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The composition and structure of macrofungus communities in boreal upland type forests and peatlands in North Karelia, Finland

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As part of the 7th Finnish National Forest Inventory (7NFI), a network of permanent sample plots was established in North Karelia, Finland in 1980. All basidiocarps of macrofungi on each sample plot, 100 sq.m in size, were collected, counted, weighed and identified in 1981–1984. The sample plots represent nutrient-poor mineral soil and peatland site types with Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*) (sometimes with downy birch, *Betula pubescens*, on mesic mineral soils and mires) as the dominant tree species. The mires include virgin, recently drained, transitional and old peatland drainage sites. The commercial forests have undergone intensive logging (clear felling and thinning) in the past few years, and some mires have been ditched and fertilized.

Altogether 316 species of fungi were determined: 232 species of macrofungi (Polyporales, Boletales, Agaricales, Russulales) representing 61 genera, 73.4% of all mycoflora; 49 species, representing 34 genera, of Aphyllophorales (15.5%); and other fungi incl. Ascomycotina, 35 species (11.1%), representing 26 genera. The richest genera among the macrofungus species were *Cortinarius* (27 species), *Mycena* (19), *Russula* (16), *Lactarius* (15), *Tricholoma* (10), *Hygrophorus* (9) and *Collybia* (9). The 316 species of fungi that were identified were classified into three main ecological groups: mycorrhizal species according to their host tree species; saprophytic species (eight fertility groups according to what they usually acted upon); and parasites. Mesic forest site types had more versatile composition of mycorrhizal and saprophytic macrofungus species than did dryish and dry forest site types. Mycorrhizal macrofungus species accounted for more than 40% of all macrofungi in mineral soil forest and peatland site types. Drained peatland site types (especially pine bogs) had more macrofungus species than did virgin mires. TWINSPAN classification and DCA ordination were suitable in analysing the data on the macrofungi. The diversity of the macrofungi in mineral soil forest and peatland site types is discussed.

Key words: Basidiomycotina, Ascomycotina, macrofungus community, ecological group, mycorrhizal and saprophytic fungus, composition, structure, diversity, ordination, classification, boreal upland type forest, peatland, Finland

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Contents

Symbols

Forest site types in the middle boreal vegetation zone:

ECT	*Empetrum–Calluna* Type
EVT	*Empetrum-Vaccinium* Type
VMT	*Vaccinium-Myrtillus* Type
DeMT	*Deschampsia-Myrtillus* Type
GOMT	*Geranium-Oxalis-Myrtillus* Type

Development classes of tree stands:

0	Treeless site
1	Open area or seed tree stand
2	Small seedling stand
3	Advanced seedling stand
4	Young thinning stand
5	Advanced thinning stand
6	Mature stand
7	Shelterwood stand

Tree species:

0	Treeless site
1	Scots pine (*Pinus sylvestris*)
2	Norway spruce (*Picea abies*)
3	Silver birch (*Betula pendula*)
4	Downy birch (*Betula pubescens*)
5	Aspen (*Populus tremula*)
6	Grey alder (*Alnus incana*)
7	Common alder (*Alnus glutinosa*)
8	Rowan (*Sorbus aucuparia*)
9	Goat willow (*Salix caprea*)

Peatland site types:

RhK	Herb-rich hardwood-spruce mire
KgK	Oligo-mesotrophic paludified spruce forest
MK	*Vaccinium myrtillus* spruce mire
VSR	True tall sedge pine mire
PK	*Vaccinium vitis-idaea* spruce mire
KR	Spruce-pine mire
PsR	*Carex globularis* pine mire
IR	True dwarf shrub pine bog
TR	*Eriophorum vaginatum* pine bog
RaR	*Sphagnum fuscum* pine bog
LkN	Ombrotrophic small sedge bog

Fertility classes of site types applied in Huikari's system (e.g. Huikari 1974):

II	Rich forest types, herb-rich mires
III	Mesic forest types, tall-sedge and *Vaccinium myrtillus*-rich mires
IV	Dryish forest types, small-sedge and *Vaccinium vitis-idaea*-rich mires
V	Dry forest types, cottongrass and dwarf shrub-rich bogs
VI	Barren forest types, ombrotrophic *Sphagnum fuscum* rich bogs

Drainage stages:

lt	Natural stage
oj	Recently drained peatland
mu	Transitional drained peatland
tkg	Old peatland forest

Introduction

Compared to research carried out in the field of phytosociology, mycosociology (the study of communities of fungi) is a branch of science that has not been practised very much in Finland or elsewhere. This lack of research is explained by the complexity of mycocommunities, the great number of species in them, the dynamics of and seasonal variation in the production of their fruit bodies, the life cycle of ectomycorrhizal fungi and the lack of systematic sample plot networks.

At present, fungal studies have concentrated mainly on the production of fruit body, structures which constitute merely one stage in the life cycle of the fungi. The presence of fruit bodies is an indication of only one aspect of the ecology of a particular species.

Several studies dealing with yields of fungi and their species composition include results pertaining to fundamental issues associated with fungal communities and mycoecology in mineral soil forest sites: Haas (1932), Friedrich (1936, 1937) and Leischner–Siska (1939) in Germany; Wilkins & Harris (1946) in Britain; Lisiewska (1965, 1974, 1978), Gumińska (1966) and Holownia (1978) in Poland; Darimont (1973) in Belgium; Barkman (1976) in the Netherlands; Tortić & Lisiewska (1978) in Croatia; and De Dominicis & Barluzzi (1983) in Italy.

Working in Austria Höfler (1937) carried out one of the first methodological fungal studies in beech forests. He counted the number of fruit bodies and then determined their fresh weight. Höfler contended that fungi can be regarded as one component of a plant association alongside vascular plants and mosses, or that associations of fungi could be considered as sociological units of their own. Kalamees (1968, 1971, 1979, 1980a, 1980b), in Estonia, studied methodology-related problems of fungal communities, the

taxonomy of fungi, their occurrence during the different seasons of the year and ecological groups of macrofungi.

The yield study done by Petrenko (1978) also dealt with the structure of fungal communities. This work represents the first true mycosociological study in Russia. In the former Czechoslovakia, Fellner (1987, 1988a) investigated the problems associated with the classification of fungal communities

Mycosociological examination of fungi inhabiting mires was conducted by Lange (1948), in Denmark, who studied the occurrence of fungi as members of the plant community. Favre (1948) did research on fungi in bogs in the alpine and sub-alpine zone of the Jura Mountains in Switzerland. Since that times the fungal communities of various mires have been studied in many countries in Europe; examples include the works of Kreisel (1954), Kotlaba & Kubìč ka (1960), Veijalainen (1974), Einhellinger (1976, 1977, 1982), Salo (1979), Kalamees (1982), Kalamees & Raitviir (1982), Saari & Salonen (1983), Heimala–Raimas (1986) and Salonen & Saari (1990).

The first ecological study on fungi to be done in Finland was conducted in 1892–1894 and dealt with the larger fungi in the Vyborg region (Thesleff 1920), which now belongs to Russia. The yields of larger fungi on the mineral soil sites of southern and central Finland were studied, e.g. by Rautavaara (1947), Sjöblom et al. (1979), Vauras & Huhtinen (1980) and Hintikka (1988), the yields of larger fungi in northern Finland being studied, e.g. by Metsänheimo (1982, 1987), Herva & Norokorpi (1983), Ohenoja & Koistinen (1984) and Ohenoja (1993).

In Sweden Kardell et al. (1980) conducted a yield study of fungi in connection with a national forest inventory. Since then, several studies have been conducted in Sweden on the impacts of silvicultural measures on fungal yields (Wästerlund & Ingelög 1981, Kardell 1984, Kardell & Eriksson 1987).

In Norway, attention began to focus on mycosociology in the late 1970s and early 1980s (Gulden 1982), as shown by the ecological and sociological theses completed at the University of Oslo (Østmoe 1979, Kristoffersen 1981, Markussen 1982). Mehus (1986) studied the relationships between forest types and fungus flora.

The increasing application of computerised methods in connection with sociological studies that occurred in the 1980s introduced more quantitative aspects into the study of fungi. Arnolds (1981) and Jansen (1981) did research on the mycoecology and mycosociology of heaths and oak forests in the Netherlands. Later, Jansen & De Nie (1988) investigated the relationship between mycorrhizae and the fruit bodies of fungi in plantations of Douglas fir. In North America, the yields of mycorrhizal and saprophytic fungi in coniferous forests have been studied by several researchers, such as Vogt et al. (1980, 1981), Bills et al. (1986), and Villeneuve et al. (1989).

The pollution and decline of vast forest areas that was first observed in Central Europe in the mid-1980s also caught the attention of mycologists. It was observed that many ectomycorrhizal fungi had vanished from polluted areas over a span of just a few years. Damage was observed to have taken place in the fine roots and mycorrhizae (Hartig's net) of conifers, and it was generally thought that acid rain was responsible for the disappearance of the fungi (e.g. Meyer 1987, Blaschke 1988). The changes that have occurred in the chemistry of the soil have been the subject of intensive research during the past few years (e.g. Nilsson & Bergkvist 1983, Tyler 1985, Dighton & Skeffington 1987, Jansen 1988, van Breemen & van Dijk 1988, Dighton & Harrison 1990, Jansen & Dighton 1990). Field trials conducted in Germany by Winterhoff (1984), in the Netherlands by Arnolds (1985, 1988, 1991) and by Jansen & van Dobben (1987) have all observed a drop in the number of fruit bodies. In the former Czechoslovakia, Fellner (1988b, 1989) considered mycorrhizal fungi to be useful bioindicators of polluted air.

Studies dealing with the structure of plant communities have put multivariable methods to widespread use for the past fifteen years or so (Økland 1990). Finnish studies investigating the structure of fungal communities have applied ordination and classification methods to some extent (Jäppinen et al. 1986). Hansen (1988, 1989) used the principal component analysis method and discriminant analysis when studying the occurrence of macrofungi in beech forests in Sweden. The structure of fungal populations and fungal communities on mineral soil forest sites has been studied in Sweden by Dahlberg &

Stenlid (1990), Dahlberg (1991) and Dahlberg & Stenström (1991). In Canada, Nantel & Neumann (1992) used two canonical correspondence analyses and principal coordinates analysis to clarify the structure of tree and ectomycorrhizal-basidiomycete communities.

The purposes of this project were (1) to clarify the species composition of mycorrhizal and saprophytic fungi, and the structure of macrofungus communities in commercially logged forests of different ages on mineral soil sites and (2) to compare the species composition of the macrofungi of drained peatlands to those of virgin peatland sites. A further aim was (3) to test the applicability of community ecology methods in the grouping of sample plots and in classifying macrofungi.

Material and methods

Study area and sample plot network

The study area is situated within the middle boreal forest vegetation zone and the southern part of the Pohjanmaa fen region; i.e. in the transition area between the southern and middle boreal coniferous zones (Ahti et al. 1968, Kalliola 1973) (Fig. 1).

The study area is characterised by nutrient-poor mineral soil and peatland site types, the dominant tree species being Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*), and sometimes downy birch (*Betula pubescens*) on mesic mineral soil sites. Acidic podsol is the mineral soil type occurring in the area. The mires include both virgin and drained sites. The mineral soil forests of the region have been subjected to intensive logging (clear felling and thinning) in the past few years. Mires in the region have been ditched and fertilized.

The area has a mean elevation above sea level of 175 m in the southern parts, 190 m in the central parts and 200–220 m in the northern parts. The effective temperature sum (>5 °C) of the area during the growing season is c. 1000 d.d. (Sevola 1983). The average duration of the growing season (<5 °C) in the study area ranges from 145 to 150 days and the precipitation for the growing season is c. 300 mm, while the annual rainfall ranges between 550 and 600 mm (Kolkki 1966). The underlying bedrock in the study area consists mainly of granitic gneiss with small amounts of veined gneiss and granite (Pohjois-Karjalan luonnonympäristö 1974).

As part of the 7th Finnish National Forest Inventory (7NFI), a network of permanent all-purpose sample plots was established during the summer of 1980, in the area covered by the Nurmes Plan (Sevola 1983) within the Nurmes and Lieksa districts of the Forest and Park Service (Fig. 2). The area covered by the Nurmes Plan as well as the Lieksa district, serving as a control area, have a sample plot network that is denser than normal and within which the inventory blocks are located at intervals of 4 km instead of 8 km (Fig. 2). As a systematic sample, three permanent sample plots were marked out in each block of the field to be inventoried (Fig. 3). The figures include 54 additional sample plots examined in 1983 (stump and growing stock sample plots) and located 200 m away from the permanent sample plots (Fig. 3).

The distribution of the sample plots inventoried in 1981-1984 according to forest and peatland site types is shown in Table 1. Three main stages were distinguished in the successional development of peatlands: recently drained sites, transitional sites, and old peatland drainage sites (Sarasto 1957, 1961). These stages are included in the main classes of peatlands, while peatlands in their natural state are shown in parentheses (Table 1). Mixed forest and

Table 1. Numbers of sample plots representing various types of forest and peatland sites in the middle boreal vegetation zone (Pohjanmaa-Kainuu) in 1981–1984. Natural peatland site types in parentheses.

Year	GOMT	VMT	DeMT	EVT	ECT	Spruce mires	Pine mires and bogs	Treeless bogs and fens	Mixed forest and peatland site types	Total
1981	2	13	9	10		9(4)	17(6)	1(1)	18	79
1982		24	33	12		8(4)	44(7)	1(1)	14	136
1983		38	50	12		18(7)	44(6)	8(5)	22	192
1984		36	51	13		15(5)	44(6)	6(3)	24	189
Total	2	111	143	47		50(20)	149(25)	16(10)	78	596

GOMT *Geranium-Oxalis-Myrtillus* Type
VMT *Vaccinium-Myrtillus* Type
DeMT *Deschampsia-Myrtillus* Type
EVT *Empetrum-Vaccinium* Type
ECT *Empetrum-Calluna* Type

peatland site types have been placed into a category of their own, and they were also treated separately in the statistical processing of the material. The relative proportions of mixed forest and peatland types were determined visually. Vegetation cover analyses were employed as a means of ensuring the correctness of mixed forest and peatland type classifications.

With regard to sample plots located on forested land (forest land, scrub land, waste land), dryish (EVT) and mesic (VMT, DeMT) mineral soil forest types were well represented. Dry (ECT) and rich mineral soil sites (GOMT) were relatively rare (Table 1). Common peatland types included *Vaccinium myrtillus* spruce mires, true dwarf shrub pine bogs, *Eriophorum vaginatum* pine bogs, and *Carex globularis* pine mires and drained areas of the same, of various ages. Bogs characterised by *Sphagnum fuscum*, herbs and eutrophic fens were relatively rare.

Measurements and observations

When the permanent sample plots were established in 1980, the NFI crew recorded the parameters on the stand and the growing stock. Biologists made botanical assessments of the forest, peatland classifications, descriptions of vegetation cover, estimates of canopy cover, and berry and mushroom yield studies. The forest and peatland flora of the study area and the classification of the site types have been treated elsewhere by Hotanen & Nousiainen (1990).

Of the parameters on the growing stock recorded by the NFI crew, the following were used in this study: development class, dominant tree species, and other tree species present. In the field mineral soil sites were classified into the various site types (Lehto & Leikola 1987) and peatlands into mire, bog and fen types (Heikurainen & Pakarinen 1982, Huikari et al. 1964, 1974, Heikurainen 1986). Drained sites were also assessed for their drainage stage (recently drained, transitional, old drainage site) as described by Sarasto (1961). Regressive *Polytrichum commune* and *P. strictum* transitional sites were coded in this connection as being transitional drainage sites of the particular peatland type, without separating them into groups of their own.

The vegetation cover of species present in the field and ground layers were estimated from eight squares, each 1 m^2 in size, using a scale of +, 0.5, 1, 2, 3, 5, 7, 10, 12, 15, 20, 25...85, 90, 93, 95, 97, 98, 99, 100. Eight plant squares were systematically placed in the corners and in the middle of the sides of the mycoflora sample plot (Fig. 4).

In this study, the macrofungi include four orders: Polyporales, Boletales, Agaricales and Russulales. In addition to the macrofungi collected from the sample plots during 1981–1984, certain other fungi readily visible to the naked eye were also identified: Aphyllophorales, Heterobasidiomycetes, Gasteromycetes and Ascomycotina (Table 2).

The fungi were inventoried three times during the growing seasons of 1981 (79 sample plots) and 1982 (136) and twice (192 sample plots) in 1983. In 1984, the sample plots (189) were inventoried once. The total number of different sample plots visited was 596 (Table 1). Multivariable methods were used to analyse the macrofungal material collected in 1981.

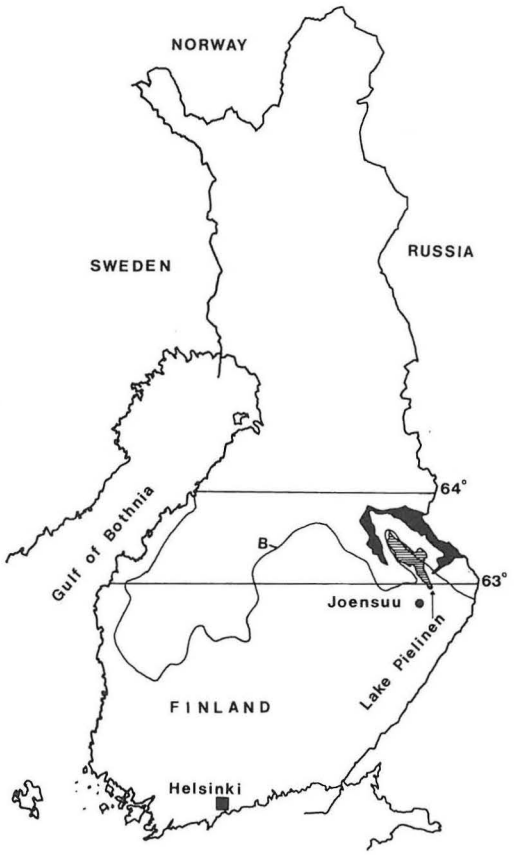

Fig. 1. Location of the study area (darkened). B = border between southern and middle boreal vegetation zones (Ahti et al. 1968).

The mycoflora sample plots were 0.01 (10 x 10 m) ha in size (Fig. 4). All basidiocarps of fungi found in the sample plots were collected, the numbers per species were tallied and their fresh weights were measured. A study concerning mushroom yields will be presented at a later date. All unidentified species were subjected to microscopic examination. The specimens are archived at H, JOE and OULU.

The following taxonomy and nomenclature were applied: Hämet-Ahti et al. (1986) for the vascular plants; Koponen et al. (1977) for mosses; and Ahti (1981) for lichens. The fleshy fungi largely follows that of Hansen & Knudsen (1992). The orders Aphyllophorales,

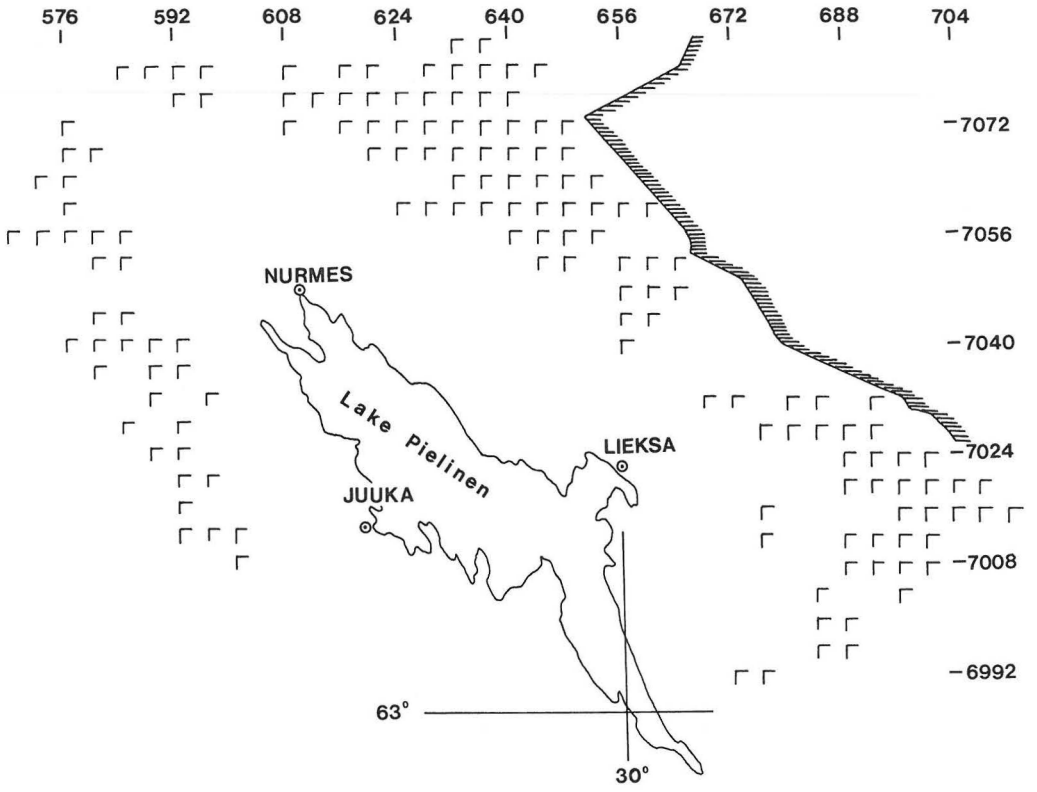

Fig. 2. Location of the inventory tracts and basic map (1:20 000) coordinates.

Heterobasidiomycetes and Gasteromycetes are treated in accordance with Jülich (1984) and Niemelä (1988). Ascomycetes according to Dennis (1978) and Breitenbach & Kränzlin (1981).

Table 2. The occurrence of various fungal groups in the sample plots studied.

Basidiomycotina	**293**
Polyporales, Boletales, Agaricales, Russulales	232
Aphyllophorales	49
Heterobasidiomycetes	9
Gasteromycetes	3
Ascomycotina	**23**
Discomycetes	17
Pyrenomycetes	5
Plectomycetes	1
Total	**316**

Numerical analysis

The measurement data collected from the sample plots were merged to form a file in which the record types were arranged in ascending order on the basis of the sample plot coordinates (y, x) and the number of the sample plot. The mean coverages of the plant species, expressed in percentages, were output for the forest and peatland sample plots and the mixed sites. TWINSPAN classification (Hill 1979a) and DCA ordination (Hill & Gauch 1980) were used in analysing the data on the macrofungi. The CONDENSE and DATAEDIT (Singer 1980) programs were used to process the data on the macrofungi. The data were grouped, according to the species of macrofungi as mycorrhizal fungi and saprophytic fungi. All species of Aphyllophorales, Heterobasidiomycetes, Gasteromycetes and Ascomycotina encountered on the sample plots were deleted from the data during the course of analysis.

Saprophytic fungi acting upon the dung of many herbivores can flourish on all forest and peatland site types visited by elk and hares. Mycorrhizal fungi specific to a single tree species (e.g. Scots pine) occur only on such forest and peatland types where this particular tree species

grows. Interpretations concerning the occurrence of mycorrhizal fungi are made difficult by fungi which can form mycorrhiza with more than one tree species. In this connection, the downweighting option of DCA was used to reduce the effect of rare species (Hill 1979b). Prior to the DCA analysis (under DATAEDIT), the fungus material was subjected to a logarithmic transformation serving to reduce the significance of fungus species with high biomasses. By observing the cluster of points (mycoflora sample plots) obtained in the ordination, conclusions were drawn as to the species of macrofungi on forest and peatland site types and also as to the grouping of the mycoflora sample plots in relation to one another.

In this study the variable used in connection with the TWINSPAN classification was the biomass of the macrofungus species (g/a), which was applied so that the abundance threshold values for indicator species were (on a logarithmic scale): 0, 0.3, 0.8, 1.2 and 2 g. In accordance with these threshold values, the biomasses were determined respectively as follows: 1 = 0.100–1.00 g, 2 = 2.00–6.29 g, 3 = 6.30–15.89 g, 4 = 15.90–99.99 g and 5 = more than 100.00 g. The TWINSPAN printouts for the forest and peatland site types and the mixed sample plots were drawn only up to the second divisional level; further divisional levels were impractical because the insufficiency of sample plots would have led to splitting of the material into units too small from the point of view of both interpretation and methodology.

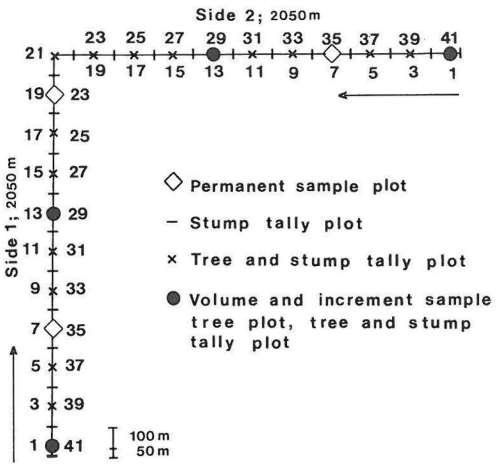

Fig. 3. Layout of a tract.

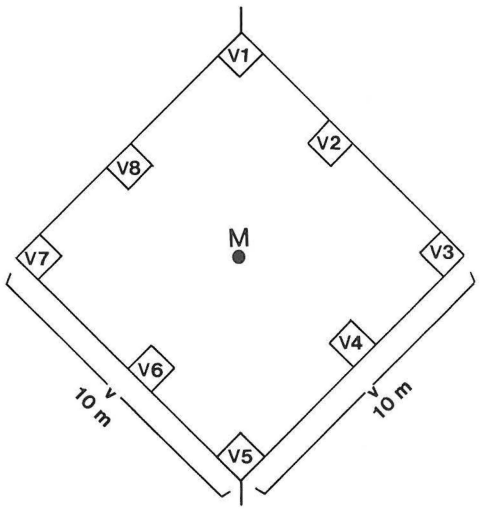

Fig. 4. Mycoflora sample plot (M) (100 sq.m) and location of vegetation sample plots (V) (8 x 1 sq.m).

Results

Mycoflora and ecological groups

During the period of 1981 to 1984, the following identifications were carried out: 316 species and groups of mycoflora; 232 species of macrofungi (Polyporales, Boletales, Agaricales, Russulales), representing 61 genera, 73.4% of all mycoflora; 49 species, representing 34 genera, of Aphyllophorales (15.5%) and other fungi incl. Ascomycotina, 35 species (11.1%), 26 genera (Table 3).

The richest genera among the macrofungus species were *Cortinarius* (27 species), *Mycena* (19), *Russula* (16), *Lactarius* (15), *Tricholoma* (10), *Hygrophorus* (9) and *Collybia* (9) (Table 3). Some genera containing unknown near-species were also identified in the cource of this study. *Cortinarius* spp. describes the group which includes near-species in the subgenera *Telamonia.*

The 316 species of fungi which were identified were placed into three main ecological groups: mycorrhizal species according to their host tree species; saprophytic species (eight fertility groups according to what they usually acted upon); and parasites (Table 4). The fertility groups of some mycorrhizal and saprophytic species were basis of the determined the literature (Trappe 1962, Hacskaylo 1965, Hintikka & Näykki 1967, Maas Geesteranus 1975, Brown & Sinclair 1981, Strid 1982 and Heiskanen & Ohenoja 1986). The composition of mycorrhizal species, wood, litter and other saprophytes is given in Tables 5–8.

Table 3. Mycoflora in boreal upland type forests and peatlands in North Karelia, Finland, 1981-1984.

BASIDIOMYCOTINA

I HYMENOMYCETES

1. Polyporales, Boletales, Agaricales, Russulales

1. *Lentinus conchatus* (Bull.: Fr.) Schroet.
2. *L. lepideus* (Fr.: Fr.) Fr.
3. *Pleurotus pulmonarius* (Fr.) Quél.
4. *Polyporus brumalis* (Pers.: Fr.) Fr.
5. *P. ciliatus* Fr.: Fr.
6. *P. varius* (Pers.) Fr.
7. *Hygrophoropsis aurantiaca* (Wulf.: Fr) Schroet.
8. *H. olida* (Quél.) Métr.
9. *Paxillus involutus* (Batsch : Fr.) Fr.
10. *P. atrotomentosus* (Batsch : Fr.) Fr.
11. *Boletus edulis* Bull.: Fr.
12. *B. pinophilus* Pilát & Dermek
13. *B. subtomentosus L.*: Fr.
14. *Chalciporus piperatus* (Bull.: Fr.) Bat.
15. *Leccinum vulpinum* Watl.
16. *L. aurantiacum* (Bull.) S. F. Gray
17. *L. versipelle* (Fr.) Snell
18. *L. niveum* (Fr.) Rauschert
19. *L. scabrum* (Bull.: Fr.) S. F. Gray
20. *L. variicolor* Watl.
21. *Chroogomphus rutilus* (Schaeff.: Fr.) O. K. Miller
22. *Gomphidius roseus* (Fr.) Fr.
23. *G. glutinosus* (Schaeff.: Fr.) Fr.
24. *Suillus flavidus* (Fr.: Fr.) J. S. Presl
25. *S. luteus* (L.: Fr.) Roussel
26. *S. bovinus* (L.: Fr.) Roussel
27. *S. variegatus* (Sw.: Fr.) O. Kuntze
28. *Tylopilus felleus* (Bull.: Fr.) Karst.
29. *Hygrophorus karstenii* Sacc. & Cub.
30. *H. piceae* Kühn.
31. *H. olivaceoalbus* (Fr.: Fr.) Fr.
32. *H. korhonenii* Harmaja
33. *H. agathosmus* (Fr.) Fr.
34. *H. pustulatus* (Pers.: Fr.) Fr.
35. *H. camarophyllus* (Alb. & Schw.: Fr.) Dumèe, Grandjean & Maire
36. *H. hypothejus* (Fr.: Fr.) Fr.
37. *Hygrophorus* sp.
38. *Armillaria borealis* Marxmüller & K. Korhonen
39. *Baeospora myosura* (Fr.: Fr.) Sing.
40. *Cantharellula umbonata* (Gmel.: Fr.) Sing.
41. *Clitocybe gibba* (Pers.: Fr.) Kumm.
42. *C. candicans* (Pers.: Fr.) Kumm.
43. *C. clavipes* (Pers.: Fr.) Kumm.
44. *C. fragrans* (With.: Fr.) Kumm.
45. *C. diatreta* (Fr.: Fr.) Kumm.
46. *C. ditopus* (Fr.: Fr.) Gill.
47. *C. vibecina* (Fr.) Quél. ss. lat.
48. *Clitocybe* spp.
49. *Collybia confluens* (Pers.: Fr.) Kumm.
50. *C. acervata* (Fr.) Kumm.
51. *C. putilla* (Fr.: Fr.) Sing.
52. *C. maculata* (Alb. & Schw.: Fr.) Kumm.
53. *C. butyracea* (Bull.: Fr.) Kumm.
54. *C. cirrata* (Pers.) Kumm.
55. *C. tuberosa* (Bull.: Fr.) Kumm.
56. *C. dryophila* (Bull.: Fr.) Kumm.
57. *C. succinea* (Fr.) Quél.
58. *Cyphellostereum laeve* (Fr.) Reid
59. *Cystoderma carcharias* (Pers.) Konr. & Maubl.
60. *C. amianthinum* (Scop.) Konr. & Maubl.
61. *C. granulosum* (Batsch : Fr.) Kühn.
62. *Fayodia maura* (Fr.) Sing.
63. *Flammulina velutipes* (Curt.: Fr.) Sing.
64. *Hohenbuehelia petalodes* (Bull.: Fr.) Schulz.
65. *Laccaria bicolor* (Maire) Orton
66. *L. proxima* (Boud.) Pat.
67. *L. laccata* (Scop.: Fr.) Berk. & Br.
68. *Lyophyllum fumosum* (Pers.: Fr.) Orton
69. *L. palustre* (Peck) Sing.
70. *Lyophyllum* sp.
71. *Marasmius epiphyllus* (Pers.:Fr.) Fr.
72. *M. androsaceus* (L.: Fr.) Fr.
73. *Megacollybia platyphylla* (Pers.: Fr.) Kotl. & Pouz.
74. *Melanoleuca* sp.
75. *Micromphale perforans* (Hoffm.: Fr.) S. F. Gray
76. *Mycena viscosa* Maire
77. *M. epipterygia* (Scop.: Fr.) S. F. Gray
78. *M. vulgaris* (Pers.: Fr.) Kumm.
79. *M. rorida* (Fr.: Fr.) Quél.
80. *M. clavicularis* (Fr.) Gill.
81. *M. galopus* (Pers.: Fr.) Kumm.
82. *M. sanguinolenta* (Alb. & Schw.: Fr.) Kumm.
83. *M. rosella* (Fr.) Kumm.
84. *M. rubromarginata* (Fr.: Fr.) Kumm.
85. *M. flavoalba* (Fr.) Quél.
86. *M. pura* (Pers.: Fr.) Kumm.
87. *M. cinerella* Karst.
88. *M. megaspora* Kauffm.
89. *M. galericulata* (Scop.: Fr.) S. F. Gray
90. *M. urania* (Fr.: Fr.) Quél.
91. *M. metata* (Fr.) Kumm.
92. *M. laevigata* (Lasch : Fr.) Gill.
93. M. stipata Maas G. & Schwöbel
94. *Mycena* sp.
95. *Omphaliaster borealis* (M. Lange & Skifte) Lamoure
96. *Omphalina umbellifera* (L.: Fr.) Quél.
97. *O. philonotis* (Lasch) Quél.
98. *O. oniscus* (Fr.: Fr.) Quél.
99. *O. fibula* (Bull.: Fr.) Quél.
100. *Panellus mitis* (Pers.: Fr.) Sing.
101. *P. serotinus* (Schrad.: Fr.) Kühn.
102. *Strobilurus stephanocystis* (Hora) Sing.
103. *S. esculentus* (Wulf.: Fr.) Sing.
104. *Tricholoma inamoenum* (Fr.: Fr.) Gill.
105. *T. album* (Fr.) Kumm.
106. *T. nauseosum* (Blytt) Kytövuori

107. *T. fulvum* (DC.: Fr.) Sacc.
108. *T. pessundatum* (Fr.) Quél. non ss. Lange
109. *T. aestuans* (Fr.) Gill.
110. *T. flavovirens* (Pers.: Fr.) Lundell
111. *T. portentosum* (Fr.) Quél.
112. *T. virgatum* (Fr.: Fr.) Kumm.
113. *Tricholoma* sp.
114. *Tricholomopsis rutilans* (Schaeff.: Fr.) Sing.
115. *T. decora* (Fr.) Sing.
116. *Xeromphalia campanella* (Batsch : Fr.) Kühn. & Maire
117. *X. caulicinalis* Kühn. & Maire
118. *X. fellea* Maire & Malenç.
119. *Amanita porphyria* (Alb. & Schw.: Fr.) Mlady
120. *A. virosa* (Fr.) Bertilloni
121. *A. muscaria* (L.: Fr.) Hook.
122. *A. regalis* (Fr.) Michael
123. *A. vaginata* (Bull.: Fr.) Vitt.
124. *A. fulva* (Schaeff.) Pers.
125. *Pluteus atricapillus* (Batsch) Fayod
126. *Pluteus* sp.
127. *Lepiota clypeolaria* (Bull.: Fr.) Kumm.
128. *Coprinus cinereus* (Schaeff.: Fr.) S. F. Gray
129. *C. radiatus* (Bolt.: Fr.) Pers.
130. *Coprinus* sp.
131. *Psathyrella candolleana* (Fr.: Fr.) Maire
132. *Psathyrella* sp.
133. *Hypholoma fasciculare* (Huds.: Fr.) Kumm.
134 *H. capnoides* (Fr.) Kumm.
135. *H. lateritium* (Schaeff.: Fr.) Schroet.
136. *H. myosotis* (Fr.) Moser
137. *H. udum* (Pers.: Fr.) Kühn.
138. *H. elongatum* (Pers.: Fr.) Rick.
139. *Hypholoma* sp.
140. *Kuehneromyces mutabilis* (Schaeff.: Fr.) Sing. & Smith
141. *Pholiota flammans* (Batsch : Fr.) Kumm.
142. *P. mixta* (Fr.) Sing.
143. *P. alnicola* (Fr.: Fr.) Sing.
144. *P. scamba* (Fr.: Fr.) Moser
145. *Pholiota* sp.
146. *Psilocybe magnivelaris* (Peck) Høiland
147. *Psilocybe* sp.
148. *Stropharia semiglobata* (Batsch : Fr.) Quél.
149. *S. aeruginosa* (Curt.: Fr.) Quél.
150. *S. hornemannii* (Fr.: Fr.) Lundell
151. *Agrocybe* sp.
152. *Cortinarius cinnamomeus* (L.: Fr.) Fr.
153. *C. croceus* (Schaeff.) Bigeard & Guillemin
154. *C. huronensis* Ammirati & Smith
155. *C. sanguineus* (Wulf.: Fr.) Fr.
156. *C. semisanguineus* (Fr.) Gill.
157. *C. orellanoides* Henry
158. *C. bolaris* (Pers.: Fr.) Fr.
159. *C. gentilis* (Fr.) Fr.
160. *C. vibratilis* (Fr.) Fr.
161. *C. delibutus* Fr.
162. *C. trivialis* Lange
163. *C. muscigenus* Peck
164. *C. mucosus* (Bull.: Fr.) Kickx
165. *C. triumphans* Fr.
166. *C. pholideus* (Fr.: Fr.) Fr.
167. *C. traganus* Fr.: Fr.) Fr.
168. *C. camphoratus* (Fr.) Fr.
169. *C. anomalus* (Fr.: Fr.) Fr.
170. *C. armillatus* (Fr.: Fr.) Fr.
171. *C. evernius* (Fr.: Fr.) Fr.
172. *C. brunneus* (Pers.: Fr.) Fr.
173. *C. laniger* Fr.
174. *C. obtusus* (Fr.) Fr.
175. *C. paleaceus* Fr.
176. *C. hemitrichus* (Pers.: Fr.) Fr.
177. *C. flexipes* (Pers.: Fr.) ss. Kühn.
178 *Cortinarius* spp.
179. *Galerina marginata* (Batsch) Kühn.
180. *G. paludosa* (Fr.) Kühn.
181. *G. tibiicystis* coll. (Atk.) Kühn.
182. *G. cf. sphagnorum* (Pers.: Fr.) Kühn.
183. *G. hypnorum* ss. lat. (Schrank : Fr.) Kühn.
184. *Galerina* spp.
185. *Gymnopilus penetrans* (Fr.) Murr.
186. *Hebeloma longicaudum* (Pers.: Fr.) Kumm. ss. Lange
187. *H. crustuliniforme* (Bull.) Quél.
188. *Hebeloma* sp.
189. *Inocybe lanuginosa* (Bull.: Fr.) Kumm.
190. *I. lacera* (Fr.) Kumm.
191. *Inocybe* sp.
192. *Naucoria* sp.
193. *Phaeocollybia* sp.
194. *Rozites caperatus* (Pers.: Fr.) Karst.
195. *Tubaria confragosa* (Fr.) Kühn.
196. *Entoloma nitidum* (Quél.) Quél.
197. *E. cetratum* (Fr.: Fr.) Moser
198. *Entoloma* sp. 1. incl. E. nidorosum (Fr.) Quél.
199. *Entoloma* sp. 2. incl. E. sericatum (Britz.) Sacc.
200. *Lactarius deterrimus* Gröger
201. *L. scrobiculatus* (Scop.: Fr.) Fr.
202. *L. necator* (J. F. Gmel.: Fr.) Pers.
203. *L. torminosus* (Schaeff.: Fr.) Pers.
204. *L. uvidus* (Fr.: Fr.) Fr.
205. *L. musteus* Fr.
206. *L. trivialis* (Fr.: Fr.)Fr.
207. *L. utilis* (Wein.) Fr.
208. *L. vietus* (Fr.) Fr.
209. *L. glyciosmus* (Fr.: Fr.) Fr.
210. *L. mammosus* (Fr. ex Weinm.) Fr.
211. *L. helvus* (Fr.) Fr.
212. *L. rufus* (Scop.: Fr.) Fr.
213. *L. theiogalus* (Bull.: Fr.) S. F. Gray ss. Neuhoff
214. *L. camphoratus* (Bull.: Fr.) Fr.
215. *Russula adusta* Fr.
216. *R. claroflava* Grove
217. *R. foetens* Pers.: Fr.
218. *R. consobrina* (Fr.: Fr.) Fr.
219. *R. aeruginea* Lindbl.
220. *R. decolorans* (Fr.) Fr.
221. *R. paludosa* Britz.
222. *R. nitida* (Pers.: Fr.) Fr.
223. *R. vesca* Fr.

(Contd.)

Table 3. Contnd.

224. *R. vinosa* Lindbl.
225. *R. xerampelina* (Schaeff.) Fr.
226. *R. emetica* (Schaeff.: Fr.) Pers.
227. *R. rhodopoda* Zvára
228. *R. betularum* Hora
229. *R. gracillima* Schaeff.
230. *Russula* sp.
231. *Lentinellus cochleatus* (Pers.: Fr.) Karst.
232. *L. omphalodes* (Fr.) Karst.

2. Aphyllophorales

233. *Cantharellus cibarius* Fr.
234. *C. tubaeformis* Fr.
235. *Clavaria argillacea* Pers.: Fr.
236. *Clavaria* sp.
237. *Clavariadelphus ligula* (Schaeff.: Fr.) Donk
238. *Ramaria* sp.
239. *Hydnum rufescens* Fr.
240. *Cytidia salicina* (Fr.) Burt
241. *Cylindrobasidium evolvens* (Fr.: Fr.) Jülich
242. *Merulius tremellosus* Fr.
243. *Plicatura nivea* (Fr.) Karst.
244. *Stereum sanguinolentum* (Alb. & Schw.: Fr.) Fr.
245. *S. rugosum* (Pers.: Fr.) Fr.
246. *S. hirsutum* (Willd.: Fr.) S. F. Gray
247. *Phlebiopsis gigantea* (Fr.) Jülich
248. *Thelephora terrestris* Pers.: Fr.
249. *Hydnellum ferrugipes* Coker
250. *H. ferrugineum* (Fr.: Fr.) Karst.
251. *H. aurantiacum* (Batsch : Fr.) Karst.
252. *H. suaveolens* (Scop.: Fr.) Karst.
253. *Sarcodon imbricatus* (L.: Fr.) Karst.
254. *Bankera fuligineo-alba* (Schmidt : Fr.) Pouzar
255. *Phellodon tomentosus* (L.: Fr.) Banker
256. *Coltricia perennis* (L.: Fr.) Murrill
257. *Inonotus obliquus* (Pers.: Fr.) Pilát
258. *Phellinus pini* (Brot.: Fr.) Ames
259. *P. conchatus* (Fr.) Quél.
260. *P. tremulae* (Bond.) Bond. & Borisov. in Bond
261. *P. nigricans* (Fr.) Karst.
262. *P. igniarius* (L.: Fr.) Quél.
263. *Ganoderma lipsiense* (Batsch) Atk.
264. *Scutiger confluens* (Alb. & Schw.: Fr.) Bond. & Sing.
265. *S. ovinus* (Schaeff.: Fr.) Murrill
266. *Piptoporus betulinus* (Bull.: Fr.) Karst.
267. *Hapalopilus rutilans* (Pers.: Fr.) Karst.
268. *Postia tephroleuca* (Fr.) Jülich
269. *Postia* sp.
270. *Bjerkandera adusta* (Willd.: Fr.) Karst.
271. *Cerrena unicolor* (Bull.: Fr.) Murrill
272. *Lenzites betulinus* (L.: Fr.) Fr.
273. *Pycnoporus cinnabarinus* (Jacq.: Fr.) Karst.
274. *Trametes multicolor* (Schaeff.) Jülich
275. *T. pubescens* (Schum.: Fr.) Pilát
276. *Trichaptum abietinum* (Pers.: Fr.) Ryv.
277. *T. hollii* (J. C. Schmidt) Kreisel
278. *Fomes fomentarius* (L.: Fr.) Fr.
279. *Fomitopsis pinicola* (Sw.: Fr.) Karst.
280. *Gloeophyllum sepiarium* (Wulf.: Fr.) Karst.
281. *Heterobasidion annosum* (Fr.) Bref.

3. Heterobasidiomycetes

31. Tremellales

282. *Exidia glandulosa* Fr.
283. *Pseudohydnum gelatinosum* (Scop.: Fr.) Karst.
284. *Tremella mesenterica* Retz.
285. *T. foliacea* Pers.: Pers.

32. Dacrymycetales

286. *Calocera viscosa* (Pers.: Fr.) Fr.
287. *Dacrymyces stillatus* Nees : Fr.

33. Exobasidiales

288. *Exobasidium vaccinii* (Fuckel) Woronin
289. *E. karstenii* Sacc. & Trott.
290. *E. sundstroemii* Nannf.

4. Gasteromycetes

41. Lycoperdales

291. *Bovista nigrescens* Pers.: Pers.
292. *Lycoperdon pyriforme* Schaeff.: Pers.
293. *L. perlatum* Pers.: Pers.

ASCOMYCOTINA

I DISCOMYCETES

1. Pezizales

294. *Gyromitra esculenta* (Pers.) Fr.
295. *G. infula* Schaeff.: Quél.
296. *Peziza badia* Pers.: Fr.
297. *Peziza* sp.
298. *Otidea leporina* (Batsch : Fr.) Fuck.
299. *Scutellinia scutellata* (L.: Fr.) Lambotte
300. *Nannfeldtiella aggregata* Eckbl.
301. *Byssonectria aggregata* (Berk. & Broome) Rogerson & Korf

2. Leotiales

302. *Leotia lubrica* Pers.: Fr.
303. *Heyderia abietis* (Fr.) Link
304. *H. pusilla* (Alb.: Schwein.) Link
305. *Cudonia circinans* (Pers.) Fr.
306. *C. confusa* Bres.
307. *Rutstroemia firma* (Pers.) Karst.
308. *Ascocoryne sarcoides* (Jacq.: Fr.) Groves & Wilson
309. *Bisporella citrina* (Batsch : Fr.) Korf & Carpenter
310. *Lachnellula subtilissima* (Cooke) Dennis

II PYRENOMYCETES

1. Clavicipitales

311. *Cordyceps ophioglossoides* (Ehrh.: Fr.) Link
312. *C. canadensis* Ellis & Everhart

(Contd.)

Table 3. Contnd.

2. Sphaeriales

313. *Podostroma nybergianum* Ulvinen, ined.
314. *Nectria cinnabarina* (Tode : Fr.) Fr.
315. *Hypoxylon multiforme* (Fr.: Fr.) Fr.

III PLECTOMYCETES

1. Plectascales

316. *Elaphomyces granulatus* Fr.

Finnish forestry suffers great annual losses because of the damage to heartwood caused by many Aphyllophorales species, presented as wood saprophytes although many of them are also parasitic (Table 6). The species observed on live (and dying) trees growing on the sample plots were as follows: *Phellinus pini* (on pine), *P. tremulae* (on aspen) and *P. nigricans, P. igniarius, Inonotus obliquus, Fomes fomentarius, Piptoporus betulinus* (on birches) and *Fomitopsis pinicola* (on spruce). *F. pinicola* was observed to occur on spruce stumps although the species usually favours the boles of dead spruces as its substrate. *Stereum sanguinolentum* is a wound parasite of spruce; its spores infect live trees through above-ground root injuries, through holes made by increment bores and through pruning scars (Kauppila & Niemelä 1986). *S. sanguinolentum* is presented as a wood saprophyte; each time it was observed, it had established itself on spruce stumps at sites that had been logged (Table 6).

The largest group of other saprophytes (Table 8) consisted of saprophytes feeding on forest and peatland mosses; these 17 species inhabited the uppermost forest moss layer (made up of *Pleurozium schreberi, Dicranum polysetum, Hylocomnium splendens*) of the mineral soil (podsol) type. The hyphae of the fungi are often below this live layer, in the litter and the dead part of the moss layer. The species of fungi that grew among *Sphagnum* species were classified as *Sphagnum* saprophytes.

Peat saprophytes (Table 8) grew in the peat substrate provided by the banks of peat alongside the ditches of drained areas. *Omphalina umbellifera* forms a symbiotic association with

Table 4. Distribution of macrofungi into different ecological groups.

I Mycorrhizal fungi of coniferous and deciduous trees — 125 species, 39.6%

1. Scots pine (*Pinus sylvestris*) — 51 species
2. Norway spruce (*Picea abies*) — 38 species
3. Downy birch (*Betula pubescens*) — 29 species
4. Silver birch (*Betula pendula*) — 6 species
5. Aspen (*Populus tremula*) — 1 species

II Saprophytes— 184 species, 58.2%

1. Wood saprophytes —82 species

11. Scots pine
12. Norway spruce
13. Silver and downy birch
14. Aspen
15. Grey alder (*Alnus incana*)
16. Rowan (*Sorbus aucuparia*)
17. Goat willow (*Salix caprea*)
18. Rotten conifer wood
19. Rotten deciduous wood

2. Litter saprophytes — 71 species

21. Conifer and deciduous litter
22. Saprophytes specialising in certain parts of litter
221. Herbs and grasses
222. Needles of Scots pine and Norway spruce
223. Cones of Scots pine and Norway spruce
224. Aspen leaves

3. Moss saprophytes — 17 species

31. Forest bryophytes
32. *Sphagnum* species on peatlands

4. Saprophytes on herbivore dung — 5 species
5. Peat saprophytes — 3 species
6. Saprophytes on an organic base in mineral soil — 3 species
7. Fungal saprophytes —2 species
8. Saprophytes on burnt ground — 1 species

III Parasites — 7 species, 2.2%

1. Trees — 2 species
2. Dwarf-shrubs — 3 species
3. Fungi — 2 species

Table 5. Mycorrhizal fungi of coniferous and deciduous tree species.

Scots pine, 51 species

Suillus flavidus
S. luteus
S. bovinus
S. variegatus
Boletus pinophilus
Tylopilus felleus
Leccinum vulpinum
Comphidius roseus
Chroogomphus rutilus
Hygrophorus karstenii
H. hypothejus
H. camarophyllus
Laccaria bicolor
Tricholoma nauseosum
T. pessundatum
T. portentosum
T. aestuans
T. flavovirens
Tricholoma sp.
Amanita fulva
A. porphyria
Inocybe lacera
Hebeloma longicaudum
Cortinarius huronensis
C. croceus
C. semisanguineus
C. gentilis
C. traganus
C. muscigenus
C. mucosus
C. laniger
C. obtusus
C. croceus
Rozites caperatus
Russula adusta
R. decolorans
R. vesca
R. paludosa
R. emetica
Lactarius musteus
L. helvus
L. rufus
L. mammosus
Telephora terrestris
Hydnellum ferrugipes
H. ferrugineum
H. aurantiacum
H. suaveolens
Sarcodon imbricatus
Bankera fuligineo-alba
Phellodon tomentosus
Elaphomyces granulatus

Norway spruce, 38 species

Xerocomus subtomentosus
Chalciporus piperatus
Boletus edulis
Comphidius glutinosus
Hygrophorus piceae
H. olivaceoalbus
H. korhonenii
H. agathosmus
H. pustulatus
Hygrophorus sp.
Laccaria laccata
L. proxima
Tricholoma inamoenum
Amanita regalis
A. virosa
Cortinarius cinnamomeus
C. sanguineus
C. orellanoides
C. camphoratus
C. trivialis
C. delibutus
C. vibratilis
C. evernius
C. brunneus
C. flexipes
Cortinarius spp.
Russula consobrina
R. xerampelina
R. rhodopoda
Lactarius scrobiculatus
L. deterrimus
L. necator
L. utilis
L. trivialis
L. camphoratus
L. theiogalus
Cantharellus tubaeformis
Hydnum rufescens

Downy birch, 29 species

Leccinum versipelle
L. variicolor
L. holopus
L. scabrum
Paxillus involutus
Tricholoma fulvum
Amanita vaginata
A. muscaria
Inocybe lanuginosa
Inocybe sp.
Hebeloma crustuliniforme
Hebeloma sp.
Naucoria sp.
Cortinarius bolaris
C. triumphans
C. armillatus
C. paleaceus
C. hemitrichus
Russula foetens
R. vinosa
R. aeruginea
R. nitida
R. betularum
R. gracillima
Russula sp.
Lactarius torminosus
L. uvidus
L. vietus
Cantharellus cibarius

Silver birch, 6 species

Tricholoma album
T. virgatum
Cortinarius pholideus
C. anomalus
Russula claroflava
Lactarius glyciosmus

Aspen, 1 species

Leccinum aurantiacum

green algae, and is considered to be a lichen (Heikkilä & Kallio 1966). This symbiotic association may benefit *O. umbellifera* through the more active production of fruit bodies, for instance; *O. umbellifera* is common in the palsa bogs of Finnish Lapland (Tuomikoski 1960) and the raised bogs in the Jura mountains of Switzerland, where it grows among *Sphagnum* communities (Favre 1948).

Heterobasidion annosum is concidered here to be a parasite (alternatively also a wood saprophyte) (Table 9) that establishes itself in trees by infecting first the root of the tree and then the bole, eventually causing the tree to die. Tree death opens the way for a host of wood saprophytes (Cooke & Rayner 1984). Another parasite of trees is *Armillaria borealis* (Table 9). *Armillaria* has been found to include both parasitic and saprophytic species (Korhonen 1978, Hansen & Knudsen 1992).

Table 6. Wood saprophytes. Gill fungi (agarics) underlined.

Tree species and substrate	Trunks	Branches	Stumps
Scots pine	*Phellinus pini*		*Lentinus lepideus* *Phlebiopsis gigantea*
Norway spruce	*Hygrophoropsis aurantiaca* *Pholiota flammans* *Galerina marginata* *Trichaptum abietinum* *T. hollii*	*Panellus mitis* *Cylindrobasidium evolvens* *Dacrymyces stillatus*	*Paxillus atrotomentosus* *Tricholomopsis decora* *T. rutilans* *Collybia acervata* *Mycena viscosa* *M. laevigata* *M. stipata* *Xeromphalia campanella* *Hypholoma capnoides* *Pholiota scamba* *Gymnopilus penetrans* *Stereum sanguinolentum* *Postia tephroleuca* *Fomitopsis pinicola* *Gloephyllum sepiarium* *Pseudohydnum gelatinosum* *Calocera viscosa* *Ascocoryne sarcoides* *Lachnellula subtilissima*
Silver and downy birch	*Pleurotus pulmonarius* *Flammulina velutipes* *Pluteus atricapillus* *Inonotus obliquus* *Phellinus nigricans* *P. igniarius* *Piptoporus betulinus* *Lenzites betulinus* *Trametes pubescens* *Fomes fomentarius* *Bisporella citrina*	*Polyporus brumalis* *P. varius* *Lentinellus omphalodes* *Stereum rugosum* *Postia* sp. *Cerrena unicolor* *Pycnoporus cinnabarinus* *Tremella mesenterica* *T. foliacea* *Scutellinia scutellata* *Nectria cinnabarina* *Hypoxylon multiforme*	*Polyporus ciliatus* *Panellus serotinus* *Mycena galericulata* *Hypholoma lateritium* *H. fasciculare* *Kuehneromyces mutabilis* *Lentinellus cochleatus* *Merulius tremellosus* *Stereum hirsutum* *Bjerkandera adusta*
Aspen	*Phellinus tremulae* *Ganoderma lipsiense*		*Trametes multicolor*
Grey alder	*Pholiota alnicola* *Plicatura nivea*	*Exidia glandulosa* *Rutstroemia firma*	
Rowan	*Panus conchatus*		
Goat willow	*Phellinus conchatus* *Hapalopilus rutilans*	*Cytidia salicina*	
	Trunk, branches and stumps		
Rotten conifer wood	*Megacollybia platyphylla* *Galerina hypnorum ss. lat.* *Pholiota* sp. *Phaeocollybia* sp. *Lycoperdon pyriforme* *Gyromitra infula*		
Rotten deciduous tree wood	*Pluteus* sp. *Tubaria confragosa*		

Ordination and classification of sample plots on the basis of macrofungi

Mineral soil forest site types

Ordination of the seventy-nine sample plots established on the basis of macrofungi in 1981 provided a complex picture. The greatest sample point values for axis 1 were obtained for the ECT sample plots. The sample plots closest to origin represented drained bogs and mires; mixed sample plots also occurred in different parts of the ordination, without any systematic order. This is understandable, as the mixed sample plots varied highly in their proportions of peatland and mineral soil and in their macrofungi. The greatest sample plot point values for axis 2 were obtained for the LkN sample plot, two virgin RaRs and four TRs, three of which were in the virgin state. With this initial analysis as the basis, the material was divided into the following strata: sample plots of the forest site type with mineral soil (34 in number); sample plots of the peatland site type

Table 7. Litter saprophytes.

Litter of coniferous and deciduous tree species, 54 species (or species groups)

Hygrophoropsis olida
Omphaliaster borealis
Clitocybe clavipes
C. gibba
C. candicans
C. fragrans
C. diatreta
C. ditopus
C. vibecina
Clitocybe spp.
Lyophyllum fumosum
Lyophyllum sp.
Marasmius androsaceus
Collybia confluens
C. succinea
C. dryophila
C. butyracea
C. maculata
Collybia sp.
Mycena vulgaris
M. clavicularis
M. rorida
M. sanguinolenta
M. flavoalba
M. pura
M. rosella
M. rubromarginata
M. metata
Mycena sp.
Xeromphalia caulicinalis
X. fellea
Entoloma nitidum
E. cetratum
Cystoderma amianthinum
C. carcharias
C. granulosum
Stropharia hornemannii
Hypholoma sp.
Psilocybe sp.
Pholiota mixta
Clavaria argillacea
Clavaria sp.
Clavariadelphus ligula
Ramaria sp.
Coltricia perennis
Scutiger confluens
S. ovinus
Lycoperdon perlatum
Gyromitra esculenta
Otidea leporina
Leotia lubrica
Cudonia circinans
C. confusa
Podostroma nybergianum

Saprophytes specialising in certain parts of litter, 17 species

Herbs and grasses
Melanoleuca sp.
Mycena epipterygia
Lepiota clypeolaria
Corpinus sp.
Psathyrella candolleana
Psathyrella sp.
Agrocybe sp.
Psilocybe magnivelaris
Stropharia aeruginosa
Bovista nigrescens

Needles of Scots pine and Norway spruce
Heyderia pusilla (Scots pine)
H. abietis (Norway spruce)
Micromphale perforans (Norway spruce)

Cones of Scots pine and Norway spruce
Strobilurus stephanocystis (Scots pine)
S. esculentus (Norway spruce)
Baeospora myosura (Norway spruce)

Aspen leaves
Marasmius epiphyllus

(27); and mixed sample plots (18), the last mentioned stratum containing elements of both forest and peatland site types in the one sample plot or two different forest or peatland site type segments.

The commonest dwarf shrubs on the forest site type sample plots were *Vaccinium vitis-idaea* and *V. myrtillus*; they were present on every sample plot (Table 10). Other common dwarf shrubs were *Empetrum nigrum* coll. (fr. 21) and *Calluna vulgaris* (fr. 21). Grasses and herbs were not abundant in the field layer. The commonest species was *Deschampsia flexuosa* (fr. 22). Forest mosses (*Dicranum polysetum*, *Pleurozium schreberi*, *Dicranum scoparium*, *Hylocomium splendens*) were common in the ground layer (Table 10). Lichens (e.g. *Cladonia rangiferina, C. deformis, C. arbuscula*) were common, and formed extensive communities on ECT and EVT sample plots.

The first axis of the DCA analysis is a complex one, depicting mainly the nutritional state; it is also associated with the tree species (Fig. 5). The highest values were obtained for sample plots representing dry mineral soil sites. Sample plots representing the most fertile dryish and mesic mineral soil sites and rich mineral soil sites were located closer to the origin (Fig. 5).

In the TWINSPAN classification performed on the basis of the macrofungal species, dry heath forest soil sites and dryish and mesic heath forest soil sites emerged on the first divisional level (Fig. 6). The indicator species for dry heath forest mineral soil sites were *Cortinarius semisanguineus*, *Suillus variegatus* and *Cortinarius croceus*. Dryish and mesic heath forest mineral soil sites were characterised by *Laccaria laccata*, *Mycena galopus*, *Hypholoma capnoides* and *Clitocybe* spp. (Fig. 6).

On the second divisional level, where the dryish and mesic heath forest mineral soil sites were divided into two groups, the indicator species for mesic mineral soils sites were *Cortinarius* spp. Three sample plots in the group of dry heath forests soil sites; their indicator species were *Cortinarius muscigenus* and *Mycena sanguinolenta* (Fig. 6). The TWINSPAN classification was continued to the third divisional level, but owing to the small amount of material in question, it was not meaninful (from the ecological point of view) to

Table 8. Other saprophytes.

Moss saprophytes, 17 species
- Forest bryophytes
  - *Omphalina fibula*
  - *Cyphellostereum laeve*
  - *Cantharellula umbonata*
  - *Mycena galopus*
  - *M. cinerella*
  - *M. urania*
  - *Entoloma* sp. 1. (incl. *E. nidorosum*)
  - *Galerina* spp.
- *Sphagnum* species on peatlands
  - *Omphalina philonotis*
  - *Lyophyllum palustre*
  - *Mycena megaspora*
  - *Entoloma* sp. 2. (incl. *E. sericatum*)
  - *Hypholoma elongatum*
  - *H. myosotis*
  - *Galerina paludosa*
  - *G.* cf. *sphagnorum*
  - *G. tibiicystis* coll.

Saprophytes on herbivore dung, 5 species
- *Coprinus cinereus*, Elk
- *C. radiatus*, Elk
- *Stropharia semiglobata*, Hare
- *Nannfeldtiella aggregata*, Elk
- *Byssonectria aggregata*, Elk

Peat saprophytes, 3 species
- *Omphalina umbellifera*
- *O. oniscus*
- *Hypholoma udum*

Saprophytes on an organic base in mineral soil, 3 species
- *Hohenbuehelia petaloides*
- *Peziza badia*
- *Peziza* sp.

Fungal saprophytes on rotten *Lactarius* and *Russula* species, 2 species
- *Collybia tuberosa*
- *C. cirrhata*

Saprophyte on burnt ground, 1 species
- *Fayodia maura*

Table 9. Parasites and hosts.

Tree parasites	Hosts
Armillaria borealis	Norway spruce
Heterobasidion annosum	Norway spruce
Dwarf-shrub parasites	
Exobasidium vaccinii	*Vaccinium vitis-idaea*
E. karstenii	*Andromeda polifolia*
E. sundstroemii	*A. polifolia*
Fungal parasites	
Cordyceps ophioglossoides	*Elaphomyces granulatus*
C. canadensis	*E. granulatus*

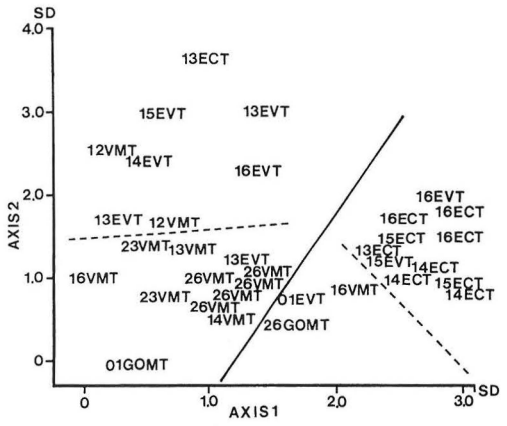

Fig. 5. DCA ordination of forest site types on the basis of macrofungi. TWINSPAN cut levels: 1. division = ———, 2. division = -----. Eigenvalues: 1. axis = 0.494, 2. axis = 0.376. The numbers in front of the abbreviations for the forest site types represent the dominant tree species and development class. Dominant tree species: 0 = Treeless site, 1 = Pine, 2 = Spruce, 3 = Silver birch, 4 = Downy birch. Development class: 0 = Treeless site, 1 = Open area or seed tree stand, 2 = Small seedling stand, 3 = Advanced seedling stand, 4 = Young thinning stand, 5 = Advanced thinning stand, 6 = Mature stand, 7 = Shelterwood stand.

try to interpret findings for the small groups obtained. According to the main division obtained with the TWINSPAN method, sample plots representing dryish and mesic heath forest soil sites dominated by spruce received lower values for the first axis than did pine-dominated sample plots.

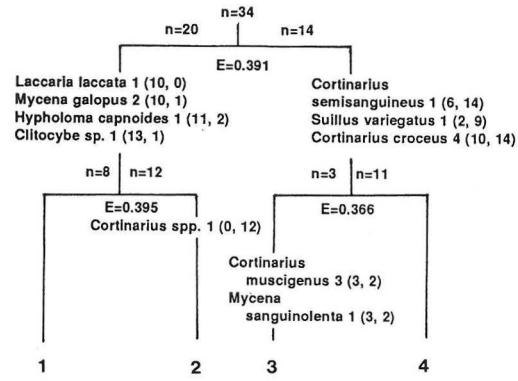

Fig. 6. TWINSPAN dendrogram of mineral forest site types on the basis of macrofungi. The indicator species of each division are given. The number after the name of a species gives the abundance value of pseudospecies formation. The numbers in parentheses give the frequencies of the species in the different groups.

TWINSPAN Group 1 consisted mainly of sample plots representing dryish heath forest soil sites (5 x EVT, 2 x VMT, 1 x ECT; Figs. 5 and 6). The dominant tree species was pine; five of the sample plots belonged to development classes 1–3 (young stands), in which the dominant height of the pines ranged from 2 m to 4 m. The percentage of canopy cover on these sample plots was 5–10%. Mycorrhizal species typical of dryish heath forest soil sites was *Cortinarius brunneus*, saprophytes being represented by *Entoloma cetratum* and *Mycena clavicularis* (Table 11). *Lactarius rufus* was common (6 sample plots) only in the dryish forest site type.

TWINSPAN Group 2 consisted of sample plots representing ten VMT, one EVT and one GOMT. Five mature VMT sample plots dominated by spruce were situated in the middle of the group (Fig. 5). The growing stock on the sample plots was taller than that on sample plots of TWINSPAN Group 1. The canopy coverage of the trees ranged from 40% to 90% except for three sample plots (on GOMT, VMT and EVT site types), the canopy coverage of which was 10–20%. Mycorrhizal species typical of mesic heath forest soil sites were *Lactarius vietus* and *Cortinarius armillatus*. Common saprophytes were abundant: *Mycena vulgaris*, *M. galopus*, *Micromphale perforans*, *Collybia dryophila* and *C. succinea* (Table 11). These fungi consumed tree litter, herbs and grasses of the field layer, and

Table 10. Frequencies of the 20 most abundant plant species in the field and ground layers in mineral soil forest, peatland and mixed forest and peatland site types (fr. = frequency).

Dwarf shrubs, herbs and grasses, sedges and sedge-like plants Mosses and lichens	Forest site types n = 34 fr.	Peatland site types n = 27 fr.	Mixed forest and peatland site types n = 18 fr.	Total fr.
Vaccinium vitis-idaea	34	19	16	69
V. myrtillus	34	18	17	69
Empetrum nigrum coll.	21	20	12	53
Vaccinium uliginosum	–	22	11	33
Deschampsia flexuosa	22	–	10	32
Rubus chamaemorus	–	21	10	31
Carex globularis	–	14	15	29
Melampyrum pratense	15	–	8	23
Calluna vulgaris	21	–	–	21
Eriophorum vaginatum	–	18	–	18
Andromeda polifolia	–	17	–	17
Ledum palustre	8	–	8	16
Chamaedaphne calyculata	–	15	–	15
Betula nana	–	14	–	14
Solidago virgaurea	14	–	–	14
Luzula pilosa	10	–	–	10
Epilobium angustifolium	10	–	–	10
Linnea borealis	–	–	9	9
Pleurozium schreberi	32	24	18	74
Dicranum polysetum	34	17	16	67
Cladonia rangiferina	26	16	11	53
Polytrichum commune	19	16	12	47
Sphagnum angustifolium	–	24	13	37
Hylocomium splendens	21	–	15	36
Cladonia deformis	21	–	14	35
Sphagnum russowii	–	22	12	34
Dicranum scoparium	21	–	11	32
Polytrichum strictum	–	21	11	32
Cladonia arbuscula	22	–	–	22
Aulacomnium palustre	–	21	–	21
Cladonia cornuta	18		–	18
Sphagnum magellanicum	–	17	–	17
Cladonia gracilis	16		–	16
Sphagnum fuscum	–	13	–	13

mosses of the ground layer. The plant material available on mesic sites was more versatile than that on dryish or dry sites.

TWINSPAN Group 3 had the following composition: a mature GOMT sample plot dominated by spruce close to the sample plots of Group 2; a treeless EVT regeneration site; and a mature VMT sample plot dominated by pine (Fig. 5). The ground layer was characterised by an extensive cover of two forest mosses, *Pleurozium schreberi* and *Hylocomium splendens*. Species of macrofungi commonplace on the sample plots included *Cortinarius muscigenus* and *Mycena sanguinolenta*; these did not occur abundantly on any other sample plots of forest type. Another feature of the sample plots was the relative rarity of mycorrhizal fungi and the abundance of saprophytes, for which reason these sample plots stood out from among the rest in the TWINSPAN classification even though, in terms of their plant species composition (field and ground layers), they would have been classified into the category of mesic heath forest mineral soil sites.

Table 11. Frequencies of the 29 most abundant mycorrhizal (M), saprophytic litter (L) and wood-rotting (W), and parasitic (P) macrofungus species. Total number of macrofungi in parentheses in each forest site type (fr. = frequency).

Macrofungi		Forest site types, n=34 ECT n=10 (59) fr.	EVT DeMT n=9 (72) fr.	VMT n=13 (102) fr.	GOMT n=2 (25) fr.	Total fr.
Marasmius androsaceus	(L)	8	7	10	2	27
Galerina spp.	(L)	8	7	10	1	26
Cortinarius croceus	(M)	9	5	10	–	24
Cystoderma amianthinum	(L)	8	6	7	–	21
Entoloma cetratum	(L)	8	9	3	–	20
Cortinarius semisanguineus	(M)	9	6	5	–	20
Collybia tuberosa	(L)	3	3	9	2	17
Mycena clavicularis	(L)	6	8	2	–	16
M. vulgaris	(L)	–	2	10	2	14
Gymnopilus penetrans	(W)	4	5	4	–	13
Hypholoma capnoides	(W)	2	4	6	1	13
Clitocybe spp.	(L)	–	4	7	1	12
Cortinarius spp.	(M)	–	1	10	1	12
Suillus variegatus	(M)	6	1	4	–	11
Mycena galopus	(L)	–	1	9	1	11
Cortinarius brunneus	(M)	2	6	3	–	11
C. cinnamomeus	(M)	6	2	2	–	10
Laccaria laccata	(M)	–	2	6	2	10
Lactarius vietus	(M)	–	2	8	–	10
Cortinarius gentilis	(M)	5	–	5	–	10
Micromphale perforans	(L)	–	–	7	2	9
Chroocomphus rutilus	(M)	4	1	4	–	9
Cantharellula umbonata	(L)	3	4	1	–	8
Collybia dryophila	(L)	–	1	7	–	8
C. succinea	(L)	–	2	6	–	8
Tricholoma flavovirens	(M)	6	1	–	–	7
Paxillus involutus	(M)	–	3	2	2	7
Cortinarius armillatus	(M)	–	1	6	–	7
Armillaria borealis	(P)	1	2	3	1	7

TWINSPAN Group 4 consisted of nine dry (ECT) and two dryish (EVT) heath forest mineral soil sites dominated by pine; the canopy coverage on all these sample plots averaged 40%. The sample plots contained an abundance of dwarf shrubs and lichens and only a couple of grass and herb species. Species of mycorrhizal fungi typical of dry heath forest mineral soil sites included *Cortinarius semisanguineus*, *C. croceus*, *C. cinnamomeus*, *Suillus variegatus* and *Tricholoma flavovirens* (Table 11).

Saprophytes were fewer in number on dry mineral soil sites than on sites representing the other forest site types. The following species occurred as saprophytes common to all forest site types: *Marasmius androsaceus* on the branches of coniferous and deciduous trees, on needles, pieces of bark, cones and on decomposing leaves; *Collybia tuberosa* in the decomposing fruit bodies of other fungi; and *Hypholoma capnoides* in decaying conifer wood. *Cystoderma amianthinum* was common as a decaying agent of forest mosses, *Mycena clavicularis* being common on dry and dryish heath mineral forest soils among pine needles (Table 11).

The greatest number (102) of macrofungus species grew on mesic (VMT) sites (Table 11). In all, 138 macrofungus species (Table 14) and 102 plant species were identified in forest site types in 1981.

Peatland site types

The peatland sample plots differed from each other distinctly when subjected to DCA grouping on the basis of macrofungi species (Fig. 7). The main gradient (eigenvalue 0.504) was interpreted as being chiefly a fertility axis, though its complexity is indicated by the bog-mire gradient, the centre-edge gradient, and the pine-spruce (birch) tree species gradient. The beginning of axis 1 included nutrient-poor *Eriophorum vaginatum* pine bog sample plots (3 x TRlt, 1x TRoj), and the greatest values on axis 1 were obtained for the fertile spruce mire sample plots (2 x RhKlt, 1 x MKlt, 1 x MKmu) (Fig. 7). The sample plots midway along axis 1 correspond to the 3rd and 4th fertility classes as defined by Huikari (1974) (Fig. 7).

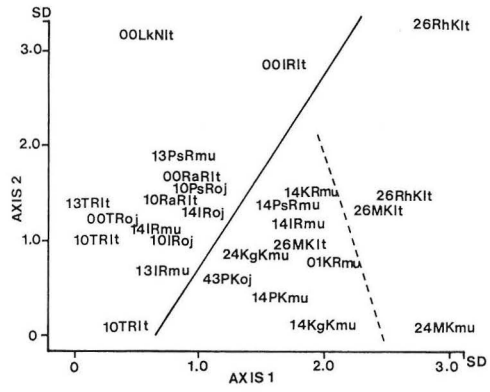

Fig. 7. DCA ordination of peatland site types on the basis of macrofungi. TWINSPAN cut levels: 1. division = ——, 2. division = -----. Eigenvalues: 1. axis = 0.504, 2. axis = 0.401. Other explanations as in Fig. 5.

There were 27 peatland sample plots in the material for 1981; on the first divisional level of the TWINSPAN classification these were separated mainly into spruce mires and pine bogs (Figs. 7 and 8). The indicator species on sample plots representing spruce mires and transitional pine mires and bogs were *Mycena vulgaris* and *Micromphale perforans* (Fig. 8), which were also common on mesic forest site types. *M. perforans* grew in spruce needle litter in fertile spruce mires and in transitional pine mires and bogs which, alongside pine, had admixtures of spruce and birch as part of the growing stock.

The other main group consisted of virgin and drained bogs of 5th and 6th fertility classes (Huikari 1974), two mires (PsR) of the 4th fertility class, and one treeless ombrotrophic small sedge bog (LkN) (Fig. 7). *Cortinarius huronensis* was the indicator species (Fig. 8); it occurred as a mycorrhizal fungus of pine in the *Sphagnum* surfaces of all pine bog sample plots.

The dominant tree species on the treed sample plots of TWINSPAN Group 1 was pine, and the average height of the trees ranged from 2 m to 7 m. Each sample plot had an abundance of dwarf shrubs with high coverage percentages; there were few grasses and herbs, the most common species being *Rubus chamaemorus*. Of the sedge-like plants, *Eriophorum vaginatum* was the commonest, forming extensive communities on virgin and drained *Eriophorum vaginatum* pine bogs (TR).

The commonest mycorrhizal species growing on nutrient-poor pine bogs (both virgin and drained) were *Cortinarius huronensis*, *Laccaria laccata*, *Lactarius rufus*, *Cortinarius semisanguineus* and *Suillus variegatus* (Table 12). *Russula emetica* is also a species inhabiting pine mires and bogs; it was observed on sample plots which in the TWINSPAN classification belonged to Group 2. Common saprophytes were *Galerina tibiicystis* coll., *G. paludosa* and *Omphalina umbellifera* (Table 12), which grew in and among *Sphagnum* species and on the bare peat alongside ditches. Saprophytes feeding upon *Sphagnum* species on virgin bogs included *Hypholoma elongatum*, *H. myosotis*, *Omphalina philonotis* and *Lyophyllum palustre*.

Group 2 and Group 3 stood out on the second level of the TWINSPAN classification (Fig. 8). The former group was characterised by *Lactarius vietus* as the indicator species, the indicator species for the latter being *Galerina tibiicystis* coll. and *Mycena sanguinolenta* (Fig. 8). The drained spruce and pine mires of Group 2 represented young stands or young thinning stands dominated by pine, spruce or downy birch, and the height and canopy coverage of trees exceeded those of sample plots in Group 1 (Fig. 7). Of the sample plots belonging to this group, *Vaccinium myrtillus* spruce mire (MK) was in its virgin state, with a mature growing stock (Fig. 7). The four sample plots of the group (PsRmu, IRmu, 2xKRmu) were pine sites drained long ago, while the other KR sample plot of the group was a treeless regeneration site (Fig. 7).

The sample plots in Groups 2 and 3 were characterised by less dwarf shrubs and more herbs and grasses in the field layer than in the sample plots representing peatland Group 1 of pine bogs.

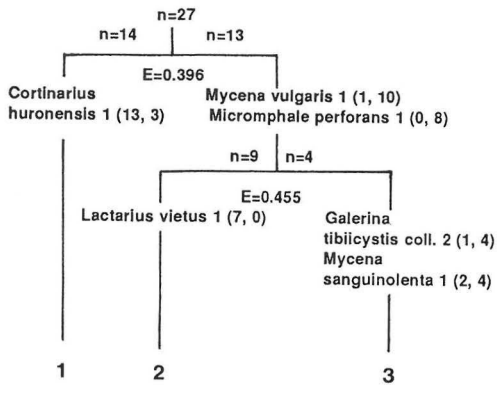

Fig. 8. TWINSPAN dendrogram of peatland site types on the basis of macrofungi. Explanations as in Fig. 6.

The commonest forest moss species was *Pleurozium schreberi*, the coverage of which was considerable on drained pine bogs (IR, PsR, KR) and on sample plots representing fertile spruce mires. Virgin pine bogs and recently drained pine bogs were marked by the total absence or relative rarity of *P. schreberi*. The commonest peatland mosses were *Sphagnum angustifolium*, *S. magellanicum*, *S. fuscum* and *Polytrichum strictum* on pine bogs and *Sphagnum russowii* and *Polytrichum commune* in spruce mires (Table 10).

Mycorrhizal species of pine typical of Group 2 were *Russula paludosa* and *Cortinarius semisanguineus*. Nearly all sample plots in the group included pine, spruce and downy birch, and the accompanying mycorrhizal species. *Lactarius vietus* grew in dense stands of spruce, while *Paxillus involutus* occurred under groups of downy birch (Table 12). It is difficult to specify any typical saprophytes, as *Marasmius androsaceus* was common in spruce mires and recently drained pine bogs (Table 12). *Mycena vulgaris*, *M. galopus* and *Micromphale perforans* grew in spruce stands in and among the forest mosses or litter of spruce needles (Table 12). The spruce and pine mire sample plots of the group were found to contain 67 species of macrofungi (Table 12). The other sample plot, representing an oligo-mesotrophic paludified spruce forest (transitional drained peatland, KgKmu), the canopy coverage of which was 80% and development class 4, was found to contain the greatest number of macrofungus species — 32 in all.

In the herb-rich hardwood-spruce mire of Group 3, the dominant tree species was spruce; three sample plots were mature stands, and one sample plot was a young thinning stand (Fig. 7). The growing stock in the mature stands was large in size, its height ranging from 14 m to 26 m. Typical mycorrhizal species of this group were *Russula nitida*, *Lactarius theiogalus*, *L. glyciosmus*, *Cortinarius sanguineus* and *C. armillatus*. Saprophytes were plentiful on the sample plots; 28 species were identified, eleven of which were of the genus *Mycena*, the most frequent being *Mycena vulgaris*, *M. galopus*, *M. sanguinolenta* and *M. epipterygia*. A total of 63 macrofungus species were identified on four sample plots of the group. The greatest number (34) of macrofungus species grew on a sample plot representing a *Vaccinium myrtillus* spruce mire (MKmu). In all, 106 macrofungus species (Table 14) and 109 plant species were identified in peatland site types.

Mixed forest and peatland site types

In the DCA ordination of the mixed sample plots, Group 1 included sample plots 1, 3, 4, 5, 6; i.e. sample plots formed of site type segments with spruce mire or mesic forest (Fig. 9). Group 2 included the sample plots whose peatland segment corresponded to a mire or a bog with a fertility class of 2–5 and a forest segment from within the range of dry to rich heath forest (Fig. 9). In the TWINSPAN classification, the indicator species for the first divisional level were, on the left, *Cortinarius* spp. (small brown species of the subgenus Telamonia), *C. gentilis* and *C. armillatus* and, on the right, *Paxillus involutus*, *Laccaria laccata* and *Hypholoma capnoides* (Fig. 10).

Dwarf shrubs were common in the field layer on sample plots of both groups. Of the herbs and grasses, *Rubus chamaemorus* and *Deschampsia flexuosa* formed contiguous communities on some sample plots. In the ground layer, common heath forest moss species *Pleurozium schreberi*, *Dicranum polysetum* and *Hylocomium splendens* formed extensive communities on almost every sample plot. *Sphagnum* mosses occurred in both groups, on a total of sixteen sample plot; the most common ones were *Sphagnum russowii* in spruce mire segments and *S. angustifolium* in pine bog segments (Table 10). The groups differed from one another in their tree species composition;

Table 12. Frequencies of the 28 most abundant mycorrhizal (M), saprophytic litter (L) and wood-rotting (W) macrofungus species. Total number of macrofungi in parentheses in each fertility class. Fertility classes (II–VI) of peatland site types as defined by Huikari (1974) (fr. = frequency).

		Peatland site types (n=27)					
		2xRhKlt	2xMKlt 1xMKmu 2xKgKmu	1xPKoj 1xPKmu 2xKRmu 2xPsRoj 1xPsRmu	3xTRlt 1xIRlt 1xTRoj 2xIRoj 3xIRmu	2xRaRlt 1xLkNlt	
Macrofungi		II (37) fr.	III (67) fr.	IV (59) fr.	V (58) fr.	VI (13) fr.	Tot. fr.
Galerina tibiicystis coll.	(L)	2	3	5	9	3	22
Cortinarius huronensis	(M)	–	2	2	9	3	16
Marasmius androsaceus	(L)	1	4	5	6	–	16
Cortinarius spp.	(M)	1	4	3	5	2	15
Mycena galopus	(L)	1	4	4	3	–	12
M. vulgaris	(L)	2	3	4	2	–	11
Laccaria laccata	(M)	1	3	1	6	–	11
Galerina paludosa	(L)	–	–	3	4	3	10
Micromphale perforans	(L)	2	3	3	–	–	8
Cortinarius semisanguineus	(M)	–	–	3	5	–	8
Lactarius vietus	(M)	–	4	3	–	–	7
C. croceus	(M)	1	2	1	3	–	7
Lactarius rufus	(M)	–	–	1	6	–	7
Russula emetica	(M)	–	2	2	3	–	7
R. paludosa	M)	1	2	3	1	–	7
Collybia tuberosa	(L)	1	1	3	2	–	7
C. dryophila	(L)	–	2	3	1	1	7
Omphalina umbellifera	(L)	–	2	2	3	–	7
Cystoderma amianthinum	(L)	–	1	2	4	–	7
Suillus variegatus	(M)	–	–	1	4	1	6
Lactarius theiogalus	(M)	1	3	2	–	–	6
Paxillus involutus	(M)	–	1	3	2	–	6
Hypholoma capnoides	(W)	1	2	1	2	–	6
H. elongatum	(L)	–	–	1	4	1	6
Collybia succinea	(L)	–	1	3	2	–	6
Gymnopilus penetrans	(W)	–	1	3	2	–	6
Mycena galericulata	(W)	–	3	2	1	–	6
M. sanguinolenta	(L)	2	4	–	–	–	6

every sample plot (except sample plot 10) of Group 1 there had both spruce and downy birch trees, while the spruce mire segments also had goat willow and rowan. In the other group (consisting of 8 sample plots), only three sample plots had spruce trees, while pine was often the dominant species or an additional species.

Cortinarius croceus, *C. semisanguineus*, *Suillus variegatus* and *Russula paludosa* were the most abundant mycorrhizal species of pine (Table 13). Of the mycorrhizal fungus species of spruce, *Laccaria laccata*, *Lactarius vietus*, *L. trivialis*, *Cortinarius sanguineus* and (those of birch) *Cortinarius armillatus* and *Leccinum scabrum* were common fungus species in the sample plots.

Litter saprophytes were common in both groups, the most common being *Mycena galopus, M. vulgaris* and *Marasmius androsaceus* (Table 13). Group 1 contained 77 macrofungus species, and Group 2 contained 95 macrofungus species (Table 13). The ordination and classification of mixed sample plots indicated that the more vegetational (i.e. site quality) variety there was on the sample plots, the more diverse the fungus

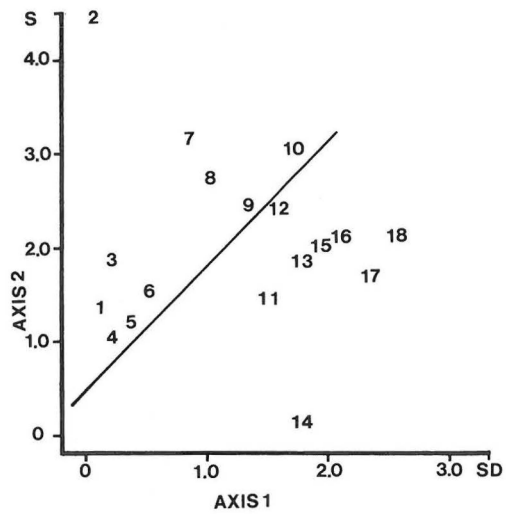

Fig. 9. DCA ordination of mixed forest and peatland site types on the basis of macrofungi. TWINSPAN cut level: 1. division = ———. Eigenvalues: 1. axis = 0.507, 2. axis = 0.418. Other explanations as in Fig. 5. Sample plot number and forest and peatland site types and their relative proportion in each sample plot as follows: 1 = 26MK95% + 24KgK5%, 2 = 13ECT50% + 13PsR30% + 13IR20%, 3 = 14KR90% + 26VMT10%, 4 = 26RhK80% + 26MK20%, 5 = 14PK70% + 23VMT30%, 6 = 43KgK90% + 23RhK10%, 7 = 16EVT80% + 26VMT20%, 8 = 10IRmu95% + 00LkN5%, 9 = 14Vtkg60% + 14EVT40%, 10 = 10IR60% + 10VSR40%, 11 = 45GOMT50% + 15VMT50%, 12 = 13ECT90% + 10IR10%, 13 = 43PKmu60% + 13PsR40%, 14 = 26VMT95% + 14KgK5%, 15 = 14ECT85% + 15EVT15%, 16 = 26VMT90% + 16PK10%, 17 = 12VMT70% + 42RhK30%, 18 = 14Vtkg70% + 12EVT30%.

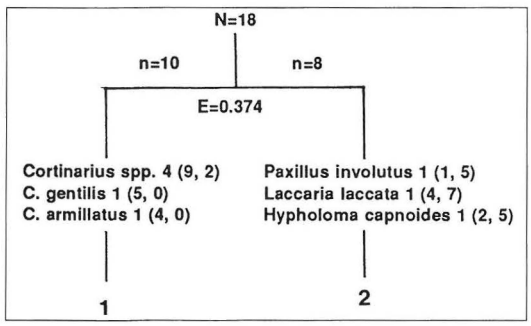

Fig. 10. TWINSPAN dendrogram of mixed forest and peatland site types on the basis of macrofungi. Explanations as in Fig. 6.

communities were. In all, 121 macrofungus species (Table 14) and 106 plant species were identified on the mixed sample plots.

Plant and macrofungus species and communities

Forest and peatland site types were classified on the basis of the frequencies of dominant plant species (Table 10). Macrofungus communities were classified on the basis of the frequencies of the most abundant mycorrhizal and saprophytic species in forest site types (Table 11) and peatland site types (Table 12). Plant and macrofungus communities were characterized by a few species (generally 5–6 dominant species). Seven plant and macrofungus communities typical of a particular forest site type and peatland site type group are given here.

1. *Empetrum-Calluna Type (ECT)*

Vaccinium vitis-idaea — Calluna vulgaris — Empetrum nigrum coll. — *Pleurozium schreberi — Cladonia* spp.

Cortinarius semisanguineus — C. croceus — Suillus variegatus — Tricholoma flavovirens — Marasmius androsaceus — Cystoderma amianthinum

2. *Empetrum-Vaccinium Type (EVT)*

Vaccinium vitis-idaea — V. myrtillus — Empetrum nigrum coll. — *Pleurozium schreberi — Dicranum polysetum*

Cortinarius brunneus — C. semisanguineus — Lactarius rufus — Entoloma cetratum — Mycena clavicularis — Marasmius androsaceus

3. *Vaccinium myrtillus Type (VMT) and Deschampsia-Myrtillus Type (DeMT)*

Vaccinium myrtillus — V. vitis-idaea -—Deschampsia flexuosa — Pleurozium schreberi -— Dicranum polysetum — Hylocomium splendens

Cortinarius spp. — *Lactarius vietus — Cortinarius armillatus — Galerina* spp. — *Mycena vulgaris — M. galopus — Micromphale perforans*

4. *Peatland site types PsR, IR, TR, fertility classes IV–V; contain drained sites*

Betula nana — Vaccinium uliginosum — Empetrum nigrum coll. — *Eriophorum vaginatum — Rubus chamaemorus — Sphagnum fuscum — S. russowii — S. angustifolium — Polytrichum strictum*

Table 13. Frequencies of the 27 most abundant mycorrhizal (M), saprophytic litter (L) and wood-rotting (W) macrofungus species in mixed forest and peatland site types. The total number of macrofungi is given in parentheses for each TWINSPAN group (fr. = frequency).

Macrofungi	TWINSPAN Group 1 n = 10 (77) fr.		TWINSPAN Group 2 n = 8 (95) fr.	Total fr.
Mycena galopus	(L)	9	6	15
Marasmius androsaceus	(L)	8	6	14
Mycena vulgaris	(L)	6	7	13
Galerina spp.	(L)	8	5	13
G. tibiicystis coll.	(L)	7	6	13
Laccaria laccata	(M)	4	7	11
Cortinarius croceus	(M)	9	2	11
Cortinarius spp.	(M)	9	2	11
Mycena clavicularis	(L)	5	5	10
Collybia tuberosa	(L)	4	6	10
Lactarius vietus	(M)	5	5	10
Suillus variegatus	(M)	5	4	9
Micromphale perforans	(L)	6	2	8
Collybia succinea	(L)	4	4	8
Cortinarius semisanguineus	(M)	5	2	7
C. muscigenus	(M)	6	1	7
Collybia dryophila	(L)	4	3	7
Cystoderma amianthinum	(L)	3	4	7
Entoloma cetratum	(L)	2	5	7
Hypholoma capnoides	(W)	2	5	7
Russula paludosa	(M)	3	3	6
Cortinarius huronensis	(M)	5	1	6
Paxillus involutus	(M)	1	5	6
Cortinarius gentilis	(M)	6	–	6
Mycena galericulata	(W)	2	4	6
M. epipterygia	(L)	1	5	6
Micromphale perforans	(L)	3	3	6

Cortinarius huronensis — Lactarius rufus — Laccaria laccata — Cortinarius semisanguineus — Galerina tibiicystis coll. *— Marasmius androsaceus*

5. *Virgin peatland site types TR, RaR, LkN, fertility classes V–VI*

Vaccinium uliginosum — Chamaedaphne calyculata -— Andromeda polifolia — Eriophorum vaginatum — Sphagnum fuscum — S. russowii

Cortinarius huronensis — Galerina paludosa — Hypholoma elongatum — Lyophyllum palustre

6. *Drained peatland site types KgK, PK, KR, fertility classes III–IV*

Vaccinium myrtillus — V. vitis-idaea — Carex globularis — Polytrichum commune — Pleurozium schreberi

Lactarius vietus — Russula paludosa — Marasmius androsaceus — Mycena galopus — M. vulgaris — Collybia dryophila (C. succinea)

7. *Virgin peatland site types RhK, MK and drained MK, fertility classes II and III*

Vaccinium myrtillus — Carex globularis — Sphagnum girgensohnii — Pleurozium schreberi

Lactarius theiogalus — Cortinarius armillatus — C. sanguineus — Russula nitida — Micromphale perforans — Mycena sanguinolenta -— M. epipterygia

Macrofungi in mineral soil forest and peatland site types in 1981–1984

In all, 232 macrofungus species or groups were identified in North Karelian forest and peatland site

Table 14. Frequencies and the total number of macrofungus species in mineral soil forest (F), peatland (P) and mixed forest and peatland site types (F+P), and the total number of sample plots (n) in 1981–1984. M = mycorrhizal species, L = litter saprophytes incl. saprophytes on mosses and peat, on an organic base in mineral soil or burnt ground and fungal and herbivore dung saprophytes, W = wood saprophytes, P = parasites (fr. = frequency).

Macrofungi		1981			1982			1983			1984			Total
		F	P	F+P	F	P	F+P	F	P	F+P	F	P	F+P	fr.
	n =	34	27	18	69	53	14	100	70	22	100	65	24	
* *Cortinarius* spp.	(M)	25	15	11	25	8	4	56	30	11	21	13	3	222
** *Galerina* spp.	(L)	26	4	13	15	–	–	22	22	5	2	7	4	120
Lactarius rufus	(M)	6	7	4	10	17	3	12	16	6	12	13	2	108
Cortinarius semisanguineus	(M)	20	8	7	7	4	1	22	3	6	10	3	–	91
Laccaria laccata	(M)	11	11	11	6	8	–	11	10	5	10	5	2	90
Collybia tuberosa	(L)	17	7	10	10	9	2	13	5	4	1	2	–	80
Cortinarius croceus	(M)	13	7	11	2	9	1	16	7	2	1	7	2	78
Micromphale perforans	(L)	9	8	8	14	5	3	13	4	5	6	2	1	78
Marasmius androsaceus	(L)	27	16	14	1	–	–	12	4	1	1	–	–	76
Mycena galopus	(L)	12	12	15	5	6	1	7	9	4	2	1	1	75
Cortinarius armillatus	(M)	7	3	5	8	2	2	26	10	6	8	1	–	75
Mycena sp.	(L)	15	7	8	4	2	–	18	5	6	2	2	2	71
Cystoderma amianthinum	(L)	21	4	7	15	1	2	16	2	1	–	1	–	70
Cortinarius muscigenus	(M)	6	3	7	6	–	–	22	4	2	10	3	1	64
Galerina tibiicystis coll.	(L)	12	22	13	1	11	1	1	1	1	–	–	–	63
Entoloma cetratum	(L)	21	–	4	12	–	–	12	–	6	2	–	–	57
Russula emetica	(M)	2	7	5	3	7	1	8	13	3	2	3	2	56
Lactarius vietus	(M)	10	6	10	–	2	–	7	6	4	3	3	–	51
Mycena clavicularis	(L)	16	1	10	4	4	1	7	5	2	–	–	–	50
Cortinarius gentilis	(M)	10	1	6	7	1	–	15	2	4	2	1	–	49
Suillus variegatus	(M)	11	6	9	4	1	–	7	1	–	6	1	–	46
Paxillus involutus	(M)	7	6	6	3	10	1	1	4	4	–	1	1	44
** *Clitocybe* spp.	(L)	12	5	5	2	2	–	4	7	2	2	1	–	42
Mycena vulgaris	(L)	14	11	13	–	1	–	2	1	–	–	–	–	42
Russula paludosa	(M)	5	7	6	–	4	–	2	10	5	–	2	–	41
Galerina paludosa	(L)	–	10	5	–	7	4	–	6	3	–	6	–	41
Collybia dryophila	(L)	8	7	7	1	2	1	2	5	–	–	6	1	40
Rozites caperatus	(M)	3	1	2	–	–	–	17	2	1	8	2	–	36
Gymnophilus penetrans	(W)	13	6	1	6	–	–	9	–	–	1	–	–	36
Russula decolorans	(M)	–	5	3	–	1	1	9	3	1	7	3	2	35
Cortinarius cinnamomeus	(M)	10	1	1	2	5	–	7	3	4	–	1	–	34
Collybia succinea	(L)	8	6	8	–	1	–	6	4	–	1	–	–	34
Cortinarius huronensis	(M)	–	16	–	–	4	1	1	7	–	–	2	1	32
Hypoloma capnoides	(W)	13	6	7	2	–	–	3	1	–	–	–	–	32
Leccinum scabrum	(M)	4	4	5	1	2	–	7	1	1	2	3	1	31
Lactarius theiogalus	(M)	2	6	1	1	2	1	–	4	3	1	5	3	29
Hebeloma sp.	(M)	7	–	3	4	2	–	3	3	2	1	1	1	27
Cantharellula umbonata	(L)	8	4	3	2	–	–	7	1	1	1	–	–	27

(contnd.)

Table 14. contnd.

Macrofungi		1981			1982			1983			1984			Total
		F	P	F+P	F	P	F+P	F	P	F+P	F	P	F+P	fr.
	n =	34	27	18	69	53	14	100	70	22	100	65	24	
Mycena galericulata	(W)	5	6	6	4	–	–	2	–	1	–	2	–	26
Chroogomphus rutilus	(M)	9	2	2	1	1	–	4	2	–	3	1	–	25
Russula vinosa	(M)	1	1	1	–	1	–	13	4	2	2	–	–	25
Cortinarius brunneus	(M)	11	5	2	1	1	1	1	2	–	–	–	–	24
Omphalina umbellifera	(L)	2	7	2	–	8	–	1	3	–	–	1	–	24
Cortinarius mucosus	(M)	4	2	3	3	–	1	7	1	1	–	–	–	22
Russula sp.	(M)	3	–	–	–	–	–	10	2	1	5	1	–	22
Entoloma sp. 1 (incl. *E. nidorosum*)	(L)	6	5	7	–	–	–	3	–	–	1	–	–	22
Lactarius helvus	(M)	–	4	3	–	3	–	4	3	1	1	1	1	21
Russula claroflava	(M)	–	2	2	–	1	–	1	4	2	2	5	2	21
Lactarius mammosus	(M)	5	2	1	2	1	–	1	1	1	3	1	2	20
Stropharia hornemannii	(L)	3	2	4	2	1	1	2	1	3	–	1	–	20
Entoloma sp. 2 (incl. *E. sericatum*)	(L)	–	1	–	–	7	–	–	7	–	–	4	–	19
Mycena epipterygia	(L)	6	5	6	–	–	–	2	–	–	–	–	–	19
Lactarius glyciosmus	(M)	4	1	4	–	1	–	1	4	2	–	1	–	18
Russula nitida	(M)	1	4	3	–	5	2	–	1	2	–	–	–	18
Polyporus ciliatus	(W)	4	2	1	1	–	1	5	1	–	1	1	–	17
Leccinum vulpinum	(M)	6	–	2	2	–	–	1	–	–	5	1	–	17
Cortinarius pholideus	(M)	4	2	5	–	–	–	2	–	2	–	1	–	16
Hypholoma elongatum	(L)	–	5	1	–	–	–	1	6	3	–	–	–	16
Lactarius utilis	(M)	2	2	2	2	–	–	4	–	–	–	1	1	14
Polyporus brumalis	(W)	3	2	1	3	–	1	3	–	–	1	–	–	14
Lactarius trivialis	(M)	2	2	2	–	2	–	3	2	–	–	1	–	14
Armillaria borealis	(P)	7	1	2	–	–	1	3	–	–	–	–	–	14
Cortinarius traganus	(M)	1	2	2	1	–	–	2	1	–	2	2	–	13
Galerina marginata	(W)	5	1	2	2	–	–	2	–	–	1	–	–	13
Leccinum variicolor	(M)	3	3	3	1	–	–	–	1	–	–	–	1	12
L. versipelle	(M)	4	2	–	–	–	–	–	1	1	3	–	1	12
Xeromphalia caulicinalis	(L)	4	3	3	1	–	–	1	–	–	–	–	–	12
Russula xerampelina	(M)	3	–	–	–	–	–	5	–	–	3	–	1	12
Mycena sanguinolenta	(L)	2	6	3	–	–	1	–	–	–	–	–	–	12
Clitocybe vibecina	(L)	5	3	3	–	–	–	–	1	–	–	–	–	12
Pholiota sp.	(W)	5	–	2	3	–	–	2	–	–	–	–	–	12

(contnd.)

Table 14. contnd.

Macrofungi		1981			1982			1983			1984			Total
		F	P	F+P	F	P	F+P	F	P	F+P	F	P	F+P	fr.
	n =	34	27	18	69	53	14	100	70	22	100	65	24	
Clitocybe clavipes	(L)	5	1	2	1	–	–	1	1	–	–	–	–	11
Cystoderma granulosum	(L)	3	2	3	1	–	–	1	1	–	–	–	–	11
Hypholoma fasciculare	(W)	2	4	1	2	–	–	–	1	–	1	–	–	11
Mycena rubromarginata	(L)	3	–	4	2	1	–	1	–	–	–	–	–	11
M. rorida	(L)	3	1	5	–	1	–	1	–	–	–	–	–	11
Collybia cirrhata	(L)	5	–	–	–	–	–	–	–	–	4	1	1	11
Hygrophorus olivaceoalbus	(M)	2	–	2	–	–	–	3	4	–	–	–	–	11
Mycena megaspora	(L)	1	3	2	1	1	–	1	1	1	–	–	–	11
Xerocomus subtomentosus	(M)	2	–	1	1	–	–	2	–	–	3	1	–	10
Xeromphalia campanella	(W)	2	1	2	–	1	–	3	–	1	–	–	–	10
Hypholoma sp.	(L)	–	–	2	2	–	–	1	1	–	2	2	–	10
Inocybe sp.	(M)	2	1	–	1	–	–	4	–	1	–	–	1	10
Omphalina philonotis	(L)	2	3	–	–	1	–	–	3	–	–	1	–	10
Inocybe lanuginosa	(M)	2	5	2	–	–	–	1	–	–	–	–	–	10
Leccinum niveum	(M	–	2	4	–	–	–	–	1	1	–	–	1	9
Collybia putilla	(L)	3	–	1	–	–	–	2	–	–	3	–	–	9
Amanita fulva	(M)	2	1	1	–	–	–	1	3	–	–	–	–	8
Collybia butyracea	(L)	3	–	1	–	–	–	3	1	–	1	–	–	8
Cortinarius orellanoides	(M)	3	–	2	–	1	–	–	–	1	–	1	–	8
Mycena rosella	(L)	1	2	2	1	–	–	2	–	–	–	–	–	8
M. pura	(L)	4	1	2	1	–	–	–	–	–	–	–	–	8
Panellus mitis	(W)	2	1	4	–	–	–	–	1	–	–	–	–	8
Cortinarius sanguineus	(M)	2	–	2	–	1	–	1	–	1	–	–	–	7
Pleurotus pulmonarius	(W)	3	1	2	–	–	–	–	1	–	–	–	–	7
Hypholoma udum	(L)	–	1	1	–	3	–	–	2	–	–	–	–	7
Amanita vaginata	(M)	–	–	–	1	–	–	3	1	2	–	–	–	7
Stropharia semiglobata	(L)	1	–	2	–	–	–	3	–	–	1	–	–	7
Tricholoma sp.	(M)	2	–	1	–	–	–	4	–	–	–	–	–	7
T. flavovirens	(M)	7	–	–	–	–	–	–	–	–	–	–	–	7
Psathyrella candolleana	(L)	–	2	1	1	–	–	–	1	–	–	1	–	6
Mycena viscosa	(W)	1	–	–	1	2	2	–	–	–	–	–	–	6
Omphalina oniscus	(L)	–	2	1	–	1	–	–	–	–	–	2	–	6
Hygrophorus sp.	(M)	3	1	2	–	–	–	–	–	–	–	–	–	6
Mycena metata	(L)	1	–	–	3	–	–	2	–	–	–	–	–	6
Suillus bovinus	(M)	3	–	–	2	–	–	–	–	1	–	–	–	6
Strobilurus esculentus	(L)	–	2	–	–	4	–	–	–	–	–	–	–	6
Lyophyllum palustre	(L)	–	4	–	–	–	–	–	2	–	–	–	–	6
Amanita porphyria	(M)	–	–	2	–	1	1	–	–	1	–	–	–	5
Pholiota mixta	(L)	2	–	–	–	–	–	–	–	–	2	–	1	5

(contnd.)

Table 14. contnd.

Macrofungi		1981			1982			1983			1984			Total
		F	P	F+P	F	P	F+P	F	P	F+P	F	P	F+P	fr.
	n =	34	27	18	69	53	14	100	70	22	100	65	24	
Hygrophoropsis aurantiaca	(W)	–	–	–	1	–	–	2	–	–	2	–	–	5
Hebeloma longicaudum	(M)	–	5	–	–	–	–	–	–	–	–	–	–	5
Suillus luteus	(M)	–	–	–	–	–	–	1	1	–	1	1	–	4
Gomphidius roseus	(M	–	–	–	–	–	1	–	1	–	1	1	–	4
Kuehneromyces mutabilis	(W)	–	–	1	–	1	–	1	1	–	–	–	–	4
Lactarius torminosus	(M)	1	–	–	–	1	–	1	–	1	–	–	–	4
Russula consobrina	(M)	–	1	–	–	–	–	2	1	–	–	–	–	4
Panellus serotinus	(W)	3	–	1	–	–	–	–	–	–	–	–	–	4
Phaeocollybia sp.	(W)	1	–	3	–	–	–	–	–	–	–	–	–	4
Pholiota flammans	(W)	–	3	1	–	–	–	–	–	–	–	–	–	4
Baespora myosura	(L)	3	–	–	–	–	–	1	–	–	–	–	–	4
Hygrophorus hypothejus	(M)	3	–	–	–	–	–	–	1	–	–	–	–	4
Gomphidius glutinosus	(M)	1	–	–	–	–	–	1	1	–	–	–	–	3
Cortinarius camphoratus	(M)	1	–	1	–	–	–	–	–	–	–	1	–	3
Marasmius epiphyllus	(L)	1	1	–	–	–	–	–	–	–	–	1	–	3
Tricholoma fulvum	(M)	1	1	1	–	–	–	–	–	–	–	–	–	3
Coprinus sp.	(L)	2	1	–	–	–	–	–	–	–	–	–	–	3
Cortinarius hemitrichus	(M)	–	2	1	–	–	–	–	–	–	–	–	–	3
Hypholoma lateritium	(W)	–	1	2	–	–	–	–	–	–	–	–	–	3
Inocybe lacera	(M)	2	–	1	–	–	–	–	–	–	–	–	–	3
Laccaria proxima	(M)	–	–	–	1	–	–	2	–	–	–	–	–	3
Mycena laevigata	(W)	1	–	–	2	–	–	–	–	–	–	–	–	3
M. stipata	(W)	–	–	–	1	–	–	2	–	–	–	–	–	3
Russula aeruginea	(M)	2	–	–	–	–	–	–	–	1	–	–	–	3
R. gracillima	(M)	–	–	–	–	–	–	1	–	–	2	–	–	3
Suillus flavidus	(M)	–	1	–	–	–	–	–	2	–	–	–	–	3
Coprinus radiatus	(L)	2	–	1	–	–	–	–	–	–	–	–	–	3
Collybia confluens	(L)	–	1	–	–	–	–	–	–	1	–	–	–	2
Cortinarius delibutus	(M)	1	–	–	–	1	–	–	–	–	–	–	–	2
C. triumphans	(M)	1	–	1	–	–	–	–	–	–	–	–	–	2
C. obtusus	(M)	1	1	–	–	–	–	–	–	–	–	–	–	2
Hygrophoropsis olida	(L)	–	–	1	–	–	–	1	–	–	–	–	–	2
Lactarius necator	(M)	–	–	–	–	–	1	–	1	–	–	–	–	2
Lepiota clypeolaria	(L)	1	–	1	–	–	–	–	–	–	–	–	–	2
Lyophyllum fumosum	(L)	–	–	–	1	–	–	1	–	–	–	–	–	2
Megacollybia platyphylla	(W)	1	1	–	–	–	–	–	–	–	–	–	–	2
Mycena flavoalba	(L)	–	–	–	–	–	–	1	–	–	1	–	–	2
Psathyrella sp.	(L)	–	–	1	–	–	–	1	–	–	–	–	–	2
Omphalina fibula	(L)	1	1	–	–	–	–	–	–	–	–	–	–	2
Russula betularum	(M)	–	–	–	–	–	–	1	–	–	1	–	–	2

(contnd.)

Table 14. contnd.

Macrofungi		1981			1982			1983			1984			Total
		F	P	F+P	F	P	F+P	F	P	F+P	F	P	F+P	fr.
	n =	34	27	18	69	53	14	100	70	22	100	65	24	
R. rhodopoda	(M)	1	–	1	–	–	–	–	–	–	–	–	–	2
Tricholoma virgatum	(M)	–	–	1	–	–	–	1	–	–	–	–	–	2
Tricholomopsis rutilans	(W)	–	–	1	–	–	–	–	–	–	1	–	–	2
Tubaria confragosa	(W)	1	1	–	–	–	–	–	–	–	–	–	–	2
Lentinellus cochleatus	(W)	1	–	–	–	–	–	1	–	–	–	–	–	2
L. omphalodes	(W)	1	–	1	–	–	–	–	–	–	–	–	–	2
Tricholoma inamoenum	(M)	–	–	–	–	–	–	1	–	1	–	–	–	2
Clitocybe diatreta	(L)	2	–	–	–	–	–	–	–	–	–	–	–	2
C. candicans	(L)	–	–	2	–	–	–	–	–	–	–	–	–	2
Hygrophorus korhonenii	(M)	–	–	2	–	–	–	–	–	–	–	–	–	2
Laccaria bicolor	(M)	–	–	2	–	–	–	–	–	–	–	–	–	2
Lactarius musteus	(M)	–	–	–	–	–	–	–	–	–	2	–	–	2
Leccinum aurantiacum	(M)	–	–	–	–	–	–	–	–	2	–	–	–	2
Paxillus atrotomentosus	(W)	2	–	–	–	–	–	–	–	–	–	–	–	2
Lyophyllum sp.	(L)	2	–	–	–	–	–	–	–	–	–	–	–	2
Strobilurus stephanocystis	(L)	–	–	–	2	–	–	–	–	–	–	–	–	2
Boletus edulis	(M)	1	–	–	–	–	–	–	–	–	–	–	–	1
B. pinophilus	(M)	1	–	–	–	–	–	–	–	–	–	–	–	1
Coprinus cinereus	(L)	1	–	–	–	–	–	–	–	–	–	–	–	1
Cortinarius flexipes	(M)	1	–	–	–	–	–	–	–	–	–	–	–	1
C. trivialis	(M)	1	–	–	–	–	–	–	–	–	–	–	–	1
C. laniger	(M)	1	–	–	–	–	–	–	–	–	–	–	–	1
C. paleaceus	(M)	1	–	–	–	–	–	–	–	–	–	–	–	1
C. evernius	(M)	1	–	–	–	–	–	–	–	–	–	–	–	1
Cyphellostereum laeve	(L)	1	–	–	–	–	–	–	–	–	–	–	–	1
Entoloma nitidum	(L)	1	–	–	–	–	–	–	–	–	–	–	–	1
Hohenbuehelia petaloides	(L)	1	–	–	–	–	–	–	–	–	–	–	–	1
Hygrophorus piceae	(M)	1	–	–	–	–	–	–	–	–	–	–	–	1
Panus conchatus	(W)	1	–	–	–	–	–	–	–	–	–	–	–	1
Pluteus sp.	(W	1	–	–	–	–	–	–	–	–	–	–	–	1
Polyporus varius	(W)	1	–	–	–	–	–	–	–	–	–	–	–	1
Stropharia aeruginosa	(L)	1	–	–	–	–	–	–	–	–	–	–	–	1
Psilocybe sp.	(L)	1	–	–	–	–	–	–	–	–	–	–	–	1
Melanoleuca sp.	(L)	–	–	–	1	–	–	–	–	–	–	–	–	1
Mycena urania	(L)	–	–	–	1	–	–	–	–	–	–	–	–	1
Hygrophorus karstenii	(M)	–	–	–	1	–	–	–	–	–	–	–	–	1
Tricholoma pessundatum	(M)	–	–	–	1	–	–	–	–	–	–	–	–	1
Collybia maculata	(L)	–	–	–	–	–	–	1	–	–	–	–	–	1
Cystoderma carcharias	(L)	–	–	–	–	–	–	1	–	–	–	–	–	1
Russula vesca	(M)	–	–	–	–	–	–	1	–	–	–	–	–	1

(contnd.)

Table 14. contnd.

Macrofungi		1981			1982			1983			1984			Total
		F	P	F+P	F	P	F+P	F	P	F+P	F	P	F+P	fr.
	n =	34	27	18	69	53	14	100	70	22	100	65	24	
R. adusta	(M)	–	–	–	–	–	–	1	–	–	–	–	–	1
Clitocybe gibba	(L)	–	–	–	–	–	–	1	–	–	–	–	–	1
C. fragrans	(L)	–	–	–	–	–	–	1	–	–	–	–	–	1
Cortinarius bolaris	(M)	–	–	–	–	–	–	1	–	–	–	–	–	1
Lentinus lepideus	(W)	–	–	–	–	–	–	1	–	–	–	–	–	1
Psilocybe magnivelaris	(L)	–	–	–	–	–	–	1	–	–	–	–	–	1
Tricholoma aestuans	(M)	–	–	–	–	–	–	1	–	–	–	–	–	1
T. album	(M)	–	–	–	–	–	–	1	–	–	–	–	–	1
Amanita muscaria	M)	–	–	–	–	–	–	1	–	–	–	–	–	1
Omphaliaster borealis	(L)	–	–	–	–	–	–	1	–	–	–	–	–	1
Amanita regalis	(M)	–	–	–	–	–	–	–	–	–	1	–	–	1
Chalciporus piperatus	(M)	–	–	–	–	–	–	–	–	–	1	–	–	1
Hygrophorus pustulatus	(M)	–	–	–	–	–	–	–	–	–	1	–	–	1
Tricholoma nauseosum	(M)	–	–	–	–	–	–	–	–	–	1	–	–	1
T. portentosum	(M)	–	–	–	–	–	–	–	–	–	1	–	–	1
Tricholomopsis decora	(W)	–	–	–	–	–	–	–	–	–	1	–	–	1
Cortinarius vibratilis	(M)	–	1	–	–	–	–	–	–	–	–	–	–	1
Galerina hypnorum s. lat.	(W)	–	1	–	–	–	–	–	–	–	–	–	–	1
Hypholoma myosotis	(L)	–	1	–	–	–	–	–	–	–	–	–	–	1
Lactarius camphoratus	(M)	–	1	–	–	–	–	–	–	–	–	–	–	1
Mycena cinerella	(L)	–	1	–	–	–	–	–	–	–	–	–	–	1
Pholiota alnicola	(W)	–	1	–	–	–	–	–	–	–	–	–	–	1
P. scamba	(W)	–	1	–	–	–	–	–	–	–	–	–	–	1
Galerina cf. *sphagnorum*	(L)	–	–	–	–	1	–	–	–	–	–	–	–	1
Lactarius uvidus	(M)	–	–	–	–	1	–	–	–	–	–	–	–	1
Fayodia maura	(L)	–	–	–	–	–	–	–	1	–	–	–	–	1
Hebeloma crustuliniforme	(M)	–	–	–	–	–	–	–	1	–	–	–	–	1
Lactarius deterrimus	(M)	–	–	–	–	–	–	–	1	–	–	–	–	1
L. scrobiculatus	(M)	–	–	–	–	–	–	–	1	–	–	–	–	1
Amanita virosa	(M)	–	–	–	–	–	–	–	–	–	–	1	–	1
Agrocybe sp.	(L)	–	–	1	–	–	–	–	–	–	–	–	–	1
Cortinarius anomalus	(M)	–	–	1	–	–	–	–	–	–	–	–	–	1
Pluteus atricapillus	(W)	–	–	1	–	–	–	–	–	–	–	–	–	1
Russula foetens	(M)	–	–	1	–	–	–	–	–	–	–	–	–	1
Naucoria sp.	(M)	–	–	1	–	–	–	–	–	–	–	–	–	1
Flammulina velutipes	(W)	–	–	1	–	–	–	–	–	–	–	–	–	1

(contnd.)

Table 14. contnd.

Macrofungi		1981			1982			1983			1984			Total
		F	P	F+P	F	P	F+P	F	P	F+P	F	P	F+P	fr.
	n =	34	27	18	69	53	14	100	70	22	100	65	24	
Hygrophorus agathosmus	(M)	–	–	–	–	–	1	–	–	–	–	–	–	1
Clitocybe ditopus	(L)	–	–	–	–	–	1	–	–	–	–	–	–	1
Xeromphalia fellea	(L)	–	–	–	–	–	1	–	–	–	–	–	–	1
Collybia acervata	(W)	–	–	–	–	–	–	–	–	1	–	–	–	1
Tylopilus felleus	(M)	–	–	–	–	–	–	–	–	–	–	–	1	1
Mycorrhizal species		64	46	56	30	33	17	58	48	38	37	37	22	
		46.4	**43.4**	**46.3**	**42.9**	**55.9**	**51.5**	**50.4**	**57.1**	**66.7**	**59.7**	**63.8**	**75.9**	
Litter saprophytes		50	42	44	28	23	12	43	30	16	18	18	7	
		36.2	**39.6**	**36.4**	**40.0**	**39.0**	**36.4**	**37.4**	**35.7**	**28.1**	**29.0**	**31.0**	**24.1**	
Wood saprophytes		23	17	20	12	3	3	13	6	3	7	3	–	
		16.7	**16.0**	**16.5**	**17.1**	**5.1**	**9.1**	**11.3**	**7.2**	**5.2**	**11.3**	**5.2**	**–**	
Parasites		1	1	1	–	–	1	1	–	–	–	–	–	
		0.7	**1.0**	**0.8**	**–**	**–**	**3.0**	**0.8**	**–**	**–**	**–**	**–**	**–**	
Total number of macrofungi		138	106	121	70	59	33	115	84	57	62	58	29	

* *Cortinarius* spp. containing some species in the subgenus *Telamonia*
** *Galerina* spp. and *Clitocybe* spp. two or three different species

types in 1981–1984. Ninety-five macrofungus species were identified in only one or two sample plots (Table 14). The percentages of mycorrhizal species, litter and wood saprophytes and parasites in mineral soil forest, peatland and mixed forest and peatland site types are given in Table 14.

The good mushroom yield of 1981 is indicated by the observations that all the inventoried sample plots (n = 79) had macrofungus species (on most of the sample plots, the number of species identified exceeded 10). In the poor mushroom yield year of 1982, inventories covered 136 sample plots; 21 plots had no macrofungi and 53 sample plots had only three species present, or less. During the middling year of 1983 (n = 192), thirteen sample plots were void of macrofungi. The species composition study conducted in 1984 as a single inventory (n =189) revealed 65 sample plots void of macrofungi; of these, 36 sample plots represented heath forest sites. The great number of sample plots void of macrofungi was the result of dry weather at the beginning of the growing season in May–June.

Discussion

Diversity of macrofungus communities and composition of ecological groups

The sampling method used here, whereby sampling is made from square-shaped permanent mycoflora sample plots (each 0.01 ha in size) located inside the inventory blocks used in the National Forest Inventory, involves systematic sampling. For the purposes of this study, the species of fungus collected from a permanent plot 0.01 ha in size provided an adequate picture of the occurrence of fungal communities during the study years, especially with regard to mesic (n = 111), dryish (n = 143) and dry (n =47) heath forests. The macrofungi of the most nutrient-poor drained sites of varying ages of pine mires and bogs (n = 149) and spruce mires (n = 50) differed from one another and from the macrofungi of virgin mire sites (total of 55 sample plots). The study material had a fairly low number of forest and peatland site types defined as fertile on the basis of their vegetation. The plant flora in rich heath forests and mires characterised by an abundance of herbs, tall

sedges and *Vaccinium myrtillus* (incl. drained sites) was more versatile than in the poorest forest and peatland site types; thus, the fertility of the sample plots at least enhances the chances for the occurrence of saprophytic fungi.

Podsol soil types typically exhibit an acidic raw humus layer (pH c. 4) overlaying the uppermost (leached) layer of mineral soil, the said humus layer being composed of the densely interwoven roots of dwarf shrubs and other plants so that it has a felt-like appearance. Many saprophytic fungi acting upon the raw humus and litter inhabit this slowly decomposing moss and litter layer, the A 1 horizon. Saprophytes feeding on forest mosses can also be referred to as conditional saprophytes acting upon the raw humus layer. The substrate of most mycorrhizal fungi consists of the acidic raw humus layer, which lacks (or contains only small populations of) earthworms, bacteria and protozoa, these being more abundant in the less acidic mull soil.

The commonest soil class was that of loams and moraine. Sorted material was present on only a few sample plots. In 1990, to meet the needs of the present study, soil and peat samples were taken from more than 100 sample plots, which were analysed for the main nutrients and their pH (unpublished material). Mineral soil and peatland site samples totalling 194 were analysed; the average pH was 4.18 (range of variation 3.70–4.79). Thus, the soil-based macrofungi on the forest and peatland site types appeared to be mainly of the acidophilic kind.

Some study results are compared to those of earlier European studies (Table 15). The ecological groupings in those studies differ from those used here: The high percentage of terrestial fungi (soil fungi) in evergreen oak woods (*Quercus ilex* woods) is caused by the way such woods are managed (cuttings are carried out every 12–14 years) and particularly by the type of litter produced (De Dominicis & Barluzzi 1983) (Table 15). In actual fact, *Quercus ilex* leaves fall in late spring, when they are two years old, and they remain on the ground for a long time, forming a thick and compact cover. Their humification proceeds slowly and only in the layer at the ground surface, as the top layer protects the soil from evaporation and rapid temperature changes. The ecological conditions are favourable for the production of terrestrial fungi (soil fungi) but unfavourable for the development of litter fungi (De Dominicis & Barluzzi 1983).

In hemiboreal coniferous and decidious forests the percentage of terrestial fungi (if mycorrhizal species and litter saprophytes are combined) is almost the same (83.9%) as in evergreen oak woods (84.5%), but lower (65.3%) than in boreal coniferous and mixed forests and peatlands (Table 15).

The macrofungi of chestnut forests is very different from that of oak forests. It is characterised by a large admixture of acidophilous species, some of which also occur in coniferous forests (Tortić & Lisiewska 1978). It is astonishing to note that many macrofungi are common to both chestnut forests (and acidophilous beech and oak forests) and the coniferous forests of North Karelia, Finland. Examples include *Amanita fulva*, *A. muscaria*, *A. vaginata*, *Boletus edulis*, *Cantharellus cibarius*, *C. tubaeformis*, *Cortinarius muscigenus*, *C. trivialis*, *Laccaria laccata*, *Paxillus involutus*, *Russula foetens*, *R. xerampelina*, *Lactarius camphoratus*, *L. uvidus* and *Tylopilus felleus*, most of which are mycorrhizal species of Norway spruce and birch (Table 4). All mycorrhizal species mentioned above can live in symbiosis with *Castanea vesca*, *Quercus petraea* and *Fagus silvatica*, the main tree species in chestnut forests (Tortić & Lisiewska 1978).

Kalamees (1980b) describes 735 macrofungi encountered on various sites in Estonia. Although the overall variety of macrofungi reported by Kalamees was clearly larger than in this study, the relative proportion of mycorrhizal species and parasites was nearly the same (Table 15). In the present study, wood saprophytes amounted to 32.6%, whereas Kalamees obtained a figure of 15.1% (Table 15). The explanation for this significant difference is that the figures for the present study (in addition to macrofungi) include 61 species of fungi belonging to the orders Aphyllophorales, Heterobasidiomycetes and Gasteromycetes and 23 Ascomycotina fungi not included in the study by Kalamees (1980b).

The number of saprophyte species was notably high in the study of Kalamees (1980b) (Table 15). The reason for this is that some of Estonia's mineral soils support a high variety of tree and shrub flora, and fertile forest types have an abundance of grasses and herbs. The litter is more versatile both qualitatively and quantitatively, and it is decomposed by a richer flora of saprophytes than can be maintained nutrient-poor heath forests of Karelia and their acidophilic saprophyte flora. In addition to forest and peatland types, in his study

Table 15. Number of fungi and percentage of the ecological groups in some deciduous forests of southern and central Europe, in the hemiboreal forest zone of Estonia and in the boreal coniferous forest zone of Finland. M = mycorrhizal species, S = soil fungi incl. both saprophytic and mycorrhizal species, L = litter saprophytes incl. humus saprophytes, saprophytes on mosses and peat, on an organic base in mineral soil or burnt ground and fungal and herbivore dung, W = wood saprophytes and P = parasites.

Forests (woods)	M No of fungi, %	S No of fungi, %	L No of fungi, %	W No of fungi, %	P No of fungi, %	Total no of fungi	Source
Hornbeam oak woods		237 **75.7**	48 **15.3**	23 **7.4**	5 **1.6**	313	Darimont (1973)
Beech woods		130 **49.0**	69 **26.0**	66 **24.9**		265	Lisiewska (1974)
Acid oak woods	102 **32.6**		123 **39.3**	81 **25.9**	7 **2.2**	313	Jansen (1981)
Evergreen oak woods		153 **84.5**	14 **7.7**	11 **6.1**	3 **1.7**	181	De Dominicis & Barluzzi (1983)
Hemiboreal coniferous and deciduous forests	285 **38.8**		332 **45.1**	111 **15.1**	7 **1.0**	735	Kalamees (1980b)
Boreal coniferous and mixed forests and peatlands	125 **39.6**		81 **25.6**	103 **32.6**	7 **2.2**	316	This study

Kalamees (1980b) included meadows on mineral soils (alvar meadows, moraine hill meadows, typical meadows) rich in humus and saprophytic macrofungi acting upon litter; yet abundant mycorrhizal macrofungi were also reported to occur on these meadows (Kalamees 1980a).

Mycorrhizal species are generally easy to distinguish; i.e. species of genera such as *Boletus*, *Lactarius*, *Leccinum*, *Cortinarius*, *Russula*, *Suillus* and *Tricholoma* are beyond doubt. Species of some genera, such as *Bankera*, *Hydnellum*, *Hydnum*, *Phellodon* and *Sarcodon*, have been presented as saprophytic species (Maas Geesteranus 1975, Heiskanen & Ohenoja 1986). Hintikka & Näykki (1967) considered them to be mycorrhizal. *Coltricia perennis* and *Scutiger* spp. can be considered to be litter saprophytes. Alternatively, they may be seen as being mycorrhizal.

Wood saprophytes growing on trunks, branches, stumps of trees and rotten wood are easy to distinguish. It is readily noticed that deciduous trees are a more preferable substrate for wood saprophytes (46 species) than conifers (36 species) (Table 6). In this study the ratio of species is 1:0.8; according to Kalamees (1980b) the ratio is 1:0.5. A few macrofungi are wood saprophytes of both deciduous and coniferous trees; i.e. *Gymnopilus penetrans*, *Hypholoma fasciculare*, *Mycena galericulata* and *Pluteus atricapillus*.

It is not always easy to distinguish litter saprophytes from humus saprophytes. In the case of some species, it was difficult to determine whether the species grew in the humus or in the fallen leaves. This study rejected the idea that humus saprophytes form their own ecological group; instead a litter saprophytes group was formed which also contained saprophytes specializing in certain parts of the litter, and what may be referred to as humus saprophytes constitute one component of the litter saprophytes of conifers and deciduous trees (Table 7). Jansen (1981) formed both a humus saprophytes group — the species of the genera *Clitocybe*, *Cystoderma*, *Entoloma*, *Psathyrella* etc. — and a litter saprophytes group. As litter saprophytes, Jansen (1981) considered the species of the genera *Ciboria*, *Clavariadelphus*, *Collybia* (except *C. fusipes*), *Marasmius*, *Psilocybe*, *Rickenella*,

Typhula and some of the species of the genera *Galerina* and *Mycena*.

The difference between parasites and saprophytes is not always clearly defined. Traditionally, Aphyllophorales species have been taken to form one family, *Polyporaceae*, and many genera of which are classified as being wood saprophytes. Nowadays, Tremellales, Aphyllophorales and Hymenochaetales species are divided into eleven families. Species of Coriolaceae and Poriaceae are real polyporus fungi (Niemelä 1988). In connection with the present study, Aphyllophorales species (Table 6) were considered to be wood saprophytes with the exception of *Heterobasidion annosum*, which is both a tree parasite and a wood saprophyte.

Many of the Aphyllophorales species kill living trees and also act as wood saprophytes. *Fomes fomentarius*, *Inonotus obliquus* and *Piptoporus betulinus* are parasites and wood saprophytes on birches, *Phellinus conchatus* on living and dead willows, *P. igniarius* on all deciduous trees (seldom on aspen); *P. pini* is a parasite and secondarily a wood saprophyte of Scots pine and *P. tremulae* is a parasite of living aspens (Niemelä 1988). The spores of most heartwood-decaying polyporus fungi gain entry into the wood or under the bark through stem and root injuries, through broken branches and through passages made bark beetles. Castello et al. (1976) mention *Fomitopsis pinicola* as an example of the last mentioned route of entry; this polyporus fungus is a common saprophyte of conifer wood, and it is the cause of considerable economic losses (Niemelä 1988).

Lyophyllum palustre and *Galerina paludosa* were considered to be moss saprophytes living on *Sphagnum* species (Table 8) and *Cystoderma* species litter saprophytes depending on the litter of coniferous and deciduous tree species (Table 7). According to Untiedt & Müller (1985), *Lyophyllum palustre* is a parasite, because its mycelium can penetrate through plant cell walls and decompose the contents cells; the cell walls are, however, left intact. Afflicted *Sphagnum* mosses die in a few days, and saprophytic species then begin commence to decompose the surroundings of the fruit body, whereupon a light-coloured spot appears on the *Sphagnum* moss. *Galerina paludosa* infects the cells of the protonema and absorbs nutrients from it (Redheard 1981). *Cystoderma* species can de-compose the base of dead mosses or, alternatively, *Cystoderma* species can live in symbiosis with mosses and they can be parasites of forest mosses (Harmaja & Korhonen 1991).

Ordination and classification methods of macrofungi

The macrofungus material for the year 1981 did not include sample plots containing only one or two species that would have made it necessary to exclude the sample plot in question as a non-conforming observation. The ordination and classification methods that were applied required the presence of several fungus species on each sample plot. The classification method has previously been used in connection with plant material studies conducted in Finland (e.g. Oksanen 1984, Kuusipalo 1985, Sepponen 1985, Lahti & Väisänen 1987, Tonteri et al. 1990); The problem of overly uniform material did not arise in those studies as the field and ground layers generally contain several plant species.

The material sampled in 1981 (mineral soil forest, peatland and mixed forest and peatland site types) provide supplementary data on the structure of mycocommunities. In a method that makes hierarchical divisions, the probability of obtaining a correct classification is highest with the first division, whereafter the probability decreases. Owing to the size of the material, the data obtained were defined using two divisional levels.

In the case of forest and peatland types resembling one another in terms of their macrofungi, the classification method appeared to work well, and the indicator species were members of the basic species forming the groups (Figs. 5 and 6). TWINSPAN classification highlighted the selectiveness of the program, as the mixed sample plots in the material for 1981 formed a heterogenic sample plot cluster of their own, thus making it possible to stratify the material into sample plots of forest and peatland site types and into mixed sample plots. In the mixed sample plots (e.g. 12VMT70% + 42RhK30%), the macrofungi included species characteristic of heath forests and mires, and consequently the indicator species do not necessarily dominant species depicting the group.

Distributions made in connection with DCA analyses on the basis of vegetation cover analyses (% coverage scale) are often askew, especially those for rare species. In addition, the distributions may have twin peaks, and

consequently the frequencies of species rarely take on the form of a normal distribution. Many saprophytic fungi depend on a specific substrate, such as aspen leaves, spruce cones, elk dung or hare droppings. Random variation thus plays a significant role in the occurrence of many saprophytic fungi. Aspen leaves may be carried far inside a barren site where aspen as such does not occur. Similarly, a squirrel may carry a spruce cone from a GOMT sample plot to an ECT sample plot.

The sample plots grouped according to their plant species in the study by Salo (1979) formed six separate sample plot groups when viewed in six dimensions. Six sample plot groups were also formed when the material was examined according to species of fungi, but these groups were located closer to one another and were partly overlapping in the ordination space. This closeness and overlapping were due to differences in the composition of plant species on drained and fertilized *Sphagnum fuscum* pine bog sample plots, for instance (i.e. *Pleurozium — Calluna* and *Sphagnum fuscum — Calluna* plant communities), whereas their macrofungi were the same. The sample plot group of virgin true dwarf-shrub pine bogs differed from the other peatland type sample plot groups in terms of both its plant and fungus flora (Salo 1979). The results obtained in the present study confirmed the consept that drained peatland site types (especially pine bogs) have a more versatile macrofungi than virgin mires (Salo 1979).

Virgin pine bog sample plots and a virgin ombrotrophic small sedge bog sample plot (LkN) had less fungus species in this study than did sites that had been recently drained or sites that were classified as being in the transitional stage following drainage. Drainage had improved the supply of oxygen to roots, and this was made evident by the improved height growth of pines and the increased number of species and occurrence of mycorrhizal fungi.

Jäppinen et al. (1986) used DCA analysis on VT and MT forest types when they grouped sample plots according to the species composition and the biomass of macrofungi. DCA analyses revealed that in a dry year, a mesic heath forest (MT) and a dryish heath forest (VT) resembled one another in terms of mushroom yield and species composition. In this study in the good mushroom yield year of 1981, sample plots representing a mesic heath forest (VMT) and a dryish heath forest (EVT) contained many of the same species of macrofungi, whereas mature mesic heath forests had a macrofungi differing both from that of younger forests of the same forest type and from that of dryish heath forest sample plots. The macrofungi in mature heath forests on mesic mineral soil sites are more versatile than the macrofungi in heath forests of younger development classes or in dryer heath forest soils, because the microclimate and the moister conditions of the ground layer are more favourable to the growth of saprophytic species than in forests with dryer soils and developmentally younger classes of trees.

According to Hintikka (1988), the number of basidiocarps in an oligotrophic pine forest reaches its peak in 20-year-old, relatively dense stands, being smaller in regeneration areas and over-aged stands. Stands known as pole stage stands had an average height of 4–9 m and a canopy density of 80–95%; the dense tree stand presents favourable conditions for the growth of mycelia, because the humus and moss layers stay moist longer than in more open stands. In addition, the microclimate is less extreme with regard to frosts (Hintikka 1988). In normal mushroom years, the yields of macrofungi and the number of basidiocarps in oligotrophic young pine stands (pole-aged stands) can be high, though the number of mycorrhizal and saprophytic species is less than in mesotrophic pine and spruce forests (VMT).

The macrofungi of transitional drained spruce mire sites (KgKmu, PKmu) and pine mire and bog sites (KRmu, PsRmu, IRmu) contained many of the same mycorrhizal and saprophytic species as did mature mesic and dryish heath forests (VMT and EVT). The fertile spruce mires group (RhK, MK) contained mostly saprophytic species, many of them also being common in mesic (VMT) and rich (GOMT) heath forests.

The mycorrhizal species compositions of virgin spruce mires, pine bogs and fens differ distinctly from one another, owing to differences in tree, shrub and dwarf shrub species composition: They also differ with regard to saprophytic species; because of their richer surface vegetation, spruce mires have more plant material to be decomposed. The results of the present study also indicate the significance of intermediate peatland site types from the standpoint of the macrofungi: Spruce-pine mire (KR) sample plots are characterised by the fact

that they contain species of both spruce mires and pine bogs.

In the classification of macrofungi, it is necessary to realise that fungi are not as firmly fixed to their substrate as plants are. The fact that fungi are attached to trees, shrubs and dwarf shrubs, litter, humus, mosses and peat makes it more difficult to interpret a particular species of fungus as a member of the mycocommunity. The occurrence of fungi is subject to succession similar to that of plants. Different species dominate in the development classes of stands of the various forest types. Closing of the canopy is followed by the appearance of new species of fungus, along with changes in tree species and surface vegetation species composition. The downweighting option used in DCA analysis improved the interpretability of fungus species in certain cases by reducing the significance of rarer species. A particular fungus species may occur on a sample plot by chance, and in doing so it can cause an error in the ordination, or a sample plot may move towards another group. In the present study, a typical "chance fungus" was *Stropharia semiglobata*; it can grow in hare droppings on any sample plot visited by hares.

The classification method employed made it possible to distinguish clear groups among the sample plots in forest and peatland site types. The sample plot group for forest site types also evidenced overlapping (Fig. 5). It was difficult to separate mycocommunities within vegetation types, owing to the gradual and multidimensional variation of mycocommunities. Forest types also tend not to be distinctly delimited in terms of their fertility gradient (e.g. dry and dryish heath forests; Kuusipalo 1985, Hotanen & Nousiainen 1990). With the DCA results as the basis, the structure of mycocommunities can be described as to heath forest vegetation, for instance, by means of a one-dimensional moisture — fertility gradient even though the primary gradient is complex (Fig. 5).

Macrofungus communities have multi-dimensional (complex) structures and there is much room for variation, because many environmental factors (and perhaps the fungi themselves) influence the formation of fruit bodies. Factors influencing the structure of mycocommunities include tree species composition, stand age (development class) and canopy coverage, the physiological state of trees and fungal hyphae, precipitation and temperature during the growing season, the fertility of the substrate, moisture and dryness, the quantity and quality of plant species and of litter in field and ground layers, the thickness and moisture content of humus and moss layers, internal competition between fungus species, their ability to regulate spore production in favourable and unfavourable times, airborne pollutants, and soil acidity.

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