INFORMATION FRÅN

LÄNSSTYRELSEN HALLAND

Diversity of saproxylic fungi on decaying beech wood in protected forests in the county of Halland

[Vedlevande svampar på bok i skyddade skogar i Hallands län]

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HabitatVision

Frontpage: Hericium coralloides (koralltaggsvamp) inhabiting a large beech snag in Mårås. The black conks show that *Fomes fomentarius* (fnösketicka) have been present in an earlier stage of decomposition. In Halland this is consistently the case for trees inhabited by *Hericium coralloides*. Photo: Jacob Heilmann-Clausen.

Backcover: Jacob Heilmann-Clausen in action, Rågetaåsen nature reserve. Unknown polypore *Tyromyces* sp. growing on beech log at Skrockeberg nature reserve. Photos: Örjan Fritz.

Örjan Fritz edited this report, March 2005.

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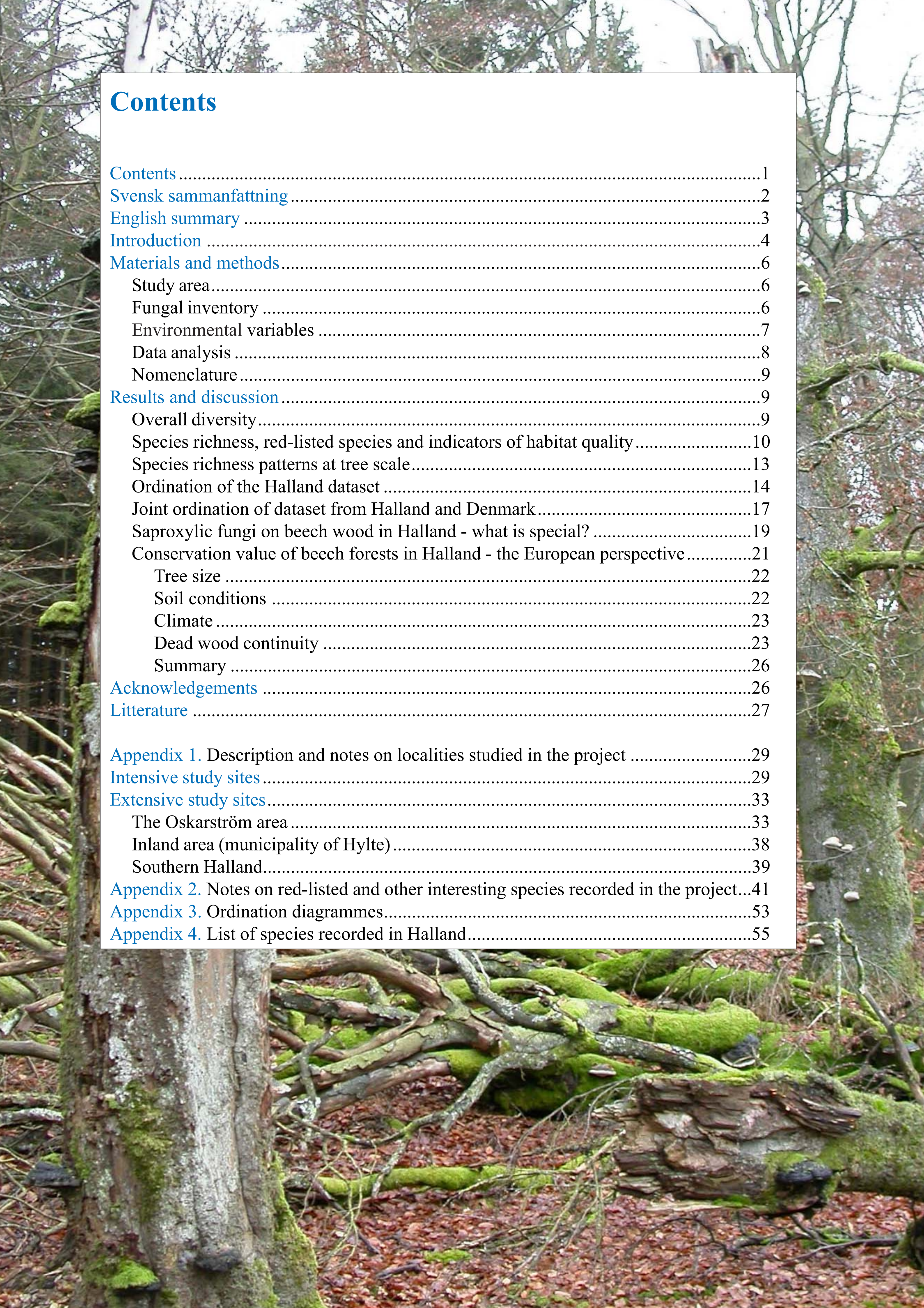

Svensk sammanfattning

Totalt 200 döda bokar fördelade över sju gamla bokskogsbestånd undersöktes på förekomsten av fruktkroppar av svampar. Ett standardprotokoll följdes för ifyllande av uppgifter utvecklat inom det EU-finansierade projektet Nat-Man (www.flec.kvl.dk/natman). För varje bok antecknades alla arter av storsvampar, utom barkväxande basidiesvampar och några få ytterligare grupper, under tre olika tillfällen under svampsäsongen 2004, baserat på förekomsten av fruktkroppar. Protokollet har tidigare tillämpats i Danmark, Nederländerna, Belgien, Slovenien och Ungern och möjliggjort en jämförelse av storsvampsamhällen på död bokved inom Europa. Som tillägg till nämnda intensivstudie inventerades ytterligare 13 gamla bokskogar mera extensivt på innehåll av vedlevande svampar.

Pholiota aurivellius. Photo: Örjan Fritz.

Totalt 284 arter av svampar påträffades i undersökningen, varav 20 var rödlistade. Fem arter rapporteras här för första gången från Sverige; *Galerina pallida*, *G. pseudomniopila*, *G. vexans*, *Hohenbuehelium auriscalpium* och *Psatyrella larga*. På boklågor i Halland hittades i medeltal 13,1 arter av storsvampar, beroende på trädstorlek, nedbrytningsstadium och lokal. Artdiversiteten var högst på träd i mellanliggande nedbrytningsstadier och ökade generellt med trädstorleken. Den mest betydelsefulla samhällsgradienten, dvs det största skiftet i artuppsättning, befanns vara kopplad till nedbrytningsstadium av de studerade träden.

Olikheter i artuppsättningar mellan de sju intensivstuderade områdena var begränsade. Detta kontrasterar till situationen i de flesta andra Nat-Man länderna, där en distinkt omsättning i artuppsättning mellan de studerade områdena rapporterats i de flesta fallen. Den tydligaste orsaken för denna brist på artskillnader i Halland är den begränsade variationen i klimat och jordmån mellan de studerade lokalerna. På liknande sätt är olikheter orsakade av skillnader i markanvändningshistoria mellan de studerade lokalerna i Halland inte tydligt uttryckta i den totala artstocken.

Den funna artstocken av svamp på bokved i Halland var mycket lik den som rapporterats från centrala Jylland i Danmark. Båda områdena karaktäriseras av näringsfattiga jordar och ett tämligen fuktigt och kyligt klimat, vilka förefaller påverka svampflorans artsammansättning. Även från ett europeiskt perspektiv tycks klimatiska skillnader ha en mycket tydlig påverkan på svampflorans samhällsstruktur. Sålunda är svampfloran på bokved i Slovenien och Halland överraskande lika med tanke på det geografiska avståndet. Båda områdena karaktäriseras av en hög årsnederbörd, som tycks ha en tydlig inverkan på konkurrensförhållanden och sålunda artsammansättningen på död ved.

Sett utifrån ett svenskt naturskyddsperspektiv är bokskogarna i Halland mycket viktiga för skyddet av vedlevande svampar, men endast måttligt viktiga sett från en europeisk horisont. Fyra arter med skyddsintressen rapporterades i en högre frekvens i Halland jämfört med andra bokskogsregioner studerade i Nat-Man-projektet; skinntagging *Dentipellis fragilis*, koralltaggsvamp *Hericium coralloides*, vedlavklubba *Multiclavula mucida* och borstskölding *Pluteus umbrosus*. Dessutom är två tickor, *Skeletocutis vulgaris* och *Tyromyces* sp., unika för Halland bland de bokskogsregioner som studerats hittills. De största skyddsvärdena noterades för lokalerna Biskopstorp, Valaklitt och Mårås samt för ett antal lokaler samlade strax norr och öster om Oskarström i den norra delen av Halmstads kommun. Substratförekomst, särskilt förekomsten av gamla stora träd samt dödvedkontinuitet från en lokal till landskaps skala, identifierades som viktiga faktorer som påverkar det nuvarande skyddsvärdet av enskilda studerade lokaler. I ett europeiskt perspektiv tycks det måttliga skyddsvärdet av vedlevande svampsamhällen i halländska bokskogar spegla den mellanliggande nivån av dödvedkontinuitet på en landskapsskala, likaväl som de halländska bokskogarnas position i utkanten av bokens utbredningsområde, vilket begränsar förekomsten av flera sällsynta vedlevande svamparter som lever på bokved i andra delar av Europa.

English summary

In total 200 dead beech trees distributed across seven old-grown beech forests stand in Halland were investigated for fungal sporocarps. A standard European protocol developed in the EU funded project Nat-Man (http://www.flec.kvl.dk/natman) was followed. On each tree all species of macrofungi, except corticoid basidiomycetes and a few other groups were recorded on three occasions during the fungal season, based on the occurrence of sporocarps. The protocol has earlier been applied in Denmark, The Netherlands, Belgium, Slovenia and Hungary, making a comparison of macrofungal communities on dead beech wood possible at the European scale. In addition to the intensive study sites, 13 old-grown beech forests were investigated for saproxylic (wood-inhabiting) fungi using a more extensive approach.

A total of 284 fungal species were recorded in the project, including 20 red-listed species. Five species, viz. *Galerina pallida, G. pseudomniophila, G. vexans, Hohenbuehelium auriscalpium* and *Psathyrella larga* are reported for the first time in Sweden. Fallen beech trees in Halland were found to host an average of 13.1 macrofungal species, depending on tree size, decay stage and locality. Species diversity was highest on trees in intermediate decay stages and increased generally with trees size. The most important community gradient (i.e. the biggest shift in species composition) was found to relate to the decay stage of the study trees.

The differentiation in species composition among the seven intensive study sites was limited. This contrasts the situation in most of the Nat-Man countries, where a distinct turnover in species composition among study sites has been reported in most cases. The most obvious reason for this lack of differentiation in Halland is the limited variation in climatic conditions and soil types among the studied localities. Likewise, differences caused by variations in management history among study sites in Halland are apparently not clearly expressed in the overall species composition.

Trametes hirsuta. Photo: Örjan Fritz.

The fungal species composition on beech wood in Halland was very similar to that reported from Central Jutland, Denmark. Both areas are characterized by nutrient poor soils and a rather wet and cool climate, which both seems to affect the fungal species composition. Also at the European scale, climatic differences appear to have a very pronounced impact on the fungal community structure. Thus, the funga on beech wood in Slovenia and Halland appear to be surprisingly similar considering the geographical distance. Both areas are characterized by a high annual precipitation which seems to have a marked influence on the competitive environment and hence the species composition in dead wood.

In a conservation perspective the beech forests of Halland are concluded to be highly important for conservation of saproxylic fungi in a Swedish context and of moderate importance in a European perspective. Four species of conservation interest, viz. *Dentipellis fragilis, Hericium coralloides, Multiclavula mucida* and *Pluteus umbrosus* was recorded with higher frequency in Halland than in other beech forest regions surveyed in the Nat-man project. In addition, two polypores, viz. *Skeletocutis vulgaris* and *Tyromyces sp.* are unique to Halland, among the beech forest regions studied intensively so far. The biggest conservation interests were recorded in Biskorpstorp, Valaklitt, Mårås and for a number of sites aggregated north and east of Oskarström. Substrate abundance, especially the presence of old, large diameter trees, and dead wood continuity at the local to landscape scale were identified as important factors influencing the present conservation value of individual study sites. At the European scale the moderate conservation value of saproxylic communities in Halland beech forests appear to reflect the intermediate level of dead wood continuity at landscape scale, as well as the marginal position of the Halland beech forests, which restricts the occurrence of several rare fungi inhabiting beech wood in other parts of Europe.

Diversity of saproxylic fungi on decaying beech wood in protected forests in the county of Halland

Introduction

The county of Halland hosts one of the northernmost coherent beech *(Fagus sylvatica)* populations in Europe (Bengtsson 1999b). Beech established in the area about 2000 years ago, and became an important tree species in the mixed mainly deciduous forests of Halland north to the Åkulla-area close to Varberg during the subsequent 1000 years. The spread of beech was, like in other parts of south Scandinavia, closely linked to anthropogenic disturbances (Lindbladh et al. 2000). Beech was favoured by temporal clearings of forests to farmland and became an important tree species especially in the "mellanbygden" zone i.e. the transition zone between the coastal lowlands dominated by open farmland and the inland forest tracts (Bengtsson 1999b).

The present forest cover of the mellanbygden zone exceeds 70 %, but beech is not dominant. Norway spruce has expanded much in Halland over the last centuries, mostly due to plantations, and remaining beech forests occur mostly as isolated stands surrounded by extensive coniferous forest landscapes. Concentrations of remaining beech forests are found on the northern slopes of Hallandsåsen, at Biskopstorp NE of Halmstad and at Åkulla SE of Varberg (Fritz & Larson 2000). Even in these landscapes, spruce forests are however dominating (Bengtsson 1999b; Fritz & Larson 2000; Fritz & Berlin 2002), with beech forests occurring as a mosaic of more or less confluent patches in a matrix dominated by coniferous forests or in part open land (Hallandsåsen).

The discomycete *Bulgaria inquinans* (limsvamp) is common on newly fallen beech logs and larger fallen branches in Halland. Sporocarps are typically formed in abundance already the first year after a tree has broken down, but fruiting ceases already one or two years later. The species is probably present in an endophytic, symptom-less stage in living trees and initiates growth and wood decay soon after a tree or tree part has died. Photo: Örjan Fritz.

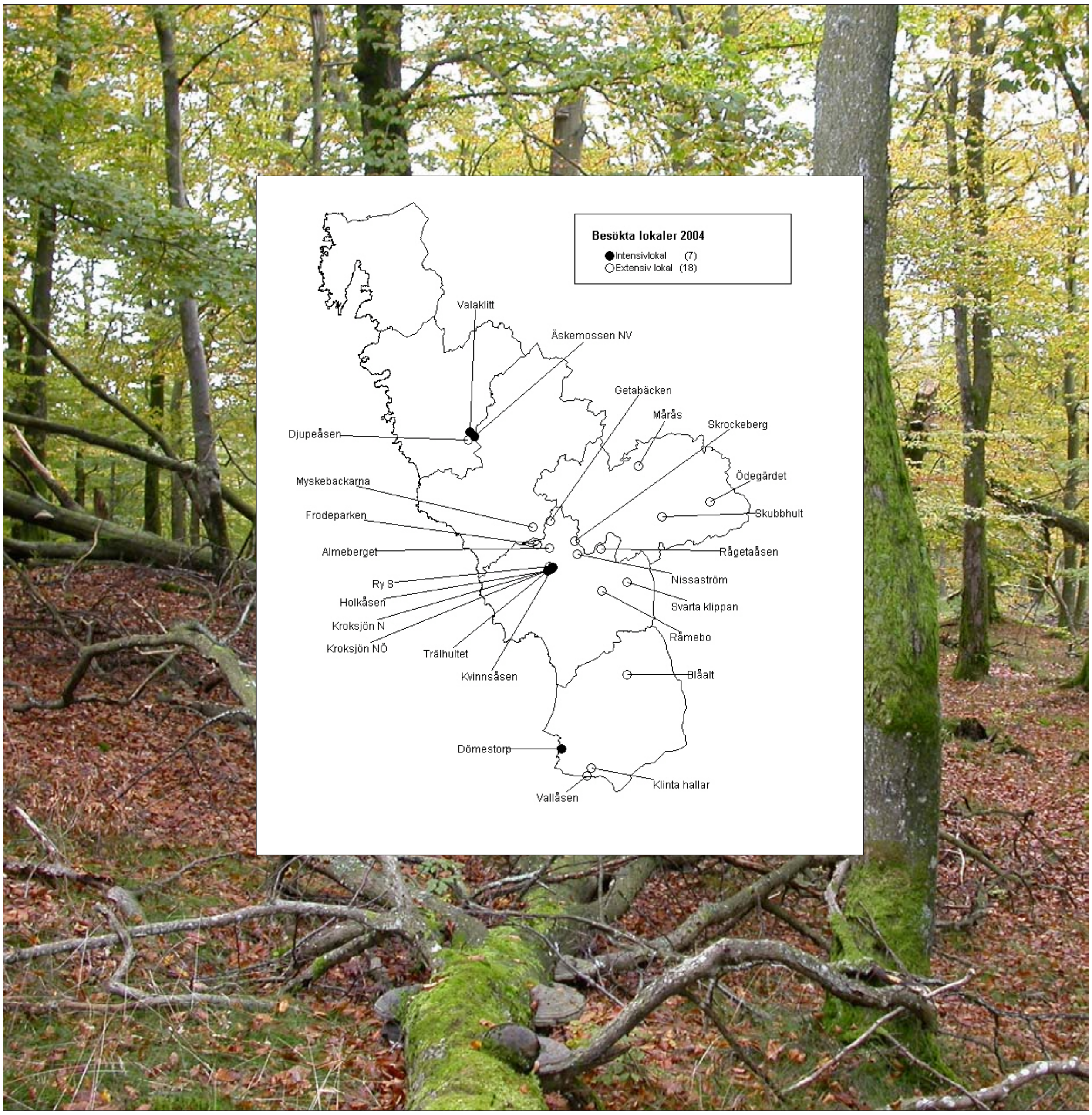

Figure 1. Map showing the location of study sites inventoried for wood inhabiting fungi during the project. Of the extensive localities Djupeåsen, Ry S, Kroksjön NÖ, Almeberget and Klinta Hallar were only visited at the summer visit, at which agarics were very sparsely represented by sporocarps. Background photo from the beech forest reserve Råmebo. Photo: Örjan Fritz.

Since their establishment, the beech forests of Halland have been used intensively for livestock grazing, firewood collection and timber production. Some areas have even been cleared for agriculture for shorter or longer periods (Bengtsson 1999b). None of the beech forests in Halland are accordingly pristine virgin forests, but should be seen as seminatural habitats developed in concert with cultural development. Not all types of human forest use have been detrimental to forest biodiversity, and especially forest grazing may have benefited species depending on large trees growing in warm, semi-open forest types (Bengtsson 1999b). Dead wood has probably been a sparse resource in Halland beech forests at most places and times. The most remote and inaccessible areas (e.g. stands rich in steep cliffs, ravines etc) have probably developed more natural stands with minimum human intervention and a continuous presence of standing and lying dead wood. Even periods of human disaster, e.g. cattle plague, war and major epidemics, have caused large fluctuations in forest use and naturality.

In a European perspective the natural conditions of Halland beech forests can be characterized as humid, cool and nutrient poor. The nutrient poor soil limits the growth rate of beech in most sites. Trunks with a diameter exceeding 80 cm are exceptional, while trees with a diameter well below 50 cm may be more than 250 years old (Bengtsson 1999a). As a consequence of poor growth conditions and former management many beech stands are rather light open but humid, due to the high precipitation and the spatial continuity of forests. This creates a perfect environment for epiphytic lichens and bryophytes associated with beech. Halland is maybe the most valuable region in the whole of North Europe for this group of organisms (cf. Fritz 2001).

Investigations of saproxylic insects have shown that some of the beech forests in Halland host rich communities of rare and endangered species (Jansson 2004). Preliminary investigations, especially in the Biskopstorp area, have indicated that the same may be the case for saproxylic fungi (Fritz 2004a). Detailed investigations on the funga of Halland are however sparse, and very few reports have been published, giving any insight in the mycological conservation value of Halland beech forests.

The aim of this report is to provide insight in the diversity and conservation value of saproxylic fungal communities in Halland; both in a regional and an international perspective. Recently published reports (Ódor et al 2004a, b) of the EU-funded project Nat-Man (http://www.flec.kvl.dk/natman) have given a unique opportunity to put Halland on the European beech forest map. This opportunity was taken in the current project in which the standard sampling protocol of the Nat-Man project was applied in a detailed investigation of macrofungal diversity of 200 decaying beech trees in Halland. The 200 trees were distributed in seven study sites in Dömestorp, Biskopstorp and Åkulla. In addition 13 old-grown beech stands in other parts of Halland were investigated for saproxylic fungi, using a more extensive approach.

Materials and methods

Study area

The county of Halland is situated in southernmost Sweden along the coast of Kattegat. The climate of the area is temperate, with an annual mean temperature ranging from 5-7° C, and an annual mean precipitation of 1000-1500 mm (SMHI: http://www.smhi.se). Phytogeographically the area belongs to the nemoral zone, except for a few extensive inland study sites which are situated in the boreo-nemoral zone (cf. Bengtsson 1999b). The bedrock is in the whole area dominated by acidic granites. Glacial tills of variable thickness are present in all localities, but are often shallow or lacking on higher points. The bedrock is hence exposed to a variable degree in all sites. The soils are generally nutrient poor and acidic with a vegetation dominated by low grasses and dwarf scrubs *(e.g. Deschampsia* spp, *Myrtillus* spp.*)*. Dömestorp forms an exception due to the presence of base-rich tills supporting a relatively rich flora. Even some of the extensive inland localities have richer soils due to local occurrence of base-rich amfibolit.

In all 20 localities were investigated in the project (Fig. 1). Seven of these are intensive localities in which a variable number of dead, fallen beech trees were studied intensively at three occasions during the fungal season. Another 13 sites were extensive localities, visited only at one occasion, at which the whole locality were investigated more extensively. All study sites are at present unmanaged, but to a variable degree marked by former management.

Fungal inventory

For the intensive study a total of 200 dead beech trees, distributed across seven individual localities were selected. At each locality trees were selected with the intention to get a comparable and balanced representation of predefined tree decay and size classes across all localities. In practice trees were

Table 1. Overview of intensive localities in Halland giving basal data on forest history, numbers and sizes of study trees.

Locality	Number of study trees	Min, average and max DBH of study trees	Years since last cutting	Max tree age
Dömestorp	50	20 - **48.5** - 68 cm	20*	200
Holkåsen	50	33 - **47.2** - 70 cm	50*	300
N Kroksjön	25	34 - **54.2** - 92 cm	12	250
Kvinnsåsen	15	31 - **42.8** - 50 cm	30*	270
Trälhultet	10	42 - **57.1** - 78 cm	12	270
Valaklitt	25	23 - **52.5** - 68 cm	55*	250*
Äskemossen	25	20 - **42.6** - 56 cm	30*	200*

*Estimates of last year since cutting respectively max tree age.

Fomes fomentarius (fnösketicka) is clearly the most important decay agent in beech forests in Halland. It causes a vigorous white rot in infected wood. Occupied logs are often almost completely decayed in 10 years. Photo: Örjan Fritz.

selected by walking across each locality filling up a predefined matrix until all size/decay class combinations were equally represented. Trees, with a standing snag higher than c. 8 m, were not considered relevant for the project and were hence omitted from the selection procedure. The variation in numbers of selected trees at each site does partly reflect the availability of fallen trees but was decided before the project start in dialog with Örjan Fritz. It should be noted that it was not possible to fill out the size/decay class matrix in the same way in all sites due to natural and management related differences in tree sizes. Accordingly the average size of study trees differ considerably among sites (cf. Table 1).

In the intensive study sites fungal inventories were conducted in late summer (12-18 Aug), mid-autumn (29 Sept – 7 Oct) and late autumn (1-4 Nov). At each occasion all selected trees, including eventual snag and branches thicker than 10 cm, were carefully inventoried for fungal sporocarps, which were either identified in the field or collected for microscopical identification. Within the basiodiomycetes all morphological groups, ex-cluding fully resupinate corticoid fungi, were included, while non-stromatic pyrenomycetes and inoper-culate disco-mycetes with sporocarps regularly smaller than 10 mm were excluded from the ascomycetes.

Extensive localities were visited only once, at mid autumn (1-9 Oct), and surveyed by walking around inspecting all suitable pieces of dead beech wood for fungal sporocarps. One to three hours of field work was used on each extensive locality, mainly depending on size and dead wood abundance. For logistic reasons some localities were however investigated more briefly, see appendix1 for details.

Environmental variables
Environmental variables were recorded at both the tree level and the site level. Tree variables include tree type (uprooted, broken at root neck, broken with distinct snag), dbh (diameter at breast height), decay stage, moss cover, soil humidity, wind exposure and sun exposure. In addition the relative cover/distribution of two key wood decayers, *Fomes fomentarius* and *Kretzschmaria deusta,* were noted.

Site variables include geographical location (east coordinate, north coordinate, northeast coordinate, northwest coordinate), climatic key characteristics, soil type, maximum tree age and time since last cutting. For details see Table 2.

Table 2. List of recorded tree and site variables used in the analysis of the datasets. Site variables, written in italics, were only included in the analysis of the joint Halland/Danish dataset.

Variable name	scale	Range	Details
DBH	cm	20 - 92	Measurement (1.3 m above ground)
Decay stage	Class (ordinal)	1 - 6	From undecayed (stage 1) to completely decayed (stage 6)*
Bark cover	%	0 - 100	Estimated to the nearest 10 % of the log surface
Soil contact	%	1 - 100	Estimated to the nearest 10 % of the log surface
Soil humidity	Class (ordinal)	1 - 5	From dry soils (stage 1) to partly inundated soils (stage 5)*
Wind exposure	Class (ordinal)	1 - 5	From open hilltops and edges (stage 1) to sheltered hollows and ravines (stage 5)*
Sun exposure	Class (ordinal)	1 - 5	From fully exposed openings (stage 1) to closed, multi-layered forest (stage 5)*
Moss cover	%	0 - 100	Estimated to the nearest 10 % of the log surface
Tree Type	Class (nominal)		Four types distinguished (Uprooted, Broken at root neck, Broken with distinct snag, Rebroken)
Fomes cover	Class (ordinal)	0 - 3	From absent (stage 0) to dominant on wood surface(stage 3)
Kretszchmaria cover	Class (ordinal)	0 - 3	From absent (stage 0) to dominant on wood surface(stage 3)
Site	Class (nominal)		One variable stage for each site
Region	Class (nominal)		Seven regions distinguished (Møn, C Zealand, N Zealand, C Jutland, S Halland, C Halland and N Halland)
East coordinate	km	33 - 246	Based on standard maps
North coordinate	km	11 - 247	Based on standard maps
Northeast coordinate	km	121 - 333	Based on standard maps
Northwest coordinate	km	0 - 225	Based on standard maps
Soil/bedrock type	Class (nominal)		Five types distinguished (granite, sand, sandy till, loamy till and lime stone)
Average Jan. Temperature	ºC	-1.5 to 0.8	Based on data from DMI and SMHI**
Average July temperature	ºC	15.5 - 16.7	Based on data from DMI and SMHI**
Annual average temperature	ºC	6.5 - 8.1	Based on data from DMI and SMHI**
Average annual precipitation	mm	586 - 1150	Based on data from DMI and SMHI**
Years since last cutting	Years	10 - 80	Based on published and unpublished data***
Max tree age	Years	140 - 350	Based on published and unpublished data***

* For further details see Heilmann-Clausen and Christensen 2003, **Frich et al., 1997, Laursen et al., 1999, http://www.smhi.se, ***Bengtsson 1999a, Fritz & Berlin 2002, Niklasson 2003, Heilmann-Clausen & Christensen 2005 and Örjan Fritz (pers. comm.).

Data analysis

Apart from simple numerical comparisons a number of more advanced analytical tools were used to evaluate the properties of the fungal dataset and to compare it with the Nat-Man datasets from other European countries.

Detrended corresponden-ce analysis (DCA) (Økland 1990) was used to investigate the overall structure of the dataset(s). DCA is an indirect ordination technique, which means that the dataset is analysed based solely on the presence of species across samples (in this case the study trees). DCA order samples in the so-called ordination space based on similarities in species composition. The ordination space is defined by ordination axes which express community gradients in the dataset. The first ordination axis in DCA is always the strongest community gradient i.e. the gradient which most efficiently expresses similarities and dissimilarities in species composition among samples. Subordinary axes express remaining variation not expressed by the preceding axes. DCA ordination axes are associated with two numeric descriptors: The Eigen-value express how well the axis expresses variation in the dataset while the gradient length is a measure of species turnover (á-diversity) along the axis.

Kendall rank correlation (Legendre & Legendre 1998) was used to evaluate relations between fungal species richness per tree and investigated environmental variables. Rank correlation was preferred from its parametric alternatives due to its insensitivity to non-normal data. Kendall rank correlation was also used in the interpretation of community gradient extracted by DCA ordination.

One way ANOVA (Zar 1999) was used as an alternative to Kendall rank correlation for testing relations between species richness (or ordination axis scores) and variables on nominal scale (e.g. tree and soil type)

Multiple linear regression (Zar 1999) was used to evaluate complex relations between species richness scores and several independent variables at one time. Selection of variables for the model was made manually, guided by correlation analyses and one way ANOVA's.

Nomenclature

Nomenclature in general follows Hansen & Knudsen (1990, 1992, 1997).

Results and discussion

Overall diversity

In total 284 fungal species were identified in the project. Of these 244 are macrofungi according to the Nat-Man criteria, while 40 species are corticoid basidiomycetes or non-stromatic pyrenomycetes. The true diversity within the two latter groups in the study area is without doubt much higher than recorded, as only occasional collections of the most conspicuous species were made within these groups. Of the macrofungi, 197 species were recorded on the 200 intensively studied trees, while 47 species were recorded as supplementary on the intensive localities or in the surveys of extensive localities.

The most common species in the intensive dataset are shown in Fig. 2. Only *Xylaria hypoxylon* and *Fomes fomentarius* were recorded on more than half of the study trees. Six of the ten most frequent species are agarics. It is important to notice that the fact that a species is common not necessarily implies that it is a dominant decay agent. *Fomes fomentarius* and to a lesser extent *Eutypa spinosa* are truly dominant species occupying large territories already in living trees. *Stereum hirsutum* and *Panellus serotinus* are restricted to wood in early decay stages, but do often occupy rather large wood volumes, judged by widespread appearance of sporocarps. *Galerina marginata, Mycena haematopus* and *Psathyrella piluliformis* are mostly seen on decayed wood and

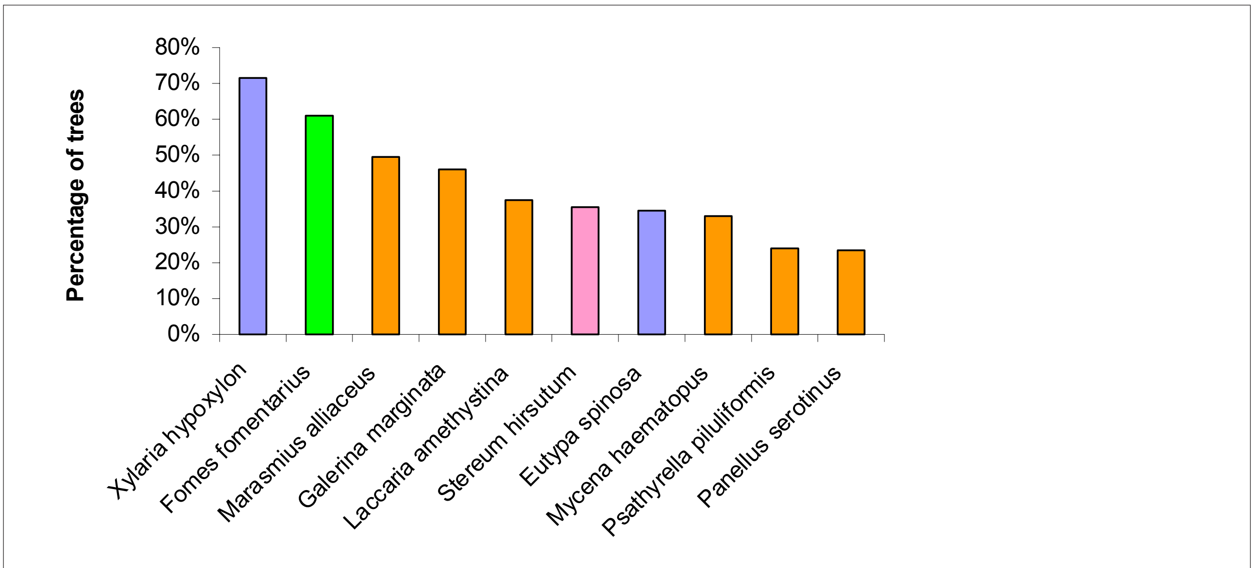

Figure 2. The ten most commonly recorded wood inhabiting macrofungi in the project. Blue columns indicate pyrenomycetes, green polypores, orange agarics and pink crust-forming corticoid basidiomycetes.

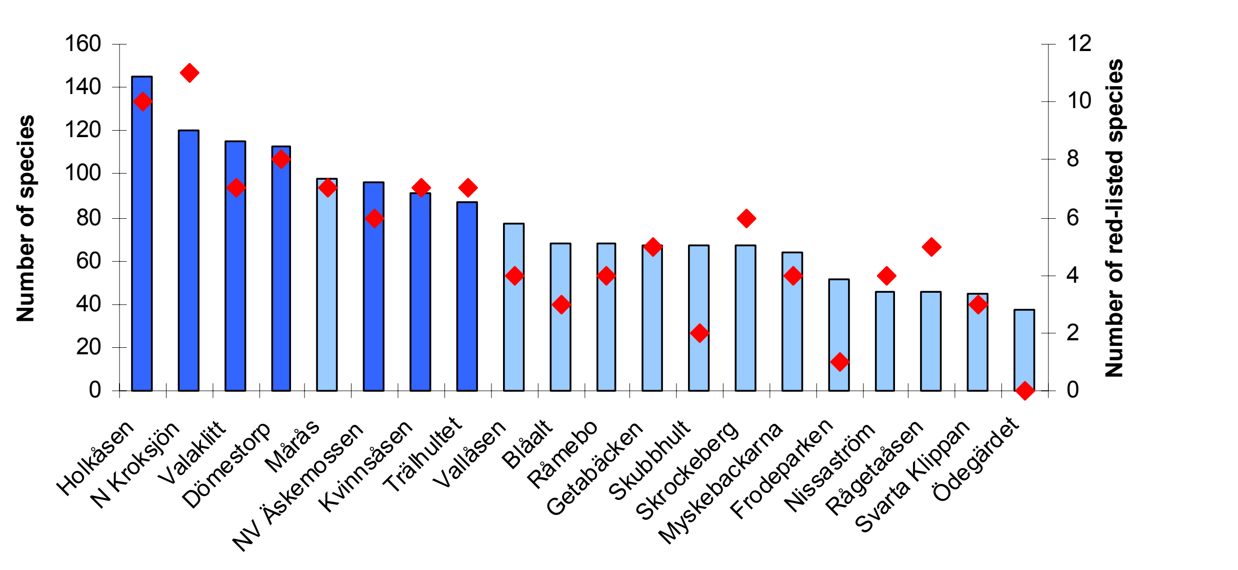

Figure 3. Total (columns) and red-listed (dots) species numbers recorded on each study site. Dark columns indicate intensive study sites. Red-listed species corresponds to Gärdenfors (2000).

mostly in small localized groups. It is uncertain whether this correlates to small occupied territories in the decaying wood or reflect a localized sporulation strategy. *Marasmius alliaceus* and *Xylaria hypoxylon* both occur throughout most of the decay process. Sporocarps typically occur scattered on several parts of decaying trees, which probably reflect the presence of several rather small, individual mycelia. Finally *Laccaria amethystina* is an ectomycorrhizal fungus occurring mostly on strongly decayed wood. Its role in wood decay is unknown, but it might be actively involved in the breakdown of residual wood components or withdraw nutrients from mycelia of wood decay fungi (Heilmann-Clausen 2003).

At least five of the recorded species, viz. *Galerina pallida, G. pseudomniophila, G. vexans, Hohenbuehelium auriscalpium* and *Psathyrella larga,* are reported as new to Sweden, while *Cereceomyces sulphurinus* is reported for the second time in Sweden, with the previous record, from Femsjö, dating back to 1940. In total 20 of the recorded species are listed in the Swedish redlist (Gärdenfors 2000). Two of the recorded species appear to be undescribed and may thus be new to science.

Species richness, red-listed species and indicators of habitat quality

The highest species number from a single locality was recorded in Holkåsen, where a total of 145

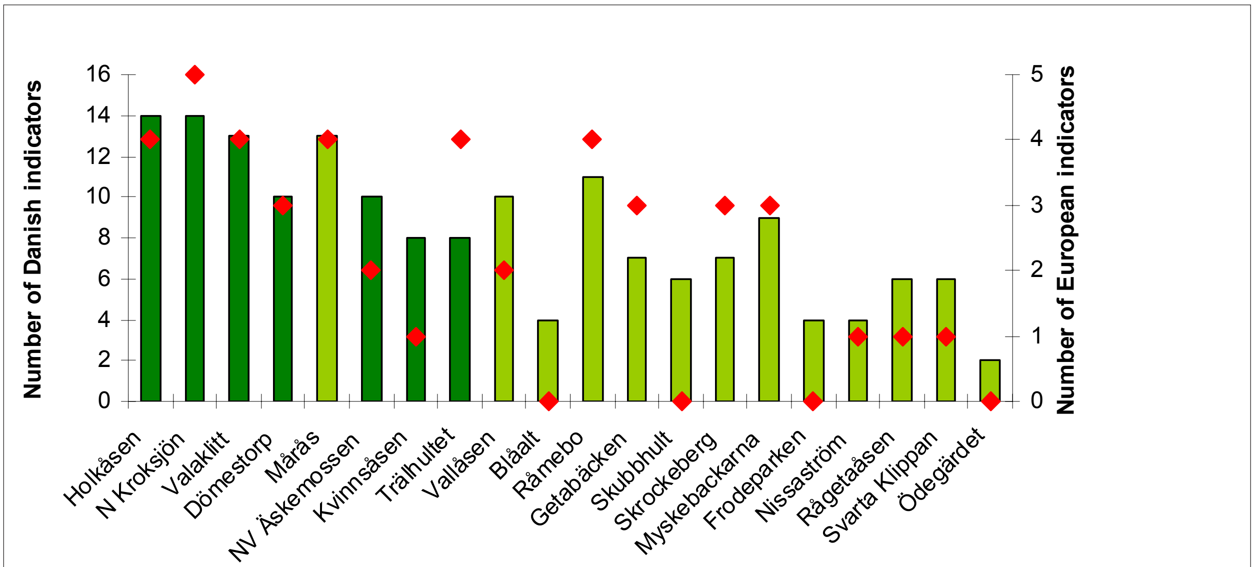

Figure 4. Number of indicator species recorded on each study site. Columns refer to the Danish indicator system (Heilmann-Clausen & Christensen 2000), dots to the European system (Christensen et al. 2005). Localities are listed in the same order as in Fig. 3.

Table 3. Overview of red-listed species, indicator species and species new to Sweden, recorded in the investigated localities. The column "Biskopstorp" present a summary of species recorded in all Biskopstorp localities. Yellow shading indicates that the species was not recorded on a given locality in the current project.

	Redl data book status[1]	**Indicator EU system[2]**	**Indicator DK system[3]**	**Signalart[4]**	Dömestorp	Holkåsen	N Kroksjön	Kvinnsåsen	Trälhultet	NÖ Kroksjön	S. Ry	**Biskopstorp**	Valaklitt	Äskemossen	Mårås	Getabäcken	Blåalt	Skubbhult	Frodeparken	Myskebackarna	Skrockeberg	Svarta Klippan	Råmebo	Vallåsen	Nissaström	Rågetaåsen	Ödegärdet	**Number of sites**
Inonotus cuticularis	**VU**	**X**	**X**	**X**			1					**1**										1						**2**
Phleogena faginea	**VU**		**X**	**X**	1	1	1		1			**1**	1	1				1										**7**
Multiclavula mucida	**VU**			**X**		1	1	1	1		1	**1**			1						1							**8**
Peziza saniosa	**VU**			**X**																					1			**1**
Volvariella bombycina	**NT**	**X**	**X**	**X**		1	1					**1**																**2**
Camarops tubulina	**NT**	**X**	**X**	**X**	1	1	1					**1**	1	1	1	1					1							**8**
Dentipellis fragilis	**NT**	**X**	**X**	**X**	1								1		1	1				1	1		1			1		**8**
Hericium coralloides	**NT**	**X**	**X**	**X**	1	1	1		1			**1**	1		1	1				1	1		1	1	1			**12**
Ossicaulis lignatilis	**NT**	**X**	**X**	**X**																1								**1**
Pluteus umbrosus	**NT**	**X**	**X**	**X**		1	1	1	1			**1**		1	1									1				**7**
Lentinellus vulpinus	**NT**	**X**	**X**	**X**					1			**1**											1					**2**
Hypoxylon cohaerens	**NT**		**X**	**X**	1	1	1	1	1			**1**	1	1	1	1	1	1	1	1		1	1	1		1		**18**
Ceriporia excelsa	**NT**			**X**	1	1	1	1				**1**		1			1								1	1		**8**
Lentaria epichnoa	**NT**			**X**																				1				**1**
Mycena renati	**NT**			**X**	1	1	1	1				**1**	1								1							**7**
Bolbitius reticulatus	**NT**			**X**		1		1	1			**1**		1	1		1											**6**
Stypella subgelatinosa	**NT**			**X**	1																							**1**
Gloeohypochnicium analogum	**DD**		**X**																			1				1		**2**
Ceraceomyces sulphurinus	**DD**								?	1		**1**					?											**1**
Hohenbuehelia auriscalpium[5]		**X**	**X**										1															**1**
Lentinellus ursinus		**X**							1			**1**											1					**2**
Omphalina epichysium			**X**	**X**				1				**1**			1													**2**
Pluteus luctuosus			**X**	**X**		1	1	1				**1**	1		1								1	1	1			**8**
Pluteus pellitus			**X**	**X**																			1					**1**
Pluteus phlebophorus			**X**		1	1	1					**1**			1						1			1		1		**7**
Inonotus nodulosus			**X**		1		1	1				**1**	1	1	1		1	1		1	1	1		1	1		1	**15**
Eutypa spinosa			**X**		1	1	1	1	1	1	1	**1**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**24**
Henningsomyces candidus			**X**			1						**1**																**1**
Inonotus obliquus			**X**										1							1			1					**3**
Nemania atropurpurea			**X**		1	1	1	1	1	1		**1**	1	1	1				1			1	1	1				**13**
Nemania chestersii			**X**		1	1						**1**	1	1	1	1	1	1		1			1	1		1		**12**
Pholiota aurivellus			**X**			1	1	1				**1**	1		1	1		1	1	1	1		1					**11**
Stereum subtomentosum			**X**			1	1					**1**		1														**3**
Ascotremella faginea				**X**	1	1			1			**1**					1											**4**
Oxyporus corticola				**X**					1			**1**																**1**
Pluteus nanus				**X**		1						**1**																**1**
Pluteus plautus				**X**	1	1						**1**		1					1									**4**
Pluteus podospileus				**X**		1	1					**1**	1	1	1				1					1				**7**
Pluteus salicinus				**X**	1																				1			**2**
Pluteus semibulbosus				**X**	1	1	1	1	1			**1**			1		1	1					1	1				**10**
Skeletocutis vulgaris				**X**	1		1		1		1	**1**	1	1		1		1			1			1				**10**
Stigmatolemma urceolata				**X**		1						**1**																**1**
Galerina pallida[5]																									1			**1**
Galerina pseudomniophila[5]					1	1			1			**1**																**3**
Galerina vexans[5]															1			1										**2**
Psathyrella larga[5]						1	1					**1**							1									**3**
Ascocoryne sp.					1		1		1			**1**	1				1			1								**6**
Tyromyces sp.																1					1				1	1		**4**
Number of redlisted species					8	10	10	6	7	0	1	**12**	6	6	7	4	3	2	1	4	5	2	4	4	3	3	0	**17**
Number of Indicators (EU)					3	4	5	1	4	0	0	**7**	4	2	4	3	0	0	0	3	3	1	4	2	1	1	0	**10**
Number of Indicators (DK)					10	14	14	8	7	2	1	**18**	13	9	13	7	4	6	4	9	7	6	11	9	4	6	2	**24**
Number of "Signalarter" (S)					13	17	14	9	11	0	2	**22**	9	9	11	5	5	4	3	4	6	2	7	8	5	3	0	**30**

[1]According to Gärdenfors (2000); VU: Vulnerable; NT: Near threatened; DD: Data deficient. [2]Christensen et al. (2005). [3]Heilmann-Clausen & Christensen (2000). [4]Hallingbäck & Aronsson (1998), Nitare (2000). [5]Reported here as new to Sweden.

species was identified. The lowest number of species (37) was recorded from Ödegärdet (Fig. 3). The recorded species richness was generally highest in the intensive localities, and among these, recorded species richness generally increases with the number of studied trees. It is however remarkable that the recorded species richness in Dömestorp, with 50 studied trees, is lower than in both N. Kroksjön and Valaklitt, each with 25 studied trees. Among the extensive localities, Mårås stand out as exceptionally species rich.

Numbers of red-listed species recorded per locality does largely reflect the recorded species richness per

Ectomycorrhizal fungi are very common on strongly decayed wood in Halland beech forests, probably reflecting that dead wood offers an important nutrient resource in the generally nutrient poor forest soils. Here sporocarps of the ectomycorrhizal agaric *Laccaria amethystina* (ametistskivling) occur closely associated with *Mycena haematopus* (blodhätta), which is a more typical wood decay fungus. Photo: Jacob Heilmann-Clausen.

locality (Fig. 3). Among the extensive localities Ödegärdet, Frodeparken and Skubbhult stands out as comparably poor in red-listed species, while Rågetaåsen has a remarkable high number of red-listed species on record, considering the rather low overall species richness.

Two different indicator systems were used to evaluate the conservation value of individual localities in the study (Fig. 4). In both case a few records made by Örjan Fritz within the last years have been included in the dataset. Of the 42 indicators proposed for valuation of Danish beech forests (Heilmann-Clausen & Christensen 2000b) 24 was found in the present study. N. Kroksjön was the high-scorer with 16 indicators, closely followed by Holkåsen, Valaklitt and Mårås. Based on experiences with use of the Danish indicator system in Denmark and Europe a preliminary pan-European indicator system was proposed by Christensen et al. (2005) (see also Heilmann-Clausen & Christensen 2004a). Of the 21 species included in this scheme, ten were recorded in Halland: Five were recorded in the intensive study and another five as supplementary records in intensive localities or from the extensive study sites. The highest number of European indicators was recorded from N. Kroksjön, but it should be remarked that two of these were not recorded in 2004. In general the two indicator systems result in a comparable ranking of the localities (Fig. 4). Especially Ödegärdet, Frodeparken, Blåalt and to some extent Skubbhult stands out as localities of limited value for fungi inhabiting beech wood according to both indicator schemes, while Råmebo, Skrockeberg, Mårås, Valaklitt, Dömestorp and several of the Biskopstorp localities are consistent high scorers. A more general assessment of the conservation value for saproxylic fungi for all study sites are given in Table 4. This assessment accounts for records of other interesting wood decay fungi, and even take into account more general aspects, like the size of each locality and its future potential as judged by the author.

An overview of recorded red-listed species, indicators and other species of special interest are given in Table 3. More details on individual localities are given in Appendix 1, while the conservation value of the Halland beech forest in a European perspective is discussed in the last paragraph of the Results and discussion section.

Table 4. A general assessment of the conservation value in a Swedish context of the study sites based on the occurrence of saproxylic fungi on beech wood, and the future development potential.

Conservation value	Localities	Criteria
Very high	Holkåsen N Kroksjön Valaklitt Getabäcken Mårås Råmebo Skrockeberg	• 4-10 Red-listed species • 7-14 Danish indicator species* • 3-5 European indicator species** • Several species of conservation concern recorded in larger populations • Rather large localities with good prospects for future development
High	Dömestorp Trälhultet Kvinnsåsen Äskemossen Nissaström Rågetaåsen Myskebackarna Svarta Klippan Vallåsen	• 2-8 Red-listed species • 4-10 Danish indicator species* • 1-3 European indicator species** • Species of conservation concern recorded as single individuals or in small populations • Small to large localities with moderate to good prospects for future development
Low to Moderate	Blåalt Frodeparken Skubbhult Ödegärdet	• 0-3 Red-listed species • 2-6 Danish indicator species* • 0-1 European indicator species** • Species of conservation concern recorded as single individuals • Small to large localities with moderate to good prospects for future development

* According to Heilmann-Clausen & Christensen 2000; **According to Christensen et al. 2005

Species richness patterns at tree scale

On the 200 intensively studied trees a total of 2619 unique records were made representing a total of 197 species. Species richness per tree varied from 1 to 27, with an average of 13.1. All figures are close to the averages from the Nat-Man project (Table 5).

Average species richness per tree varied from 10.7 in Dömestorp to 16.0 in Valaklitt (Fig. 5) and was strongly correlated also with *dbh* and *decay stage* of study trees as well as with their degree of *Fomes cover* (Fig. 6, Table 6). The multiple regression model show that *site, decay stage* and *dbh* all contribute individually to explain recorded differences in species richness between trees. Finally there is a small but significant effect of *Kretzschmaria cover*, while an effect of *Fomes cover* is delimited (Table 7). Least square means of the complete model show that species richness per tree is significantly lower in Dömestorp than in Holkåsen, Valaklitt and Kvinnsåsen (Fig. 7), i.e. after accounting for the effects of *dbh, decay stage* and *Kretzschmaria cover*. It is beyond the scope of this report to try to interpret this difference, but it should be emphasized that accidental differences in rainfall during the fungal season in 2004 may be responsible for part of the difference. The relations between species richness per tree and the variables *decay stage* and *dbh* seem to be fairly universal for beech forests in Europe (Heilmann-Clausen & Christensen 2003, 2004b; Ódor et al. 2004a). Thus species richness increases with increasing tree size, which is not surprising, and peaks on trees in intermediate stages of decay, which most likely reflect a peak in the number of available niches for saproxylic fungi. See Heilmann-Clausen & Christensen (2003) for further details. The negative relation between *Kretzschmaria cover* and species richness, probably reflect a defensive decay strategi in *Kretzschmaria deusta*. The species keep occupied wood dry in order to minimize competition from

Table 5. Summary of species diversity data from the Nat-Man project and the intensive investigation of 200 beech logs in Halland.

	Halland	Denmark	Belgium	The Netherlands	Hungary	Slovenia	Totals/ Averages
Number of study trees	200	200	195	198	207	214	1214
Number of study sites	7	6	1	8	2	2	26
Number of species	197	257	190	155	227	207	485
Number of species occurrences	2619	2938	3264	2300	2635	1819	15.575
Average number of species per tree	13.1	14.7	16.7	11.6	13.1	9.1	12.8

Peziza micropus (kortfotad storskål) was recorded quite abundantly in several study sites, mostly on distinctly to strongly decayed logs and snags. For unknown reasons it was not recorded at all in Dömestorp, while it occupied 40 % of the trees in Holkåsen, and at least 16 % of the trees in all other intensive study sites. Photo: Örjan Fritz.

basidiomycetes. As a result the decay process is slowed down, and the realised actual species richness is decreased (Heilmann-Clausen 2001).

Ordination of the Halland dataset

The dataset used in the ordination analysis contained, after exclusion of species poor trees (< 5 species), rare species (< 3 occurences) and outliers, 2459 species records, representing 129 species on 179 trees. The DCA ordination of this dataset revealed one very clear community gradient expressed by axis 1 with an Eigen-value of 0.56 and a gradient length of 5.13 SD units. Eigen-values, as well as gradient-lengths, of subsequent axes are much smaller (Axis 2: 0.19 and 2.74 respectively; Axis 3: 0.17 and 2.40 respectively) pointing to a much lower importance for resolving variation in the dataset. Subsequent ordination axes above axis 3 were not extracted. The dominant community gradient expressed by axis 1 is clearly successional, dividing trees according to their *decay stage*. The second and much weaker gradient to some degree divide trees according to study *sites*, while the third gradient relates to *dbh* as well as *site* (Table 6, Fig. 8). The optima of study sites along axis 2 give few hints to understanding the underlying community gradient. The lowest axis scores are generally obtained by trees in Dömestorp and Valaklitt, which are the southern-most and northern-most localities, respectively. Dömestorp is characterized by rather base-rich glacial tills, while Valaklitt are on a south facing slope with rather deep developed soils. The highest axis scores are obtained by trees in N. Kroksjön, Kvinnsåsen and Äskemossen. The two first localities are situated in the Biskorpstorp area, while the third is in the Åkulla area. The three sites seems not to have much in common in general aspects and management history but are at least partly characterized by very thin soils and marginal growth conditions for beech. It is thus possible that the axis express a weak soil richness gradient.

The distribution of fungal species in the ordination space show that *Ascocoryne sarcoides, Hypoxylon fragiforme, Inonotus nodulosus, Nectria coccinea, Schizophyllum commune* and *Trametes hirsuta* are species with optima on fresh, only slightly decayed wood (Appendix 3). Strongly decayed wood, on the

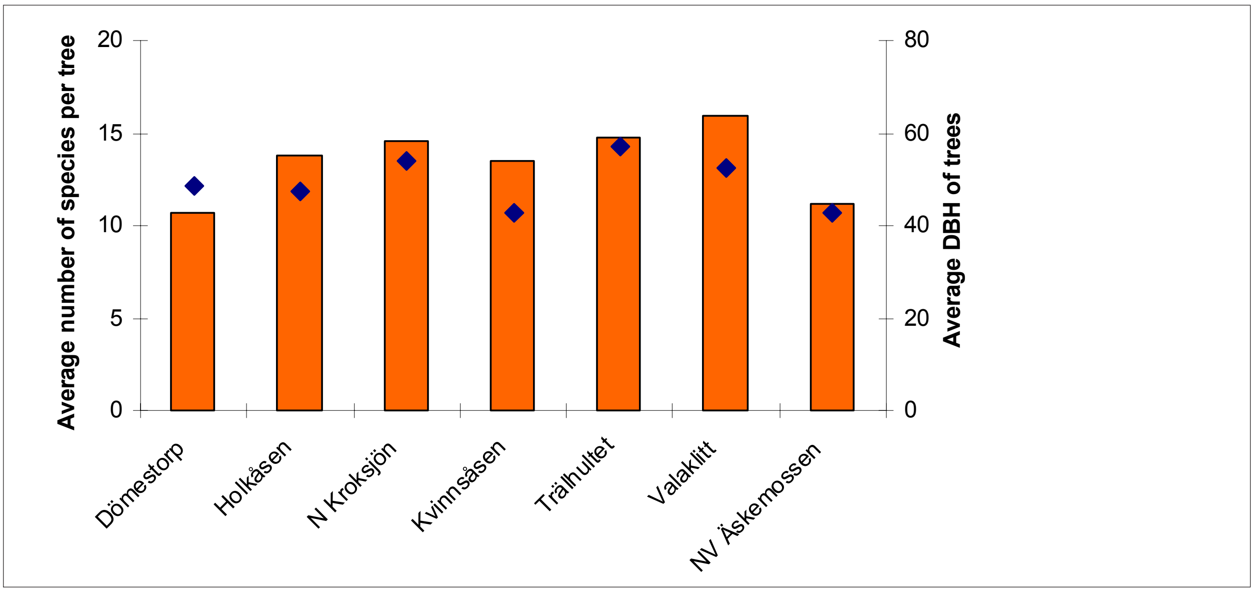

Figure 5. Average species richness per tree (columns) and average DBH of study trees (dots) in each of the intensive study sites.

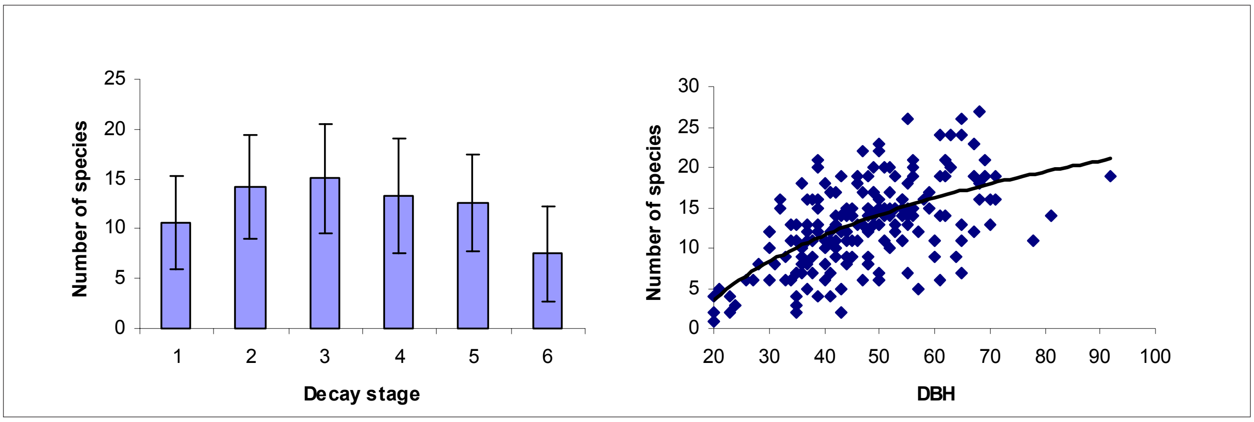

Figure 6. Relations between species richness per tree and the key variables decay stage and DBH of the study trees. The whiskers on the left hand figures indicate standard deviations of the average species richness for each decay stage.

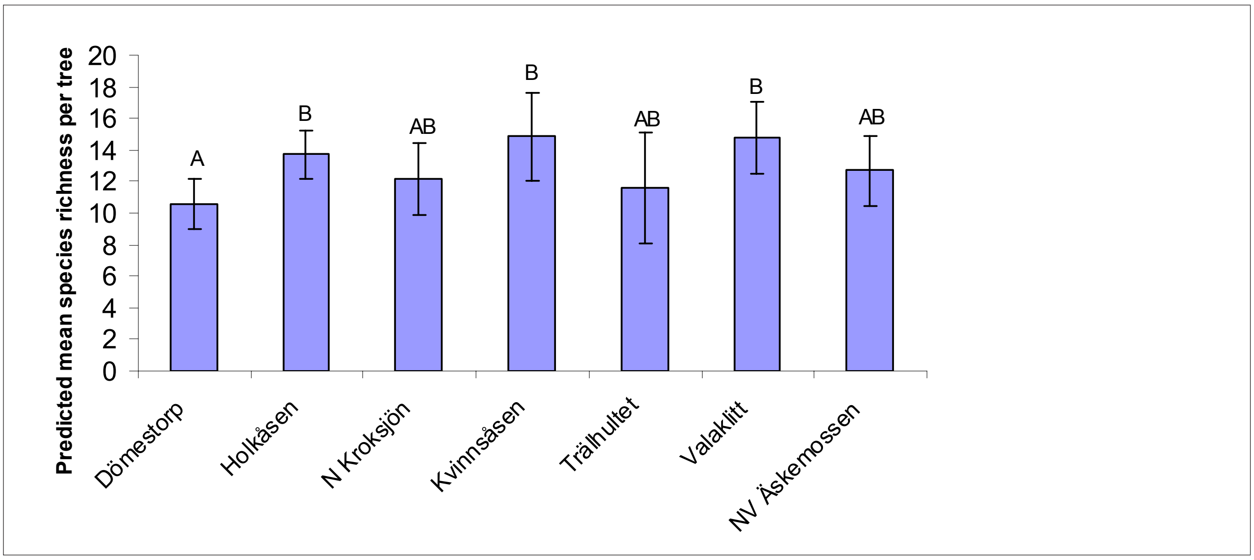

Figure 7. Predicted mean species richness per tree per site based on least square means of the multiple regression model. Whiskers indicate 95% confidence intervals. Similar letters indicate localities with means not significantly different from each other. For details of the model see Table 7.

Table 6. Overview of univariate relations between environmental variables and species richness and ordination scores per tree. Site variables given in italics were only included in the analysis of the ordination axes resulting from the joint ordination of the datasets from Halland and Denmark. For relations between environmental variables and species richness Kendalls tô are given, except for relations involving the ordinal variables *decay stage, soil moisture, wind exposure, tree type, soil/bedrock type, site* and *region* where F-statistics from one-way ANOVA's are given.

	Halland				Halland + Denmark		
Variable	Species richness	DCA axis 1	DCA axis 2	DCA axis 3	DCA axis 1	DCA axis 2	DCA axis 3
DBH	0.40****			-0.21****		0.17****	
Decay Stage	4.58**	146.7****	2.32*	2.30*	149.2****	2.44*	
Bark cover		0.68****				0.09*	
Moss cover		-0.27****			-0.10*		
Soil Contact		-0.55****			-0.44****	-0.20****	
Sun exposure			2.44*			7.28****	
Wind exposure				2.68*		31.94****	
Soil humidity					4.16*	4.03*	3.72*
Tree type		28.67****	3.37*		12.39****	34.67****	
Fomes cover	0.20***	0.15*			0.18****	-0.30*	
Kretzschmaria cover			0.15*		-0.11*	0.25****	
Site	4.26**		6.03****	5.14****	1.79*	52.52****	4.65****
Region					3.41*	106.1****	7.97****
East coordinate						-0.16****	
North coordinate						-0.55****	
Northeast coordinate						-0.33****	
Northwest coordinate						-0.48****	
Soil/bedrock type					3.89**	127.3****	7.63****
Average Jan. Temperature						0.50****	
Average July temperature					-0.12*	0.55****	
Annual average temperature						0.56****	
Average annual precipitation						-0.59****	-0.10*
Years since last cutting					-0.09*	0.33****	
Max tree age						0.24****	-0.09*

Significance levels: * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; **** $P < 0.0001$.

other hand, is characterized by the occurrence of several ectomycorrhizal fungi, e.g. *Cantharellus tubaeformis, Cortinarius anomalus, Laccaria laccata* and *Russula ochroleuca,* but also by strictly saproxylic late stage agarics e.g. *Bolbitius reticulatus* and *Pluteus spp*. Species with a more central position in the ordination space either have their optima on intermediately decayed trees, or have no distinct decay stage preference. The latter is the case for some of the most common pyrenomycetes, *Eutypa spinosa, Kretzschmaria deusta* and *Xylaria hypoxylon* which have a defensive decay strategy and persist fruiting through most of the decay process (Heilmann-Clausen 2001). Species with a preference for trees in intermediate decay stages include some corticoid and polyporoid species, e.g. *Antrodiella semisupina, Polyporus varius, Steccherinum ochraceum* as well as cord forming basidiomycetes, e.g. *Armillaria lutea, Hypholoma fascicularis* and *Lycoperdon spp.* The distribution of species along axes 2 and 3 ads little to the interpretation of the expressed community gradients and is not discussed here. Considering the low Eigen-values of both axes it is most reasonable to treat them as expressions of weak tendencies in overall species composition relating to weak and partly unknown habitat factors.

In summary the ordination analysis shows that the most important community gradient in the Halland dataset relates to the decay stage of the study trees. This result is in agreement with the situation in other European countries (Heilmann-Clausen 2001; Ódor et al. 2004a). The rather limited geographical differentiation between individual study-sites in Halland along subsequent axes in the ordination, on the other hand, is in contrast to the situation in all Nat-Man countries involving more than one study site (Ódor et al. 2004b). The obvious reason for this low degree of differentiation in Halland is that the variation in climatic conditions and soil types among localities is more limited than in other Nat-Man countries.

Joint ordination of dataset from Halland and Denmark

A further DCA ordination was performed using the Halland dataset combined with the corresponding Danish Nat-Man dataset. Again species poor samples, rare species and outlying samples were omitted. The resulting dataset contained 5283 species records, representing 185 species on 366 trees. The DCA based on this dataset resulted in the expression of two distinct community gradients, with Eigen-values of 0.47 and 0.30 respectively and gradient lengths of 4.51 and 3.91 SD units. The third ordination axis was considerably weaker (Eigen-value 0.17; gradient length 3.27 SD units) and is not evaluated any further here, since it was not found to relate distinctly to recorded tree or site variables.

The first DCA axis does, like in the pure Halland dataset, represent a clear decay gradient, while the second axis represents a distinct geographical gradient (Table 6). Trees from sites in Halland form a distinct cluster along axis 2, together with trees in Silkeborg Vesterskov and Velling in Central Jutland. Another cluster is formed by trees in the two sites in Zealand. Finally trees from Store Klinteskov, Møn forms a third cluster opposite to the Halland/Central Jutland cluster (Fig. 9) The distribution of sites along Axis 2 relates to a concurrent, distinct turnover in soil types and climatic conditions (Table 6), and a multiple regression analysis revealed that both factors contribute individually to explaining the distribution of sample trees along the axis (result not shown). From an overall perspective, the axis accordingly express the shift from dry and warm, calcareous sites in Møn, over typical mesic beech forest on richer soils in Zealand to wet and cool beech forest on poor soils in central Jutland and Halland.

With respect to species composition it is striking that a high number of ectomycorrhizal agarics, e.g. *Cantharellus tubaeformis, Cortinarius spp., Inocybe petiginosa, Laccaria spp., Lactarius spp.* and *Rusulla spp.* have optima in Halland and Central Jutland (Appendix 3). All are common species in Denmark and south Sweden, but were only rarely recorded on dead wood in Danish study sites on richer soils. This probably reflects that dead wood is an important

Phlebia radiata (ribbgrynna) is a common, but beautiful corticoid fungus on dead beech wood in Halland. It is most common on rather hard wood (decay stage 2), and disappear gradually as decay proceeds. Photo: Örjan Fritz.

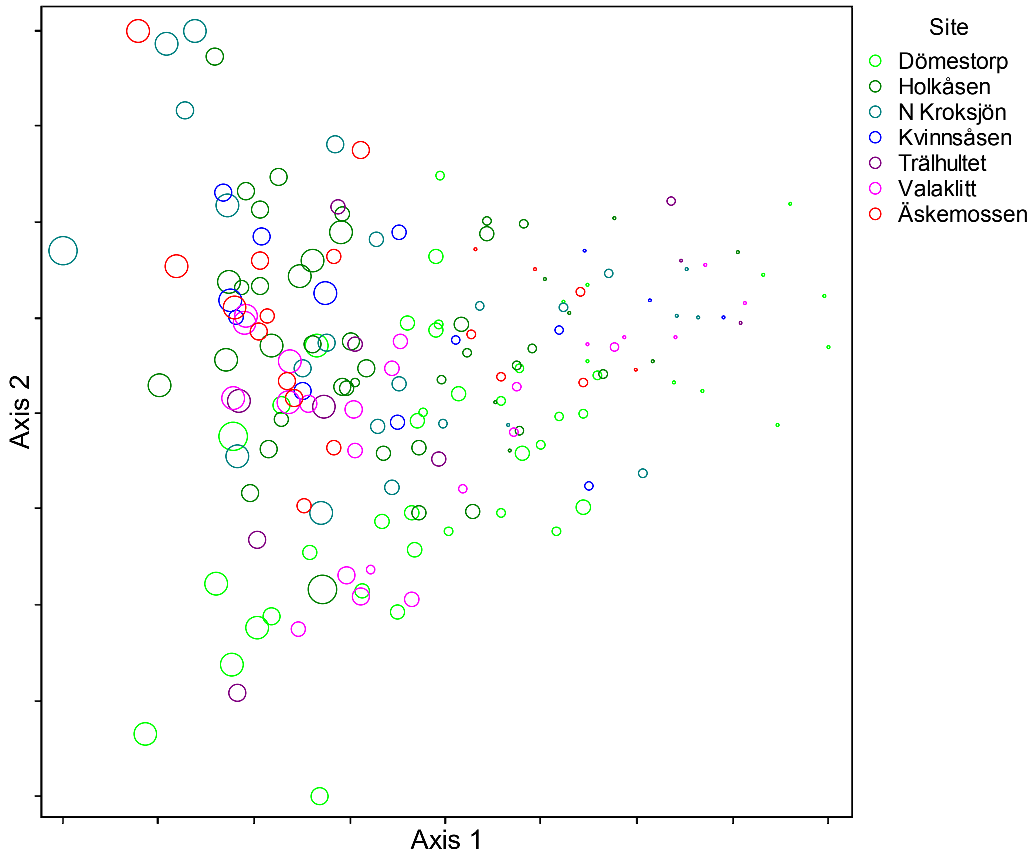

Figure 8. Diagram showing the location of individual study trees in the ordination space defined by axis 1 and 2 in the DCA ordination of the Halland dataset. Bubble sizes illustrate the decay stages of individual trees. Large bubbles are most decayed.

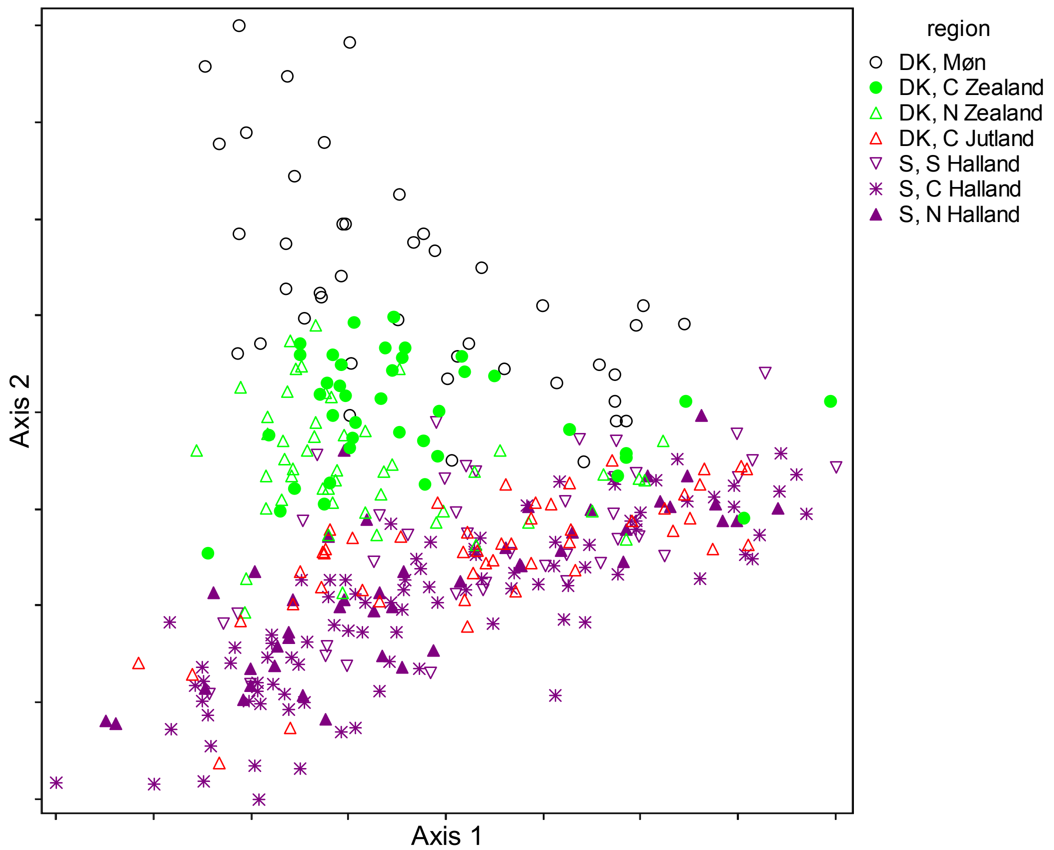

Figure 9. Diagram showing the location of individual study trees in the ordination space defined by axis 1 and 2 in the DCA ordination of the joint datasets from Halland and Denmark. Trees located in different regions are indicated by different symbols.

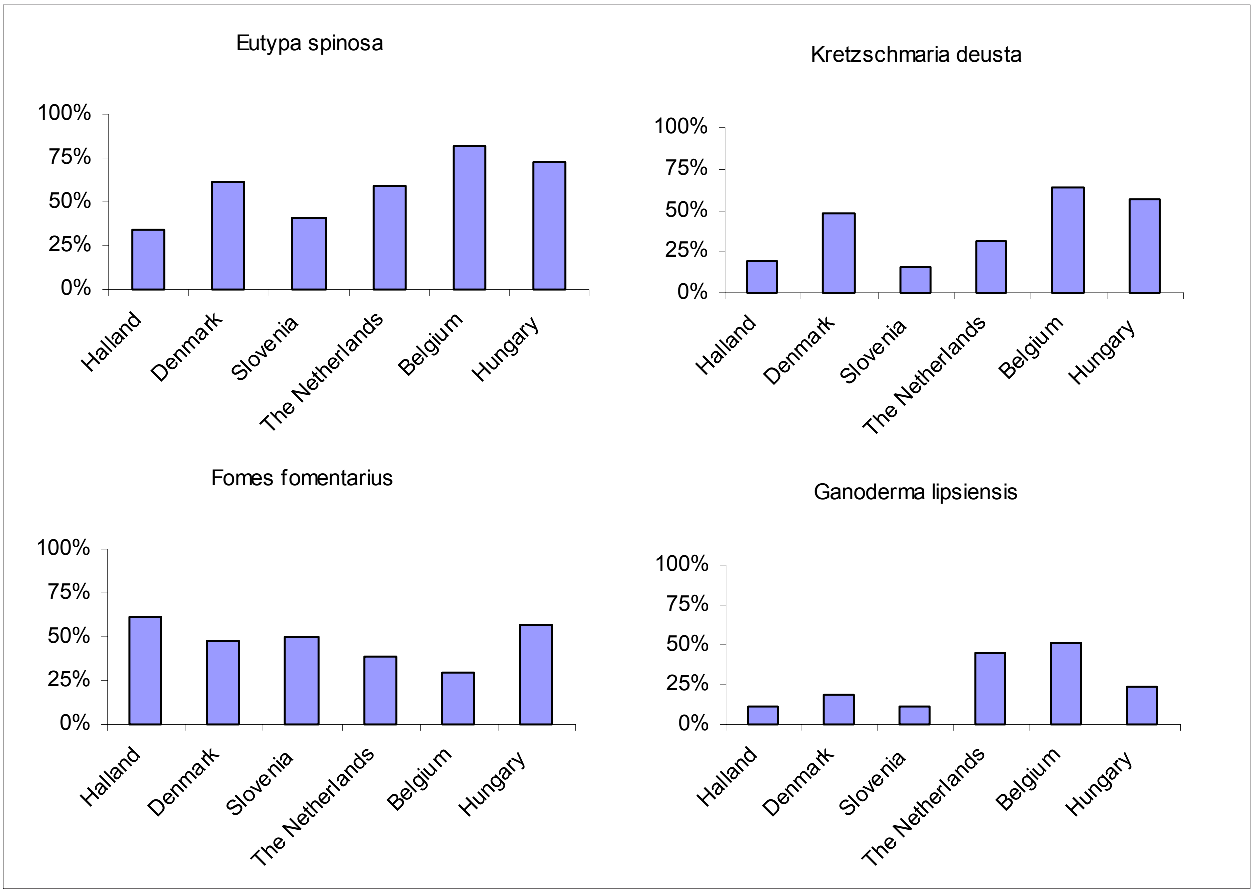

Figure 10. Frequencies (% of study trees) of four key primary decay agents in beech wood in Halland and each of the Nat-Man countries.

nutrient resource for ectomycorrhizal fungi mainly on naturally nutrient poor soils. True wood decay fungi with optima in Halland e.g. *Hericium coralloides, Nemania atropurpurea, Pluteus podospileus* and *Skeletocutus vulgaris* may, on the other hand, be benefiting from a more cool and moist climate. The same is the case for the lichenized *Multiclavula mucida.*

A mixing of climatical and soil type aspects is evident also in the other end of the gradient. Thus, several species with optima in the calcareous beech forests on Møn and C Zealand are known or suspected to have a preference for base-rich soils. This is e.g. the case for *Ceriporia reticulata, Micromphale brassicolens, Pluteus romellii* and *Steccherinum fimbriatum.* Other species like *Camarops polysperma, Ischnoderma resinosum, Phellinus ferruginosus* and *Xylaria polymorpha* which also have optima in the Danish sites outside Jutland, probably reflect the climatical aspect of the gradient, i.e. a preference for a drier and/or drier climate than occurring in Halland.

Saproxylic fungi on beech wood in Halland – what is special?

Of the 197 macrofungi (ss. Nat-Man) identified on the 200 intensively studied trees in Halland, 19 were not recorded in any of the original Nat-Man countries. Most of these were recorded on one or two trees only, while five species were recorded on eight trees or more (Table 8). Most species overrepresented in Halland are ectomycorrhizal agarics or leaf-litter saprotrophs. This probably reflects the general nutrient poor soils in Halland. Several, e.g. *Cysto-*

Table 7. Summary of the multiple regression model ($p < 0.0001$; $R^2 = 0.50$) for fungal species richness per tree in the Halland dataset.

Variable	Degrees of freedom	Prefix of parameter estimate	Type III Sum of Squares	Mean Square	F Value	Pr > F
DBH	1	+	1678.6	1678.6	105.3	<0.0001
Decay stage	5		679.9	136.0	8.53	<0.0001
Site	6		452.0	75.33	4.73	0.0002
Kretzschmaria cover	1	-	75.95	75.95	4.76	0.03

Table 8. Species overrepresented in Halland, i.e. species recorded on at least 5 trees in Halland, and at least twice as frequent here than in any of the Nat-Man countries. Percentages refer to the fraction of intensively investigated trees presenting the actual species in each of the countries.

Species	Halland	Denmark	Belgium	The Netherlands	Hungary	Slovenia
Mycena cinerella L	20%	2%	0%	2%	0%	0%
Antrodiella semisupina W	16%	6%	1%	7%	2%	0%
Inocybe petiginosa M	15%	2%	1%	0%	0%	0%
Nemania atropurpurea W	11%	3%	0%	0%	0%	2%
Lactarius blennius M	9%	3%	0%	0%	0%	1%
Russula mairei M	9%	4%	1%	0%	0%	0%
Cantharellus tubaeformis M	7%	1%	0%	0%	0%	1%
Helvella lacunosa M?	7%	1%	0%	0%	0%	0%
Hydnum rufescens M	6%	0%	0%	0%	0%	0%
Mycena hiemalis W	6%	2%	1%	1%	0%	2%
Ascocoryne sp W	5%	0%	0%	0%	0%	0%
Skeletocutis vulgaris W	5%	0%	0%	0%	0%	0%
Cystoderma amianthinum L	4%	0%	0%	0%	0%	0%
Mycena metata L	4%	0%	0%	0%	0%	0%
Stropharia hornemannii L	4%	0%	0%	0%	0%	0%
Lepiota felina L	3%	0%	1%	0%	0%	0%
Cortinarius anomalus M	3%	0%	1%	0%	0%	0%
Galerina mniophila s.l. B	3%	0%	0%	0%	0%	1%

Ecological codes: B: Bryophyte-associated; L: Litter saprotroph; M: Ectomycorrhizal; W: Wood saprotroph

Table 9: List of *non*-Halland species, i.e. species absent or occurring with very low frequency (<5 trees) in Halland, but recorded as common (at least 10 % of trees) in one or more of the Nat-Man countries. Percentages refer to the fraction of intensively investigated trees presenting the actual species in each of the countries.

Species	Halland	Denmark	Belgium	The Netherlands	Hungary	Slovenia
Mycena arcangeliana W	0%	0%	2%	13%	51%	14%
Meripilus giganteus W	0%	6%	9%	16%	3%	0%
Pluteus nanus L	0%	1%	14%	0%	14%	<1%
Postia tephroleuca W	0%	0%	8%	16%	3%	<1%
Ceriporiopsis gilvescens W	0%	0%	11%	2%	6%	6%
Pluteus hispidulus W	0%	1%	17%	2%	0%	2%
Skeletocutis nivea W	0%	2%	3%	11%	<1%	<1%
Xylaria polymorpha W	1%	8%	18%	4%	9%	9%
Hyphodontia paradoxa W	1%	7%	0%	17%	9%	<1%
Pluteus salicinus W	1%	6%	5%	2%	3%	0%
Stereum subtomentosum W	1%	5%	19%	27%	2%	<1%
Simocybe centunculus W	1%	4%	7%	0%	14%	9%
Ramaria stricta W	1%	14%	1%	1%	<1%	0%
Mycena crocata W	2%	28%	6%	0%	32%	10%
Mycena pura L	2%	1%	0%	1%	11%	2%

Ecological codes: L: Litter saprotroph; W: Wood saprotroph.

derma amianthinum, Lepiota felina, Mycena cinerella and *Stropharia hornemannii* are more typical for other habitat types than beech forest, including coniferous forests, birch forests and heaths (cf. Hansen & Knudsen 1992), and are common in these habitat types in at least some of the Nat-man countries. Three species, viz. *Antrodiella semisupina, Nemania atropurpurea* and *Skeletocutis vulgaris* are, however, distinctly wood associated, and could be regarded as Hallandic specialities in a European beech forest perspective. The same may be the case for *Ascocoryne sp.,* but it is possible that this species is included in the concept of other *Ascocoryne* species in some of the Nat-Man countries.

As well as typical Halland species it is worthwhile to consider distinct *non*-Halland species; these are listed in Table 9. Of the listed species *Mycena* *arcangeliana* has distinct optima in Hungary and Slovenia, *Stereum subtomentosum* seems to prefer sites in Belgium and the Netherlands, while *Ceriporiopsis gilvescens* appear to be a distinct southern species, lacking in both Denmark and Sweden (the species is actually recorded in both countries, but only from very few sites). *Meripilus giganteus* and X*ylaria polymorpha* are quite frequent in most or all of the Nat-man countries and could be considered as the most distinct *non*-Halland species, probably for climatical reasons. *Mycena crocata* is (almost) lacking in both Sweden and the Netherlands and even very infrequent in Belgium. This most likely reflects a preference for rich soils, though climatical factors may contribute as well.

Two very common pyrenomycetes, *Eutypa spinosa* and *Kretzschmaria deusta* were recorded with lower frequency in Halland and Slovenia than in the other Nat-Man countries (Fig. 10). Both are well adapted to low water potentials (Heilmann-Clausen 2001) and are likely to be less competitive in a humid climate. *Ganoderma lipsiensis* was, for unknown reasons, recorded with low frequency in Halland, Denmark and Slovenia, while *Fomes fomentarius* was very frequent in all countries, except Belgium and to a lesser extend the Netherlands. The species is clearly the most important primary decay agent in Halland and was generally found to occupy larger volumes of wood in individual trees, than in other Nat-Man countries. Unlike *Ganoderma spp.* and *Kretzschmaria deusta* it causes predominantly decay in the central part of the trunk of living trees, making them liable to break 5-8 meter above the ground. The resulting snags are a very prominent feature in beech forests in Halland (Bengtsson 1999b) and seem to support special fungal communities. Thus, *Camarops tubulina, Nemania atropurpurea, N. chestersii, Sistotrema sernanderi* and *Trechispora nivea* were predominantly found in association with standing or fallen beech snags decayed by *Fomes fomentarius.*
The comparison of Bray-Curtis similarity index scores shows that the overall species composition in the Halland-dataset has most similarities to the Danish Nat-Man dataset (Table 10). While this is not surprising, it is remarkable that the Slovenian dataset is the second most similar, though it is geographically the most distant. The sites in Slovenia and Halland have two important characteristic in common, which are not shared by any other Nat-Man study sites: Winters are cool (average temperature of January c. -1º C) and the average annual precipitation is exceeding 1000 mm (cf. Ódor et al. 2004a). Soil conditions are entirely different between the study areas, as the Slovenian sites are on limestone. Therefore the climatical similarities are the most probable explanation for the found similarities. Three species, *Multiclavula mucida, Galerina mniophila s.l.* and *Mycena pseudocorticola,* were recorded frequently in the study sites in Halland and Slovenia, but not or very scarcely in the other Nat-Man countries. They are not important wood decayers, but all are likely to prefer a humid forest climate. The first due to its algal symbiont, the second due to its dependence on bryophyte-covered logs, and the third because of its very small, desiccation sensitive sporocarps. The Hungarian dataset is the most different from the Halland dataset according to similarity index scores. Also here climatical factors are a likely explanation. Thus the Hungarian sites have the most continental climate in the whole dataset, with large differences between summer and winter temperatures (difference between average January and July temperatures ˜ 20º C), and a rather low annual average precipitation (<900 mm) (cf. Ódor et al. 2004a).

Conservation value of beech forests in Halland - the European perspective

In the European perspective the number of indicator species (ss. Christensen et al. 2005) recorded in Halland beech forests is not too impressing (Table 11). Even when all Biskopstorp localities are merged to one area, corresponding to the situation for many of the European sites in the table, the number of indicators only adds up to seven (Table 12). This places the Biskopstorp area well below the most valuable sites in Denmark, France, UK and Eastern Europe, but on line with the most valuable sites known so far in Skåne, i.e. Maltesholm, Ivø and Skäralid. Other investigated sites in Halland had only up to four indicator species in total (see Table 3).

In Fig. 11 the presence of European beech forest indicators (Christensen et al. 2005) is compared among the standardised datasets from Halland and the Nat-Man countries. It is evident also in this comparison that the number of indicator species in Halland is in the low range, +/- equal to the situation in Belgium and the Netherlands, but well below the scores in Denmark, Slovenia and Hungary. However, the proportion of records made up by indicators in Halland is rather high. This reflects that some indicator species were recorded rather frequently in Halland. In fact three species, viz. *Camarops tubulina, Hericium coralloides* and *Pluteus umbrosus,* appeared to be more common in Halland than in any of the Nat-Man datasets.

From an overall point of view the beech forests of

Table 10. Bray-Curtis (qualitative Sørensen) similarity matrix for comparisons of the datasets from Halland and the Nat-Man project. Higher scores indicate higher degree of similarity.

	Sweden	Denmark	Slovenia	The Netherlands	Belgium	Hungary
Sweden	1	0.67	0.55	0.52	0.47	0.44
Denmark	0.67	1	0.54	0.56	0.58	0.52
Slovenia	0.55	0.54	1	0.49	0.42	0.54
The Netherlands	0.52	0.56	0.49	1	0.60	0.41
Belgium	0.47	0.58	0.42	0.60	1	0.39
Hungary	0.44	0.52	0.54	0.41	0.39	1

Halland can thus be stated to have a moderate conservation value in the European perspective, while they appear to be highly valuable in a Swedish context. However, it is highly relevant to ask if the used indicator species indicate anything interesting, apart from the sheer presence of dead wood. This question is addressed in some detail in the following sections considering potential causal factors behind the rather low indicator scores in Halland.

Tree size

Tree size has often been quoted to be an important factor for endangered saproxylic organisms (e.g. Bader et al. 1995). Beech trees in Halland are generally rather small, and it could be argued that some fungal species are limited by the lack of suitable large diameter trees. In Fig. 12 the recorded distributions on diameter classes are illustrated for the four most common indicator species in Halland. *Camarops tubulina* and *Hericium coralloides* both appear to have a preference for large diameter trees, while *Dentipellis fragilis* and *Pluteus umbrosus* show very unclear trends. The figure is based on sparse data and does of course not tell anything about diameter preferences of indicator species not recorded in the study. In an extensive discussion on the subject Heilmann-Clausen & Christensen (2004b), concluded tree size or rather tree age to be of importance mostly for species causing heart rot. The infection strategies of *Camarops tubulina* and *Hericium coralloides* are unknown, but the latter species is suspected to be a selective successor of *Fomes fomentarius* and *Inonotus spp.* (Niemelä et al. 1995). Several others of the indicators are well known to be heart rot agents and it is possible that some of these are in fact limited in Halland due to the scarcity of old or big trees. The hypothesis is impossible to test based on the current material, but it is noteworthy that trees with a dbh exceeding 60 cm are very scarce in several of the study sites in Halland, e.g. in Äskemossen and Kvinnsåsen, which had lower indicator scores and smaller maximum tree sizes than the other intensive study sites (compare Table 1 and 3).

Table 11: Indicator species for assessing conservation value of beech forests in Europe, listed by Christensen et al. (2005), and their status in Sweden and Halland.

Species	Known from Halland	Known from Sweden
Aurantioporus alborubescens		X*
Camarops tubulina	X	X
Ceriporiopsis gilvescens		X
Ceriporiopsis pannocincta		X
Climacodon septentrionalis		X
Dentipellis fragilis	X	X
Flammulaster limulatus		X
Flammulaster muricatus		X
Ganoderma pfeifferi		X
Hericium coralloides	X	X
Hericium erinaceum		X
Hohenbuehelia auriscalpium	X*	X*
Inonotus cuticularis	X	X
Ischnoderma resinosum		X
Lentinellus ursinus	X	X
Lentinellus vulpinus	X	X
Ossicaulis lignatilis	X	X
Phlebia nothofagi		
Pholiota squarrosoides		X
Pluteus umbrosus	X	X
Spongipellis delectans		X

*Not listed in Hallingbäck & Aronsson (1998).

Soil conditions

As previously discussed the fungal species composition on decaying beech wood in Halland seems to be distinctly influence by the dominant nutrient poor soils. The high proportion of ectomycorrhizal fungi in late decay stages is most striking, but it is relevant to ask if soil conditions are of direct importance for any of the indicator species, and hence for the rather low indicator scores in Halland. Most of the indicators are normally associated with rather hard wood and for these a causal relation between soil nutrient status and establishment success / competitive ability is unlikely. Theoretically, it is possible that wood chemistry, as affected by soil nutrient status, may affect species in an unbalanced way, but as yet

Table 12. List of beech forests of conservation value in Europe, based on the occurrence of 21 saproxylic fungi suggested as indicators of habitat quality by Christensen et al. (2005). Swedish sites are shaded.

Country	Site name	Score from 21 possible
Slovakia	Stuzica	16
Slovakia	Rozok	16
Czech Republic	Zofin	15
France	Fontainebleau (La Tiliaie)	15
Denmark	Jægersborg Dyrehave	14
Slovakia	Havesová	13
UK	Wood Crates	13
Denmark	Suserup Skov	12
Denmark	Strødam forest reserve	12
UK	Denny Wood area	12
Slovenia	Rajhenav Rog	11
Hungary	Öserdö	11
UK	Windsor Bears Rails/Wild Boar area	11
UK	Windsor Highstanding Hill	10
Denmark	Store Bøgeskov	9
Sweden	Maltesholm, Skåne	9
UK	Whitley Wood	9
UK	Norbury Park	9
Denmark	Romsø	8
Hungary	Kekes	8
Slovakia	Udava	8
UK	Lullingstone Park	8
Denmark	Krenkerup Haveskov	7
Denmark	Åhuse	7
Denmark	Stenderup	7
Sweden	Ivö, Skåne	7
Sweden	Skäralid, Skåne	7
Sweden	Biskopstorp, Halland	7
UK	Mark Ash Inclosure	7
UK	Gritnam Wood	7
UK	Ebernoe Common	7
Germany	Waldhaus	7
Denmark	Slagslunde	6
Denmark	Store Klinteskov	6
Denmark	Nørreskoven	6
Slovenia	Krokar	6
Poland	Poland Biaskidy E	6
Belgium	Kerssellaerspleyn	6
UK	The Mens & Cut	6
Germany	Mittelsteighütte	6

relevant experiments have not been published. For species living in more decayed wood, effects are more likely, because the importance of the soil/wood interface increases as decay proceeds, due to animal activity, physical break down of wood and transport of nutrients through fungal mycelia. Following this way of arguing *Flammulaster limulatus* and *F. muricatus* are the species most likely to be limited in Halland due to the nutrient poor soils, but even for these a direct soil effect is considered most unlikely in the current case. Thus, *Flammulaster limulatus* is recorded from at least 50 sites in Sweden according to Sveriges Mykologiska Förening (http://www.svampar.se/index.asp), and is not restricted to regions with base-rich soils.

Climate

As previously discussed climatic conditions seem to play an important role for the fungal species composition on dead beech wood at the European scale. It is therefore reasonable to discuss if climatic factors play an important role for the recorded indicator scores in Halland. This clearly seems to be the case. Halland is at the extreme limit of the distribution area for several of the European indicators. This is e.g. the case for *Ceriporiopsis gilvescens, Ganoderma pfeifferi* and *Spongipellis delectans* which are southern species in Europe (Ryvarden & Gilbertson 1992-3), while *Climacodon septentrionalis* and *Pholiota squarrosoides* are south-eastern, continental species (own observations). It is likely that these species were never represented by stable populations in Halland in the past, meaning that the potential maximum indicator score in Halland is somewhat lower than in central Europe. To account for this it could be relevant to include more species in the evaluation of conservation value of beech forest sites in Halland. Especially *Multiclavula mucida*, *Skeletocutis vulgaris* and *Tyromyces sp.* are interesting in this context. All are potentially of European conservation interest, and are more or less restricted to Halland beech forests in the Nat-man context. However, more knowledge on their habitat preferences, distribution patterns and taxonomic status (*Tyromyces sp.)* is needed before their indicator values can be evaluated in detail.

Dead wood continuity

Most of the old grown beech forest remnants in Halland are small (<10 ha), isolated, but partly aggregated at landscape scale. This is particularly the case in the Åkulla and Biskopstorp areas and to a

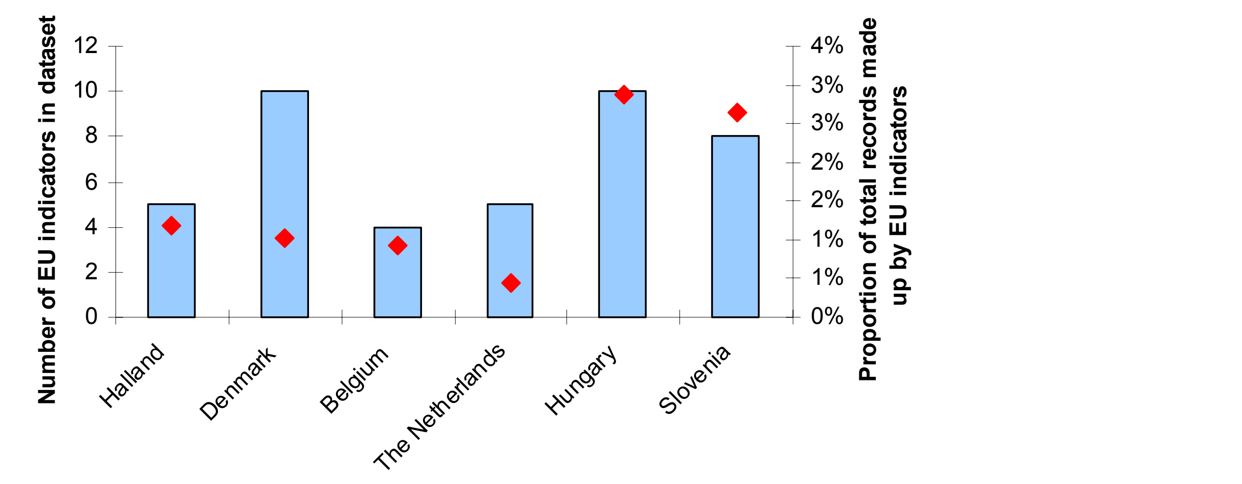

Figure 11. Total number of indicator species (ss. Christensen et al 2005)(columns)and their proportions of total species records (dots) in the intensive datasets from Halland and the Nat-Man countries.

lesser extent in the landscapes north and east of Oskarström. Present day dead wood amounts are considerable in several of the individual localities, but dead wood abundance is mostly of recent date, though small spots may represent long local dead wood continuity. In the present landscape the beech forests are aggregated in matrix of extensive coniferous forests (forest cover >60 %). The forest cover has increased during the last centuries, but at the same time the area with beech forests have declined considerably. Most of the remaining beech forests hence have roots back to the more extensive deciduous forests of the past. In a European perspective this (very grossly) points to an intermediate level of dead wood continuity at the landscape scale: The large continuous beech forests of the historical Halland most likely secured a continuous presence of at least some dead wood in the landscape, unlike the situation in most of the northwest European lowlands, where forest was very scattered and highly overused in the past. The other end of the gradient is represented by mountainous regions in Eastern Europe, which are still rather rich in virgin forest remnants with very natural forest structures and, apparently, unbroken dead wood continuity since the ice age.

Generally, saproxylic fungi have good abilities for long range dispersal and have for this reason been questioned as relevant indicators of habitat continuity. Nordén & Appelqvist (2001) for instance suggested that "many wood-decay fungi are … probably more favoured by a regionally rich supply of microhabitats than by long persistence of local forest stands". Rolstad et al. (2002) went even further and stated that "indicator species of forest continuity (including saproxylic fungi; my insertion) fail to fulfil all the criteria of a suitable indicator". Considering the very strict habitat requirements in some saproxylic fungi and their general lack of precision in dispersal Christensen et al. (2005) challenged this view and stated that "wood-inhabiting fungi can provide relevant biodiversity information, which cannot be gathered directly from simple structural indicators, e.g. volume of dead wood per ha" and stated the indicator system used here to be "especially suitable for identifying relatively large areas (25-10,000 ha) possessing dead wood continuity". A scientific sound testing of these partly conflicting views are far beyond the scope of this report, but still a closer look on data is worthwhile.

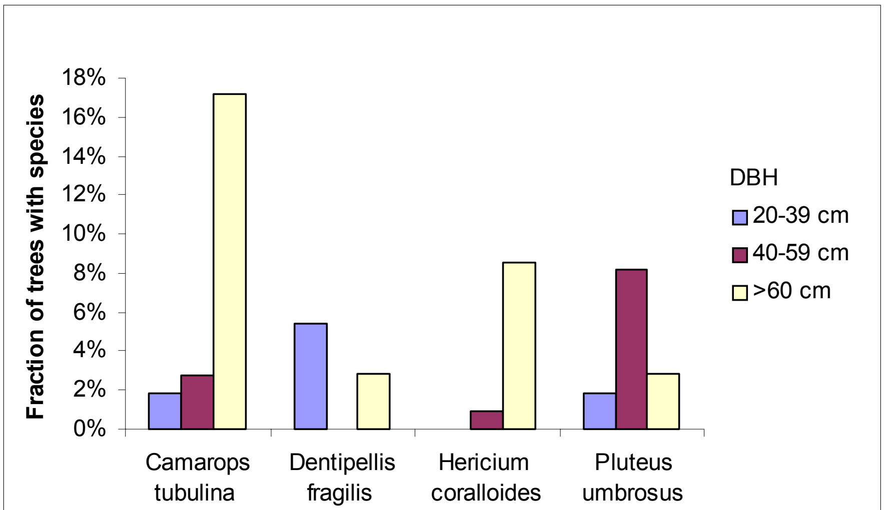

Figure 12. Frequencies of the four most common indicator species (ss. Christensen et al. 2005) on different tree size classes in the Halland dataset.

Stropharia hornemannii (stor kragskivling) is normally a fungus of coniferous forests, but in Halland it was quite common on strongly decayed beech logs. It has not been recorded on beech wood in any of the Nat-Man datasets, and seems to be a speciality for Halland in a beech forest perspective. Photo: Jacob Heilmann-Clausen.

If rare wood-inhabiting fungi were predominantly substrate limited a close correlation between local dead wood quality and amounts and indicator scores would be expectable. As mentioned above, there in fact seem to be a positive relation between the presence of old, large diameter trees and high indicator scores, pointing to a possible affect of substrate limitation. In other cases such a relation is not evident, while an effect of lacking dead wood continuity is probable. Thus, no indicator species were recorded in three of the most isolated stands, viz. Blåalt, Skubbhult and Ödegärdet, though the amounts of dead wood in all sites are considerable. This could reflect local extinction of indicator species, due to broken dead wood continuity locally and in the surrounding landscapes. Sites with high indicators scores, on the other hand, are either large (Mårås) or situated in landscapes rich in old-grown beech forest reserves. Here dead wood continuity, either locally or at landscape scale, is more likely to have persisted during the last centuries.

At the species level it is remarkable that several of the indicators have a limited distribution in Halland according to known data. This could reflect localised survival of remnant populations during a bottle-neck in dead wood abundance, like suggested for the tineid, saproxylic moth *Scardia boletella* in the same landscape (Fritz 2004b). *Scardia boletella* is rather widely distributed in Halland but the core-area is clearly in the Biskopstorp/Oskarström area. At least four potential fungal indicator species have a similar distribution pattern, viz. *Lentinellus vulpinus, L. ursinus, Tyromyces* sp. and *Multiclavula mucida* (for the two latter species see Fig. 13). There is no doubt that wood-inhabiting have better abilities for long range dispersal than *Scardia boletella*, which appear to be poorly able to colonize new habitats situated just a few km's away from existing ones (Fritz 2004b). *Scardia,* however has much denser populations than most of the rare wood-inhabiting fungi discussed, and occur typically on dozens of *Fomes*-infected trees in occupied localities. In summary, rare wood-inhabiting fungi, including the indicators, tend to have much stricter habitat requirements but better dispersal ability than *Scardia boletella* and probably many other saproxylic insects. Wood-inhabiting fungi are accordingly better able to colonize new suitable habitats, but still they are only able to survive if the landscape as a whole offers a certain amount of suitable dead wood habitats. A bottleneck in dead wood abundance in Halland during the last centuries most likely has lead to the extinction of some indicator species in Halland, e.g.

Ascotremella faginea (dallerskål) on a beech log at Holkåsen. Photo: Örjan Fritz.

Ischnoderma resinosum which occur in several sites in Skåne and Zealand as well as in the rainy beech forests of Slovenia. Within Halland the localized distribution of several indicator species seem to point to landscapes with a higher degree of dead wood continuity than general in Halland. This most clearly is the case in the Biskopstorp/Oskarström area, which clearly should be the priority area for conservation of wood-inhabiting fungal communities on beech wood in Halland.

Summary
In conclusion, it seems reasonable to assume that the current distribution of indicator species within Halland reflect the quality and abundance of current dead wood habitats at local scale and the historical continuity in dead wood abundance at landscape scale. The sites richest in indicators all have high conservation value, either due to a high local continuity in natural forest features (Mårås) and/or due to their position in landscapes with spatio-temporal continuity in the presence of dead wood.

In the European perspective, the rather low number of indicators recorded in the whole region partly reflects the general, moderate level of dead wood continuity at the landscape scale. Climatic constraints, however, seem to play an important role for several indicators, meaning that the potential maximum indicator score in Halland are lower than in other parts of Europe.

The high frequencies of *Dentipellis fragilis, Hericium coralloides, Multiclavula mucida* and *Pluteus umbrosus* in Halland suggest that the beech forests of Halland in fact have a somewhat higher conservation value than the raw indicator scores suggest. The presence of the rarely recorded polypores *Skeletocutis vulgaris* and *Tyromyces sp.* points in the same direction.

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Appendix 1. Description and notes on localities studied in the project

Intensive study sites

Dömestorp is situated at the northern slopes of Hallandsåsen close to the E6. The studied stand is distinctly influenced by former management, and is mostly homogenous and even-aged, consisting of generally healthy trees. Dead wood is present in moderate amounts, mostly due to break-down of sub-dominant or suppressed canopy trees, but also some large, dominant canopy trees have broken down in recent years. Large, strongly decomposed logs are scarce. The biggest and most decayed trees are generally found in small spots along the northern border of the area, often in small copses facing coniferous plantations or younger beech stands. The soils are generally richer than in other parts of Halland, due to deposits of glacial tills containing lime-rich material (Fritz & Berlin 2002). Growth conditions for beech are accordingly comparably good, and most trees are tall and rather fast grown. The oldest trees have been found to be about 200 years old (Niklasson 2003), while the DBH of the biggest study tree was 69 cm.

Dömestorp stands out as the intensive locality with the lowest average species richness per tree and even overall species richness is low, considering the number of study trees (Fig. 3). The numbers of red-listed species and indicators are moderate (Table 3) pointing out the site to be of only moderate value for saproxylic fungi. Notable records include *Dentipellis fragilis* on two logs and *Stypella subgelatinosa (syn. Protodontia subgelatinosa)* on one. The latter is presently only known from two other localities in Sweden, and is new for Halland. Also the record of the little known *Dacrymyces enatus* is worth mentioning. Dömestorp is the top site for ecto-mycorhizal fungi in Halland, with occurrence of several red-listed species (Fritz & Berlin 2002). The richness of epiphytic lichens and bryophytes is moderate, while the saproxylic insect fauna is poorly known. The rather limited value of Dömestorp for saproxylic fungi most likely reflects former intensive use of the forests for lifestock grazing and/or timber/firewood production. The lack of well decayed logs points to a break in the continuity of dead wood presence, which may have been detrimental to some of the most demanding saproxylic species. In the coming years the amounts of dead wood at Dömestorp are likely to increase considerably. It will be interesting to follow if saproxylic diversity will be restored in the coming years as dead wood amounts increase.

The Biskopstorp area

The landscape of Biskopstorp is situated 10-15 km N of Halmstad and is the best preserved example of a Mellanbygd forest landscape in Halland. The number of woodland key habitats, especially old-grown deciduous forests, is exceptional and the number of red-listed species unsurpassed in Halland (Fritz 2004a). A 865 ha reserve is presently being designed in the area. Four sub-localities in the Biskopstorp area were studied intensively in the project, while two sub-localities were investigated shortly at the summer-visit. All sub-localities are situated within a circle with a diameter of 2 km, and are connected by more or less continuous beech forests. This means that exchange of fungal

A typical forest interior from Dömestorp, characterized by even-aged, tall and mostly healthy beech trees. However, *Lobaria pulmonaria* and some other redlisted lichens grow on the tree in the foreground. Photo: Örjan Fritz.

Snags, partly decayed by *Fomes fomentarius,* are a very characteristic aspect of old-grown beech forests in Halland, as here in Holkåsen. The upright position of snags causes a drier microclimate than in fallen logs, and this seems to slow down the decay process. Several species seem to prefer standing snags, e.g. *Camarops tubulina, Hericium coralloides, Phleogena faginea,* while others typically sporulate in abundance after a standing snag has broken down, e.g. *Nemania atropurpurea* and *Sistotrema sernanderi.* Photo: Örjan Fritz.

spores is likely to be almost unhindered and continuous between the studied sublocalities. It is therefore considered most likely that populations of most saproxylic fungi not strongly divided in subpopulation. In a European perspective it is therefore reasonable to treat all sub-localities in a collective sense. Doing this, the number of indicators adds up to seven, according to the European indicator scheme (Christensen et al. 2005), placing Biskopstorp among the most important areas for fungi inhabiting dead beech wood, known so far in Sweden (Table 11). No other study localities in Halland hosted more than four indicator species, though intensified studies may increase the number of indicators in several sites. Also for red-listed species Biskopstorp is outstanding, with records of 13 species associated with decaying beech wood, including *Ceraceomyces sulphurinus*, which was found for the first time in Sweden since 1940 (Table 3).

Holkåsen is the most intensively surveyed of the sub-localities at Biskopstorp, with 50 study trees. The area consists of a rounded ridge covered by up to 300 years old beech trees (Bengtsson 1999a). The stand is fairly even-aged, with an average age close to 260 years, and partly very open due to collapse of old beech trees and removal of scattered Norway spruce. Other parts are still closed forest, and especially the northern, north exposed parts are well protected from desiccation from wind. The humus layer is mostly shallow and growth conditions are fairly marginal except for a few spots with deeper soils at the bottom of the ridge. The DBH of the biggest study tree was 70 cm, but most of the trees had a DBH well below 60 cm.

Holkåsen stands out as the most species rich of all study sites (Fig. 3). Ten redlisted species were recorded (Table 3). Most notable is the presence of *Volvariella bombycina,* which was not found in other localities during the project. *Hericium coralloides* was recorded on five trees, while *Multicalvula mucida* was recorded on not less than 30% of the study trees. This means that Holkåsen may host the

Small and very slow-grown beeches like these in N Kroksjön are characteristic for several of the old grown beech forests in Halland. They point to very poor soil conditions and/or an earlier history of coppicing and livestock grazing. Photo: Örjan Fritz.

biggest population of this species in the whole of southern Scandinavia. Apart from saproxylic fungi three uncommon ectomycorrhizal fungi were recorded viz. *Cortinarius anthracinus, C. sanguineus* and *Lactarius fuliginosus*. The locality is of outstanding value for saproxylic insects (Jansson 2004) and of high value for epiphytic lichens and bryophytes (Fritz 2001). The high biodiversity value of Holkåsen does without doubt reflect the unusual high tree age, the high amounts of dead wood in all stages of decay, and the high variation in edaphic conditions.

N Kroksjön is situated just NE of Holkåsen which are separated by a narrow stretch of natural bog. 25 trees were studied. The area is very heterogeneous. The SW part is a thinned stand of well grown, rather tall beech which was managed until recently (1992). The central part consists of lower, more slowly grown trees on a low granite knoll, while the NE part is on a low-lying plateau. Parts of the latter area are unusually dark and closed for the area, while the central and SW part is more open due to thinning, poor growth conditions or, more locally, due to natural breakdown of smaller tree groups. The humus layer is well developed in most parts and the growth conditions for beech are generally more favourable than in Holkåsen. Several trees with DBH exceeding 60 cm are included in the study, with a maximum of 92 cm.

N Kroksjön hosted a remarkable high number of redlisted species and was the only locality with more than four indicators species following the European indicators scheme (Table 3). Two of these, *Inonotus cuticularis* and *Volvariella bombycina,* were not recorded in the present study, but are likely still to thrive at the locality. The very high value of N Kroksjön for saproxylic fungi is somewhat surprising considering the rather distinct signs of recent management. However, the bigger size of study trees may benefit some demanding heart-rot agents and the vicinity to Holkåsen secures an unhindered exchange of spores between the two localities. The locality is of rather high value for epiphytic lichens and bryophytes (Fritz 2001), while the fauna of saproxylic insects is unknown.

Kvinnsåsen is situated about 2 km NE of Holkåsen on a rather steep W to NW-facing slope. 15 trees were studied. The stand is uneven-aged and in most parts dense, closed and rather dark with a moist microclimate. The oldest trees are recorded to be about 270 years old (Bengtsson 1999a). Growth conditions for beech are poor to average and the trees are mostly rather small and slow-grown. The DBH of the biggest study tree was 52 cm.

Six red-listed species were recorded at Kvinnsåsen (Table 3) of which *Multiclavula mucida* is the most noticeable. Other interesting records are *Hohenbuehelia fluxilis* and *Omphalina epichysium* which were found on a single log each. The locality had a low score of indicator species, and is at present, the least valuable of the intensive sub-localities in Biskopstorp. This probably reflects the rather low amounts of dead wood and the rather small dimensions of most fallen trees.

Trälhultet is situated adjacent to Kvinnsåsen, on rather steep SE facing slopes. Ten trees were studied. The stand is distinctly influenced by former management (up to 1992), and consists of large and tall, widely spaced trees. The oldest trees are recorded to be between 200 and 250 years old (Bengtsson 1999). Dead wood amounts are moderate, but several large trees in different decay stages are present. Growth conditions are comparatively favourable, thanks to the warm, local microclimate and the rather deep developed soils. Several study trees had a DBH exceeding 60 cm, with a maximum of 78 cm.

Seven red-listed species were recorded, including *Hericium coralloides, Lentinellus vulpinus* and rich occurrences of *Multiclavula mucida*. Other noticeable records include *Lentinellus ursinus* and *Oxyporus corticola*. The latter species was not recorded in any other localities during the project, while the two *Lentinellus* species were not found in any other sites in the Biskopstorp area. The high share of red-listed species and indicators in Trälhultet is remarkable considering the small size of the area and the moderate amounts of dead wood. The general large size of the trees may be one explanation for this, but the favourable, warm microclimate may also benefit some specialised heart-rot agents. It seems likely that more rare species may appear in Trälhultet as dead wood amounts increase in the coming years.

NÖ Kroksjön and **S Ry** were visited only briefly during the summer visit, and very few indicators or red-listed species were recorded. Most remarkable is the find of the strongly yellow corticoid basidiomycete *Ceraceomyces sulphurinus* which is known from very few sites in Scandinavia.

Åkulla

The Åkulla area is situated about 15 km E of Varberg in a landscape rich in small lakes and steep ridges. The landscape hosts the northernmost concentration of old-grown beech forests in Halland, and woodland key habitats are well represented (Fritz & Larsson 2000). Two intensive localities were studied in the area. They are situated about 2.5 km apart, separated by farmland, coniferous plantations and swamps/lakes. It is therefore considered most likely that they are functioning as discrete entities with only limited exchange of fungal spores. For this reason they are not treated in a collective sense with respect to the European indicator scheme, as was done with the study sites in Biskopstorp.

Valaklitt is situated on rather steep, S-facing slopes facing a small lake. The stand is rather heterogeneous. Large parts are dominated by collapsing, overmature trees and several very large sun-exposed canopy gaps are prominent. However, regeneration is well developed, and other parts of the stand are dominated by young or mature trees. As a whole the stand gives the impression of very high naturalness with a pronounced, though large-grained mosaic-structure with well developed patch-dynamics as described e.g. from Suserup Skov in Denmark (Emborg et al 2000). The soils are partly deep developed, resulting in rather good growth conditions for beech. Several study trees had a DBH exceeding 60 cm, with a maximum of 69 cm. 25 trees were studied.

Six red-listed species were recorded at Valaklitt (Table 3). Of these, *Dentipellis fragilis, Camarops tubulina* and *Hercium coralloides* were recorded on three trees each. The latter was in one case found in company with *Inonotus obliquus* which is an almost obligate associate in Danish beech forests (Heilmann-Clausen & Christensen 2000b). *Hohenbuehelia auriscalpium*, which is not previously published from Sweden, was found on two logs, while *Meripilus giganteus*, which is very scattered in Halland, was recorded on one tree. With four indicators, following the European indicator scheme (Christensen et al. 2005), Valaklitt is clearly among the most valuable sites for saproxylic fungi in Halland. It is most likely that more indicators and red-listed species could be added by inventories in the following years. The high value of the site reflects the long history of non-intervention and the high abundance of dead wood in all stages of decay. In addition the dominant SE-facing slopes may secure a rather warm microclimate beneficial to some demanding species.

NV Äskemossen is very different from Valaklitt.

NV Äskemossen in the Åkulla area is a rather small, old grown beech stand dominated by slow-grown beech trees of rather small dimensions. Photo: Örjan Fritz.

Most of the locality is situated on a low, undulating plateau with small wet depressions and streams. The stand is mostly dense and rather dark with only small canopy gaps. The amounts of dead wood are moderate, and most dead trees are of fairly small dimensions. Growth conditions for beech are poor to moderate and most trees are small and slow-grown. This probably reflect nutrient poor, partly waterlogged soil conditions or the effects of former heavy livestock grazing. The largest study tree had a DBH of 56 cm. 25 trees were studied.

Six red-listed species were recorded at the locality, most on single or very few trees. Most interesting is the recording of *Pluteus umbrosus* which was not found in Valaklitt. The corticoid *Sistotrema raduloides* was found on a natural stump, associated with *Camarops tubulina*. The species is rare in all parts of Scandinavia, red-listed in Finland (Kotiranta & Niemelä 1996), and according to Hallingbäck & Aronsson (1998) not previously recorded in south Sweden. The number of indicators in Äskemossen is rather low and the value of the site for saproxylic fungi is at present only moderate. It is possible that this will change as dead wood amounts increase in the future.

Extensive study sites

The Oskarström area

Getabäcken is situated about 10 km north of Oskarström in a densely forested landscape. The locality was investigated rather briefly and several large beech logs were not surveyed in detail.

The locality is dominated by rather closed and dark stands of tall beeches growing on gentle W-facing slopes. Locally, steep, exposed cliff-faces occur. The forest structure gives an unusual natural impression, being uneven-aged with a well developed mosaic-structure. According to Niklasson (2003) the oldest trees are about 285 years old. Growth conditions for beech are favourable and most trees are unusually tall and thick for Halland. Dead wood is present in moderate amounts with a good balance between decay stages. A majority of the dead wood is present as large logs. Uprooted trees are common, pointing to a deep developed soil layer and perhaps to *Fomes fomentarius* being less dominant than typical in Halland.

Except for the rocky outcrops Getabäcken almost gives the impression of a Danish beech forest on rather rich soil dominated by tall and large trees. Photo: Örjan Fritz.

Four red-listed species were recorded, including the richest occurrences of *Dentipellis fragilis* (seven logs) and *Camarops tubulina* (three logs) met with in the project. The possibly undescribed polypore *Tyromyces sp.* was seen on four logs. Although the number of recorded indicators is rather low the rich occurrence of the above mentioned species points to very high mycological values. The visit at Getbäcken was rather short and it is highly probable that more detailed investigations would lead to records of more rare species. The locality is very rich in red-listed saproxylic insects and second in Halland only to Holkåsen in Biskopstorp in conservation value in this respect (Jansson 2004).

Myskebackarna is situated 5 km WSW of Getabäcken, closer to the arable farmlands along Kattegat. The locality was investigated rather throughoutly but some of the smaller dead trees were not surveyed. The locality is dominated by rather low, often multistemmed beech trees on three rocky hills. Many trees show distinct signs of former coppicing and individual stems are generally small. The amounts of dead wood are rather low to moderate, with a dominance of recently dead wood. The oldest trees are dated to be 240 years old, but most are almost 100 years younger (Niklasson 2003).

Four redlisted species were recorded at the locality (Table 3). Except for *Hypoxylon cohaerens* all were recorded only once, within a small area ("provplats 4" in Niklasson 2003, p. 33). *Hericium coralloides* and *Ossicaulis lignatilis* were in fact found on the same log, meaning that the three most interesting red-listed species were recorded on only two logs! In the same area *Inonotus obliquus* was recorded on an old beech snag while *Mycena crocata* was found on beech litter. *Inonotus obliquus* is generally rare on beech and mainly confined to beech forests with high dead wood continuity (Heilmann-Clausen & Christensen 2000b). *Mycena crocata* is quite seldom in the region, and mainly restricted to beech forests on rich soils. The highly localised co-occurrence of several demanding species is striking. The area is S-facing and stands out from the rest of the locality by the occurrence of some large standing beech snags, and a relative richness of large, living beech trees. It is unclear if the local mycological values reflect a special local forest history or special growth conditions on the steep south-facing slopes. Jansson

The beech trees in Halland are generally of rather small dimensions. More scattered, like in Nissa-ström, much larger trees occur, due to more favourable soil conditions. Photo: Örjan Fritz.

(Niklasson 2003), fairly even-aged and homogeneous. Dead wood amounts are moderate to high and several large gaps occur in the canopy.

Despite the high dead wood volumes only one red-listed species were recorded at the locality and even the number of indicators is remarkably low (Table 3). The area is rich in old stone-heaps pointing to former farming and a break in forest continuity. This may explain the lack of rare fungal species, though it should be remarked that the richness of red-listed saproxylic insects is rather high (Jansson 2004).

Skrockeberg consist of mainly E and SE-facing, rather steep slopes situated in the densely forested landscapes north of Nissa-ström. The site was investigated rather briefly, but most dead trees were surveyed. The forest is unusually rich in large pines but also spruces occur scattered. The trees are generally between 150 and 200 years old. Some of the pines show distinct signs of forest fires in the 19^{th} century, probably of anthropogenic origin (Niklasson 2003). Niklasson (2003) interpret the stand to be generally a secondary natural forest, unmanaged since livestock grazing was abandoned 150-200 years ago. Five red-listed saproxylic fungi are known from Skrockeberg, including *Camarops tubulina, Hericium coralloides* and *Multiclavula mucida* which were all found in the present investigation, the latter on at least four trees. *Dentipellis fragilis* was not found in the present investigation, but have been seen in recent years. Other interesting records include the possibly undescribed *Tyromyces sp.* on at least two beech logs. Skrockeberg has a rich fauna of saproxylic insects, including several red-listed species (Jansson 2004), and is even rich in epiphytic lichens (Niklasson 2003).

(2004) found the locality in general to be the least valuable site for saproxylic insects among 15 beech forests inventoried in Halland. This corresponds well with the overall impression of the value of the site for saproxylic fungi, but it is unclear if any insect traps were placed in the small area where the interesting fungi were recorded.

Frodeparken is a small beech forest reserve on flat, deep developed soils midway between Biskopstorp and Myskebackarne. The site was visited rather briefly, but almost all dead trees were inventoried. The growth conditions for beech are favourable and the locality is characterized by unusually tall and big beech trees. The stand is about 200 years old

Unlike the situation in many other beech forest reserves in Halland, spruce is allowed to grow freely in Rågetaåsen. As a result the forest is rather dark with several very large spruces and rich reproduction of spruce offering serious competition for the beech saplings Photo: Örjan Fritz.

Nissaström is located along the banks of the river Nissan, 5 km north of Oskarström. The locality was visited rather briefly. It is a very heterogeneous locality with several small areas with old beech forest, intermixed with oak forest and mixed deciduous forest including alder, lime and aspen. Parts of the locality show distinct signs of former human use, but the steepest cliffs along Nissan has probably always been forested. The amounts of dead wood are rather low, but several unusually large beech logs occur. The soils are partly very rich for Halland, with occurrence of several ectomycorhizal fungi with a very restricted distribution in Halland, e.g. *Cortinarius citrinus, Craterellus cornucopiae* and *Hygrophorus nemoreus*.

Three red-listed fungi were found on dead beech wood in Nissaström (Table 3), including *Peziza saniosa,* which has not previously been recorded from Halland. The species normally grows on rich soil, but is known from dead beech wood also in Denmark. Two other red-listed saproxylic fungi are known from Nissaström, i.e. *Dentipellis fragilis* and *Clavicorona pyxidata* but occurring on other hosts (lime? and aspen, respectively). Only the former was recorded in the present investigation. Also the possibly undescribed polypore *Tyromyces sp.* was found (on one log), while *Galerina pallida* was recorded as new to Sweden. Despite the distinct human impacts, Nissaström is a locality of considerable importance for saproxylic fungi. This probably reflect the unusual size of the trees at the site, the rich soil conditions, the local warm microclimate on the steep cliff-faces and probably a high, local dead-wood continuity on the steep cliffs.

Råmebo is an old beech forest on rather flat terrain 10 km SE of Oskarström. Half of the stand was thinned and cultivated for regeneration 10-20 years ago while another half part has been untouched for several decades. The canopy layer is fairly even-aged, consisting of tall, 250-280 years old trees (Niklasson 2003). Dead wood amounts are moderate, but most dead wood is present as large logs and snags. Most of the fallen logs were investigated, except for the thinned parts where vigorous beech regeneration makes most logs virtually inaccessible.

Mårås is clearly the most valuable inland locality for wood-inhabiting fungi in Halland. Parts of the stand give a very natural impression, with a well developed mosaic structure and a good balance between regeneration and breakdown of old trees. Photo: Örjan Fritz.

Four red-listed, saproxylic fungi are known from the locality, including *Dentipellis fragilis, Hericium coralloides* and *Lentinellus vulpinus* (Table 3). The latter was found on three trees in the present investigation, while *Hericium coralloides* is only known from earlier years. Other noteworthy records on beech include *Inonotus obliquus, Lentinellus ursinus* and *Pluteus pellitus.* The indicator scores are among the highest for extensive localities in the project (Table 3) and the locality is among the most valuable in Halland also for saproxylic insects, epiphytic lichens and bryophytes (Fritz 2001, Jansson 2004). This points to high, unbroken forest continuity, even in the presence of dead wood and veteran trees.

Rågetaåsen is situated 10 km NE of Oskarström on steep, rocky ESE-facing slopes. The locality is characterized by several small streams and bogs and the presence of several very large spruces. Parts of the stand are probably in a successional change from open beech-forest with scattered spruce to a mixed coniferous stand, where beech is likely to play only a subordinate role.

Niklasson (2003) found the oldest trees to be only 130 years old, but this probably exclude the oldest generation of beech trees which occur as scattered, mostly dead or dying veterans. The stand was probably open grassland with only scattered trees until the mid part of the 19th century (Niklasson 2003). Dead wood amounts are moderate, with a good balance between dead wood in various decay stages. The locality was visited rather briefly, but most of the oldest beech trees were investigated carefully.

Four red-listed species were recorded, with *Gloeohypochnicium analogum* and *Dentipellis fragilis* as the most noteworthy species. Even the possibly undescribed *Tyromyces sp.* was recorded on the base of a rotten beech snag. *Gloeohypochnicium analogum* is known from very few records in Sweden. The species has a southern distribution in Europe and its presence in Rågetaåsen may be of relict character, pointing to warmer, more light-open conditions in the past. It is doubtful whether any of the above mentioned species will be able to persist as the stands gets cooler and darker due to the vigorous growth of spruce and the dieback of the old beech generation.

The inland locality Skubbhult host rich communities of redlisted lichens and saproxylic insects, but only few interesting wood-decay fungi were recorded. Photo: Örjan Fritz.

Svarta Klippan is situated 7 km E of Råmebo facing the small river Fylleån. The studied area is situated on very steep W facing rocky slopes, and consists of mixed deciduous stands with oak and beech being dominant. Generally the growth conditions for beech are rather poor, but locally, close to sheltering rocks, larger trees occur. The oldest beech-trees are dated to be about 300 years old (Niklasson 2003). The steep part of the locality with the oldest trees was investigated throughoutly.

Three red-listed saproxylic fungi are known Svarta Klippan (Table 3). Most interesting is the presence of *Inonotus cuticularis* and *Gloeohypochnicium analogum*. Both have a southern distribution in Scandinavia and their presence points to a local, warm microclimate on the steep cliff-faces. For saproxylic insects Svarta Klippan is only of rather limited value (Jansson 2004) which may indicate a break in dead wood continuity. Dead wood amounts are still rather sparse and it is interesting if more rare species will occur at the locality when more of the old trees collapse in the future.

Inland area (municipality of Hylte)

Mårås is situated right north of Hyltebruk and is the biggest and by far the most natural of the beech forest reserves in the eastern part of the county of Halland (belonging to the landscape of Småland). The locality includes 6-7 ha of very natural looking beech forest with a well-developed mosaic structure and a good balance between tree generations. The most natural area is situated on a rather low hill and has all expositions. The oldest dated beech in Sweden was found in the area in 2001. It was at that time dated to be at least 400 years old, but died in 2002 (Niklasson & Fritz 2003). Several other trees in the stand are known to be more than 300 years old (Niklasson 2003). Growth conditions are generally fairly good and many trees are tall and rather thick. Dead wood amounts are high and show a very good balance between decay stages. The locality was investigated rather throughoutly, but only the most interesting looking logs were inventoried carefully.

With seven red-listed species Mårås is clearly the top scorer among the extensive localities. *Dentipellis fragilis, Hercium coralloides* and *Pluteus umbrosus* were each recorded on two or three trees, while *Camarops tubulina* and *Multiclavula mucida* were recorded on a single tree each. The latter was found in very sparse amounts on a dead log adjacent to the southern border of the forest facing open land. The species has not previously been recorded at Mårås and is probably in the phase of colonization. The occurrence of wood decaying agarics was remarkably rich, with high frequencies of *Omphalina epichyisum* and several *Pluteus* species. Mårås has a very rich flora of epiphytic lichens (Niklasson & Fritz 2003), while the fauna of saproxylic insects is rather poorly developed (Jansson 2004).

The discrepancy between the richness of saproxylic insects and fungi in Mårås is intriguing and hard to explain. It is worth noticing that the interesting wood decay fungi were found very scattered across the whole locality, while most of the other top sites in Halland were characterized by an often strikingly localized co-occurrence of several rare species. In other words, it is possible that the more natural forest structure in Mårås means that the most demanding species occur more scattered, because their required substrates occur scattered. This contrasts with localities characterized by more even-aged generations of very old trees offering local hotspots of substrate abundance. If the differences in forest structure has this effect, it is likely that the rather low number of insect traps in Mårås has been able to catch up with only a limited part of the total insects diversity at the site. The fungal inventory, in contrast, covered the whole locality and most likely recorded a very high fraction of the total diversity. Alternatively, it is possible that saproxylic insects and fungi differ in important habitat requirements and therefore have responded differently to breaks in forest continuity and/or have variable affinity to the present habitat conditions.

Skubbhult is situated next to the lake Mellan-Färgen right north of Femsjö parish; the birth place of Elias Fries. Three adjacent beech stands were studied. Most time was used in the central part of the area (corresponding to "kärnområdet" in Fritz (2001)), while two areas closer to the lake were inventoried less carefully. The central stand is in almost level terrain and gives a fairly even-aged impression. Niklasson (2003) found it to be about 170 years old, with very few older trees. The amounts of dead wood are moderate and newly dead wood predominate.

Only two red-listed species were recorded in Skubbhult, with *Phleogena faginea* being the most interesting. Even the numbers of recorded indicators are low and as a whole Skubbhult seem to of limited importance for saproxylic fungi. In contrast the locality is rich in red-listed epiphytic lichens and bryophytes and saproxylic insects (Fritz 2001, Jansson 2004).

Ödegärdet is the eastern-most of the study sites in the municipality of Hylte. The locality is quite heterogeneous but most of the study area consists of low-grown, fairly even-aged beech forest. Dead wood amounts are generally low to moderate, and most dead wood are of rather recent date. The area show distinct signs of former human use and is an important archaeological locality. At least parts of the site have been used for farming at various times during the last 2000 years. Most of the old beech trees are between 200 and 250 years old, while a few fallen veteran oaks are considerably older (Niklasson 2003).

No red-listed fungi were recorded in Ödegärdet and even the number of indicators is strikingly low (Table 3). The locality was visited rather briefly under poor light conditions and some species may have been overlooked. Nevertheless it seems clear that the site is of limited value for saproxylic fungi, which probably reflect breaks in dead wood continuity in the past. Some of the slopes facing the small road east of the locality were found to host interesting ectomycorrhizal fungi including *Cortinarius variegates* and *Tricholoma portentosum* which are only rarely found in pure deciduous forest.

Southern Halland

Blåalt is a rather big, but fairly isolated forest reserve SW of Mästocka in the southern part of Halland. The area is very heterogeneous and includes mixed deciduous stands with oak, beech and pine as well as pure beech forests. The locality was visited both at the summer and the mid autumn visit. At the latter occasion only parts with large amounts of dead beech wood were inventoried, i.e. the western-most part of the reserve S of the parking place and the areas along a small ravine in the central part of the reserve (SE of "provplats" 3 in Niklasson (2003)). In both areas many beeches show distinct signs of former coppicing. Some are multi-stemmed, while others have basal scars and cavities pointing to old wounds. The oldest beech stems was dated by Niklasson (2003) to be about 200 years old. The stands are still generally closed and dead wood amounts are moderate.

Despite much time used in the field only few red-listed fungi were recorded at Blåalt (Table 3). More

Several of the old-grown beech forests in Halland are marked by former management. This is also the case in Vallåsen, which is characterized by a fairly even-aged, widely spaced generation of beech trees. The stand is now collapsing and a decrease in dead wood amounts are foreseeable within the coming generations. The massive front of conifers in the background indicates another problem. Many old grown beech stands are isolated and surrounded by other habitat types which may hinder effective spore-dispersal between suitable habitats rich in dead wood. Photo: Örjan Fritz.

noteworthy are the records of *Coprinus extinctorius* and *Entoloma placidum.* Both are known from very few records in Sweden, but are normally not associated with beech forests of high conservation value in Denmark (pers. obs.). The number of recorded indicator species is low and Blåalt has, as a whole, rather low to moderate value for saproxylic fungi at present. Most striking is the lack of several species associated with old fallen logs and snags, i.e. *Camarops tubulina, Dentipellis fragilis, Hericium coralloides, Inonotus cuticularis* and *Tyromyces sp.* The locality is among the most valuable sites for epiphytic lichens and bryophytes in Halland (Fritz 2001), while the importance for saproxylic insects is relatively low (Jansson 2004).

Vallåsen is situated at the central part of Hallandsåsen, 10 km SE of the intensive study site Dömestorp. Vallaåsen is a fairly even-aged beech stand in undulating terrain. Most of the surrounding areas are covered by coniferous plantations and the stand is fairly isolated from other old beech stands. The amounts of dead wood are high due to increasing break down of old canopy trees. Several large canopy gaps occur and many logs are sun-exposed. The stand is generally wide-spaced and most trees are tall and thick-stemmed. The oldest trees are about 200 years old (Niklasson 2003). The locality was visited both at the summer and the mid autumn visit.

Four red-listed species were recorded, including *Pluteus umbrosus, Hericium coralloides* (two trees) and *Lentaria epichnoa* (three trees). The latter species was not recorded in other localities in the project and is new to Halland. Interesting is also the abundancy of *Peziza micropus* which was not recorded in the nearby intensive locality, Dömestorp. Also several *Pluteus* species were much more abundant in Vallåsen than in Dömestorp. Vallåsen has high value for saproxylic fungi but the small size and isolated position may in the long run cause problems for the local survival of the present populations of the most demanding species.

Appendix 2. Notes on red-listed and other interesting species recorded in the project.

Phleogena faginea (VU), pulverklubba, is a very unusual heterobasidiomycete forming groups of tiny club-shaped sporocarps, reminding of myxomycete fructifications. In cases of doubt a strong smell of curry may help in the identification. It is often found on hard and dry wood, e.g. on rather fresh snags or underneath recently broken logs. The species fruits late in the season and was found in all intensive localities except Kvinnsåsen. Most likely it occurs even in many of the extensive localities, which was visited only in mid-autumn. The species was especially abundant in Holkåsen, where it was found on 20 % of the studied trees. The species is considered very rare in most parts of Europe, but is most likely widely overlooked due to the inconspicuous sporocarps, formed late in the year. The species is not previously recorded from Halland, and according to recent information from Anders Dahlberg at "Art-Databanken" the species was known from only ten localities in Sweden prior to the present investigation. It was listed as an indicator of habitat quality in Danish beech forests by Heilmann-Clausen & Christensen (2000b), but omitted from the European indicator system (Christensen et al. 2005), due to the rather inconspicuous sporocarps and uncertainty regarding ecological preferences.In Britain more than 100 records are known, some made on oak saplings (Martyn Ainsworth pers. comm.)

Stypella subgelatinosa (syn. Protodontia subgelatinosa)(NT), lövgråtagging, is a heterbasidiod, corticoid fungus forming masses of tiny greyish spines underneath dead wood. It was found as new to Halland in Dömestorp. The species is red-listed also in Denmark (Stoltze & Pihl 1998) and Norway (Bendiksen et al. 1997). It inhabits strongly decayed deciduous wood and probably has a preference for richer soils. It is found in all parts of Scandinavia north to Torne Lappmark. The sporocarps are very inconspicuous and the true rarity of the species is debatable.

Ceraceomyces sulphurinus (DD), svavelskinn, is a corticoid fungus forming conspicuous strongly yellow sporocarps with numerous mycelial cords. The species was during the project found for the second time in Sweden. The first record dates back to 1940, when the species was found close to Femsjö.

Dentipellis fragilis (skinntagging) occurred in abundance on fallen beech snags in Getabäcken. Photo: Örjan Fritz.

Outside Sweden the species is in Scandinavia known from a few localities in Finland. The new record was made in NÖ Kroksjön at Biskopstorp underneath strongly decayed wood of beech. In the field the species were taken for *Phlabiella vaga* which form similarly coloured sporocarps. The species might be quite distributed in Halland as similar looking sporocarps were seen at the summer visit also in Blåalt and Trälhultet, but not collected. At the mid-autumn visit the species was not found again, and the species may have a rather short period of sporulation.

Gloeohypochnicium analogum (syn. Hypochnicium analogum) (DD), lundkrämskinn is a corticoid fungus forming rather thick, pinkish cream sporocarps with a powerful fruity smell. It was recorded as new to Halland with finds in Rågetaåsen and Svarta Klippan. The species has a southern distribution in Scandinavia with very scattered records from Denmark, Skåne, Blekinge and the Mälaren-area in Sweden. It was listed as an indicator of habitat quality in Danish beech forests by Heilmann-Clausen & Christensen (2000b), but omitted from the European indicator system (Christensen et al. 2005), due to the rather inconspicuous sporocarps. In contrast, Ainsworth (2004) still list it among the indicators for important sites for saprotrophic fungi on beech in the UK.

Sistotrema raduloides is a corticoid fungus forming masses of small, whitish to pale brownish spines on a slightly paler subiculum. It was found as new to Halland at Äskemossen on a rotten beech snag. The species is red-listed in Finland (Kotiranta & Niemelä 1996), and according to Hallingbäck & Aronsson (1998) not previously recorded in south Sweden.

Dentipellis fragilis (NT), skinntagging, grows on deciduous wood and is in Scandinavia most common on beech and aspen. It was recorded from eight of the study sites but occur rather widespread in the county of Halland (Fig. 14). The largest sporulating population was encountered in Getabäcken, where sporocarps were seen on at least seven trees. It was not found in the Biskopstorp sites, and is not previously recorded in the area. This is surprising considering the general high fungal diversity of the area. *Dentipellis fragilis* is red-listed also in Denmark (Stoltze & Pihl 1998), Norway (Bendiksen et al. 1997) and Finland (Kotiranta & Niemelä 1996), listed as an indicator of biologically valuable old growth forests in both Estonia (Parmasto & Parmasto 1997)

Hericium coralloides (koralltaggsvamp) is unmistakeable due to its delicate branched, coral-shaped sporocarps. Nissaström/Getabäcken. Photo: Örjan Fritz.

Lentinellus ursinus (björnmussling), showing the characteristic contrast between the dark felty central part of caps, and the paler and almost smooth margins. Råmebo. Photo: Örjan Fritz.

and the former Yugoslavia (Tortiè 1998), and included among the European beech forest indicators by Christensen et al. (2005). The species has an eastern distribution in Europe and is not known from the UK. In Halland it was mainly found on standing high snags or recently downed logs/snags, which had been standing dead for several years. Only in one case it was associated with a log strongly infected with *Fomes fomentarius*. Details on the ecological role of the species and its infection strategy are still unknown.

Hericium coralloides (NT), koralltaggsvamp, is a well known and beautiful decayer of deciduous wood. In Sweden it occurs mainly on beech, birch and aspen (Hallingbäck & Aronsson 1998). It was recorded from 12 study sites and is a fairly widespread species in Halland (Fig. 14). The richest occurrence was found in Holkåsen. The species is red-listed in most European countries and considered as an important indicator of old natural forests in Denmark, Estonia, Poland, UK and the former Yugoslavia (Parmasto & Parmasto 1997; Tortiè 1998; Heilmann-Clausen & Christensen 2000b; £uszyñski 2003; Ainsworth 2004). It is even included among the European beech forest indicators by Christensen et al. (2005). All records were made on standing or recently downed beech snags which had been standing dead for some years. *Hericium coralloides* seem to have quite strict associations with other wood decay fungi (Niemelä et al. 1995). In Halland it was in all cases found in association with *Fomes fomentarius,* while *Inonotus obliquus* and less often *I. cuticularis* are the most common associated species in Denmark (Heilmann-Clausen & Christensen 2000a).

Lentinellus vulpinus (NT), rynkmussling is rather closely related with *Hericium coralloides* and allies. Its sporocarps are however of the agaric type, but rather tough and with irregular, serrated gills. The cap is pale tan to pinkish brown with a distinctly ribbed cap-margin. It grows on various deciduous hosts. The species has been much confused with the closely related *L. ursinus,* which differs in its distinctly brown-tufted pileus. The species was found as new to Halland in Trälhultet and Råmebo. The species is red-listed also in Denmark (Stoltze & Pihl 1998) and Norway (Bendiksen et al. 1997) and included among the European beech forest indicators by Christensen et al. (2005). The record in Trälhultet

The mysterious *Tyromyces sp.* photographed on a large beech log in Nissaström. Future work is planned in collaboration with Professor Leif Ryvarden, Oslo, to sort out the status of the species. Photo: Jacob Heilmann-Clausen.

were made on a still living but partly rotted beech tree while it was found on a standing, dead snag in Råmebo. It seems probable that the species forms heart-rot in living trees.

Lentinellus ursinus, björnmussling, has been much confused with the above species and *L. castoreus.* In Sweden it has mostly been treated under the latter name (e.g. Hallingbäck & Aronsson 1998). For this reason the true distribution of the species in Sweden is unknown. In the current circumscription *Lentinellus ursinus* is defined by being distinctly brown hairy to furry at the central part of the cap, strongly contrasting to the paler and smoother cap-margin. The species was recorded as new to Halland on the same two localities as the above species, and one might wonder if they are really different at the species level. It is included among the European beech forest indicators by Christensen et al. (2005) and used also in regional indicator systems in Belgium and the UK (Ainsworth 2004; Walleyn et al. 2004). In Halland it was found on standing or fallen beech snags which had been standing dead for several years. In several cases it was occurring in large amounts. The same ecology seems to be typical in Denmark and Fountainebleau in France, where the species is quite distributed (pers. obs). The species may be a heart-rot agent of old, over-mature trees or be dependent on one or more specific predecessor as *Hericium coralloides.*

Ceriporia excelsa (NT), rosenporing, is a resupinate polypore forming fragile, often widely effused, pinkish to violaceous or orange sporocarps. The species is difficult to separate from the related *C. viridians,* which differ mainly by its duller and often greenish colours. It is possible that the two species are conspecific or belongs to a still unresolved species complex. It grows on decaying deciduous wood and was recorded from eight study sites in the project. In Denmark the species is rather common and not strictly associated with valuable natural forests. It is not included in the beech forest indicator schemes by Heilmann-Clausen & Christensen (2000b), Ainsworth (2004), Christensen et al. (2005), though it is regarded as a indicator of habitat quality in Sweden (Hallingbäck & Aronsson 1998). In Halland the species was typically found on dead beech logs or branches in medium decay stages. It was not particularly common in any of the study sites.

Inonotus cuticularis (VU), skillerticka, forms aggregated clusters of rusty brown sporocarps on living and recently dead deciduous trees, particularly beech. It was not seen fertile during the project, but old sporocarps were seen on two living trees; one in

N. Kroksjön and one in Svarta Klippan. There is little doubt that the species still thrive in both trees, but probably sporulating was not initiated in 2004, because of the rather cool and rainy summer. The species has a southern distribution in Scandinavia and is known only from one recent record in Norway (Bendiksen et al. 1997), while it is rather distributed in Denmark. In Halland it is known from four localities in total (Fig. 13). It is included among the European beech forest indicators by Christensen et al. (2005) and its presence in the two sites probably points to an unbroken continuity in the presence of suitable veteran trees and a favourable, warm microclimate at the local scale.

Inonotus obliquus, sprängticka, is very common on birch in most parts of Scandinavia where it forms black, asexual, irregular conks on living trees. The poroid, resupinate sporocarps are formed less commonly on recently dead, fallen or still standing trunks. On beech the asexual, black conks are never seen and it is possible that the species growing on beech is a distinct, undescribed taxa. In Halland *Inonotus obliquus* was recorded on beech in three sites, in all cases on sun-exposed, standing snags. This ecological preference is very distinct for the beech form in Denmark too (pers. obs) while the typical birch form grows in all kind of expositions. The form on beech was included among the indicators of habitat quality in Danish beech forests by Heilmann-Clausen & Christensen (2000b) but omitted from the European system (Christensen et al. 2005) due to the unclear taxonomical status. It would be interesting to do mating and/or DNA studies with both forms to resolve if they are distinct taxa or not.

Skeletocutis vulgaris, sydlig gräddporing, was recently separated from the probable sib species *S. lenis,* gräddporing (Niemelä & Dai 1997). Both form white to cream-coloured, thin and strictly resupinate, poroid sporocarps on dead deciduous and coniferous wood. The ecology and distribution of *Skeletocutis vulgaris* is still poorly known, but the species seems to be quite distributed in Halland, with records from 10 study sites. It was mainly found on rather bulky substrates, both snags and lying logs. A preference for rather fresh, undecayed wood, as mentioned by Niemelä & Dai (1997), was not evident, as the species in several cases was found on very rotten wood. It is unclear if the species has a preference for sites of high natural value, but it is noteworthy that the very similar *S. lenis* is included in the red-lists in both Sweden and Finland (Kotiranta & Niemelä 1996; Gärdenfors 2000). *Skeletocutis vulgaris* was not recorded at all in the Nat-Man project (Ódor et al. 2004a), and may be a Halland speciality in a European beech forest perspective.

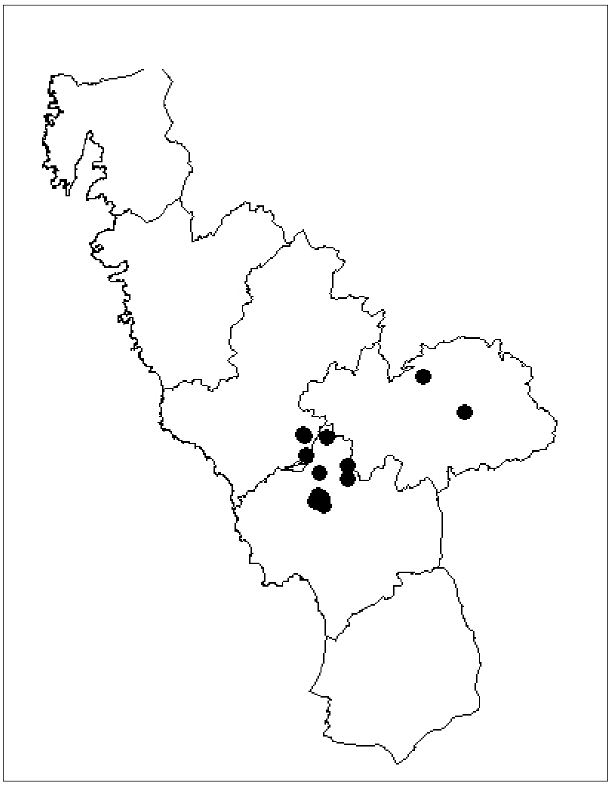
Tyromyces sp. Already before the beginning of the field-work in Halland, Örjan Fritz mentioned the existence of a strange, yellowish, unnamed polypore in some of the old beech forests in Halland. At the mid-autumn visit I had the chance to study the species myself on a total of seven large beech trees in four different localities, but could not suggest a plausible name. Since then several Danish mycologists has been consulted and dried material has been checked by Professor Leif Ryvarden in Oslo. The preliminary conclusion is that the species is undescribed or at least not well known in Europe. Macroscopically the species has some resemblance to *Tyromyces kmetii* but the spores are narrower than in this species. Also *Ceriporiopsis gilvescens* is rather similar, but differs in the strictly resupinate sporocarps, a narrower pore-layer and pinkish colours. It is planned to assess the taxonomic position of the species by DNA sequencing as basis for an eventual scientific description of the species as a new taxa.

The species seem to be restricted to the wettest part of study area, where it is known from five sites in total (Fig. 13). It would be highly relevant to investigate further potential sites for the species. Known sites deserve the biggest possible conservation attention, as the species may be very rare at the global scale.

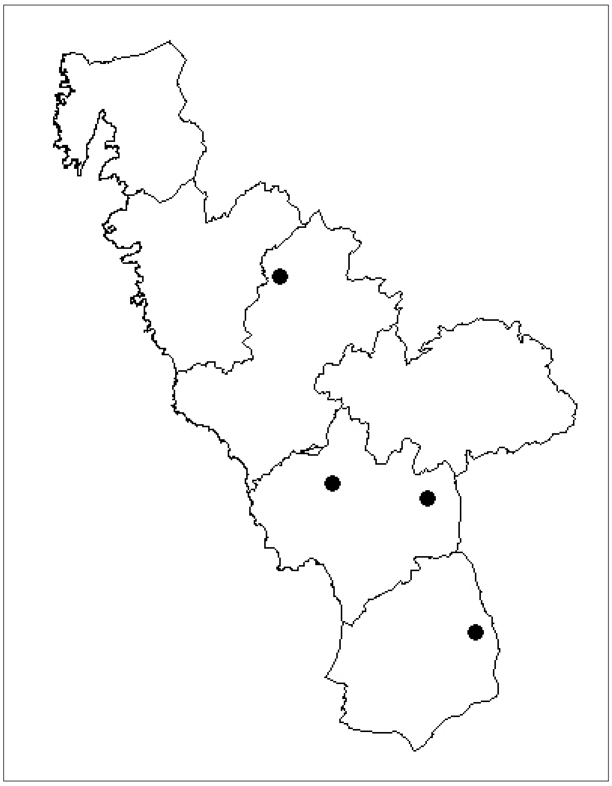
Lentaria epichnoa (NT), vit vedfingersvamp, forms tiny coral-shaped sporocarps on rotten deciduous wood. The species was recorded on three logs in Vallåsen and is new to Halland. It is generally more common in central Sweden and is considered as a good indicator of habitat quality in aspen stands (Nitare 2000). In Denmark most of the few records are from heaps of sawdust, but it is also found on decaying beech logs in two localities, both of high conservation value.

Multiclavula mucida (syn. Lentaria mucida) (VU), vedlavklubba, is a lichenized basidiomycete forming dense groups of small whitish club-shaped sporocarps on rotten wood, which is coloured green by the algal photobiont. It was recorded in eight study sites and was especially abundant at Holkåsen. The population in Halland is restricted to the Biskopstorp area and a few sites north and east hereof (Fig. 13). The species is more distributed in central Sweden (Nitare 2000), with only very scattered records south of Lake Vänern. The species most likely depends on a stable,

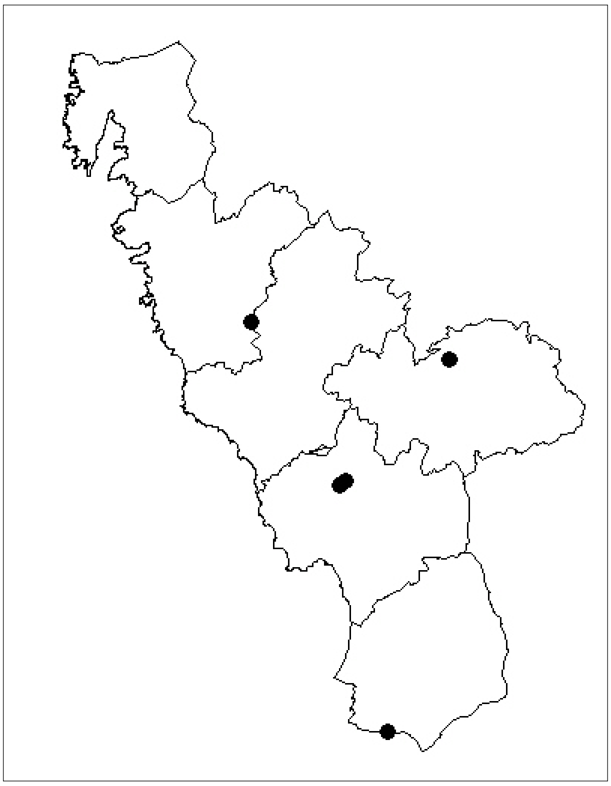
Tyromyces sp.



Multiclavula mucida

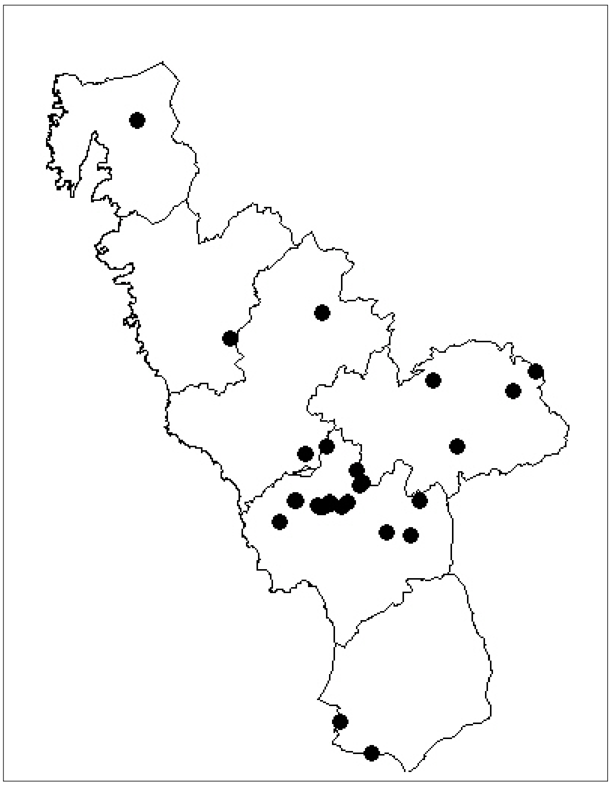


Inonotus cuticularis

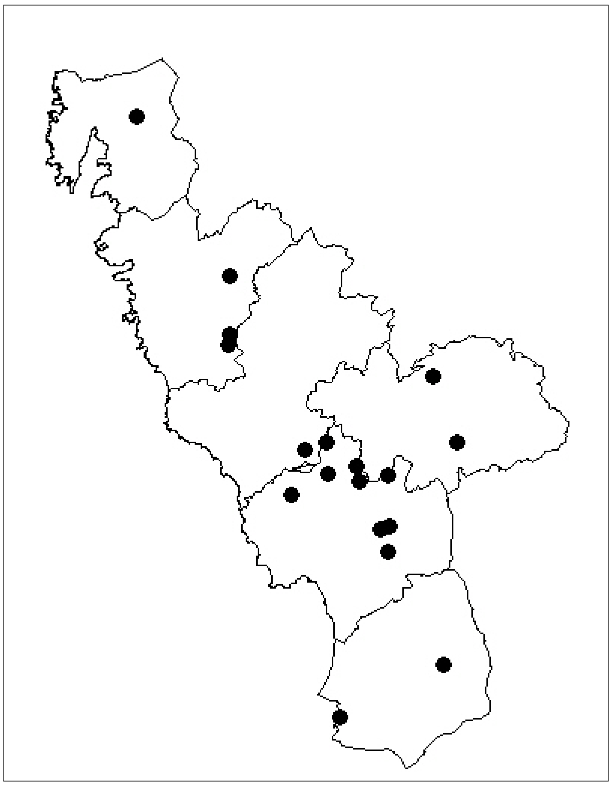


Pluteus umbrosus

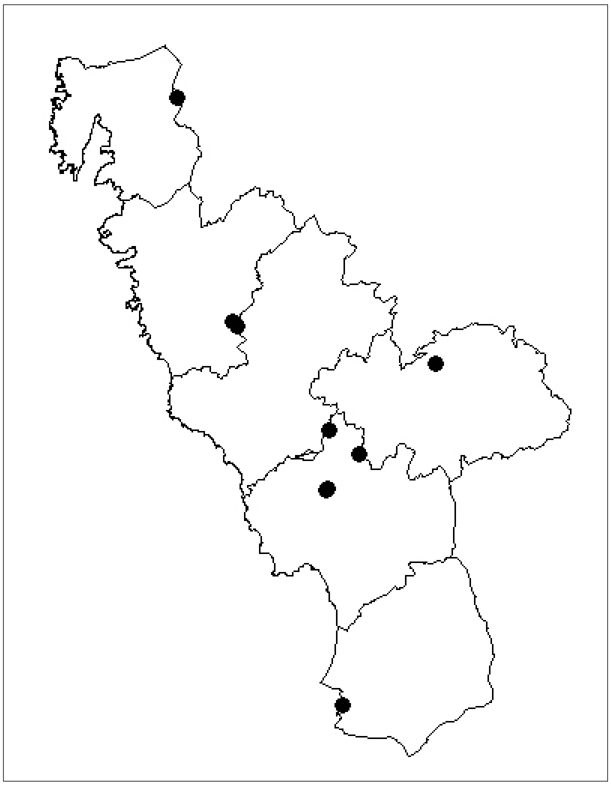
Figure 13. Distribution maps of *Tyromyces sp., Multicalvula mucida, Inonotus cuticularis* and *Pluteus umbrosus* in Halland, based on this and previous investigations. All have a very restricted distribution in Halland. The two first mentioned are recorded mainly in the Oskarström area, while the two latter are each recorded from about a handful of localities scattered over the county.



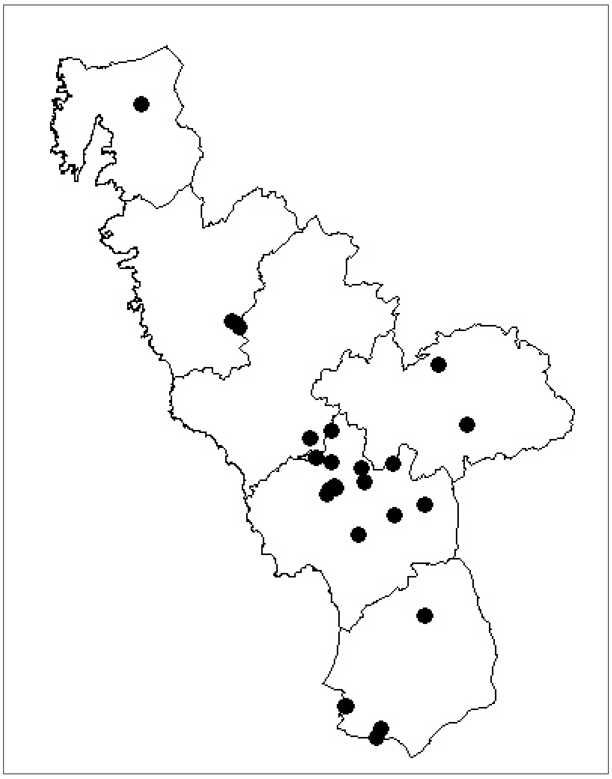
Hericium coralloides



Dentipellis fragilis



Camarops tubulina



Hypoxylon cohaerens

Figure 14. Distribution maps of *Hericium coralloides, Dentipellis fragilis, Camarops tubulina* and *Hypoxylon cohaerens* in Halland, based on this and previous investigations. All occur fairly widespread in the county.

The delicate sporocarps of *Lentaria epichnoa* (vit vedfingersvamp) was found on several strongly decayed beech logs in Vallåsen. Photo: Jacob Heilmann-Clausen.

humid forest climate, and the rich occurrence in central Halland probably benefit from the high precipitation in the region. It is not known from Denmark and was in the Nat-Man project only recorded from Slovenia, where both the study sites are in high precipitation areas. According to Holec (2003) it is restricted to forests minimally influenced by human activities in the Böhmerwald, the Czech

Multiclavula mucida (vedlavklubba) growing on its green mat of algae on strongly decayed beech wood in Holkåsen. Photo: Jacob Heilmann-Clausen.

Republic, and should probably be regarded as a indicator of forests of high conservation value as suggested by Nitare (2000)

Bolbitius reticulatus (NT), hinnskivling, is a small agaric reminding of a *Pluteus* but differing by the ochre gills and the sticky pileus. It was found in six study sites, in all cases on strongly decayed, mostly large beech logs. It is found north to northern central Sweden and seems to have a preference for richer soils (Hallingbäck & Aronsson 1998). It might be a good indicator of habitat quality in the region, though it is not included in any of the beech indicator schemes used in the rest of Europe.

Coprinus spelaiophilus (syn. Coprinus extinc-torius ss. auct) is a rather large but thin-fleshed *Coprinus.* Macroscopically it is reminding of *C. domesticus,* but it differs among other things by the structure of the veil and the more pure white cap. It is typically associated with hollows in living trees (Rald 1989) and the record in Blåalt was made in exactly this habitat. The species is poorly known in Sweden, but a single record from Skåne is listed in Hansson & Hägg (2000). It seems to be a rare species in Europe (Rald 1989) and is included in the Danish red-list (Stoltze & Pihl 1998). The indicator value of the species is unknown but probably limited as it often grows in solitary trees in cities and parks (Rald 1989).

Galerina pallida is a very unusual *Galerina* characterized by striking pale colours and hyaline, dextrinoid spores. For this reason it was first described in its own genus as *Velomycena pallida.* In Scandinavia it is known only from a few finds in Norway (Gro Gulden pers. comm.) and is here recorded as new to Sweden. It was found on rotten beech wood in Nissaström, and was in the field mistaken for an albino form of *G. marginata.* In the Nat-Man project it was even recorded on beech wood in the Slovenian virgin forest site Rajhenavski Rog (Piltaver et al. 2002). The present collection was determined by Gro Gulden, Oslo.

Galerina pseudomniophila & G. vexans are two bryophyte associated *Galerina's* which are here published as new to Sweden, thanks to determination work by Gro Gulden. *Galerina pseudomniophila* forms small yellow brown sporocarps reminding of *G. mniophila,* but characterized by a slightly different microscopy. It was recorded from Vallåsen and N. Kroksjön. *Galerina vexans* is a slightly larger and more yellow species close to *G. pumila.* It was found in Mårås and Skubbhult. Both species are probably widespread in Sweden, but have been intermixed with other species in the genus. In the ordination of the joint datasets from Halland and Denmark and in the calculation of similarity coefficients between all Nat-Man datasets *Galerina pseudomniophila* was included under *G. mniophila.*

Hohenbuehelia auriscalpium is a spathulate agaric, characterized by its pale felty pileus and a number of microscopical characters. It was found on two large beech logs at Valaklitt, both in an intermediate stage of decay. The species is not earlier reported from Sweden, but it is possible that some records of *H. reniformis* refer to the species. *Hohenbuehelia auriscalpium* is included among the European beech forest indicators by Christensen et al. (2005) and seems to be obligate in the most valuable beech forest reserves in Europe, where it typically grows on large beech logs. There are however also records from other tree species and less valuable habitat types and the indicator value has still to be proven.

Mycena renati (NT), gulfotshätta, is a beautiful *Mycena* characterized by a yellow stipe, a pinkish cap and a distinct alkaloid smell. It was found in seven study sites in Halland, mostly during the summer visit. The species inhabit various types of dead deciduous wood and is not uncommon in fertile deciduous forests in SE Denmark. It seems to have an eastern distribution in Scandinavia and the occurrence in Halland is slightly surprising as it is missing form similar habitat-types in Jutland, Denmark. Likewise it was not recorded from Belgium and the Netherlands during the Nat-Man project (Ódor et al 2004a). It is listed as a relict fungi of primeval forests in central Poland (£uszyñski 2003), but according to my experience the species is restricted more by climatical and forest type constraints than breaks in dead wood continuity.

Omphalina epichysium, grånavling, is a small grey agaric with a striate pileus and decurrent gills. It was found in Kvinnsåsen and Mårås, and occurred quite abundantly at the latter locality. All records were made on large, strongly decayed beech logs with rich communities of saprotrophic agarics. In central and northern Sweden it is mostly found on dead wood of spruce and aspen and is regarded as an indicator of habitat quality (Hallingbäck & Aronsson 1998). It was included among the indicators of habitat quality in Danish beech forests by Heilmann-Clausen & Christensen (2000b), but omitted from the European indicator system (Christensen et al. 2005), mostly due to the rather small and shortlived sporocarps. In Denmark it is only known from one site, Suserup Skov, which is among the very best sites for

Hohenbeuhelia auriscalpium is recognized on account of the pale, tough, slightly felty and spathuliform sporocarps. Valaklitt. Photo: Jacob Heilmann-Clausen.

saproxylic fungi on beech wood in NW Europe (Heilmann-Clausen & Christensen 2004a).

Ossicaulis lignatilis (syn. Clitocybe lignatilis) (NT), vedtrattskivling, is a fleshy, white to pale grey agaric with a strong mealy smell. During the project it was found on a single beech log at Myskebackarna, associated with *Hercium coralloides*. The same association was noted to be characteristic in virgin forests in eastern Slovakia (Heilmann-Clausen & Christensen 2004a). *Ossicaulis lignatilis*, however, seems to have rather wide ecological amplitude and is known from a large number of deciduous hosts. It occurs in all parts of Sweden and is even known from subalpine birch forests (Artdatabanken 2000a). In beech forests it seem to be more or less restricted to habitats of high conservation value and it is included in the indicator systems of Heilmann-Clausen & Christensen (2000b), Ainsworth (2004) and Christensen et al. (2005). *Ossicaulis lignatilis* is one of the rather few agarics that cause brown rot and it is most likely a heart rot agent, associated mainly with old, overmature trees.

Pluteus umbrosus (NT), borstskölding, is a highly characteristic species, identified by the flesh-coloured gills with a dark edge and the beautiful velvety brown cap surface. The species belongs to a characteristic society of agarics growing on deciduous wood in a rather advanced stage of decay. It is found on dead wood of several deciduous tree species, of which beech, birch and aspen appear to be most common in Sweden (Hallingbäck & Aronsson 1998). It was found in seven of the study sites (Fig. 13) and was slightly more common in Halland, than in any of the Nat-Man datasets (cf Ódor et al. 2004a). The species is apparently a good indicator of sites with a stable representation of well decayed deciduous wood, and is included in the indicator systems of both Heilmann-Clausen & Christensen (2000b), Nitare (2000) and Christensen et al. (2005).

Psathyrella larga is a rather large *Psathyrella* which is here reported as new to Sweden, thanks to determination work by Leif Örstadius, Kristiansstad. The species is rather widely distributed in Sweden, but has previously been confused with similar looking species like *P. obtusata* and *P. rostellata*. It is even collected in Germany, Denmark, Norway and Finland. It has no special connection to beech forests, but occurs in most forest types on soil and wood. In the present study it was found in two localities; N Kroksjön and Frodeparken, in both cases on strongly decayed beech wood. (All data on ecology and distribution are due to Leif Örstadius pers. comm.).

Volvariella bombycina (NT), silkesslidskivling, is a large, fleshy agaric, which grows in dense clusters

Pluteus umbrosus (borstskölding), on strongly decayed beech log in Holkåsen. Photo: Jacob Heilmann-Clausen.

on dead deciduous wood. The cream-coloured, silky fibrillose cap and the volvate stem base makes the species unmistakeable. It was found in a cavity on a living beech in Holkåsen, but has also been recorded in a similar situation from N Kroksjön by Örjan Fritz (pers. comm.). The species has a southern to eastern distribution in Scandinavia and is mostly recorded in regions with high summer temperatures. It grows on several deciduous tree species and is most common on cavities in still living, somewhat sun-exposed trees, but is also recorded from fallen logs and dead snags. In Halland it seems to depend on a warm, local microclimate. *Volvariella bombycina* is red-listed also in Denmark (Stoltze & Pihl 1998) and Norway (Bendiksen et al. 1997), and included in the beech forest indicator systems of both Heilmann-Clausen & Christensen (2000b), Ainsworth (2004) and Christensen et al. (2005).

Hypoxylon cohaerens (NT), liten bokdyna, is a pyrenomycete forming rather small, adpressed, blackish stromata on dead beech wood. It is far the most frequently recorded red-listed species in the project with records from almost all study sites (Fig. 14). In the intensive localities it was found on 34 of 200 study trees. The species grows on rather fresh beech wood, especially on thick branches, and is most likely a latent invader being present in a passive, endophytic stage in living trees. It is almost strictly associated with beech. The species is rather common in Denmark, but was included among the indicators of habitat quality in Danish beech forests by Heilmann-Clausen & Christensen (2000b). It was later omitted from the European indicator system (Christensen et al. 2005) because of a rather weak association with special habitat qualities.

Nemania atropurpurea & N. chestersii are pyrenomyces forming thin but widely effused, blackish stromata on dead wood. Macroscopically both species looks quite like the more well-known *N. serpens,* and it requires some field experience to distinguish the three species in the field, with just some success. Microscopically the species are easily distinguished (e.g. Læssøe et al. 2000). Both species are here reported as new to Halland, but appear to be quite widespread in the county. This is especially the case for *N. atropurpurea* which was found on 13 study sites and 11 % of the intensive study trees. This frequency is considerably higher than recorded in any of the Nat-Man countries. *Nemania atropurpurea & N. chestersii* were both included among the indicators of habitat quality in Danish beech forests by Heilmann-Clausen & Christensen (2000b), but were omitted from the European indicator system (Christensen et al. 2005) because of the lack of good macroscopical characters. In Halland the two species were found to be associated with snags decayed by

Camarops tubulina (gransotdyna) on beech wood in Skrockeberg. Photo: Örjan Fritz.

Fomes fomentarius, either standing or recent fallen. Especially *N. atropurpurea* was very characteristic in this habitat.

Camarops tubulina (NT), gransotdyna, is a stromatic pyrenomycete, forming large and thick, black stromata on dead wood of fir, spruce and beech. It was recorded from eight study sites in the current project, all of high to very high conservation interest (Fig. 14). In Sweden the species has previously been recorded mostly from fertile spruce forests rich in dead wood (Artdatabanken 2000b). In Central Europe the species occur in pure beech forests and mixed fir/beech forests and is included in the beech forest indicator systems of both Heilmann-Clausen & Christensen (2000b) and Christensen et al. (2005). According to Holec (2003) the species is restricted to forests minimally influenced by human activities in Böhmerwald, the Czech Republic. In Halland it occurred in all cases on standing or fallen beech snags, which seem to be a preferred habitat also in Denmark. As shown in Fig. 17 it seems to have a preference for large diameter trees.

Peziza saniosa (VU), blåmjölkig storskål, is a discomycete forming blackish lens-shaped sporocarps (apothecia), exceeding blue "milk" upon breakage. It was recorded in Nissaström as new to Halland. The species usually grows on exposed, rich clay soils in ditches, hazel-groves etc. More occasionally it is found on strongly decayed wood as in the present case. The species is rare in Sweden with scattered records mainly in the southern part of the country (Gärdenfors 2000).

Ascocoryne sp. Two species of *Ascocoryne* are commonly reported from dead wood in Scandinavia, i.e. *A. sarcoides* and *A. cylichnium* (e.g. Christensen & Heilmann-Clausen 2000; Hansen & Knudsen 2000). Both were recorded in this project, but in addition a third species, characterized by rather small, brownish sporocarps and distinctly capitate paraphyses, were found in several localities. Material has been send to Viktor Kucera in Slovakia which is presently working on the genus in his PhD project.

Appendix 3. Ordination diagrammes

Diagram showing the optima of fungal species in the ordination space defined by axis 1 and 2 in the DCA ordination of the Halland dataset (Fig. 8). Species with optima on slightly decayed tree have high scores on axis 1, while the opposite is true for species with optima on strongly rotted trees. Species names are abbreviated according to Appendix 4.

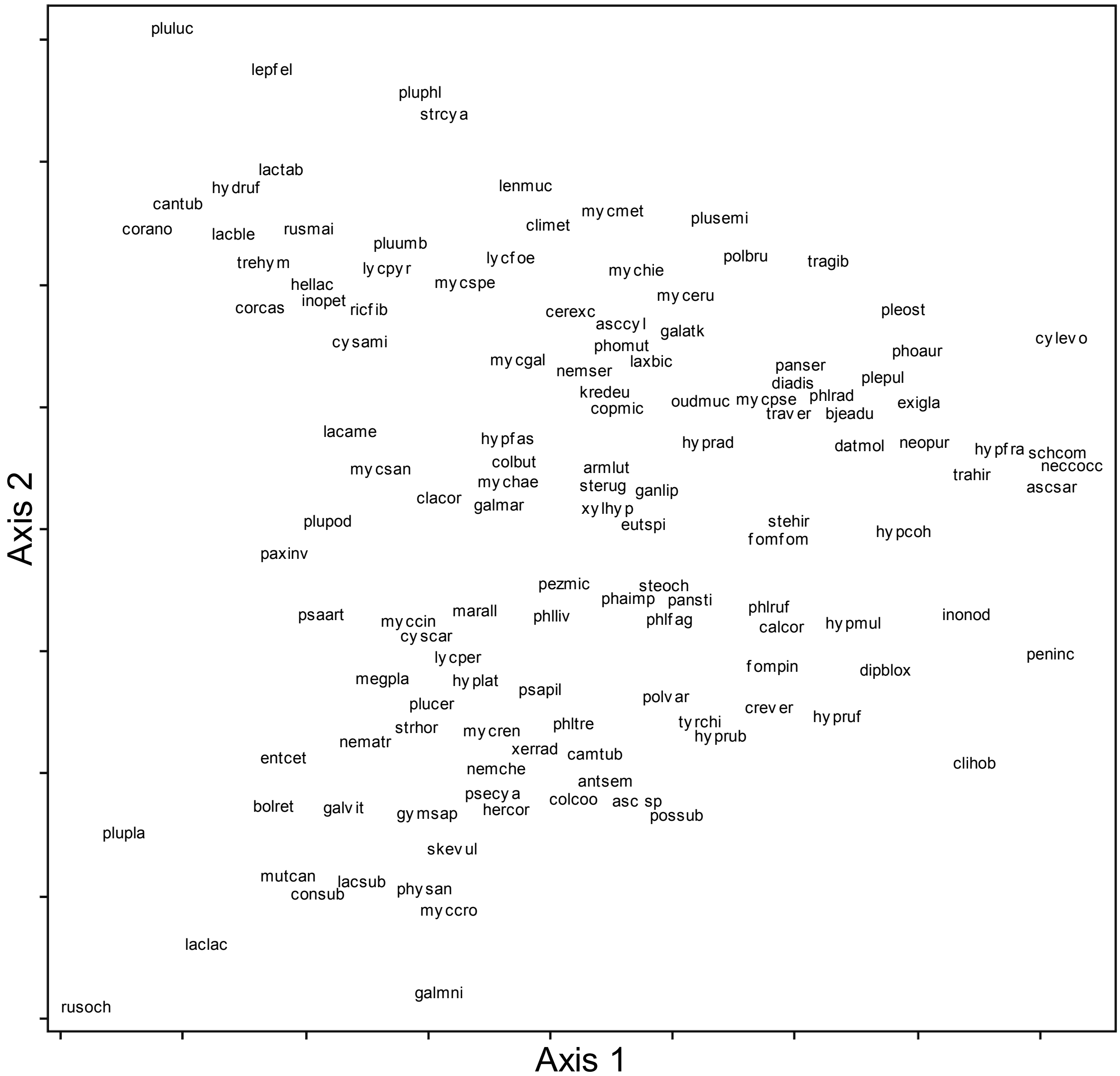
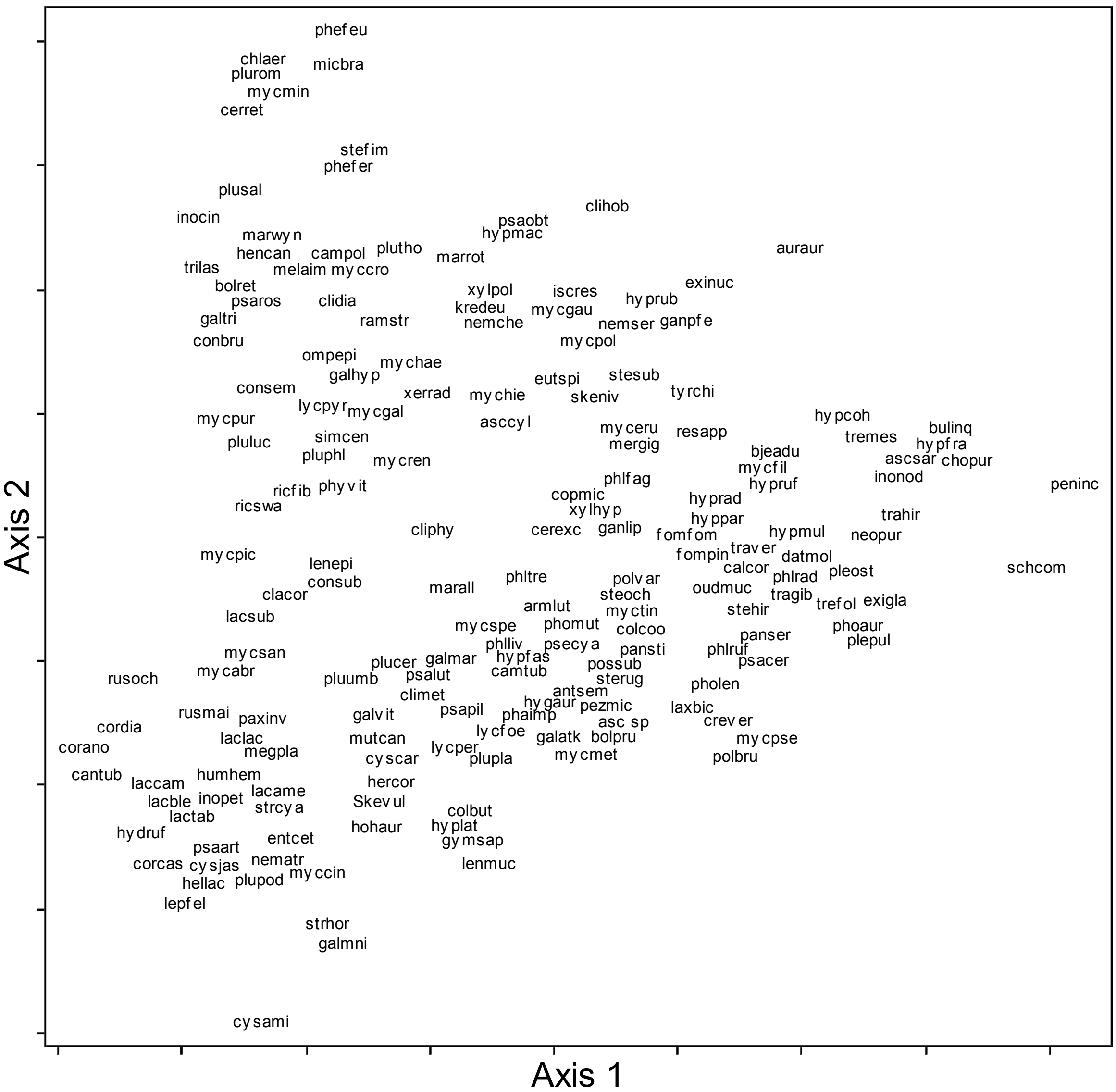


Diagram showing the optima of fungal species in the ordination space defined by axis 1 and 2 in the DCA ordination of the joint datasets from Halland and Denmark (Fig. 9). Species with optima in Halland and Central Jutland have low scores on axis 2. Species names are abbreviated according to Appendix 4, except for the following species, which were not recorded in Halland: *Auricularia auricula-judae* (auraur), *Camarops polysperma* (campol), *Chlorociboria aeruginascens* (chlaer), *Clitocybe diatreta* (clidia), *Conocybe brunnea* (conbru), *C. semiglobata* (consem), *Exidia nucleata* (exinuc), *Galerina hypnorum* (galhyp), *Ganoderma pfeifferi* (ganpfe), *Hypoxylon macrocarpum* (hypmac), *Ischnoderma resinosum* (iscres), *Kavinia himantia* (kavhim), *Marasmius rotula* (marrot), *M. wynnei* (marwyn), *Melanophyllum aimatospermum* (melaim), *Micromphale brassicolens* (micbra), *Mycena filopes* (mycfil), *M. galopus* (mycgau), *M. minutula* (mycmin), *M. picta* (mycpic), *Pluteus romellii* (plurom), *Pluteus thomsonii* (plutho), *Skeletocutis nivea* (skeniv), *Steccherinum fimbriatum* (stefim) and *Tricholoma lascivum* (trilas).



Appendix 4 lst of species recorded in Halland	Code used in ordination diagrams	number of trees	Number of sites	Dömestorp	Holkåsen	N Kroksjön	Kvinnsåsen	Trälhultet	Valaklitt	NV Äskemossen	NÖ Kroksjön	S. Ry	Mårås	Getabäcken	Blåalt	Almeberget	Skubbhult	Frodeparken	Myskebackarna	Skrockeberg	Svarta Klippan	Råmebo	Vallåsen	Klinta hallar	Nissaström	Rågetaåsen	Ödegärdet	Djupeåsen
Ascomycetes,pyrenomycetes																												
Bombardia ambigua var. carbonaria Rehm ss. Munk		0	1												X													
Camarops tubulina (Alb. & Schw.) Shear	camtub	10	8	4%	4%	8%			12%	4%			X	X						X								
Diatrype disciformis (Hoffm.: Fr.) Fr.		3	6	X	X		X		X				X	X														
Diatrype flavovirens (Pers.: Fr.) Fr.		1	3						X				X	X														
Diatrype stigma (Hoffm.: Fr.) Fr.		2	3	X			X										X											
Eutypa spinosa (Pers.: Fr.) Tul. & C.Tul.	eutspi	69	24	30%	34%	40%	33%	30%	64%	12%	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Eutypella cf. scoparia (Schwein.) Ellis & Everh.		1	2	X											X													
Eutypella quaternata (Pers.: Fr.) Rappaz		2	5			X			X				X		X											X		
Hypocrea argillacea W. Phillips & Plowr.		1	1	2%																								
Hypocrea citrina (Pers.: Fr.) Fr.		1	3						4%					X								X						
Hypocrea pulvinata Fuckel		1	1		2%																							
Hypocrea rufa (Pers.) Fr.	hypruf	9	5	8%		8%	7%	10%	4%																			
Hypoxylon cohaerens (Pers.: Fr.) Fr.	hypcoh	34	18	18%	12%	24%	13%	10%	24%	16%			X	X	X		X	X	X		X	X	X	X		X		
Hypoxylon fragiforme (Pers.: Fr.) Kickx	hypfra	28	25	18%	4%	20%	13%	20%	20%	12%	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hypoxylon multiforme (Fr.: Fr.) Fr.	hypmul	22	13	8%	8%	20%		10%	24%	8%					X		X	X	X						X	X		X
Hypoxylon rubiginosum (Pers.: Fr.) Fr.	hyprub	6	8	6%	2%	4%		10%						X			X								X		X	
Kretzschmaria deusta (Hoffm.: Fr.) P. Martin.	kredeu	39	22	22%	18%	4%	27%	10%	28%	24%	X		X	X	X	X	X	X	X	X		X	X	X	X	X		X
Lasiosphaeria hirsuta (Fr.: Fr.) Ces. & De Not.		0	2										X		X													
Nectria coccinea (Pers.: Fr.) Fr.		17	15	10%	2%	8%	13%	10%	16%	8%	X		X		X		X	X		X		X	X					
Nectria peziza (Tode.: Fr.) Fr.		1	3							X			X									X						
Nectriopsis violacea (J.C. Schmidt: Fr.) Maire		0	1											X														
Nemania atropurpurea (Fr.: Fr.) Pouzar	nematr	21	14	6%	14%	8%	13%	20%	16%	4%	X		X					X			X	X	X					
Nemania chestersii (J.D. Rogers & Whalley) Pouzar	nemche	12	12	4%	4%				16%	16%			X	X	X		X		X			X	X			X		
Nemania serpens (Pers.: Fr.) Gray	nemser	22	15	22%	2%	8%	7%		8%	20%					X	X	X		X	X	X	X	X				X	
Xylaria hypoxylon (L.: Fr.) Grev.	xylhyp	143	22	66%	70%	76%	80%	60%	80%	72%		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	
Xylaria polymorpha (Pers.: Fr.) Grev.	xylpoly	1	1	2%																								
Ascomycetes,discomycetes																												
Aleuria aurantiaca (Pers.: Fr) Fuckel		0	1																	X								
Ascocoryne cylichnium (Tul.) Korf	asccyl	33	14	20%	10%	24%	20%	10%	24%	8%			X	X					X		X	X	X		X			

	Code used in ordination diagrams	number of trees	Number of sites	Dömestorp	Holkåsen	N Kroksjön	Kvinnsåsen	Trälhultet	Valaklitt	NV Åskemossen	NÖ Kroksjön	S. Ry	Mårås	Getabäcken	Blåalt	Almeberget	Skubbhult	Frodeparken	Myskebackarna	Skrockeberg	Svarta Klippan	Råmebo	Vallåsen	Klinta hallar	Nissaström	Rågetaåsen	Ödegärdet	Djupeåsen
Ascocoryne sarcoides (Jacq.: Fr.) Groves & Wilson	ascsar	18	11	12%	6%	12%		10%	20%				X		X		X				X					X	X	
Ascocoryne sp.	asctas	9	6	8%		12%		10%	4%						X				X									
Ascotremella faginea (Peck) Seaver		2	4	2%	X			10%							X													
Bisporella citrina (Batsch.: Fr.) Korf & S.E. Carp.		10	17	4%	2%	4%	7%		12%	8%			X	X	X		X	X	X	X			X		X	X	X	
Bulgaria inquinans (Pers.: Fr.) Fr.	bulinq	6	13	2%	4%	4%			X	8%	X		X	X	X		X	X		X					X			
Chlorociboria aeruginascens (Nyl.) Kanouse		0	1																						X			
Claussenomyces atrovirens (Pers.: Fr.) Korf & Abawi		0	1																	X								
cf. Diplocarpa bloxamii (Berk. ex W. Phillips) Seaver		6	4		X	X	X		X																			
Helvella bulbosa (Hedw.: Fr.) Kreisel		2	3		4%		X										X											
Helvella lacunosa Afzel.: Fr.	hellac	13	6	2%	14%		33%										X		X				X					
Humaria hemisphaerica (Wigg.: Fr.) Fuckel	humhem	3	4	X	4%				4%												X							
Neobulgaria pura (Fr.) Petrak	neopur	28	20	10%	10%	24%	27%	30%	16%	4%			X	X	X		X		X	X	X	X	X		X	X	X	
Ombrophila sp		1	1		X																							
Peziza micropus Pers.: Fr.	pezmic	43	15		40%	16%	33%	40%	20%	20%	X		X	X		X				X	X	X	X			X		
Peziza saniosa Schrad.: Fr.		0	1																						X			
Basidiomycetes,heterobasidiomycetes																												
Calocera cornea (Batsch: Fr.) Fr.	calcor	24	18	20%	6%	12%	20%		4%	16%			X	X	X		X		X	X	X	X	X		X	X	X	
Dacrymyces enatus (Berk. & M.A. Curtis) Massee		1	1	X																								
Exidia glandulosa (Bull: Fr.) Fr.	exigla	10	5	2%	2%	8%			16%	8%																		
Myxarium subhyalinum (A. Pearson) D.A. Reid		1	1	X																								
Phleogena faginea (Fr.: Fr.) Link	phlfag	22	8	8%	20%	12%		10%	8%	8%							X											
Stypella subgelatinosa (P. Karst.) P. Roberts		1	1	X																								
Tremella foliacea Pers.	trefol	1	2					10%					X															
Tremella mesenterica Retz: Fr.	tremes	2	4	2%		4%								X								X						
Tulasnella violea (Quél.) Bourdot & Galzin		2	2	X			X																					
Basidiomycetes,corticoids																												
Botryobasidium aureum Parmasto		7	16	X	X	X	X	X	X	X			X	X	X	X	X	X		X		X	X		X	X	X	
Botryobasidium conspersum J. Erikss.		6	7	X			X	X	X					X	X								X					
Botryobasidium subcoronatum (Höhn. & Litsch.) Donk		0	1										X															
Botryohypochnus subisabelinus (Fr.) J. Erikss.		0	1																X									

	Code used in ordination diagrams	number of trees	Number of sites	Dömestorp	Holkåsen	N Kroksjön	Kvinnsåsen	Trälhultet	Valaklitt	NV Äskemossen	NÖ Kroksjön	S. Ry	Mårås	Getabäcken	Blåalt	Almeberget	Skubbhult	Frodeparken	Myskebackarna	Skrockeberg	Svarta Klippan	Råmebo	Vallåsen	Klinta hallar	Nissaström	Rågetaåsen	Ödegärdet	Djupeåsen
Ceraceomyces sulphurinus (P. Karst) J. Erikss. & Ryvarden		0	1					?			X				?													
Chondrostereum purpureum (Pers.: Fr.) Pouz.	chopur	3	4		2%	4%	7%																				X	
Coniophora puteana (Schumach.: Fr.) Karst.		2	2	X				X																				
Cylindrobasidium evolvens (Fr.: Fr.) Jülich		12	5	10%	2%	8%			8%	8%																		
Gloeohypochnicium analogum (Bourdot & Galzin) Hjortstam		0	2																		X					X		
Hyphoderma puberum (Fr.) Wallr.		2	2	X		X																						
Hyphoderma setigurum (Fr.) Donk		2	2			X				X																		
Hyphodontia paradoxa (Schrad.: Fr.) E.Langer & Vesterh.	hyppar	1	2	2%									X															
Hyphodontia radula (Pers.: Fr.) E.Langer & Vesterh.	hyprad	4	3	6%						4%			X															
Hypochnicium eriksonii Hallenb. & Hjortstam s.l		2	2						X	X																		
Laxitextum bicolor (Pers.: Fr.) Lentz	laxbic	7	10	6%	2%	8%				4%			X		X	X						X	X	X				
Leucogyrophana sp		1	2			X																X						
Mycoacia cf. aurea (Fr.) J. Erikss. & Ryvarden.		2	2			4%	7%																					
Peniophora cinerea (Pers.: Fr.) Cooke		2	2	2%		4%																						
Peniophora incarnata (Pers.: Fr.) Karst.	peninc	4	4	4%			7%	10%							X													
Phanerochaete filamentosa (Berk. & M. A. Curtis) Burds.		1	5	X										X		X			X					X				
Phanerochaete velutina (DC.: Fr.) Karst.		7	5	X	X		X		X	X																		
Phlebia livida (Pers.: Fr.) Bres.	phlliv	20	11	12%	4%	12%	13%		16%	12%			X				X			X	X				X			
Phlebia radiata Fr.: Fr.	phlrad	44	15	14%	24%	28%	40%	10%	28%	16%			X	X	X		X	X	X	X		X						
Phlebia rufa (Pers.: Fr.) M.P.Christ.	phlruf	14	6	12%	4%		13%		8%	8%								X										
Phlebia tremellosa (Schrad.: Fr.) Burds. & Nakas.	phltre	11	13	2%	2%	12%		20%	16%	X			X	X			X					X	X		X	X		
Sistotrema raduloides (Karst.) Donk		1	1							X																		
Sistotrema sernanderi (Litsch.) Donk		3	3			X	X		X																			
Sistotremastrum niveocremeum (Höhn. & Litsch.) J. Erikss.		1	1						X																			
Steccherinum ochraceum (Pers.: Fr..) Gray	steoch	30	14	24%	6%	8%	20%	X	24%	16%			X	X				X	X	X					X	X		
Stereum hirsutum (Willd.: Fr.) Gray	stehir	71	25	22%	42%	40%	33%	40%	60%	20%	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Stereum rugosum (Pers.: Fr.) Fr.	sterug	36	20	22%	24%	16%	13%	10%	20%	4%			X	X	X	X	X		X	X	X	X			X	X	X	X
Stereum subtomentosum Pouz.	stesub	2	3		X	4%				4%																		
Trechispora farinacea (Pers.: Fr.) Liberta		1	1			X																						
Trechispora hymenocystis (Berk. & Broome) K.H. Larss.		14	11	X	X		X	X	X	X				X				X	X		X		X					
Trechispora nivea (pers.) K.H. Larss.		3	5	X	X	X			X													X						

	Code used in ordination diagrams	number of trees	Number of sites	Dömestorp	Holkåsen	N Kroksjön	Kvinnsåsen	Trälhultet	Valaklitt	NV Äskemossen	NÖ Kroksjön	S. Ry	Mårås	Getabäcken	Blåalt	Almeberget	Skubbhult	Frodeparken	Myskebackarna	Skrockeberg	Svarta Klippan	Råmebo	Vallåsen	Klinta hallar	Nissaström	Rågetaåsen	Ödegärdet	Djupeåsen
Basidiomycetes,polypores																												
Antrodiella semisupina (Berk. & Curt.) Ryvarden & Johans.	antsem	32	16	30%	12%	12%	13%		24%				X	X	X		X	X	X	X		X	X	X			X	
Bjerkandera adusta (Willd.: Fr.) Karst.	bjeadu	46	19	24%	18%	36%	27%	20%	20%	20%			X	X	X	X	X	X	X	X	X	X			X		X	
Ceriporia excelsa (Lund.) Parm.	cerexc	12	8	8%	2%	8%	20%			8%					X										X	X		
Ceriporia reticulata (Hoffm.: Fr.) Dom.	cerret	2	3	2%					4%						X													
Daedaleopsis confragosa (Bolt.: Fr.) Schroet.		0	1		X																							
Datronia mollis (Sommerf.: Fr.) Donk	datmol	20	13	8%	12%	24%	7%	10%	4%	4%				X	X				X			X			X	X		
Diplomitoporus lindbladii (Berk.) Gilb. & Ryvarden		0	1														X											
Fomes fomentarius (L.: Fr.) Fr.	fomfom	122	25	68%	54%	64%	53%	70%	64%	56%	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fomitopsis pinicola (Swartz: Fr.) Karst.	fompin	35	22	36%	10%	12%	27%	X	12%	8%		X	X	X	X		X	X	X	X	X	X	X	X		X	X	X
Ganoderma lipsiensis (Batsch) Atk.	ganlip	22	14	22%	12%	16%	X		X	4%			X	X		X		X	X	X				X	X			
Hapalopilus rutilans (Pers.: Fr.) Karst.		0	1												X													
Inonotus cuticularis (Bull.: Fr.) Karst.		0	1																		X							
Inonotus nodulosus (Fr.) Karst.	inonod	8	16	4%		8%	7%		8%	4%			X		X	X	X		X	X	X		X		X		X	
Inonotus obliquus (Pers.: Fr.) Pilat		0	3						X										X			X						
Lenzites betulinus (L.: Fr.) Fr.		1	1		2%																							
Meripilus giganteus (Pers.: Fr.) Karst.		0	1						X																			
Oxyporus corticola (Fr.) Ryvarden		1	1					10%																				
Oxyporus populinus (Schum.: Fr.) Donk		0	5				X			X				X	X										X			
Phellinus ferreus (Pers.) Bourd. & Galz.	phefer	2	4	4%		X									X											X		
Phellinus ferruginosus (Schrad.: Fr.) Pat.	phefeu	0	1																	X								
Physisporinus sanguinolentus (Alb. & Schw.: Fr.) Pilat	physan	6	12	4%		4%		10%	8%				X	X				X	X	X	X		X			X		
Physisporinus vitreus (Pers.: Fr.) Karst.		2	3	2%						4%															X			
Polyporus brumalis (Pers.) Fr.: Fr.	polbru	9	8		10%	X	7%	10%	8%									X	X			X						
Polyporus ciliatus Fr.: Fr.		0	1																									
Polyporus varius (Pers.) Fr.: Fr.	polvar	12	13	8%	6%		7%	20%	8%		X		X	X		X		X			X		X		X			
Postia subcaesia (David) Jülich	possub	7	10	6%	2%	8%			4%				X					X	X	X		X				X		
Postia tephroleuca (Fr.: Fr.) Jülich		0	1			X																						
Pycnoporus cinnabarinus (Jacq.: Fr.) Karst.		0	1		X																							
Skeletocutis vulgaris (Fr.:) Niemelä & Y.C. Dai	Skevul	10	10	6%		X		10%	20%	4%		X		X			X			X			X					
Trametes gibbosa (Pers.: Fr.) Fr.	tragib	6	9	6%			7%	10%	4%				X			X			X		X		X					

	Code used in ordination diagrams	number of trees	Number of sites	Dömestorp	Holkåsen	N Kroksjön	Kvinnsåsen	Trälhultet	Valaklitt	NV Äskemossen	NÖ Kroksjön	S. Ry	Mårås	Getabäcken	Blåalt	Almeberget	Skubbhult	Frodeparken	Myskebackarna	Skrockeberg	Svarta Klippan	Råmebo	Vallåsen	Klinta hallar	Nissaström	Rågetaåsen	Ödegärdet	Djupeåsen
Trametes hirsuta (Wulfen: Fr.) Pilat	trahir	10	17		4%	16%		10%	12%		X	X	X		X		X	X	X	X	X	X	X				X	X
Trametes versicolor (L.: Fr.) Quel.	traver	17	16	4%	10%	24%	7%	20%	4%				X	X	X	X	X	X		X		X	X	X				
Tyromyces chioneus (Fr.: Fr.) Karst.	tyrchi	8	12	4%	2%	12%	X		8%						X		X	X	X	X		X	X					
Tyromyces sp.		0	4											X						X					X	X		
Basidiomycetes,other aphyllophorales and gastromycetes																												
Cantharellus tubaeformis (Bull.: Fr.) Fr.	cantub	13	9		6%	8%	20%			20%			X				X				X	X	X					
Clavulina coralloides (L. : Fr.) J. Schroet.	clacor	3	5			4%	7%		4%												X		X					
Dentipellis fragilis (Pers.: Fr.) Donk	denfra	4	7	4%					8%				X	X					X			X				X		
Henningsomyces candidus (Pers.: Fr.) O.K.	hencan	1	1		2%																							
Hericium coralloides (Scop.: Fr.) Pers.	hercor	4	11		4%	X		X	8%				X	X					X	X			X		X			
Lentaria epichnoa (Fr.) Corner	lenepi	0	1																				X					
Lycoperdon foetidum Bonord.	lycfoe	4	1		8%																							
Lycoperdon perlatum Pers.: Pers.	lycper	35	18	8%	24%	16%		40%	16%	28%			X	X	X		X	X	X	X	X		X		X	X	X	
Lycoperdon pyriforme Schaeff.: Pers.	lycpyr	24	16		32%	12%		10%	8%	8%			X	X			X	X	X	X	X	X	X		X	X		
Mucronella calva (Alb. & Schwein.) Fr.		1	1		X																							
Multiclavula mucida (Pers.: Fr.) R.H. Petersen	mulmuc	21	9		30%	16%	7%	10%				X	X			X				X								
Mutinus caninus (Huds.: Pers.) Fr.	mutcan	3	5				7%	10%	4%									X					X					
Phallus impudicus L.: Pers.	phaimp	5	6	2%	4%	4%			4%										X				X					
Ramaria stricta (Pers.: Fr.) Quél.		2	5		X				4%	4%			X												X			
Scleroderma citrinum Pers.		1	1			4%																						
Stigmatolemma urceolata (Wallr.: Fr.) Donk		1	1		2%																							
Basidiomycetes,agarics and boletes																												
Agaricus dulcidulus S. Schulz. in Kalkbr.		0	1		X																							
Agaricus sylvicola (Vitt.) Peck		0	1		X																							
Amanita citrina (Scheaff.) Pers.		0	1																				X					
Armillaria lutea Gillet	armlut	31	19	6%	24%	4%	20%	X	40%	8%			X	X	X		X	X	X	X	X	X	X			X	X	
Bolbitius reticulatus (Pers.: Fr.) Rick.	bolret	5	6		2%		7%	10%		8%			X		X													
Boletus pascuus (Pers.) Krombh.		2	2						8%								X											
Boletus pruinatus Fr.		2	3	2%						4%			X															
Clitocybe metachroa (Fr.: Fr.) Kumm.	climet	9	7		12%			10%		8%			X		X					X						X		

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Clitocybe odora (Bull.: Fr.) Kumm.		1	3		2%								X									X						
Clitocybe phyllophila (Pers.: Fr.) Kumm.	cliphy	1	2		2%								X															
Clitopilus hobsonii (Berk.) P.D.Orton	clihob	3	6	4%		4%							X	X			X	X										
Collybia cookei (Bres.) J.D.Arnold	colcoo	4	6						12%	4%										X			X		X	X		
Collybia fagiphilus (Velen.) Antonín, Halling & Noordel.		2	2						4%	4%																		
Conocybe subpubescens P.D.Orton	consub	6	7	4%	4%			10%	4%				X							X			X					
Coprinus lagopus (Fr.: Fr.) Fr.		1	1					10%																				
Coprinus micaceus (Bull.: Fr.) Fr.	copmic	20	14	8%	14%	4%	7%	30%	12%	4%			X				X	X	X		X	X	X					
Coprinus spelaiophilus Bas & Uljé		0	1												X													
Cortinarius (telamonia) sp. 1		1	1						4%																			
Cortinarius (telamonia) sp. 2		1	1			4%																						
Cortinarius anomalus (Fr.: Fr.) Fr.	corano	6	4		2%	4%			4%	12%																		
Cortinarius casimiri (Velen.) Huijsman	corcas	3	2				13%		4%																			
Cortinarius cf. albovariegatus (Velen.) Melot		1	1				7%																					
Cortinarius decipiens (Pers.: Fr.) Fr.		2	1							8%																		
Cortinarius diasemospermus D. Lam.		2	2			4%				4%																		
Crepidotus applanatus (Pers.) Kumm.		0	2											X											X			
Crepidotus versutus (Peck) Sacc.	crever	3	3		2%	8%																	X					
Cystoderma amianthinum (Scop.) Kon. & Maubl.	cysami	8	9		10%			10%	4%	4%			X		X					X			X			X		
Cystoderma carcharias (Pers.) Konr. & Maubl.	cyscar	4	8	2%	2%				8%				X	X			X			X			X					
Cystoderma jasonis (Cooke & Mass.) Harm.		2	3				7%			4%			X															
Entoloma albotomentosum Noordel. & Hauskn.		1	1	2%																								
Entoloma cetratum (Fr.: Fr.) Moser	entcet	4	5		4%				4%	4%			X							X								
Entoloma conferendum (Britz.) Noordel.		2	2	2%					4%																			
Entoloma placidum (Fr.: Fr.) Noordel.		1	2	2%											X													
Entoloma proterum Noordel. & Wölfel		1	1		2%																							
Entoloma rhodopolium (Fr.: Fr.) Kumm.		0	1																						X			
Galerina atkinsoniana A.H.Smith	galatk	9	6	2%	8%	4%	7%	10%		4%																		
Galerina cf. laevis (Pers.) Sing.		0	1																				X					
Galerina marginata (Batsch) Kühner	galmar	92	20	28%	56%	44%	47%	70%	56%	44%			X	X	X		X	X	X	X	X	X	X		X	X	X	
Galerina pallida (Pilát) Horak & Moser		0	1																						X			
Galerina pseudobadipes Joss.		0	1																		X							

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Galerina pseudomniophila Kühner	galmni	7	3	8%	2%			10%																				
Galerina sahleri (Quel.) Kühn.		0	1																	X								
Galerina triscopa (Fr.) Kühner	galtri	1	1			4%																						
Galerina vittaeformis (Fr.) Singer	galvit	10	9	2%	8%	8%			8%	4%			X		X		X				X							
Galerinia vexans Smith & Sing.		0	2										X				X											
Gymnopilus sapineus (Fr.: Fr.) Maire	gymsap	6	9		2%			10%	12%	4%				X	X					X		X	X					
Hebeloma crustuliniforme (Bull.) Quél.		1	1							4%																		
Hohenbuehelia auriscalpium (Maire) Singer		2	1						8%																			
Hohenbuehelia fluxilis (Fr.: Fr.) P.D. Orton		1	1				7%																					
Hydnum rufescens Fr.	hydruf	11	3			8%	20%			24%																		
Hygrophoropsis aurantiaca (With.: Fr.) Maire	hygaur	1	1					10%																				
Hypholoma fasciculare (Huds.: Fr.) P.Kumm.	hypfas	39	21	8%	18%	32%	13%	10%	32%	28%			X	X	X	X	X	X	X	X	X	X	X	X	X		X	
Hypholoma lateritium (Schaeff.: Fr.) P.Kumm.	hyplat	10	16	2%	8%	4%	7%	10%	4%	4%			X	X	X			X	X	X		X	X			X		
Hypholoma marginatum (Pers.: Fr.) Schroet.		2	4				7%		4%						X				X									
Hypsizygus tessulatus (Bull.: Fr.) Sing.		0	1										X															
Inocybe cincinnata (Fr.: Fr.) Quél.		1	1						4%																			
Inocybe petiginosa (Fr.: Fr.) Gillet	inopet	29	14	2%	18%	32%	27%	10%	12%	12%			X	X	X							X	X		X		X	
Inocybe sindonia (Fr.) Karst.		1	1							4%																		
Laccaria amethystina Cooke	lacame	75	19	24%	44%	32%	47%	50%	40%	44%			X	X	X	X	X	X	X	X	X	X	X				X	
Laccaria laccata (Scop.: Fr.) Berk. & Br.	laclac	10	6	12%	4%	4%			4%				X												X			
Lactarius blennius (Fr.: Fr.) Fr.	lacble	17	12		8%	8%	7%		4%	36%			X		X		X				X	X	X				X	
Lactarius camphoratus (Bull.: Fr.) Fr.	laccam	3	2						4%	8%																		
Lactarius subdulcis (Bull.: Fr.) Gray	lacsub	13	6	8%			13%		24%	4%								X		X								
Lactarius tabidus Fr.	lactab	9	10		4%	16%	7%	10%	4%				X	X	X					X		X						
Lentinellus cochleatus (Pers.: Fr.) Karst.		0	1			X																						
Lentinellus ursinus (Fr.) Kühn.		0	2					X														X						
Lentinellus vulpinus (Sowerby: Fr.) Kühn. & Maire		0	2					X														X						
Lepiota felina (Pers.) Karst.	lepfel	5	5		8%	4%								X								X	X					
Lepista nuda (Bull.: Fr.) Cooke		0	1			X																						
Marasmiellus ramealis (Bull.: Fr.) Singer		0	1		X																							
Marasmius alliaceus (Jacq.: Fr.) Fr.	marall	99	21	58%	54%	40%	33%	20%	48%	56%			X	X	X		X	X	X	X	X	X	X		X	X	X	X
Megacollybia platyphylla (Pers.: Fr.) Kotl. & Pouz.	megpla	26	19	10%	14%	12%	7%	40%	12%	12%		X	X	X	X	X	X	X	X	X			X	X			X	

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Mycena abramsii (Murr.) Murr.	mycabr	2	2		2%	4%																						
Mycena cinerella (Karst.) Karst.	myccin	39	9	14%	24%	24%	20%	20%	24%	12%			X										X					
Mycena crocata (Schrad.: Fr.) Kumm.	myccro	3	4	6%	X								X						X									
Mycena epipterygia (Scop.: Fr.) S.F.Gray.		1	2		2%																						X	
Mycena erubescens Höhn.	myceru	21	12	2%	22%	16%	7%	30%		4%			X	X			X		X	X		X						
Mycena galericulata (Scop.: Fr.) Quél.	mycgal	33	19	8%	16%	28%	27%	20%	24%	8%			X	X			X	X	X	X	X	X	X		X	X	X	
Mycena galopus (Pers.: Fr.) Kumm.		0	1																								X	
Mycena haematopus (Pers.: Fr.) Kumm.	mychae	66	19	22%	32%	24%	33%	50%	48%	44%			X	X	X		X	X	X	X	X	X	X		X	X		
Mycena hiemalis (Osb.: Fr.) Quél.	mychie	12	6		16%		13%			8%					X		X		X									
Mycena metata (Fr.) Kumm.	mycmet	8	7	2%	8%	4%	7%	10%									X									X		
Mycena mirata (Peck.) Sacc.		1	1				7%																					
Mycena polygramma (Bull.: Fr.) Gray		1	3	2%				X					X															
Mycena pseudocorticola Kühn.	mycpse	8	5		2%	8%	13%		8%	4%																		
Mycena pura (Pers.: Fr.) Kumm.	mycpur	3	2	4%	2%																							
Mycena renati Quél.	mycren	6	7	2%	2%	8%	7%		4%							X				X								
Mycena sanguinolenta (Alb. & Schw.: Fr.) Kumm.	mycsan	9	6	2%	4%	4%		30%	8%																	X		
Mycena speirea (Fr.: Fr.) Gillet	mycspe	28	10	4%	8%	24%	27%	20%	16%	24%												X			X	X		
Mycena tintinabulum (Fr.) Quél.		1	1		2%																							
Mycena zephirus (Fr.: Fr.) Kumm.		1	4				7%								X		X						X					
Omphaliaster asterospora (Lange) Lamoure		1	1							4%																		
Omphalina epichysium (Pers.: Fr.) Quél.		1	2				7%						X															
Ossicaulis lignatilis (Pers.: Fr.) Redhead & Ginns		0	1																X									
Oudemansiella mucida (Schrad.: Fr.) Höhn.	oudmuc	23	18	4%	16%	12%	13%		24%	8%			X	X	X		X	X	X	X	X		X		X	X	X	
Panellus serotinus (Pers.: Fr.) Kühn.	panser	47	14	20%	24%	40%	20%	30%	20%	16%					X		X		X		X	X				X	X	
Panellus stipticus (Bull.: Fr.) Karst.	pansti	4	8	2%	2%		7%		4%				X	X			X		X									
Paxillus involutus (Fr.) Fr.	paxinv	4	5		4%	4%			4%				X	X														
Pholiota aurivellus (Fr.) Kumm.	phoaur	3	11		4%	4%	X		X				X	X			X	X	X	X		X						
Pholiota lenta (Pers.: Fr.) Singer		1	6		2%								X		X							X				X	X	
Pholiota lubrica (Pers.: Fr.) Sing.		1	1	2%																								
Pholiota mutabilis (Scop.: Fr.) Kumm.	phomut	9	10	4%	10%		7%		X	4%			X				X	X		X					X			
Pholiota squarrosa (Weigel: Fr.) Kumm.		0	1																X									
Pleurocybella porrigens (Pers.: Fr.) Singer		0	1																	X								

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Pleurotus dryinus (Pers.: Fr.) Kumm.		0	8		X	X		X		X				X	X				X			X						
Pleurotus ostreatus (Jacq.: Fr.) Kumm.	pleost	5	5		4%	X		10%	4%	4%																		
Pleurotus pulmonarius (Fr.) Quél.	plepul	13	8		8%	12%	X	10%	16%	4%						X						X						
Pluteus cervinus (Batsch) Singer	plucer	45	19	18%	26%	20%	20%	40%	24%	20%			X	X	X		X	X	X	X	X		X	X		X	X	
Pluteus luctuosus Boud.	pluluc	4	8		4%	8%	X		X				X									X	X		X			
Pluteus nanus (Pers.: Fr.) Kumm.		0	1		X																							
Pluteus pellitus (Pers.: Fr.) Kumm.		0	1																			X						
Pluteus petasatus (Fr.) Gillet		0	2		X	X																						
Pluteus phlebophorus (Dittm.: Fr.) Kumm.	pluphl	7	7	4%	6%	8%							X							X			X			X		
Pluteus plautus (Weinm.) Gillet	plupla	3	4	2%	2%					4%								X										
Pluteus podospileus Sacc. & Cub.	plupod	19	7		22%	8%			16%	8%			X					X					X					
Pluteus salicinus (Pers.: Fr.) Kumm.	plusal	1	2	2%																					X			
Pluteus semibulbosus (Lasch) Gill.	plusem	4	10	2%	X	4%	7%	10%					X		X		X					X	X					
Pluteus umbrosus (Fr.) Kumm.	pluumb	11	7		6%	4%	27%	20%		4%			X										X					
Psathyrella artemisiae (Pass.) Konr. & Maubl.	psaart	8	14		4%	4%	7%	30%	4%				X	X	X		X	X		X		X	X			X		
Psathyrella cernua (Vahl.: Fr.) Hirsch		2	3		2%	4%															X							
Psathyrella cotonea (Quél.) Konr. & Maubl.		1	4						4%						X					X								
Psathyrella fusca (Schum.) A.Pears.		1	1		2%																							
Psathyrella larga (Kauffman) A.H. Smith		2	3		2%	4%												X										
Psathyrella obtusata (Pers.: Fr.) A.H.Smith	psaobt	2	3		2%								X														X	
Psathyrella piluliformis (Bull.: Fr.) P.D.Orton	psapil	48	19	20%	20%	36%	13%	50%	40%	8%			X	X	X		X	X	X	X	X	X	X			X	X	
Psathyrella rostellata Örstadius	psaros	0	1																				X					
Psathyrella sarcocephala (Fr.) Sing.		0	1																X									
Pseudoclitocybe cyathiformis (Bull.: Fr.) Singer	psecya	11	7		12%	4%		X	16%				X	X													X	
Resupinatus applicatus (Batsch: Fr.) Gray		1	2		2%																	X						
Rhodocollybia butyracea (Bull.: Fr.) Lennox	colbut	7	9	6%	6%			10%					X	X					X			X	X			X		
Rickenella fibula (Bull.: Fr.) Raith.	ricfib	13	11	6%	6%	4%	13%		12%	4%					X		X			X	X	X						
Rickenella swartzii (Fr.: Fr.) Kuyper	ricswa	1	1						4%																			
Russula fellea (Fr.) Fr.		1	1						4%																			
Russula mairei Singer	rusmai	18	14	2%	6%	16%		10%	12%	24%			X		X		X	X	X		X	X	X					
Russula ochroleuca Pers.	rusoch	4	4	6%		4%							X					X										
Schizophyllum commune Fr.: Fr.	schcom	7	10	2%	2%	4%		20%	8%								X		X			X	X	X				

	Code used in ordination diagrams	number of trees	Number of sites	Dömestorp	Holkåsen	N Kroksjön	Kvinnsåsen	Trälhultet	Valaklitt	NV Äskemossen	NÖ Kroksjön	S. Ry	Mårås	Getabäcken	Blåalt	Almeberget	Skubbhult	Frodeparken	Myskebackarna	Skrockeberg	Svarta Klippan	Råmebo	Vallåsen	Klinta hallar	Nissaström	Rågetaåsen	Ödegärdet	Djupeåsen
Simocybe centunculus (Fr.: Fr.) Karst.	simcen	2	4		2%	4%								X									X					
Simocybe rubi (Berk.) Singer		2	1		4%																							
Sphaerobolus stellatus Tode: Pers.		1	1							4%																		
Stropharia aeruginosa (Curt.: Fr.) Quél.		0	1																				X					
Stropharia cyanea (Bull.) Tuomikoski	strcya	7	10	4%	4%	4%	7%			4%			X	X			X		X	X								
Stropharia hornemannii (Fr.: Fr.) Lundell	strhor	8	12	X	2%	12%	7%	20%		4%			X	X	X		X					X	X					
Tylopilus felleus (Bull.: Fr) Karst.		1	1				7%																					
Volvariella bombycina (Schaeff.: Fr.) Singer		0	1		X																							
Xerula radicata (Relhan: Fr.) Dörfelt	xerrad	15	16	6%	12%	4%	13%	30%	X	X	X		X	X	X	X		X		X			X				X	
Sterile mycelia																												
Anthinia flammea (Jungh.) Fr.		1	1			X																						

Appendix 4. List of all fungal species recorded in the project, sorted in major morphological groups. The locations of study sites are shown in Fig. 1. For the intensive study sites (Columns 5 – 11) the percentages of trees with sporocarps of each species are given. An “X” indicate that the species was only recorded supplementary on trees not included in the intensive study.