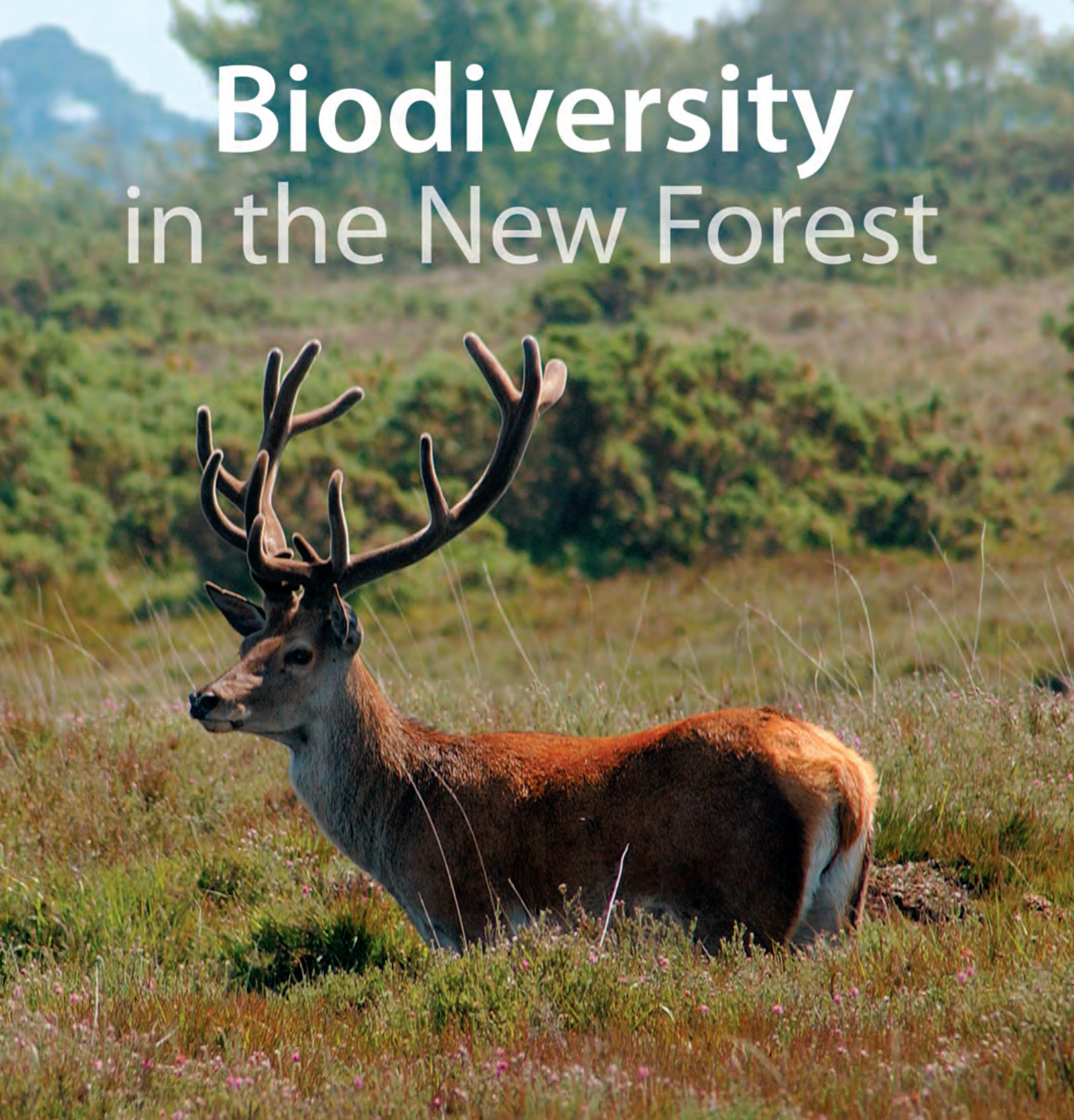
Biodiversity in the New Forest



Edited by Adrian C. Newton

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Dedicated to the memory of
Muriel Eliza Newton (1929–2009),
who loved the New Forest,
especially the donkeys.

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Back cover: Wood Crates (Adrian Newton)

The maps in this book are for illustrative purposes only, and do not represent the legal definition of National Park boundaries or any other feature

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10 **Fungi**

Adrian C. Newton

Introduction

It is now recognised that fungi make up one of seven major kingdoms, with an estimated 1.5 million species occurring worldwide, around 12,000 of which occur in the British Isles (Spooner and Roberts 2005). This compares with a national total of around 2,000 species of vascular plant. Major groups of fungi include the Ascomycetes (cup fungi or discomycetes), Basidiomycetes (including most larger fungi), Glomeromycetes (endomycorrhiza-formers) and Zygomycetes (Spooner and Roberts 2005). The focus here is primarily on larger fungi (macrofungi); relatively little is known about microfungi, and it is likely that many species of the latter await discovery within the New Forest.

The most significant milestone in the history of mycology in the New Forest was undoubtedly the publication of the Mycota in 1996 (Dickson and Leonard 1996). This incorporated a collation of previous records, together with an assessment of herbarium accessions at the Royal Botanic Gardens, Kew, and records from previous forays organised by the British Mycological Society (BMS). These records were supplemented by the results of additional field surveys focusing on selected sites. Some 25,000 records were compiled, covering approximately 2,600 species.

During the past 10 years, fungal recording has intensified through the activities of the Hampshire Fungus Recording Group (HFRG) (http://www.hampshirefungi.org.uk/). Founded in 1988, the HFRG currently has around 30 members active in fungus recording throughout Hampshire, and holds an annual programme of 20–30 fungus forays, many of which are held in the New Forest. Records are made available to the BMS, which maintains a national database of fungal records (http://194.203.77.76/fieldmycology/FRDBI/FRDBI.asp). Knowledge of fungi in the New Forest has also benefited from a number of systematic surveys organised by the Hampshire Wildlife Trust, of which details are provided below. Special mention should also be made of individual mycologists who have collected intensively within the area over many years, including Gordon Dickson, Peter Orton, Alan Lucas and Martyn Ainsworth.

The particular aim of this chapter is to evaluate the importance of the New Forest as a habitat for fungi, and to highlight some of those species for which the New Forest is particularly important. Some information is also provided on current trends in the status and distribution of selected species, although it should be emphasised that such information is always highly tentative, because of the difficulties of providing robust monitoring information for fungi (Watling 2001). This overview is necessarily selective, because of the large number of species that occur in the area and the poor state of knowledge of many fungal groups. The focus is primarily on species or groups that have attracted particular conservation attention in recent years, at the national or international scale. The fungal partners of lichens are not considered here (see Chapter 9).

It is only in the past two decades that fungi have become the focus of significant conservation interest. This growth in concern has largely been driven by reports of rapid declines in a number of species in continental Europe (Arnolds 1991), primarily as a result of the combined effects of habitat loss and aerial pollution (Jansen and Van Dobben 1987, Arnolds and De Vries 1993). While conservation practitioners and policy makers in the UK were perhaps rather slow to recognise the issue, the importance of conserving fungi is now widely appreciated, supported both by scientific symposia (Pegler *et al*. 1993, Moore *et al*. 2001) and by regular features in the mycological literature and articles in the popular press. The inclusion of fungi in the Biodiversity Action Plan process was a particularly important milestone, and has stimulated a substantial increase in systematic survey effort for selected taxa (Fleming 2001). A national conservation strategy for fungi has also recently been developed (Plantlife International 2008).

This chapter first provides a brief evaluation of importance of the New Forest as a locality for fungi, by comparing species richness estimates with those obtained for other areas. Selected species are then considered in greater detail, namely stipitate hydnoids, waxcap grassland fungi, *Poronia punctata*, beech deadwood fungi and *Hericium* spp. The potential impacts of fungal harvesting, and the conservation management of fungi, are then briefly considered.

Species richness of New Forest fungi: how does it compare?

Estimates of fungal species richness are available for selected areas in the UK, where records have been compiled and /or targeted survey work has been undertaken. Comparison of these estimates should be undertaken with caution, as they vary substantially in terms of survey effort and taxonomic scope. As noted by Watling (2001), knowledge of the British mycota has increased rapidly in recent decades, with around 700 species described or added to the national list over the past 40 years. Earlier accounts are therefore likely to provide lower estimates than those employing more recent taxonomic treatments. However, the data suggest that the number of fungal species recorded in the New Forest records favourably with some areas that are much larger in extent (Table 23). In contrast, some much smaller areas (such as Kew Gardens, Esher

Common and Slapton Ley) have provided species richness estimates that are roughly the same as, or even greater than, that of the New Forest. Significantly, each of these three areas has been intensively surveyed over many years by professional mycologists, with a wide range of taxonomic expertise. The figures in Table 23 therefore largely reflect survey effort and the expertise of the surveyors; many groups of fungi are difficult to identify, and require specialist knowledge that is difficult to acquire. The implication of these data is that many more species could potentially be added to the New Forest mycota, should the area be surveyed more intensively by experts in lesser-known groups.

Although a large number of fungal species have been recorded in the New Forest, and many others doubtless await discovery, it is not only the high species richness that is important, but the communities of fungi that occur in association with particular habitats. From a mycological perspective, it is the existence of an extensive area of long-established semi-natural woodland that affords the New Forest its particular value and interest. Other important habitat features include the relatively large number of ancient or 'veteran' trees, large volumes of coarse woody debris, and extensive areas of unimproved grassland. Although distinctive fungal communities are also likely to be associated with the heathland, mire and reedbed communities that are present in the area, these have received relatively little attention from mycologists to date.

The importance of the New Forest for fungi was recognised by a national assessment designed to identify Important Fungal Areas (Evans *et al*. 2001). The criteria for selection included: (A) that the site holds significant populations of rare fungal species that are of European or UK conservation concern, (B) that the site has an exceptionally rich and well-recorded mycota (i.e. >500 species), and (C) that the site is an outstanding example of a habitat type of known mycological importance. In this assessment, the New Forest qualified under all three of these criteria, and was described as 'of the highest importance for fungi, especially mycorrhizal fungi and fungi of over-mature trees and deadwood'. A number of 'hotspots' were identified within the New Forest as of particular importance, namely Churchplace Inclosure, Crockford Bridge marlpit, Denny Wood, Norley Copse, Gritnam Wood, Mark Ash Wood, Millyford Bridge, Nices Hill, Roydon Wood, Rufus Stone, Stubbs Wood, Whitley Wood, Wormstall Wood (and East End Pond), and Set Thorns Inclosure (Evans *et al.* 2001). The New Forest therefore accounts for 14 of these nationally important areas out of a total of 236 for the UK as a whole (i.e. 6%).

Table 23
Comparison of fungal species richness between different areas surveyed in the UK. Note that new species have continued to be discovered for the New Forest, subsequent to the publication of Dickson and Leonard (1996).

Area	Number of species (approx)	Notes	Source
Esher Common and Oxshott Heath, Surrey	3,300	Described as 'perhaps the most comprehensively inventoried area for fungi in the world' (380 ha)	Spooner and Roberts (2005)
Hebrides	2,905	More than 30 years' collecting by the author, covering a wide range of fungal groups, with a particular emphasis on microfungi	Dennis (1986)
Kew Gardens, Surrey	2,600	Includes survey of many fungal groups (132 ha)	Spooner and Roberts (2005)
Kindrogan, Perthshire	1,235	Intensive survey activity over many years, much undertaken in connection with a fungus identification course, focusing largely on macrofungi	Newton and Davy (1997)
New Forest	2,600	Ten years' intensive survey effort largely focused on macrofungi, coupled with compilation of earlier records spanning a wide range of fungal groups	Dickson and Leonard (1996)
Orkney	1,513	Compiled from eight years collecting macrofungi combined with prior records	Watling (1999)
South-east England	2,300	Compilation of many years' recording effort, including a wide range of fungal groups	Dennis (1995)
Shetland	984	Compiled from six years collecting macrofungi combined with prior records	Watling (1992)
Skye	831	Results of three-year survey of macrofungi plus earlier records including microfungi	Watling (1983)
Slapton Ley, Devon	2,400	Includes survey of many fungal groups (250 ha)	Spooner and Roberts (2005)
Warwickshire	2,486	More than 10 years' intensive systematic surveying covering a wide range of fungal groups	Clark (1980)
Yorkshire	3,400	Compilation of foray records spanning many decades and fungal groups	Bramley (1985)

Stipitate hydnoid fungi ('tooth fungi')

Stipitate hydnoid fungi are those with a toothed hymenophore (giving rise to the commonly used epithet, 'tooth fungi' or 'hedgehog fungi'). Those of conservation interest are all considered to be ectomycorrhizal associates of trees (Pegler *et al.* 1997). The Biodiversity Action Plan (BAP) for stipitate hydnoid fungi refers to 15 species in the genera *Bankera*, *Phellodon* (Bankeraceae), *Hydnellum* and *Sarcodon* (Thelephoraceae), all of which appear to display similar habitat requirements (UK Steering Group 1999). All species tended to be associated with particular microsites, namely riverbanks, mossy woodbanks, tracksides, railway cuttings, marl pits or other areas of exposed mineral soil (Marren 2000, Ewald 2001, Newton *et al.* 2002a,b). Managed semi-natural woodland, parkland and plantations all appear to provide suitable habitats. Marren and Dickson (2000) provide a useful introductory account of the group.

The BAP for this group of fungi was developed in response to reports of widespread declines in northern and central Europe. For example, in the Netherlands 13 species of hydnoid fungus have declined by at least 50%, and eight species have apparently become extinct in recent decades (Arnolds 1989), while in the Czech Republic, considerable declines have also been reported for virtually all the species in this group (Hrouda 1999). As an illustration of this concern, stipitate hydnoid fungi are now included in the Red Lists of a number of European countries, including the Netherlands, Poland, Germany and the UK (Lizon 1993, 1995), as well as in the provisional Red List for Europe (Ing 1993). Loss and degradation of habitat appear to be the main factors that have caused decline, although aerial pollution may also have contributed (Arnolds 1989).

Two main initiatives have been undertaken in England in response to the BAP: a desk study giving an overview of the status and distribution of stipitate hydnoid fungi, commissioned by English Nature and Plantlife (Marren 2000), and a survey of tooth fungi in the New Forest undertaken by Hampshire Wildlife Trust (Ewald 2001), again with support from English Nature. Marren (2000) notes that these species appear to be fairly widely distributed throughout England, but are rare outside 'core' areas, one of which is the New Forest, along with parts of east Berkshire, west Surrey and west Kent. They appear to be entirely absent over large areas of the UK. Marren (2000) also reports little evidence for decline of these species in England, noting that this may largely be attributed to the lack of suitable data for assessing trends in abundance over time. Survey work in Scotland has indicated that hydnoid fungi are widespread, but not common, in both Caledonian pine forests and oak woodland, again indicating little evidence of decline (Newton *et al.* 2002a,b).

In the New Forest, Ewald (2001) reports a total of 37 sites with records for stipitate hydnoid fungi. Eight of these were identified for the first time during a field survey undertaken in 2000, indicating that although the area is relatively well known mycologically, information on the distribution of these fungi is still highly incomplete. Despite the number of sites located, hydnoid fungi are described by Ewald (2001) as 'extremely rare and scattered' in the New Forest, occurring primarily with broadleaved trees (especially oak), often on raised banks or ditches. The results of the survey confirm the importance of the New Forest as a stronghold for hydnoid fungi, but also provide some evidence of decline in one species. Specifically, in the 2000 survey, *Phellodon niger* was not recorded at five sites where it had previously been recorded, and only one new site was found for the species despite thorough searching of potential habitat (Ewald 2001). Further monitoring is required to verify whether this decline is genuinely occurring, and if so, what factors may be responsible. *Hydnellum concrescens* and *H. spongiosipes* consistently remain the most abundant species in the area (Table 24).

Table 24
Summary of the abundance of stipitate hydnoid species in the New Forest. Data from Ewald (2001).

Species	Number of records (to 2000)
Hydnellum concrescens	23
Hydnellum ferrugineum	1
Hydnellum scrobiculatum	4
Hydnellum spongiosipes	19
Phellodon confluens	6
Phellodon melaleucus	16
Phellodon niger	10
Phellodon tomentosus	1
Sarcodon squamosus	3
Sarcodon scabrosus	2

Waxcap grasslands

A distinctive and diverse community of saprotrophic larger fungi is associated with nutrient-poor grasslands, including members of the agaric genera *Hygrocybe* (waxcaps), *Camarophyllopsis*, *Dermoloma*, *Entoloma* and *Porpoloma*, and non-gilled fungi in the families Clavariaceae and Geoglossaceae. These fungi are associated with unfertilised or unimproved grasslands, lawns and pastures, often in swards that are shortened by grazing or mowing (Arnolds 1980, Boertmann 1995). Some evidence suggests that waxcap grasslands tend to be relatively old, with ecological continuity spanning many decades or even centuries (Keizer 1993, Feehan and McHugh 1992). Marren (1998) and Griffith *et al.* (2004) provide valuable overviews of this attractive group of fungi.

Waxcap grasslands have been the focus of increasing conservation concern in recent years as the community has undergone a rapid decline in many areas of north-west Europe (Newton *et al.* 2003a), primarily because of habitat loss and degradation (Arnolds 1991, Arnolds and de Vries 1993). Agricultural improvement and intensification, particularly use of fertilisers and the ploughing and resowing of grassland, nitrogen deposition from the atmosphere and decreasing numbers of grazing animals have all contributed to this process (Arnolds 1991, Boertmann 1995, Keizer 1993). For example, in Sweden, only 15% of grassland sites have remained unaffected by these factors over the past 20 years (Keizer 1993); some fungi have declined in range by more than 93% (Arnolds 1991). As a result, many grassland fungi are now considered to be threatened with extinction, with 268 grassland species included in Red Data Lists across Europe as a whole (Arnolds and de Vries 1993). An analysis of Red Lists for 11 European countries indicated that 89% of *Hygrocybe* species feature on one or more lists; the corresponding figure for *Entoloma* is 97% (Arnolds and de Vries 1993).

Concern about whether such declines have occurred in Britain has led to a substantial increase in survey effort over the past decade (Rotheroe *et al.* 1996), particularly after BAPs were developed for three grassland species, *Hygrocybe calyptriformis*, *H. spadicea* and *Microglossum olivaceum* (UK Steering Group 1999, Fleming 2001). As a result of these surveys, some species are now known to be much more widespread than previously thought (Newton *et al.* 2003a), and in consequence *H. calyptriformis* has been omitted from the latest revision of the BAP (2007, http://www.ukbap.org.uk).

As no systematic survey of grassland fungi has yet been undertaken in the New Forest, their current status and distribution is incompletely known. Extensive areas of apparently suitable habitat are distributed throughout the Forest, but records made to date do not indicate the presence of any individual sites of national or international importance. For example, Evans (2003) lists no New Forest sites among those considered the most important in England for grassland fungi. To qualify for this list, at least 17 *Hygrocybe* spp. or 15 *Entoloma* spp. would need to be recorded from a single site.

Available records indicate that two of the grassland species included in the BAP have been found in the New Forest (albeit at only two sites each), namely *Entoloma bloxamii* and *Microglossum olivaceum*, whereas the other two (*Hygrocybe spadicea* and *Geoglossum atropurpureum*) have not been recorded to date. A total of 27 *Hygrocybe* spp. are listed by Dickson and Leonard (1996), indicating that taken as a whole, the New Forest does support a high diversity of grassland fungi. However, these species tend to be distributed among a variety of different sites, and there is little evidence of any individual sites supporting exceptionally high diversity. This might be rectified, however, by a systematic survey such as those undertaken for stipitate hydnoids and *Hericium* spp. This might usefully focus on those sites that are somewhat base-rich, such as some of the abandoned airfields or grasslands that have been limed in the past. One particular challenge is the short fruiting season for some grassland species, particularly *Entoloma* spp., which appear to require frost-free periods of relatively high rainfall (Newton *et al.* 2003a). It may therefore take many years of sustained survey effort to accurately determine the diversity of grassland fungi on a particular site (Newton *et al.* 2003a).

Poronia punctata 'Nail fungus'

Poronia punctata is the fungus species most closely associated with the New Forest in the minds of most mycologists. The species is an Ascomycete in the family Xylariaceae. In the UK it appears to be exclusively associated with horse or pony dung, although in other parts of the world it has been reported from cow dung (Whalley and Dickson 1986); records from rabbit dung (Reid 1986) are now referred to the closely related *P. erici* (Lohmeyer 1994). The fungus produces a stalked stroma, which raises the perithecia above the surface of the dung to assist in spore dispersal (Whalley and Dickson 1986). It is the nail-like shape of the stromata from which the common name of the fungus is derived. The 'nail' is typically rooted into the dung and is topped by a flat disc of up to 15 mm across, which is dotted with the black perithecia from which the spores are produced (Spooner and Roberts 2005).

The species is referred in the BAP as 'possibly the rarest fungus in Europe' (UK Steering Group 1995), and by Cox and Pickess (1999) as 'one of the rarest fungi in Europe', but this is surely an exaggeration. The global distribution of the species is not clearly established, particularly as it has been confused in the past with other *Poronia* spp. such as *P. erici* (Lohmeyer 1994), but the species is apparently known from the USA (Koehn 1978, Jumpponen and Johnson 2005) as well as in many parts of Europe. It may be accurate, however, to describe it as one of Europe's most threatened fungus species. For example, Ing (1993) lists it among 16 species that at the European scale have experienced widespread losses, rapidly declining populations and many national extinctions, and are the focus of a high level of concern. Its widespread decline reflects its close association with unimproved pasture, a habitat that has declined markedly in extent throughout the continent (Spooner and Roberts 2005). Other factors that have been implicated in its decline include widespread use of fertilisers, and other causes of changes in the characteristics of horse manure, including use of additives to feedstuffs and improvements in veterinary care (Spooner and Roberts 2005). As noted by these authors, year-round grazing on an individual site is required for the continuous provision of dung suitable for colonisation by the fungus, and therefore the decline in the species may also partly be attributable to loss of such continuous grazing. In Belgium, the decline in the Belgian donkey population has even been implicated in the decline of the fungus (Heinemann and Thoen 1981).

Reid (1986) provides a detailed account of previous records of the species made in Britain, noting that it was considered widespread and not uncommon until the late 19th century. It then appears to have undergone a rapid decline, indicated by the lack of any accessions in the Kew herbarium between 1899 and 1967 (Reid 1986), although it could be argued that the number of specimens lodged in a herbarium more accurately reflects the activity of mycologists rather than the actual status of a species in nature. Whalley and Dickson (1986) noted that nearly all recent records from Britain are from the New Forest area, although there have been occasional sightings elsewhere. Outside the New Forest, the species has been recorded on at least five sites scattered across southern England since 1990, including some Dorset heaths, and at a single site in southern Wales (http://www.searchnbn.net/).

In the New Forest, *P. punctata* was first recorded in 1893, and again in 1899, but thereafter it was not formally recorded again until 1967 (Reid 1986). Whalley and Dickson (1986) suggested that *P. punctata* has 'always been in the New Forest and is widespread but that no-one has bothered to record it'. In response to this suggestion, Reid (1986) rather testily suggested that while the species 'may have been present' during this period, 'this is of course unsubstantiated by either specimens or literature sources and there is nothing to account for the gap in records between 1899 and 1967'. He goes on to say that the species 'at no time could have ever approached the status of being "locally common" during the last 25–30 years'. This opinion is largely based on his own unsuccessful attempts to find the fungus, despite having made 'almost annual visits over a wide area' during this period. Intriguingly, Reid (1986) therefore suggests that within the New Forest the species may have declined in the early years of the 20th century, possibly even becoming extinct, but then recovered and spread during the 1960s and thereafter.

Is it possible therefore that *P. punctata* has increased in frequency within the New Forest in recent decades? Owing to the lack of any attempt at formal monitoring over this period, this suggestion is difficult to test. However, any fluctuations in the number of ponies within the Forest might be expected to influence abundance of the fungus, given its dependence on pony dung as a substrate. Tubbs (2001) presents data describing the number of ponies depastured on the Crown lands over the past 200 years, which suggest that numbers declined from the late 19th century until the middle of the 20th century – precisely coinciding with the gap in *Poronia* records identified by Reid (1986). Thereafter, the number of ponies has increased steadily, to reach current densities that apparently are as high as at any time over the past 200 years (Tubbs 2001, Mountford and Peterken 2003). It may be the case, therefore, that *Poronia* has undergone a recent increase in abundance in the Forest, and may even still be increasing, as a result of an increase in pony numbers. On the other hand, Whalley and Dickson (1986) may be correct to suggest that the species has always been widespread in the Forest, but has simply not been recorded.

As noted by Whalley and Dickson (1986), the ecology of the species is poorly understood. These authors suggest that it occurs only on horse droppings on open grass or heathland and not on dung located in woodland. They also suggest that the species may have exacting requirements for sporome production, 'not liking really wet weather nor drought'. Typically it is found on dung of a few weeks old, which is still in lumps (Whalley and Dickson 1986). Although slow-growing in culture, the species produces diffusible metabolites that are antagonistic to other fungi that appear earlier in the fungal succession on dung (Wicklow and Hirschfield 1979), emphasising the fact that it tends to occur later in the succession rather than on fresh dung. Cox and Pickess (1999) describe the ecology of the species on some Dorset heaths, where it has recently been recorded, confirming the findings of Dickson (1997) and Cox (1999) that the species tends to be found in dung in acidic heathy areas, whereas it is hardly ever recorded on grassland that has been limed in the past, and never on fertilised grassland.

Poland (2004) describes the first attempt to survey the species systematically within selected areas of the New Forest. Surveys were undertaken along seven transect routes, each 3–8 km in length, which were visited three times between October 2003 and February 2004. A total of 40 dungpiles supporting *Poronia* were recorded from five of the seven transects, with a maximum of 3% of dungpiles supporting the fungus. Most of the *Poronia* (68%) was recorded on humid heath (NVC community H3), with 18% and 13% from M16 (wet heath) and H2c (dry heath) communities, respectively, and only a single colony recorded on grassland (U3) (Poland 2004). On the basis of these results, Poland (2004) suggested that the species is primarily confined to a transitional heathland habitat, namely the damper sub-community of dry heath (H2c), through humid heath (H3) to the drier parts of wet heath (M16) communities. The species was not found on waterlogged microsites.

In total, Dickson and Leonard (1996) list some 56 locations of the species in the New Forest, spanning more than a century. Since 1996, some 49 records have been made as a result of the activities of the HFRG and the surveys described by Poland (2004). However, this underestimates the current distribution of the fungus in the New Forest area. Following several weeks of wet weather, *Poronia* began fruiting in mid-September 2008, providing an opportunity for some additional survey work. In just a few days, the current author recorded the species in 40 different 1 ha squares, distributed throughout the New Forest. When combined with previous data, recent records indicate that the species is widely distributed in the area (Figure 52), although the survey work undertaken in 2008 suggest that the species does vary in abundance, apparently occurring at higher densities in the south-east of the Forest than elsewhere. Further survey work is required to test whether this observation is valid, and to determine more accurately the current status and distribution of the species in the New Forest, as well as its habitat requirements. Further systematic

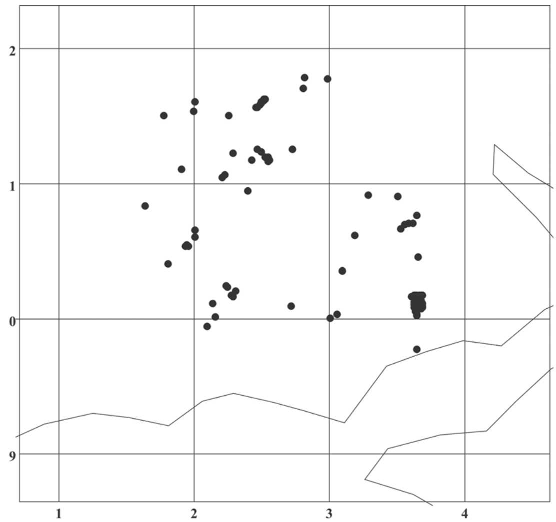

Figure 52
Current distribution of *Poronia punctata* in the New Forest, based on records made since 1996 (including foray records made by the HFRG, results presented by Poland (1994) and personal records of the author made during 2008). Each dot represents presence in a 1 ha square. Lines indicate the position of the Solent coast and the Isle of Wight. Gridlines represent OS 10 km × 10 km grid squares.

monitoring, such as that initiated by Poland (2004), is required to determine its trends in abundance.

Beech deadwood fungi

Recent research undertaken at the European scale has led to the identification of a group of fungi that could be considered as indicators of 'biotic integrity' or habitat value of old growth beech forests. An initial list of 42 species proposed for Denmark (Heilmann-Clausen and Christensen 2000) has since been extended to other European countries, with the aim of developing a method for comparing sites both within and between countries. In the UK, this research has been pioneered by Dr Martyn Ainsworth (Ainsworth 2004, 2005), who has played a major role in raising awareness of this group of fungi, both among mycologists and conservation practitioners.

Assessments have focused on a suite of saprotrophic species that form relatively conspicuous sporocarps on trunks or large branches of beech trees (Ainsworth 2005). A list of 30 species was proposed for scoring British beechwood habitats, based on previous records and expert judgement, then applied to 11 English sites. Collaboration with mycologists in other European countries enabled a list of 21 species to be developed for assessing the quality of beech deadwood habitats at a European scale, of which 15 species also featured in the British list (Ainsworth 2004, 2005).

Results of the analysis indicated that two New Forest beechwoods (Wood Crates and Denny Wood) classify among the top 10 of the 127 European sites assessed for the presence of these fungi (Table 25). Both of these sites, according to the criteria presented by Heilmann-Clausen and Christensen (2000), would qualify as of international importance based on the number of beech deadwood fungi recorded to date (i.e. >11). Within the UK, according to the list of 30 indicator species proposed for British beechwoods, five of the top 10 sites are located in the New Forest (Ainsworth 2004). This emphasises the importance of the New Forest as a habitat for this group of fungi, at both national and international scales.

Many of these proposed indicator species are poorly known and are rarely collected; many are therefore of conservation interest in themselves. Their ecological requirements are also poorly understood. Ongoing survey work in the New Forest being undertaken by members of the HFRG and others continues to add to the number of known locations of these fungi, further emphasising the importance of the New Forest woodlands. Although insufficient monitoring information is available to determine whether any of these species are changing in abundance, it is possible

Table 25
Comparison of New Forest sites with other British sites for beech deadwood fungi, according to lists of British (30) and European (16) indicators. Adapted from Ainsworth (2004).

Ranking using British score	Ranking using European score	Site name	European score (out of 16)	British score (out of 30)
1	2	New Forest, Denny Wood	12	19
2=	1	New Forest, Wood Crates	13	17
2=	4	Windsor Highstanding Hill, Berkshire	10	17
4	5=	Norbury Park, Surrey	9	16
5=	3	Windsor Bears Rails, Berkshire	11	15
5=	8=	New Forest, Mark Ash Wood	7	15
7	7	Lullingstone Park, Kent	8	14
8	5=	New Forest, Whitley Wood	9	13
9=	8=	New Forest, Gritnam Wood	7	12
9=	11	Mens and Cut, West Sussex	6	12
11	8=	Ebernoe Common, West Sussex	7	11

that they have benefited from the recent trend towards increasing volumes of deadwood within New Forest woodlands (see Chapter 13).

Hericium spp. (spine fungi)

Hericium is a Basidiomycete genus with a spiny hymenophore (Pegler *et al*. 1997). Two species are considered as indicators of beech forests of high conservation value (see above; Ainsworth 2004), namely *H. coralloides* and *H. erinaceum*. Both are uncommon fungi internationally, as illustrated by their inclusion in a provisional European Red List of macrofungi (Ing 1993). Marren and Dickson (2000) provide an excellent introductory account.

In the UK, the two species are largely restricted to southern England, and the New Forest is believed to be an important stronghold of both. This is illustrated by records accessible via the National Biodiversity Network (http://www.searchnbn.net/ accessed September 2008), which indicate that *H. coralloides* has been recorded in nine 10-km squares in the UK since 1990, mostly clustered in south-east England. Four of these squares are located in the New Forest. *H. erinaceum* appears to be somewhat more widespread; of 30 records made nationally since 1990, four of these 10 km squares are again located in the New Forest. Surprisingly, given their relative frequency, *H. erinaceum* was included on the UK BAP, but the rarer *H. coralloides* was originally omitted. However, the latter species was proposed for inclusion in the revised (2007) BAP (http://www.ukbap.org.uk/).

In the late 1990s, a field survey of *Hericium* spp. was undertaken in the New Forest by the Hampshire Wildlife Trust, together with a compilation of previous records (Wicks 1999). In 1998, a total of 34 sites were surveyed, and locations of the fungi encountered were mapped. Records of either one or both of these two species were made at a total of 14 locations (Table 26). Four of these sites had no previous records, indicating once again the value of this type of targeted field survey for providing information about current status and distribution.

The results of this project indicate that *H. erinaceum* is the more widespread of the two species in the New Forest, reflecting the national situation. Neither species is commonly encountered, however. Observations indicate that *H. erinaceum* can persist on an individual tree for at least 20 years, although not necessarily fruiting every year (Wicks 1999). Although most records of this species were from mature beech, one was from oak; and although most were recorded on standing trees, sometimes still living, five were recorded from fallen trees. In contrast *H. coralloides* was usually found on fallen logs and on dead trees only (Wicks 1999). Fruiting *H. coralloides* tends to be associated with logs at a more advanced stage of decomposition than *H. erinaceum*. It is unknown how long this species can persist on a fallen log, although observations made by the author indicate that it can do so for at least six years.

Table 26
Summary of the number of records of *Hericium* spp. made in the New Forest (adapted from Wicks 1999).

	Hericium erinaceum	*Hericeum coralloides*
Number of sites in 1998 survey	10	5
Total number of woods with records	21	6
Total number of 1-km grid squares	25	8

Evidence from previous records of *Hericium* spp. provide no indication of declines in either species, and both appear to be maintaining populations within the New Forest. However, accurate assessment of population trends would require systematic monitoring over a number of years. The survey work described by Wicks (1999) provides a basis for such monitoring in future; regular resurveying of known colonies could be highly informative. Members of HFRG and others continue to identify new colonies of both species through foraying activities and ongoing survey work, and therefore the abundance of both species is likely to be underestimated by currently available information, emphasising the need for further exploratory surveys.

One of the main challenges to obtaining accurate assessments of status and distribution of any fungus species is that surveys of vegetative mycelia, rather than reproductive structures, are difficult to achieve. As most fungal surveys focus on locating sporomes, the abundance of species is likely to be routinely underestimated, because fruiting is typically sporadic and varies both seasonally and from year to year, being highly dependent on weather conditions. Analysis of the behaviour of these species in culture suggests that they are of average competitive ability, and fruit readily, suggesting that low fruiting potential and combative ability are unlikely to be major factors contributing to the rarity of these fungi (Wald *et al*. 2004). Research by Prof. Lynn Boddy and colleagues at Cardiff University has also involved the development of PCR primers for detecting the DNA of these species in wood (Pariftt *et al.* 2005). Use of such methods could transform our understanding of the distribution and ecology of these species, and research on this aspect is ongoing.

Harvesting of fungi

Over the past two decades, the global trade in wild mushrooms has increased substantially. The Pacific Northwest of the USA, Mexico, Russia, Poland and other countries of Eastern Europe have become significant exporters of fungi harvested from the wild (Amaranthus and Pilz 1996, Marshall *et al.* 2006, Pilz and Molina 2002). In Britain, despite less of a tradition of collecting wild fungi than in many other European countries, there has been a rapid increase in interest in recent years, stimulated by television programmes and books encouraging the use of wild fungi in cookery (Rotheroe 1998).

This developing commercialisation has been accompanied by increasing concern about its potential environmental impacts. Fungal declines across Europe were first noted in widely collected edible fungi in the late 1970s (Derbsh and Schmitt 1987), although the extent to which overcollection has been the cause of such declines remains unclear. The collection of fungal sporocarps could conceivably affect production of sporocarps in subsequent years, by damaging or exhausting fungal mycelia, by influencing competitive relations with other species or by causing reproductive failure as a result of decreased spore production (Arnolds 1995). However, as parallel declines in non-edible species have been recorded in mainland Europe, there is little evidence to suggest that overpicking has been a major factor in the decline of fungal populations (Arnolds 1995). Little information is available concerning what impact removal of the sporocarp has on the vegetative mycelium of the fungus, which accounts for the main proportion of fungal biomass and is intimately bound with the substrate. Although there is no evidence suggesting that the removal of sporocarps affects the survival of mycelia (Arnolds 1991), regular picking could conceivably reduce mycelial reserves and therefore growth potential (Arnolds 1995). However, this effect is difficult to quantify. Collection of sporocarps can even have positive effects on subsequent production; for example, when a mature sporocarp is collected it may allow smaller sporocarps to mature, by reducing competition for water.

The more demonstrable effects of fungal collection are impacts on the habitat. Raking or other harvesting techniques may disturb fungal mycelia, and the trampling that can occur during collection may also be damaging. Research by Egli *et al.* (1990) found that a plot trampled intensively every two days throughout summer and autumn was associated with a 95% reduction in sporocarp harvest the following year. Trampling may therefore be the element of the commercial harvest most likely to cause damage to fungal populations, simply because of the regularity with which sites are visited. Concern has also been expressed relating to the value of fungal sporocarps as a habitat for insects and other invertebrates (Stubbs 2001) and as a food source for other organisms, which could also be negatively affected by sporocarp collection (Rotheroe 1998).

In the New Forest, concern about the impacts of commercial fungus harvesting grew in the 1990s, when it attracted a significant amount of media coverage. For example, as noted by Rotheroe (1998), the renowned Italian chef Antonio Carluccio was the focus of a demonstration by environmental activists when giving a wild mushroom cooking demonstration in London in 1996. In that same year, commercial fungus picking was banned throughout the New Forest by the Department for Environment, Food and Rural Affairs (Defra), although as noted by Rotheroe (1998), collecting continued, with some pickers thought to be earning up to £2000 a week. The ban was implemented under the Theft Act, England and Wales (1968), which specifically defines as theft the gathering of fungi for commercial purposes without permission of the landowner (Section 4(3)).

The ban was tested in the courts in the case of Brigitte Tee-Hillman, who trades as 'Mrs Tee's Wild Mushrooms' in Lymington, Hampshire. Tee-Hillman was arrested by the police in 2002 while in possession of 6 kg of fungi (*Cantharellus lutescens*), after being repeatedly ordered to stop her commercial activities by the Forestry Commission. She then challenged in the courts the legal right of the UK Government to ban her from picking fungi. After a four year court battle, the judge finally dismissed the case on grounds of pettiness, and Defra dropped the action. As a result Tee-Hillman was granted a unique personal licence from Defra, leaving her the only person with legal dispensation to pick more than the allotted 1.5 kg of mushrooms a day in the New Forest, and to trade commercially. According to her website, the fungi are currently retailed at prices of up to £48 per kilo. The total value of this legalised trade is estimated at c. £75,000, described as 'the largest commercial operation in England' (Sanderson and Prendergast 2002).

Other protection has been provided by the Forestry Commission to fungi within the New Forest by use of a local bye-law, to prevent the removal of fungi from certain woodlands (indicated by signs) between September and March (Sanderson and Prendergast 2002). These woods are Burley Old / Dames Slough Inclosure near Burley and Whitley Wood near New Park, which have been protected to enable long-term comparisons to be made between areas that are picked and those that are not. Such protection has been attempted very rarely in the UK, although collecting controls are widespread on the continent. The Forestry Commission has also developed a 'New Forest Fungi Code', which stipulates (http://www.forestry.gov.uk/forestry/infd-6e3gaz):

- no commercial collecting;
- obey any signs;
- never remove all the fungi in one area;
- 1.5 kg personal limit;
- if you don't know what it is, leave it alone.

This code reflects a national guide to fungal conservation, which was produced in 1998 by English Nature (English Nature 1998). There is no evidence available to evaluate whether or not the code is being followed, or whether it has raised awareness of the issue.

Conclusions and implications for management

There is no doubt that the New Forest remains the principal stronghold of *Poronia punctata* in Britain, and one of the most important sites in Europe for this species. This may be attributed to the fact that the New Forest is one of very few areas where horses live in the 'wild' and are allowed to forage for themselves throughout the year (Whalley and Dickson 1986). The future of the species in the New Forest is clearly dependent on maintenance of a sufficiently large population of ponies, which is allowed to graze on unimproved grassland and heathland vegetation on low-nutrient, acidic soils. Any nutrient enrichment of the vegetation, for example through atmospheric pollution, would probably be detrimental to the fungus. Despite the limited amount of systematic survey and monitoring data, evidence suggests that the species is widespread throughout the Forest, and may even be increasing in abundance. Maintenance of grazing is likely to be important for other fungi associated with grasslands in the New Forest (Newton *et al*. 2003a).

Recent field evidence emphasises the importance of the New Forest as a stronghold for other internationally threatened fungi, such as the spine fungi *Hericium coralloides* and *H. erinaceum* (particularly the former). In this case it is availability of large areas of old-growth semi-natural woodland (particularly of beech) that is of importance (Wicks 1999). Surveys of these and other fungi associated with deadwood of beech indicate that a number of the New Forest woodlands are of international importance for this entire fungal community. Management should therefore seek to maintain substantial volumes of deadwood, both standing and fallen, to ensure that populations of these fungi are maintained. The recent loss of a *Hericium* host tree through forestry operations (http://www.ukbap.org.uk/library/Reporting_pdfs/UKListID361_2002.pdf) raises serious concerns about whether information on the distribution of threatened species is reaching those involved in day-to-day management decisions.

The New Forest is also home to important populations of ectomycorrhizal fungi, some of which (such as the stipitate hydnoids) are considered threatened at an international scale. In the case of the stipitate hydnoids, the New Forest is considered to be one of the main centres for this group of species in England (Marren 2000). Other internationally scarce ectomycorrhizal species not considered in this account include *Podoscypha multizonata*, for which some 80% of the world sites are in England (Spooner and Roberts 2005), *Boletus torosus*, *Cantharellus melanoxeros* and *Phylloporus pelletieri*. Each of these is included in the revised UK BAP (2007), and has been recorded previously in the New Forest. These form part of a very diverse and distinctive community of fungi associated with ancient, semi-natural woodland, and maintenance of this habitat and the mature individual trees associated with it should be a management priority.

One of the key priorities for the future should be greater emphasis on systematic survey and monitoring of threatened fungal species (Newton *et al*. 2003b). At present, the lack of survey data prevents an accurate assessment of conservation status for more than a handful of species. Insufficient information is available to assess the long-term trends in fungal abundance with any precision, but the substantial losses of semi-natural woodland through felling and establishment of exotic conifers that occurred in the New Forest in the 20th century (Tubbs 2001) must have had a major deleterious impact on the fungi associated with them, as noted for lichens (Chapter 9).

Species such as those listed on the UK BAP would be a valuable target for future survey and monitoring efforts. The revised UK BAP (2007) lists 76 fungal species, at least 20 of which are known from the New Forest, which might usefully form the focus of future survey efforts. As noted above, a survey of grassland fungi might also be very worthwhile. Those surveys that have been completed in recent years have made a major contribution to improving our knowledge of fungi in the New Forest. In particular, the Hampshire Wildlife Trust should be commended for its role in coordinating the systematic surveys of *Hericium* spp., *Poronia* and the stipitate hydnoids, which are models of their kind, and illustrate what can be achieved with limited resources. Each of these surveys has highlighted deficiencies in our current knowledge of New Forest fungi, and future survey work is likely to emphasise still further just how important the area is mycologically. However it should not be forgotten that it is the efforts of volunteers, such as the members of HFRG and HWT, which are the backbone of fungus recording in the New Forest, and without which such surveys would not have been possible.

Although fungus collecting has been a major and controversial issue in the New Forest, its precise impacts are difficult to evaluate. It is possible that threatened fungi such as *Hericium* spp. (Marren and Dickson 2000) are among those that are being harvested for the pot, although evidence for this is lacking. The delineation of reserves where collection is prohibited is a novel initiative, but to date they have not provided any firm evidence regarding their effectiveness. Harvesting of fungi is not referred to in the latest management plan for the Crown lands (Forestry Commission 2007). While both personal and commercial collecting of fungi continue, informal observations made by the author suggest that collection intensity is currently lower than has been recorded in other parts of the UK, such as Scottish pine forests (Dyke and Newton 1999). The issue is attracting less media attention, and therefore perhaps less public interest, than it did a decade ago. Whether this represents an actual decline in collecting activity is unclear. Again, there is a need for more rigorous monitoring, both of the scale of fungus harvesting and of its impacts.

Other emerging threats to fungi potentially include climate change. Recent research has highlighted recent changes in the fruiting pattern of the fungal populations in areas near to the New Forest (i.e. within 30 km of Salisbury). When 315 autumnal fruiting species were analysed, the first fruiting date averaged across all species has become significantly earlier, whereas average last fruiting date has become significantly later, resulting in the fruiting period more than doubling in length, from 33.2 ± 1.6 days in the 1950s to 74.8 ± 7.6 days in the current decade (Gange *et al.* 2007). Whether such shifts are affecting the viability of fungal populations remains to be determined.

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References

Ainsworth, A. M. (2004). *Developing tools for assessing fungal interest in habitats. 1: Beech woodland saprotrophs*. English Nature Research Report Number 597. English Nature, Peterborough.

Ainsworth, A. M. (2005). Identifying important sites for beech deadwood fungi. *Field Mycology*, 6(2), 41–61.

Amaranthus, M. and Pilz, D. (1996). Productivity and sustainable harvest of wild mushrooms. In Pilz, D. and Molina, R. (eds.) *Managing forest ecosystems to conserve fungus diversity and sustain wild mushroom harvests*, pp. 42–61. USDA Forest Service, Pacific Northwest Research Station General technical Report PNW-GTR-371. Portland, Oregon.

Arnolds, E. J. M. (1980). De oecologie en sociologie van wasplaten (*Hygrophorus* subgenus *Hygrocybe* sensu lato). *Natura*, 77, 17–44.

Arnolds, E. (1989). Former and present distribution of stipitate hydnaceous fungi (Basidiomycetes) in the Netherlands. *Nova Hedwigia*, 48, 107–142.

Arnolds, E., (1991). Decline of ectomycorrhizal fungi in Europe. *Agriculture, Ecosystems and Environment*, 35, 209–244.

Arnolds, E. (1995). Conservation and management of natural populations of edible fungi. *Canadian Journal of Botany*, 73 (suppl. 1), 987–998.

Arnolds, E. and De Vries, B. (1993). Conservation of fungi in Europe. In Pegler, D., Boddy, L., Ing, B. and Kirk, P. M. (eds.) *Fungi of Europe: investigation, recording and conservation*, pp. 211–230. Royal Botanic Gardens, Kew.

Boertmann, D. (1995). *The genus Hygrocybe. Fungi of Northern Europe*, volume 1. Danish Mycological Society, Greve, Denmark.

Bramley, W. G. (1985). *A fungus flora of Yorkshire*. Mycological Section, Yorkshire Naturalists Union, Leeds.

Clark, M. C. (ed.) (1980). *A fungus flora of Warwickshire*. British Mycological Society, London.

Cox, J. H. S. (ed.) (1999). *The biodiversity of animal dung*. Hampshire and Isle of Wight Wildlife Trust, Eastleigh, Hampshire.

Cox, J. H. S. and Pickess, B. P. (1999). Observations concerning the ecology of Nail Fungus *Poronia punctata*, recently rediscovered in Dorset. *Dorset Proceedings*, 121, 129–132.

Dennis, R. W. G. (1986). *Fungi of the Hebrides*. Royal Botanic Gardens, Kew, Richmond, Surrey.

Dennis, R. W. G. (1995). *Fungi of South East England*. Royal Botanic Gardens, Kew, Richmond, Surrey.

Derbsch, H. and Schmitt, J. A. (1987). *Atlas der Pilze des Säarland*, Part 2: *Nachwiese, Ökologie, Vorkommen und Beschreibungen*. Ministerium für Umwelt, Saarbrücken, Germany.

Dickson, G. and Leonard, A. (eds.) (1996). *Fungi of the New Forest. A mycota.* British Mycological Society, London.

Dickson, G. (1997). Fungi are not plants – practical problems and conservation. *British Wildlife*, 9(1), 17–21.

Dyke, A. J. and Newton, A. C. (1999). Commercial harversting of wild mushrooms in Scottish forests: is it sustainable? *Scottish Forestry*, 53, 77–85.

Egli, S., Ayer, F. and Chatelain, F. (1990). Die Einfluss des Pilzsammelns auf die Pilzflora. *Mycologia Helvetica*, 3, 417–428.

English Nature (1998). *The wild mushroom picker's code of conduct*. Information and Marketing Team, English Nature, Peterborough, UK.

Evans, S. E. (2003). *Waxcap-grasslands: an assessment of English sites*. English Nature Research Reports Number 555. English Nature, Peterborough.

Evans, S., Marren, P. and Harper, M. (2001). *Important Fungus Areas. A provisional assessment of the best sites for fungi in the United Kingdom*. Plantlife, London.

Ewald, N. (2001). *Survey of the New Forest for stipitate hydnoid fungi*. Hampshire and Isle of Wight Wildlife Trust Ltd., Eastleigh, Hampshire.

Feehan, J. and McHugh, R. (1992). The Curragh of Kildare as a *Hygrocybe* grassland. *Irish Naturalist Journal*, 24 (1), 13–17.

Fleming, L. V. (2001). Fungi and the UK Biodiversity Action Plan: the process explained. In Moore, D., Nauta, M. M., Evans, S. E. and Rotheroe, M. (eds.) *Fungal conservation: issues and solutions*, pp. 209–218. Cambridge University Press, Cambridge.

Forestry Commission (2007). *Management Plan*, part B: *The Crown Lands*. Draft, November 2007. http://www.forestry.gov.uk/newforest

Gange, A. C., Gange, E. G., Sparks, T. H. and Boddy, L. (2007). Rapid and recent changes in fungal fruiting patterns. *Science*, 316, 71.

Griffith, G. W., Bratton, J. H. and Easton, G. (2004). Charismatic megafungi: the conservation of waxcap grasslands. *British Wildlife*, 16(1), 31–43.

Hrouda, P. (1999). Hydnaceous fungi of the Czech Republic and Slovakia. *Czech Mycology*, 51(2–3), 99–155.

Heilmann-Clausen, J. and Christensen, M. (2000). Svampe på bøgestammer – indikatorer for værdifulde løvskovslokaliteter. *Svampe*, 42, 35–47.

Heinemann, P. and Thoen, D. (1981). *Distributiones fungorum Belgii et Luxemburgii 1*. Jardin Botanique National de Belgique, Brussels.

Ing, B. (1993). Towards a Red List of endangered European macrofungi. In Pegler, D. N., Boddy, L., Ing, B. and Kirk, P. M. (eds.) *Fungi of Europe: investigation, recording and conservation*, pp. 231–237. Royal Botanic Gardens, Kew, Richmond, Surrey.

Jansen, E. J. and van Dobben, H. F. (1987). Is decline of *Cantharellus cibarius* in the Netherlands due to air pollution? *Ambio*, 16, 211–213.

Jumpponen, A. and Johnson, L. C. (2005). Can rDNA analyses of diverse fungal communities in soil and roots detect effects of environmental manipulations – a case study of tallgrass prairie. *Mycologia*, 97(6), 1177–1194.

Keizer, P. J. (1993). The influence of nature management on the macromycete flora. In Pegler, D. N., Boddy, L., Ing, B. and Kirk, P. M. (eds.) *Fungi of Europe: investigation, recording and conservation*, pp. 251–269. Royal Botanic Gardens, Kew.