Building the infrastructure for conservation of fungi in the UK: the Lost and Found project

Funded by the Esmée Fairbairn Foundation

Why "Lost and Found"?

We know that there are many species of fungi in the UK (around 15000 at the last count), but for many we have little idea about where they are or even whether they have become extinct. This project will focus on fungi that have been rarely recorded from our region, carrying out targeted surveys to establish whether they are still there, and if so whether they are genuinely rare or merely under-reported. These abandoned species are currently lost, and hopefully many will be found as a result of project actions. Their conservation will then be promoted in partnership with local specialists and stakeholder groups. The project will run for five years from 1 July 2014 and will be managed by the Royal Botanic Gardens, Kew, funded by a very generous donation from the Esmée Fairbairn Foundation.

The background: why are fungi so important?

Fungi comprise one of the largest, most ancient, diverse and extraordinary organism groups. It is not an exaggeration to claim that the global ecosystem could not function without them. They play many critical roles:

- as decomposers and nutrient recyclers – without their action fallen leaves in autumn would remain on the ground, and dead trees would not rot down;
- making plant roots work. Almost all plants depend on fungi for efficient uptake of water and minerals via their roots. There is evidence that these associations were essential in evolution of the first land plants;
- as plant disease organisms – but they also protect plants from being eaten by pests;
- as the source of life-saving medicines, including antibiotics and statins for cholesterol control;
- as food. They are a major food source, not just for humans but for a wide range of small and large animals;
- as partners in food production. Even meat can be considered as a fungal product – without specialised fungi that live within their guts, herbivores such as cows and sheep could not break down plant tissues to benefit from the nutrients;
- as sensitive indicators of pollution and environmental change. There is no reason to suppose that fungi are any less vulnerable to environmental change than well-studied organism groups, and much evidence that species have declined due to acid rain and pollutants such as excess nitrogen (agricultural fertilisers).

If fungi are so important in our lives, why do we know so little about them?

Fungi are incredibly diverse – around 15,000 species have been reported from the UK alone, and we believe that only 5-10% of the global total has been discovered. Most species are inconspicuous, living underground or in plant tissues and only emerging for short periods to reproduce. That makes them difficult to survey and monitor. Fungi also receive a bad press, whether the (very small proportion of) mushrooms which are dangerously poisonous, but which make the headlines much more frequently than non-toxic species, or disease-causing species such as that responsible for ash dieback. Much of this media coverage is unhelpful, overlooking the role of humans in introducing species to non-native environments, and leaving the general public fearful of the unknown, with little idea of the real risks posed by fungi or of their beneficial effects.

The conservation of fungi

In the UK, our knowledge of even the most prominent species of fungus is trivial compared with that concerning the most "boring" bird or mammal. Currently, with few exceptions, the ability to predict impact on British fungi of factors such as habitat loss, climate change, pollution or alien invasions is based largely on educated guesswork. Fungi are almost certainly declining and becoming extinct in Britain without our knowledge.

The impact of this lack of knowledge is profound, and has led to fungi being largely ignored in conservation management and policy, both in the UK and elsewhere. There is also a critical shortage of experts in their classification, recognised in successive parliamentary reports, and exemplified by the fact that Kew is the only taxonomic organisation in the whole of the UK with an explicit remit for [non-lichenized] fungi. A third major concern is the lack of accessible information on rarely recorded species that may merit conservation action. Except in a very few cases, we do not know whether these species are genuinely rare or merely overlooked. This project will boost capacity at Kew and in partner organisations to address these concerns.

Current activity at local level

Britain has a long tradition of volunteer participation in natural history recording, and research on fungi is no exception. In tandem with a steep decline in professional posts in natural history subjects, there has been a shift in recent years from a wholly centralised system to a more local approach, with some coordination on a national basis. Overall personnel levels are tiny compared with birdwatchers, for example, but we estimate there are well over 100 local volunteer groups in the UK which carry out fungal "forays" on a regular basis. Most groups are affiliated to one or more national organisations: the Association of British Fungus Groups, the British Lichen Society and the British Mycological Society, all of which operate substantial databases and other support services. Data are also frequently supplied to local conservation bodies such as the Wildlife Trusts.

Volunteer fungal surveyors in Wolfscote Dale, Derbyshire. Image © Steve Price

Conservation activities are highly dependent on baseline data, backed up by analysis of communities and survey and monitoring of species at risk. One of the reasons why birdwatching is such a popular activity in the UK is the accessibility of user-friendly information on identification, distribution and rarity. In the case of fungi, identification manuals do exist, but cover only a proportion of the better-known species and in general focus on field characters which are frequently inadequate for accurate recording without more technical analysis. This makes it much more difficult for volunteers to make meaningful contributions.

Some of the fungus volunteer groups are primarily social in nature with a strong interest in edible species, while others contain talented amateur mycologists with a strong interest in documenting biodiversity. Many of these are active and knowledgeable in general terms, but they do not in general have the information to target their surveys towards species of significant conservation concern. Their focus tends therefore to be on lists of species rather than analysis of communities. This project will provide information on target at-risk species within the volunteer groups' area of study, and mentor and coordinate them to establish scientifically valid survey and monitoring programmes that can be used in support of conservation actions.

Kew's support for UK fungal conservation volunteers

Kew mycology has historically focused on British fungi, describing and improving the classification of UK species, and working closely with the UK specialist societies and volunteer communities. Almost all of the current cadre of expert identifiers will have been trained and mentored at some stage by Kew staff. The Kew fungal collection (the largest in the world) has benefited immeasurably from this relationship, and many species recognised by Kew in recent times as new to the UK (or indeed to science) were originally collected by volunteers and sent for our expert analysis.

Kew is *the* major repository of expertise in fungi in the UK, with a full-time staff of eight scientists and conservation specialists. By contrast, academic institutions and partners such as NHM, RBGE and NMW have reduced spending in this area in recent years. We also play a major role in global fungal conservation efforts and fora. Income for the Mycology team comes from a range of sources including grant-in-aid, project grants from Natural England, the EU and the Charles Wolfson Charitable Trust, and unrestricted support from the Kew Foundation.

Most of Kew's recent work in this arena has been in partnership with volunteer groups, with support from the statutory agencies and conservation bodies. An example is the recent publication of the first formal UK Red Data List for boletes, the first in a series of RDLs for fungi other than lichens (lichens are symbiotic partnerships between fungi and algae). The bolete RDL used a large body of volunteer-collected data, backed up by collaborative investigations of particular species. We now know that 13 of our 66 bolete species are threatened with extinction, with a further 6 assessed as near-threatened (i.e. rare and likely to be threatened in the future) and 16 needing further data to elucidate their status. If this ratio is applicable to UK fungi as a whole, around 5,000 species would be accorded a threatened or near-threatened status.

A further example of Kew's work alongside the UK volunteer community is a recently completed Defra- and Scottish Natural Heritage-funded project on waxcaps, one of the few fungal groups benefiting from historical conservation investment. No fewer than 85 individuals and/or recording groups across the UK contributed collections for analysis at Kew. We concluded that the number of waxcap species in Great Britain is at least double the fifty or so previously recognised, and many of these may be endemic and/or threatened. Their analysis continues, but a publication generated from the project described the first two new species, and its dissemination has already led to a significant increase in the known range of one of them (see box opposite). This demonstrates that volunteer groups will make good use of information on actually or potentially threatened species of fungi.

Gliophorus reginae, a waxcap fungus named in commemoration of the Queen's Diamond Jubilee. Following dissemination of Kew's findings, its distribution is now known to extend north from the Midlands to Cumbria due to the work of local volunteer recorders.

Photo © Rob Foster

A third major initiative in support of UK fungal conservation is the development of web-based information and identification tools (see http://fungi.myspecies.info). This uses innovative software generated by the Natural History Museum to bring together descriptions, images, keys, ecological data and conservation information. We are currently setting up a formal consortium of UK institutions and specialist societies to develop the resource further and improve its sustainability.

Kew has already carried out some small pilot projects investigating fungi previously believed to be extinct in Britain. Historically, British fungi have been assumed to be extinct if there are no recorded sightings in the last fifty years. However, to satisfy IUCN criteria (the global red-listing standard), "exhaustive surveys" in suitable habitat over an appropriate timeframe are also required. We rediscovered two species of fungi associated with plants of conservation concern in the UK, the bird's-eye primrose smut (*Urocystis primulicola*) and the moon carrot rust (*Puccinia libanotidis*), not recorded in Britain for 106 and 63 years respectively. A similar Kew/Natural England pilot project rediscovered the cowbane rust (*Puccinia cicutae*), not recorded for 56 years. As these fungi are entirely dependent on their plant hosts, they must by definition be at least as threatened. Conservation measures are now being considered alongside those for their hosts. This work provides proof-of-concept for other carefully targeted survey and monitoring activities in collaboration with relevant local volunteer groups.

The project: the rare, the threatened, the extinct – or the overlooked?

A key concern for fungal conservation is that a substantial number of British species are known from only one or a small number of sites, and many have not been recorded at all in recent years. In addition, species new to Britain (or indeed to the whole of science) are still regularly discovered. Before conservation measures can be considered, we need to know whether these species are genuinely rare, or merely apparently rare due to the lack of survey work. This project aims to focus on 100 fungi thought to be among the most threatened. Our plan is:

1. to select one hundred species that have been reported in Britain from five or fewer sites, or have not been detected during the last fifty years
2. to provide accurate and comprehensive information on their appearance, associations, relationships and habitat, via our website and other appropriate media
3. to carry out initial highly targeted field surveys to rediscover species, to identify threats and to assess their conservation status
4. to initiate an ongoing campaign for monitoring populations of threatened British fungi with the help of the citizen science community, including training of volunteers
5. to review the "top 100" list on a regular basis, removing species that are considered to be either non-threatened or extinct, and adding in new candidates for survey and monitoring.

Outcomes of the project

1. **Establishment of a monitoring scheme for 100 British fungi thought to be at risk**
   Unlike for most other organism groups, there are currently almost no organised activities for charting threats and population change for any species of fungus in the UK.
2. **Robust, evidence-based conservation assessments, highlighting species of genuine concern**
   Based on reliable distribution data and other information acquired via educated and committed volunteer groups, these will provide a strong knowledge base for conservation management, enabling effective targeting of resources. The user community includes landowners, national and local authorities, charities and conservation organisations such as the Wildlife Trusts, National Trust, community nature reserves etc.
3. **An enhanced, more science-driven volunteer community for UK mycology**
   This will involve leadership, training, coordination and mentoring in areas including identification skills, targeted survey and monitoring methods. Efficient information exchange and feedback will result in increased sustainability and support in the future.

Monitoring progress

Project progress will be assessed in a number of different ways. The first task will be to select the target species. This will be a significant piece of work in itself, due to the number of possible criteria for selection. The first premise will be to target species that fall into one of two categories: those not found at all in the UK for a given period (likely to be fifty years to link in with historical conservation assessments), or those recorded from a very restricted number of sites (probably with a focus on recently discovered species). In addition, some species officially recognised as being of principal importance for UK biodiversity conservation would be candidates, for example those listed in legislation (the so-called Section 41/42, Scottish Biodiversity List and Northern Ireland Priority species). These have already had some of the necessary analytical work carried out on their British distribution patterns, but no formal monitoring scheme is in place. Yet further criteria would include ease of observation (minute species would be problematic unless they occupy very specific niches), ease of identification and accessibility. An initial selection will be discussed and ratified externally including by representatives from the volunteer community. The target list will then be further refined to remove those species for which insufficient information is available to allow meaningful surveys, or where it is known that their British sites have changed irrevocably since the species was first discovered (e.g. through land redevelopment). At a later stage in the project these will be replaced by further target fungi.

The next stage will be analysis of existing collections and associated data, and gathering together information useful for identification (descriptions, images, localities, ecology etc.). This will be made accessible via a dedicated section of our UK fungi website http://fungi.myspecies.info. Metrics such as number of species assessed and number of species with full data sets accessible will be tracked, based on the "100 species" target.

Stage three will be to work with the relevant volunteer groups to introduce them to an initial restricted set of target species, assess skills and workloads, investigate potential sites and agree survey procedures. This will be a critical stage of the process, as it will be essential to ensure that volunteers are fully committed to the research. It is likely that further support will be needed for some groups, for example collaborative surveys or extra mentoring.

Some of this may be carried out by local paid consultants, depending on workloads and cost-effectiveness, and a modest budget line has been included for this purpose. In the early stages of the project, we propose to work with a small number of the more skilled volunteer groups, to maximise the potential for successful searches and to establish the programme. The plan is that they will be seen as "super-volunteers" and encourage other groups to set up similar surveys.

Stage four will be to examine voucher material of new collections of the target species, to ensure that identifications are robust, and to provide feedback to the volunteer surveyors. Many of the species are likely to be poorly known on a global basis, and the new collections will add significantly to the body of knowledge. It is likely that in some cases modifications to species definitions will be appropriate, and possibly also the recognition of cryptic species similar to those initially targeted. The whole process will be one of mutual feedback. Various methods of assessing progress will be employed here, including identification success rate, number of samples submitted for verification, number and quality of surveys carried out (whether or not target species are detected). Setting figures at this stage is difficult as some of these targets will work against each other; for example a high identification success rate is likely to result in fewer specimens being sent for verification. The number of surveys needed will also depend on success rates, and the extent to which we are able to combine searches for multiple rare species in the same locality.

Cryptomyces maximus is a weak, non-damaging parasite of willow bark, only known in the UK in modern times from a single locality in Pembrokeshire. The story of its conservation in Wales can be found in *Fungal Conservation* **3**: 7-11 (2013).

Once the species are fully characterised and we know where they live and have a reasonable idea of how rare they are, IUCN-compliant conservation assessments will be made, and information on the species will be disseminated to landowners, local and regional conservation organisations etc. The plan is that the volunteer groups will adopt species as "theirs", maintaining monitoring programmes, ensuring that others know about the species concerned and recruiting new volunteers. Exactly this has happened with a recording group in Pembrokeshire; once aware that a nationally rare species was restricted to their "patch" (see opposite), they liaised with the relevant authorities to promote its conservation, established an annual monitoring programme, and publicised "their" species and its conservation significance.

How change will happen

The key activities to be implemented are as follows:

1. **Selection of candidate species**. There are several thousand species of fungi in Britain that are known only from a small number of collections, and/or have not been seen for many years. A substantial number of these are species with minimal descriptions and inadequate dried collections, such that they cannot be linked reliably with modern finds. These will be filtered out as "beyond hope" – in itself a useful if depressing conservation activity. The remaining species will need to be filtered further using a range of different criteria, including ease of recognition, geography, ecology and plant associations. Many fungi occupy very specific niches (e.g. those that are restricted to leaves or roots of a particular plant), thus facilitating targeted surveys. Our aim is to select one hundred species that have been reported in Britain from five or fewer sites, or have not been detected during the last fifty years. The selection process will have a strong pragmatic element – it would be possible to spend a considerable amount of time ranking species according to an extensive range of eligibility criteria – to ensure that we can progress to the directly conservation-related aspects of the project. Species will be chosen on an individual basis so that further work can be done prior to finalisation of the "top 100" list.
2. **Information gathering**. By definition, the species selected will be poorly known and unlikely to be included in field guides. We will therefore need to provide accurate and comprehensive information on their appearance,

associations, relationships, last known locations and habitat. This will require literature searches, and also re-examination of dried specimens in the Kew collections. Verification of the identity of dried specimens will also be required so that historical observations can be substantiated. Errors in identification do occur and changes also happen in the way in which species are defined; for example, our recent conservation assessment work on bolete fungi showed that one species thought to be present in the UK and also statutorily protected is not British at all. The species information will be made available primarily via our website http://fungi.myspecies.info, which will also be used for project updates, news on latest finds etc. If requested by volunteer groups, we can also provide printable data such as species summaries to help in fieldwork.

3. **Field surveys**. As species are selected and associated information gathered, campaigns will be initiated to re-find them in the wild, in partnership with local volunteer groups. Information from searches (whether successful or unsuccessful) will be recorded for conservation evaluation purposes, and new finds will be fully documented with specimens sent back to Kew for preservation. Remote access will be given to our website so that volunteer groups can upload their own images and associated information. In addition to information on the species themselves, assessments will be made of potential threats to their populations from incorrect management practices, habitat destruction etc. Training of volunteers will take place, either via organised workshops or mentoring on an individual group basis.
4. **Conservation assessment and monitoring of target species**. Once species are confirmed as present (i.e. not extinct) we will initiate an ongoing campaign for monitoring their populations with the help of the citizen science community, focusing particularly on fungi at risk of extinction. Our experience is that volunteer groups are highly motivated for such activities once it is clear that particular species are at risk. We also expect that non-mycologists within the conservation arena (e.g. members of Wildlife Trusts and wardens of reserves) will be included in these activities, and we will provide further training and mentoring where needed. Formal conservation assessments will be published for the species on our "top 100" list, based on the project findings and compliant with the IUCN Red List system.
5. **Review of the "top 100" list**. We do not see the list of targeted species as a static document. We will review the list on a regular basis, removing or de-prioritising species that are considered to be either non-threatened or extinct, and adding in new candidates for survey and monitoring. We expect this process to continue beyond the lifetime of the project, with a gradual increase in the number of species monitored and the number of volunteers committed to the project. Depending on future commitments, Kew would be able to support this process at a reduced level using core funds, but we anticipate that further funding sources might be identified once the success of the project has been demonstrated.

Project Management – Partnerships

As in many of our past projects, we shall work closely with a range of organisations and individuals to achieve the goals described in this document. These include: national institutions (e.g. Natural History Museum, National Museum of Wales, Royal Botanic Garden Edinburgh), specialist societies (e.g. British Mycological Society, British Lichen Society), individual recording groups (not all of which are affiliated to specialist societies), local Wildlife Trusts and other conservation bodies, and individual experts. Coordination and providing feedback will be important to ensure success and sustainability, and this will be an important component of the programme.

In order to ensure that good relations are maintained with the various partners, we shall set up a standing committee to oversee project progress, including representation from the major stakeholders.

The most important people in this project are the volunteer recorders. Their opinions on progress and direction will provide one of the main drivers for success. They will need a substantial amount of support and guidance to ensure that they can take on a new role as biodiversity surveyors and conservation specialists. However, the number of volunteer groups that we consider are likely to wish to participate in this programme is too large for us to be able to support at the same time. Our plan therefore will be to engage with a small number of the groups (maybe four or five, in different parts of the country) which have already shown interest in this sort of work and which have the basic skills to take it on. We will encourage them to pass on their newly acquired expertise to other groups, and will provide extra support as required. Wide circulation of the activities and successes of the original

groups will provide extra incentive for new ones to join, and we anticipate strong support from the national societies and other organisations for this process.

Sustainability

One of the primary aims of the project is to achieve a step-change in the quality and scientific validity of fungal surveys by volunteer groups throughout the UK. By its very nature, this will be a benefit that endures well beyond the project lifespan and should be permanent. It will also make new initiatives possible, for example the research needed for scientifically valid designation of Important Fungus Areas as counterparts to the Important Plant Areas championed by Plantlife.

In order that the legacy of this project will be fully realised, there are three ongoing activities which will need to continue. Firstly, ongoing surveys will be needed beyond the lifetime of the project to monitor continuing presence of rare species, changes in site condition, new threats etc. The costs for this will be modest unless substantial travel is involved, and we are confident that in the main these could be met within the volunteer groups themselves and/or in partnership with local conservation management agencies. The second area is to expand the number of volunteer groups with the necessary skills to carry out survey work, especially to increase geographical coverage. This will be a process that will not be complete within the project timespan, and we expect the national societies to play a leading role in this area, providing modest funding if necessary. The final legacy area will be to expand the programme by identifying new fungal candidates for survey and conservation assessment, and providing information to facilitate their identification. This process will be a partnership between the volunteer groups themselves and Kew, as it is likely that the initial surveys will detect new species of interest as "by-catch". At least some support will be provided by Kew as part of its continuing commitment to the public, but it is possible that the success of the project will be such that a new permanent post would be justified.

Urocystis pulsatillae, a smut fungus found on the leaves of pasque flower, is a recent example of fungal survey "by-catch". There were no known British records since 1931. Then it was found, quite by chance, in 2012 by a volunteer surveyor looking for a rust fungus on bastard toadflax, a plant sharing the same habitat.

Photo © Martyn Ainsworth

There are various opportunities for further funding of this work beyond the lifetime of the project. National and regional bodies with a responsibility for nature conservation such as Natural England and Scottish Natural Heritage have modest funds to support relevant survey work, which is currently rarely awarded to mycology-related groups due to the low level of knowledge and skills. Furthermore, some preliminary survey data are often required as evidence before country agencies can prioritise potential target species for in-depth survey. Other organisations, such as the National Trust, National Parks authorities and the Wildlife Trusts, could potentially also provide small grants to ensure that rare species on their land are protected. The skills acquired by the volunteer groups would also make them eligible to carry out work such as environmental impact analysis – currently very few EIAs include a fungal component.

Fungi are critical to the health of our ecosystem, and fungal species merit conservation on equal terms to that for animals or plants. Changing public perceptions of fungi from the current state where the emphasis is almost entirely on species deleterious to humans to a balanced approach will require a long-term strategy. This project will encourage volunteer groups and ultimately the public at large to treasure particular fungal species, and will make an important contribution to achieving this goal.