The third 'F' — fungi in Australian biodiversity conservation: actions, issues and initiatives

Alison M. Pouliot [1]* & Tom W. May [2]

[1] PO Box 101 Daylesford, Victoria, 3460, Australia
[2] Royal Botanic Gardens Melbourne, Private Bag 2000, South Yarra, Victoria 3141, Australia

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Abstract: Australia's biota, including fungi, is highly diverse and highly endemic with many species also highly at risk of extinction. Despite ratifying international conventions and the development of national biodiversity conservation strategies, little has changed in the conservation status of Australian fungi over the last decade. Fungi remain largely neglected in most conservation legislation, notwithstanding their importance to ecosystem functioning and consequently to humanity, and there are very few mycologists employed in reference collections or conservation agencies. Few fungi have been included on formal threat status lists and a coordinated national approach toward compiling a threat status list for fungi is urgently required. Given the anthropogenic impacts on biodiversity including climate change, increases in wildfire and subsequent habitat destruction, there is a pressing need for recognition and incorporation of fungi in management and conservation initiatives. Community groups are making an increasingly significant contribution to fungal conservation, especially through mapping and monitoring, but their efforts need greater support from government. There remains a need for a coherent national strategy for the conservation of Australian fungi.

Key words: Australia, biodiversity, conservation, EPBC, fungi, IUCN, mycology, RED lists

Introduction

Australia is one of 17 countries described as being 'megadiverse' in terms of biological diversity. In addition to a high level of endemism Australia also has a very high extinction rate since European settlement a little over 200 years ago. Although inventory and documentation of the fungi are very incomplete, the fungi of Australia are undoubtedly megadiverse because of the numerous interconnections between them and plants. The huge diversity of Australian fungi compounded by insufficient knowledge and resources, presents significant challenges to their conservation.

Fungi have been neglected in most Australian conservation initiatives due to poor recognition of their ecological importance and because they have been overshadowed by higher profile, so-called 'charismatic' species. The challenge is to incorporate 'The third F', that is, fungi, into biodiversity management so that the varying needs of fungi, flora and fauna are all addressed (Bougher 2009). Interdependencies between fungi and other biota, such as through ectomycorrhizas and mycophagy, offer possibilities to draw attention to the vital ecological roles of fungi and therefore the importance of their conservation.

A review of the conservation status of Australian fungi was prepared as part of a national conservation review of 'non-vascular plants' (Scott *et al.* 1997). The conservation of Australian fungi was further reviewed by Buchanan & May (2003) and May *et al.* (2003). Issues impeding fungal conservation in Australia are common to many countries and include the paucity of baseline taxonomic and distribution data; poor public and governmental recognition of the role of fungi in natural ecosystems; a dearth of resources, mycologists

*Corresponding author: e-mail: alison@alisonpouliot.com

and funding; and poor public profile. The most significant improvement in the current situation is through community-based initiatives such as the Fungimap scheme that are slowly but significantly increasing the knowledge and profile of Australian fungi.

The aim of this paper is briefly to review existing knowledge, resources, legislation, issues and actions in the area of fungal conservation in Australia and make proposals for increasing public knowledge of fungi as well as offer suggestions for conservation approaches for the preservation of Australia's unique mycota.

Knowledge and publications

The current estimate for the number of known Australian fungi is 11,846 (Chapman 2009) including 3,540 lichens (McCarthy 2009). Many species remain to be collected and formally described. The estimated expected number of species of macrofungi is 10,000, of which about half are known. Due to the high diversity of native plants (25,000 species) one would expect there to also be a high diversity of microfungi. Estimates for the total number of fungi range from 50,000 to 250,000 species. Even with conservative estimates of total fungal biodiversity, there are tens of thousands of species yet to collect and describe. Some 35 % of Australian lichens are endemic (McCarthy 2009) and due to the high level of endemism of native plants, many of the non-lichenised fungi will also be endemic, particularly among the leaf-inhabiting microfungi and ectomycorrhizal macrofungi.

There is no up-to-date catalogue for all groups of Australian fungi. The on-line *Interactive Catalogue of Australian Fungi* covers macrofungal *Basidiomycota* and *Myxomycota* and includes 3,214 accepted species. The new *Atlas of Living Australia* is a nationally-funded project aimed at developing the infrastructure for a comprehensive biodiversity data management system. A complete on-line catalogue of the names of all known Australian biota, including all groups of fungi, will be delivered by 2011.

Distribution data from databased reference collection specimens are available online through *Australia's Virtual Herbarium.* Significant fungal holdings accessible through the AVH include the more than 70,000 collections in the fungal part of the National Herbarium of Victoria (MEL). However, important fungi collections, such as those in the fungal part of the State Herbarium of South Australia (AD) are yet to be databased. The National Collection of Fungi (NCOF, comprising reference collections BRIP, DAR and VPRI) predominantly includes plant pathogens of agriculture but also houses significant collections of fungi from native plants. The NCOF collections are included in the Australian Plant Pest Disease Database (APPD), but this is not publicly accessible.

There are few collections of fungi in reference collections, compared to vascular plants. In 1997, for example, 90 % of the species of fungi held in MEL were represented by less than five collections (May & Avram 1997). There are relatively few new accessions of fungi into these collections due to lack of resources and some do not house fungi or actively encourage lodging of specimens. The recent rise of activity among fungal studies groups in Australia has led to an increase in the number of well documented collections of fungi lodged in reference collections.

Descriptions of Australian fungi are scattered in the technical literature, and for most groups there are no recent comprehensive monographs. The *Fungi of Australia* series is produced by the Australian Biological Resources Study. In the decade since its commencement, only three taxonomic volumes have been published (on smut fungi, *Septoria* and *Hygrophoraceae*). However, excellent progress has been made with lichens and five volumes (in the *Flora of Australia* series!) have now been published. There are some excellent field guides to macrofungi, profusely illustrated with high-quality photographs, such as Fuhrer (2005) and Grey & Grey (2005). As well as facilitating identification of fungi for field study and mapping, such field guides play an important role in raising the profile of fungi, by highlighting their beauty and diversity.

Conservation legislation and government initiatives

Australia has conservation legislation for threatened species and communities nationally and for each of the seven states and territories (Scott *et al.* 1997; Makinson 2008). Responsibility for environmental conservation is mainly assigned to individual states and territories while the federal government assumes an administrative role. Improved co-ordination between jurisdictions in their approaches to conservation is necessary for a uniform and integrated national approach to conservation management (Hutchings & Ponder 1999). Local level government also has some responsibility for environmental management in the area of administering planning and development applications.

Fungi are tacitly included in most environmental legislation, although rarely explicitly mentioned. A major shortcoming of this approach is the underlying assumption that protection of fauna and flora also provides adequate protection of fungi (Buchanan & May 2003). In recent years environmental management has moved more towards managing landscapes, habitats and ecosystems, as opposed to a species level approach (Park 2000). While these approaches may prove propitious to 'non-target' organisms such as fungi, surveying and monitoring are necessary to determine their effectiveness.

The key national environmental legislative tool is the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The national framework for protecting Australia's biodiversity is *The National Strategy for the Conservation of Australia's Biological Diversity.* Neither the EPBC Act nor the *Strategy* specifically address fungi, although fungi get some recognition in one objective of the Strategy which aims to

'…undertake appropriate conservation action for less well known groups such as invertebrates, bryophytes, fungi and microorganisms'. *A conservation overview of Australian non-marine lichens, bryophytes, algae and fungi* (Scott *et al.* 1997) was prepared for the federal government. The review made explicit recommendations including some specifically for fungal conservation, however, over a decade later, few have been implemented.

In addition to national strategies each state and territory has various biodiversity acts, regulations and strategies, most of which overlook fungi.

The national EPBC Act is designed to provide a legal framework to 'protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places …. '. There are no fungi (not even lichenised fungi) among the 1,761 species listed, but *Phytopthora cinnamoni* (root rot) and chytrid fungus (resulting in chytridiomycosis in amphibians) are listed as key threats. While recognizing the seriousness of these threats, the fact that fungi (and fungus-like organisms such as the *Phytophthora*) are only listed in the context of threats and no species are listed for protection inadvertently adds to deeply entrenched and commonly held negative attitudes to fungi. Interestingly, numerous orchids are listed under the EPBC Act, every one of which requires a fungal symbiont.

RED lists and threat assessment

There is currently no national RED (Rarity, Endangerment and Distribution) data list for threatened species or communities but most states/territories have RED lists for plants and vertebrates. The EPBC lists do not yet contain all listings from individual jurisdictions. The World Conservation Union (IUCN) Red List is widely recognised as the most authoritative and objective system for classifying species by their risk of extinction (Butchart *et al.* 2004). While IUCN criteria are gradually being incorporated into listing processes, compliance varies between jurisdictions, with one State, Victoria, fully adhering to IUCN criteria for flora assessment (Makinson 2008). Progress is being made in the various approaches to assessment with greater alignment between jurisdictions, increased application of IUCN criteria and improved communication and information exchange.

There has not been a comprehensive threat assessment for fungi at a national or state/territory level. In some states/territories, assessments are being undertaken based on subsets of data or regions, based mainly on rarity. An example is the assessment for the macrofungi of the Deep Creek Conservation Park in South Australia by Catcheside & Catcheside (2008), in which one species was identified as Vulnerable and seven species were Rare (of which four were not yet formally named).

Only 14 species of non-lichenised fungi and one fungal community are formally listed under state legislation. There are nine species and one community listed under the *New South Wales Threatened Species Conservation Act, 1995* and one under the *Victorian Flora and Fauna Guarantee Act 1998*. Four species are listed under the *Western Australian Wildlife Conservation Act* as under consideration for declaration as 'rare flora', but are in urgent need of further survey. Even for listed species, very little biological and ecological data are available, particularly in regard to habitat and substratum requirements and basic life history characteristics such as size of individuals and genetic structure of populations.

Funding for research and management of rare and threatened species is strongly biased to formally listed species. The lack of listed fungi (and hence funding) is a great impediment to improving knowledge of fungal biology and management. Species level protection is sometimes driven by perceived charisma of species, rather than from rationale of repercussions for the environment or humanity from their loss. This has been to the detriment of fungi which are not widely viewed as charismatic.

Because of the link between formal listing and funding and research priorities it is imperative that more fungal species be listed. Formal listing would also raise the profile of fungi as integral and vital components of ecosystems. The lack of listed fungal species reflects the lack of nominations in the first place. Although nominations for listing can be submitted by anyone, there is a critical shortage of professional or amateur mycologists with sufficient knowledge, time or resources to make nominations. Secondly, there are few listed fungi because current approaches to threat assessment of animals and plants are not adequate for assessment of fungi due to differences in distribution patterns and levels of endemism. Most listed animal and plant species are endemics with small geographic ranges. Species are often listed as threatened on the basis of their restricted distribution. Where data exist, most fungi have been found to be widely distributed. Threat listing must therefore rely on more detailed knowledge of threats, which is absent for most fungi.

There is a critical need for development of threat status assessment protocols that are specific to fungi and take into account the unique biology of the kingdom, especially in relation to difficulties in delimiting and counting individuals. It is most appropriate that these protocols are developed internationally under the IUCN. Adoption of IUCN assessment procedures specific for fungi would mutually benefit interactions at a regional, national and international level, create more consistent and flexible data management, as well as greater opportunity to defend listed species and communities (Hilton-Taylor *et al.* 2008).

Protected areas

Australia has an extensive system of reserves and protected areas. The first protected area (Royal National Park in New South Wales) was established in 1879, the second in the world to be sanctioned by national legislation. Australia's *National Reserve System Program* incorporates 9000 protected areas comprising 11.5 % of the country's area and aims to protect

regions of high biodiversity including rare and threatened species. Unsurprisingly, management plans for protected areas very rarely mention fungi. *The National Reserve System Strategy 2009-2030* which aims for the long-term protection of Australia's terrestrial biodiversity was released in May 2009 and is yet another strategy that lacks any specific mention of fungi. As a further example, The Australian Government invested 36 million dollars in the *Maintaining Australia's Biodiversity Hotspots Programme,* which aims to maintain biodiversity values and manage threats in high conservation areas through acquisition and stewardship of known hotspots. Fungi once again fell through the cracks in this program, because of a lack of knowledge about fungal hotspots.

On a more positive note, given that protected areas worldwide are rarely declared on the basis of fungi, the listing of an urban bushland at Lane Cove in Sydney on the *Register of National Estate* on the basis of a fungal (Hygrocybeae) community was a small victory for fungal conservation (Kearney & Kearney 2000). The Register of the National Estate lists 13,000 natural, indigenous and historic heritage places, including those of scientific significance. Listing of the Hygrocybeae community led to funding being made available for production of educational and management material about the fungal community (Department of Environment and Climate Change NSW, 2008).

Conserving vegetation for fungi

The main threat to fungi is habitat destruction. There is an assumption that conserving fungi is adequately addressed by conserving habitat. However, the effectiveness of habitat as a general 'umbrella' for fungi is largely untested as is the hypothesis that management of forests for vegetation or individual rare animals is also optimum for fungi. Recent research in one catchment in Tasmania indicates that conserving different vegetation types does adequately conserve macrofungi, at least for common species (McMullan-Fisher *et al.* 2010). However, this study needs to be replicated in different vegetation types and extended to wider scales. There are currently no data on the effectiveness of conserving vegetation types on the conservation of the numerous groups of microfungi.

Fire and fungi

Fire is an inherent part of the Australian landscape and native biota has evolved to live with fire. There is a suite of pyrophilous fungi that appear immediately after fire, including disc-fungi and species of *Laccocephalum* that develop from sclerotia or pseudosclerotia (Robinson & Bougher 2003). There are also fungi that prefer long-unburnt forests or substrata such as large fallen logs.

Fire in Australian ecosystems is managed through control burning. Burning regimes are tailored for vegetation or specific endangered mammals, but rarely take into account other biota. Fire regimes maximised for vegetation may not be optimal for fungi or invertebrates (Clarke 2008). Fire regimes are also changing, most probably in response to climate change. More frequent and intense fires are predicted for southern Australia due to higher temperatures and consequent drying as well as an increased frequency of electrical storms.

Cool temperate rainforest dominated by *Nothofagus* occurs extensively in Tasmania and in scattered pockets along the east coast of Australia. There appear to be many ectomycorrhizal fungi restricted to this habitat. Large, intense and frequent fires can reduce the extent of cool temperate rainforest. This may result in the decline of fungal species associated with rainforest trees. Reduction in the area of rainforest will also affect fungi that rely on the moist rainforest microclimate, which is altered in the recolonising eucalypt forest. The volatility and vulnerability to fire is also much higher in eucalypt forest, hence the increased likelihood of further fires.

Many saprotrophic fungi rely on particular substrata. Fire prevention measures often involve fuel-reduction through burning or clearing that removes understorey vegetation, leaf litter and coarse woody debris, all of which are viewed as fuel for fire, but at the same time are food for fungi. Understorey clearing through inappropriate and too-frequent control burning regimes could have impacts on certain fungal groups such as wood decay fungi and leaf-inhabiting microfungi of shrubs. Recent catastrophic large-scale fires in southern Australia have led to reappraisal of legislative and social responses to fire. An example is the introduction of the *10/30 Right* legislation in Victoria that allows landholders greater freedom to remove native vegetation surrounding their homes to reduce fire risk. A Royal Commission was initiated following the fires of February 2009 that affected more than 400,000 hectares in Victoria. The Commission will address all aspects of the Victorian government's bushfire strategy including the contentious issue of fuel-reduction programs. It is imperative that sound science is used to inform the debate about the right balance between protection of life and property and biodiversity preservation, but data about fungi to inform this debate are lacking.

Given the key role of fire in Australian ecosystems and the likelihood of more extreme fires as a result of climate change, research on fungi and fire is a priority. This research should include identification of particular fungi or fungal communities that require specific management in terms of the optimal fire regime, or that may be vulnerable to altered fire regimes.

Harvesting of wild fungi for consumption

Wild fungi are harvested for food and other uses in over 80 countries (Boa 2004). There is concern in many countries about the impacts of unsustainable harvesting of wild edible fungi. This has not been an issue in Australia because there is not a strong tradition of wild fungi harvesting. While

Australian Aboriginal people are known to have collected fungi for consumption, medicinal and other purposes for thousands of years, there has been very little ethnomycological research in Australia. The identities of fungi collected are little known except for a few truffles utilised by central desert peoples such as the Walpiri (Kalotas 1996; Trappe *et al.* 2008). Various permits are required to collect fungi for research purposes depending on the land tenure and conservation status of the plant community. Harvesting of fungi for food is permitted in some forests, but there are no specific Australian regulations with protocols for such harvesting.

Public knowledge of fungal diversity and ecology is scant relative to that of many countries, reflected in both Australia's poor fungal conservation profile, but also in the lack of wild fungi collecting traditions. Interestingly, while unregulated fungi collection may lead to overharvesting and habitat destruction, low-level regulated wild harvesting could create increased public awareness about fungi, and their ecology and conservation.

Education

The public and governmental perception of fungi is an issue that needs to be addressed. The poor profile of fungi has largely precluded interest and understanding of fungal ecology and hindered conservation efforts. There are various options to improve the profile of fungi such as highlighting the connection of fungi with iconic taxa, especially those associated with seemingly more charismatic organisms such as orchids that rely on symbiotic fungi or highly threatened marsupials that utilise truffle-like fungi (Buchanan & May 2003).

Notably, resources need to be developed to reflect not only informational but also inspirational aspects of fungi. Many mycologists and field naturalists were first drawn to fungi because of their aesthetic beauty. Creating awareness of fungal conservation must also capture people's imagination. Fostering a sympathetic affiliation with fungi and natural environments, renewing kinship, providing opportunities for creative expression (e.g. via arts projects) can serve as a bridge to connectedness, focusing energy, interest and obligation. Strategies that combine both knowledge and inspiration can potentially increase understanding and connection that lead to vital changes in attitudes and behaviours.

Dissemination of information to the general public requires a multifaceted approach including further development of field guides and non-technical references, positive media exposure, exhibitions, displays and documentaries, training workshops and increased web presence. While most Australians could name dozens of animal or plant species, at least by common name, few could name more than the field mushroom (*Agaricus campestris*) and perhaps the conspicuous introduced fly agaric (*Amanita muscaria*).

Fungi are rarely included in primary or secondary school curricula and there is currently no tertiary undergraduate mycology program and few postgraduate opportunities. Some excellent education resources are slowly appearing such as the *Forgotten Flora* educational kit and *Hidden in Plain View* travelling exhibition (produced by Royal Botanic Gardens Melbourne) and the Fungibank website produced by CSIRO to provide information on the role of mycorrhizal fungi in forest health and methods to include fungi in rehabilitation. New ways of targeting different audiences and opportunities for increasing circulation of information need to be further explored.

Other initiatives to develop public awareness of fungi conservation could address the inclusion of fungi in local conservation and planning issues, through developing materials to empower conservation groups to act as advocates for fungi. Resources such as rapid assessment methods using indicator species also need to be developed, for example, for park managers who may need guidance for best management practice for fungi. All campaigns need to be well-publicised and well-resourced with clearly defined objectives to maximise their success.

People and organisations

Almost all action on fungal conservation in Australia has been initiated by mycologists employed in reference collections or from field naturalists and other amateur groups. Fungal research receives negligible funding and there is a dire lack of resources including very few professional mycologists. Permanently employed mycologists with responsibility for native fungi exist in only two state reference collections (MEL and NSW). Only one state conservation agency employs a fungal ecologist (Western Australia) and just a handful of researchers are working on fungal ecology or taxonomy in Australian universities. The lack of fungal ecologists within state and federal management agencies is a particular impediment to advancing fungal conservation.

The Australasian Mycological Society provides a network for mycologists and facilitates the conservation of Australasian fungi through a Fungi Conservation Special Interest Group. The special interest has recently run a workshop on the threat status listing process in different Australian states.

Fungal studies groups

Fungi have been included in the activities of field naturalists clubs in Australia since the 1880s (May 2005) but the last two decades have seen an increase in the number and activity of fungal studies groups across the country. These groups have as their focus the study of macrofungi in the field. Active fungal studies groups now exist in most states and territories, either as independent organizations (such as the Queensland Mycological Society) or under the umbrella of field naturalists clubs (such as the Fungi Group of the Field Naturalists Club of Victoria [FNCV]). Several groups, such as the FNCV

Fungi Group organise forays led by experts that are designed to improve the identification skills of members and to obtain species distribution data. The Perth Urban Bushland Fungi Project (under the Western Australian Field Naturalists Club) has run nearly 100 workshops and forays in the Perth region since 2003. The Queensland Mycological Society has recently developed an online resource aimed at introducing gardeners to some of the more common macrofungi.

Fungimap Incorporated is a national non-government organisation whose mottos are 'Putting Australian fungi on the map' and 'Community-based science in action'. Fungimap promotes public knowledge and interest in fungi by disseminating information and providing training for members and other interested people via a website, newsletters, forays and a bi-annual conference. Additionally, Fungimap provides critical input into conservation policy development such as submissions to draft conservation strategies including *Australia's Biodiversity Conservation Strategy 2010-2020.*

Mapping and monitoring

High quality baseline data on species diversity and distribution are an essential prerequisite to effective conservation programs. Factors such as species rarity or the determination of vulnerable environments cannot be ascertained until these data are recorded. The great majority of this recording is undertaken by volunteers through a slowly growing network of fungal studies groups. New resources such as the Fungimap target list and the book *Fungi Down Under* (Grey & Grey 2005) have all markedly contributed to the increased popularity and professionalism of data recording. Fungal ecology workshops and seminars are usually well attended and there is an unmet demand across Australia from field naturalists, land managers and the general public for education about fungi and their ecological roles.

A mapping scheme is a major focus of Fungimap, which commenced in 1996. Mapping focuses on 105 target species that are readily recognizable in the field, recorded largely by amateur mycologists, with guidance from professional mycologists in regard to target choices and identification. Thirty thousand records have already been entered in the Fungimap database. The target list was recently expanded to include five lichen species.

Distribution maps of the Fungimap targets have been published in *Fungi Down Under* and the *Fungimap CD-ROM.* An interactive on-line fungimapper will shortly be released. The dataset generated by Fungimap serves as a baseline against which environmental impacts can be measured and has also been valuable in confirming the distribution of rare or restricted species, in support of formal threat listing. The efficacy of logging records for all fungal species from experienced recorders is currently being trialed.

In Western Australia, the Department of Environment and Conservation has an integrated biodiversity monitoring program called Forestcheck that provides information to assist forest management for silviculture and also fire management. Forestcheck is innovative in its inclusion of not only plants and vertebrates, but also lichens and macrofungi, with more than 750 macrofungal species recorded on regular surveys of permanent plots. Scientific analysis of macrofungal monitoring is already available in relation to factors such as fire (Robinson *et al.* 2008). Implementation of similar programs in other states would make a very significant contribution to increasing knowledge of fungal distribution and conservation status and providing a sound basis for the management of fungi in forest ecosystems.

The future of Australian fungal conservation

Acquiring knowledge of the diversity and distribution of macrofungi is a vital first step for their effective conservation. Deficiency of fungal data, relative to that of animals and plants, is common to most countries. Rather than waiting for the compilation of a total inventory for fungi, fungal conservation programs and biodiversity assessments should focus on using existing knowledge of distribution and abundance and obtaining new data that can be readily acquired (New 1993). Given the lack of resources, it is important to ensure that priority species or groups are targeted for intensive survey, and that these targets are representative of trophic, taxonomic and ecological groups within fungi, particularly among the microfungi. Adequate conservation relies not only on distribution data but also knowledge of biology, so there is also a need for increasing understanding of all areas of fungal biology including population genetics, life history, potential threats and responses to anthropogenic disturbance including climate change.

Additional resources need to be allocated in terms of funding and personnel to develop a baseline inventory of selected Australian fungal taxa. The dearth of taxonomic experts and knowledge is severely hampering fungal conservation. New (1999) noted 'the magnitude of … Earth's biota has become increasingly apparent over a period marked by rapid decline in the taxonomic workforce and the lessening of interest in the science of systematics in university teaching'. This 'taxonomic impediment' has been extensively documented in recent years. While this trend is occurring on a global scale (e.g. Cotterill 1995; Cracraft 1995), knowledge of Australian mycology lags over a century behind that of other so-called developed countries.

More fungal taxonomists need to be trained and positions established in reference collections and universities, ideally with both macrofungal and microfungal taxonomists employed in all state/territory reference collections. Fungal ecologists are also required in conservation and management agencies. A national approach toward compiling a threat status list for fungi that includes representatives across taxonomic and trophic groups is needed (Buchanan & May 2003).

The process of listing species will hopefully provide an impetus for funding, research and management. Surveys of representative habitats in major Australian biogeographic regions are required to determine fungal diversity and distribution baselines for indigenous target species (and especially for threatened species) to serve as benchmarks for assessing change due to anthropogenic and other impacts.

An understanding of the congruence of vegetation and fungal communities is needed to ensure that fungi are being adequately protected under the surrogate of vegetation. Whether management regimes that work for plants also work for fungi is not yet known. This is particularly important in the context of fire which is an integral part of many Australian environments.

Conclusion

Governments, communities and individuals all have stewardship responsibilities for protecting biodiversity including fungi. While the state of legislative fungal protection in Australia remains largely unchanged, there is at least slow progress in the areas of recognition and knowledge of fungi. Non-government organisations such as Fungimap and local fungal studies groups have certainly witnessed growing interest and are expanding their databases and producing new resources.

Non-experts make significant contributions to fungal conservation. Such efforts are most productive as a partnership with government; with financial and strategic support from government being vital to catalyze and maximise the effectiveness of voluntary contributions. A modest injection of funding in support of volunteers could significantly boost knowledge. However, science alone will not ensure protection of Australian fungi and both professional and amateur mycologists must galvanise governments into action on fungal conservation, particularly in the areas of policy and staffing.

Against a background of current limited knowledge, lack of resources and training, and the omission of fungi from biodiversity and management plans, there is an urgent need for an integrated, strategic and whole-continent approach to conservation of Australian fungi. Such a strategic approach should focus not only on listing and conservation of individual species but also alternative approaches such as identification of fungal hotspots and the issue of vegetation as an umbrella for fungi. Only through a coherent and comprehensive strategy developed specifically for fungi and their ecological functions with realistic objectives, targets, timelines and support that fully acknowledge the size of the challenge, can conservation of Australian fungi be adequately addressed.

Changing awareness and attitudes to fungi remains a continuing challenge. Encouraging an approach that is sympathetic and understandable at the public, political and administrative levels is a vital step (Yen & Butcher 1997). The establishment of the International Society for Fungal Conservation is a positive step toward creating a collective voice for global fungal conservation.

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