WOODLAND TRUST

Wood Wise

Woodland Conservation News • Autumn 2015

FABULOUS FUNGI

DEATH BRINGS LIFE TO WOODS

LIVING TOGETHER IN HARMONY

SEARCHING FOR OUR LOST FUNGI

TO PICK OR NOT TO PICK?

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Cover photo: Chicken of the Woods, *Laetiporus sulphureus* by Shizhao.FlickrLick

Coral spot, *Nectria cinnabarina*

The wonders of fungi

The importance of fungi in woodland has previously been compared to the networks of pipes and cables that support a bustling city.[1] As with man-made electricity and water infrastructure, fungi are the underground conduits that link and support woodland life – but they are also the ever-active workmen that seek out new tasks and opportunities.

Many of us take our human support mechanisms for granted and do not fully understand their complexity or importance until they cease to function. We often pay too much attention to the outcome (e.g. a computer) than to the various support systems that allow it to function (e.g. an electricity supply).

There is a parallel with the woodland ecosystem. Many people appreciate, understand and fight for the protection of endearing red squirrels or magnificent ancient trees. But fewer look deeper into the soil, to those species that may be more cryptic and less charming but make the cycle of life possible.

History and significance

Over centuries, fungi have been used and revered by various human cultures for medicinal and culinary purposes, to drive away evil spirits, for ritual purification, and a variety of other functions and ceremony. Unfortunately they have also been misunderstood, with some believing them to be the work of evil spirits or witches, or growths of the earth.

Delve into their world and fungi are in fact so special they are now classed in their own kingdom of life on earth. Of the estimated 0.8 - 5.1 million species of fungi in the world, over 70,000 species have been identified; living on land, in the air and water, even on and in plants and animals. Many are extremely beneficial, to us and other species, and a number have significant economic benefits. But others are harmful and act as pathogens which cause disease and even death.

Evolutionary importance

Plants and fungi may now be separated into their own kingdoms, but they were once clumped together. This may be wrong in biological terms, but less so in evolutionary ones. As life moved from the Earth's water to colonise the land over 400 million years ago, plants and fungi worked and evolved together to achieve this.

Plants likely evolved from simple green algae, but it was fungi that provided the root systems. The plants utilised sunlight and carbon dioxide in the air through photosynthesis, while the fungi broke down the rock to access its nutrients. Evidence to support this is shown by the earliest plant fossils having mycorrhizae. Would plants have become as dominant and terraformed the planet to eventually allow us to evolve without this vital partnership?

Fabulous fruits

For the majority of their lives fungi exist as filamentous networks in virtual anonymity, beneath or within structures. But it is their fruiting bodies, the toadstools or mushrooms, which appear to herald their existence and reproduce through the development and release of spores. For some fruiting bodies the conditions of autumn encourage their growth, for others it is spring, and some are found year-round, but not all appear each year and the rarest are often difficult to record.

The following fungi articles focus on those areas of greatest significance for woodland ecosystems – positive and negative.

[1] *Raynor, A. D. M. (1993) The fundamental importance of fungi in woodlands. British Wildlife, 4: 205-215*

Yellow brain fungus, *Tremella mesenterica*

Hyphal network

Decomposers fuelling life

by Kay Haw

Death may not be a happy thought, but they say 'there is no life without death' – and it seems without certain life forms, there is no more life.

Imagine a world without decomposition, where finite resources were used just once and dead organisms had merely piled up across the globe millennia ago. Evolution would likely have worked itself into a dead-end on such a planet. Thankfully, our Earth evolved fungi, bacteria and other decomposers to recycle nutrient molecules from dead bodies back into the system for use by the next generation of species, and so their lives support the life and evolution of everything else.

Chernobyl is a useful place to witness the effects of losing decomposers. On 26 April 1986, a deadly explosion at the nuclear power plant blew radioactive particles into the atmosphere that rained back down into the soil. In September 2007, a research team placed 572 bags of uncontaminated dry leaf litter from four tree species into 20 forest sites around Chernobyl.[1] A 40 per cent reduction in litter mass loss was shown in those areas where the death of soil microorganisms from radiation poisoning was greatest. This decrease in decomposition reduces nutrient recycling and affects plant growth.

Deathly white fingers

Pick up an old, rotting branch in a wood and working their way in from the soil are pale fronds and filaments; patterns of great beauty and strength. These are the real body of a saproxylic fungus, the hyphal networks that impregnate the earth and search out the dead for repurposing. Fungal hyphae decompose by means of a two-pronged attack strategy.

Without chlorophyll to photosynthesise or mouths to eat, fungi use extracellular enzymes to dissolve plant and animal material. They are heterotrophic so absorb the nutrients they have externally broken down from other organisms. Their hyphae secrete the acids and enzymes that enable this and then absorb the resulting nutrients.

Sulphur tuft, *Hypholoma fasciculare*, wood rotting fungus

However, the hyphae not only release secretions to break materials down, they are also extremely powerful. Hyphae grow continuously from their tips, termed apical growth as they grow from the apex, and extension can be rapid - up to 40 micrometres per minute. The sheer force of this growth exerts extreme pressure on the material into which they are growing. It is the combination of this and their secreted enzymes that enable them to penetrate and break down some of the toughest natural materials, like cellulose, lignin, and even rock, that other organisms are unable to.

Keeping the forest alive

Mature woodland ecosystems have a profusion of dead and dying wood containing cellulose and lignin, tough materials found in bark and leaves that help give trees their strength and longevity. These materials are not easily digested and broken down by mammals or birds. Yet they are made up of essential nutrients that must be recycled back into the food chain, and here the fungal powerhouses come into their own.

Cellulose is a polysaccharide, a long chain (hundreds or thousands) of sugar molecules, which makes up most of a plant's cell wall and gives it incredible strength. Ruminants (e.g. cows) break down these chains only because of special bacteria that live in their gut. Lignin is another complex organic polymer (large molecule) and is only exceeded in abundance on Earth by cellulose. It too is vital in providing strength and longevity to plant cells, as it is tough to rot, especially wood and bark.

A tree's ability to reach a hundred or thousand (and some many more) years of age is enabled by the tough, durable properties of cellulose and lignin. So it makes sense that it would take special organisms with super powers to break them down over time. The large molecules (macromolecules) of cellulose and lignin are broken down by the fungi into smaller molecules, which can be taken up and used by themselves and others.

Food for all

Decomposition activity not only benefits the fungi themselves, it also increases the nutrients available to other species. Following the breakdown of organic matter by fungal hyphae, the resulting small, nutrient-rich molecules can be taken up by the roots of plants as well. Plant roots and fungal hyphae coalesce happily together in woodland soils, benefiting them both and others.

Certain elements, such as nitrogen and phosphorous, are not naturally abundant in the environment, but they are in great demand in many ecosystems and by many species. Were it not for the industrious fungi and friends, these elements would be tied up in the bodies of the dead, and the dead would be ruling the world.

Maintaining the balance

There is a need to keep deadwood in woods. Yet in the UK many have too little, being young or over-managed. All woods need some deadwood, so the Woodland Trust seeks to promote a rich and diverse habitat by retaining as much of it as possible to allow life to flourish.

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[1] *Mousseau, T. A. et al. (2014). Highly reduced mass loss rates and increases litter layer in radioactively contaminated areas. Oecologia, [online] 175 (1), pp. 429-437. Available from: www.link.springer.com/article/10.1007%2Fs00442-014-2908-8*

A tale of two communities

by Ray Woods

Woodland is so much more than just a collection of trees.

To imagine that you could create a town by just sticking a few houses in the ground seems dangerously naive. Its inhabitants would soon find life intolerable with no water, power or communications with the rest of the world. Getting the right sort of house is also critical. A mud-walled house might work well in sub-Saharan Africa but fail totally in the moist climate of Manchester.

Human settlements are not unlike woods. Yet we still expect to create woodland by planting trees, which might come from somewhere miles away, in whatever bit of ground happens to be available, and trust that the essential infrastructure will somehow appear.

Creating new woods

Let us look at the infrastructure requirements of a tree and the challenge we are presenting new trees within their new home. They have been well looked after from the nursery bed and you have carefully planted and perhaps watered them. But where were the trees from? If the Woodland Trust supplied them recently we can be assured they were grown in the UK from UK seeds.

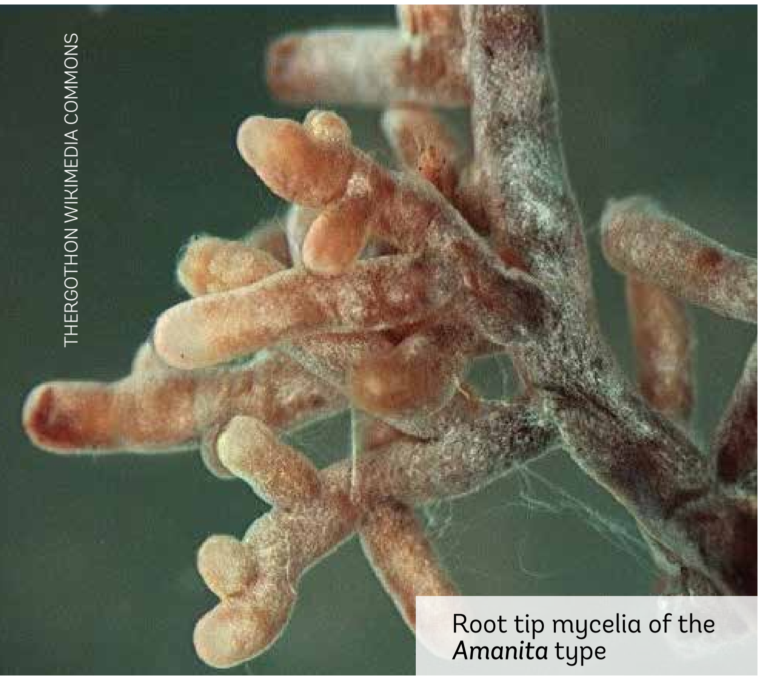
However, many nurseries still import trees from as far away as Eastern Europe and the seed may have come from further afield. Where you come from may not seem to be too important. But if you are a silver birch adapted to come into leaf in spring once a certain day length is reached and you have been moved a long way south of your provenance, your measure of when spring has arrived is far too early and you will be tempted into leaf before the frosts have gone.

Fly agaric, *Amanita muscaria*, has a mycorrhizal relationship with birch, *Betula* sp., trees

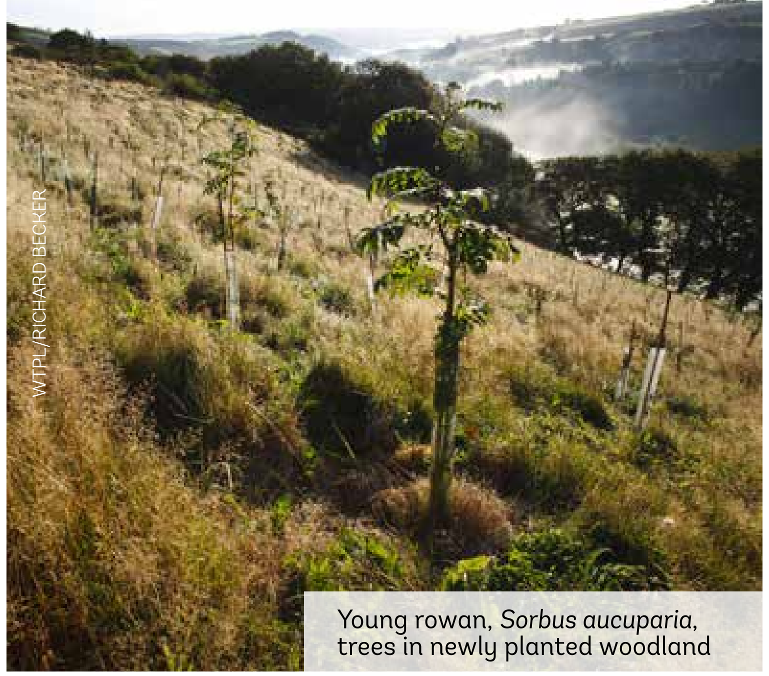
Intimate relationships

Most trees have a high dependency on fungi to acquire enough minerals. These species, called mycorrhizal fungi, live in or sheath the roots and their fine feeding strands or mycelia penetrate deeply into the soil. Mycelia are incredibly fine, have a surface-to-volume ratio of over a hundred times that of a root hair and can penetrate soil and rock particles down to depths no tree roots ever venture. There they scavenge phosphates, in particular, and pass them on to the tree in exchange for sugars.

It is uncertain just how well adapted your tree's nursery-acquired mycorrhizal fungi are compared those in its new home. Only recently, by examining the DNA of mycorrhizal fungi, have we come to discover quite how many different types can be present. More than 60 in a short length of root are not uncommon. Some of these fungi at least harbour helper bacteria that assist in the formation of the relationship with the tree and may also hinder the establishment of other potentially competing fungi. This very diversity is hopefully all to the good, since if our tree started out with a poorly adapted collection of fungi this might be quickly remedied by new colonisation.



Root tip mycelia of the *Amanita* type



Young rowan, *Sorbus aucuparia*, trees in newly planted woodland

Look underground and the wood-wide web of fungal feeding strands links tree to tree and shares out the nutrients and sugars. If one tree grows well its neighbours can also benefit. In an existing wood, saplings can plug into this web but in a new wood it all has to be created.

Whatever you do, do not be tempted to add extra artificial fertilizer to "help the tree grow" as this might completely wreck the underground partnership of tree and fungi. We still have no clear indications as to the challenge we have set the tree and its helpers if we had to plant the tree in soil previously soaked in artificial fertilizers from intensive farming use – too many phosphates inhibit the development of mycorrhizae. With poor mycorrhizal helpers we have only recently discovered that drought becomes more of a problem for the tree, since the fungi supply the tree with water from deep in the soil as well as nutrients.

Within and without

Probe every other bit of the healthy tree and we find yet more fungi. Some seem to colonise in the seed bed and live in the tree throughout its life, perhaps staving off infection by other less desirable fungi and bacteria. They only reproduce and become visible to us once the tree has died. Tree leaves and buds are full of fungi – more than 100 species have been found in a single tree. Many of these fungi house their own bacteria and together create an extraordinary array of toxic and messenger chemicals, most of which undoubtedly benefit the tree and protect it from attack by pathogens and herbivores.

Fungi live in, and between, the cells of leaves, buds and bark, and can vary in abundance and diversity throughout the year. Tree lifespans and turnover times are long and in consequence the tree's ability to evolve to meet the challenge of changing climate and new pathogens (that can themselves replicate several times each year) is limited. In having more rapidly evolving helpers, the tree is at a clear advantage – even if this army of helpers has to be fed, watered and kept in their place.

Quite how all these helpers get into a tree and how they vary from place to place has still to be discovered. There may well be considerable long-term advantages in not planting trees from afar, but with patience a new wood can be created through natural regeneration from local stock. Our woodland might then acquire through their seeds and by local colonisation the most efficacious and locally well-adapted helpers. As a town is more than just houses, so a wood is more than just trees.

Chanterelle, *Cantharellus cibarius*, is a mycorrhizal fungus

The bad and the ugly

by Kay Haw & Helen Jones

While the success of plants around the world has certainly been significantly influenced by some fungi, the darker side is that there are also many deadly fungal pathogens.

Of the different groups of pathogens (including bacteria and viruses), fungi are the most important organisms that attack plants – from a human perspective. In 2012, plant mycologists associated with the journal *Molecular Plant Pathology* voted on their top fungal plant pathogens.[1] Those chosen directly affect key human food crops/supplies, and therefore our survival and the economy – below is the ranked list.

List of the world's top fungal plant pathogens:

1. *Magnaporthe oryzae* – world's most important fungal rice disease
2. *Botrytis cinerea* – attacks over 200 plant species
3. *Puccinia* spp. – contains over 4,000 species of rusts
4. *Fusarium graminearum* – devastating blight of wheat and barley
5. *Fusarium oxysporum* – some strains cause wilt in various plants
6. *Blumeria graminis* – causes powdery mildew in important cereals
7. *Mycosphaerella graminicola* – second most important disease of wheat
8. *Colletotrichum* spp. – causes diseases of the Proteaceae plant family
9. *Ustilago maydis* – smut pathogen of corn and teosinte
10. *Melampsora lini* – rust disease on flax and linseed

FOREST RESEARCH

Phytophthora austrocedri affecting juniper

Asexual spore of *Phytophthora ramorum*

Fungal pathogens can also be devastating to the woodland and forestry world. As well as impacting on native species, whose loss has serious negative effects on ecosystems and food chains, they also have consequences for non-native and economically important forestry species.

Plants arch nemeses

The genus *Phytophthora* contains a large number of species; 100 are known to science and it is estimated there may be another 500 yet to be discovered. They are morphologically like fungi, but operate in different ways. The name is derived from the Greek language and translates as "plant destroyer", "phyto" meaning plant and "phthora" meaning destroyer. A large number of Phytophthora species are root pathogens, so are often spread from tree to tree by water and contaminated soil, and transported through their network of roots.

Phytophthora species are among the world's most destructive plant pathogens. One many people have heard of is potato blight, *P. infestans*. It was a contributor to the Great Irish Potato Famine in the late 1840s, which resulted in the deaths of over one million people through starvation. Today it still causes around $6 billion (approximately £4 billion) of crop damage a year and is extremely difficult to combat.

Tree pathogens

Phytophthora species also impact on forestry and native trees in the UK. Introduced *P. ramorum* is devastating non-native larch, *Larix* sp. plantations across the country; whereas juniper, *Juniperus communis*, woodland in Scotland and Northern England is being threatened by *P. austrocedri*. Juniper is considered to be an important native species and much of the juniper woodland in Britain is protected because it is so rare.

P. austrocedri was first described on the conifer species *Austrocedrus chilensis* in Argentina in 2007, while the earliest report in the UK was in 2011. The current distribution of the pathogen is still limited, as far as is known, to Argentina and the UK, so there is still a great deal to learn about it.

Ophiostoma novo-ulmi synemmata developing within a wound on an elm branch

Juniper trees become infected with *P. austrocedri* through their roots and, as the disease spreads, the foliage dies off and becomes brown or bronze in colour. The phloem contained within the inner bark becomes stained with cinnamon-brown lesions. These eventually girdle the entire stem, preventing nutrients from being transported around the tree and ultimately resulting in its death.

Foreign invaders

The hot topic on a lot of tree-people's lips is Chalara dieback of ash. First found in a nursery in 2012, the *Hymenoscyphus fraxineus* fungus is threatening the survival of our beautiful European ash, *Fraxineus excelsior*, trees. As one of Britain's three most abundant trees, the loss of ash from our countryside will be a serious blow to biodiversity, nature connectivity and landscape resilience (for more information on ways you can help tackle this disease see pages 15-18 of the spring 2015, citizen science issue of **Wood Wise**).

Britain is still reeling from the loss of over 60 million elms, *Ulmus* spp., from the Dutch elm disease (DED) epidemics. The first was caused by the *Ophiostoma ulmi* fungus in the 1920s. This caused the loss of 10-40 per cent of elms, but it had died down by the 1940s. The second was caused by its far more aggressive and destructive relation *O. novo-ulmi*, first recorded in the 1970s and imported to Britain on infested elm logs.

It is believed these dark warriors originally came from the Himalayas. The term 'Dutch elm disease' simply reflects the location of early research carried out on the pathogen by female Dutch scientists between 1919 and 1934. Work was also carried out by Dr Tom Peace of the UK Forestry Commission in the late 1920s.[2]

Both fungi have spread across Europe, North America and central Asia in two waves of migration. The spores are spread by elm bark beetles, *Scolytus* sp.; carried on their bodies and transferred to trees as they burrow into the bark. Once inside, the fungi then invade the water conducting system of the elms, causing the foliage to wilt and die. It seems these beetles specifically choose trees of a certain size or age, which is why young elms can still be seen but mature ones are now very rare.

Shutting the floodgates

If we are to stem the tide of pathogens being introduced to Britain we need to ensure biosecurity is as tight as possible. UK border controls are being increased, and forestry workers and visitors are being advised to clean boots and equipment before entering and leaving woods to prevent the transport of pathogens across the country.

Research is also being carried out to find strains of tree species that have resistance to some of the major diseases impacting them. The Conservation Foundation is carrying out The Great British Elm Experiment; propagating cuttings taken from mature elms that have resisted Dutch elm disease for over 60 years. Saplings are being distributed to interested schools, community groups, local authorities and private landowners that commit to being part of this long-term experiment. These trees will now be monitored to assess their levels of resistance to DED. In the hope magnificent, mature elms, which once covered the countryside, can be brought back to Britain.

In Denmark, genetic field trials have identified Tree 35 and 18 as two ash strains showing the highest levels of resistance to Chalara dieback of ash. Tree 35 is highly heterozygous, meaning

Graphium type spores of *Ophiostoma ulmi* in elm bark beetle gallery it has two different genetic alleles for a single trait. British scientists have teamed up with the Danish researchers, and are bringing hope to concerns over the deadly disease that threatens the future of Britain's 80 million ash trees – Denmark is already losing 60-90 per cent of its ash[3].

At the Woodland Trust's Hucking Estate, Kent, and Pound farm, Suffolk, the Trust is working on Chalara dieback of ash resistance screening trials with scientists at Forest Research and the Forestry Commission. This research involves trialing plantations of young ash trees to find individuals or strains that are naturally resistant to the disease. Any trees with a natural resistance will be used in breeding programmes, so we can protect the future of our beautiful ash.

The battle continues

While the ruthless effectiveness of fungal pathogens must be admired, they are by far one of the greatest of nature's destroyers. Humans have been battling against them for centuries and, with new species evolving all the time through their introduction into new areas and the resulting DNA transfer between previously separated species, this war seems unlikely to end anytime soon.

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[1] *Dean, R. et. Al. (2012). The top 10 fungal pathogens in molecular plant pathology. Molecular Plant Pathology. Available online: www.onlinelibrary.wiley.com/doi/10.1111/j.1364-3703.2011.00783.x/full*

[2] *Brasier, C. (1996). New Horizons in Dutch Elm Disease Control. Forestry Commission. Available online: www.forestry.gov.uk/pdf/New_horizons_DED.pdf/$file/New_horizons_DED.pdf*

[3] *Gray, R (2013). How trees 35 and 18 could enable fight back against ash dieback. The Telegraph. Available online: www.telegraph.co.uk/news/earth/agriculture/forestry/9962602/How-trees-35-and-18-could-enable-fight-back-against-ash-dieback.html*

The Lost and Found Fungi Project -

by Brian Douglas & Kay Haw

Fungi need conservation action, just like plants and animals, but many are genuinely rare and often overlooked. One project aims to rediscover some of the UK's lost fungal species.

Contrary to common misconceptions, fungi are not just mushrooms and moulds. They are a dazzlingly diverse kingdom of organisms, including tooth fungi, coral fungi, puffballs, earthstars, earth-tongues, crusts, cup fungi, rusts, smuts, yeasts, and obscure microfungi. As with plants and animals, many are adapted to very distinct, diverse, and fragile ecological niches and habitats, and so can be vulnerable to habitat destruction, pollution and climate change.

Such species may need conservation attention, but it can be complicated to know which species are truly vulnerable and to justify this to other people. Fungal fruit bodies are often difficult to find and survey, they are often small, difficult to identify and short-lived and so apparently rare species could in fact just be under-recorded. Relatively few people are actively searching for rare fungi in the UK, and this lack of manpower causes major problems in establishing rarity or finding new sites for genuinely rare species. As a result, available baseline data for fungal conservation is very incomplete compared to that for plants and animals, and not yet fit for purpose.

Improving the baseline data is a big challenge. The scale of the problem can be seen in the fact that approximately 15,000 species of fungi have been recorded in the UK, but over 2,000 have been reported just once. Many are known from only one or a few of sites, and were last seen over 50 years ago. Such species could be considered extinct, but if no one is actively searching for these species, then how can we know if this assessment is true?

Earthstar species, *Geastrum marginatum*

Royal Botanic Gardens Kew's The Lost and Found Fungi Project is trying to find out.

Hunting for rare fungi

To effectively conserve species we need to know as much about them as possible. Key areas include reliable identification, general ecology and an understanding of the microhabitats they inhabit. Knowing what species are present in specific habitats, or where historical records were found, can give important clues about where to start the search. Using this data, targeted surveys can determine where populations actually occur, leading to much better assessments of species distribution and their conservation needs.

The first and easiest places to look can be close to home. Many rare fungi require specific habitats or host plants that occur in ancient woodlands, wetlands, unfertilised waxcap grasslands and similar unspoiled habitats, which are often nature reserves or SSSIs. Fungi are as important and fascinating treasures of such sites as plants and animals. But if we want to find out if they are present or not, we have to go out and look for them.

Small pilot projects have been carried out by Kew to find some species that were presumed extinct. New sites and populations have been found, and previously recorded locations resurveyed. Examples of rediscovered fungi now include a smut fungus, ***Urocystis primulicola***, which is only found on bird's-eye primrose, ***Primula farinosa***, not recorded since 1884; and a rust fungus, ***Puccinia libanotidis***, only found on moon carrot, ***Seseli libanotis***, not recorded since 1946.

Multiclavula vernalis

In 2010, Kew successfully found both 'extinct' fungi by targeted surveying on both red-listed plants, and conservation measures for these fungi are now being put in place alongside those for the hosts.

Boosting fungal conservation networks

Supported by the Esmée Fairbairn Foundation, the five-year Lost and Found Fungi Project hopes to build on the success of the pilots on a much bigger scale. The aim of the project, which started in July 2014, is to establish the beginnings of a robust, data-led approach and mechanism for fungal conservation assessment.

Its methodology involves:

- Compiling a list of 100 target species reported in Britain from five or fewer sites, or that have not been detected during the last 50 years, or are of other conservation interest;
- Facilitating volunteer involvement by providing the best available information (e.g. online images, descriptions, maps and datasheets) identification confirmation and advice;
- Co-ordinating targeted field surveys to rediscover species, to identify threats and to assess their conservation status;
- Initiating an ongoing campaign for monitoring populations of threatened British fungi with the help of the field-recording community, including training of volunteers;
- Reviewing 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.

Kew hopes the project will lead to:

- **Establishment of a monitoring scheme for 100 British fungi thought to be at risk**
  There are currently almost no other organised activities for assessing threats and population change for fungi in the UK, unlike for other organism groups.
- **Robust, evidence-based conservation assessments, highlighting species of genuine concern**
  Reliable distribution data and other species-specific data will be used to undertake conservation assessments of target species, providing a strong knowledge base for end users of this information (landowners, national and local authorities, charities and conservation organisations).
- **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.[1]

What to look for

The project's Top 100 Fungi list comprises a wide diversity of species spread across much of the fungal Kingdom. Most are distinctive enough that plausible candidates can be found in the field by people with little or no mycological experience, albeit with a little help from species datasheets, online images, maps and a treasure-hunting attitude.

Species currently fruiting include:

- The coral tooth fungus, *Hericium coralloides*, and the bearded tooth fungus, *H. erinaceus*, both forming distinctive and beautiful white/cream growths on beech in old woodlands;
- The zoned rosette, *Podoscypha multizonata*, which forms upright reddish/pinkish brown lobes arranged like a "fungal rose", growing on soil, in grassy parks or woodlands and associated with roots of old oaks or sometimes beech;
- The oak polypore *Piptoporus quercinus*, a bracket fungus growing from old oak heartwood and one of the few fungi specially protected under Schedule 8 of the Wildlife and Countryside Act (1981);
- And many more...

Bearded tooth fungus, *Hericium erinaceus*

Conserving rare fungi

Many rare fungi are found on nature reserves and careful management is essential to properly conserve them. But reserve managers can only do this if they know what fungi are on those sites and understand what they need. Certain management practices can help create habitats for rare or under-recorded fungi. For instance, gorse burning can create habitats for *Thyronectria roseovirens* (visible as vivid yellow patches on charred gorse), or holly coppicing habitats for the tiny greenish cup fungus *Mollisia subglobosa*.

However, management actions can also accidentally destroy important habitats in unexpected ways. Clearance of heathland birch can remove the birch-bark-stripper fungus *Xenotypa aterrima*, which is parasitised by the extremely rare cup fungus *Dencoeliopsis johnstonii*. Forestry or coppicing could damage populations of the tobacco-coloured crust *Hymenochaete tabacina*, which the extremely rare and beautiful willow gloves fungi, *Hypocroepsis lichenoides*, parasitises.

Rare wood-rotters of veteran trees, such as *Piptoporus quercinus* and *Hericium* spp., can be destroyed if unsafe or fallen trees are chipped, but can happily survive and fruit on relocated cut logs. Tree clearance and woodland fires can damage or kill the web-like mycelium body of rare root-associated mycorrhizal fungi, for example the palefoot saddle, *Helvella leucopus*, or the guilded domecap, *Lyophyllum favrei*. This can be a major problem if there is only one colonised tree in a wood or if it is the only known site in the UK for a species.

Encouraging site managers and local enthusiasts to get involved in efforts to find and protect rare fungi in their localities could be one of the best ways to help preserve the UK's rarest fungi. This will all help people to value and appreciate their strange and fascinating fungal beauty.


VAVRIN WIKIMEDIA COMMONS

Oak polypore, *Piptoporus quercinus*

Making progress

The Lost and Found Fungi Project was conceived and developed at Kew by Dr Paul Cannon and Dr Martyn Ainsworth, and is being co-ordinated by Dr Brian Douglas. A project assistant will soon be joining to help manage the increasing number of finds. Regional groups and individuals are actively participating, most affiliated to one or more of the national organisations: the British Mycological Society, the British Lichen Society, and the Fungus Conservation Trust (formerly the Association of British Fungus Groups). Botany enthusiasts are also being encouraged to participate, since finding the correct plants for host-specific fungi is often the hardest part of the search. Everyone with an interest in learning about the UK's most rarely recorded fungi is very welcome to get in touch and get involved.

Around 30 of the 100 target species have so far been recorded and many of these are at new sites. Some records are the first for over 50 or 100 years, or first country and/or county records. Contributors are also sending in records and important additional data, which are not currently in national databases. These data support the hypothesis that many 'extinct' fungi are still out there, and although some may be far more common than we think, others may truly be restricted to only a few sites in the UK and really need to be protected.

Join the search

Spreading the word about the importance, diversity, and vulnerability of fungi, and supporting their conservation is needed more now than ever. If you want to get involved in this important project, or to see further information and images of the 100 species currently being targeted, please go to: www.fungi.myspecies.info/content/lost-found-fungi-project, or email Brian Douglas at b.douglas@kew.org.

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[1] *Kew, 2014. Building the infrastructure for conservation of fungi in the UK: the Lost and Found Project. Online: www.fungi.myspecies.info/content/lost-found-fungi-project*

Foraging: sustainability and impact

by Emma Bonham

Foraging for wild resources such as berries, nuts, moss, wood and fungi is increasingly popular.

Fungi are a foraging staple for both recreational and commercial collectors. But as demand increases there are concerns over the ecological impact and sustainability of this practice.

Impacts on fungi

Unsustainable harvesting practices (leaving no fruiting bodies to produce spores) and unselective collecting are key areas of concern. A few studies have investigated the effect of harvesting on fungal populations. In 2006, results of a 29 year Swiss study[1] into the effects of picking or cutting fungal fruit bodies on future harvests, showed long-term and systematic harvesting reduced neither future yields of fruit bodies nor species richness. However, trampling of the surrounding soil through fungi collecting reduced fruit body production to around 70 per cent of that of untrampled areas and decreased the number of species fruiting.

A similar conclusion was reached in a 10 year investigation of commercial harvesting techniques on American matsutake, *Tricholoma magnivelare*[2]. Harvesting through careful picking showed no negative impact. Yet disturbance or removal of the litter layers during harvesting caused highly reduced fruiting in the subsequent year and remained so for the duration of the study.

An ecosystem service?

Worldwide, the United Nations Food and Agriculture Organisation estimates wild edible fungi are collected in more than 80 countries. Elsewhere in Europe the use of wild food is more widespread than in the UK and a wide variety of fungi species are collected and used, providing not just a recreational and food provisioning service but a cultural one as well[3].

The UK picture

In 2006, a Forestry Commission Scotland survey of wild harvesting found only 16 per cent of respondents who had foraged in Scottish woods over the last five years had gathered mushrooms. In comparison, 54 per cent had collected berries[4], which many find easier to identify.

The 10 most common fungi gathered were:

- Chanterelle, *Cantharellus cibarius*
- Boletes (penny buns, etc.), *Boletus edulis*, and close allies
- Field mushroom, *Agaricus campestris*
- Horse mushroom, *Agaricus arvensis*
- Hedgehog fungus, *Hydnum repandum*
- Puffball, *Lycoperdon*, and close allies
- Giant puffball, *Calvatia gigantea*
- Parasol, *Macrolepiota procera*
- Inkcap, *Coprinus comatus*
- Wood blewit, *Lepista nuda*

A number of commercial wild fungi traders exist in the UK, but though there are around 12-15,000 species of fungi recorded in the UK only a few are collected for their marketable value. Commercial species include the cep, *Boletus edulis*, chanterelle, giant puffball and morel, *Morchella esculenta*. However, there is limited information on the true extent of commercial collecting in UK woods. In 2006, a business trading in Scottish-sourced wild plants and fungi was reported as exporting 4-12 tonnes of chanterelles annually[5] and another was collecting over 50 tonnes a year[6].

Common puffball, *Lycoperdon perlatum*

Rufous milkcap, *Lactarius rufus*

Alarm bells ringing

Concern over the sustainability of foraging resulted in attempts to produce guidelines for collecting wild fungi such, as the Scottish Wild Mushroom Code and The Wild Mushroom Pickers' Code of Conduct. These emphasise the need to minimise the potential impact on fungal populations through advice such as only collecting what you intend to use and collecting from plentiful populations. A number of organisations are currently working on issuing new codes and guidance on the sustainability of collecting wild foods.

Protecting what we have

Fungi have some protection through the Wildlife and Countryside Act (1981), where it is an offence to intentionally remove any species from the land on which it is growing without permission from the landowner or occupier. Several species, listed on Schedule 8, have additional legal protection against picking, uprooting, damage and sale. The Theft Acts for England, Wales and Northern Ireland specifically mention fungi, where their collection without landowner permission would not be considered theft unless picked 'for reward or for sale or other commercial purpose'. Under Scottish Common Law gathering without landowner permission for whatever purpose is theft.

Individual sites may also have a local bylaws prohibiting foraging. These can be passed for example by statutory bodies and local councils. In practice, prosecutions such as the 20 widely reported in 2013-14 for illegal collecting in Epping Forest were successfully bought under the local bylaw. A failed prosecution by the Forestry Commission against a collector in 2006 in the New Forest was brought under the Theft Act rather than the legislation enacted for wildlife protection[7].

Managing sustainable collecting

Different landowners and managers have different approaches to managing collecting. For example, at Burnham Beeches fungi picking is prohibited and scientific collection limited by licences. In Epping Forest, after a failed licence trial, no collection is allowed. Both these directives are backed by bylaws enacted by the City of London Corporation. A similar bylaw, passed under the National Trust Act (1907), prevents the unauthorised collection of fungi on National Trust property.

A different approach is taken by the Forestry Commission in England, which allows personal but not commercial picking and relies on existing legislation and signposting areas where visitors should not collect. The New Forest is one such site where this applies. On Sites of Special Scientific Interest collection may be prohibited without permission from the relevant country government agency[7].

Access rights, such as those granted under the Countryside Right of Way, do not confer collection rights for either personal or commercial purposes. However fungi are not specifically covered. The Scottish Access Code excludes access rights for commercial picking of fungi.

Stolen fungi confiscated at Epping Forest

Maintaining future harvests

For many people, gathering is a way of connecting to the natural environment and a motivation for spending time outdoors[4]. A review of studies on protected area management around the world indicates positive social and conservation outcomes were more apparent in areas where sustainable resource use was promoted, where appropriate, rather than enforcing stricter protection[8]. Whether this approach would work for fungi or wild food gathering in the UK would require further debate, although the sustainable use of plants and fungi is an objective highlighted in the strategy for the conservation of the UK's fungi 2008-15 produced by The Fungus Conservation Forum[9].

Fungi are under threat as a result of habitat loss, pollution and nutrient enrichment[10]. An evaluation of national Red Data Lists from across Europe indicates somewhere between 2000–3000 species of macrofungi are in decline[11]. However, there is still a lack of knowledge and understanding surrounding their lifestyles and requirements. While foraging can play a positive role in inspiring and connecting people with nature, it must be managed properly in order to ensure sustainable populations of fungi that continue to perform all the functions for which they are so important.

Hedgehog fungus, *Hydnum repandum*

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Wood Wise

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