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Mini-review

Developing a comprehensive strategy for fungal conservation in Europe: current status and future needs

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ABSTRACT

We review the state of fungal conservation in Europe. Despite a large public interest in fungi, they are often insufficiently considered in the conservation initiatives of most countries and not adequately heeded in international biodiversity agreements. We attribute this to the generally low profile of fungi among conservation stakeholders and decision makers together with limited efforts of mycological scientists to put mycological knowledge into a conservation context. Recent advances in mycological knowledge, taxonomy, distribution, ecology and threats now categorically enable fungi to be included within national and European conservation agendas. 33 European countries have produced fungal Red-Lists reporting the status of macrofungi and these are official in 20 countries. These lists indicate that at least 10 % of European larger fungi are threatened, mainly due to changing land use and nitrogen deposition. Fungal biodiversity may benefit from many general conservation efforts, but many specific fungus values are also overlooked. We advocate increased interaction between scientists and conservation coordinators and practitioners, greater promotion of fungi and their conservation and ecosystem service values by mycologists, the production of a European fungal Red-List and the need to integrate fungi with animals and plants in conservation issues.

Introduction

Fungi are an important component of terrestrial ecosystems. They comprise a large proportion of species richness and are major contributors to key ecosystem processes. However, in contrast to the animal and plant kingdoms, fungi have been overlooked in nature conservation and are not included in any international biodiversity agreements. The reasons for this are largely historic; fungi have been considered a strange group of organisms, poorly understood and difficult to study due to their cryptic nature and frequently sporadic and often short-lived sporocarps.

Fungi constitute a separate Kingdom but share different aspects of their lifestyle, e.g., clonality, reproduction, longevity and dispersal, with other organisms. However, the combination of lifestyle characteristics is unique to fungi, and their cryptic nature continues to make the pattern and dynamics of fungal individuals and populations challenging to assess. Mycological knowledge, e.g., taxonomy, phylogenetics, distribution, ecology, population dynamic, genetics,

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interactions and impacts on ecosystem processes, has significantly increased during recent decades (e.g., Mueller *et al.* 2004; Spooner & Roberts 2005; Smith & Read 2008). On this basis we assert that, in practice, the time is ripe to raise the awareness of fungus conservation. Sporocarp distribution data and detailed ecological observations by field mycologists can now be combined with scientific studies to identify and rank the conservation status of many fungi to provide prioritized management recommendations.

Interest in fungus conservation has progressed substantially in Europe in recent decades (Moore *et al.* 2001; Senn-Irlet *et al.* 2007; Heilmann-Clausen & Vesterholt 2008). Here, we present an overview of the state of fungal conservation in Europe up to 2009. Firstly, we discuss why and how fungi should be considered in conservation. We then summarize the state of fungal knowledge together with achievements and ongoing conservation activities. This review is largely based on a report by the European Council for Conservation of Fungi (ECCF) for the European Commission (Senn-Irlet *et al.* 2007). The report was a compilation of publications, expert knowledge and a synthesis of a questionnaire sent to mycologists in all European countries within the ECCF network in 2007. After discussing how conservation action can be achieved, particularly the value of red listing, we finally discuss challenges for mycologists. Since fungus conservation has hitherto dealt mainly with macrofungi, i.e., species having sporocarps at least 2 mm in diameter, irrespective of taxonomic affiliation, this review takes the same perspective. Lichens are traditionally and successfully dealt with separately by lichenologists (e.g. Church *et al.* 1996).

Fungi and conservation

Setting the scene

The Convention on Biological Diversity (CBD), a global treaty, was adopted in 1992. Since then, conservation of biodiversity has become a commonly agreed objective. It is not currently at the top of political agendas in the same way as climate change, but closely linked to this agenda because of the threat it poses to ecosystems and their species. Biodiversity is not just species, rather the diversity of genes, species, and ecosystems of a region, country or the world. Biodiversity matters for a whole variety of reasons: ethically, emotionally, environmentally and economically. It is at the very foundation of our society and the basis of our economic success and well being. Conservation of biodiversity is a complex task, where focus on specific groups of organisms, and fungi in particular, are merely one of a whole variety of aspects.

The 192 countries that have signed the CBD have committed themselves to its three main goals: (1) the conservation of biodiversity; (2) sustainable use of its components; and (3) the equitable sharing of the benefits arising from the utilisation of genetic resources. The global target for 2010 is 'to achieve a significant reduction of the current rate of biodiversity losses' (Convention of Biological Diversity 2009).

Biodiversity in Europe is under immense pressure. European ecosystems have suffered more from human induced habitat loss, decline and fragmentation than in any other continent (Millennium Ecosystem Assessment 2005). Much of the land in Europe is being used intensively and urban areas are rapidly expanding into the countryside. The European Union formulated a more ambitious political commitment than CBD, namely to halt biodiversity loss within the EU by 2010 (Anonymous 2008). The goal will be postponed as it will not be reached, but has resulted in widespread efforts to safeguard the EU's most important habitats and species (EEA 2009).

Over the last century nature conservation has undergone a transformation from merely direct protection of specific species or sites, to an adaptive management approach (Johnson 1999) that applies to both protected sites and the wider landscape. Certain species of fungi may only be conservable in protected areas, with or without specific management, while others may persist in the wider landscape if appropriately managed. Adaptive management recognises that the most appropriate management will change, over time and space, as our knowledge of species lifecycles and habitat requirement increases. As such, management solutions will differ between location, over time, as well as by local opportunities. Science plays an important role in supporting this approach, thereafter management must be subject to review and modification in order to achieve conservation objectives (Salafsky *et al.* 2001). Adaptive management may not necessarily aim to maintain or reinstate natural or anthropogenic disturbance regimes known to have provided suitable habitat in the past, rather to ensure that appropriate conditions are produced and maintained. This may include the recreation of conditions that were historically maintained by particular fire, coppicing or grazing regimes. Identification of conservation priorities and objectives has become an essential step in conservation planning. There is a great need, and potential, for fungal scientists to provide appropriate, fact-based ecological knowledge about how land should be managed to benefit different aspects of fungal biodiversity.

International conservation of fungi

Conservation actions generally take place locally or nationally, but are influenced by international commitments and ranking lists. However, long-term survival of species is not dependent on country borders but on a continuum of habitats at appropriate spatio–temporal scales. This is especially relevant for fungi, which are good dispersers with often extensive but sparse populations. Hence, the conservation value at regional, continental, or preferably the global scale, is often used to identify and set national priorities. The IUCN Red-List operates at the global scale and European scale Red-Lists have been produced for many groups of organisms. Naturally, these lists, and subsequent conservation priorities, have a bias towards well-known groups of species. The global Red-List comprises almost 45 000 species of which 26 000 are vertebrates. In contrast, only three fungi are listed; two lichens and the Sicilian endemic fungus *Pleurotus nebrodensis* (IUCN 2009). The reason for the strikingly low number of listed fungi is that the global Red-List is not systematically coordinated to evaluate all groups of species, but conducted on the basis of the interest, initiatives and resources of individuals or organisation. At the European level, Red-Lists have been produced for