

New records of *Funalia trogii*, *Perenniporia tenuis* and *Polyporus pseudobetulinus* from Finland, with notes on their habitat requirements and conservation implications

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We report the results of three extensive surveys between 1996 and 1999 on the polypore flora of dead aspen trees (*Populus tremula* L.) in eastern Finland. These surveys yielded several new finds and new information on the habitat requirements of three polypore species classified as endangered in Finland: *Funalia trogii* (Berk.) Bondartsev & Singer, *Perenniporia tenuis* (Schwein.) Ryvarden and *Polyporus pseudobetulinus* (Pilát) Thorn, Kotir. & Niemelä. Our observations confirm that *F. trogii* is a thermophile preferring sun-exposed habitats. Similarly, all new records of *P. tenuis* were made in open habitats. *P. pseudobetulinus* has also been found occasionally on retained aspens in clear-cut areas, although it is usually located in old-growth forests. Our results suggest that these and other threatened species with similar habitat requirements could possibly survive even in a managed forest landscape, provided that potential host trees are retained in sufficient numbers. Most of the new records derive from trees killed by notching or girdling, indicating that suitable host trees for these species can be created even by killing trees. However, notching or girdling should be used with caution because it will reduce the availability of aspen trees in the future.

Key words: aspen, conservation implications, *Funalia trogii*, habitat ecology, *Perenniporia tenuis*, *Polyporus pseudobetulinus*, threatened polypores

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Introduction

Funalia trogii (Berk.) Bondartsev & Singer, *Perenniporia tenuis* (Schwein.) Ryvarden and *Polyporus pseudobetulinus* (Pilát) Thorn, Kotir. & Niemelä, are rare polypore species seldom found

in Europe and there are only a few records of their existence in the Nordic countries (Niemelä et al. 1992, Ryvarden & Gilbertson 1993, 1994, Olofsson 1996). All of these species are classified as

endangered in Finland (Rassi et al. 1992, Kotiranta & Niemelä 1996) and almost all records in the Nordic countries derive from aspen trees (*Populus tremula* L.). Aspen trees, especially large living trees, snags and logs, are an important host for hole-nesting birds (Hågvar et al. 1990), invertebrates (Siitonen & Martikainen 1994, Siitonen 1999), wood-rotting fungi (Kotiranta & Niemelä 1996), bryophytes (Andersson & Hytteborn 1991, Kuusinen 1996) and lichens (Kuusinen 1994, 1995).

The first record of *Funalia trogii* in Finland was made in 1988 in Ilomantsi, eastern Finland (Niemelä et al. 1992). It was rediscovered in 1992 at the same site, but until now there have been no other records from the country. *P. tenuis* has been recorded twice in Finland: *Etelä-Häme*, Tammela, in 1879 on *Alnus incana* (L.) Moench and *Pohjois-Karjala*, Lieksa, Patvinsuo National Park in 1989 on aspen (Niemelä et al. 1992). *P. pseudobetulinus* is a very rare species all throughout the world (Thorn et al. 1990). In Finland it was known for a long time at two sites: *Pohjois-Häme*, Karstula (1956), and a viable population from north-western Finland in *Perä-Pohjanmaa*, Rovaniemi municipality and Tervola, Pisavaara Strict Nature Reserve (Kotiranta & Niemelä 1996). During the 1990s it was intensively sought in extensive surveys of old-growth forests (The Old Forest Inventory Programme) and by 1996, it had been spotted 25 times (Kotiranta & Niemelä 1996). After 1996, it was discovered in at least 15 new localities in Finland.

The taxonomy of these three species has been discussed by Thorn et al. (1990) and Niemelä et al. (1992). Here, we compile new records of *Funalia trogii*, *Perenniporia tenuis* and *Polyporus pseudobetulinus* from Finland together with information on accompanying species. We provide up-to-date distribution maps for these three species as well new information on their habitat requirements, and discuss the implications for their conservation.

Materials and methods

Most of the new finds derive from two intensively studied areas and three independent inventories. In addition, some scattered records from other areas are included. The material is preserved in the herbaria H, HPP, JYV and OULU (Holmgren et al. 1990) and/or reference collections of Heikki Kotiranta (H.K.), Harri Lappalainen (H.L.), Otto Miettinen (O.M.), Tuomo Niemelä (T.N.), Reijo Penttilä (R.P.) and Pertti Renvall (P.R.). We use

the biological provinces of Finland, and indicate the collecting sites according to the Finnish national uniform grid system (Grid 27° E; Heikinheimo & Raatikainen 1981). In the distribution maps every dot covers 10 × 10 km and can thus include either one or several separate patches where the fungus is found. The nomenclature of accompanying fungal species follows Niemelä (1999; polypores) and Hjortstam (1984; corticioid fungi). The authors of the species are cited in those publications and are not repeated in the text.

Habitat notes of *F. trogii* and *P. tenuis* derive from our own records, but for *P. pseudobetulinus* information from other adequate records (i.e., containing more dated information on habitats) was used as well.

Study areas and inventories

Savonranta: The study area is situated in the biological province Pohjois-Savo, in eastern Finland, and belongs to the southern boreal subzone (Ahti et al. 1968). The records in Savonranta were made during a survey of polypore flora on fallen aspen trunks, conducted by P.M. and R.P. in 1996–97. Over 100 fallen trunks of aspen were examined in two localities: Raatelamminsalu (6908:602) and Muhamäki (6910:604).

The old-growth forest reserve "Raatelamminsalu" is one of the most outstanding examples of aspen-rich old-growth forests in southern Finland; some aspens reach a diameter of 90 cm and a height of over 30 m. The size of the reserve is 69 ha, of which about 10 ha had been clear-cut during the winter of 1991–92. Most of the aspens (over 200) in the clear-cut area had been left standing, but many of them had fallen soon after cutting (Fig. 2).

The old-growth reserve "Muhamäki" is 55 ha in size, of which 10 ha was clear-cut in 1984. Practically all aspens were notched (killed with herbicides) one year before the clear-cutting. Later, almost every tree had lost its bark and fallen (Fig. 5). The area has been replanted with pine.

Kuhmo – Sotkamo: The study area is situated in the province Kainuu in eastern Finland ca. 300 km north of Savonranta and belongs to the middle boreal subzone (Ahti et al. 1968). An extensive inventory of living and dead aspen trees and goat willows (*Salix caprea* L.), and three polypore (including *P. pseudobetulinus*) and one lichen species associated with these tree species, took place during the years 1997–1999, and covered 100 km². The total number of aspen trees studied (DBH > 15 cm) was almost 35 000 (see Gu et al. 2000).

The southern part of the study area is dominated by old-growth spruce forests and large old aspens are common in the area. Only a small proportion of the aspens have been purposefully killed, and the area is much less influenced by forest management than the northern part of the study area, where the proportion of old-growth forest is lower and the old-growth forests are more fragmented.

Another study of polypores on dead aspens was carried out by the author O.M. in 1998 in Kuhmo, in the large aspen and goat willow inventory area. The survey covered 9 km²: 3 km² was aspen-rich old-growth forest and 6 km² was managed landscape with more scattered occurrence of aspen.

Results

Funalia trogii: Seven of the new *F. trogii* records were made in Savonranta and one in Kuhmo (Appendix). All the records of *F. trogii* in this study (as well as the first record from Fin-

land; Niemelä et al. 1992) are from thick (mean DBH = 41 cm) aspen trunks lying in sun-exposed locations (Table 1, Figs. 1, 2). Although we examined the same number of similar aspen trunks in old-growth forests as counted in clear-cuts in Savonranta, we did not find the species inside

Table 1. Characteristics of host trees and forest habitats inhabited by *Funalia trogii*.

Tree no	Habitat	Quality	Treatment	DBH (cm) ^a	Decay stage (1–5) ^b	Bark Coverage (%)	Fruitbody condition
1	clear-cut	fallen trunk	no	60	3	50	mostly dead
2	clear-cut	fallen trunk	no	41	1	80	young, alive
3	clear-cut	fallen trunk	no	45	1	80	young, alive
4	sapling stand	fallen trunk	cut	30	3	0	mostly dead
5	sapling stand	fallen trunk	notched	42	3	30	dead
6	sapling stand	fallen trunk	notched	44	3	10	dead
7	sapling stand	fallen trunk	notched	40	3	30	dead
8	sapling stand	fallen trunk	— ^c	26	3	70	dead
Mean				41		44	

^a Diameter at breast height.

^b Dominant decay stage in the host tree. For a description of different decay stages see Renvall (1995).

^c Data missing.



Fig. 1. Fruit body of *Funalia trogii* on a fallen aspen. Raatelamminsalo, Savonranta. Photo P. Martikainen.



Fig. 2. Habitat of *Funalia trogii* in Raatelamminsalu, Savonranta. The more distant fallen trunk in the front hosted several young fruit bodies of the species. Photo P. Martikainen 1996.

the forest. In Kuhmo, hundreds of fallen aspen trunks were examined both inside and outside old-growth forests and *F. trogii* was found only from an open sapling stand. Half of the records were also from purposefully killed trees (Table 1).

Funalia trogii seems to favour fresh, only slightly decayed trunks: in Savonranta vigorously growing fruit bodies were observed as early as four years after the tree had fallen (trunks with decay stage 1; Table 1). Conversely, nearly all of the fruit bodies found on trunks that were notched in 1983, were dead in 1997 (trunks with decay stage 3; Table 1). *Trametes ochraceae*, *Bjerkandera adusta* and *Gloeophyllum sepiarium*, which are the most frequent accompanying species (Table 4), are also known to start producing fruitbodies at an early stage of wood decomposition.

***Perenniporia tenuis*:** *P. tenuis* was found three times in Kuhmo, once in Muhamäki, Savonranta and once in Pampalo, Ilomantsi (Appendix). All these records were made in open clear-cut or sapling areas (Table 2, Fig. 4). All the records,

except one, were also made in aspen-rich spots, where dead trunks were more common than in the surrounding landscape.

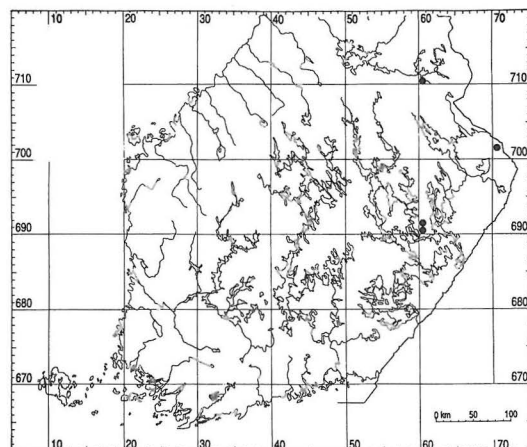


Fig. 3. Distribution of *Funalia trogii* in Finland.

Table 2. Characteristics of host trees and forest habitats inhabited by *Perenniporia tenuis*.

Tree no	Habitat	Quality	Treatment	DBH (cm) ^a	Decay stage (1–5) ^b	Bark Coverage (%)	Fruitbody condition
1	sapling stand	loose branch	notched	6	2	0	alive
2	clear-cut	fallen trunk	notched	50	3	0	alive
3	sapling stand	piece of fallen trunk	— ^c	15	3	0	alive
4	sapling stand	fallen trunk	girdled	30	4	0	alive
5	sapling stand	fallen trunk	no	19	3	0	alive
Mean				24		0	

^a Diameter at breast height.^b Dominant decay stage in the host tree. For a description of different decay stages see Renvall (1995).^c Data missing.

Most of the records were from trees killed by notching or girdling. The size of the host tree is not as important for *P. tenuis* as for *F. trogii*, because it was found even from a separated branch (Figs 3, 4), and from both thin and thick trunks (mean DBH of host trees = 24 cm; Table 2). *P. tenuis* prefers decorticated trees at rather advanced stages of decay (Table 2). The most frequent accompanying species was *Gloeophyllum sepiarium* (Table 4), a thermophilic species preferring open, sunny habitats.

***Polyporus pseudobetulinus*:** The inventory in the Kuhmo and Sotkamo study area yielded several new records of *P. pseudobetulinus*. Although the southern part of the study area was thought to be most suitable for *P. pseudobetulinus*, it was found only in Heinävaara area, which belongs to the more managed northern part of the study area. The number of aspens is high in Heinävaara, but almost all of the trees have been killed by notching. In the inventory years 1998 and 1999, *P. pseudobetulinus* was found on 19 trees within an area of about 2 km². This area contains now the richest known population of the species in Europe, and probably also worldwide (see Thorn et al. 1990). Almost all observations (17 of the 19 host trees) of *P. pseudobetulinus* in Heinävaara, Sotkamo were made on trees killed by notching. The richest occurrence (8 trees) was in fern-rich (*Matteuccia struthiopteris* (L.) Tod.), moist brookside, where the largest aspens were about 70–80 cm in diameter (Fig. 7). Other trees with *P. pseudobetulinus* were distributed in rather scattered fashion in the rest of the area. Most records were from small old-growth forest patches, but five were also from clear-cut areas.

The complete data set of habitat notes (Table 3) shows that *P. pseudobetulinus* prefers old-

growth forests (n = 43). However, some records (n = 11) derive from clear-cuts or sapling stands. The richest populations in Finland (Heinävaara and Pisavaara) are on rich, luxuriant sites dominated by spruce (see Fig. 7).

P. pseudobetulinus has principally been observed on dead trees (n = 42) – the species has been found only 10 times on living aspens (Table 3). Furthermore, many of the living trees were almost dead, which seems to indicate that *P. pseudobetulinus* is able to colonise only weakened or dead trees, or perhaps more likely, it only produces fruit bodies on such trees. It prefers large (mean DBH = 38 cm), standing trees or snags (n = 44). However, occasionally (n = 9) living fruit bodies were found on recently fallen trees and even on trees that had fallen several years earlier.

A large proportion of host trees were notched or girdled (n = 23), the remainder (n = 21) were alive or had died naturally (Table 3). *Phellinus tremulae*, a very common polypore species in mature aspens (Niemelä 1999), is the most frequent accompanying species (n = 17/30; Table 4). There were few other accompanying species, and on eight occasions no other species was found on the same tree.

Discussion

Habitat requirements: The preference of *F. trogii* for open habitats is well documented in the Finnish material. Furthermore, we found this species earlier under similar conditions in the Kivach Nature Reserve (Siitonen et al. 1996) and in the Vodlozersky National Park (Siitonen et al. 2000) in the Republic of Karelia, Russia. All of this confirms that *F. trogii* is a thermophilous species, as suggested by Kotiranta and Niemelä (1996). One

Table 3. Characteristics of host trees and forest habitats inhabited by *Polyporus pseudobetulinus*.

Tree no	Habitat	Quality	Condition	Treatment	DBH (cm) ^a
1	old forest	standing tree	dead	— ^b	—
2	old forest	standing tree	dead	—	—
3	old forest	standing tree	dead	girdled	20
4	old forest	standing tree	dead	girdled	46
5	clear-cut	standing tree	dead	girdled	—
6	clear-cut	standing tree	dead	girdled	—
7	old forest	standing tree	dead	girdled	—
8	old forest	standing tree	dead	—	—
9	old forest	fallen trunk	dead	—	—
10	clear-cut	snag	dead	notched	31
11	clear-cut	snag	dead	notched	28
12	clear-cut	snag	dead	notched	20
13	clear-cut	fallen trunk	dead	notched	18
14	old forest	standing tree	alive	no	39
15	old forest	standing tree	dead	notched	18
16	old forest	standing tree	dead	notched	22
17	old forest	snag	dead	notched	29
18	old forest	snag	dead	notched	51
19	old forest	standing tree	dead	notched	44
20	old forest	fallen trunk	dead	no	26
21	old forest	fallen trunk	dead	notched	25
22	old forest	fallen trunk	dead	notched	30
23	old forest	standing tree	dead	notched	32
24	old forest	standing tree	dead	notched	12
25	old forest	standing tree	dead	notched	30
26	old forest	fallen trunk	dead	notched	34
27	clear-cut	fallen trunk	dead	girdled	30
28	old forest	standing tree	dead	notched	35
29	old forest	fallen trunk	dead	no	27
30	old forest	standing tree	dead	no	27
31	old forest	standing tree	alive	girdled	—
32	old forest	snag	dead	—	—
33	old forest	snag	dead	—	—
34	old forest	standing tree	dead	no	40
35	sapling stand	standing tree	dead	—	38
36	old forest	standing tree	alive	—	45
37	old forest	standing tree	dead	no	35
38	old forest	standing tree	alive	no	40
39	sapling stand	standing tree	dead	no	45
40	old forest	—	—	—	—
41	old forest	—	—	—	—
42	clear-cut	standing tree	dead	no	—
43	clear-cut	standing tree	dead	no	—
44	old forest	standing tree	alive	no	48
45	old forest	standing tree	dead	no	64
46	old forest	standing tree	alive	no	64
47	old forest	snag+fallen trunk	dead	no	64
48	old forest	standing tree	alive	no	54
49	old forest	standing tree	alive	no	41
50	old forest	standing tree	alive	no	48
51	old forest	standing tree	alive	no	67
52	old forest	standing tree	dead	no	62
53	old forest	standing tree	dead	no	64
54	old forest	standing tree	dead	no	22
TOTAL	old forest 43 clear-cut 9 sapling stand 2	standing tree or snag 44 fallen trunk 9	dead 42 alive 10	notched or girdled 23 no treatment 21	mean DBH 38 cm

^a Diameter at breast height.^b Data missing.



Fig. 4. Bright yellow fruit body of *Perenniporia tenuis* on decorticated, thin branch of aspen. Muhamäki, Savonranta. Photo R. Penttilä 1997.

of the most frequently accompanying species was *Gloeophyllum sepiarium*, which also prefers open habitats, such as clear-cuts (Niemelä 1999) and burned areas (Penttilä & Kotiranta 1996). The information on the habitat requirements of *F. trogii* in northern China (Dai 1996), Siberia, Irkutsk Region and Russian Far East, Magadan Region (Kotiranta, unpublished) corresponds with our data. In those areas, *F. trogii* is mostly found in standing trees, fallen trunks and stumps of *Populus* or *Salix* on open, sunny sites. In northern China it also seems to prefer fresh wood as it was often found on freshly cut logs and stumps.

An important reason for the rarity of *F. trogii* in Nordic countries is evidently the lack of suitable hosts (large aspen trunks in open places) in managed and even in protected forests (Siitonen & Martikainen 1994, Linder et al. 1997, Östlund et al. 1997, Martikainen 2000). The species is found here also at the western and northern limits of its distributional range. *F. trogii* is widespread in warmer parts of Europe (Ryvarden & Gilbertson 1993) and seems to be more common in central, southern and Eastern Europe than in the Nordic

countries (Niemelä et al. 1992). In northern China (Dai 1996), Siberia and Russian Far East (Kotiranta, unpublished), it is rather common. This may indicate that the climate in Nordic countries is not favourable (i.e. warm and continental enough) for *F. trogii*.

The new records of *P. tenuis* from clear-cuts and sapling stands are surprising, as the previous record from 1989 was made in an old-growth forest. For instance, Kotiranta and Niemelä (1996) assumed that this species would require undisturbed, moist and shaded conditions. Our observations suggest that factors other than microclimate are important for the survival of this species. However, *P. tenuis* probably needs more moisture in its habitat than *F. trogii* does as most records in Finland are from trees lying on rather moist ground.

Strict habitat requirements do not seem to explain the rarity of *P. tenuis*; other reasons for its rarity may be poor competitive ability or problems in dispersal and colonisation. Dispersal problems could be the best explanation because almost all finds from Finland are from aspen-rich



Fig. 5. The habitat, 13 years old clear-cut, of *Perenniporia tenuis* in Muhamäki, Savonranta. The separated branch containing the fruit body of the species leaning towards its host tree. Photo R. Penttilä 1997.

“hot spots” where the availability and continuity of suitable host trees is very good. Muhamäki in Savonranta is an example of such a “hot spot”, as indicated by the exceptionally rich fauna of saproxylic beetles living on aspen in that region (Rutanen 1995, Martikainen 2000). Besides *P. tenuis* and *F. trogii*, several threatened fungi in Finland, such as *Antrodia pulvinascens*, *Gelatoporia pannocincta*, *Protomerulius caryae*, *Radulodon erikssonii*, *Scytinostroma galactinum* and *Skeletocutis odora* were found on only 22 trunks in the Muhamäki clear-cut, giving additional support for the long substrate continuity in the area.

Of the three species studied, *P. pseudobetulinus* is most strongly associated with old-growth forests. However, even this view may be erroneous, since large, old aspens are mainly located in old-growth reserves and such trees are usually absent in managed forests (Siitonen & Martikainen 1994, Hazell 1999). In old forests, *P. pseudobetulinus* seems to prefer rather open habitats (Thorn et al. 1990, Olofsson 1996) and on a few occasions it has been found on trees left in clear-cut areas. Consequently, if more suitable host trees were available in managed forests, *P. pseudobetulinus* could possibly be maintained also in managed forest landscape. Another reason for

Table 4. Accompanying species in trees inhabited by *Funalia trogi*^a (n = 8), *Perenniporia tenuis*^b (n = 5) and *Polyporus pseudobetulinus*^c (n = 30).

Species	Frequency ^a	Frequency ^b	Frequency ^c
<i>Antrodiella semisupina</i>	1	—	—
<i>Armillaria borealis</i>	—	—	1
<i>Bjerkandera adusta</i>	4	—	3
<i>Ceriporia viridans</i>	1	—	—
<i>Chondrostereum purpureum</i>	1	—	—
<i>Fomes fomentarius</i>	2	—	3
<i>Fomitopsis pinicola</i>	2	—	—
<i>Gelatoporia pannocincta</i>	—	—	1
<i>Gloeophyllum sepiarium</i>	5	3	—
<i>Hyphodontia aspera</i>	—	1	—
<i>Phellinus populicola</i>	1	—	—
<i>Phellinus tremulae</i>	2	—	17
<i>Phlebia fuscoatra</i>	—	1	—
<i>Pleurotus</i> sp.	—	—	3
<i>Polyporus brumalis</i>	1	—	—
<i>Polyporus leptoccephalus</i>	—	—	2
<i>Postia alni</i>	—	2	—
<i>Postia tephroleuca</i>	—	1	—
<i>Postia undosa</i>	—	1	—
<i>Pycnoporus cinnabarinus</i>	1	—	—
<i>Rigidoporus corticola</i>	4	—	1
<i>Scytinostroma galactinum</i>	—	1	—
<i>Skeletocutis odora</i>	—	1	—
<i>Trametes hirsuta</i>	—	—	1
<i>Trametes ochraceae</i>	8	1	2
<i>Trametes</i> sp.	—	1	—
<i>Tyromyces chioneus</i>	1	—	—

its rarity could be that it seems to prefer rather fertile, productive habitats with large, old aspens (see Fig. 7); such habitats are very rare in managed forests.

The records of *F. trogi*, *P. tenuis* and *P. pseudobetulinus* [and of several other threatened species previously assumed to be old-growth forest specialists (Kotiranta & Niemelä 1996)] from open areas suggest that many fungal species that preferentially live on aspens and other deciduous trees do not necessarily need the humid microclimate of an old-growth forest to survive. Aspen is an early-successional tree species and it used to be common in the deciduous phase following fire in the natural boreal and hemiboreal landscape (Hazell 1999). It is adapted to frequent disturbances caused by fire (Zackrisson 1985), and therefore it is likely that many species that preferentially live on aspen or other early-successional deciduous tree species can survive frequent disturbances and are able to inhabit open areas. This hypothesis is supported also by recent studies on saproxylic beetles: a comparison between clear-cut areas and old-growth forests showed that the number and abundance

of threatened beetles associated with dead aspen was actually higher on clear-cut areas (Martikainen 2000). Similarly, Kaila et al. (1997) found that several threatened saproxylic beetles could survive in open habitats. Moreover, *Lobaria*

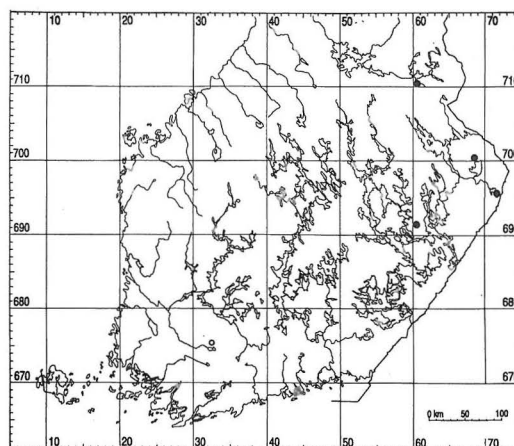


Fig. 6. Distribution of *Perenniporia tenuis* in Finland. (○ – record made before 1960, ● – record made after 1960).

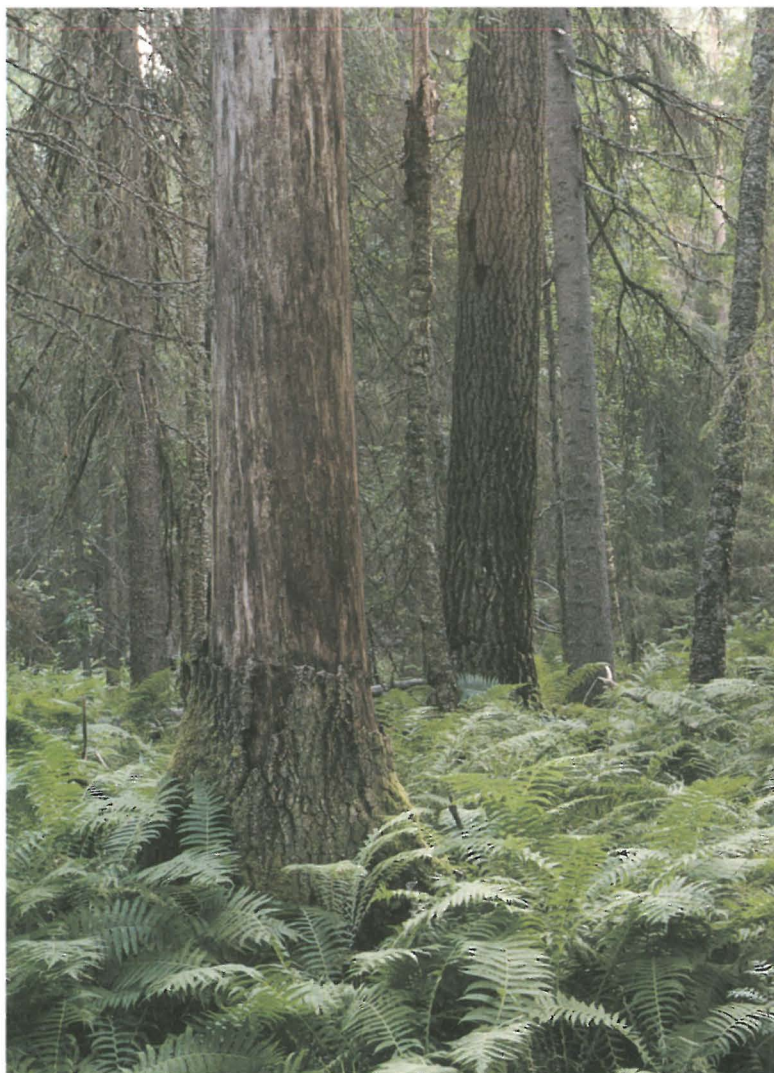


Fig. 7. Fernrich and moist habitat of *Polyporus pseudobetulinus* with large, notched aspens. Heinävaara, Sotkamo. Photo R. Penttilä 1997..

pulmonaria (L.) Hoffm., a lichen often used as an indicator of old-growth forests (Andersson & Appelqvist 1987, Kuusinen 1994, 1996), may survive better in more open forests (or within groups of retained old trees in clear-cuts) than in old, shaded forests (Hazell & Gustafsson 1999, Kuusinen, unpublished).

Conservation implications: There are at least three important reasons why the conservation of threatened species associated with aspen cannot be based solely on protection of old-growth forests in Finland. Firstly, several empirical and theoretical studies (see e.g. Andrén 1994, 1996,

With & Crist 1995, Fahrig 1997, Hanski 1999, Virkkala & Toivonen 1999) predict that when the size of an original habitat of a species decreases, for example, to the extent of old-growth forests in southern Finland, the probability of a species surviving in the long run is low. Secondly, the proportion of deciduous trees is likely to decrease in the existing forest reserves because major disturbances (such as forest fires), which are essential for the regeneration of pioneer tree species, are currently lacking in the reserves (Linder et al. 1997, Östlund et al. 1997). For example, young aspens are almost absent in the

Raatelamminsallo and the Kotinen old-growth forests, which are among the most aspen-rich forest reserves in southern Finland (Kuusinen & Penttinen 1999, Martikainen 2000). Thirdly, many species associated with aspen may actually prefer conditions that are rather different from those prevailing in shady old-growth forests (this study, Martikainen 2000).

Taken together this means that several complementary methods are needed for the successful conservation of species associated with aspen. Despite the limitations mentioned above, old-growth reserves are indispensable for many species, especially for those dependent on the specific microclimate or continuity of old-growth forests (Berg et al. 1994, 1995, Kotiranta & Niemelä 1996). The fact that protected areas are often the only places where large, old aspens can be found in high numbers further emphasizes the role of old-growth forests in the preservation of threatened species. It is, however, important to ensure that aspens are also available in the area in the future, and here the surrounding forests may prove to be very important. As the regeneration of aspen may require controlled burning or even clear-cutting with green tree retention (Linder 1998, Hazell 1999), such actions should preferably be taken outside the core old-growth forest areas.

The protection of old forests is apparently not the best possible conservation strategy for threatened species such as *F. trogii* and *P. tenuis*, which can tolerate sun exposure or are even adapted to open habitats. Instead, their successful conservation may require suitable host trees being available in sufficient numbers in open areas (Martikainen 2000). A recommendation to leave live and dead aspens on clear-cuts is thus warranted for the survival of many species.

Dead aspen is suitable for each saproxylic species for only a limited number of years. For instance, in our study notched aspens that had been dead for more than ten years no longer seemed to be suitable for *F. trogii*. To survive in a certain region, the species should be able to colonise new trees at the same rate as it disappears from those trees that have become too decayed to be suitable habitats. Thus, although the widespread and intensive notching of aspen in eastern Finland in the 1970s and 1980s created many suitable habitats for threatened species, the positive impact of this activity remains temporary. All the trees treated died almost simulta-

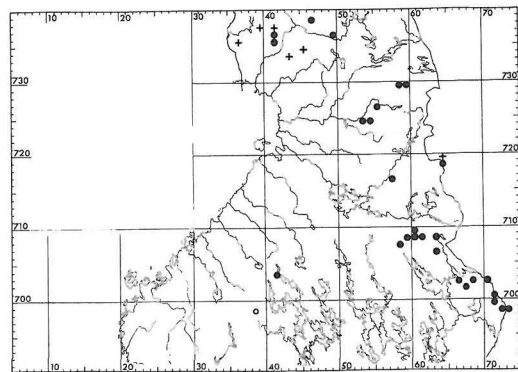


Fig. 8. Distribution of *Polyporus pseudobetulinus* in Finland. (○ – record made before 1960, ● – record made after 1960, + – record with no preserved specimens).

neously; thus the continuity of dying aspens will be interrupted for a long time. This was already visible in Muhamäki, where *F. trogii* seems to be disappearing and it will take at least 100 years until suitably large aspens are available at that site again. The same phenomenon is seen in Heinävaara, Sotkamo, where the abundant population of *P. pseudobetulinus* is in danger of disappearing, due to the lack of continuity of suitable host trees.

The girdling of aspen (bark is removed around the trunk) would probably be better than notching, if it is necessary to kill the trees that are retained on clear-cuts, because girdled trees take several years to die, and all of the trees do not always die at the same time (Aulén 1988, Siitonen & Martikainen 1994). However, as is the case with notching, the continuity of new dead trees will be interrupted later on. Leaving at least part of the retained trees untreated would be a better option for the preservation of saproxylic species, as it is likely to maintain the continuity of dying trees at a particular site.

In many regions the future of rare aspen-specialists seems uncertain because new host trees are not becoming available at a sufficient rate. In such cases, the killing of aspen trees might be the best way to produce decaying wood that, according to our observations, would be suitable for many threatened species (see also Aulén 1988, Martikainen 2000). In some critical cases, it may even be necessary to transport fresh aspen logs to the target area.

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Appendix. Collecting sites, dates, collectors and preserved specimens of the records of *Funalia trogii*, *Perenniporia tenuis* and *Polyporus pseudobetulinus* used in Tables 1, 2 and 3. Tree numbers as in Tables 1, 2 and 3.

Funalia trogii

Tree no	Collecting site	Coordinate	Collecting date	Collectors	Preserved specimens
1	PS: Savonranta, Raatelamminsalu	6908:602	30.VIII.1996	Martikainen, Penttilä	no
2	PS: Savonranta, Raatelamminsalu	6908:602	30.VIII.1996	Martikainen, Penttilä	no
3	PS: Savonranta, Raatelamminsalu	6908:602	30.VIII.1996	Martikainen, Penttilä	R.P. 11137
4	PS: Savonranta, Muhämäki	6910:604	30.VIII.1996	Martikainen, Penttilä	no
5	PS: Savonranta, Muhämäki	6910:604	11.X.1997	Martikainen, Penttilä	R.P. 11730
6	PS: Savonranta, Muhämäki	6910:604	11.X.1997	Martikainen, Penttilä	R.P. 11733
7	PS: Savonranta, Muhämäki	6910:604	11.X.1997	Martikainen, Penttilä	no
8	Kn: Kuhmo, Jauhovaara	7102:603	17.IX.1998	Miettinen	O.M. 451

Perenniporia tenuis

Tree no	Collecting site	Coordinate	Collecting date	Collectors	Preserved specimens
1	PS: Savonranta, Muhämäki	6910:604	11.X.1997	Martikainen, Penttilä	R.P. 11786
2	PK: Ilomantsi, Pampalo	6995:714	23.IX.1998	Martikainen, Lappalainen	H.L., P.R.
3	Kn: Kuhmo, Jauhovaara	7102:604	16.IX.1998	Miettinen	O.M. 445
4	Kn: Kuhmo, Jauhovaara	7101:604	4.X.1998	Miettinen	O.M. 653
5	Kn: Kuhmo, Jauhovaara	7101:604	4.X.1998	Miettinen	O.M. 660

Polyporus pseudobetulinus

Tree no	Collecting site	Coordinate	Collecting date	Collectors	Preserved specimens
1	PH: Pihtipudas, Alvajärvi	7033:411	1996	Perälä	JYV
2	PK: Valtimo	707:58	14.VIII.1997	Korhonen	H
3	PK: Lieksa, Saaravaara	7063:633	12.VII.1992	Sorvari, Ikonen	H
4	PK: Lieksa, Juurikkavaara	7022:665	29.VII.1992	Sorvari	H
5	PK: Nurmes, Uuronvaara	7086:632	28.VII.1992	Tynkkynen	no
6	PK: Nurmes, Louhivaara	7088:631	28.VII.1992	Tynkkynen	H

7	PK: Nurmes, Paistinvaaara	7082:611	7.XI.1993	Nissinen	H
8	PK: Ilomantsi, Korpi-Pampalo	6995:715	16.VIII.1996	Bondartseva, Lositskaya	H
9	PK: Ilomantsi, Lakonjärvi SW	6998:717	16.VIII.1996	Bondartseva, Lositskaya	H
10	Kn: Sotkamo, Heinävaara	7097:606	2.VII.1999	Penttilä et al.	no
11	Kn: Sotkamo, Heinävaara	7097:606	6.VII.1999	Penttilä et al.	no
12	Kn: Sotkamo, Heinävaara	7097:606	6.VII.1999	Penttilä et al.	no
13	Kn: Sotkamo, Heinävaara	7097:606	13.VII.1999	Penttilä et al.	no
14	Kn: Sotkamo, Heinävaara	7097:606	23.VII.1999	Penttilä et al.	no
15	Kn: Sotkamo, Heinävaara	7098:606	31.VIII.1998	Penttilä et al.	no
16	Kn: Sotkamo, Heinävaara	7098:606	31.VIII.1998	Penttilä et al.	no
17	Kn: Sotkamo, Heinävaara	7098:606	2.IX.1998	Penttilä et al.	no
18	Kn: Sotkamo, Heinävaara	7098:606	2.IX.1998	Penttilä et al.	no
19	Kn: Sotkamo, Heinävaara	7098:606	2.IX.1998	Penttilä et al.	no
20	Kn: Sotkamo, Heinävaara	7098:606	2.IX.1998	Penttilä et al.	no
21	Kn: Sotkamo, Heinävaara	7098:606	2.IX.1998	Penttilä et al.	no
22	Kn: Sotkamo, Heinävaara	7098:606	3.IX.1998	Penttilä et al.	no
23	Kn: Sotkamo, Heinävaara	7098:606	4.IX.1998	Penttilä et al.	no
24	Kn: Sotkamo, Heinävaara	7098:606	4.IX.1998	Penttilä et al.	no
25	Kn: Sotkamo, Heinävaara	7098:606	9.IX.1998	Penttilä et al.	no
26	Kn: Sotkamo, Heinävaara	7098:606	9.IX.1998	Penttilä et al.	no
27	Kn: Sotkamo, Heinävaara	7096:607	12.VII.1999	Penttilä et al.	no
28	Kn: Sotkamo, Heinävaara	7096:607	1999	Penttilä et al.	no
29	Kn: Sotkamo, Sammakkomäki	7084:591	11.IX.1998	Juntunen	no
30	Kn: Sotkamo, Niemilehto	7084:590	11.IX.1998	Juntunen	no
31	Kn: Sotkamo, Porkkasalo	7086:604	16.&30.VI.1992	Koivisto, Sauso	H
32	Kn: Hyrynsalmi, Pöhlövaara	7167:576	1.VIII.1994	Soppela	no
33	Kn: Hyrynsalmi, Pöhlövaara	7167:576	1.VIII.1994	Soppela	H
34	Kn: Suomussalmi, Kankivaara	7189:646	11.VIII.1993	Karjalainen	H
35	Ks: Taivalkoski, Kylmävaara	7268:551	13.X.1996	Ohenoja	H, OULU
36	Ks: Kuusamo, Vasikkavaara	7291:590	27.VI.1995	Soppela	H
37	Ks: Kuusamo, Visavaara	7296:581	29.VII.1993	Nissinen	no
38	OP: Pudasjärvi, Haapomaa	7248:535	28.X.1994	Karp	no
39	PeP: Ylitornio, Nilinotsa-Pahtalaki	7379:390	9.VII.1993	Kokkonen	no
40	PeP: Rovaniemen mlk., Lomalampi	7367:419	28.VIII.1993	Ollila	H
41	PeP: Rovaniemen mlk., Rantakivalo	7385:462	12.X.1995	Hiltunen	no
42	PeP: Rovaniemen mlk., Tuiskukivalo	7343:454	1996	Martikainen	no
43	PeP: Rovaniemen mlk., Tuiskukivalo	7343:454	1996	Martikainen	no
44	PeP: Rovaniemen mlk., Pisavaara	7353:414	20.VIII.1987	Kotiranta	H.K. 6472
45	PeP: Rovaniemen mlk. / Tervola, Pisavaara	7353:413	29.VII.1979	Niemelä, Kotiranta	no
46	PeP: Rovaniemen mlk. / Tervola, Pisavaara	7353:413	29.VII.1979, 7.IX.1982	Niemelä, Kotiranta	T.N. 1524, 1525, H.K. 18, 4147, 4148
47	PeP: Rovaniemen mlk. / Tervola, Pisavaara	7353:413	18.VIII.1987	Kotiranta	H.K. 6459
48	PeP: Rovaniemen mlk. / Tervola, Pisavaara	7353:413	18.VIII.1987	Kotiranta	HK 6458, HPP
49	PeP: Rovaniemen mlk., Pisavaara	7353:414	20.VIII.1987	Kotiranta	no
50	PeP: Rovaniemen mlk., Pisavaara	7353:414	20.VIII.1987	Kotiranta	H.K. 6473
51	PeP: Rovaniemen mlk., Pisavaara	7353:410	18.VIII.1987	Kotiranta	no
52	PeP: Rovaniemen mlk. / Tervola, Pisavaara	7353:413	7.IX.1982, 18.VIII.1987	Kotiranta	H.K. 4153, 6461, H
53	PeP: Rovaniemen mlk., Pisavaara	7353:414	24.VIII.1988	Kotiranta	no
54	PeP: Rovaniemen mlk. / Tervola, Pisavaara	7353:413	5.IX.1989	Kotiranta	H.K. 7802, H