. We divided the species into three categories: (1) Obligatory saproxylic species. Larvae live only in dead-wood microhabitats, i.e. in decaying wood or wood-decomposing fungi. (2) Facultative saproxylic species. Larvae live in both wood-decomposing and epigeal fungi. (3) Non-saproxylic species. Larvae live only in other microhabitats: in fruit bodies of mycorrhizal and litter-decomposing fungi, in fungous litter, birds nests, burrows of mammals, or on mosses or liverworts.

We found that there are about 650 obligatory saproxylic species constituting over 40% of the whole species pool of Sciaroidea in Fennoscandia. The proportion of them varied between 10% and 100% depending on the family. In addition, several hundreds of species are facultative saproxylics.

Table 1. An estimate for the number of obligatory saproxylic species in different families or subfamilies of Sciaroidea. Known number of species in the world, approximate total number, proportion and number of saproxylic species within the Fennoscandian area are given.

Family/subfamily	No. of species		Saproxylic, %	No. of saproxylic species
	World	Fennoscandia		
Bolitophilidae	55	25	15	3
Ditomyiidae	90	2	100	2
Diadiocidiidae	10	5	100	5
Keroplatidae	800	50	100	50
Mycetophilidae	4000	700	50	350
Porricondylinae	620	200	70	140
Lestremiinae	550	200	30	60
Sciaridae	1900	300	10	30
∑ (rounded)	8000	1500		650

* P.Vilkamaa (pers. comm)

Saproxylic thrips in Finland

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Saproxylic thrips (Thysanoptera) live on or under the bark of trunks and branches, where they forage on spores and hyphae of many fungus species. Most species have a flightless breeding phase and a flying dispersive phase. Production of latter is triggered by deteriorating resource conditions and crowding. Many saproxylic species (e.g. genus *Hoplothrips*) live typically in colonies, where males defense the oviposition sites.

All saproxylic thrips species known in Finland belong to the family Phlaeothripidae and the most abundant genus is *Hoplothrips.* The former checklist included a total of 112 species with 11 saproxylic ones. Now the number of thrips in Finland is 133 with 22 saproxylics, which is thus doubled after beginning (2003) of our study. This indicates that our thrips fauna is still poorly known.

In two studies in Eastern Finland thrips were collected by trunk-window traps at 2001–2003. Result was 10 saproxylic species previously unknown from Finland. Thrips preferred cut areas and trunks around 50% bark left, but there was no difference between burned and unburned areas in species assemblages.

Artificial dead-wood habitat for beetles

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As much as a quarter of Finnish forest species need decayed wood to exist. The largest group of insects are beetles, and each species is adapted to live in a particular type of decayed wood. A single individual tree decays slowly, and the species of beetles constantly change as the decay process progresses.


As part of its biodiversity programme, UPM started a study in 2003 where spruce and aspen trees retained in connection with felling operations were cut into stumps some four metres tall on two separate sites. Over 200 cubic metres of wood per hectare had been felled. The aim was to monitor the occurrence of beetle species over time as the stumps decay.

More than 400 different beetle species have been observed so far, including a number of threatened species. These findings demonstrate the positive impact nature management methods can have when implemented as part of normal commercial forest management. It also shows that endangered species living in decaying wood can occur in intensively-managed commercial forests provided that their substrata and habitats are preserved, or more are created.

Man-made stumps are one method of creating large diameter deadwood in commercial forests. UPM is continuing species monitoring.

Key habitats and valuable habitats: a comparison of terminology and definitions between Finland and Sweden

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The conservation of forest biodiversity in Nordic countries has been in focus during the last 15 years. As a result of this new terms and definitions have been developed in each country. These terms are also used in the international forums, and there is a need to make comparisons of the work and situation in safeguarding the biodiversity in different countries. It is very difficult and confusing if the same terminology is used but the definitions of the terms are different.

Woodland Key habitat or Key habitat is in Finland originally defined as a habitat where demanding and threatened (red-listed) species are likely to occur (Metsäkeskus Tapion julkaisuja 12/1995, p.1). In Finnish the recommended synonym for Key habitat is Valuable habitat. This definition differs from the Swedish one which is strictly connected to the occurrence of red-listed species. The Swedish definition for Key habitat is an area where one or more red-listed species occur, or the very nature of the forest it self should indicate a strong likelihood of finding red-listed species (Svensk Botanisk Tidskrift 1992, vol. 86: 219–226) The Swedish definition is purely biological, and according to this definition a Key habitat can be anything from a single ancient oak tree in the south of Sweden to an area of several hundreds of hectares of old coniferous forest in the north.

The confusion in the use of the term Key habitat in Finland is mainly caused because of the terminology used in the legislation. The Forest Act from 1997, Section 10, defines Habitats of special importance, and The Nature Conservation Act also from 1997 defines Protected nature types of which three concern forests. The term Key habitat is not used in the legislation, and the habitat definitions are not only biological. According to the legislation the size of the habitats is limited, and the list of habitat types is limited as compared with the Swedish selection of Key habitats. All other habitats which are not mentioned in the Finnish legislation are called Other valuable habitats. If one wants to compare the results of the Finnish inventory of Habitats of special importance with the Swedish inventory of Key habitats, all the Valuable habitats should be included to the Finnish results and figures. And even in this case there are differences in definitions mentioned above. Direct comparison of Finnish and Swedish inventory results is impossible because only the Habitats of special importance has been inventoried in Finland. Therefore in Finland the term Key Habitat is not recommended to be used when one is referring to the habitats defined in legislation.

One of the most important differences between the Swedish Key habitats and Finnish Habitats of special importance is that old growth stands with Key habitat qualities, for example including dead wood, old aspens and indicator species, is a Habitat of special importance in Finland only if classified as herb-rich forest, or if it is combined with the geomorphological formations mentioned in the Forest Act. The Forest Act also limits the size of the habitats. No exact area is given, but in practice the area is seldom more than two hectares. One important difference is also that the Swedish Key habitats are located on productive forest land, whereas a large part of the Finnish Habitats of special importance are located on nutrient poor sites such as rocky outcrops and open mires with sparse stand.

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