CIEEM
in practice
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What's that Fungus? A Guide to Finding and Identifying Fungi

Waxcap Grasslands: The Forgotten Treasure

Using Bryophytes as Indicator Species in Habitat Surveys

Know Thy *Sphagnum*: Lessons for Understanding Bogs

Bryophytes, Lichens and Fungi

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Editorial

Welcome

This is an unusual edition of *In Practice* in that it is focused on a specific group of organisms. Not only that, but it is concerned with a group that are unusual and often overlooked: the bryophytes (mosses, liverworts and hornworts), fungi and lichens. These are sometimes referred to as 'lower plants'. That's not because they are small and often found growing on the ground, but because they were some of the first organisms to colonise land. Often grouped together, they are not actually closely related and their ecological requirements can be quite different. What they have in common is that they are frequently overlooked in ecological surveys and assessments, such as the waxcap grasslands described by Anderson and Barden (page 32). This is unfortunate as Ireland and Britain support some unique communities of these species, including globally important populations of oceanic bryophytes in Atlantic 'temperate rainforest' on the west coasts of Ireland, Scotland and Wales. Both recognition and conservation action are required to preserve and enhance these valuable components of our native ecosystems.

Many of these communities are under threat from factors such as climate change and land-use changes. Climate change can impact species in all of these groups as many are dependent upon specific local microclimatic conditions. Some species will increase their range in response to a changing climate (see Pakeman *et al.*, page 27) but this is not possible for species that are already at the edge of their range, such as specialist montane bryophyte communities found in late-lying Scottish snowbeds.

However, it is habitat loss from land-use change that is currently the main driver of species change in these three groups. Grazing was found to be the most dominant pressure on bryophyte and lichen communities in Scotland's 'rainforest zone' (Simpson 2022). Overgrazing can lead to a loss of woodland and heathland and an increase in grassland, particularly in the uplands. For species sensitive to local humidity, this can increase the potential impacts of climate change. There are 'hyperoceanic' bryophytes in Ireland which are found only on north-east-facing slopes of mountains in the very west, where there are more than 220 wet days per year (Hodd and Sheehy Skeffington 2011). Historic overgrazing has reduced the cover and height of the heathland in which these species grow, changing the local microclimate and reducing humidity. This makes these globally important bryophyte populations more susceptible to changing climatic conditions (Hodd and Sheehy Skeffington 2011).

Overgrazing can also facilitate invasion of woodlands by non-native species, which further impacts native species regeneration and can reduce light availability. This affects bryophytes and lichens differently as many woodland bryophytes are tolerant of low light conditions and some rare species can actually thrive in dark, humid, impenetrable thickets of rhododendron scrub (see Hodd, page 42). This could create a dilemma for ecologists as rhododendron prevents native tree species from regenerating and is a hostile environment for light-loving lichen species. Lichens are impacted by undergrazing to a greater extent than bryophytes, as they tend to be more light-demanding and are easily lost from grassland, heathland and woodland when the vegetation becomes tall and shady.

Bryophytes, fungi and lichens are also very sensitive to the effects of elevated nutrients on habitats. As they are small they are easily outcompeted, for instance by tall grass species in fertilised grassland. But there is also the direct impact of high levels of nutrients such as ammonia and nitrates, which can lead to bleaching and browning of bryophytes and lichens in woodlands and on bogs. The sensitivity of these species to changes in climate, land use, grazing, drainage and nutrient levels makes them useful indicator species, which is explored in articles by Denyer (page 21), Massey (page 18), Pakeman *et al*. and Smith (page 14).

Many of the impacts described here are either reversible or can be ameliorated by correct policy and habitat management and restoration. But first we need to increase our knowledge and appreciation of these diverse and important species groups. As a bryologist myself I will be re-reading the articles by Anderson and Barden, Cooch *et al*. (page 38) and Orr (page 8) to improve my fungi knowledge. Hopefully the articles in this dedicated issue of *In Practice* will contribute to your learning in this area too.

Joanne Denyer MCIEEM

Acknowledgements

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Cover photo: Sporophytes of the genus *Bryum*, a genus of mosses in the family Bryaceae. Photo credit: Dave Genney.

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CIEEM News

Recent webinars

We continue to run a full and varied series of webinars for members and the sector. Readers may be interested in the below recent webinars that are available on the CIEEM Resource Hub.

- ENDS 100 Power List Discussion Panel
- Early Careers Webinar: Top tips on applying for a job in the sector
- Defra's Nature Green Paper and Environmental Targets
- Becoming a Chartered Ecologist
- An Overview of CIEEM's CPD Tool, MyCareerPath

Past webinars are available in the CIEEM Resource Hub (https://cieem.net/i-am/resources-hub/). Also look out for future webinars in events and training listing on the website (https://events.cieem.net/Events/Event-Listing.aspx).

Recent blog posts

Recent blog posts on the CIEEM website (https://cieem.net/news/) include:

- Conservation detection dogs: searching for best practice – by Louise Wilson and Angela Winstanley
- Floodplain meadows: the sustainable and productive choice for landscape scale lowland floodplain restoration – by Emma Rothero, Catriona Bass and Sarah Wells
- *Sphagnum*: An Ecosystem Engineer – by Penny Anderson CEcol FCIEEM(rtd)
- Let's Celebrate Volunteers: A Word from the CIEEM President
- Let's Celebrate Volunteers: Members Groups
- Let's Celebrate Volunteers: Professional Development Team
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- Economics for Ecologists – Knowing your ESG from your GCN – by Morgan Taylor CEnv MCIEEM
- We Are At The Crossroads of the Climate Emergency; It Is Now or Never to Keep 1.5°C Alive – Blog
- Key Actions to Tackle the Climate Emergency and Biodiversity Crisis: Everyone Can Make a Difference – by John Box
- The Disappointing Environmental Credentials of the Next UK Prime Minister – by Jason Reeves

If you would like to contribute your own blog, please contact SophieLowe@cieem.net.

Staff changes

In July, **Will Filmore** joined the team as Finance Officer. And in August we welcomed **Dannii Mathews** as Professional Standards Administrator and **Lea Nightingale** as Equality, Diversity and Inclusion Engagement Officer. **Alison Wells** starts on 1 September as Membership and Marketing Administrator.

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Date	Title	Location
23–24 November	2022 Autumn Conference: Delivering a Nature Positive, Carbon Negative Future	Edinburgh

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Edition	Theme	Article submission deadline
December 22	Non-themed (submissions welcome on any topic)	n/a
March 23	Rewilding, Habitat Restoration & Species Reintroductions	18 November 22
June 23	Invertebrates	17 February 23
September 23	Diversity, Accessibility & Capacity in the Sector	19 May 23
December 23	Non-themed (submissions welcome on any topic)	18 August 23

If you would like to contribute to one of these issues, please contact the Editor at nikprowse@cieem.net. Contributions are welcomed from both members and non-members. Further information and guidance for authors can also be found at: https://cieem.net/in-practice/

Did You See?

Survey of local authorities highlights lack of capacity to deliver Biodiversity Net Gain

A study commissioned by Defra shows the levels of resource, capacity and expertise in English local authorities cannot deal with existing planning workload, let alone any increase required for additional work on Biodiversity Net Gain (BNG). Only 5% of respondents said their current ecological resource is adequate to scrutinise all applications affecting biodiversity, while fewer than 10% reported that their current expertise and resources will be adequate to deliver BNG.

https://cieem.net/survey-of-local-authorities-highlights-lack-of-capacity-to-deliver-biodiversity-net-gain/

'Business for Biodiversity' platform launched in Ireland

Irish Government is encouraging businesses to sign up to Business for Biodiversity, a new platform to guide action on the biodiversity crisis. The platform will help businesses to measure, design and demonstrate their biodiversity impact, drawing on a network of expertise led by Natural Capital Ireland, the National Biodiversity Data Centre and Business in the Community Ireland.

https://www.gov.ie/en/press-release/4510f-new-business-for-biodiversity-platform-will-help-businesses-to-take-strategic-action-for-biodiversity/

Five highly protected marine areas planned for English waters

Five highly protected marine areas (HPMAs) could be created by the government to ban all fishing and rewild the sea. The designations are proposed for the coast of Lindisfarne in Northumberland and at Allonby Bay, Cumbria, and at three offshore sites, two in the North Sea and one at Dolphin Head in the English Channel. The sites are expected to lead to full HPMA status for some or all of the English sites in 2023 following a consultation.

https://www.theguardian.com/environment/2022/jun/20/five-highly-protected-marine-areas-set-up-in-english-waters-fishing-ban

Interim Environmental Protection Assessor for Wales issues first annual report | Asesydd Interim Diogelu'r Amgylchedd Cymru: Adroddiad Blynyddol

Dr Nerys Llewelyn Jones was appointed as the Interim Environmental Protection Assessor for Wales in March 2021 to consider concerns raised by the public about the functioning of environmental law in Wales. This is the first annual report on the submissions received and any action that has been taken in relation to them.

https://gov.wales/interim-environmental-protection-assessor-wales-annual-report-2021-22

https://llyw.cymru/asesydd-interim-diogelur-amgylchedd-cymru-adroddiad-blynyddol-2021-22?_ga=2.10786674.791575674.1656679190304361932.1645736813

Venue and date confirmed for biodiversity COP15

The Convention on Biological Diversity (CBD) has confirmed that the COP15 meeting – at which a new Global Biodiversity Framework (GBF) will be agreed – will take place in in Montreal, Canada from 7–19 December 2022.

https://cieem.net/venue-and-date-confirmed-for-biodiversity-cop15/

Scottish Government launches draft Biodiversity Strategy

Scottish Government has published a draft Biodiversity Strategy, setting a new goal to end biodiversity loss by 2030 and restore biodiversity by 2045. The high-level document sets out series of outcomes for both 2030 and 2045 in six areas, including: Farmland, Woodlands and Forestry, Soils and Uplands; Marine Environment; Freshwater Environment; Coastal Environments; Urban Environments, and Overall Health, Resilience and Connectivity.

https://cieem.net/scottish-government-launches-draft-new-scottish-biodiversity-strategy/

EU Nature Restoration Law: A boost for biodiversity and climate

The European Commission has proposed a new nature restoration law with binding targets on pollinators, wetlands, rivers, forests, marine ecosystems, urban areas and peatlands. The new law aims to bring nature back across the continent for the benefit of biodiversity, climate and people.

https://www.iucn.org/news/europe/202206/eu-nature-restoration-law-a-boost-biodiversity-and-climate

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Feature

What's that Fungus? An Introduction to Finding and Identifying Fungi

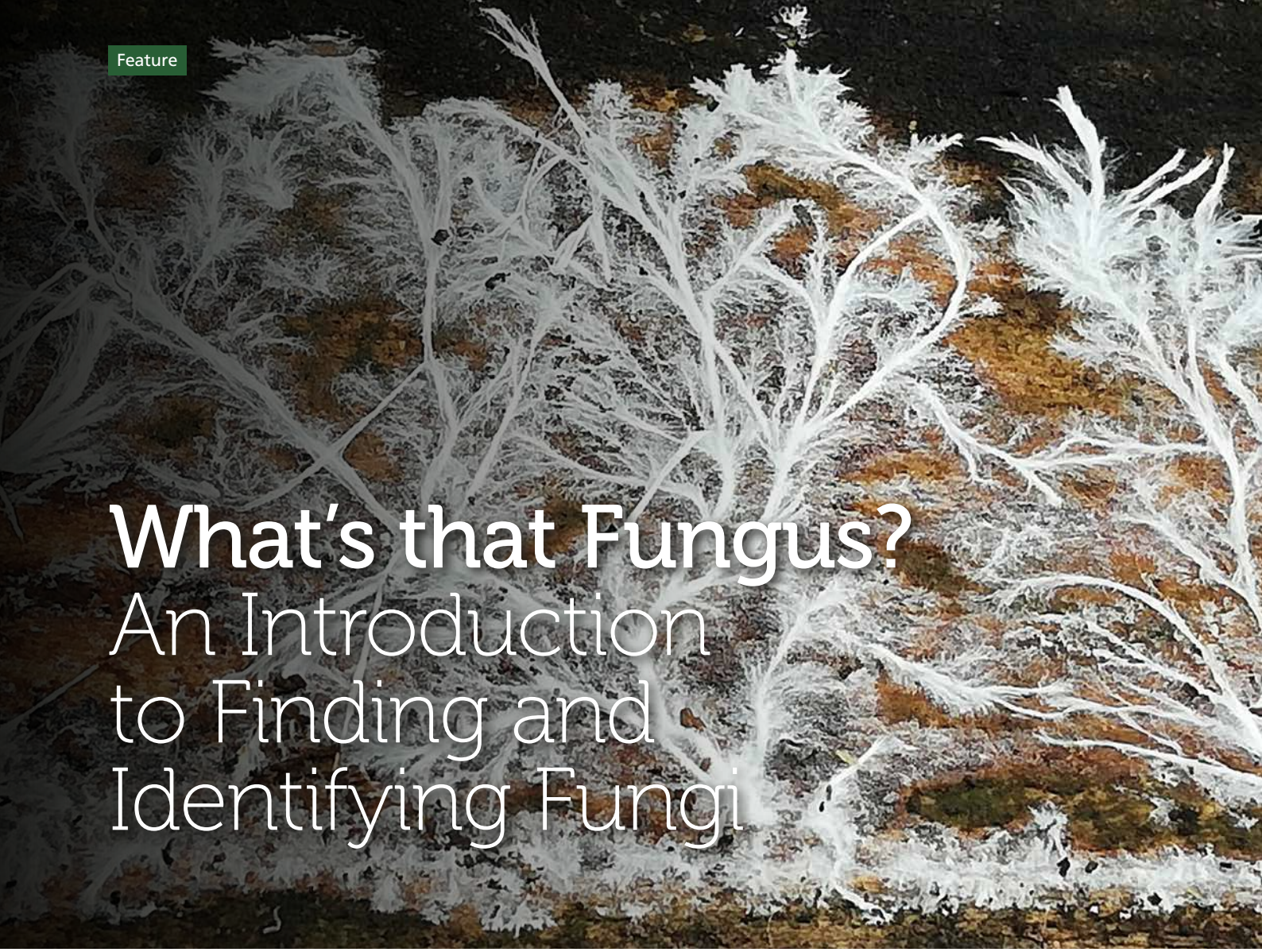

Figure 1. A mycelial network on damp wood.

Nathan Orr
Tetra Tech

Keywords: cap, mycelium, mycorrhizal, parasite, pore surface, saprotroph, spore, stipe

When setting out to identify a fungus and to incorporate its presence into the biological assessment of a site, it is important to understand the multiple roles that fungi play. This branch of life has been under-represented because it is often unseen. Only given their own branch on the tree of life in the 1960s, and with no specific degree-level courses in mycology offered by any UK university, fungi are truly the 'forgotten kingdom'. In this article I will introduce you to the roles that fungi play in our environment and the methodology used in their identification. I hope to inspire you to take a closer look and take note of fungal diversity.

Introduction

Studies have shown that fungi were one of the earliest life forms to move onto land and that they were towering over the early plants, growing several metres tall, over 420 million years ago (Brahic 2007). It is now more generally accepted that they formed, and continue to form, a critical role in ecosystem formation, maintenance and function. Their ability to crack rock and break down dead material to increase nutrient supply, especially in poor soils where plants would not survive, was crucial for the colonisation of land. The fungal network associated with plant roots gives plants the ability to gather resources that would otherwise be inaccessible, and from a wide area. This relationship and their abilities to process dead and often toxic materials may offer hope for the remediation of contaminated landscapes in future. The

adaptations of fungi helped shape the planet, with its vast diversity of habitats, and fungi play essential roles in most of them. However, despite this, they are often overlooked even in ecology.

But what is a fungus? Even though only 120,000 species of fungi have been identified, it is estimated there are somewhere between 2 to 4 million species in total (Hawksworth and Lücking 2017). There are three major groups:

1. single-celled microscopic yeasts, the co-creators of bread and alcohol
2. multicellular filamentous moulds, the providers of penicillin
3. macroscopic filamentous fungi, which create the reproductive organs that we call mushrooms or toadstools (I believe that, traditionally, edible fungi are called mushrooms and inedible or poisonous ones are called toadstools).

Macroscopic filamentous fungi are made up of tiny strands called hyphae. They weave and burrow through their chosen substrate, forming interconnecting, immensely complex webs called mycelia (Figure 1). In an ancient woodland, a teaspoon full of soil can contain 100 million hyphae or more, which form a significant portion of the soil mass (Stamets 2005). This group is the focus here, as they are the type of fungus we are most likely to encounter as ecologists and they can be more easily used as indicators of biodiversity in a habitat.

Fungus identification: where do you start?

When beginning to assess the fungi in a habitat the first step is finding them. The most prolific time of year for fungi is the autumn, from September to November, but you will find them at all times of the year if you know where to look. Some fungi are brightly coloured, big and showy, but the majority are small, unassuming and grow in out-of-the-way corners. Fungi are capable of constructing and inflating their fruiting bodies very quickly, but need water to do so, so looking a day or two after rain is also a good way to increase your chances of finding fruiting bodies. A notebook, camera or mobile phone (I use a phone as the macro-photographic capability on many phones is amazing) and sample pots are essential for fungal identification. There are also chemical reagents that can help identification: potassium hydroxide solution and Melzer's reagent cause colour changes in certain fungi. As with all chemical reagents they should be used with caution and following the correct guidance and training.

The last thing on the list for field identification is a reference guide. A good fungi book is a great starting point, but online sources have more flexibility to keep up with the changes in taxonomic information. My first fungi book was *Mushrooms* by Roger Phillips (2006), which has common names and detailed photos, although the classification is now out of date. I use Geoffrey Kibby's *Mushrooms and Toadstools* volumes 1–3 (Kibby 2017, 2020, 2021) but this does not use common names which makes it less accessible when you are starting out. Online resources are able to keep up with the rapid changes in fungal classification and are covered at the end of this article.

Location, location, location

Once out in the field it is good to know where to start to look and the roles of fungi in different environments. Fungi can occur in a range of habitats from grasslands to woodlands and gardens, and checking tree stumps, log piles, dead wood (on the ground or still attached), animal scat and dead plant material can lead you to the saprotrophs ('the rotters'), which make the nutrients in dead or decaying material available to other organisms (Figure 2).

The mycorrhizal species are those that form a relationship with the roots of plants and exchange nutrients and water for the complex hydrocarbons that plants produce through photosynthesis. There are four UK tree genera or species that you should look for first as they have a range of fungal partners, so increasing your chance of finding mycorrhizal fungi: these are English oak (*Quercus robor*), beech (*Fagus sylvatica*), birch (*Betula* spp.) and pine (*Pinus* spp). Beneath any of these is a good place to start your search. But don't stop looking beneath other trees

Figure 2. The saprotrophic velvet shank, *Flammulina velutipes*.

Figure 3. Fly agaric (*Amanita muscaria*), a mychorhizal fungus that grows with a number of tree species. I find it most often with birch and pine and the species has one of the most iconic mushrooms.

Figure 4. Scarlet caterpillar club (*Cordyceps militaris*), a parasitic fungus whose host is an insect larva, in this case probably the larvae of a crane fly (*Tipula* spp.). This was found in my own garden; toothpick shown for scale.

"The first step is finding the fungi. The most prolific time of year is the autumn, from September to November, but you will find them at all times of the year if you know where to look."

or shrubs, as you never know what you will find. Over 90% of all plants rely on a relationship with fungi in their roots (Feijen *et al.* 2018) (Figure 3).

The final role that a fungus can play is as a parasite. It is harder to predict where a parasite will crop up, but you may well have encountered some, like honey fungus, *Amarilla* spp., before. There are parasitic fungi for plants, other fungi and even animals, particularly the arthropods. Some parasitic fungi of insects can control or hijack a host, forcing it to move to a place where the fungal spores will better infect the next generation of insects. *Entomophthora muscae* may be in your home already as it is a fungus that infects housefly species. Another example of a fungus that parasitises insects is shown in Figure 4.

Identification features

Field identification of fungi is not a simple task and, in fact, definitive species identification in the field is not possible for many. Fungi and their fruiting bodies are diverse to say the least and can be very variable, even within a species. For example, one species, *Laccaria laccata,* has the common name of the deceiver as its appearance between individual specimens varies so significantly. There are certain species that are very identifiable by their shape or colour, but most will need microscopic analysis of their spores and the mechanisms that deliver the spores. Many of fungal identification guides, including the Kibby and Phillips guides mentioned above, show spore size, shape and colour. Websites, like first-nature.com, supply images of the spores and identifying structures that you can reference. However, there are some fungi that can only be distinguished to species level through DNA analysis. I have tried to give you a few starting points to help identification, but practice and experience are key (it has taken me 8 years to gather the knowledge I have now).

Cap

Once you have found a fungus the first thing to look at is the cap. The shape, colouration, texture and markings can be distinctive. Caps can be viscid (slimy), rough and hairy, smooth, waxy, ribbed or felt-like. They may be flattened, bell-shaped, funnel-shaped or rolled over at the rims. These descriptions aren't exhaustive: there are lots of variations. Cap features will help to narrow your search and can be indicative of a particular fungal family or genus (Figure 5).

Figure 5. Examples of cap variation. (a) Pleated inkcap (*Parasola plicatis*) has a ribbed cap. (b) Weeping widow (*Lacrymaria lacrymabunda*) is almost furry and weeps a blue liquid when damaged. (c) Rosey bonnet (*Mycena rosea*) has a distinctive bonnet shape.

"The first thing to look at is the cap. Shape, colouration, texture and markings can be distinctive. Cap features will help narrow your search and can be indicative of family or genus."

Spore-producing surface

One of the most important things to look at in fungi is the spore-producing surface. Basidiomycetes, the spore droppers, use gills, spines or tube-like features on the pore surface to drop their spores. Ascomycetes, the spore shooters, in contrast, form their spores in a sack-like ascus which ejects the spores (Phillips 2006). With gilled fungi, the spacing of the gills, their thickness and the colouration are all important indicators. How the spore surface attaches to the stipe (or stem; see below) can provide one way to ascertain the family. For example, the funnel caps tend to have gills that run down onto the stipe and the gills of *Amanita* spp. are 'free', which means they do not attach to the stipe. Spore surfaces may have other characteristics: one of the identifying features of the *Russula* or brittlegills, is that if you rub the gills they break and look like almond flakes. Another group, the *Lactarius* or milkcaps, can bleed a latex-like liquid when damaged. The *Cortinarius* or webcaps can be distinguished from other genera by the fact that as their cap expands a filamentous web can often be found from the edge of the cap to the stipe. Other mushrooms use pore tubes to deliver their spores: when you turn the cap it looks like a velvet cushion with tiny holes all over. Pore surfaces can be brightly coloured, and some species show a colour change when damaged. Some even turn blue! The Ascomycetes are often cup-shaped or, due to their method of sporulation, have crazily contoured surfaces and can send out a cloud of spores if blown on (Figure 6).

Stipe

The stipe, or stem, of a fungus can help you in the process of identification. What is its texture? Colouration? Thickness? Is it brittle? Is it hollow?

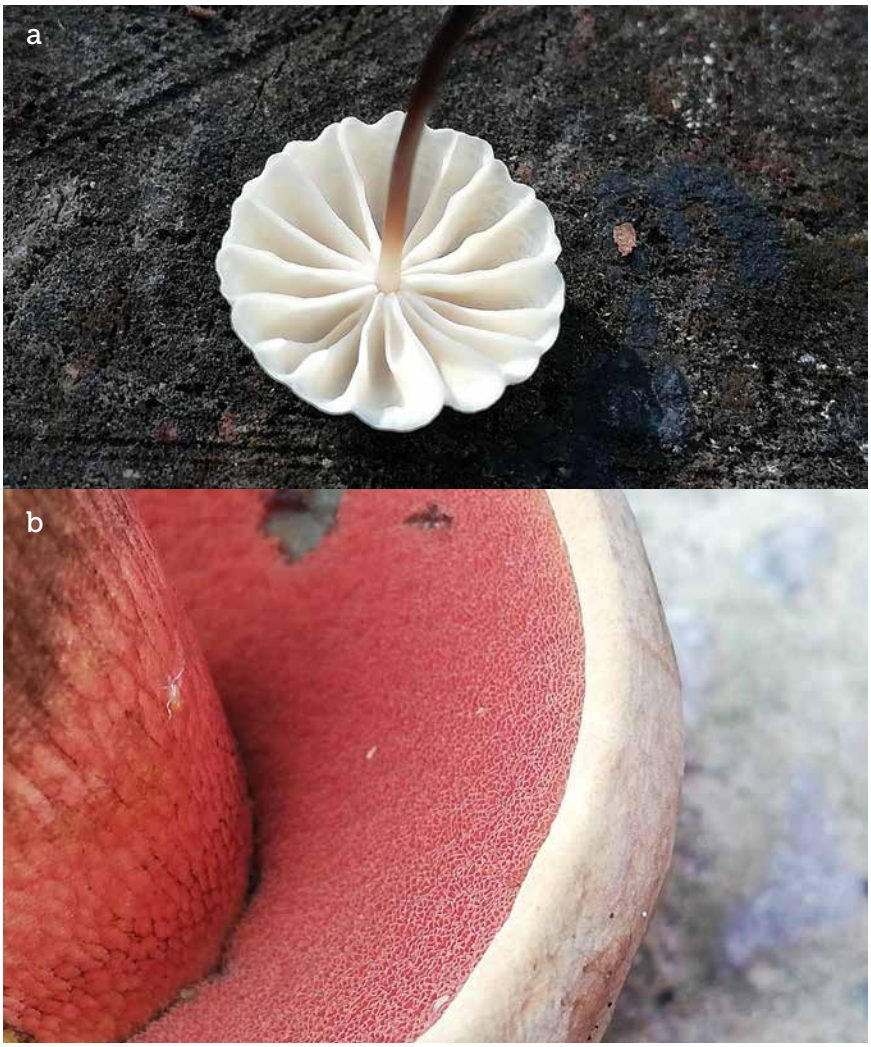

Figure 6. Examples of spore surfaces. (a) *Marasmius* spp., with its wide, simple gills. (b) *Bolete* spp., with a bright pore surface.

Figure 7. When the cap of the fly agaric (*A. muscaria*) bursts through the universal veil it forms the 'spots' and the 'skirt'.

Does it have any marks or ribbing? Is it bulbous at the bottom or even missing entirely? Is there evidence of the universal veil? The universal veil is the egg-like structure that *Amanita*, stinkhorns (*Phallus impudicus*), and other species grow from (Figure 7).

Dissection

Cutting a fungus in half, both the cap and stipe, can often provide more data for your identification. It may be hollow, brittle or thickly fleshed. Cutting may also stimulate a colour change, or the production of latex.

Sniff test

After you have conducted your visual checks it's time to use your other senses. Give the fungus a good old sniff! Many fungi have a distinctive smell that can be indicative of species. Some smell of ammonia, bleach or almonds, some can smell mealy or just plain mushroomy. If you find a stinkhorn or its relatives, I advise you to not breathe too deeply as their common name is well deserved; they smell of rotting flesh to attract flies to spread their spores! It is not dangerous to smell fungi but always wash your hands after handling them; the reasons for this discussed below.

Setting and collection

Finally, look at the environment where you found your fungus. What is it growing from? Is it from dead material or from the ground? What plants, not just trees, but shrubs, herbs and even mosses, are present? One of the key indicators of potential waxcap grassland is its moss content, so what may appear to be a flower-poor, grazed or cut grassland in August is actually much more than that in October when the mushrooms appear.

After all the field observations are recorded there is another simple check that can be undertaken. Collect a sample mushroom and, when you get home, place the pore surface of of the mushroom's cap down on a piece of paper, or onto a microscope slide if you have one. Place a cup or pot over it to stop draughts and leave it overnight. Any dropping spores will be deposited on the paper. They could be white, black, brown, pink or any shade in between and this colouration can help identify the genus of the fungus if not

> **The online community is one of the greatest tools for identifying fungi. There are many great mycology groups out there, full of enthusiasts and experts who can point you in the right direction.**

its species. Most identification guides and websites provide information on spore and print colouration as it is a key identifying feature.

Collection of fungi is necessary for identification purposes, but I always err on the side of caution when picking samples to minimise the impact. I pick samples when there is more than one fruiting body and I try to take only one sample of each species. Although you are not harming the fungus, and the mushroom is only a reproductive fruiting body, I feel we should all manage our impact on the environment and remove as little as possible from the habitats we study. There are also species that are listed on the Red Data list, compiled by the British Mycology Society and found on their website (for the address see the next section), such as *Cortinarius saginus*, a fungus that is coloured blood red, and these should not be picked. This list of over 800 threatened fungi has yet to be included as an official IUCN Red List as it is still under development. For these reasons, I feel that photography and field records are critical and that sample taking should be managed sensibly, although this is a personal preference.

There are also issues with toxicity in fungi, but there are no fungi that are dangerous to touch in the UK. I don't wear gloves to handle samples; it is the ingestion of the mushroom or the toxins they carry that causes illness, pain and even death. Always wash your hands after handling samples, especially before you eat. There are many mushrooms that are dangerous if consumed and I do not recommend that any fungi are eaten if you are even a little unsure of their identification. If you mis-identify a fungus and eat a toxic one, it may result in death or at best make you severely unwell. I do not collect wild mushrooms for food for this very reason. There is also a species that is illegal to possess as it is a class A drug, the liberty cap, or 'magic mushroom' (*Psilocybe semilanceata*), so avoid picking this one! Please remember to store any fungal specimen safely and keep away from children and pets.

Online resources

Once you have collated the information on your fungal assemblage it's time to hit the books or use one of the greatest tools for identification of fungi: the online community. There are many great mycology groups out there, full of enthusiasts and experts who can help point you in the right direction.

I use www.first-nature.com to check my species identification and often visit the website (www.britmycolsoc.org.uk/) and the Facebook group of the British Mycology Society, who also organise local events. The Coal Spoil Fungi Community Page and Mushroom Identification Forum (UK) on Facebook are amazing resources through which you can gain expert input.

Look at @ukfungusday for content and great articles from people like Professor Lynne Boddy of Cardiff University. There are some great mycologists online, including Paul Stamets (@paulstamets), whose TED talks are worth checking out. @fascinatedbyfungi provides insight and an infectious enthusiasm for the subject.

Conclusion

I hope I have stimulated an interest in looking a little closer and into taking more notice of the fungi that form such an important and interconnecting role in our environment. From the micro to the macro, fungi are everywhere! There is still so much more to discover and to talk about with fungi, like waxcap meadows, fungal relationships with gastropods or insects, fungal invasive species and much more, but that will have to wait for a future opportunity.

Photo credits

All photographs show species from the UK and were taken by the author on a mobile phone camera.

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Feature

Know Thy *Sphagnum*: Species-specific Lessons for Understanding Bogs

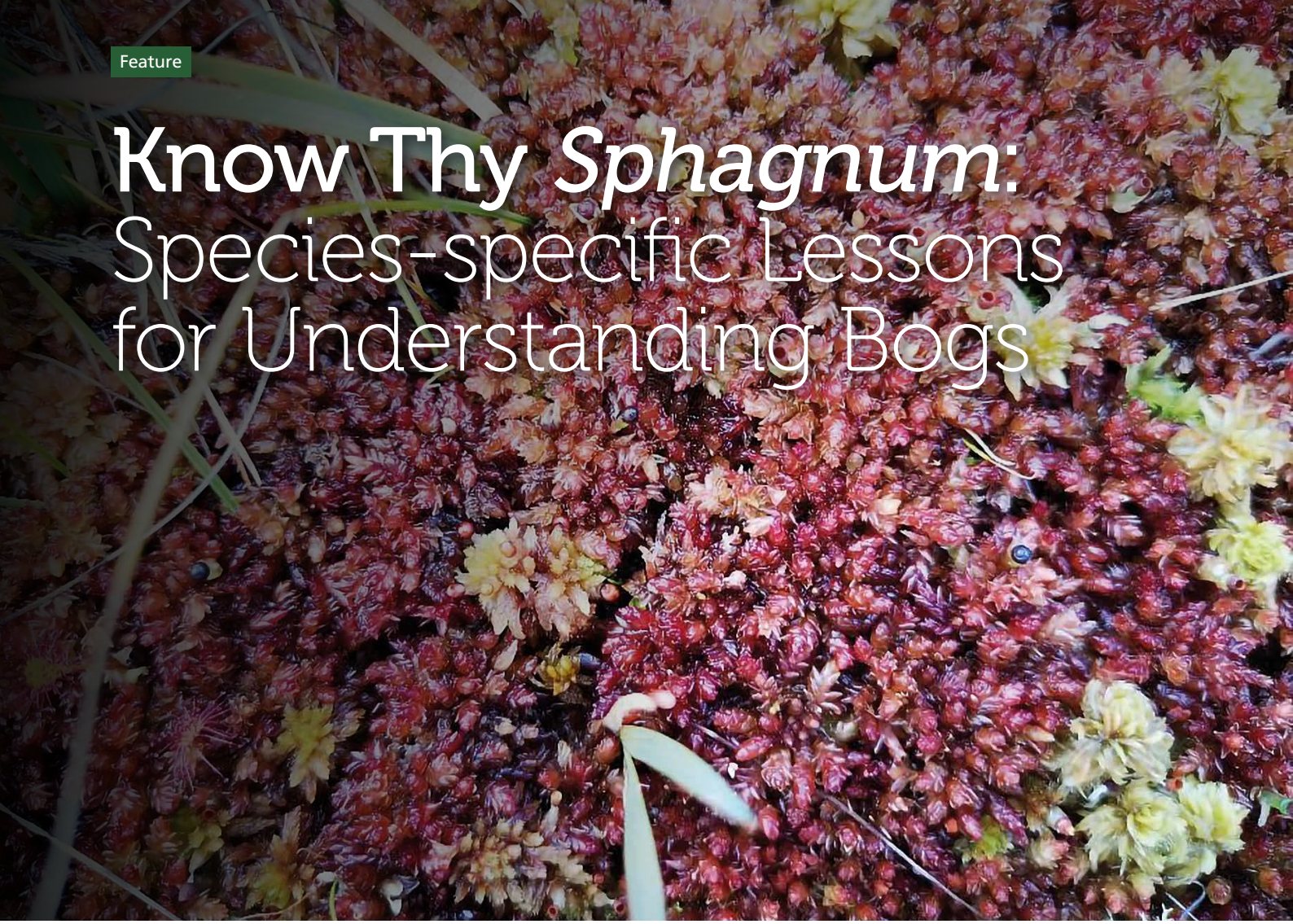

Figure 1. *Sphagnum medium*. Photo credit: George Smith.

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Keywords: bryophytes, indicators, peatlands, restoration, flush, cutover

Sphagnum species are the most important group of plants in Irish and British bogs. Because they have a reputation for being difficult to identify to species level, they are often lumped together in assessments. With some practice, however, most can be confidently identified in the field. Here, I provide some pointers on distinguishing the main bog Sphagna and how different species can be used to assess conservation condition, hydrology and restoration potential of near-intact bogs and bogs that have been damaged by peat extraction or other disturbances.

Introduction

Let's be honest. When we're surveying and assessing bogs, how many of us look at the carpets of greeny-browny-red moss and just jot down a few notes on the cover of "*Sphagnum* spp."? Would we do the same and lump together other groups of plants, like sedges or grasses, in our survey work and expect that was enough to evaluate the conservation value or condition of a habitat? Of course not. Like other groups of plants, *Sphagnum* species have their own individual habitat preferences and functions within the ecosystem. Since *Sphagnum* mosses are the creators and powerhouses of the bog, understanding the characteristics of individual species can provide considerable information. The species present can tell us about the conservation value of the bogs where they live and the ecosystem services they provide. This overview of some of the key bog *Sphagnum* species focuses on raised bogs in Ireland and Britain, but much of it will also apply to blanket bogs.

Sphagnum species have a reputation for being difficult to identify. There is some justification for this, but in reality they are no more difficult than many groups of higher plants, such as sedges. Most bog species can be confidently identified in the field with practice, and there are a number of excellent guides that can help. Perhaps the best is the British Bryological Society's *Mosses and Liverworts of Britain and Ireland: a Field Guide* (Atherton *et al.* 2010). There are also some guides that are *Sphagnum*-specific, such as the Field Studies Council key (Godfrey and Rogers 2021) and the older *Sphagnum: a Field Guide* (Hill 1992), the latter of which is available for download on the British Bryological Society website.

Indicators of good condition

The most important question about the conservation condition of a raised bog is whether it is peat-forming or not. Bogs that are actively forming peat correspond to the priority Habitats Directive Annex I habitat active raised bogs [*7110]. Two large, chunky bog Sphagna that are good peat-formers are *Sphagnum papillosum* and *Sphagnum medium* (Figure 1) (these species were formerly part of *Sphagnum magellanicum*; see Blockeel *et al*. (2021) for the most recent changes to the names of *Sphagnum* and other bryophytes). These species are distinguished from all others on the open bog by their size, stubby branches and hooded stem leaves. They are easily separated from each other by the yellow-brown colour of *S. papillosum* and the wine red of *S. medium*. These two species are found in damp hollows, and often form extensive lawns in active raised bog. A healthy cover of *S. papillosum* on cutover bog (an area of bog where peat extraction has removed the upper layers of peat and vegetation) is a good sign it is rewetting either naturally or as a result of restoration work.

Sphagnum rubellum (formerly *S. capillifolium* ssp. *rubellum*; Figure 2) is perhaps the most common *Sphagnum* in Ireland and Britain and is also reported to be a good peat-forming species (Laine *et al.* 2009). It is often the only *Sphagnum* found in the drier parts of bogs, however, and so it isn't always a reliable indicator of good conditions. *S. rubellum* is a small species, usually candy pink, that forms low hummocks. It is often green or mostly green, especially when shaded. This is often a source of frustration, but with experience, even most green forms can be confidently identified from other field characters.

Perhaps the two best indicators of high-quality raised bog habitat are the hummock-forming species *Sphagnum austinii* and *Sphagnum beothuk* (formerly aggregated with *Sphagnum fuscum*). *S. austinii* is usually described as brown, but in reality each shoot is usually a blend of colours from green in the centre to yellow-orange to rosy red. Leaves are tightly pressed to their tapering branches, and the whole hummock is dense and tight as a drum. *S. beothuk* is a delicate, handsome chocolate brown species. These species are quite rare in England and Wales; they remain widespread but uncommon in Ireland and Scotland (Blockeel *et al.* 2014). Healthy and frequent hummocks of these two species is a good sign of a bog in excellent condition. Since their hummock form is ideal for retaining water, however, scattered hummocks can linger for a long time on parts of bogs that are otherwise in poor shape. They can even resist fire when the surrounding bog, including looser-growing *Sphagnum*, has been burnt. *S. austinii* and *S. beothuk* seem to be slow to colonise new habitat. They are quite rare on cutover bog, even when they are present on the adjacent high bog and the cutover is wet, long-abandoned and supports other *Sphagnum* species.

In contrast, the aquatic *Sphagnum cuspidatum* is a rapid coloniser of blocked drains and rewetted bog, including cutover. It is usually easy to identify from its yellow-green colour and very fine branch leaves, which notoriously resemble wet fur when the plant is submerged. Abundant *S. cuspidatum* in bog pools or areas of shallow standing water on restored cutover bog indicates a fairly stable, high water table. It appears to be sensitive to being disturbed and dislodged by the wind, and so may be absent from larger areas of open water with a long fetch.

Indicators of poor condition

Bogs are naturally wet, nutrient-poor ecosystems and can be damaged by a number of activities that change these conditions. Drains in a bog or proximity to steep banks where peat extraction has taken place can lead to drier, degraded conditions. Fire on a bog directly damages vegetation and can change the structure and composition of the upper peat layers. Fire and drainage increase the availability of nutrients through the breakdown and mineralisation of peat. Airborne nitrogen deposition from agricultural and other sources can directly increase the fertility of bogs.

Figure 2. *Sphagnum rubellum*. Photo credit: George Smith.

Figure 3. *Sphagnum subnitens*. Photo credit: George Smith

Drier and more nutrient-rich conditions can lead to changes in the abundances of *Sphagnum* and other moss species. Two species, *Sphagnum tenellum* and *Sphagnum subnitens* (Figure 3), are normally found in small quantities on bogs in good condition. They respond well to disturbance, however, and become more abundant on damaged or stressed bogs. *S. tenellum* is a very small *Sphagnum* that is easily recognised by its size, its bright yellow-orange colour, and spreading leaves at branch tips that resemble a bird's open beak. On good-quality bogs it is usually intermingled with other *Sphagnum* species. On bogs in poor condition, it forms larger patches on degraded peat.

S. subnitens resembles a slightly larger, scruffier version of *S. rubellum* (Figure 2), but its colour is well-lit conditions is salmon pink and the centre of the capitulum (the fuzzy 'head' of young branches at the top of a shoot) is usually green. Although it is naturally found in small amounts on bogs, it prefers more mineral-rich habitats than most bog Sphagna, such as transition mires, wet heaths and peaty hollows in woodlands. *S. subnitens* being more abundant on a bog than usual suggests that nitrogen deposition or other damaging activities have led to an increase in nutrient availability.

Indicators of flushing

Another group of *Sphagnum* species is a valuable indicator of flushed conditions, where flowing water increases availability of nutrients and oxygen in the peat, or other places with slightly elevated nutrients or alkalinity. On near-intact bogs, flushes or soaks can form where surface water runoff is concentrated along a particular flow path. Using *Sphagnum* species to identify flushes can improve our understanding of bog hydrology, which is important for bog restoration efforts. Likewise, the appearance of flush species in a new location can indicate changes in surface water flow caused by subsidence in the parts of a damaged bog that are drying out. On cutover bogs, flushed conditions can also arise along surface water flow paths. They are also found where peat has been cut down to a level where there is some mineral input from groundwater, but where conditions remain acidic and mainly nutrient-poor. In the latter case, the long-term outcome of restoration work may not be active raised bog, but poor fen instead.

Sphagnum fallax, a slender yellow-green to golden species with a typically neat appearance, is characteristic of flushed situations. There are also two similar, closely related but rarer species to be aware of, *Sphagnum angustifolium* and *Sphagnum flexuosum*, that are indicative of more base-rich environments than *S. fallax* prefers.

Sphagnum palustre (Figure 4) is probably the most eye-catching flush species. It is a large species, pale green to yellow-brown with hooded branch leaves. It can resemble *S. papillosum* sometimes, but is usually distinguishable by its longer, more pointed branches and by the darker peach or brownish-red colouration in the centre of the capitulum.

S. palustre is also the most important indicator species for the Habitats Directive Annex I priority habitat bog woodland [*91D0]. Bog woodland in good condition is characterised by deep cushions of *S. palustre* as well as other flush Sphagna, including *S. fallax* and *Sphagnum fimbriatum* (Figure 5). The

Figure 4. *Sphagnum palustre* in bog woodland. Photo credit: George Smith.

Figure 5. *Sphagnum fimbriatum* in bog woodland. Photo credit: George Smith.

latter is particularly characteristic of bog woodland. *S. fimbriatum* at first glance is green and non-descript, but it is easily identified in the field with a closer look at the stem leaves. Pull off the capitulum, and you can see around the stem the broad, erect leaves with a ragged margin that are often described as looking like an Elizabethan ruff.

Sphagnum divinum has recently been separated from *S. medium*. It resembles that species in its large size, hooded stem leaves and wine red colour. It tends to be slightly paler, but its most diagnostic characters are longer branches that taper to a finer point with leaves more closely appressed. Its habitat preferences in Ireland and Britain are still being learned, but it seems to be frequent enough on somewhat flushed cutover bog, at least in the Irish midlands.

The lagg zone of an intact raised bog is the transition zone between the bog and the surrounding mineral soil. Historically, lagg zones comprised a range of fen and other wetland habitats. As a result of peat extraction and reclamation for agriculture, only fragments of lagg zone habitats remain in Ireland or Britain. Carrownagappul Bog and Carrowbehy Bog in County Roscommon in Ireland both support some near-intact lagg zones. In addition to *S. subnitens* discussed above, base-tolerant Sphagna are characteristic of these areas, with *Sphagnum contortum* and *Sphagnum teres* the most frequent. *S. contortum* is usually a biscuit brown to orange-brown colour with curved branches. *S. teres* is unmistakeable when well grown: it is ginger brown with a green-centred capitulum that sports a prominent conical terminal bud. *S. contortum* also occurs on cutover bog where peat extraction has reached down to the groundwater-influenced fen peat layers. Such areas are of conservation interest, and also present an opportunity for lagg zone restoration, which has received little attention thus far in Ireland or Britain. Lagg zones are a rare and valuable ecosystem in and of themselves, but in addition their restoration would benefit the hydrology of the adjoining bog by supporting the maintenance of a high water table (Crowley *et al.* 2022).

And more…

Understanding the ecological preferences of *Sphagnum* species and learning how to identify them can provide valuable insights into the ecology, hydrology and conservation status of bogs. Similarly, knowledge of other bryophyte species can add to our understanding of bogs and other bryophyte-rich habitats. For example, the pale whitish-green *Leucobryum glaucum* forms dense hummocks similar to *Sphagnum austinii*, and it is most abundant in wet, actively peat-forming bogs. Learning to identify *Sphagnum* and other bryophyte species can be daunting at first, but there are several resources available to help, including the *Field Guide* (Atherton *et al.* 2010) mentioned above. The British Bryological Society – both the website (www.britishbryologicalsociety.org.uk) and the members – is a wealth of information, and several local groups hold regular field meetings where beginners are always welcome. Learning from others in the field is the best way of getting to grips with a new group of plants or animals, and bryologists are always eager to make converts.

Acknowledgements

I am grateful to all the British Bryological Society members who generously gave their time to help me better understand *Sphagnum*. Dr Joanne Denyer provided helpful insights into species responses to nitrogen deposition and disturbance.

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About the Author

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Feature

Is Rusty Bog-moss an Indicator of Undisturbed Blanket Bog?

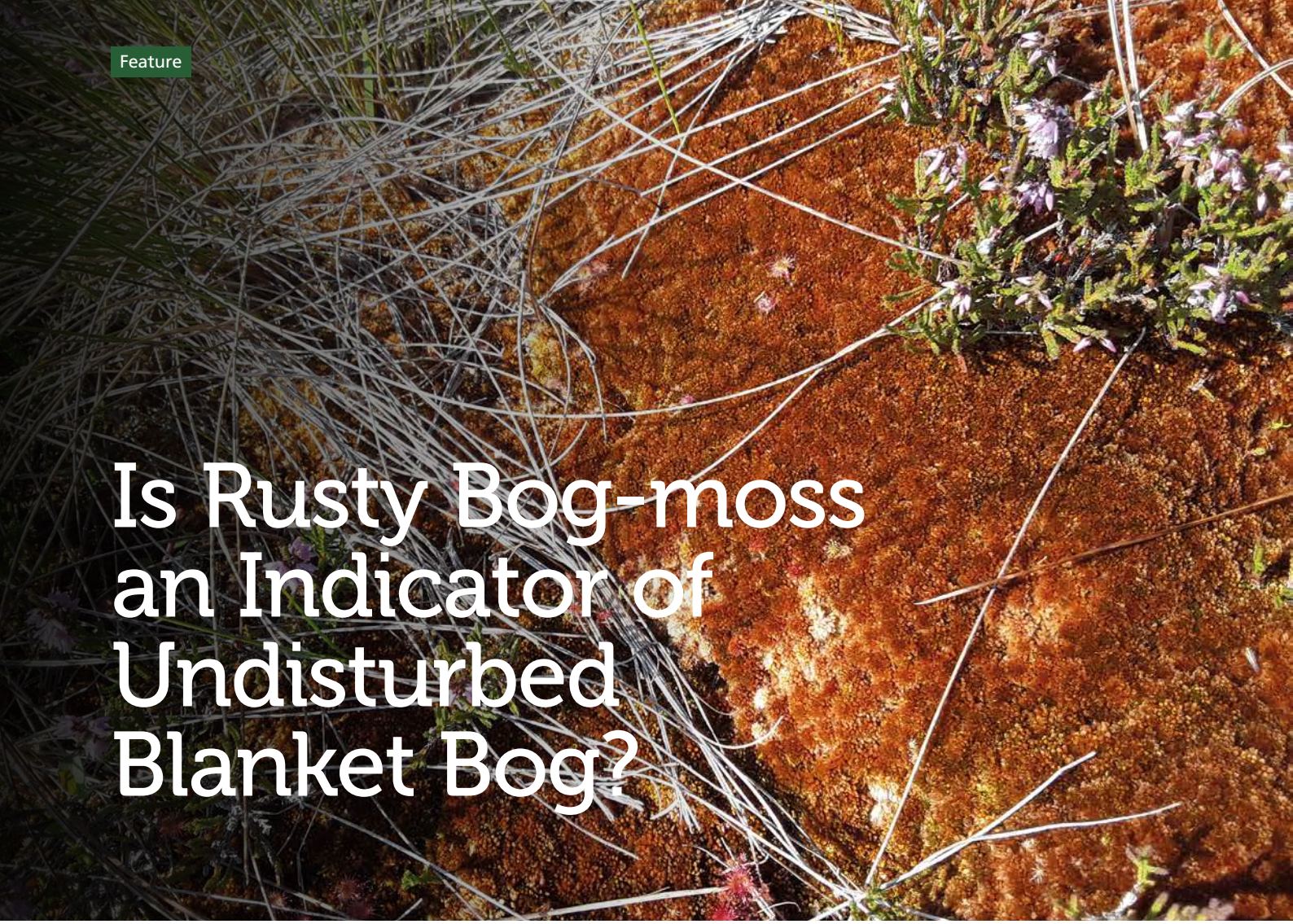

Figure 1. A wet, near-natural bog with a hummock of rusty bog-moss, Scotland 2021. Photo credit: Kate Massey.

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Keywords: blanket bog, indicator species, rusty bog-moss

Rusty bog-moss (*Sphagnum fuscum*) is sometimes used in peatland guidance as a species whose presence indicates near-natural or undisturbed blanket bog. But does its presence alone indicate that the blanket bog is undisturbed or in near-natural condition? This short article describes field situations from upland Scotland which demonstrate that rusty bog-moss is not necessarily an indicator of undisturbed or near-natural blanket bog and is actually found across a spectrum of bog conditions. Rather, its presence in degraded conditions may indicate a relic of former high-quality bog habitat and better indicates a strong potential for blanket bog restoration.

Introduction

Rusty bog-moss (*Sphagnum fuscum*) (and its recently recognised, closely associated dark morph *Sphagnum beothuk*; Hill 2017[1]) is a bog-moss that forms compact, ginger-brown hummocks in upland blanket bogs. The hummocks are conspicuously coloured and prominent within the landscape as they are typically up to 50 cm tall and 75 cm across at the base, although can be much larger (Atherton *et al*. 2010). There are numerous records of rusty bog-moss across the whole of the UK and Ireland on the NBN Atlas, with the highest concentrations in Scotland appearing to be around the Cairngorms and the Flow Country (NBN Atlas, nd). These areas are where most of the rusty bog-moss field observations reported in this short paper have taken place.

The relatively common *S. fuscum* is not on UK species lists (e.g. Scottish Biodiversity List, Biodiversity List – England, Biodiversity List – Wales,

UK Biodiversity Action Plan) and has no legal protection. Nevertheless, this readily identifiable bog-moss has become an important consideration for ecologists and Ecological Impact Assessment (EcIA) practitioners in relation to wind farm applications in Scotland. This is because it has been reported to occur on undisturbed blanket bog and has been used as an indicator of such (e.g. JNCC 1994, Atherton *et al*. 2010, NatureScot 2020, NBN Atlas nd). The blanket bog Site of Special Scientific Interest selection criteria states that rusty bog-moss is a "plant species indicating peat formation capability and/or lack of disturbance" (JNCC 1994). It goes on to report that blanket bogs with hummocks of rusty bog-moss are therefore "near-natural and of high quality" (JNCC 1994). Based on this, the presence of rusty bog-moss has been listed in NatureScot's recent guidance (2020) on development – for example, for wind farms and other renewable energy proposals on peatland habitats – as a potential reason for statutory objection to developments and has been listed as a reason for objections including at public local inquiries.

Thus, currently, and rather unexpectedly, rusty bog-moss now has some bearing in the policy implementation of Scottish renewables development.

Rusty bog-moss in field situations

This situation posits the question: does the presence of rusty bog-moss alone indicate that the blanket bog is in near-natural condition (and so an indicator of undisturbed or high-quality bog) or is reality more nuanced? Without doubt, rusty bog-moss can be found in blanket bogs that are in near-natural condition, often among bog pools and with a variety of bog-moss species also present. Where rusty bog-moss occurs in near-natural conditions it provides a striking visual characteristic across the blanket bog landscape of burnt umber hummocks beside wet hollows (Figure 1). In these instances, the rusty bog-moss hummocks are likely to be in a 'building' phase of hummock formation and an important component of carbon sequestration.

Figure 2. Rusty bog-moss within areas of degraded blanket bog, Scotland 2021. Photo credit: Kate Massey.

During field surveys across upland Scotland rusty bog-moss has been recorded in blanket bog habitats which have clearly been degraded through current and historic management practices such as high grazing pressure, drainage and burning. This often results in erosion features being widespread (e.g. Figure 2). It has been recorded in small pockets of blanket bog vegetation surrounded by extensive habitat degradation. How long rusty bog-moss can survive in these situations is unclear, but it is likely that the degrading management practices of drainage and over-grazing have been occurring for decades, if not centuries. Relic hummocks of rusty bog-moss therefore appear to remain long after the blanket bog has ceased to be in a near-natural condition.

Indeed, sometimes rusty bog-moss has been recorded on the edge of large erosion features in blanket bog modified through a combination of deer grazing pressure and wind/rain erosion (e.g. Figure 3). In these situations, the hummocks are likely to be in a degraded phase rather than the building phase and less important to carbon sequestration. Clearly in these instances rusty bog-moss is not growing within blanket bog with a 'lack of disturbance' or in a 'near-natural' condition. However, it may be more likely to persist in degraded areas with wetter climes, for example those areas with particularly high rainfall or at altitude with high levels of cloud cover.

When considering if a blanket bog is in near-natural condition or has experienced a lack of disturbance the ecological context needs to be considered carefully. For example, are there signs of current and historic management practices that have impacted the bog? Is there a natural surface pattern of hummocks and hollows and waterlogged conditions?

Therefore, the presence of rusty bog-moss only really indicates that a blanket bog has had a lack of disturbance, or is in near-natural conditions, when other indicators are also present, including bog pools, the bog vegetation being wet underfoot, an intact bog surface with a natural surface pattern of hummocks and hollows and a complex of microforms. Where rusty bog-moss is found within a degraded context it is clearly not indicating a lack of disturbance or high-quality near-natural bog. So, what does the presence of rusty bog-moss indicate under these circumstances? It is likely that, in these circumstances, rusty bog-moss is a relic of former high-quality bog and perhaps indicates a strong potential for habitat restoration. This is something to consider exploring under enhancement measures or Biodiversity Net Gain in EcIA.

Conclusion

The conclusion from working on multiple upland sites across Scotland is that a binary present/absent approach, when considering rusty bog-moss, is not appropriate as an indicator of undisturbed blanket bog. Rusty bog-moss is found across a spectrum of conditions, not only in those of

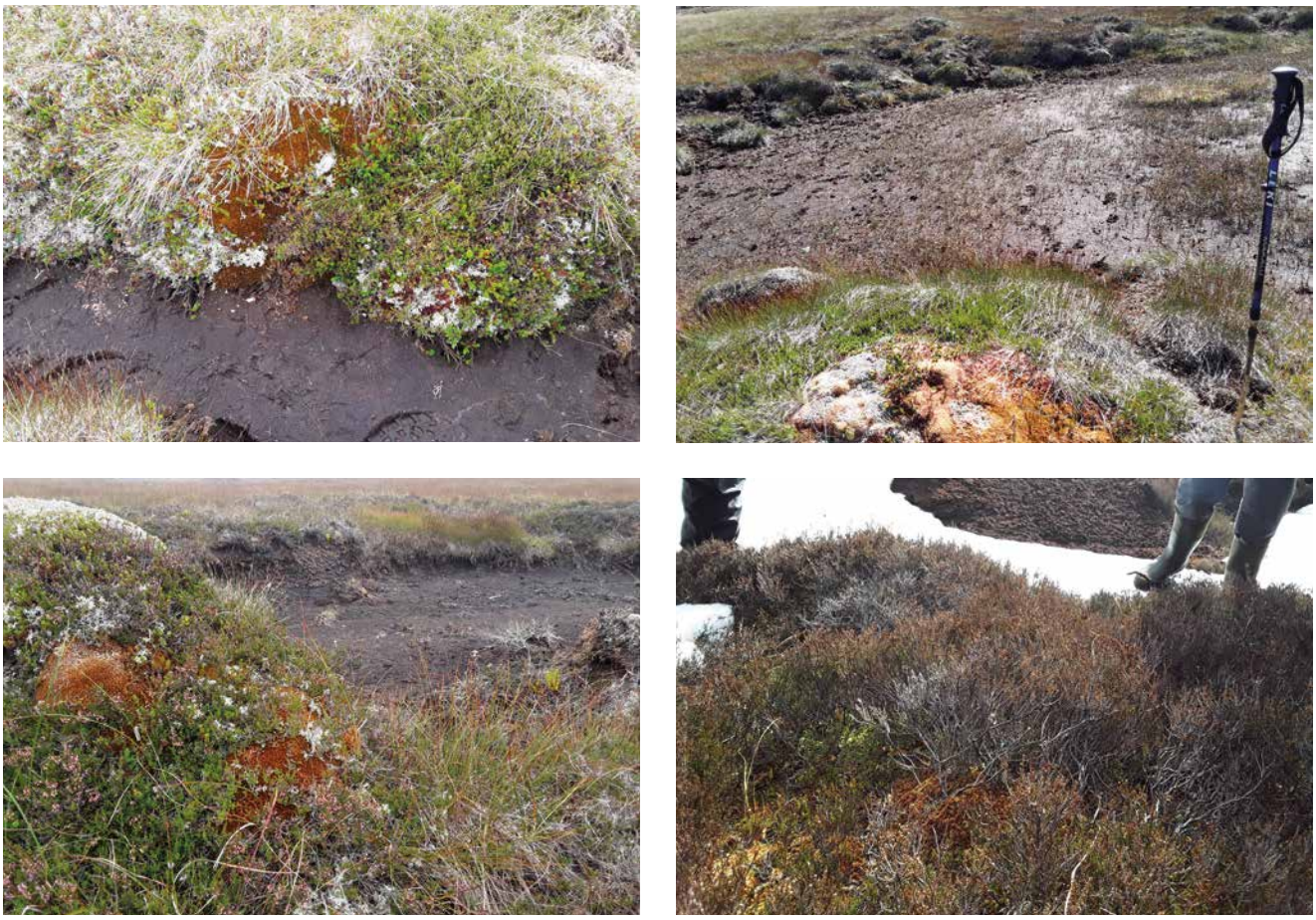

Figure 3. Rusty bog-moss beside erosion features, Scotland 2021 and 2022. Photo credits: Kate Massey.

undisturbed or near-natural conditions. This is likely to be obvious to botanists and plant ecologists: there are very few species that are 100% associated with one habitat, type of soil, etc. The combined indicator values of all species are what should be used together with the characteristics of the physical environment and management practices. Clearly, when assessing the importance of ecological receptors such as blanket bog, for example as part of an EcIA, practitioners should consider a whole range of characteristics as per EcIA guidelines (CIEEM 2018).

The answer to the question posed in the title is that rusty bog-moss is not necessarily an indicator of undisturbed or near-natural blanket bog and is found across a spectrum of bog conditions. Rather, its presence in degraded conditions may be as a relic species and indicate former high-quality bog habitat and better indicates a strong potential for blanket bog restoration. Therefore, development guidance on peatland habitat should be amended to reflect the reality of its occurrence.

Acknowledgements

Many thanks to Dr Peter Cosgrove FCIEEM for his encouragement and support in writing this paper.

Note

1 *Sphagnum fuscum* has recently been separated by some authorities into two species: *Sphagnum fuscum* and *Sphagnum beothuk*. The species are very similar in the field and can only be reliably separated by experienced bryologists under microscopic examination (Hill 2017). In the current paper only *S. fuscum* is referred to, to correspond with historic references and for ease of reference in the field, but it is acknowledged that *S. beothuk* may be incorporated into the paper under the guise of *S. fuscum*.

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Using Bryophytes as Indicator Species in Habitat Surveys

Figure 1. *Cinclidotus fontinaloides* (brown moss on rocks) marking the high (winter) water level of a turlough in the west of Ireland. Photo taken in the summer when the turlough was almost completely dry. Photo credit: Joanne Denyer.

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Keywords: fen, grassland, habitat classification, liverwort, moss

Bryophytes (mosses, liverworts and hornworts) are a fascinating and diverse group. However, many botanists do not record or use bryophytes in their survey work as they are known as a 'difficult group' to identify. This misses an opportunity, as bryophytes can provide information on environmental conditions useful to habitat surveyors, such as seasonal changes in water levels, soil and water nutrients and pH, air pollution and habitat condition. These habitat features are not always obvious when assessing a habitat using vascular plants alone, or when a survey is undertaken outside of the main flowering plant season (e.g. winter). Knowledge of some common bryophytes can therefore provide useful information for botanists undertaking habitat survey, even if bryophytes are not the target of the survey.

Introduction

This article outlines why bryophytes are useful indicator species and how field ecologists and botanists would gain information by learning some common species. Examples from grassland and fen habitats are presented to demonstrate how bryophytes can be used as indicator species. The final section gives some useful resources to help ecologists and botanists to develop their own bryophyte indicator lists for use in their projects. There are notes on getting started with bryophyte identification, but that is not covered in detail in this article.

What is an indicator species?

In ecology, indicator species are species which can be used to provide information about an environment that might not otherwise be obvious. Information from an indicator species could be soil or water pH, which would otherwise require water sampling to assess; or the winter flood

levels of a seasonal water body, which would not be obvious to a surveyor visiting in summer.

The key characters of an indicator species are that they are (1) characteristic of specific habitat types and/or environmental conditions, (2) fairly widespread geographically and (3) possible to identify in the field with a hand lens and a little experience. It is rare that one species can act as an indicator on its own and so by using information from more than one species more accurate habitat information will be obtained.

An indicator species could be an animal, lichen or fungus, but this article is focused on using plants as indicator species for habitat surveyors. Indicator species can provide information useful for habitat surveyors to assist with habitat classification and mapping and assessing the condition of a habitat.

What makes bryophytes useful indicator species in habitat surveys?

Experienced botanists frequently use vascular plant species to classify, evaluate and map habitats. Bryophytes can provide useful additional information due to a number of key characteristics, as follows.

- Many species are widespread geographically (bryophytes often have wider global distributions than vascular plants).
- Bryophytes are present in most habitats and habitat niches (including urban habitats, montane grassland, dry exposed rock, humid woodland, brackish coastal habitats and freshwater environments).
- Bryophyte species are the most abundant (biomass and/or surface area cover) in some habitats (for example raised and blanket bog, alkaline fen, upland woodland, montane grassland, petrifying springs and metalliferous mine spoil).
- Bryophytes are (mostly) not seasonal in their growth and are present and identifiable at all times of the year.

Bryophytes are highly sensitive to environmental conditions which makes them useful indicator species (Vanderpoorten and Goffinet 2009). Unlike vascular plants, bryophytes do not have roots (although they may have rhizoids which anchor them to a surface) and most species lack internal water and nutrient transport systems (Goffinet and Shaw 2009). The leaves of most mosses, leafy liverworts and simple thalloid liverworts are largely one cell thick to assist easy uptake of water and nutrients directly over the leaf surface. As they have limited control over nutrient uptake into their cells they can be very sensitive to levels of nutrients in air, water and in the substrate they are growing on (including rock and tree bark; Goffinet and Shaw 2009). Likewise, as they cannot control water loss from leaves, or replace lost water through roots, they cannot prevent their leaves from drying out. Species that can tolerate drought (those on dry, exposed walls for instance) do so by being desiccation-tolerant, or poikilohydric (Goffinet and Shaw 2009). This means that they photosynthesise when wet and 'shut down' when dry. They have mechanisms to protect cells from drying damage and can resume photosynthesis (and growth) rapidly when re-wetted. Some of these species can tolerate years of being dry and physiologically inactive. On a dry wall or natural rock, mosses can appear dry, brown and shrivelled. If sprayed with water from a bottle they can rapidly open their leaves and appear green in colour and look like completely different species: this can be important for identification.

Conversely, there are some species which are highly sensitive to changes in humidity and cannot tolerate drying out. These species tend to have westerly oceanic/Atlantic distributions in Ireland and Britain (Ratcliffe 1968), where humidity is higher. The most sensitive of these species (the hyperoceanic species) are not only restricted to the extreme west (Preston and Hill 1999, Hodd *et al.* 2014), where there is high rainfall, they also occur only in habitats and habitat niches that protect them from drying, such as north-east-facing heathy slopes on mountains or ravine woodlands (Hodd and Sheehy Skeffington 2011).

As bryophytes can be highly sensitive to local conditions, they can be used to indicate a range of factors such as climate, local humidity, air pollution, soil nutrients, soil, water and tree bark acidity (pH), whether or not a peat system

"Habitat features are not always obvious when using vascular plants alone. Knowledge of some common bryophytes can provide useful information for botanists undertaking habitat survey."

is actively peat-forming, and water levels in wetland systems. For instance, *Cinclidotus fontinaloides* (Figure 1; often known as turlough moss in Ireland) can indicate the winter high water levels of turlough systems (the seasonal water bodies on limestone frequent in parts of Ireland). In winter it will be completely inundated, but in summer it may be high and dry for months, well away from any remaining standing water (Figure 1). This can be very useful to help assess if a wetland is a turlough that floods in winter and when mapping the extent of a turlough in the summer months when water levels are low.

Examples of using bryophytes to classify habitats

Usually no single species will act as an indicator, but there are some species (in particular those typical of calcareous habitats) which have very strong habitat preferences and may sometimes be useful as indicators on their own (e.g. *Ctenidium molluscum*; Figure 2). Overall bryophyte abundance and diversity is also helpful in assessing habitat age, condition and quality. Some examples of the use of bryophytes in classifying and assessing grassland and wetland habitats are given in Boxes 1 and 2. These are based on Irish habitat classifications, but the species are also found in the UK. The aim is not to provide a definitive reference for grassland habitats but more to demonstrate how bryophytes may be provide useful information.

How to start?

This may seem daunting, but just a limited number of bryophytes (fewer than 50) can assist in separating many different habitats. Most of these should be identifiable in the field with a ×10 or ×20 hand lens (see Box 3). The

Figure 2. The moss *Ctenidium molluscum* is restricted to base-rich (high pH) habitats and is a good indicator of calcareous grasslands. It is a very distinctive species with a golden colour, feathery branching and curled leaves. The circle shows a small patch of the pale yellow-green *Tortella tortuosa* (also restricted to calcareous habitats). Photo credit: Joanne Denyer.

Box 1. Grassland habitats

Grassland habitats are not usually bryophyte-dominated (excluding some upland or montane grasslands). However, bryophytes can still provide usually habitat information, particularly when visiting a site outside of the main field season for vascular plants. Bryophytes can help one decide whether the grassland at a site is potentially of conservation interest and whether a repeat survey (in the main field season) is required. In grasslands, bryophytes can indicate soil fertility, soil pH and wetness. In the examples shown in Table 1 bryophytes are used (in conjunction with vascular plants) to identify different grassland types for habitat classification and mapping purposes.

Bryophytes can also be used to assess grassland habitat condition, for instance as part of a condition assessment for an EU Habitats Directive Annex I habitat. Lists of positive and negative indicator species are used as part of an overall habitat condition assessment. For Irish grasslands there are a number of indicator species lists (e.g. Martin *et al.* 2018 and O'Neill *et al.* 2013) and these are updated as more habitat information is obtained from national surveys. In Ireland, the moss *Ctenidium molluscum* is an indicator of the Annex I habitat 'Semi-natural dry grasslands and scrubland facies on calcareous substrates' [6210] and the calcareous sub-community of the Annex I priority habitat 'Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas (and sub-mountain areas, in Continental Europe)' [*6230].

Box 2. Wetland habitats

In wetland habitats, bryophytes can be used to identify gradients in wetland fertility (nutrient levels), pH, water levels and water source (groundwater versus surface water). The presence/absence and abundance of particular species can be used to classify and assess the condition of various fen habitats. For instance, both poor fen and bog habitats are acidic, but poor fens have some nutrient input from surface water and therefore have a different bryophyte community from rain-fed (nutrient-poor) bogs. The *Sphagnum* species *Sphagnum palustre*, *S. fallax* and *S. fimbriatum* are all typical and abundant in poor fen, but are absent from good-quality raised and blanket bog habitats. This highlights the value of learning a few common *Sphagnum* species as they can be excellent indicators (see also George Smith's article on Know Thy *Sphagnum* elsewhere in this issue, pp. 14–17). Higher nutrient levels in wetlands can also be indicated by the presence of *Calliergonella cuspidata* (Figure 3). Where this species is abundant a habitat is likely to be wet meadow or marsh, rather than lower-nutrient alkaline fen. 'Brown mosses' such as *Palustriella falcata* (Figure 4) indicate high pH levels, such as found in alkaline fen and springs. In Table 2 an example is provided of the use of bryophytes to assist in the identification of four Annex I wetland habitats that share similar vascular plant species and can sometimes be hard to separate.

examples above were developed using a range of resources. So, if you're new to all this, where should you start? First, decide what you want to use bryophytes to indicate. Is it to help with habitat mapping, to assess habitat condition, or to assess air pollution impacts? Is it for a particular habitat or habitat group? What geographic area are you working in? Then look at what resources are available to create lists of potential bryophyte indicator species for your particular survey needs. Useful resources include the following.

- The British Bryological Society (BBS) field guide *Mosses and Liverworts of Britain and Ireland* (Atherton *et al.* 2010): in the back of the book there are lists of common species for the main habitat types found in Ireland and Britain. These are very useful to help beginners get to know the key species for each habitat.

"Starting to identify bryophytes may seem daunting, but knowing just a limited number can assist in separating many different habitats."

Figure 3. The moss *Calliergonella cuspidata* dominating an area of wet grassland/marsh, clearly visible during a winter survey. Photo credit: Joanne Denyer.

Figure 4. *Palustriella falcata* is one of the 'brown mosses' that indicates alkaline fen. Here it is abundant at the edge of a pool at the springhead of an Annex I priority petrifying spring, clearly visible in a winter survey. Photo credit: Joanne Denyer.

- *BRYOATT: Attributes of British and Irish Mosses, Liverworts and Hornworts* (Hill *et al*. 2007). This resource lists key attributes for all bryophytes in Ireland and Britain and is available as both a PDF and an Excel spreadsheet. It gives scores for each species that indicate that species' tolerance of factors such as light, moisture, nutrients and pH. It can be freely downloaded from the Biological Records Centre (BRC) website: www.brc.ac.uk/biblio/bryoatt-attributes-british-and-irish-mosses-liverworts-and-hornworts-spreadsheet (note that some species have changed names since this was published).
- *The Atlas of British and Irish Bryophytes* (vols 1 and 2; Blockeel *et al.* 2014) gives relatively recent distribution maps for bryophytes and includes some habitat and ecology information in the species accounts.

Table 1 Grassland examples

	Improved grassland
Soil pH	Usually neutral to slightly acid/basic
Soil wetness	Dry–damp
Soil fertility	High
Bryophyte indicator species	Br*achythecium rutabulum, Kindbergia praelonga, Oxyrrhynchium hians* and *Rhytidiadelphus squarrosus*
Species notes	Typical bryophyte species are generalist bryophytes and can be found in most urban lawns.
Bryophyte diversity	Low
Bryophyte cover	Low

Table 2 Using bryophytes to separate four Annex I wetland habitats

	***Molinia* meadows on calcareous, peaty or clayey-silt laden soils [6410]**
Bryophyte indicator species	*Calliergonella cuspidata* is the main bryophyte present.
Bryophyte diversity	Low
Bryophyte cover	Low–moderate

Unimproved neutral grassland	Unimproved acid grassland	Unimproved calcareous grassland	Wet grassland
Usually neutral to slightly acid/basic	Acidic	Basic	Usually neutral to slightly acid/basic
Dry–damp	Dry–damp	Dry	Damp–seasonally flooded
Low	Low	Low	Low to moderate
As for improved grassland, but with *Pseudoscleropodium purum*	**Tall vegetation** *Brachythecium albicans, Pleurozium schreberi, Rhytidiadelphus loreus, Hypnum jutlandicum* and *Hylocomium splendens* **Short vegetation/bare ground** *Campylopus* species, *Ceratodon purpureus* and *Polytrichum* species Humid vegetation *Sphagnum* species	**Mosses** *Ctenidium molluscum, Flexitrichum gracile, Didymodon fallax, Encalypta streptocarpa, Eurhynchium striatum, Fissidens dubius, Homalothecium lutescens, Hypnum cupressiforme* var. *lacunosum, Neckera crispa, Tortella tortuosa, Trichostomum brachydontium* and *Trichostomum crispulum* **Liverworts** *Leiocolea turbinata* and *Scapania* aspera	*Calliergonella cuspidata*
Pseudoscleropodium purum can be found in grasslands of most pH, but is usually only abundant in low to moderately fertile habitats.	Species of wet heath and bog, such as *Sphagnum* species, may occasionally be present, for instance where *Molinia caerulea* is abundant on previously cut-over peat.	Calcareous grassland has species which are more restricted to calcareous (high pH) habitats and the only a few species may be needed to identify potentially interesting calcareous grassland.	Wet grassland types usually have moderate to high cover of *Calliergonella cuspidata*. This can be useful when surveying grassland in a dry summer as it gives an indication of winter wetness levels.
Low	Moderate	High	Moderate
Low–moderate	Moderate–high	Moderate–high	Usually high

Alkaline fens [7230]	Transition mires and quaking bogs [7140]	Petrifying springs with tufa formation [*7220]
Calliergonella cuspidata less prominent and 'brown mosses' are dominant.	Elements of both acidic poor fen and alkaline fen: 'Brown mosses'† present: most commonly species with a tolerance for slightly lower pH such as *Bryum pseudotriquetrum, Calliergon giganteum, Campylium stellatum* and *Scorpidium scorpioides*. Sphagnum species are usually present, particularly species which can tolerate higher pH habitats such as *S. contortum*.	'Brown mosses'† are present but species with the highest pH tolerance are usually dominant (e.g. *Palustriella commutata* and *P. falcata*) with additional bryophytes not usually found in alkaline fen such as *Eucladium verticillatum* and *Didymodon tophaceus*. The liverworts *Aneura pinguis* and *Pellia endiviifolia* are more prominent in petrifying springs than alkaline fen.
High	High	High
High	High	High

†Brown mosses is a term used to refer to a group of bryophytes typical of alkaline fen condition (many of which, but not all are golden or brownish in colour). A broad definition of 'brown mosses' would include *Bryum pseudotriquetrum, Calliergon giganteum, Campylium stellatum, Ctenidium molluscum, Fissidens adianthoides, Palustriella commutata, Palustriella falcata, Sarmentypnum sarmentosum*, *Scorpidium cossonii, Scorpidium revolvens, Scorpidium scorpioides* and *Warnstorfia sarmentosa*.

- Habitat condition assessment guidance for the area you are interested in. In Ireland this is usually included in the latest *Irish Wildlife Manual* for that habitat (e.g. grassland, fen, upland habitats, petrifying springs) and will list bryophytes that can be used as positive and negative indicators. These are available on the National Parks and Wildlife Service (NPWS) website (www.npws.ie). There are comparable guides in other areas (such as the JNCC Common Standards Monitoring guidance).
- The article 'A new checklist of the bryophytes of Britain and Ireland, 2020' (Blockeel *et al.* 2021). This is the latest checklist with the most up-to-date nomenclature for bryophytes. A checklist which cross-references older names (from 2008) with the 2020 names is available to download from the BBS website in the Resources section (www.britishbryologicalsociety.org.uk/).
- *Bryophyte Ecology* (Glime 2021) is an online book which is free to download and contains chapters on physiological ecology and habitats.

Box 3. A note on bryophyte identification

An expert bryologist must have a high level of both field and microscope skills and it may take years to gain sufficient experience to be able to undertake dedicated bryophyte site surveys. However, not everyone will want to become an expert bryologist with the expertise required to undertake site specific surveys of bryophyte-dominated habitats such as oceanic woodland, dune slacks, snowbeds, petrifying spring and metalliferous soils. It is possible to learn a good range of bryophyte indicator species relatively quickly to assist with habitat surveys. With a little practice many of these species can be identified in the field with a ×10 or ×20 hand lens and do not require microscopic identification.

The BBS field guide *Mosses and Liverworts of Britain and Ireland* (Atherton *et al.* 2010) is a useful book for beginners. This field guide has an introduction to bryophyte key identification features and a field key which includes most indicator species likely to be needed for habitat survey.

The BBS website contains much useful information on getting started with bryophyte identification, useful downloads (census catalogue, species lists, recording cards, spell-checker for Word, etc.), details of referees, recent news, lists of regional groups, forthcoming meetings and courses.

Conclusion

A knowledge of bryophytes can assist botanists undertaking habitat surveys by providing useful information on environmental factors such as local climate, air pollution, soil and water nutrients, soil and water pH and water levels of seasonal water bodies. This can be used, in conjunction with information from the vascular plant flora present, to identify and map habitat types and assess the condition of a habitat. It is particularly useful for bryophyte-dominated habitats and when an initial site visit is made outside of the main vascular plant flowering season (e.g. for winter survey work). Most botanists should be able (if they wish) to learn a small number of bryophytes to assist in habitat survey work. This article lists some of the main resources available (many free to download) to help surveyors get started in this area.

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About the Author

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Can We Use Bryophyte and Lichen Species Occupancy Data as Indicators of Global Change?

Figure 1. *Polytrichastrum alpinum*. Photo credit: Dave Genney.

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Large quantities of unstructured biodiversity data are collected every year, some of which contribute to publications like the *State of Nature* (Hayhow *et al.* 2019). These data can be linked to information about species habitat and climate preferences to identify the impact of different global change drivers on different taxa. This article describes two approaches using bryophyte and lichen occupancy data and their use as indicators of ecosystem health.

Keywords: bryophytes, climate, habitat preferences, indicators, lichens, nitrogen pollution, Scotland

Introduction

The readers of *In Practice* do not need reminding about the ongoing biodiversity crisis and the evidence marshalled to demonstrate it, not least in the recent Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) report (IPBES 2019) and the *State of Nature* reporting. In order to respond appropriately to these losses, trends in biodiversity have to be attributed to different drivers.

Attribution may be straightforward for some species, especially where research has identified the links between population or range loss and specific drivers. For instance, the loss of arable weeds is associated with changing cultivation practices, better seed cleaning

and herbicides (Robinson and Sutherland 2002). However, synthesising such information can be beset by problems of bias towards well-studied species or easily studied drivers. An alternative approach to identify drivers without such bias is to link information on species trends to information on ecological preferences that in turn serve as a proxy for a driver. This requires species groups with existing, comprehensive information on their ecological preferences: these include bryophytes and lichens.

We have tried different approaches to test this using two types of indicator. Firstly, we used a set of ecological preferences first developed by Ellenberg (1988), and familiar to many plant ecologists, where species have been assigned a score – usually on a scale of 1 to 9 – based on the conditions they are normally found in. These describe a species' preferences, among others, for moisture (F), light (L), nitrogen (N) and soil pH (R) (Hill *et al.* 2007 for bryophytes, Wirth 2010 for lichens). These can be linked to drivers such as land use change and pollution. Secondly, we used climate attributes calculated as the mean precipitation (Prec), mean January (TJan) and mean July (TJul) temperatures of species ranges in the British Isles for bryophytes (Hill *et al.* 2007) and Great Britain for lichens (Pakeman *et al.* 2022), which are clearly linked to climate change.

What is driving changes in bryophyte and lichen occupancy?

The Combined Marine and Terrestrial Biodiversity Indicator for Scotland (Eaton *et al.* 2021) built on work undertaken for the *State of Nature* report for Scotland (Walton *et al.* 2019) to produce species trend data for 380 species based on abundance trends and 1578 species based on occupancy trends. Occupancy is defined in this context as the presence of a species with a 10 km × 10 km grid square (hectad). We took this occupancy trend data for 326 bryophyte (218 mosses and 108 liverworts) and the 437 lichen species and analysed these trends according to ecological and climate preferences (Pakeman *et al.* 2022).

Trend data were available for the short- (2005–2015) and long-term (1971/1972–2015) for both bryophytes and lichens and the analysis covered habitats, four ecological preference indicators and three climate preference indicators. Only a portion of the analysis can be summarised here, and we specifically focus on short-term trends, but the paper (Pakeman *et al.* 2022) is available as open access with all the analyses.

Analysis of short-term trends in bryophyte occupancy by European Nature Information System (EUNIS) level 1 habitats shows positive trends for the majority of species from coastal (B), heathland (F) and woodland, scrub and hedgerow (G; including F9 and FA; Figure 2a). Short-term trends for lichen species of woodland and heathland are negative (Figure 2b) but there are positive trends for species of grasslands (E). The positive trend for woodland bryophytes may be related to woodland expansion, but as this in turn may be related to conversion of heathland to woodland the overall positive response of heathland bryophytes must be a response to improved conditions, potentially due to reduced grazing levels. The opposite trends for lichens in heathlands and woodlands is striking, suggesting that they may be in competition for space and that there is replacement of lichens by bryophytes. This also highlights how combining analyses for bryophytes and lichens may miss important patterns.

There is very strong evidence that species of drier locations are more likely to show positive trends for both bryophytes (Figure 3a) and lichens (Figure 3b). For bryophytes, a similar, but only moderately strong, pattern is seen for Ellenberg moisture preferences; species of drier habitats are more likely to have positive trends than those of wetter ones (not shown). This suggests that both bryophyte and lichen communities are shifting towards

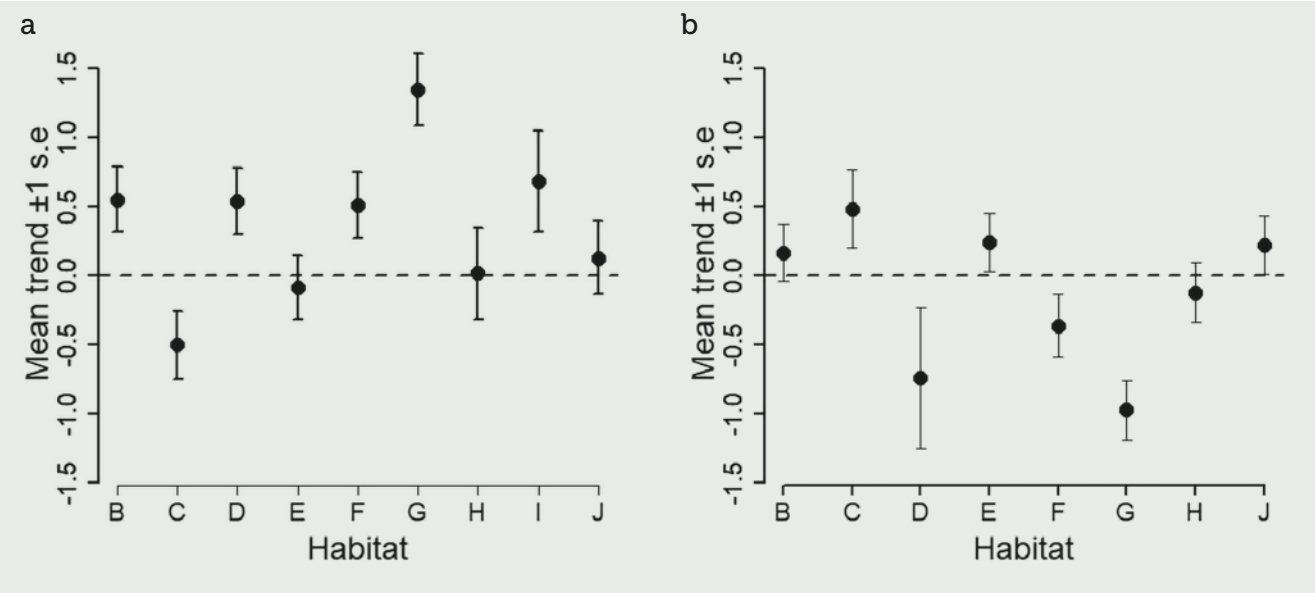

Figure 2. Mean (±1 standard error) short-term (2005–2015) trends of (a) bryophyte and (b) lichen species by EUNIS level 1 habitat class with overlapping membership of each habitat class. B, coastal habitats; C, inland surface waters; D, mires, bogs and fens; E, grasslands; F2 to F4, heath, G and F9/FA, woodland and forest; H, inland unvegetated or sparsely vegetated habitats; I, regularly or recently cultivated habitats; J, constructed, industrial and other artificial habitats.

those more tolerant of limited moisture. While Scotland is getting wetter, the response may show that bryophytes and lichens are responding to periods of drought that are longer or more intense (Kirkpatrick Baird *et al.* 2021).

Other notable trends are that bryophytes of shadier, nutrient-rich and warmer areas are more likely to show positive trends than those of more open, nutrient-poor or cooler areas. This suggests that levels of disturbance are dropping in both woodland and open habitats and that potentially woodland expansion has had an effect, and also that there are continuing impacts of nitrogen pollution and climate change on bryophyte communities. Lichens of more base-rich substrates are also more likely to expand in occupancy than those of more acid ones, potentially indicating recovery from acidic deposition.

Can we develop new indicators based on occupancy data?

A second approach that skips the stage of calculating species trends was tested for Scottish bryophytes (Pakeman *et al.* 2019). All occurrence records from the National Biodiversity Network Atlas were downloaded for bryophytes from 1960 to 2016, and these were converted to simpler presence/absence data, specifically one record per 10 km × 10 km grid cell per year in those cases where a species was present. Each record was then replaced by its respective ecological or climate preference value. For instance, in the analysis of trends in bryophyte nitrogen preferences, records of *Rhytidiadelphus squarrosus* were assigned their Ellenberg N score of 4. Means for each hectad per year were calculated and these were used to model trends through time accounting for repeated measures and spatial autocorrelation.

The analysis revealed some clear and, mostly, interpretable trends. The national trend for Ellenberg's light (L) indicator is a linear decrease with time (Figure 4a) and can be interpreted as a response to increased tree planting, reduced woodland management and a general reduction of grazing in many habitats leading to denser shade from the canopy. There is a clear, and significant, quadratic trend for Ellenberg's nitrogen (N) indicator values with a peak around 1998 (Figure 4b). Nitrogen deposition peaked in 1990, so this analysis suggests the recovery was delayed but that there has been a shift since 1998 towards recording of bryophytes of less nutrient-rich habitats. There was also a strong linear increase in the two temperature indicators, TJul (Figure 4c) and TJan (not shown), suggesting that increased temperatures have had an impact on bryophyte communities.

The advantage of this approach over one based on species trends is that it is easier to identify non-linear responses and that all species are used in the calculations, not just those common enough to generate a trend. The clear interpretability of the nitrogen and July temperature trends has led to these two metrics being adopted as national Ecosystem Health Indicators 14a and 14b in Scotland (see Resources).

Methodological considerations

There are some clear potential issues with both sets of analyses. Firstly, all the data have been collected in an *ad hoc* fashion rather than with set sampling designs and protocols. However, the sheer size of the datasets means that it is difficult to see how biases in data collection could affect the detected results. For instance, the contrasting trends in bryophyte and lichen occupancy are not the result of a reduction in recorder effort for lichens. Also, occupancy may not be a good measure of population size, but for many species of bryophytes and lichens their small size and microhabitat distributions make accurate monitoring extremely challenging. Secondly, using Ellenberg indicators restricts species to

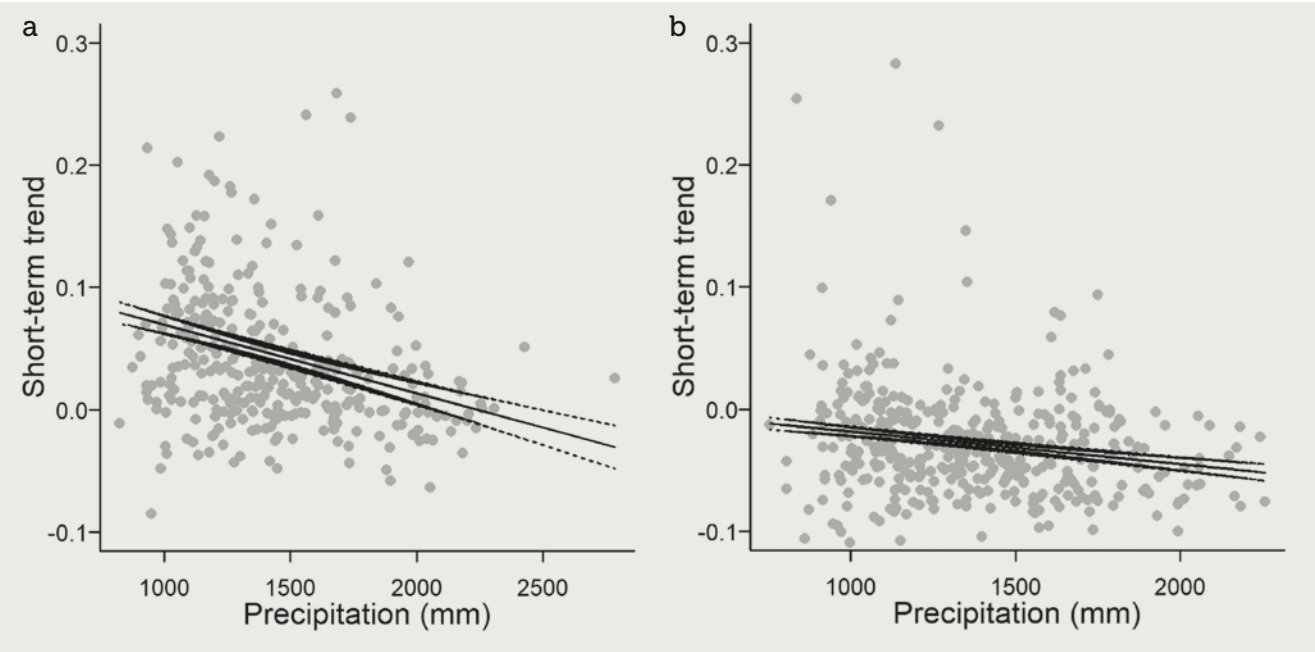

Figure 3. Short-term (2005–2015) trends of (a) bryophyte and (b) lichen species occupancy according to the mean annual precipitation of their range (mm). Fitted relationship (solid line) and 95% confidence intervals (dashed lines) from the generalised linear model.

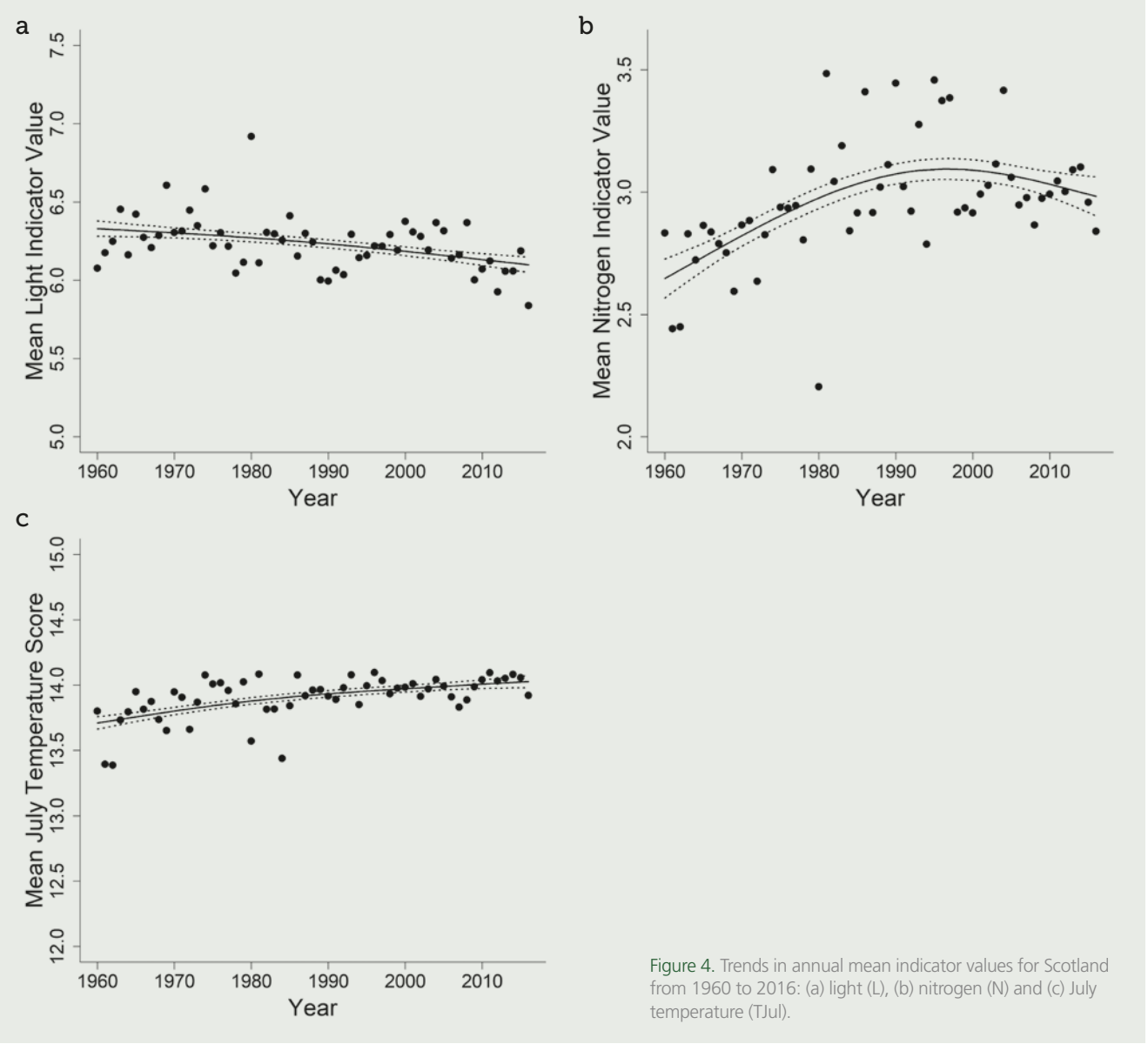

Figure 4. Trends in annual mean indicator values for Scotland from 1960 to 2016: (a) light (L), (b) nitrogen (N) and (c) July temperature (TJul).

Figure 5. *Dicranum bergeri* (*undulatum*). Photo credit: Dave Genney.

a place on a whole-number scale with little precision, but many studies (e.g. Schaffers and Sýkora 2000) have shown that conclusions are robust. Finally, there are issues around allocating species to habitats and how to weight generalists against specialists. The analysis we have done so far gives specialists and generalists within a habitat the same weight. More information about changes within habitats is held in the trends of specialist species as the trends in generalist species are affected by changes in multiple habitats, but we need to identify data to allocate the trends of generalists across habitats. Working on the statistical issues with this allocation is something we are still getting to grips with.

Conclusions

Bryophytes and lichens are usually fairly low down the pecking order in terms of biodiversity interest, but they are a major part of Scotland's contribution to European and global biodiversity. The alignment of the availability of large quantities of occurrence records and good ecological knowledge of their preferences has allowed us to demonstrate which drivers might be affecting occupancy trends and, in turn, tell us about the state of Scotland's natural capital.

Both approaches are largely in agreement. There is a tendency for species with positive trends to be those from warmer and drier parts of the country, indicating that climate change has already left a signature in both bryophyte and lichen communities. There is also a clear tendency for species of shadier habitats to increase, potentially reflecting reduced disturbance and woodland expansion. There was one exception to the agreement in behaviour: the analysis of species trends indicated that bryophyte species preferring nitrogen-rich habitats were increasing, but the analysis of the hectad data suggested a reduction in mean N score since 1998. A potential reason for this disagreement is that the analysis of trends does not take into account the overall frequency of a species, so a moderately rare species has the same weight in that analysis as a ubiquitous one, and it ignores species that are too rare to have trends fitted.

Huge numbers of species records are available, in the UK via the National Biodiversity Network and internationally via the Global Biodiversity Information Facility (GBIF), and the approaches we have taken here demonstrate how ecological understanding can be garnered from such *ad hoc* data. We are currently developing the methods to cover other species groups and to deal with the issue of habitat specificity.

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Waxcap Grasslands: The Forgotten Treasure

Figure 1. Parrot waxcap, *Gliophorus psittacinus*, usually has some green colouring and very sticky cap; in acid grassland, south west Peak District. Photo credit: Penny Anderson.

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Keywords: fungi, grasslands, waxcaps

Grassland fungi are often overlooked in ecological surveys, yet recent investigations show the very high value of some sites, especially in the uplands, frequently on a European scale and in grasslands often lacking plant diversity. We seek to raise awareness of these neglected grassland fungi, demonstrate their diversity and beauty, and indicate where to find and evaluate them. Recent advances in eDNA analysis are offering a new approach to fungi identification and site evaluation, but field mycology remains essential at the appropriate time of year.

Introduction

Not all grasslands of high nature conservation value boast a diverse flora of colourful wildflowers and grasses buzzing with insects. Grassland fungi can be equally colourful and diverse. Grassland fungi sites have been overlooked frequently in the past for conservation and protection owing to their often low floristic diversity; they are dismissed too frequently as florally dull. Yet the UK is home to some of the most important waxcap grasslands in the world, particularly in Wales, Scotland and the Pennines.

The specialist grassland fungi included in the generic 'waxcap' label are dominated by waxcaps (Hygrophoraceae). They are part of a grassland fungal assemblage that includes spindles, club and coral fungi (Clavarioids), pinkgills (*Entoloma*), earthtongues (*Geoglossum* and relatives) and crazed caps (*Dermoloma* and relatives). These groups are

collectively labelled as CHEGD (the initials represent the different genera; Box 1), although recent DNA investigations have now split Hygrocybe into six new genera and some of the other groups remain poorly understood, taxonomically. Genetic research is still separating out new CHEGD species which may appear morphologically similar but are genetically distinct, especially pinkgills and earthtongues.

Box 1. CHEGD species

The five broad CHEGD groups consist currently of the following genera:

1. **Calvarioid** fungi: *Clavaria*, *Clavulinopsis*, *Ramariopsis*
2. **Hygrocybe s.l**.: *Cuphophyllus*, *Gliophyllus*, *Gloioxanthomyces*, *Hygrocybe s. str.*, *Neohygrocybe*, *Porpolompsis*
3. **Entoloma s.l.**
4. **Geoglossoid** fungi: *Geoglossum*, *Glutinglossum*, *Microglossum*, *Sabuloglossum*, *Trichoglossum*
5. **Dermoloma**: *Dermoloma*, *Porpoloma*, *Camarophyllopsis*, *Hodophilus*

Where to find good CHEGD grasslands

Potentially good CHEGD sites have one or more of the following characteristics: a short turf (grazed, mown or hay cut and then grazed), often plenty of mosses like *Rhytidiadelphus squarrosus* (which often indicates high sheep grazing pressures), well-drained soils, no evidence of disturbance (such as ploughing or drainage) for many years, little or no liming and low nutrient levels. The best grasslands are those close to or matching the U4 *Agrostis capillaris/Festuca ovina* community, with or without the accompanying herbs, MG5 mesotrophic grasslands (*Cynosurus cristatus/Centaurea nigra*) and calcareous grasslands CG1 and CG2 (*Festuca/Carlina* and *F. ovina/Avenula pratensis*) in the National Vegetation Classification (Rodwell 1992). There are some specialists of other habitats like heathland, and a few favour boggy wet sites or more acidic grasslands. Coastal clifftops, slopes and sand dunes, urban sites like lawns and parks, reservoir banks, old mineral workings, church and chapel grounds and roadside verges can all support grassland specialist fungi (Bosanquet *et al*. 2018). In the UK, the waxcap assemblage grows largely in grasslands, and are considered to be outcompeted by ectomycorrhizal fungi associated with trees in woodlands (Gareth Griffith, Chair in Mycology, Aberystwyth University, personal communication).

CHEGD grasslands: a relatively new phenomenon

Waxcap grasslands have been widely lost owing to agricultural improvements and nearly 90% of all waxcap species are on one or more European national Red Lists for threatened fungi. This emphasises their British importance and the very significant contribution our sites make to their international conservation. The threatened state of CHEGD fungal assemblages was not realised until the 1980s after research in The Netherlands and later in Scandinavia (Griffith *et al*. 2013) and their conservation status has been supported in the UK by several grassland Site of Special Scientific Interest notifications and the inclusion of some species in Biodiversity Action Plans. Subsequent surveys have shown that Britain is a stronghold in a European context for CHEGD fungi (Evans 2004) and more sites are being found annually.

The range of CHEGD species

A warm summer and wet autumn will herald a good waxcap year, as in 2020. Waxcaps, of which there are about 50 species, produce often brightly coloured, generally quite small toadstools and are usually the easier group to identify. Their textures vary from felt-like, to buttery or slippery and they have thick waxy gills. They are thought to be largely saprophytic. Box 2 provides identification guidance.

One of the commonest waxcaps is the pale orange-brown meadow waxcap (*Cuphophyllus pratensis*), growing in small groups (termed troops by mycologists). Parrot waxcap (*Gliophorus psittacinus*) is smaller, sticky and glistening and shows some greenish colouring (Figure 1). The scarlet waxcap (*Hygrocybe coccinea*) has a moist, domed cap and red or yellow gills, while the golden waxcap (*Hygrocybe chlorophana*) reflects its name. Snowy waxcap (*Cuphophyllus virgineus*) is another widespread species with a white (usually), moist cap and stem with decurrent gill attachment. Some

Box 2. Help with waxcap identification

Waxcap identification depends on observing:

- colour of the cap and stipe (which can vary along its length)
- shape of the cap – flat, convex, concave, conical, with a central point, etc. – and of the stipe
- colour of gills
- gill texture, type of attachment to the stipe and spacing
- cap and stipe texture: dry, sticky, oily, waxy, etc.
- fungal size
- smell.

Some of these features change with age.

Good identification guides:

- Wood and Dunkelman (2017) provides good photographs and summary features for a wide range of CHEGD and other grassland fungi.
- Information from Aberystwyth University where much waxcap research is being undertaken (www.aber.ac.uk/waxcap). This includes a waxcap key.
- Plantlife leaflet *Waxcaps and Grassland Fungi. A Guide to Identification and Management*, which includes photographs (www.plantlife.org.uk/application/files/6915/0460/9899/Waxcap_ID_guide_low_res_website.pdf).
- The Outer Hebrides Biological Recording group has a good waxcap key on their website: www.ohbr.org.uk/documents/leaflets/waxcaps-key.pdf
- There is a new online waxcap key too: https://sxbrc.org.uk/recording/keys/waxcaps/

species, such as the heath (*Gliophorus laetus*) and splendid waxcaps (*Hygrocybe splendidissima*), thrive better in acid sandy soils whereas others, like the pink or ballerina (*Porpolomopsis calyptriformis*; Figure 2) and the oily waxcaps (*Hygrocybe quieta*), prefer more neutral areas with deeper soils, often towards the bottom of slopes. The citrine waxcap (*Hygrocybe citrinovirens*) favours wetter conditions, while the egg-yolk waxcap (*Gloioxanthomyces vitallinus*) prefers peaty soil at moorland edges.

Some species are regarded as indicators of high-value sites, suggesting a good assemblage is likely to be present. These include the crimson waxcap (*Hygrocybe punicea*), which is generally much larger than those already described (Figure 3), the brown-capped dingy waxcap (*Hygrocybe ingrata*) and the nitrous waxcap (*Hygrocybe nitrata*), notable by its smell of spent gunpowder or fireworks.

Figure 2. Pink or ballerina waxcap, *Porpolomopsis calyptriformis*: medium-sized waxcap with distinctive pinkish cap and white stipe; south west Peak District. Photo credit: Penny Anderson.

Other members of the CHEGD fungal assemblage are equally important. Common club and coral fungi represent some 12% of the CHEGD taxa and include the white and golden spindles (*Clavaria fragilis* and *Clavulinopsis fusiformis*), the yellow and apricot clubs (*Clavulinopsis helvola* and *C. luteoalba*) and meadow coral (*Clavulinopsis corniculata*). There are at least 25

Figure 3. Crimson waxcap, *Hygrocybe punicea*, a large dark-red coloured waxcap found in acid grassland; Lyme Park, Cheshire. Photo credit: Penny Anderson.

Figure 4. Smoky spindles, *Clavaria fumosa*, in acid grassland, near Axe Edge, Peak District. Photo credit: Penny Anderson.

grassland clubs and corals of *Clavaria*, *Clavulinopsis* or *Ramariopsis* genera (Figure 4), varying in colour from rose to violet, smoky or apricot. Among the rarer species are violet coral (*Clavaria zollingeri*), rose spindles (*Clavaria rosea*) and beige coral (*Clavulinopsis umbrinella*). The violet coral is on the UK and European Red Lists, while the straw club (*Clavaria straminea*) is nationally restricted.

Pinkgills (a large group containing currently more than 100 species) usually have some bluish, lilac, violet or bluish-grey colouring or are more dull-coloured. They have pale, crowded gills in their mushroom-like cap and are difficult to identify, needing microscopic examination and considerable experience. As a result, their true distribution is less well understood than that of waxcaps.

The earthtongues (Geoglossoid fungi) are simple, small tongue or club-shaped structures which are blackish, green,

Figure 5. The rare olive earthtongue, *Microglossum olivaceum*, a Biodiversity Action Plan species, in acidic grassland on limestone, Dovedale tributary valley, Peak District. Photo credit: Penny Anderson.

purplish or even dark red. *Geoglossum* and *Microglossum* have smooth fruiting bodies while *Trichoglossum* species are covered with tiny bristles (visible with a lens). All the *Microglossum* species are rare (Figure 5). Crazed caps (*Dermoloma* and similar) are dry-capped mushrooms with cuticles that crack in a crazy pattern when flexed. *Dermoloma cuneifolium* is quite common, although others also occur, like *Dermoloma magicum*, which blackens when bruised.

Date waxcap (*Hygrocybe spadicea*), big blue pinkgill (*Entoloma bloxamii* s.l.) and olive earth tongue (*Microglossum olivaceum*) are sufficiently rare and threatened to have their own Biodiversity Action Plans. Date waxcap, with striking brown cap and yellow gills, prefers dry, warm, south-facing slopes. Big blue pinkgill and olive earthtongue status has been muddied by recent DNA sequencing, splitting them into more species. Other rarer grassland fungi include more pinkgills and orange, citrine, yellow foot, dingy and fibrous waxcaps (*Hygrocybe citrinopallida*, *H. flavipes*, *H. ingrata* and *H. intermedia*).

Surveying for CHEGD assemblages

CHEGD field surveys depend on the fruiting bodies being in evidence and their production varies with climate and season. The drought in 2018 resulted in a particularly poor fruiting season, suggesting the need for surveys over more than 1 year. Moreover, the first species might appear in August or earlier in some years but continue through to November or December, depending on frosts that kill off the fruiting bodies, meaning that surveys need to be undertaken ideally at least three times during this period to be sure of finding the majority of species. Pinkgills are often the first to appear, although some waxcaps like the fibrous waxcap (*H. intermedia*) emerge in August. In contrast, some of the earthtongues are more abundant in November or later.

It is not easy to find additional data on sites. There is no central database for CHEGD fungi, although the British Mycological Society holds some data on individual sites. Natural England (Evans 2004) collated existing information through contacts with individuals and organisations, but this is out of date now owing to the additional sites that have been surveyed. Some County Wildlife Trusts, affiliated groups or other organisations like Plantlife have some data.

“The first species might appear in August or earlier and continue to November or December. Undertake surveys at least three times during this period to be sure of finding the majority of species.”

Advances in genetic analyses recently has enabled soil samples to be analysed for their CHEGD species as well as other grassland fungi and some associated plants. Aberystwyth University is leading this research into metabarcoding of soil eDNA as a method for assessing the biodiversity of fungi (Griffith *et al*. 2019). The results often reveal more species than found in field surveys. For example, as part of recent research in the South West Peak Landscape Partnership Scheme (2022) programme, eDNA of grassland fungi was sampled on 25 farms. Of the top six farms, an average of only 66% of the eDNA fungi identified were also found in the field surveys. In addition, the fluid taxonomic status of some of the groups makes it difficult to provide exact species counts and identification. For example, in the same South West Peak eDNA survey, of the 137 named CHEGD fungi detected, 19 had previously been found in Europe but not the UK and six only from outside Europe.

The advantages of eDNA analyses for CHEGD species is that they can be undertaken at any time of year with little variation in the results and are less dependent on antecedent weather conditions compared with field surveys for fruiting bodies. There is no substitute, though, for the additional in-field evaluation of site, situation and findings that an experienced field mycologist/ecologist can bring.

Evaluating CHEGD grasslands

Waxcap sites are ranked by the total CHEGD taxa, preferably totalled from more than one visit. Until recently, a minimum number of waxcap taxa and waxcap-like fungi (H+D) was used to rank sites as being of international (22+), national (17–21), regional (9–16) or local (4–8) importance (Evans 2004). New guidelines for evaluating waxcap sites have now been produced (Bosanquet *et al*. 2018), needing 19 or more waxcaps to be of national importance. Sites with 12–18 taxa should be resurveyed to see if more species occur or could be regarded as of regional value. Seven or more clubs, spindles and corals, 15 pinkgills, five earthtongues and three crazed caps and their relations now also each qualify as nationally important sites based on the lists provided. Multiple qualifying groups renders a site of particularly high value (see Box 3).

Box 3. Sources of information for CHEGD evaluation

Bosanquet *et al*. (2018)

Section 4 on grassland fungi describes the criteria for site selection, and provides lists of all species known at the time and their diversity indicator status. This standard helps differentiate between sites of national or more regional value.

Evans (2004)

This assessment is based on waxcaps as applied prior to Bosanquet’s new criteria and includes evaluation criteria for sites of less than national importance. It mentions the other grassland fungi groups too. The report also gives lists and some descriptions of the highest-value sites in England known at the time.

Bosanquet *et al*. (2018) also note all the CHEGD species that are regarded as indicators of sites that would support a high overall grassland fungal diversity. These high-diversity indicators are adapted from an earlier version through expert opinion to cover the whole of Britain. They have been chosen because of their rarity

or scarcity, their strong association with ancient grassland sites, UK-wide distribution and international status.

There are some issues in relation to selecting and identifying sites of different levels of importance. In many instances, the CHEGD fungal interest lies in hotspots among more depauperate areas. In other cases, whole fields, or localised unimproved banks in a field, may host the fungal interest. Defining a site can therefore be difficult. Evans (2004) gives some examples. In her report, she identifies the Longshaw Estate (a National Trust property in the Peak District) as the most important site in England for nearly all its CHEGD groups. It is a 259 ha estate consisting of unimproved grassland, wetlands and mixed woodland plus ancient oak woodland in a gorge. The CHEGD interest is in three main hotspots rather than occurring throughout the estate, although new species and hotspots are continuing to be found (author's personal experience, 2021).

The range of sites listed as of international importance just for their waxcaps (Evans 2004) shows a bias towards the uplands, with Longshaw, Kerridge Hill (gritstone edge on the Cheshire side of the Peak District), Blencathra in the Lake District and Crimsworth Dean (south west Yorkshire). There is a good variety of lowland sites too, including Windsor Great Park, The Patches in west Gloucestershire and Brookwood Cemetery in Surrey.

It is believed that high-quality CHEGD grasslands require a considerable period of time to develop their full suite of species and thus their value (Evans 2004). Some species are regarded as early colonisers after perhaps 10 or 20 years, such as the blackening waxcap (*Hygrocybe conica*) and snowy waxcap (*Cuphophyllus virgineus*), and they can tolerate some nutrient elevation. But species like splendid waxcap (*Hygrocybe splendissima*) may take much longer (more than 30 years; Evans 2004). Some of the best sites are thought to have been undisturbed for hundreds of years (Evans 2004), although this is rather speculative.

The significance of good CHEGD sites

The conservation of the nationally and regionally important CHEGD sites is on a par with flower-rich meadows and other habitats in urgent need of protection and conservation management to maintain this country's biodiversity. Based on current knowledge, such sites cannot be re-created, or even fully restored, once agricultural improvements or other disturbances have taken place. They are unique. Moreover, recent research as part of the South West Peak Landscape Partnership Scheme (2022) programme has revealed that a sample of CHEGD grasslands in the area also support high soil organic matter carbon, averaging 9.6% in the top 10 cm, equating to about 100 tC/ha. This is a very high figure bearing in mind that more than 60% of a soil's carbon lies below 15 cm and the average total carbon content in the upper 30 cm of an acid soil is 87 tC/ha (Anderson 2021).

Of paramount importance therefore is the need to avoid tree planting and other disturbances in the richer CHEGD sites, both to protect the fungal communities and to avoid releasing the existing carbon. This is against the backdrop of national objectives for tree planting and for the preference for the less productive marginal land to be targeted. We must guard against the loss of our best CHEGD grassland assemblages to avoid losing both biodiversity and carbon.

Conclusions

This paper emphasises the significance of our high-value grassland fungal assemblages. Waxcaps are beautiful and cheerful additions to our conservation palette. It follows that their possible presence and value need to be included in any ecological assessment when change is being considered, either through the planning process or through land management strategies. It is increasingly urgent that the value of good waxcap sites is recognised and that they are surveyed, evaluated and adequately protected to safeguard their carbon and their soils and to avoid pressure, for example, to plant trees on them.

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Feature

The England Grassland Fungi Database: A Tool to Help Safeguard Grassland Fungi Sites

Keywords: biological records, fungi, grassland, tree planting, waxcap

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Figure 1. Examples of CHEGD fungi characteristic of undisturbed grassland: (a) *Clavulinopsis umbrinella* (Clavarioid), (b) *Hygrocybe intermedia* (*Hygrocybe* and allies), (c) *Entoloma bloxamii* agg. (Entoloma), (d) *Microglossum olivaceum* agg. (Geoglossoids) and (e) *Dermoloma magicum* (Dermoloma and allies). Photo credits: a–d, Sean Cooch; e, Clare Blencowe.

In England, it is nearly 20 years since the last assessment of grassland fungi sites was undertaken. Our understanding of the conservation status of these sites has improved significantly since then. One thing that hasn't changed is the continual and existential threat from land-use change and, despite our increasing knowledge, compared to some groups such as plants the information that we have about the distribution of sites and species is far from complete. To help ensure important fungi sites are accounted for in land-use decisions, Natural England is developing the England Grassland Fungi Database with the aim for it to become a publicly accessible tool to aid decisions around land use and to safeguard these important sites.

Grassland fungi are as charismatic as fungi get with their bright colours, slimy textures and scents of honey, cedar and burnt leather. Rich assemblages of these fungi, and, more precisely, what is known as the CHEGD group (an acronym for the Clavarioids (fairy-clubs, corals and spindles), *Hygrocybe* s.l. (waxcaps), *Entoloma* spp. (pink-gills), Geoglossoids (earthtongues) and *Dermoloma* and others (crazed-caps)) are characteristic of undisturbed grasslands (Figure 1).

The autecology of many of these species is still poorly understood and certainly their relationship with plants, mosses and other fungi requires much further research. Much like the well-documented loss of flower-rich grasslands, their low tolerance for high nitrogen levels from fertilisers, along with gross disturbance from cultivation, has led to similar losses of grassland fungi sites over much of the English lowlands. It is not unusual in some lowland counties for some of the most important sites to remain in unfertilised lawns and ancient churchyards. Many of the most extensive sites for grassland fungi are now thought to occur in the uplands, the upland fringes and other marginal lands that are still managed by extensive grazing and traditional hay-cutting.

In these remaining strongholds, both in upland and lowland areas the threat to grassland fungi sites from changing land use and management is increasing due to a shifting economic environment, particularly for farm income.

Alongside the more obvious dangers of development, 'green' policies perhaps pose the greatest threat to grassland fungi. The UK Government's tree-planting target of 30,000 ha per year is expected to disproportionately affect key grassland fungi sites. It is already the case that some recent tree-planting schemes have resulted in the loss of a few important waxcap sites. The risk also remains high for Biodiversity Net Gain and rewilding projects which will focus on similarly marginal land.

The international importance of England's fungi-rich grasslands has only relatively recently been recognised, with the first major assessment by English Nature almost 20 years ago (Evans 2004). Since then, the 2009 and 2018 revisions to the Site of Special Scientific Interest (SSSI) selection guidelines for grassland fungi have been a major step forward to defining the importance of these grasslands in a national context by setting threshold 'scores' for each of the CHEGD group (Table 1; Genney *et al.* 2009, Bosanquet *et al.* 2018). Despite this, grassland fungi continue to be overlooked in conservation planning. The number of protected sites notified for grassland fungi is still a tiny fraction of those that are known to meet the SSSI selection thresholds.

Table 1. Grassland fungi, SSSI selection thresholds and the number of sites identified in the England Grassland Fungi Database (EGFD) meeting the SSSI threshold. Note: recently received datasets are expected to increase these numbers significantly.

CHEGD group, genus or genera	Common name	SSSI threshold score	England sites meeting threshold
Clavarioid fungi	Clubs, corals and spindles	7	79
Hygrocybe s.l.	Waxcaps	19	99
Entoloma s.l.	Pink-gills	15	15
Geoglossoid fungi	Earthtongues	5	15
Dermoloma, Camarophyllopsis, Hodophilus, Porpoloma (*Pseudotricholoma metapodium*)	Crazed-caps, fanvaults and meadow-caps	3	17

Other factors putting grassland fungi sites at risk include poor statuary protection, a lack of taxonomic expertise, short and sporadic fruiting periods making grassland fungi difficult to identify out of season, no obvious associated plant communities and many important fungi sites not being priority habitat grasslands. There is clearly a huge need for accessible and easily understood data for grassland fungi to reduce impact some of these barriers and ensure fungi are accounted for in land-use decisions.

The England Grassland Fungi Database

The catalyst for developing a grassland fungi database was actually plants. Similar issues exist for plants and pressures on open habitats had triggered a need to look at records of vascular plants and habitat correlations. Natural England with the Botanical Society for Britain and Ireland (BSBI) have recently developed a botanical heat map to assess sites of botanical interest, many of which were unknown or for which data was not adequate for proper site evaluation (Walker *et al.* 2022).

For grassland fungi in the CHEGD set a data analysis exercise was carried out to similarly identify grassland fungi sites. Natural England are now developing the England Grassland Fungi Database (EGFD), which is a site-level, GIS-compatible database that can be used to assess the status and location of grassland fungi sites (Figure 2). This will ultimately form a map-based layer available on platforms such as MAGIC (https://magic.defra.gov.uk/magicmap.aspx). This will allow ecologists, foresters, farmers, local authorities and others to both safeguard grassland fungi through better-informed land-use decisions as well as securing management through new agri-environment schemes such as Defra's Environmental Land Management scheme.

The EGFD follows similar grassland fungi databases in Wales and Ireland. Like these, it is underpinned by over 60,000 fungus records from the past 50 years, sourced primarily from the Fungi Records Database of Britain and Ireland (FRDBI; BMS 2022a). The collation, cleaning and standardising of records

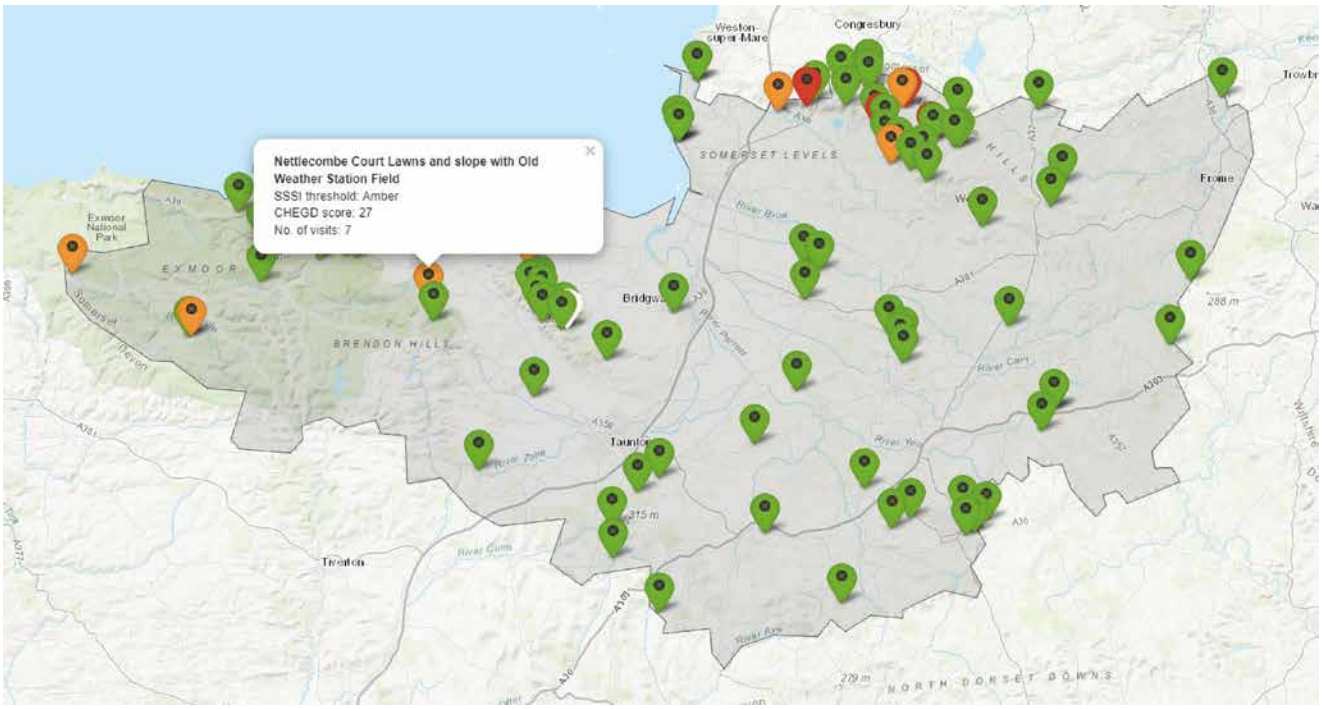

Figure 2. Provisional view of the England Grassland Fungi Database for Somerset. The EGFD is a spatial tool that can be used to identify important sites for CHEGD fungi.

has been mammoth task: duplicates (1159 records), confidential records (34 records) and poorly refenced records (2032 records) have been removed. Missing fields have been in-filled, grid references and site names have been standardised and all records have been given a 'preferred' site name and centroid grid reference.

To aid user interpretation, for each site, with 1 and 10 km grid squares, the EFGD returns CHEGD scores, indicator species (i.e. those indicative of rich fungi sites), number of site visits and whether the SSSI thresholds for each of the CHEGD fungi have been passed. New datasets have already been received from other sources and these will eventually be incorporated into the EGFD. A number of Local Environment Record Centres (e.g. Dorset and Sussex) have contributed data and a number of local fungus groups have provided county records along with the Peak District and Northumberland national parks, and of course social media has proved a useful tool for new records. There is still a lot of work to do, but the EGFD will become increasingly robust.

Caution and interpretation

The EGFD has underscored the importance of England's grassland fungi resource (Box 1). Although the EFGD

Box 1. What we've learned from the EGFD about England's grassland fungi

The EGFD confirms the importance of England's grasslands for fungi in a European context:

- 5867 CHEGD sites were identified (many functionally linked, forming larger aggregated sites)
- 44 sites in the EGFD meet the threshold for international importance for their waxcaps; up from 12 sites in 2004 (Evans 2004; Figure 3)
- 152 sites meet the threshold for SSSI designation in at least one of the CHEGD groups (Table 1)
- 52 sites passed the SSSI threshold for more than one group
- 70% of the sites that meet the SSSI threshold have no protection.

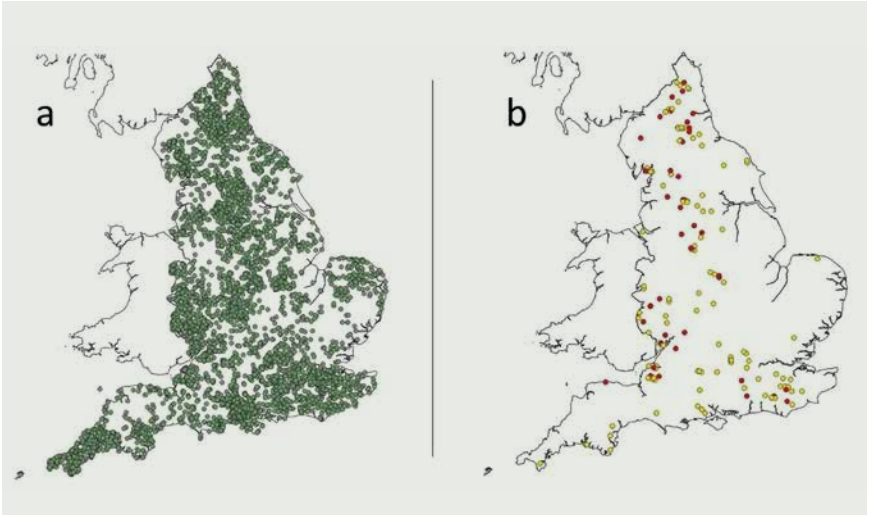

Figure 3. (a) All of England's grassland fungi sites identified through the England Grassland Fungi Database; (b) grassland fungi sites that meet the criteria for national and international (red) and national (yellow) importance.

is the most comprehensive dataset for grassland fungi available it must not be seen as a definitive inventory. Effort has been made to make the data accessible; however, ecological interpretation will always be critical. Biological records are strongly biased by access and location of local experts and reported on an *ad hoc* basis, so there are likely to be a significant number of important sites that remain unrecorded, even in lowland counties.

Many of the best grassland fungi sites have had been visited on multiple occasions, but a surprising finding from the EFGD is that it is not uncommon for nationally important sites to have been visited just once or twice. It is therefore important to survey sites with just a small number of species, especially where there are species indicative of rich grasslands (High Diversity Indicators) such as the pink waxcap, date waxcap, violet coral and big blue pinkgill (Bosanquet *et al.* 2018).

The density of sites across the country is extremely variable. Varying from isolated churchyards to dense upland clusters, however, all exist within a wider ecological network. Interpretation of any site, whether it is on the EGFD or not, needs to be viewed in this context. Moreover, adjacent sites may be indicative of other local sites, particularly in the expansive grasslands of the uplands and its fringe.

Importantly, the EGFD does not replace the need for survey but, like any other biological records, it can help better land-use decisions to be made.

Accessing the EGFD

The aim is for the EGFD to be publicly available in late 2022 via MAGIC. The ambition is that it will be a dynamic tool that is regularly updated with both the existing data sources and new records. We deeply encourage users to record and submit their fungi sightings (Box 2) and actively contribute to safeguarding important fungi sites.

Box 2. Recording grassland fungi

With a finite and unpredictable fruiting period, its important to record grassland fungi whenever they are encountered. This helps to track their conservation status and identify new CHEGD sites. CHEGD fungi will be visible from late summer until Christmas, but the bulk of records in the EGFD of all CHEGD species occurred in October and November so targeting survey effort during this period will maximise records.

Fungi can be difficult to get started with but there are good resources for grassland fungi. The waxcaps are a good place to practice identification with these useful resources:

- Waxcap Identification Support Tool, hosted by Sussex Biodiversity Records Centre (Blencowe 2019)
- Waxcap Key on Aberystwyth University's waxcap website (Griffiths and Easton 2022)
- Plantlife's *Waxcaps and Grassland Fungi. A Guide to Identification and Management* (Plantlife 2013) and their smartphone app, Waxcapp (Plantlife 2022)
- Your local fungus group is a fount of knowledge: the British Mycological Society hosts a list of contacts (BMS 2022b)
- See also other articles in this issue, including What's that fungus? by Nathan Orr (pp. 8–13).

Acknowledgements

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Feature

Dense Rhododendron as a Habitat for Rare and Threatened Bryophytes: Conservation and Management Implications

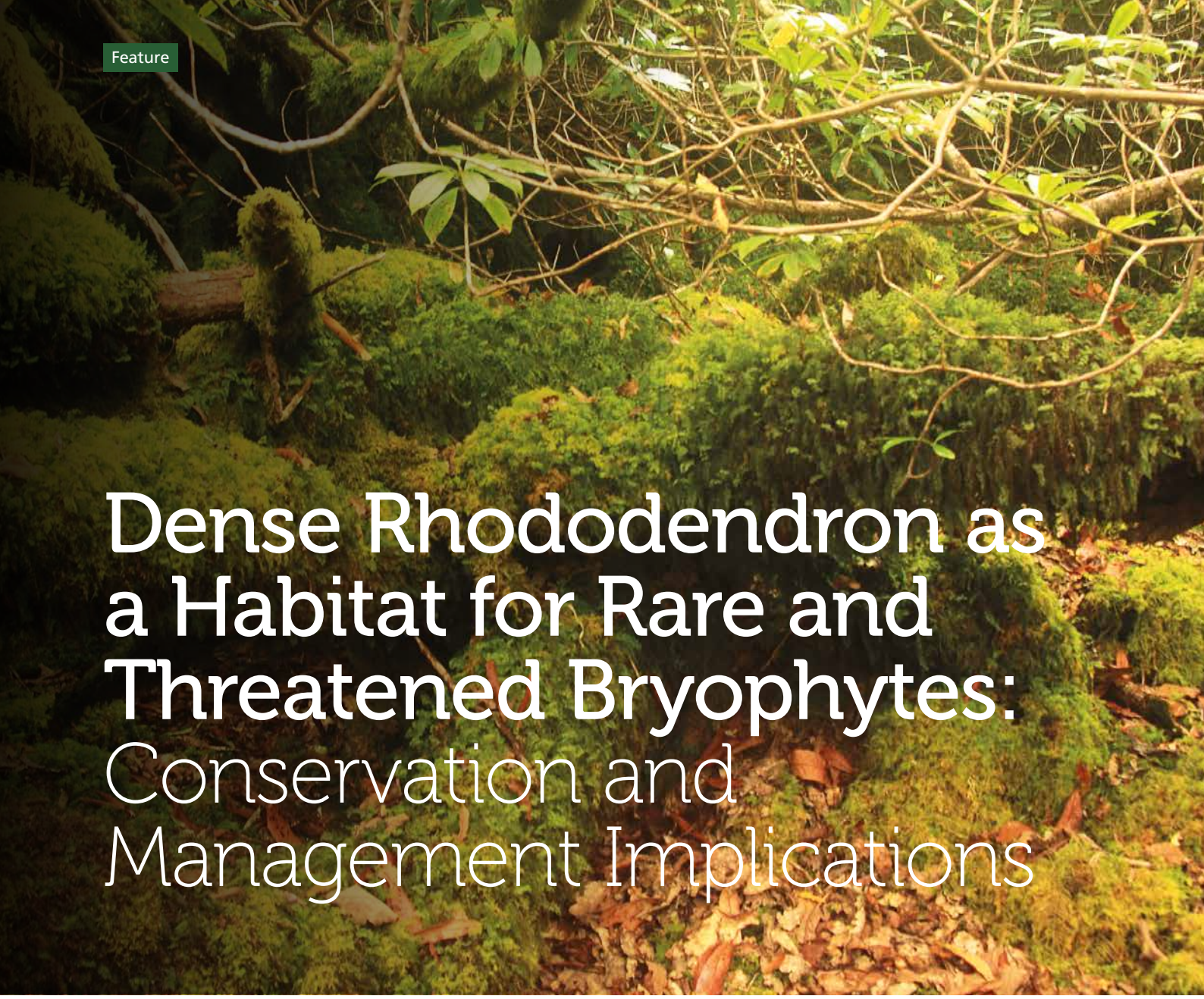

Figure 1. Dense growth of bryophytes and filmy ferns beneath dense rhododendron canopy in County Kerry. Photo credit: Rory Hodd.

Rory Hodd
Nimbosa Ecology

Keywords: bryophytes, invasive species, habitat management, oceanic woodland

Infestation by rhododendron is generally considered to be highly detrimental to vegetation of Atlantic oak woodlands. However, in some instances, perfect conditions exist beneath dense stands of rhododendron for the growth of a range of rare bryophyte (moss and liverwort) species and lush, diverse bryophyte communities thrive in less dense, older stands. This presents a conundrum regarding how to conserve these bryophytes while still effectively controlling the spread of rhododendron.

The rhododendron issue

The non-native shrub rhododendron (*Rhododendron ponticum*) is highly invasive, particularly in Atlantic oak (*Quercus petraea*) woodland in the far west of Ireland and Britain, where it forms dense stands, shading out the ground flora and inhibiting regeneration of natural vegetation. Rhododendron has been present in these islands since the 18th century and, possibly at least partially due to selective breeding and hybridisation, it has become extremely well adapted to the climate. It was widely planted in gardens and as game cover, being sold very cheaply due to its ease of propagation and readiness to set seed (Dehnen-Schmutz and Williamson 2006). It is this ease of germination and

the abundance of seed produced that makes it such a successful coloniser, alongside its ability to thrive in deep shade and, once established, to provide unsuitable conditions for the growth of virtually all other plant species. It can rapidly become very difficult to control at both a site and landscape level and removing an infestation of rhododendron requires drastic and widescale clearance of mature plants, coupled with diligent longer-term management of regeneration.

Rhododendron can spread readily in a range of habitats, including heaths and bogs, but the habitat which provides the most suitable conditions for it to rapidly become established and take over is open, overgrazed woodland with numerous moss patches and dead wood in areas with a mild, humid climate. This has resulted in many highly important stands of Atlantic oak woodland becoming swamped with rhododendron on a massive scale, eliminating most of the ground flora and changing the structure of the woodland, as well as inhibiting regeneration of the key characteristic tree species of this habitat and altering the ecosystem processes of the habitat (Casati *et al.* 2022). These Atlantic oak woodlands are highly fragmented and suffered a huge decline in area to now occupy only very small pockets, and most remaining stands are highly threatened by a combination of overgrazing and infestation by invasive species, primary among these being rhododendron. Therefore, it can be considered that these woodlands are in terminal decline and will be lost as a functioning habitat without urgent and concerted conservation action.

The oceanic bryophyte flora

One of the most important and characteristic elements of Atlantic oak woodland in Ireland and Britain is its bryophyte flora, which is one of the richest bryophyte floras, not only in Europe, but also in the world, with over 200 species of moss and liverwort to be found in many good Atlantic oak woodlands (Rothero 2005). In addition to being highly diverse, in these woodlands bryophytes grow extremely well, forming lush cushions and mats, covering every rock and tree. A high proportion of the bryophytes present in this habitat are what are termed Atlantic bryophytes. These are species that occur mainly along the Atlantic fringe of Europe, where the mild, humid climate with frequent rainfall favours their growth, and are rare or absent in more continental areas. Some of these species show remarkably disjunct distributions, occurring elsewhere thousands of kilometres away and nowhere in the intervening areas.

A suite of species occur elsewhere in the tropics and subtropics, where they can be widespread, but in Europe they are rare and highly restricted. Not only do they require the overarching highly oceanic climatic conditions to survive, they also need ideal microclimatic conditions. Primary among these conditions is high and constant humidity, for which moderate to heavy shade from sunlight and shelter from strong winds is required. Without protection from these factors, drying out would occur and these rare and highly demanding species could not persist. The required conditions are best provided in Atlantic oak woodland and in deep, wooded ravines, where the presence of a river further raises the levels of humidity. Even within the best habitats, the most demanding of these species will only grow in deep shade beneath boulders in close proximity to flowing water, meaning that the niche suitable for their growth is extremely limited. Consequently, the majority of these species are highly restricted in Europe and in some instances are legally protected where they occur, for example on the Irish Flora Protection Order (Hodgetts *et al.* 2015).

Bryophytes and rhododendron

In general, studies have shown that the invasion of Atlantic oak woodlands by rhododendron has a smaller impact on the bryophyte flora than it has on the vascular plant flora. It has been found that, while a decline in cover of bryophytes is observed due to rhododendron invasion, species diversity does not decrease and species richness is maintained. Furthermore, once clearance has occurred, a novel bryophyte-dominated community becomes established in cleared areas of woodland, while the vascular flora struggles to return due to a depleted seedbank (Maclean *et al.* 2018). It was also found that epiphytic bryophyte communities, which contain a number of rare species, recovered quickly after clearance (Maclean *et al.* 2017).

These results would suggest that rhododendron invasion and clearance has a negligible impact on the bryophyte communities of these woodlands, and that invasion followed by clearance is advantageous and increases their abundance and diversity in the medium term, leading to a relatively stable bryophyte-dominated community becoming established. However, although this post-clearance community may have an overall high cover and diversity of bryophytes present, the majority of cover is likely to consist of relatively widespread bryophytes, at least in a local context, and conditions are likely to be too open and lacking in humidity to support populations of the rarest and most shade-demanding species. Therefore, the species composition and structure of the community present post-clearance is likely to be significantly different from that which would occur beneath dense rhododendron prior to clearance.

Detailed observations over the past decade of the bryophytes present within areas dominated by mature rhododendron in south-western and western Ireland have revealed that it provides an important habitat for a range of rare bryophytes, which elsewhere within their native range in Europe grow as small populations in a very limited niche. Primary among these species is the liverwort *Cephalozia crassifolia* (Figure 2). This liverwort is found outside of Ireland only in Spain (very rarely), the Azores, Madeira, the Caribbean and Central and South America (Blockeel *et al.* 2014). In these places, it would typically grow in the dense, humid shade of evergreen tropical and subtropical forest, such as the Laurosilva of the Azores and Madeira. This species does not occur in Britain, and in Ireland it is very restricted, occurring only in 10 sites, of which nearly all are on humic soil under the shade of dense rhododendron, or were until recently. The other populations are very small and restricted to deep crevices in oak woodland (Hodd 2015a, 2015b).

The core of *C. crassifolia*'s range is in County Kerry and all of the outlying populations occur beneath dense, mature rhododendron, including one in County Tipperary, which is far to the east of where this species would be expected to occur, as climatic conditions would not be suitably oceanic for its growth, without the extra shade and humidity provided by the dense rhododendron. In its core area of occurrence in Kerry, some populations beneath rhododendron are extensive, although it is impossible to determine the precise extent of the population present, due to the impenetrability of the dense rhododendron. It can be concluded that the spread of this species has been facilitated by the spread of rhododendron, and that it is likely that without rhododendron it would be far rarer and restricted to a small handful of sites in small quantity.

Figure 2. The rare liverwort *Cephalozia crassifolia*, which grows primarily beneath rhododendron in its Irish sites. Photo credit: Claire Halpin.

Another liverwort species that has benefited from the spread of rhododendron is *Teleranea europaea*. Endemic to Europea and Macaronesia, in these islands it occurs along the west coast of Ireland and in isolated sites in Cornwall and North Wales. Similar to *C. crassifolia*, it occurs at most sites beneath dense rhododendron on humic soil, where it can form large mats. It was only recently discovered in North Wales, in an area that had been cleared of rhododendron in the past two decades. The small patch which was discovered is likely to be the relict of a larger population and it is not clear whether it will persist at its current location without the shade formerly provided by rhododendron (Watling 2013). It seems likely that further populations of this species occurred in North Wales but were lost when rhododendron was cleared, without ever being recorded by bryologists. It is impossible to know whether this species ever occurred in more natural habitat in Wales, or whether it is a more recent colonist from Ireland, which took advantage of the ideal conditions provided by dense rhododendron.

Aside from these species that have greatly benefited from the spread of rhododendron, a range of other rare oceanic liverworts and mosses grow well under rhododendron and have spread into niches that they could not survive in without the dense shade provided by rhododendron, such as on the woodland floor. A relatively brief exploration along the fringes of possibly the largest and one of the most long-established areas of rhododendron in Ireland, in County Kerry, revealed a rich diversity of bryophytes, including many rare species (Hodd 2020). Records collected during this and other explorations of this extensive rhododendron-dominated area include at least 23 species of bryophyte that are either listed as Threatened by the Red List of Irish bryophytes (Lockhart *et al.* 2012) or as Nationally Rare or Scarce in Ireland (Hodgetts and Lockhart 2013). Additionally, five species legally protected on the Flora Protection Order have been recorded from this area of dense rhododendron.

In parts of this area, where the rhododendron may be up to 150 years old, there is less of a dense tangle of branches and the structure of the canopy is slightly more open, which allows a rich carpet of bryophytes to grow, alongside dense weft of filmy ferns (*Hymenophyllum* spp.), on both the rocks and the rhododendron branches. Species grow here on the relatively open woodland floor that typically would only grow in caves by water otherwise, such as the moss *Cyclodictyon laetevirens* (Figure 3).

Both the gametophyte and young sporophyte of the Killarney fern (*Trichomanes speciosum*), recently derived from gametophyte, were found in this area, and are likely to form an established mature sporophyte colony in time. Mature sporophyte may also be present elsewhere in the large portion of this mostly impenetrable area that remains unexplored. At a number of sites, both rhododendron and its fellow invasive species cherry laurel (*Prunus laurocerasus*) provide essential shade for sporophyte and gametophyte colonies of Killarney fern. Considering the size of the area covered by dense rhododendron, and the extreme difficulty involved in navigating through it, many other populations of rare bryophytes almost certainly remain, as yet, undetected beneath dense rhododendron both at this site and at other similar sites across Ireland and Britain. It is also highly likely that many populations of rare bryophytes have been unknowingly lost as a result of rhododendron clearance in the past.

Conservation and management considerations

The presence of these bryophyte species and communities presents a potential conundrum when it comes to management and eradication of rhododendron from infested

Figure 3. The moss *Cyclodictyon laetevirens*, which is usually restricted to damp caves and crevices, but is able to grow on the open woodland floor beneath rhododendron. Photo credit: Rory Hodd.

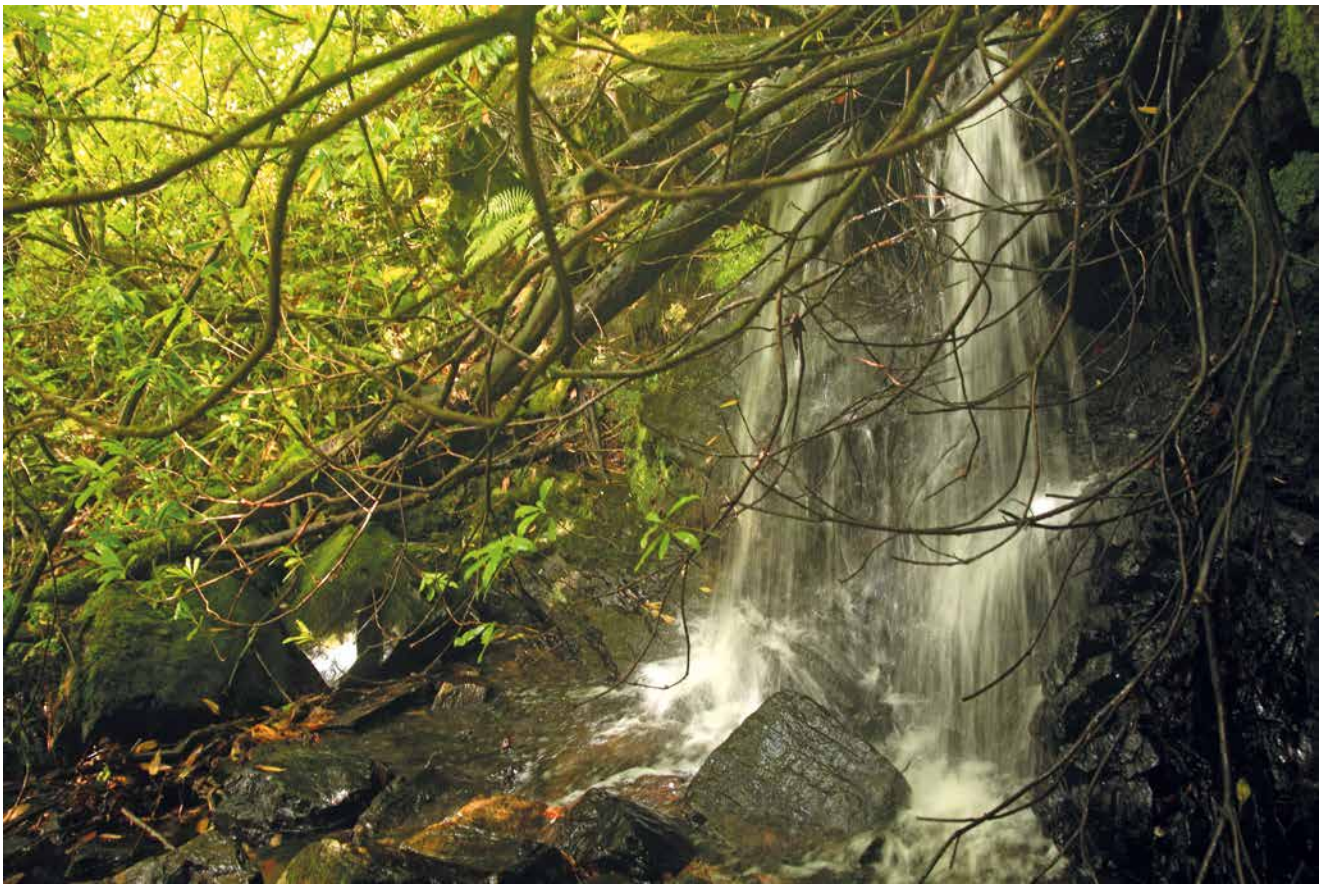

Figure 4. Habitat of the rare and protected liverwort *Lejeunea hibernica*, by a waterfall in dense rhododendron, County Kerry. Photo credit: Rory Hodd.

Atlantic oak woodland. Indiscriminate eradication of rhododendron is likely to result in the loss of populations of rare and threatened bryophytes and cause extensive damage to the bryophyte communities that have developed in the deep shade. Although these areas still remain important for many bryophyte species post-clearance, the composition is likely to change and many of the populations of rarer species will be damaged and lost. Evidence of damage to populations of rare species due to clearance has been seen at a site in County Kerry, where scattered depauperate shoots of *Cephalozia crassifolia* were discovered among other moribund bryophytes and algae in an area relatively recently cleared of dense rhododendron (Hodd 2015a). It is highly unlikely that the remaining shoots will survive at this location in the future as it is now unsuitable for the growth of this species. The question is whether this is a necessary sacrifice for the greater good of the habitat, or if it is possible to conserve these species and communities while simultaneously halting the spread of rhododendron.

While it is difficult to make an argument for retaining stands of dense rhododendron, even those which are important for rare bryophytes, indiscriminately clearing these areas without taking the bryophytes present into account would be a great mistake. Although any individual species or group of species may be of lesser importance than the functioning of the ecosystem as a whole, individually these bryophytes are among the rarest and most remarkable species which occur in these areas. As they occur at a scale below what most people pay attention to, the needs of bryophytes are often overlooked when taking conservation action. As a minimum, specialist surveys should be undertaken of well-established dense rhododendron, prior to clearance, in areas that are important for bryophytes, especially where humid ravines and rockfaces occur, to establish what stands to be lost. If important bryophytes are present in an area due to be cleared, measures should be devised to minimise disturbance to these populations and retain conditions of shade and humidity to allow them to survive into the future. Research has not been carried out into how this may best be done, but perhaps artificial shade could be put in place until shade levels from regeneration of native vegetation are sufficient to create suitable conditions for these species to survive free from human intervention. Translocation of populations of rare species to suitable areas of habitat free from rhododendron infestation may also be an option, although this is untested and may have a low success rate due to the highly specific requirements and sensitivity of the species involved.

Conclusion

Further thought and discussion is needed on this topic. Conservation measures should undoubtedly focus on restoring the remaining fragments of Atlantic oak woodland to a fully functioning and thriving ecosystem and facilitating its expansion across areas from which it has been lost. However, while endeavouring to achieve this, the rarest species of this habitat should not be unwittingly lost, even if their presence in many sites is due to the novel conditions provided by dense rhododendron growth. In the current situation of rapid biodiversity decline and habitat loss, where virtually all habitats are heavily impacted by human actions, it is of utmost importance to do everything than can be done to retain as much biodiversity as possible, a task that is often not straightforward or simple and requires careful thought about a range of elements.

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Blithe Spirit: Are Skylarks Being Overlooked in Impact Assessment?

Figure 1. Skylark, *Alauda arvensis*, in flight. Photo credit: Keith Williams.

Harry Fox MCIEEM
Clarkson and Woods

Keywords: arable farmland, bird mitigation, ground nesting birds, set-aside

In the absence of guidance, potential effects of development on ground-nesting birds (GNBs) of open habitats are being overlooked, with mitigation often being arbitrarily formulated. This article focuses on skylarks *Alauda arvensis* to encourage a re-examination and discussion of assessment and mitigation best practice for GNBs of conservation concern.

Introduction

The spiralling song of the skylark is so embedded in the national psyche that for many, it embodies much of the British landscape. The likely UK population is around 1.5 million pairs, less than half of what it was in the early 1980s (https://app.bto.org/birdtrends/species.jsp?s=skyla&year=2018). The steady decline of the skylark population since the 1970s due to agricultural intensification and habitat loss is well documented and has led to their inclusion on the IUCN Red List, as well as being Priority Species throughout the UK. Indeed, the species is emblematic of the general decline in populations of many farmland birds, especially ground-nesting birds (GNBs) of open habitats, including lapwing *Vanellus vanellus*, yellow wagtail *Motacilla flava* and grey partridge *Perdix perdix*. Yet despite the publicity, and their capability of being material considerations in the planning process, it appears that skylarks and other GNBs are often undervalued – or simply missed altogether – in ecological assessments. Furthermore, where mitigation *is* recommended, are we sure that it is based on an ecologically sound rationale?

The highest densities of skylarks occur in upland and coastal regions and the arable heartlands of the east of England. Here, and in Northern Ireland, are the scenes of the greatest losses of skylarks in recent decades (Figure 2). The Centre for Ecology and Hydrology reported in 2020 that some 768,000 ha of

grassland (including arable) were lost mostly to urban development and woodland planting between 1990 and 2015. Around 1–2% of greenbelt land is developed annually according to the Office for National Statistics, with the Government pledging to build a further 300,000 new homes per year. In a bid to tackle climate change and energy security, the Government has suggested the UK's solar energy generation capacity could grow five-fold to 70 GW and pledged a surge in support for onshore wind energy. While the fortunes of GNBs may be dramatically influenced by changes in agricultural policy, piecemeal developments have the potential to exacerbate local declines and place greater pressure on remaining habitats to absorb displaced birds.

Having examined publicly available Ecological Impact Assessments of developments on land supporting skylark territories, it would appear there is an inconsistency in understanding of not only skylark ecology, but opinion on what might constitute an impact, and what mitigation could be employed. This is likely to be the case for other GNBs but is understandable given the scant guidance on impact assessment for birds. Advice on the issue given to clients by different consultants varies wildly. This situation risks undermining the industry and creating a 'race to the bottom' where potentially ecologically harmful advice becomes prevalent.

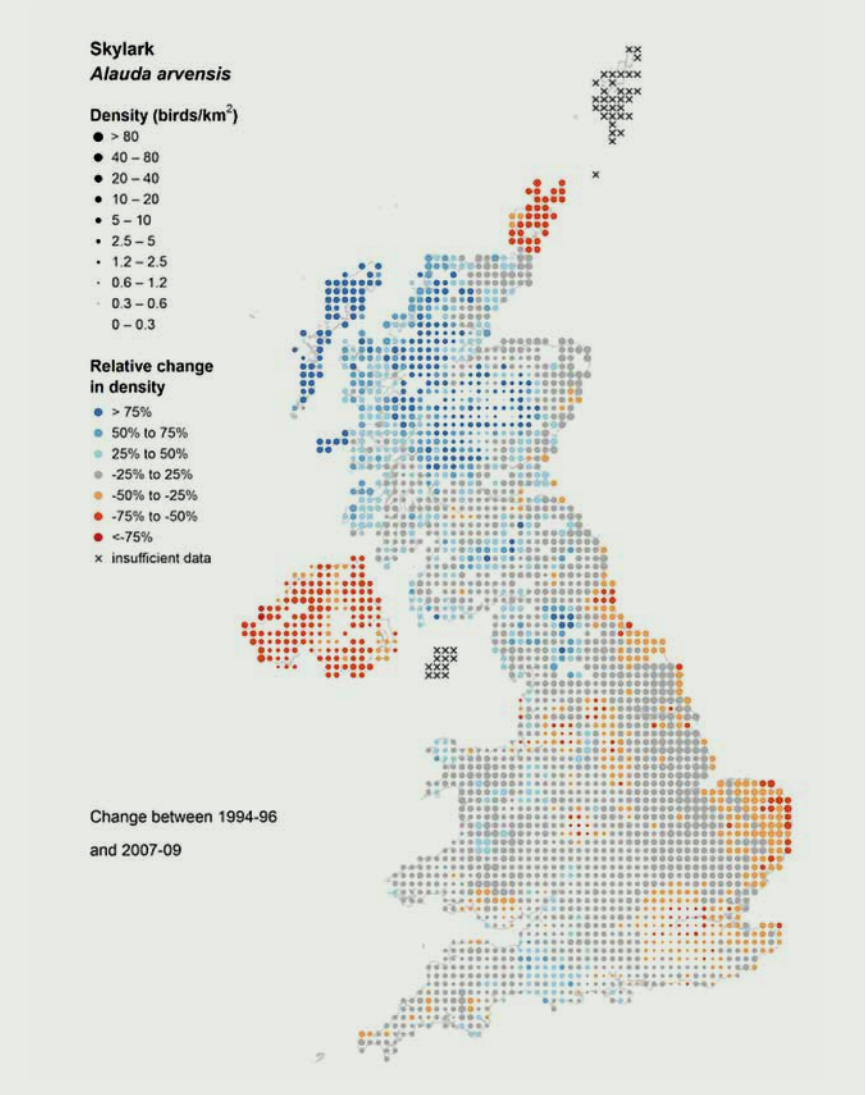

Figure 2. Skylark population change between 1994–96 and 2007–9. Data from the British Trust for Ornithology.

Skylark ecology

Skylarks have evolved to rely on secrecy and vigilance to avoid predation. Edge habitats are used by predators for hunting and cover (Donald 2004), so when selecting nest sites, skylarks require long, unbroken sightlines (Wilson *et al.* 1997). Tall structures such as trees, buildings or tall hedgerows all cause even optimal habitat to be avoided (Donald *et al.* 2001), unless the field area is particularly large (Whittingham *et al.* 2003). One study estimated the effect of dissuasion by tall structures to span approximately 200 m (Oelke 1968).

The height and density of vegetation for nesting is important because access to the ground, for moving through the vegetation back to nests, needs to be sufficiently free. Consequently, skylarks have a clear preference for vegetation height of between 20 and 60 cm, although taller crops such as linseed and rapeseed can be tolerated where the vegetation is less dense at ground level (Toepfer and Stubbe 2001).

Figure 3. Skylark nest. Photo credit: Hannah Montag.

In optimal habitat, skylarks can have up to four broods per year. The number of nesting attempts a pair is able to make each year is a strong indicator of the stability of a skylark population (Donald 2004). As arable farmland is typified by 'winter cereals' (where the next crop is sown shortly after the summer harvest), the head start that crops receive over traditional spring sowing often precludes a third – or even a second – brood as they overtop 60 cm sooner (Donald and Vickery 2000). Additionally, taller vegetation forces birds to nest closer to tramlines, thereby increasing predation rates (Morris and Gilroy

2008), while more spraying and an earlier harvest together cause significant nest mortality. The loss of spring cereals alone has been said to account for the majority of change in skylark population in the last 30 years (Donald 2004).

While chicks are almost exclusively fed on invertebrates, adult birds also feed on seeds, grains and leaf shoots. As grassland habitats are usually less productive for invertebrates than for example, woodland, skylarks nest at comparatively lower densities than many other songbirds. Table 1 shows the relative densities of skylarks foraging in different agricultural habitats. The greatest densities are in unimproved grasslands and heaths, but in an agricultural setting, set-aside and fallow (where weeds encroach) is best (Poulsen *et al.* 1998). Pasture and other improved grassland usually supports the very lowest densities of skylarks on farmland (Donald 2004).

Development impacts

On a typical housing or solar scheme, it is difficult to see how potential displacement impacts on skylarks can be overlooked. Even with the inclusion of amenity grassland, easements or buffers of retained habitats are likely to be incompatible with the requirements of nesting skylarks, unless very large, undisturbed and managed to promote invertebrates. For example, in preparing this article, no conclusive records of skylark nests within an active solar array were found. This includes data derived from the post-construction monitoring of over 100 solar installations in England and Wales by our company and from observations from associates in the industry.

Male skylarks are frequently observed advertising territories over solar arrays. However, singing is not a conclusive indicator of a viable nest. Skylarks, like many other birds, exhibit strong nest-site fidelity (Donald 2004) and results from one well-established 60 ha solar site that we monitor showed that numbers of singing birds waned following construction from a peak of seven in 2015 to zero in 2020 and 2021.

Skylarks have, however, been recorded many times foraging within solar arrays and even feeding recently fledged young. Fledglings can disperse considerable distances from their nests in just a few days and continue to be fed by parent birds for between 8 and 12 days after fledging (Donald 2004), so this behaviour alone may not be considered evidence of nesting on site. It is possible, therefore, that development sites with suitable grassland might even provide 'nursery' habitat where nesting takes place on adjacent farmland.

The fate of displaced skylarks is unclear. As ecologists we will need to decide the likely significance of effects and whether mitigation should be considered. This decision will be informed by the number of territories displaced versus retained, any wider habitat fragmentation, the habitat type and territory density on surrounding land and the management of any retained or created habitat.

Considering the above, if the carrying capacity of neighbouring habitat allows, some degree of 'absorption' into the surroundings is theoretically possible. Where sites are in proximity to heaths, moorland or coastal grassland this may be more likely. However, in intensive arable landscapes, this is less so and an acceleration of a decline of local breeding success is possible, especially in combination with other development.

Options for mitigation

Their specific nesting requirements mean that effective compensation for skylark displacement requires either the provision of newly available habitat or the enhancement of existing habitat. Habitat enhancement could be designed to increase either the carrying capacity within mitigation land (thereby hosting displaced pairs) or the breeding success of pairs already present.

Arable sward-diversification measures which have been trialled with success for GNB enhancement include 'beetle banks', wider uncultivated margins and increased numbers of tramlines. While margins may be less likely to host actual nest sites, they are often incorporated into territories to exploit the foraging habitat they support and reduce the distance flown per foraging bout (Wilson *et al.* 1997, Donald 2004).

Perhaps the most familiar enhancement is the inclusion of 'skylark plots' within neighbouring arable land. Developed

Table 1. Example skylark territory densities according to habitat type and management. Adapted from Donald (2004) with additional data from research in References.

Habitat	Average density per hectare
Coastal marshes	0.76
Organic set-aside	0.56
Heath and steppe	0.56
Spring cereals	0.46
Set-aside/fallow	0.39
Organic cereals	0.38
Organic winter cereals	0.36
Intensive set-aside	0.36
Arable farmland	0.28
Rootcrops	0.27
Natural grassland	0.27
Moorland	0.26
Winter cereals	0.23
Mixed farmland	0.23
Organic silage	0.22
Pastoral farmland	0.18
Intensive cereals	0.17
Intensive winter cereals	0.15
Legumes	0.12
Oilseed	0.12
Organic grazed pasture	0.1
Brassicas	0.1
Intensive silage	0.08
Orchards	0.07
Rough grazing	0.06
Improved grassland	0.05
Intensive grazed pasture	0.02

by the RSPB in the 1990s, skylark plots are small (approx. 5 × 5 m) patches of undrilled land within arable fields created by turning off the seed drill momentarily at a rate of two per hectare. Plots are not designed to provide nest locations; rather, once colonised by weeds, they act as oases for invertebrates upon which birds can feed, increasing prey accessibility by opening up the sward. Several studies indicate success of plots in increasing territory densities, especially later in the season as the sward rises (Ogilvy *et al.* 2006).

It is common to see ecologists propose a basic metric such as two plots for each skylark territory displaced. It is not clear how this is decided upon and appears to confuse the 2 plots/ha rate of RSPB farmland management advice with a suggested rate per displaced territory. Territory densities in cereal crops vary between approximately 0.1 and 0.4 territories/ha (Donald 2004), increasing up to 0.8/ha with plots, so it is highly unlikely that 1 ha with plots would be able to support an additional displaced territory. We therefore argue against using this rate.

More recent research suggests confounding effects of plots on breeding success. An increase in predation has been shown in fields with plots (especially alongside aforementioned sward-diversification measures which create 'edges'; Morris and Gilroy 2008). Other studies fail to show significant benefits from incorporating plots, possibly due to poor colonisation by weeds, or increased pesticide overspray (Smith *et al.* 2009, Field *et al.* 2010). It is clear that the use of plots must be carefully judged and be just one of several options used, although not in the same fields.

The reversion to traditional spring-sown regimes with retention of winter stubbles provides a longer nesting season and better winter forage (Donald 2004). This is perhaps the best conventional arable management for skylarks, while set-aside and fallow are also excellent habitats (Poulsen *et al.* 1998), with organic farming showing further benefits, owing to reduced pesticide use and slower growing varieties.

An alternative mitigation metric

In the absence of other guidance, an alternative metric is presented that promotes optimal off-site compensation based on research into territory densities across different habitat types. The following method determines the amount of land which, when managed or enhanced accordingly, should accommodate a desired number of displaced skylark territories.

1. Use survey data to quantify the number of breeding territories in the development footprint. Example: 20 territories.
2. Calculate the density of territories across all skylark-suitable habitat to be impacted (the 'donor' site). Example: 20 territories/100 ha site = 0.2 territories/ha.
3. Decide on the number of territories to be compensated.
    a. It may be appropriate to discuss 100% compensation with your client as a worst-case scenario. Depending on the balance of other likely ecological impacts and benefits, there may be an 'acceptable' number of un-compensated displaced territories. Ultimately, this will be a professional judgement call based on site and development specifics.
    b. Other ecological effects inherent in the proposals may allow for a reduction in the need for compensation. For example, where the development site will retain or create sufficient grassland *foraging* habitat for skylarks, territories close to the edges of the development may benefit through increased breeding productivity. For example, we might assume that 50% of on-site territories occurring within 75 m of the development edge may not need to be compensated when suitable foraging land will be present on site, provided *sufficient nesting habitat is present on adjacent land to absorb them*. Example: eight on-site territories within 75 m of development boundary; 50% × 8 = 4 so 20 territories to be compensated becomes 16.
    c. If sufficiently open habitat is retained within proposals, or where there is an abundance of suitable habitat nearby which is likely to be below carrying capacity for GNBs, some absorption may theoretically reduce this further. However, caution should be exercised, and this effect may require baseline survey evidence.
    d. Cumulative impacts due to other development in proximity to donor and receptor sites should be examined, potentially raising compensation requirements.

Figure 4. Skylark on the ground. Photo credit: Keith Williams.

4. Determine the baseline territory density at the receptor site either from site survey or referencing research-based figures by crop type/land use (e.g. Table 1). If the habitat is sufficiently similar to the 'donor site', it may be more appropriate to apply the figure calculated in step 2.
5. Calculate the net change in territory density possible at a receptor site before and after enhancement.
   a. Determine the theoretical territory density achievable through a positive change in management at the receptor site (see Table 1). Example: 0.56 territories/ha in set-aside.
   b. From this, subtract the actual (surveyed) or assumed (Table 1/step 2) receptor baseline. Example: 0.56 – 0.2 = 0.36.
6. Divide the number of territories to be compensated by the net density change figure (step 5b) to give the number of hectares to be positively managed to accommodate displaced territories. For example, 12/0.36 = 44.4 ha.

Candidate receptor fields should feature low (<2 m high) boundary features, no buildings and a short axis of >200 m. The more ambitious the proposed habitat enhancement (e.g. grazed pasture to set-aside), the less receptor land required. In the absence of grassland creation or arable de-intensification, this calculation could at least indicate the area over which measures such as skylark plots, margins, headlands, etc., should be adopted. The management prescriptions on farmed receptor sites resemble familiar agri-environment scheme options and would cause a slight reduction in agricultural productivity. The concept of reimbursement for income foregone is well-established and serves as a useful starting point for discussion with landowners. Agreements may need to build in a degree of crop rotation within the landholding. Compensatory management should be secured in the long term and be accompanied by a degree of monitoring to further understanding of development impacts and mitigation effectiveness.

Conclusions

The prototype methodology given here is not perfect, makes several assumptions and is as yet without monitoring data. However, it is anticipated to provide a starting point for discussion on GNB mitigation. Hopefully, potential impacts on GNBs can be better anticipated and considered within impact assessment. We look forward to hearing the opinions of other ecologists and researchers on the severity or otherwise of development upon GNBs and the potential for successful mitigation, including refinements to data in Table 1. We would like to see the development of a forum on bird mitigation for use by practitioners, with examples and resources. In time, this should improve the general understanding of bird ecology among ecologists and result in more consistency.

Since GNBs require a lot of space, it is unsurprising that these calculations often indicate large compensation areas might be required. Clearly, this is likely to result in difficult conversations with clients where previously none may have taken place. In our opinion, this only serves to reinforce the need for more scrutiny of the issue by the industry, and more widely by policy-makers.

On development projects, the onus is typically placed on developers or agents to source receptor sites, negotiate management contracts and ensure monitoring is undertaken. Often, this can lead to poor outcomes for wildlife with the breakdown of agreements or lack of follow-up, continuity of personnel or enforcement. Perhaps there is an opportunity to integrate compensation with targets under schemes such as the proposed Environmental Land Management programme? Or alternatively, a system for brokering ecological mitigation between developers and land managers along the lines of that carried out through district-level licensing or natural capital marketplaces. The reversion of relatively small areas of intensive farmland to traditional, low-intensity management with the inclusion of set-aside and wide headlands and winter stubbles could contribute meaningfully to net gain and Nature Recovery targets.

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Burdens Not Gain: Have we all Missed a Trick?

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Keywords: BNG burdens, LPA resources, private market, public sector

This viewpoint is about Biodiversity Net Gain, whether we have confidence the private market will deliver a long-lasting public good and whether we are introducing new legislation without the appropriate resources to implement it properly within the planning function of local councils. Trying to introduce new burdens without sufficient resources is also likely to manifest itself through lower job satisfaction for existing and future planning ecologists. Indeed, I have recently found my own mental and physical health being challenged.

Background

For the past 10 years I have been the Planning Ecologist for Leeds City Council. In my local planning authority (LPA) I'm the 'Nature Team'. When commenting on a planning application that is what the public see, and they may think there are several officers like me. I'm not full-time and sit alongside three Tree Officers, three Building Conservation Officers, three Landscape Architects and a bigger team of Urban Design officers and Contaminated Land officers. In this context, alongside those other disciplines, it's clear our 'Nature Team' needs to grow a bit.

Recently I've been pre-occupied with Biodiversity Net Gain (BNG), bringing planning and legal officers up to speed with this new way

of measuring biodiversity and the changing expectations of developers. I've written guidance for our website and made sure ecological consultants active in my area are aware of it. I've given presentations and training, and written board papers and reports for heads of service, directors and the Chief Executive, many of whom I had never really spoken to previously. I have suddenly become popular at planning panel meetings where I explain to decision-making local councillors what BNG is and encourage support for off-site delivery of biodiversity. I've been a very good advocate for BNG so far, and it has not become mandatory yet.

The reality of implementing BNG for an LPA

I wonder why I have been putting this pressure on myself to get BNG moving forward so quickly. For many years, people in my role have been trying hard to push developers to go the extra mile, while knowing that we don't have legislation or the measuring tools to back us up. The Environment Act 2021 has perhaps given me the courage to push BNG higher up the agenda. It is a once-in-a-lifetime opportunity to join biodiversity and planning in a meaningful way, so planning ecologists across England should be happy and optimistic, shouldn't they?

I've spent time learning about BNG, reading the primary and secondary legislation and guidance. It's all about the words and nuances of those words. As a planning agent once said to me, *"it's all very well asking us to do something, but if it's not in legislation or policy we don't have to"*. Words are the planning ecologist's main tool. So far I have kept on top of those words and the intentions behind them.

Some things have changed for the better: we now have the measuring tool for biodiversity habitats in the planning system. Previously, it was all about subjective values and negotiation. You won some, but lost often. Or, you won but then, years later (after the developer had moved on), wander around a new housing development or off-site piece of land and realise that the appropriate management is not happening, gardens have extended on to greenspace, the local residents' committee has changed how the land should be managed or land to be used for biodiversity has been sold off to a local private developer or farmer. Let's not even mention the monitoring reports that should have been submitted annually. Implementation, monitoring and enforcement are all words that are meaningful to me, and none seem to happen enough for biodiversity.

My role has always involved the first two 'R's (reading surveys and writing consultation responses) but now planning ecologists need to become biodiversity accountants and know the third 'R' of the Defra Biodiversity Metric's maths really well. Through the Environment Act, local authorities are expected to become the 'BNG police'. This new regulatory role for biodiversity means LPAs need to be fully conversant in *four* 'R's, namely reading, writing, arithmetic and, now, regulation. I'm hoping my role does not evolve into purely looking at numbers and top-down regulation and reporting (a fifth 'R'?), as this would be a bit sad.

I've done the maths for the LPA where I work (which has approximately 1200 major and minor planning applications annually) and we would need an additional £320,000 annually to employ an eight-person BNG team spread across planning, enforcement, legal, GIS and validation to implement BNG successfully. We currently have no way of covering these new regulation and reporting costs through contributions from developers. The developers will already be purchasing off-site biodiversity units from private habitat banks/brokers so that any additional financial demands from the council will not affect their economic viability.

An alternative future for BNG

I hope BNG does change the way biodiversity is delivered, but it does feel like we may all have missed a trick. Imagine for a moment if BNG worked like this: Natural England are the sole point of contact for developers to purchase biodiversity units from. The cost of those biodiversity units across England varies and is based on average land prices for each of the 333 LPAs.

Using the Defra Metric to measure on-site impacts, the residual number of biodiversity units is calculated to achieve

> **"People in my role pushed developers to go the extra mile for BNG, while knowing we don't have the legislation or measuring tools to back us up."**

the 10% gain target (as per now). The developer must buy the corresponding shortfall in biodiversity units from Natural England as a biodiversity tax (not from a private habitat bank). Natural England uses some of the money to cover its own running costs and then works with a nationally recognised habitat delivery partner (with a proven ecological track record, such as the RSPB or Wildlife Trusts) to purchase land in the same LPA area where the development impacts arose.

This off-site land would then be managed as a nature reserve in perpetuity, with carefully designed areas where the public can and can't go. Success could simply be measured in physical area of new nature reserves: this could remove a lot of the costs and concerns about condition assessments and monitoring through the Metric for those off-site areas.

We could declare a national Local Nature Reserve revolution, going beyond those targets first set by John Box and Carolyn Harrison in their excellent accessible natural greenspace standards work (Box and Harrison 1993). What about 10 ha of Local Nature Reserve per 1000 population, or even 100 ha per 1000 population? We are in danger of people only knowing the LNR acronym to mean Local Nature Recovery Strategies rather than the very thing that could instead be the focus of most nature conservation work in England.

I would support BNG more readily if it had a vision of a new network of nature reserves across every LPA, and also new national nature reserves (or extensions to existing ones). This vision of getting developers to pay for new nature reserves near to where people live would hit so many Government targets in the 25 Year Environment Plan and the Lawton review (Lawton 2010). Instead, will the current BNG proposals of relying on the private market really deliver a vision of long-lasting 'nature nearby' (Natural England 2010)?

In Leeds (before BNG kicked in) we worked with the RSPB to create a new 400 ha wetland nature reserve on a former minerals site, St Aidan's. There are areas where the public can go, and where they can't go. After just a few years there are enough pairs of breeding black-necked grebes (*Podiceps nigricollis*) to justify Site of Special Scientific Interest status and Eurasian bitterns (*Botaurus stellaris*) can also be heard booming.

My vision for off-site BNG would also focus on investment for local wildlife sites (LWSs), improving their management and size. In Leeds we get asked every year by Defra to report on the area of LWSs under positive management (which is a national indicator called SDL160). But here in Leeds we do not have resources to measure this, even though we agree it is potentially a good indicator of biodiversity. BNG could be a source of funding for investment in LWSs and employment of officers to give positive land management advice to private landowners.

The current 'vision': using the private sector

I'm not sure what the national 'vision' really is for BNG, one that we can all get behind. It has a definition that we know off by heart, but it seems like the current vision is to take money from the private development sector and invest it in another part of the private sector to deliver biodiversity. The public sector regulates the whole thing under legislation with no properly considered level of income to cover the additional costs.

It seems we are creating a complex, new landscape of private habitat banks and brokers, as well as companies selling digital recording and reporting software to LPAs for monitoring who sells what, when, where and how often. Do we really have the confidence that we can keep tabs on and control all this data, and do it in a way that allows biodiversity to win? I'm not sure I'd want to be in charge of that particular job, or even be a small part of it.

I hope the private market can deliver public goods that include biodiversity but I fear the vast majority of landowners involved in BNG are doing it for the promise of financial returns.

It will also be interesting to see how LPAs interact with BNG if they are simply expected to regulate something that benefits and is delivered by the private sector. There may be differing ideological beliefs in this working relationship unless there is an openly shared vision.

Those old enough to remember the privatisation of British Rail and various utility companies in the 1980s will understand that we moved from knowing who ran our trains or provided our gas or phone line to today's many different private companies clamouring for our custom. Have market forces really led to better service and kept the prices down? Maybe in the future legislation will be required to re-nationalise our BNG.

I can see my own role moving to one of regulation, regulation and more regulation (with some frustration thrown in when enforcement resources are stretched beyond breaking point). Personally, I have started to feel the burden of BNG weighing on my own health as I acknowledge that my expectations about BNG and the reality are mismatched. I must be prone to a new form of health anxiety that I've named 'BNG-related stress'. I've never previously had counselling, but with the help of my therapist I have now recognised this condition. I may consider changing jobs at some point to set up a counselling service offering help to other LPA ecologists also suffering from BNG-related stress.

Final word

Before I sent this article to *In Practice*, I wasn't sure which readers it would speak to. I wrote it during unexpected time off work during which time I was experiencing chest pains. At one point it was nearly a resignation note to my employer – *"Can I still find aspects of my job to enjoy in a world of number crunching and regulation?"* Maybe it's a helpful nod to my Association of Local Government Ecologists colleagues in other LPAs across England: you are not alone and BNG-related stress is a real condition. Or perhaps the audience is the private habitat banks/brokers to encourage them to deliver off-site BNG through a new network of Local Nature Reserves and improving LWSs. Or maybe the civil servants in Defra and Natural England should take back control of BNG and build biodiversity back better and bigger in places that will also be there forever (or longer than 30 years, anyway).

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Restoring Species-rich Meadows in Telford, Shropshire: Using Simple Soil Chemistry and Standard Monitoring to Allocate Financial Resources

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Keywords: grassland monitoring, meadow restoration, soil chemistry, species-rich neutral grassland

Species-rich grasslands have a high nature conservation value and are uncommon because of agricultural improvements such as fertiliser application, drainage and reseeding. Low levels of key nutrients (phosphorus and potassium) in the soil are associated with the high plant diversity found in such grasslands. Simple soil testing can be used to predict the outcome of the restoration or creation of species-rich meadows. Monitoring justifies the allocation of resources by landowners and land managers to the appropriate grassland management over time.

Introduction

Species-rich grasslands are of considerable nature conservation importance in the UK and Europe, but their extent greatly declined in the 20th century due to agricultural intensification. Effective projects are required to deliver the vision of Lawton *et al*. (2010) for the future of the wildlife sites and ecological networks in England: more, bigger, better and joined.

Existing soils, hydrology, slope, aspect, proximity to similar habitats, sources of seeds and plant materials, land ownership and habitat management will determine the likely outcome of managing a species-rich meadow as well as meadow restoration and creation

(Gilbert and Anderson 1998, Blakeley and Buckley 2016). Given a suitable site, the fundamental issues are soils, hydrology and habitat management. Soils and hydrology cannot usually be altered and changes in habitat management usually require financial inputs. Owners, regulators and those allocating financial resources to deliver the restoration, creation and continuing management of species-rich grasslands over the long-term require good evidence that making changes to land management practices and committing resources will generate the desired outcomes.

The sites

This study covered 19 urban and urban-fringe species-rich neutral grasslands in Telford (Shropshire) owned by Telford and Wrekin Council (TWC). Lodge Field and Muxton Meadow are managed by the TWC landscape and open spaces contractors in conjunction with local community groups. The other sites are held by the Severn Gorge Countryside Trust (SGCT) on long-term lease and managed in conjunction with local contractors. The sites have slightly acid loamy and clayey soils that impede drainage and are fairly flat or gently sloping. The grassland communities could generally be described as MG5 crested dog's-tail (*Cynosurus cristatus*)–common knapweed (*Centaurea nigra*) grassland or MG6 perennial rye-grass (*Lolium perenne*)–crested dog's-tail grassland (Rodwell 1992) or a mixture of the two.

Grassland management is generally grass-cutting and removal in July/August followed at some sites by aftermath grazing with sheep until winter. Removing the vegetation keeps the soil nutrients low, maintains an open sward, encourages diversity in the grassland and prevents the natural progression to tall coarse grasses and colonisation by scrub species.

Lodge Field and Muxton Meadow are not aftermath grazed because of established public access: a spring-tine harrow has been used on occasion in recent years to mimic the effects of sheep grazing, creating some bare ground for plants to colonise. Church Road Fields (north and south) are seasonally grazed by sheep. Paradise Meadow, Maws Meadow and Haywood Pastures west are no longer managed as grasslands and are in transition to scrub and woodland.

Soil chemistry literature review and methodology

A literature review (Critchley *et al*. 2002a, 2002b, Walker *et al*. 2004, Gilbert *et al*. 2009) suggested a set of interlinked values derived from soil chemical analyses that form a model, or a set of decision rules, for allocating resources to manage species-rich neutral grasslands: extractable phosphorus <10 mg/L, extractable potassium <175 mg/L and pH 5.0–6.5.

Critchley *et al*. (2002a, 2002b) and Gilbert *et al*. (2009) provide empirical evidence of the relationships between grassland plant communities and soil properties in England and have demonstrated that low concentrations of soil extractable phosphorus are associated with the most highly valued grasslands. Low levels of soil phosphorus and potassium together were a feature of the most botanically valuable unimproved neutral grasslands. The coincidence of low levels of soil phosphorus and potassium in many communities suggests that a combination of both may have a greater influence on the vegetation than low levels of one or other nutrient (Critchley *et al*. 2002a).

Soil samples taken in August 2009 (Ropewalk Meadow and Jiggers Bank Meadow), March 2011 (the other SGCT fields), June 2015 (Lodge Field and Muxton Meadow) and July 2020 (from majority of the sites) were analysed commercially for pH, Olsen bicarbonate extractable phosphorus and extractable potassium (ammonium nitrate extractant). Note: extractable is taken to mean exchangeable and soil solution nutrients available to plants.

Grassland monitoring methodology

Monitoring the SGCT sites was undertaken at intervals from 2001 to 2020 following the Common Standards Monitoring (CSM) rapid assessment method for grasslands (Robertson and Jefferson 2000). Species presence in 2 m × 2 m quadrats was recorded in June or July usually at 20 stops on a structured walk with species frequencies

"Those delivering restoration, creation and management of species-rich grasslands require good evidence that making changes to land management practices and committing resources will generate the desired outcomes."

across the quadrats assigned as frequent >40%, occasional 21–40% or rare ≤20%. The TWC sites (Lodge Field and Muxton Meadow) were subject to the CSM methodology in 2016.

The CSM methodology is designed to assess whether the nature conservation interest features of a grassland are in favourable condition by monitoring multiple attributes such as species composition, sward height, scrub cover and bare ground. These important monitoring results are difficult to represent in a simple way when using data gathered over a number of years, particularly where a number of grasslands are being compared. The representation of monitoring data over time and between sites is important for justifying the allocation of resources to the appropriate grassland management.

To address this point, a numerical output from the CSM monitoring data of a grassland, known as the Ecovalue, was derived from the species data recorded in the quadrats (Churton Ecology 2017). The Ecovalue methodology has been revised in minor ways (Box 1) and was applied to the monitoring data for the sites in this study. Different grassland sites can be easily compared, both one with another and over time (Table 1).

Soil chemistry and Ecovalue results

Soil pH values from the 19 neutral grasslands were 5.2–6.5, in the range of 5–6.5 expected for neutral grasslands from the literature review. Figure 1 shows the relationship between the soil chemistry of the 19 neutral grasslands and the Ecovalue of each grassland derived from the vegetation monitoring data that was nearest to the year with soil sampling. Grasslands with the higher Ecovalues (categories 2–5; Figure 2a) were all within the limit of 10 mg/L for

Box 1. Determining the Ecovalue of grasslands

The Ecovalue of the grasslands in the study was derived following Churton Ecology (2017) with minor revisions using the data on species present in the quadrats from the CSM monitoring. The types of vascular plant species and their frequencies across the quadrats were assigned numerical values and used to generate a score (Ecovalue) for a grassland.

The species are taken from the positive and negative indicator species for MG5 grasslands as set out in the CSM methodology (Robertson and Jefferson 2000). These indicator species were supplemented by Shropshire axiophytes (Lockton and Whild 2015, pp 7–9) that are notable plant species and are indicators of habitats of importance for nature conservation in Shropshire. The Churton Ecology (2017) methodology was modified by the omission of anthills (not a botanical feature) and hogweed (not a CSM negative indicator species) which were originally included as a positive feature and a negative indicator species respectively.

The CSM indicator species and Shropshire axiophytes present in the quadrats for each grassland were assigned numerical scores derived from arbitrary values assigned both to the type of species (Shropshire axiophytes 5, CSM positive indicator species that are not axiophytes 3, CSM negative indicator species –2) and to the species frequency across the set of quadrats (frequent 3, occasional 2, rare 1; rare was assigned 0 for negative indicator species).

As an example, a Shropshire axiophyte (value 5) that was frequent in the quadrats (value 3) would generate a score of 15, a CSM positive indicator species that was not a Shropshire axiophyte (value 3) that was rare (value 1) would generate a score of 3, a CSM negative indicator species (value –2) that was occasional (value 2) would generate a score of –4, and a CSM negative indicator species (value –2) that was rare (value 0) would generate a score of 0.

These scores were summed to generate the Ecovalue of a grassland:

- Ecovalue score ≥90 is category 5 (Site of Special Scientific Interest standard, MG5 grassland)
- Ecovalue score 50–89 is category 4 (Local Wildlife Site standard, MG5 or MG5/MG6 grassland)
- Ecovalue score 30–49 is category 3 (local or parish importance, MG5/MG6 or MG6 grassland)
- Ecovalue score 20–29 is category 2 (grassland of some nature conservation value, species-poor MG6 grassland)
- Ecovalue score <20 is category 1 (grassland of low nature conservation value, for example MG1 grassland).

Table 1. Ecovalue scores and categories from 2001 to 2020 ordered by most recent Ecovalue score. Ecovalue scores: ≥90, Ecovalue category 5 (green); 50–89, category 4 (yellow); 30–49, category 3 (blue); 20–29, category 2 (orange); <20, category 1 (pink). No data collected in 2002, 2004, 2006, 2009 and 2012.

	2001	2003	2005	2007	2008	2010	2011	2013	2014	2015	2016	2017	2018	2019	2020
Ropewalk Meadow	58			77		72				107					154
Church Road Fields south						62	50			52					84
Wilderness Meadow south	12			44			49						84		
Muxton Meadow east											76				
Wilderness Meadow north	26			39			51						60		
Wilderness Meadow middle	17			24			43						54		
Lodge Field											54				
Oilhouse Pasture west		23				39		36			38				49
Oilhouse Pasture middle		23				39		41			50				48
Jiggers Bank Meadow	10			12		23		22			28				43
Shakespeare Meadow	43				47		45					44			36
Lloyds Meadow east			18						28					30	
Maws Meadow	29				35			41					29		
Lloyds Meadow west			18			29			37					26	
Muxton Meadow west											20				
Big Crackshall														20	
Church Road Fields north						17	5								9
Haywood Pasture west	8				11			23					–9		
Paradise Meadow						5									

soil phosphorus suggested by the literature review and were generally less than 175 mg/L for soil potassium (the vertical dashed line in Figure 1). The exceptions were Church Road Fields south in 2011 and 2020 (Ecovalue 4 in both years) and Shakespeare Meadow in 2020 (Ecovalue 3) which had low concentrations of soil phosphorus but soil potassium concentrations >175 mg/L. The two grasslands that had the lowest Ecovalue (category 1) at the time of the soil sampling (Paradise, Church Road Fields north; Figure 2b) had very high soil potassium concentrations.

The Ecovalues of grasslands generally increased over time (Table 1) where the management was a haymeadow regime (cut in August, cuttings removed and usually aftermath grazing). Grasslands with more variable haymeadow regimes (Maws Meadow, Shakespeare Meadow) or that were grazed on a seasonal basis by sheep or cattle (Church Road Fields north and south, Haywood Pasture west) tended to have fluctuating Ecovalues. These five sites had soil phosphorus concentrations <10 mg/L but their soil potsassium concentrations were among the highest: all were >150 mg/L and four sites were >175 mg/L.

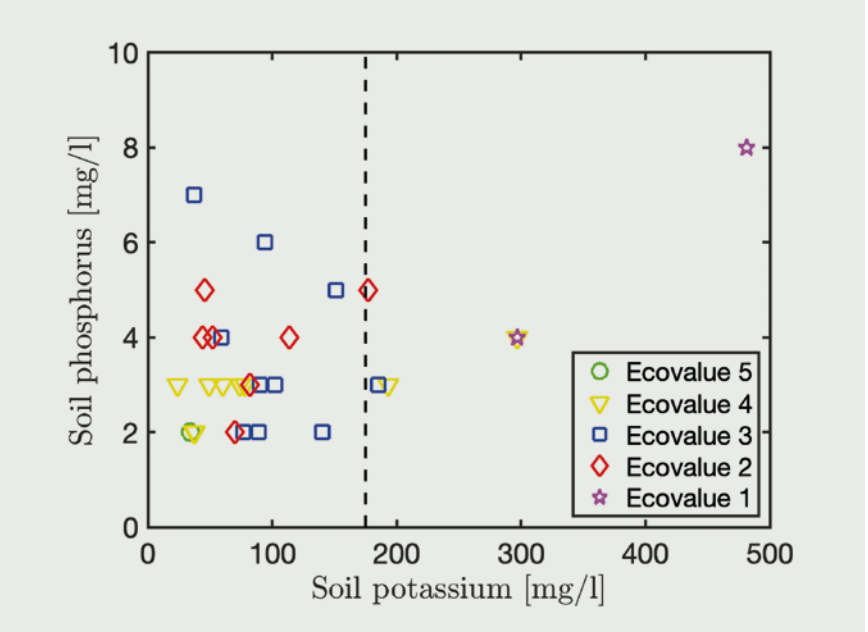

Figure 1. Soil phosphorus and potassium concentrations and Ecovalue category of the grasslands using the botanical monitoring year closest to the soil sampling date. The limit of quantification for soil phosphorus was 2 mg/L.

Counting orchids to monitor restoration

Annual monitoring of Lodge Field did not use the CSM methodology. A simpler monitoring method involved counting the flowering stems of the orchids (common spotted orchid *Dactylorhiza fuchsii*, southern marsh orchid *D. praetermissa* and their hybrid *D.* x *grandis*) in late June from 2005 to 2021. Around 20 local people walked in a line with each person holding a knot set 1.5 m apart on a string to maintain set distances between people. Each person counted the orchid stems on their right up to the next person (Figure 3).

Orchids in Lodge Field increased from 19 flowering stems in 2005 to 3338 stems in 2021 (Figure 4). The very low numbers of orchid stems in June 2020 appear to be related to it being the sunniest English spring and the driest May for England since records began in 1929 (Schulz and Tandon 2020). A logistic function fitted to the number of orchid stems (excluding 2020) implies that the number of orchid stems doubled

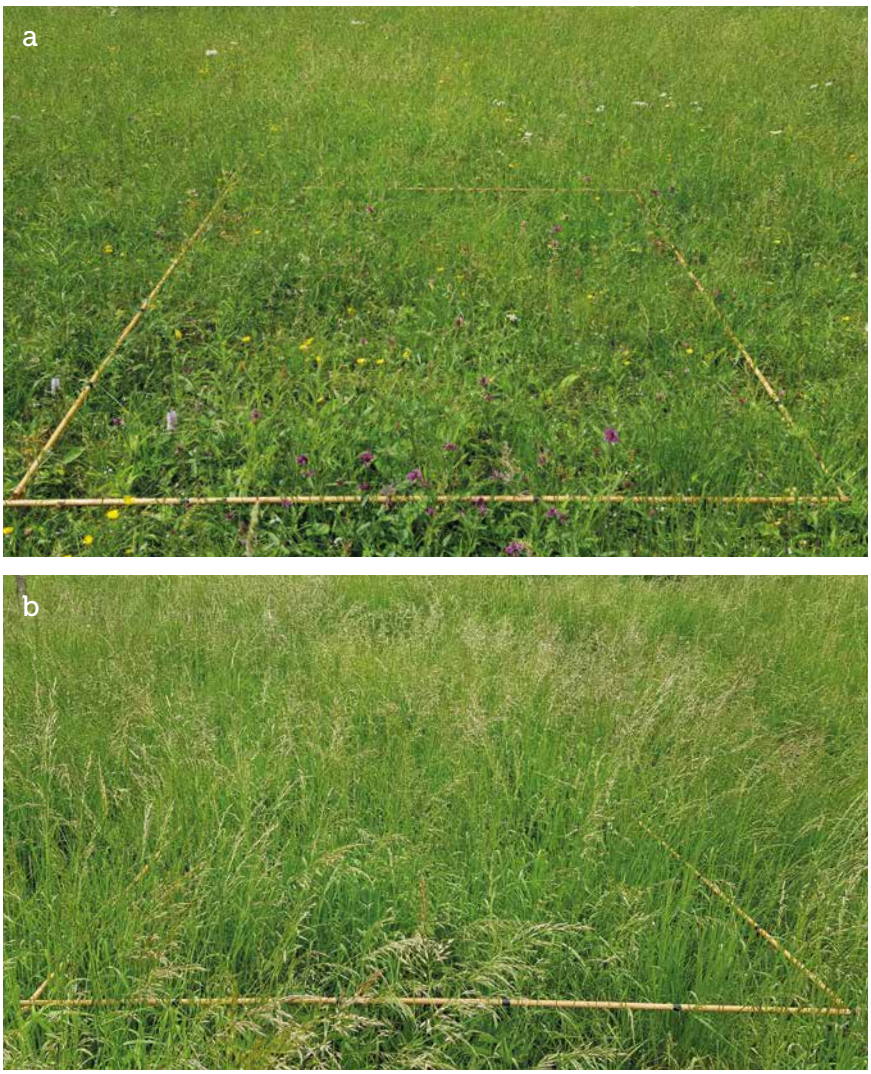

Figure 2. (a) Ropewalk Meadow, a species-rich grassland with short grasses and many herbaceous plants with the highest Ecovalue (category 5). (b) Church Road Fields north, a species-poor grassland dominated by tall grasses with the lowest Ecovalue (category 1). Photo credits: John Box.

Figure 3. Counting orchids in Lodge Field. Photo credit: Graham Peet.

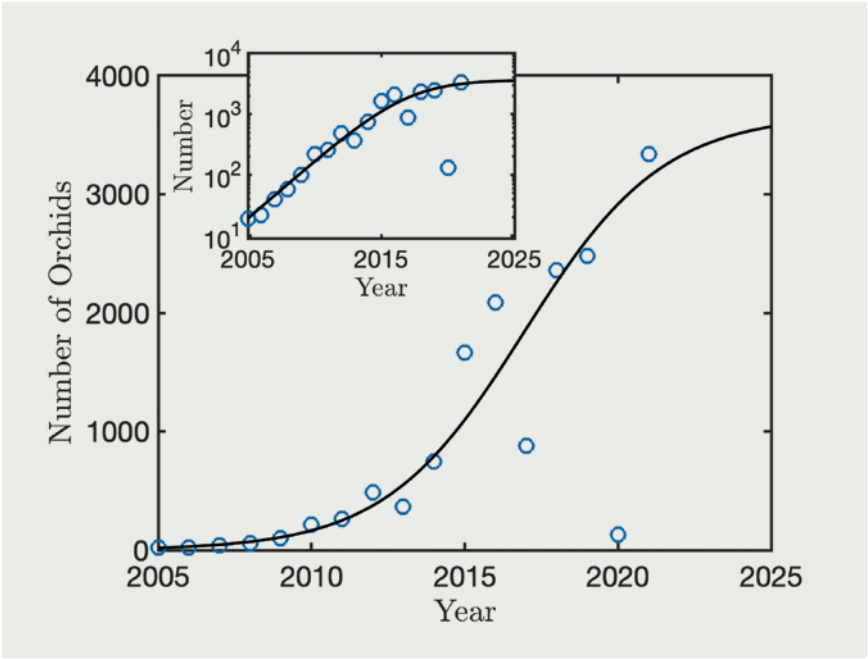

Figure 4. Counts of flowering stems of *Dactylorhiza* orchids in Lodge Field from 2005 to 2021. The curve is a logistic function fitted to the data (excluding the anomalous count in 2020) where: N_0 = 19 (the initial number of orchid stems in 2005), growth rate r = 0.44 and maximum value K = 3671. Inset: semi-log plot demonstrating exponential growth from 2005 to 2016.

“Doubling soil extractable phosphorus lowered median species richness, turning a botanically interesting community into one of limited conservation value.”

approximately every 2 years between 2005 and 2016 and that the maximum number is likely to be around 4000.

Conclusions

The results from the 19 neutral grassland sites in Telford demonstrated that species-rich neutral grasslands that are MG5 and MG6 and are of Ecovalue category 2 or higher were associated with soil phosphorus concentrations of <10 mg/L and generally with soil potassium concentrations of <175 mg/L as suggested by the literature review.

Grasslands with the highest Ecovalues (categories 4 and 5) had soil phosphorus levels of <5 mg/L. This corresponds with the findings of Gilbert *et al*. (2009) for neutral grasslands that doubling the soil extractable phosphorus from 5 to 10 mg/kg was sufficient to lower the median species richness from 22 to 14 species/m^2, effectively turning a botanically interesting community into one of limited conservation value.

Neutral grasslands with such soil chemistry merit input of resources with the aim of increasing their nature conservation value. Grasslands that are being considered for habitat restoration (for example, species-poor MG6 grassland) require investigation of the soil chemistry before resources are allocated for their restoration. Grasslands with high soil phosphorus and/or potassium concentrations may not merit allocation of resources: they could continue to be grazed as pastures or allowed to become scrub and woodland. Agri-environment schemes and land management priorities can change and any decision on whether or not to restore a grassland should be based on a rational, evidence-based assessment.

Decision rules involving soil chemistry provide a useful tool for landowners, land managers and ecologists in determining which lowland grasslands should continue to be allocated financial resources for their ongoing management or restoration or creation as species-rich meadows. Local models of the decision rules could be developed in different geographical areas using local grasslands of high nature conservation value.

The Ecovalue categories and the trends in the scores for the 19 neutral grasslands (Table 1) can be related to soil chemistry and grassland management. Ecovalue scores could be combined with the soil chemistry data and the results from CSM monitoring to examine past decisions on grassland management and would assist future decisions. The boundaries between Ecovalue categories were set subjectively rather than empirically and flexibility is required in determining Ecovalue category boundaries for datasets in other geographical areas.

Monitoring the changes in the grassland at Lodge Field using annual counts of flowering orchid stems was appealing to local residents and to a wider audience. A combination of CSM monitoring, determining Ecovalue and counting orchids provides a simple and effective monitoring methodology for species-rich neutral grasslands.

Acknowledgements

The Severn Gorge Countryside Trust has allowed use of their data on grassland management and soil analyses, and their data on the vegetation monitoring that was undertaken by their consultant ecologists Kate Thorne (Churton Ecology) and John Handley (CH Ecology). Our thanks to Graham Peet for Figure 3. Finn Box generated Figure 4 and the logistic function for the orchid data. Our very grateful thanks to Penny Anderson, James Hicks and Phil Putwain for their useful comments and wise words on drafts of this paper.

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Continuing our EDI Journey

Sally Hayns
CEcol FCIEEM
Chief Executive Officer, CIEEM

It is 2 years since we published a statement saying that 'we need to talk about diversity'. That was at a time when many of us had become increasingly conscious of the Black Lives Matter movement, following harrowing accounts of shameful treatment of people of colour. CIEEM strongly condemned then, and condemns now, the systemic issue of racism that has no place in our society or our profession.

A 2017 report by Policy Exchange[1] highlighted that the environmental professions in the UK were the second least racially diverse occupation of the 202 occupations measured (agriculture was the least diverse) and in the intervening years very little appeared to have changed. But, as our statement said, diversity and inclusivity are not just about race or ethnicity. They are also about gender identity, sexual orientation, age demographics, religion, disability and socio-economic status. We also need to look at the equity of the experiences in our profession.

We resolved to improve our own organisational performance in relation to becoming a more equitable, diverse and inclusive organisation but also to lead the profession in making change. So how are we doing?

Our **Equality, Diversity and Inclusion (EDI) Working Group** comprises both staff and member volunteers and meets regularly to identify steps that CIEEM can take in this space and review progress. For example, we have adopted the Royal Academy of Engineering and Science Council's *Diversity and Inclusion Progression Framework for Professional Bodies* which has enabled us to establish a baseline of performance in areas such as our governance, training, events and membership. Progress is slower than we would like, and much is dependent on creating a more diverse membership base from which to draw volunteers for governance roles, training delivery and conference presentations, but we are moving forwards. We also joined the **Diverse Sustainability Initiative**, a broad collaboration of companies and organisations across the environmental management space that looks to hold each other to account on corporate progress in EDI initiatives.

In 2021 we undertook a **members' survey on EDI issues** and published a report in May that year that highlighted those areas where we perform poorly as a profession. In addition to the expected low marks for racial diversity and inclusivity for people with physical disability, the survey highlighted the importance of embracing neurodiversity and recognising the impact of socio-economic background on access to ecology and environmental management careers. The report also highlighted areas of inequity where superficially members may appear 'included' but their experience and challenges were very different to those who appeared to represent the so-called 'norm'.

We followed this up with our research and report into barriers to ecology and environmental management careers for people of colour. The work, undertaken by specialist stakeholder engagement consultancy Dialogue Matters, was published in our *Breaking Down the Barriers to Inclusion* report, which identified a number of actions that CIEEM could lead or support that could, in time, start to make a real difference to the profession. We were also recognising the overlap between our EDI ambitions and our championing of the green skills agenda which aims to bring more people into the profession **to meet the environmental ambitions of emerging policy and legislation.**

As always, progress was hampered by resources, in terms of both money to do things and time to make things happen. Earlier this year CIEEM's Governing Board committed to a 5-year programme of expenditure to support our EDI work and we are delighted to welcome our newest member of staff, Lea Nightingale, as our EDI Engagement Officer. Lea has a wealth of EDI engagement experience and she will be sharing her ideas and plans in a coming edition of *In Practice*.

We want to do more, more quickly and we have been delighted that some companies and organisations who see EDI promotion as an issue of both social justice and investing in the future success of their business have agreed to help resource this important area of work as **EDI Partners** by committing £5000 per annum for 3 years towards relevant activities, including opportunities for staff engagement. Step forward (and thank you) RSK Biocensus, Arup and WSP.

RSK biocensus
EXPERTS IN ECOLOGY

ARUP

wsp

As a first step we will soon be launching a new **Green Jobs for Nature** website – not a jobs board but an online resource that will raise the visibility of green jobs in our sector, showcase the range of opportunities available, how to get them and the best and worst bits about them, and provide career advice. This will be supported by a range of activities designed to reach out to young people and potential career changers, with a particular focus on communities that are under-represented in our profession.

We recognise these are still early steps. We have far to go, and we need to encourage and work with like-minded organisations to create change. But it does feel that our journey is underway. We would be delighted to hear from you if you want to be part of that journey, whether you have felt disadvantaged by your participation in CIEEM or in your work or you just want to be part of a movement of change. You can contact us at diversity@cieem.net.

Note

1. Policy Exchange (2017) *The Two Sides of Diversity* – see https://policyexchange.org.uk/

About the Author

Sally has been an ecologist for more than 30 years, working primarily in the eNGO and public sectors across a range of challenging and enjoyable roles. She joined CIEEM as CEO in 2010 and has been instrumental in driving forward change within the Institute and the profession. Sally is also a member of the UK Government's Green Jobs Delivery Group. Sally is passionate about the need for change within the profession to become more diverse and inclusive and 'fit for purpose', to embrace new technologies and innovations, and for practitioners to be proud of the work they do.

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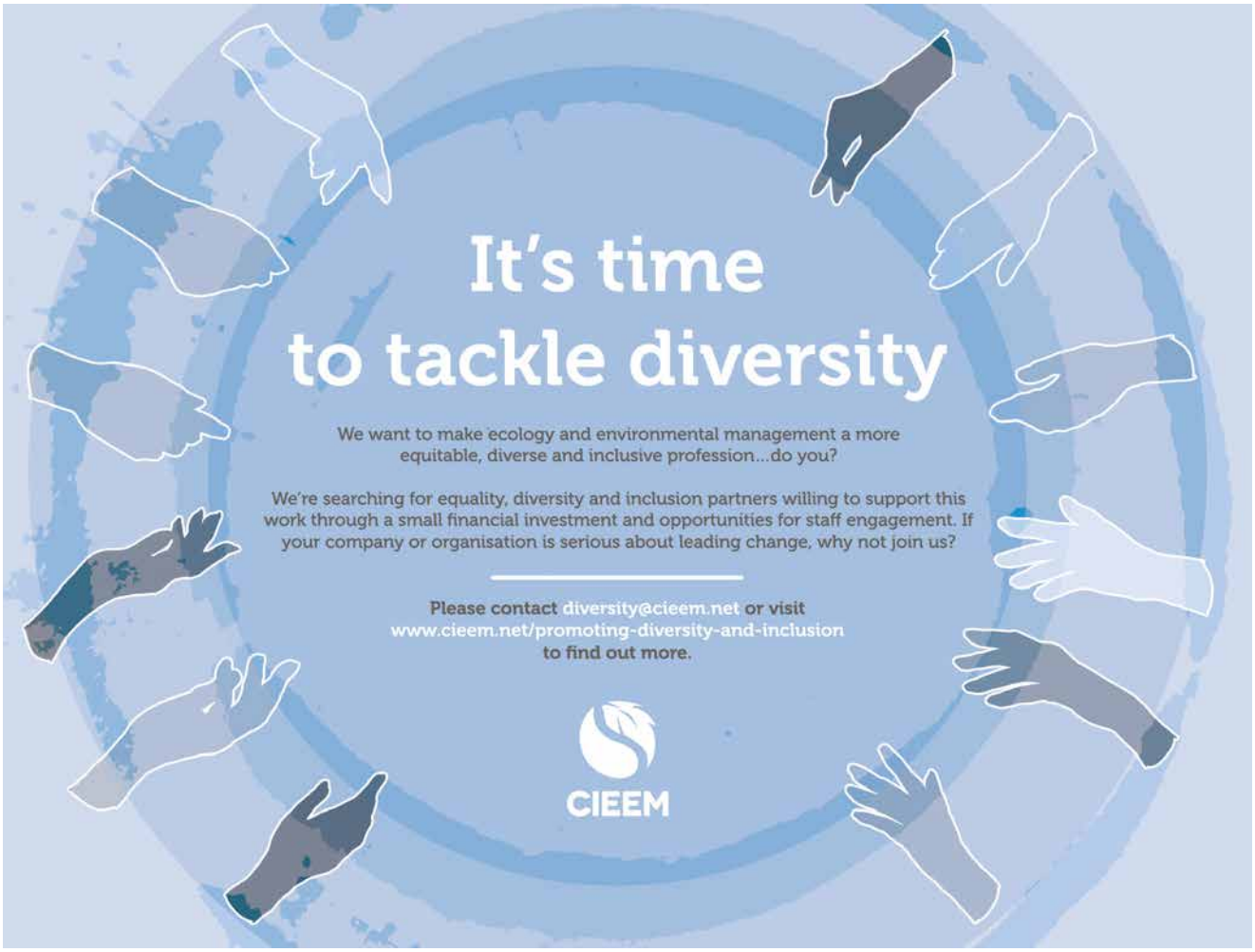

CIEEM Awards 2022: Time to Celebrate

Sally Hayns
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Summer is a very busy time for many in our profession but it is important to take some time out to reflect and celebrate our achievements and how we are delivering or biodiversity. We were therefore delighted to be able to gather together in person at the Hilton Bankside hotel in London on 22 June to celebrate the winners of the 2022 CIEEM Awards. The conversation bubbled as much as the fizz before and during lunch. Nobody was on mute, there were no dodgy internet connections, no doorbells rang at key moments and everyone was smiling.

Following the drinks reception, sponsored by Ecus, guests were welcomed by our President, Richard Handley, who introduced our host for the day, Dr Caroline McParland. Caroline soon got things underway with the first presentation, that of CIEEM's most prestigious individual award, the CIEEM Medal. Former Vice President (England) Lisa Kerslake read out the citation for David Tyldesley FCIEEM FRTPI FRSA, talking not only about his professional achievements as an authority on the interpretation of environmental legislation, especially Habitat Regulations Assessment, but also his personal qualities as a teacher, mentor and friend. David was warmly applauded as he received the Medal and gave a thought-provoking but typically modest acceptance speech.

A delicious lunch followed and again, wine and conversation flowed freely before we settled down to the serious business of revealing the winners of the rest of the awards. A huge congratulations to all the shortlisted entries and winners, but also to the audience who kept up a high level of applause from the first to the last presentation.

So, to the results…

CIEEM President Richard Handley with Medal winner David Tyldesley.

Award	Shortlisted Project/Individual	Results
In Practice Sponsored by: greenhouse Design | Print | Signage | Display	*Urban wilding: are there lessons we should learn?* – by Richard Gowing (December 2021)	Winner
	Badger dung pits as a seasonal food resource for mammals and birds: implications for urban surveys – by Morgan Hughes and Scott Brown (December 2021)	Highly Commended
	Invasive signal crayfish in the UK: survey methods to inform evidence-based management – by Dan Chadwick, Lawrence Eagle, Eleri Pritchard, Carl Sayer, Michael Chadwick, Jan Axmacher and Paul Bradley (June 2021)	Highly Commended
Postgraduate Student Project Sponsored by: Stantec	Louise Henry ACIEEM – University of Leeds – *A big house in the country: Assessing the biodiversity and ecosystem service values of trees and their management trade-offs in the Harewood Estate parkland*	Winner
	Darren Wilson – Edinburgh Napier University – *Diet composition of Eurasian sparrowhawks Accipiter nisus in Edinburgh, Scotland*	Highly Commended
	Corrie Grafton – University of Bristol – *Analysis of the factors influencing butterfly diversity and abundance at Snows Farm, Gloucestershire*	Commended
University Department/ Programme of the Year Sponsored by: Countryside Jobs Service CJS	Level 3 Award in Wildlife, Ecology and Conservation – Kingston Maurward College	Winner
	BSc (Hons), Biological Sciences (Environmental Biology) – Nottingham Trent University	Highly Commended
NGO Impact Sponsored by: greenbelt ...green by nature	CRISEP 2021–2025 (Canal & River Invasive Species Eradication Project)	Winner
	Bat Conservation Trust – BatChat Podcast	Highly Commended
	Woodland Trust – State of UK Woods and Trees	Commended
Action 2030 Sponsored by: RSK biocensus EXPERTS IN ECOLOGY	Sarah Simons CEnv MCIEEM, Amey Consulting	Joint Winner
	WSP UK Net Zero/Biodiversity & Natural Capital Campaigns	Joint Winner
	Stantec: Inside SCOPE	Highly Commended
Promising Professional Sponsored by: WILDCARE Nationwide Ecology Supplies	Charlie Ward ACIEEM	Winner
	Aoife Joyce	Highly Commended
Member of the Year Sponsored by: WILDCARE Nationwide Ecology Supplies	Dr Martina Girvan CEcol MCIEEM	Winner
	Professor David Hill CEnv FCIEEM	Highly Commended
	Kat Stanhope CEnv FCIEEM	Commended
	Philip Colebourn MCIEEM	Commended
Best Practice – Small Scale Nature Conservation Sponsored by: Thomson environmental consultants	Spains Hall Estate – Spains Hall Estate and partners (including Atkins, Environment Agency, Essex and Suffolk Rivers Trust, Essex Wildlife Trust)	Winner

Best Practice – Large Scale Nature Conservation Sponsored by: Thomson environmental consultants	Solihull Habitat and Nature Improvements Project – Solihull Metropolitan Borough Council (SMBC)	Winner
	Making Space for Nature (Green Infrastructure for Growth & Green Infrastructure for Growth 2) – Cornwall Council and University of Exeter	Highly Commended
	Farming4Water and Severn Trent Environmental Protection Scheme (STEPS) – Severn Trent Water	Commended
Best Practice – Small Scale Mitigation Sponsored by: temple	Bushey Bank Offsite Compensation Site – Environment Bank, Earth Trust and Taylor Wimpey	Winner
	Water and Abandoned Metal Mines – Calaminarian grassland mitigation in the North Pennine Moor mines – JBA Consulting, JN Bentley Ltd, the Coal Authority and the Environment Agency	Highly Commended
	Otterbourne Hill – Ecological Planning and Research (EPR) Ltd	Commended
Best Practice – Large Scale Mitigation Sponsored by: temple	East West Rail Phase 2 – East West Rail Alliance	Winner
	Large Scale Reroofing in East Sheffield: Addressing The Impacts on Bats – Ecus Ltd in collaboration with Sheffield City Council	Highly Commended
Best Practice – Innovation Sponsored by: ARCADIS	BatCam: a novel trail camera for detecting tree-roosting bats – Gareth Lang, BSG Ecology	Winner
	Ash Dieback – Mott MacDonald and Conwy County Borough Council (CCBC)	Highly Commended
	Digital Environmental Assessment – Jacobs UK Ltd	Commended
	Improving coastal ecosystem resilience to climate change in Anguilla – Anguilla's Department of Disaster Management, Anguilla National Trust, Anguilla's Department of Natural Resources and Environment Systems Ltd	Commended
Best Practice – Stakeholder Engagement Sponsored by: ARCADIS	South Scotland Golden Eagle Project – South Scotland Golden Eagle Project Board/Southern Uplands Partnership	Winner (also winner of the Tony Bradshaw Award)
	NATURE Tool – NATURE Tool Partnership led by WSP	Highly Commended
Best Practice – Knowledge Sharing Sponsored by: ARCADIS	The Beautiful Burial Ground – Caring for God's Acre	Winner
	Lancashire Peatland Initiative – Lancashire Wildlife Trust	Highly Commended
	QGIS for Ecologists – QGIS for Ecologists	Commended
Consultancy – Small Sponsored by: MFL INSURANCE GROUP	DTA Ecology	Winner
	Burton Reid Associates	Highly Commended
	Environmental Gain Ltd	Commended
	Johns Associates	Commended

Consultancy – Medium Sponsored by: MFL INSURANCE GROUP	FiveRivers Environmental Contracting Ltd	Winner
	JBA Consulting Ltd	Highly Commended
	Environment Bank Ltd	Commended
	Ecological Planning and Research (EPR)	Commended
Consultancy – Large Sponsored by: MFL INSURANCE GROUP	RSK Biocensus	Winner
	Atkins	Highly Commended
	WSP	Commended
	Mott MacDonald Ltd	Commended

A special mention must be made of the winners of the Tony Bradshaw Award. Many members will be very familiar with the work of Professor Tony Bradshaw but may not be aware that he was instrumental in the founding of the-then Institute of Ecology and Environmental Management and our first President (1991–94). The award named in his honour is not presented every year, but is only awarded if, in the opinion of the judges, there is a truly exceptional project deserving of the accolade.

Each winner of the seven Best Practice Awards categories is eligible to be considered for the Tony Bradshaw Award. This year we were delighted that the judges felt the winner of the Best Practice – Stakeholder Engagement category, the South Scotland Golden Eagle Project, was a worthy recipient.

This national project is reinforcing the small, fragmented population of the golden eagle in south Scotland. Beginning in 2018 with the translocation of three juvenile golden eagles, the project is now in year four of six, and has to date translocated 19 young golden eagles (secured from the Scottish Highlands and Islands) to establish a population higher than recorded at any time in the last three centuries. Project partners include NatureScot, Scottish Forestry, RSPB Scotland, Scottish Land and Estates, and Southern Uplands Partnership.

It was a highly contentious project (potentially releasing a heavily persecuted bird of prey into a region where there was a history of illegal persecution of raptors), and the project partners had to address the risks extremely carefully. Effective engagement with landowners and land managers were used to build trust. Public engagement through a popular website and high-profile events and opportunities for local involvement have been instrumental to the success of this species recovery project. The Project has become a beacon for wider support for conservation management in rural communities.

Congratulations again to all those who were shortlisted – it was awe-inspiring to see what you have achieved and we would like to thank all of the entrants who took the time to submit a nomination. We would also like to extend our particular thanks to our sponsors, both returning and new, for their generous support, and to our judges for their time and expertise, without whom this special event would not have been possible.

Ethical Dilemmas

This is our series of problems and conundrums that can face members during their professional practice. The purpose of the feature is to encourage you to reflect on and explore scenarios that you may face during the course of your work and to consider the appropriate ways to respond to ensure compliance with the *Code of Professional Conduct*.

In the June 2022 issue of *In Practice* we described a scenario where you are running an environmental organisation which has a goal to become net zero. To help achieve that aim, you set an objective that all staff who use their own car for work (and claim costs) should use an electric car within a specified timescale. However, given the larger capital outlay required for electric cars compared with conventional ones, it soon becomes clear that this obligation is easier for senior, better paid staff than for junior staff.

We asked: Is this fair? Also, if any members of staff opt to retain their conventionally powered car, what should you do?

Our thoughts

Clarify at the outset that pool cars or hire cars will be available for staff to use in situations where public transport, cycling and walking for work journeys are not practical options. This requirement to use a zero-emissions vehicle does not apply to commuting journeys – just to journeys where staff are travelling to do their job.

Discuss with staff the net zero goal and the plan to encourage staff to use electric or other zero-emissions cars for work travel. Give the group and individuals the opportunity to raise general and specific issues (e.g. some staff may not be able to charge a vehicle at home or may have other reasons for retaining their conventionally powered car). Adapt the plan accordingly.

Give staff as much notice as possible – at least 5 years.

Commit to a review period, during which time the effect of the plan (on obtaining the net zero goal and on staff) will be monitored and, if necessary, revisions introduced.

Provide assistance with finding appropriate government or charitable grants/loans to offset the initial capital outlay.

If necessary, the organisation should consider providing loans for the capital outlay.

Provide ongoing incentivisation by providing free (ideally renewables-powered) charging points at work.

Provide ongoing incentivisation by gradually decreasing mileage payments for conventionally powered cars – say from years 5 to 7, so that by 2030 mileage expenses for conventional cars will only be paid in agreed, exceptional circumstances.

Explain that the difference between the mileage rate paid for use of zero-emissions vehicles and the lower rate for using conventionally powered vehicles will be used to fund an appropriate scheme to offset those work miles. The organisation will not be benefitting financially from paying reduced mileage rates for the use of conventionally powered vehicles.

If, by year 5, any member of staff opts to continue using their conventional car for work trips without agreed exceptional circumstances, the organisation may wish to pursue the following approach:

- Discuss the issue with the member of staff to better understand their reasoning.
- If there is no objective reason that compels the member of staff to retain their conventional car, remind them that in those circumstances mileage payments for conventional cars will decline gradually to zero by year 7. This period should be sufficient for the staff member to change their car.

The next dilemma

You are a newly promoted ecologist working under a new line manager. Not yet confident in your role, you are keen to impress and demonstrate your potential. In one of your first assignments, you undertake a Preliminary Ecological Appraisal (PEA) for a proposed development site. You find there are a combination of factors which would make it impossible to adequately avoid, mitigate or compensate for the direct and indirect impacts on protected sites and species. These are varied but include falling within very close proximity to a Special Protection Area, where the best available evidence suggests that impacts cannot be avoided. As a result, your PEA highlights the considerable constraints and clearly states that even with additional survey work, which would be necessary to inform any subsequent planning application, it may not be possible to identify measures sufficient to offset the impacts to the satisfaction of the decision-maker.

You submit your report to your manager for quality assurance and sign off, but your manager requests that you amend your report to focus on avoidance, mitigation and compensation suggestions, noting the need for additional surveys and removing some of the emphasis on the considerable constraints of the site. Your manager strongly disagrees with your suggestion to advise the client that it may not be possible to offset the impacts and indicates that they will not sign off a report with this conclusion. What should you do in this situation?

Complaints Through the Ages: Reflections on 10 Years with CIEEM's Professional Standards Committee

Ellie Strike
CEnv MCIEEM
Acting Head of Complaints, Investigations and Enforcement – Office for Environmental Protection

My CIEEM journey has been a little emotional of late. Whilst I excitedly embark on a new role with the Governing Board, I am sad to have stepped away from the Professional Standards Committee (PSC) after more than 10 years of involvement. It has been a hugely rewarding experience, but has not been without its challenges, and perhaps not surprisingly some of these relate back to our responsibilities for handling complaints against our members.

Given this transition it felt like a logical time to pause, reflect and play back some of my observations and thoughts, and those of some of my fellow PSC members.

There have been changes to both the number and nature of complaints we've seen over the years. And as a result, we have periodically had cause to review our processes and procedures in response to that. So here I will talk a little about some of the trends, our response to them and some reflections on the culture surrounding complaints too.

The numbers

When I joined PSC I remember hearing anecdotally that people were aware of our complaints process, but saw it as a rather toothless tool. Without the qualitative or quantitative evidence to give us deeper insight into what our statistics told us we were faced with a conundrum – were the low numbers of complaints indicative of a correspondingly low occurrence of issues that might give rise to complaints (i.e. professional misconduct)? Levels of awareness of our complaints process? People's faith in the process itself? The increase in our membership? Or was it a combination of some or all these factors… and probably some others too?

These are important questions. And they are important because, over the last few years (2021 in particular) we have seen an uplift in the number of complaints made against our members (Figure 1). To understand why this is the case, it is important to recognise that the number of complaints we receive is not a clear indicator of the state of our profession, or the quality of our members. It can, and most likely does, mean much more.

Every validated complaint is assessed by a Preliminary Investigation Panel (PIP), with members fielded from the Professional Standards Committee (PSC) and a wider pool of trained volunteers who assist in the preliminary investigation phase to help manage the workload.

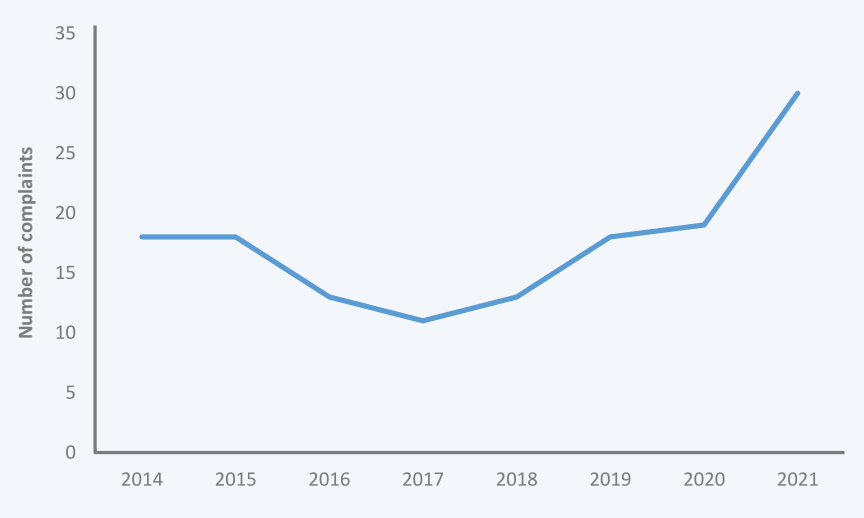


Figure 1. Number of complaints received by CIEEM. Note: prior to 2014 we did not collect/collate data in a way that allows for comparisons with the more recent data.

It is the job of the PIP to ascertain whether there is sufficient evidence of a possible breach of our Code of Professional Conduct to warrant further investigation of the complaint. If there is clearly insufficient evidence of a possible breach of the Code the complaint is dismissed. However, if the facts are not clear or there is evidence of a potential breach, and it is in the public interest to do so, the PIP will refer the case for a Professional Conduct Hearing.

The members of the Professional Conduct Hearing panels do not have access to the PIP assessments of each case. This ensures the Panel maximises objectivity and does not risk prejudicing the process. And it is reassuring that, through both these independent assessment processes, there is a strong degree of correlation. Over the last 8 years more than 83% of cases that were referred, were subsequently upheld at a Hearing.

In making a decision about whether a case should be referred, PIPs are mindful of a variety of factors. We are duty bound to consider the impacts to the subject and the complainant, the impacts to individual projects or initiatives that might be bound up in the case (e.g. what are the implications for a proposed development scheme that is currently going through a planning process?) and the level of public interest in taking the case forward (e.g. are the impacts of the alleged breach of our professional conduct such that they have caused, or could cause, significant harm, or are they at a level that would be better addressed through other means?). We also have to consider the resource implications of convening a full Professional Conduct Hearing. So, no referral is made lightly, nor is it based on any kind of precautionary principle – the weight of evidence must exist, and we must have agreement across all three PIP members before a case is referred.

So, the reason the correlation in Figure 2 reassures me is that it means we are not unduly referring cases that are subsequently found to have no merit, and there are enough cases where there is deviance (between the PIP assessment and subsequent findings of the Hearing), to show the value in having a two-tiered system.

Types of complaint

Whereas the number of complaints has changed over the years, there continue to be some common themes to the types of complaints we receive. Typically, we see a high number of complaints that relate to planning matters, and many of our complaints relate to the quality of ecological reports.

For these types of complaint we have to be mindful of a variety of factors. For one, we are aware that some of these complaints may be intended to frustrate decisions being made in relation to another process, for example, by attempting to discredit the ecological information used to inform assessments relating to planned development. I will touch a little more on the motivation of complainants below.

In respect of complaints relating to the quality of reports, we must also be mindful of our need to be proportionate in our response. Sometimes the quality of a report may be so poor as to present inaccurate or misleading information. And in these cases, there is the potential that they could directly lead to negative environmental impacts. In other instances, while there may be issues, they may be relatively superficial – and without a body of evidence to suggest that it is an endemic problem with the subject's work, it may be disproportionate, and really in nobody's best interests to pursue the matter through a full Professional Conduct Hearing.

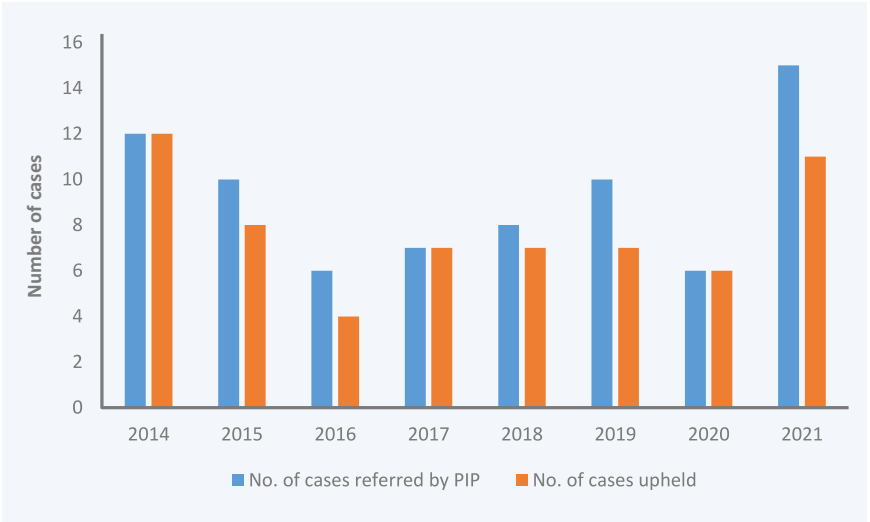


Figure 2. Number of cases referred by PIPs to a Professional Conduct Hearing, and the number of those cases where the complaint was subsequently upheld by the Hearing.

There are few other trends that can be drawn out in terms of the 'types' of complaints we receive. There was a brief period 5–6 years ago where we saw an increase in complaints relating to use of social media, and this did give us some cause for concern at the time as we saw the popularity of social media increase. We anticipated an increase in the number of complaints we might receive that related to social media, but interestingly this doesn't seem to have played out – perhaps as people have become more experienced and savvier in their use of these platforms.

The complainants

In the early days of our complaints process most complaints were from members, being made against other members. So, it very much existed in the professional realm for the professional realm. More recently this trend has shifted, and we are seeing increasingly more complaints from members of the public.

It is likely that this is because of increased awareness of our complaints process. In some quarters we are aware of local authorities highlighting our process to dissatisfied customers in the planning process. But it is also perhaps indicative of the greater level of interface that our profession now has with the public. And it may be reflective of the disconnect between our profession and how we engage with the public. Again, anecdotally, we hear of the perception that ecologists are 'in the pocket' of developers, and because they are 'on the payroll' for a development scheme this may bias their professional judgement. In respect of this last point, I can honestly say that this is not something which is regularly borne out by *our* complaints process, so it is not something that appears to have merit based on what we see.

Tone of complaints

One trend that both I, and my fellow PSC members, have noted is the increasingly emotive nature of some of the complaints we receive.

On the face of it, you might think that this relates to the previous point about complainants (i.e. that with more complaints being made by the public, they are not operating in a professional capacity, and therefore perhaps feel less obliged to check their tone, and sometimes language). But in truth, the emotive element is also seen in the rebuttals presented by the subject of the complaint – professional members of CIEEM.

Tone is so important. While we are duty bound to look at the facts and evidence as they stand before us, the way a subject engages with a complaint can be a significant indicator, and one that we do take into account. And our mandate for doing this is set out in our Code of Professional Conduct and the guidance supporting our complaints process. The following clauses of our Code are particularly relevant:

- Clause 5: act at all times with professional integrity and courtesy, avoiding or managing any conflicts of interest and avoiding actions that are inconsistent with my professional obligations.
- Clause 7: cooperate fully with, and provide full assistance to, CIEEM in any Professional Conduct Inquiry.
- Clause 8: not interfere with, frustrate or otherwise seek to compromise, whether through any act or omission, the due process of any Professional Conduct Inquiry Process undertaken under CIEEM's Professional Conduct Inquiry Procedures.
- Clause 10: accept responsibility for my professional actions and decisions.

Ownership, and taking responsibility for one's actions, is key and we advocate an approach where, if possible, we work more collaboratively to understand root causes of misconduct or poor practice so that we can all improve it together. This is only possible if a subject chooses to engage positively with the process, rather than fighting it at every turn.

Related to this, we also see complaints where it is apparent that options for informal resolution have not been fully explored. Instead, some people prefer to defer straight to the formal complaints process rather than making attempts to resolve the matter in a less contentious and emotive way. This in itself is inflammatory for those involved, if they feel they have not been afforded the courtesy of a right of reply before being subject to the level of scrutiny that our process involves.

Motivation

When looking at why people complain, there are numerous considerations and these exist at both the very individual level, and at a wider societal/cultural level. These are some of my reflections based on what I've seen over the years.

At the individual level

At the individual level when people make the decision to submit a complaint there are likely to be both practical and psychological elements at play. For the sake of ease, I think you could broadly categorise people's reasons for complaining into the following:

- ***Genuine concern*** – Where somebody has witnessed professional conduct that is so un-becoming of our profession as to make them feel duty bound to report it. Or that they have witnessed a 'harm' and are genuinely seeking to identify those responsible so they can be held to account.
- ***Personal or collective gain*** – This sounds more sinister than it sometimes is. For example, this may be somebody who wants to use our complaints process as a means of frustrating another process (such as a planning or permitting process), to safeguard something that has an intrinsic value – such as a local green space. It may, however, also be used to substantiate arguments around reasons for failure to pay fees or undertake additional survey work.
- ***Disruptive/malicious intent*** – In some instances a complaint may be made specifically and solely to cause disruption to a particular project, business or individual. This may be because of a personal or professional vendetta. And this is where we stray into the realms of complaints that are potentially vexatious or harassing in their nature.

Societal/cultural level

In addition to the circumstances surrounding an individual complainant (the practical and psychological), there are also wider contextual issues that may influence the recourse people choose. It would be almost impossible to list all of the potential externalities that may have an influencing effect but here are a couple of examples.

Political and media focus on environmental issues will have varying levels of influence, and the increased use of social media means people are much more aware of what is going on. And with this, issues of concerns receive a heightened level of public scrutiny and debate. It also means people are likely to have an increased awareness of the recourse options available to them.

We have also considered the extent to which the COVID-19 pandemic may have impacted more recently on the level of complaints. The impacts here may stem from a couple of things. Firstly, more people are likely to have been at home, with the potential to engage more with the media that will keep them informed of local issues. And secondly, there were observable increases in the extent to which people were out and about making greater use of their local spaces. This increased and direct exposure to issues on their doorstep may also be an influencing factor.

It is also possible that the evolution and improvements to our processes may have made an impact. And the increased visibility of outcomes of our complaints may have done something to convince people of the merits of complaining.

The relevance of motivation to our processes

Whereas all the above may be interesting, in terms of gaining a better understanding of 'why' people make complaints, and therefore what trends we may observe over time, it is equally important to note that when it comes to individual cases the motivation of the complainant actually has very little bearing.

As a quasi-judicial process, we have certain responsibilities, one of which is to maintain objectivity. When we are making our initial assessment of complaints (as the Preliminary Investigation Panels) we have to tread a line – between being 'motivation blind' and considering motivation to the extent that we can determine whether a complaint is vexatious or harassing in its nature. In other words, under normal circumstances we should not need to know what motivated the complainant, because we are solely concerned with the merits of the complaint as it is laid before us.

However, in some instances we may become so convinced that a complaint is intended to be vexatious or harassing to the subject that we may choose not to progress the complaint – and this decision is informed by a perception as to the complainants' motives.

To add further complexity to this, there are also instances where, while a complaint may be instigated for one reason (perhaps less positive in its motivation), we may subsequently find that it does have merit.

And fundamentally, although we need to be mindful of motivation, and the various pitfalls that come with it, we must also accept that we have limited influence over what motivates people.

Our complaints culture

As we delve into the detail of our complaints processes and the complaints we receive, it is all too easy to lose sight of why we have a complaints process in the first place.

Our role is to improve professional standards – not necessarily because of an overwhelming perception that professional practice is especially poor, but because continuous improvement should be central to the tenet of any profession. We operate in an ever-changing world, and so too must we evolve, adapt and improve in response to the change we see around us.

Of course, poor practice does exist, and as I have often reflected that we operate something of a 'carrot and stick' approach to tackling this. And it's worth noting that, through our training and development programmes, *In Practice* and numerous other member benefits, we invest significantly more into our 'carrot' offerings than we do our 'stick'. Essentially the complaints process is our backstop, the last resort for tackling poor practice and professional misconduct.

I also remain keen to stress, at every possible opportunity, we are not here to lambast and vilify people, or to give people a platform to torment or harass our members. Fundamentally, we are here to manage 'up' not 'out'. It is rarely our desire, or intention to manage people out of CIEEM – far from it! We are here to improve professional standards across our profession, and once someone leaves the Institute, we have lost our ability to influence their performance, and have lost another advocate for our wider cause, aims and objectives.

Evolution

Finally, I touched earlier on the evolution of our processes and procedures. And I have also talked about the need to evolve, adapt and improve. The same principles apply to our work in PSC. In my 10 years with the committee, I have been involved in and overseen numerous revisits of both our Code of Professional Conduct, and the principles, procedures and documents that underpin our complaints processes.

Every case we assess gives an opportunity to learn, and every time there is an important learning point we take the opportunity to review the way we do things. PSC, supported heavily by a committed and experienced secretariat, genuinely embeds the principles of continuous improvement in this area of work. And as a result of this we have a complaints process that not only stands up to external scrutiny but is considered to be one of the best in the professional body sector.

We will continue to evolve. And I hope that our membership continues to see the value in having a complaints process, which is ultimately there to protect us and our profession. Just know that it is very mindfully overseen by a group of dedicated people, who do it for all the right reasons – I shall miss them, and the world of CIEEM complaints.

About the Author

Ellie Strike MSc, BSc (Hons), CEnv, MCIEEM is currently Acting Head of Complaints, Investigation and Enforcement at the newly formed Office for Environmental Protection (OEP). Prior to that she has spent over 20 years working in the environment sector in public, private and charitable sector organisations. Ellie spent 10 years on the Professional Standards Committee, 6 of which were spent as Co-Chair. This year she has joined our Governing Board as Honorary Secretary.

Contact Ellie at: ellie.strike@theOEP.org.uk

Policy Activities Update

Amber Connett ACIEEM
Policy Officer, CIEEM

Summer recess is over and we are returning to lots of activity in environmental policy areas around the UK.

Despite delays to the biodiversity summit (COP15) which will now take place this winter, there have been continued talks to develop a new global biodiversity framework. This summer, we responded to a call for comments on the development of a long-term strategic approach to mainstreaming biodiversity and its associated action plan.

UK and England

In May, the UK Government introduced a Levelling Up and Regeneration Bill which introduces reforms to the planning system in England. One of the key reforms is the replacement of Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) with a new system of environmental assessment; Environmental Outcomes Reports (EORs). As the Bill stands at the time of writing, this will also affect the rest of the UK subject to consultation with devolved governments. We have written a short summary of measures in the Bill (www.cieem.net/what-is-the-levelling-up-and-regeneration-bill/).

We have written to the Department of Levelling Up, Housing and Communities to raise concerns that the new approach could remove opportunities to improve projects and plans as they are being developed, leaving only a retrospective assessment. We have also been engaging civil servants on the implications for the sector.

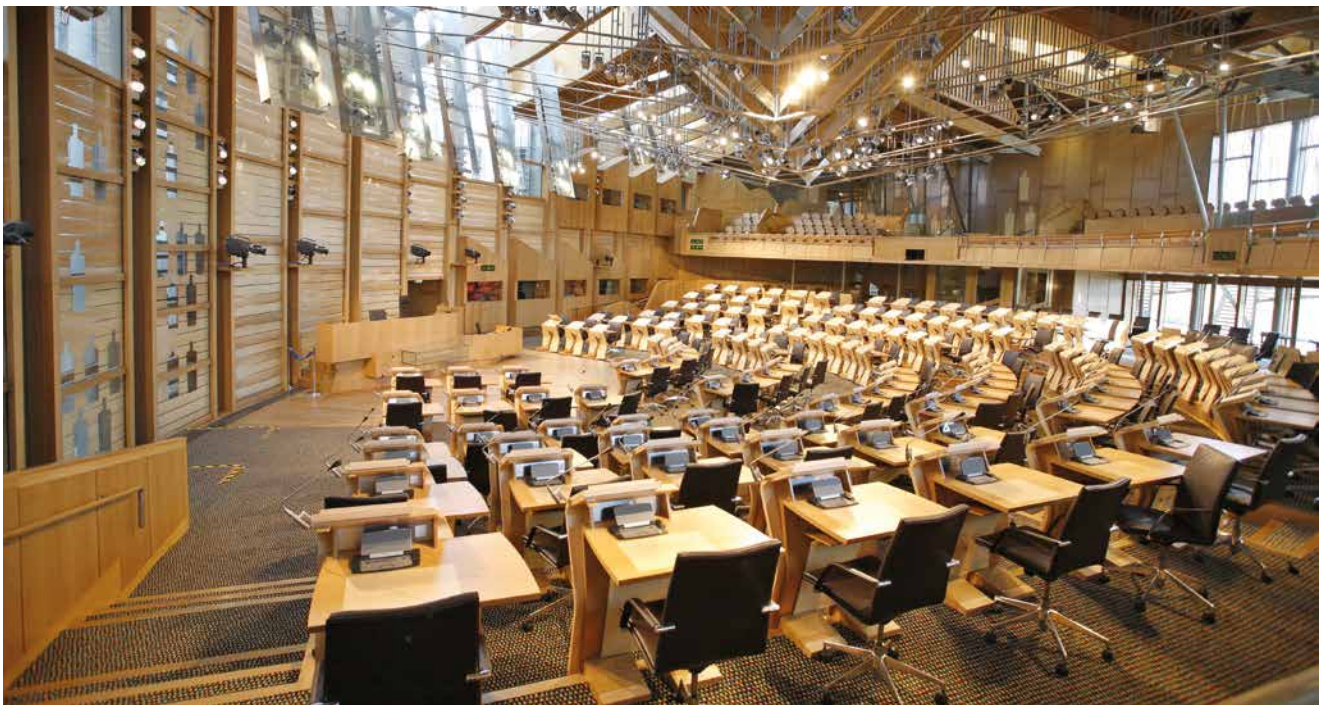
Back in the Spring, Ben Kite (Chair of CIEEM's Strategic Policy Panel) gave evidence to the House of Lords' Land Use in England Select Committee. The inquiry sought to determine whether there is sufficient capacity to deliver the Government's ambitions for climate and nature, and whether current systems support effective implementation of land use policies.

In August, our England Policy Group and marine experts from our wider membership responded to the Defra consultation on the principles of applying a mandatory Biodiversity Net Gain (BNG) to the marine environment.

We are delighted to have been invited to be a part of the UK Government's first ever dedicated group for creating green job opportunities, the Green Jobs Delivery Group. The group, co-chaired by Energy Minister Greg Hands, will support the delivery of up to 480,000 skilled green jobs by 2030 and will help ensure the UK has the skilled workforce it needs to build clean industries.

Scotland

A draft Biodiversity Strategy for Scotland was published in June, setting a new goal to end biodiversity loss by 2030 and restore biodiversity by 2045. We have been a member of the Biodiversity Strategy Development



Debating chamber, Scottish Parliament

Group and our Scotland Policy Group will be submitting a formal response to the consultation on the draft.

We have continued to promote the results of our survey of Local Planning Authority (LPA) capacity in Scotland by sharing a briefing with decision-makers that calls for sufficient training, access to expertise, and funding for LPAs to deliver biodiversity measures in NPF4 (Scotland's 4th National Planning Framework) and beyond.

In June, our Scotland Project Officer Annie Robinson met with Brian Whittle MSP for South Scotland to discuss Positive Effects for Biodiversity in planning and what is needed for Scottish Government to achieve it in a tangible, measurable way through NPF4. Brian Whittle is keen to engage with this issue and has raised questions in the Scottish Parliament.

Our Scotland Policy Group has also responded to Environmental Standards Scotland's draft strategy and we look forward to continuing to engage with the new organisation.

Wales

We recently published a briefing paper for ecologists and developers, setting out Welsh Government's approach to achieving 'Net Benefits for Biodiversity' in Wales and requirements for planning applications. We have continued to engage with Welsh Government on the issue of achieving tangible gains in biodiversity and ecosystem resilience.

As part of our membership of Wales Environment Link, we recently contributed to a briefing document setting out recommendations for the Ofwat Price Review 2024 calling for urgent action to protect and enhance freshwater and coastal systems, and restore our designated sites network. We have also contributed to a briefing on National Minimum Standards for farming and land management, and a letter to Lesley Griffiths on the same topic.

Ireland

Following our submission of a briefing document on the capacity crisis in the sector in Ireland to the Minister for Further and Higher Education, Research, Innovation and Science, Simon Harris, we were asked to send further information on how to address the issue. We are now calling for two key measures: the establishment of a Jobs for Nature Delivery Group, and funding to develop a training programme.

In June, we were approached by the Department of Agriculture, Food and the Marine to contribute to a Training Needs Analysis of the forestry licence applications process and we have now submitted our response..

Our Ireland Policy Group has recently responded to consultations on developing a Forestry Strategy and a Clean Air Strategy for the Republic of Ireland. They are continuing work in sub-groups on biodiversity in planning (including developing a briefing on Biodiversity Net Gain in Ireland), the climate emergency and biodiversity crisis, and agriculture and land use.

We are pleased to report we are now a member of Climate Coalition NI (CCNI). This group is a network of organisations and individuals working to facilitate cooperation between organisations working on climate change issues, locally and globally, in order to bring about appropriate action in Northern Ireland to tackle climate change.

Future priorities

Our priority for the coming months will be engaging with COP15 as an Observer organisation, and continuing to deliver proactive policy engagement on the green economy, natural capital, and data and evidence. Our Country Policy Groups will be responding to open consultations such as the Biodiversity Strategy in Scotland, and gearing up for forthcoming consultations on the Levelling Up and Regeneration Bill proposals.

All of our briefings and consultation responses can be found in our Resource Hub (www.cieem.net/resources-hub) under 'Policy Resources'.

Contact Amber at: AmberConnett@cieem.net

CIEEM is grateful to the following organisations for investing in our policy engagement activities:

ARCADIS Design & Consultancy for natural and built assets
RSK biocensus EXPERTS IN ECOLOGY
EPR
Stantec

Autumn and Winter Training Programme

Craig Willcock
Professional Development Manager, CIEEM

With survey season coming to an end, now is the ideal time to look at opportunities to upskill and further develop your knowledge and understanding in key areas. In support of this, the CIEEM training programme provides a range of courses at beginner, intermediate and advanced level which are delivered by a team of trainers with specialist skills and expert knowledge. The programme includes in-person field-based practical courses, classroom-based courses and courses delivered online.

Some upcoming highlights include:

- **Peregrine Falcon Ecology, Survey and Mitigation**
  (21 September, Birmingham)
  This course provides participants with the skills to undertake surveys, produce relevant and rational reports in line with national guidelines, and to advise on developments in respect of ecological constraints and mitigation measures.
- **Identifying and Managing Non-native Invasive Plant Species**
  (5 & 6 October mornings, online)
  An overview of what non-native, invasive and invasive non-native species are and why they may be a problem, then looking at the legislation listing these and control measures. For each taxon on the course will look at ecology and dispersal, survey techniques, sources of up-to-date information, reporting and devising mitigation measures. The course will also look at control measures, proposing on-site mitigation, writing and implementing management plans, and associated control measures on active sites.
- **Introduction to Nature Conservation Legislation in the UK (England)**
  (12 & 19 October mornings, online)
  An introductory level review of nature conservation legislation, looking at how the current framework translates to practical actions, and considering how effective it is in achieving its aims. Delegates will develop a strong practical understanding of the system of nature conservation governance in England, and how the new laws and policies impact the work on the ground.
- **Conifer Identification for Ecologists**
  (19 October, West Midlands)
  This course will help you recognise the major types of conifers, and start to separate the many species.
- **Winter Tree ID: Extending The Season in Ecological Surveys**
  (7 December, Shrewsbury)
  An introduction to winter tree identification, focusing on key characters to distinguish each species from similar looking plants.

For the first time since before the COVID-19 pandemic, we are now able to offer the **Train the Trainer for Ecologists** course which is being delivered on 4 and 5 October in London. This unique 2 day training course has been created to support ecologists and environmental professionals in developing techniques for designing and delivering field and classroom-based training courses. The training course is suitable for experienced trainers wishing to enhance their skills, as well as for those new to training wanting guidance in achieving a professional standard of tuition.

The training includes sessions on planning your learning objectives, matching a range of different learning styles, strategies to ensure tuition is learner focused, techniques for working effectively with mixed ability groups and ideas for checking delegates have met their learning goals.

Feedback from previous attendees has been positive:

- *"Train the Trainer was a very useful course. It equipped me with a range of practical techniques that help me ensure engagement and deeper learning for delegates." – Matt*
- *"Even after delivering training courses for over 15 years I found the Trainer the Trainer course very useful." – Hazel*

Other upcoming courses include: Biodiversity Metric V3.1 training, Beginners QGIS for Ecologists and Conservation Practitioners, Intermediate QGIS for Ecologists and Environmental Practitioners, Preliminary Ecological Appraisal, QField for Ecologists and Environmental Practitioners, Eurasian Beaver Ecology and Restoration, Ecological Report Writing, Developing Skills in Ecological Impact Assessment (EcIA) (England & Wales), Positive Planning for Biodiversity, Water Vole Mitigation, Introduction to Bat Ecology and Bat Surveys, Plant Identification and Botanical Keys, and more.

To view a full list of training courses we have to offer visit www.cieem.net/events

Contact Craig at: CraigWillcock@cieem.net

Do You Have What it Takes to be a Mentor?

Craig Willcock
Professional Development Manager, CIEEM

The role of a mentor

A mentor is someone who will encourage and support a person to make the most of their career and develop their skills. They do this by providing impartial, non-judgmental guidance and support. A mentor's role isn't to tell a mentee what to do, it is to act as a guide. Mentors aren't expected to have all the answers.

Who could become a mentor?

If you are a CIEEM member then you can sign up to become a mentor. You can be at any grade of membership, at the start of your career or even retired, in any role and from any sector. The main requirement is that you are able to commit time and effort in developing a relationship with a mentee.

Other qualities we are looking for are: helping others to reach their potential, a desire to make a difference, willingness to share your knowledge and experience, an approachable manner, and good listening, questioning and feedback skills.

What does the role entail?

- Exploring different scenarios with a mentee, widening their perspective and encouraging them to look at aspects they may otherwise not have considered before helping them to choose the most appropriate course of action for them.
- Acting as a sounding board for new ideas, listening and discussing personal and work issues that may be having an effect on their professional life.
- Asking probing and stimulating questions.
- Providing honest and constructive feedback and ongoing support and encouragement.

The time commitment can vary depending on the nature of the mentoring relationship and goal, but can be 30 minutes a week, an hour every 2 weeks, or even monthly. The duration and frequency would be agreed between you and the mentee at the start of the relationship to suit both parties. Meetings can be held online via the built-in video chat on the mentoring platform, or via MS Teams, Zoom, phone or even face to face if feasible.

Why we need your support

All CIEEM members are able to use the mentoring platform as part of their membership. However, the mentoring platform is only possible due to the support and dedication of our pool of mentors who volunteer their time to help others.

At present we have 120 mentors who are currently supporting 346 mentees, so we are keen to encourage more of our members to consider becoming a mentor. If we have more mentors available, then we can offer more of our members the opportunity to receive valuable support and advice. We are also looking to increase the range of expertise being provided to further develop the support available.

How you can help

We are looking for mentors from across the UK and the Republic of Ireland covering a range of specialisms including: becoming a Chartered Ecologist, people management, managing work/life balance, project management, business management, ecological impact assessment, upgrading membership and progressing/starting your career.

You can be from any sector, but in particular we would be keen for more mentors from academia, industry, consultancy, local government and NGOs.

We are keen to provide mentoring to final year and recently graduated members to help them with the transition from study to finding their first job. If you are a Qualifying or Associate member, then we do encourage you to sign up as a mentor as being at the early stage of your career you will be able to offer valuable support and advice to those joining the sector. More Fellows and Chartered members would also be welcomed to help provide support for those at mid and senior career stages.

How you can also benefit from being a mentor

- Develop your own problem solving skills
- Being able to pass on personal knowledge and experience
- Having the chance to give something back
- Gain the chance to work on new and exciting challenges
- Build new connections outside of your current organisation
- Feeling that you have been able to support someone else in their career
- Opportunity to develop your ability to empathise and build rapport with others
- Help with your own career progression as you will develop coaching, leadership and inter-personal skills

Do you think you have what it takes to be our next mentor?

If you are feeling inspired and would be willing to share your skills and experience with others, then why not take a look at our Mentoring Platform (https://cieem.net/i-am/continuing-professional-development/mentoring-platform/) to discover the support available and how to sign up.

Join us on 27 October for a special webinar to celebrate National Mentoring Day.

Contact Craig and the team at:
mentoring@cieem.net

Welcoming a New Fellow

The Governing Board was pleased recently to approve the nomination of Dr Graham Russell as a new Fellow.

Dr Graham Russell FCIEEM(rtd)

Graham Russell's CIEEM Fellowship has been awarded due to the extent to which his work has influenced the evolution of policies and legislation. Through his research portfolio, Graham became increasingly involved at the interface between scientific knowledge on the one hand and policy-making and implementation on the other.

He was co-leader of the quantitative modelling work package of the EU FP6 Integrated Project SEAMLESS and has also worked extensively in marine planning. Graham is currently the Planning and Environment Officer for RYA Scotland, and has also provided input to the National Marine Plan and, as part of the Clyde Marine Planning Partnership representing RYA Scotland, he has influenced the Clyde Marine Plan. Graham reviewed the RYA sustainability strategy to identify places where legislation and other matters were different in Scotland. This led to the RYA Scotland Sustainability Strategy and Action Plan, which he largely wrote.

Graham has worked with statutory agencies to share knowledge and is also a current member of the Forth Estuary Forum Management Committee, a former member of the Marine Strategy Forum of Marine Scotland, and a former member of the plenary group of the Scottish Coastal Forum. This latter stakeholder group advised Marine Scotland, from an operational perspective, on the development and implementation of policy relating to marine planning and licensing within a sustainable marine environment.

In addition, Graham has amassed over 50 years of experience in ecology and land use systems, mainly working in

academia, and has remained actively involved in environmental management since his retirement in 2009.

Do you know a CIEEM Full member who ought to be a Fellow? You may not know that it is now possible to nominate members for consideration for Fellowship of CIEEM. For more information visit www.cieem.net or contact the membership team: membership@cieem.net

From the Country Project Officers

Annie Robinson – Scotland Project Officer

Hello everyone

From speaking to members, it sounds like it has been a very busy summer season. From my days doing fieldwork I remember thinking – "wow I get paid to do this" when it was glorious sunshine to "thank goodness I get paid to do this" when it was blowing an absolute hoolie with horizontal rain. I hope the weather has been kind to you wherever you have been out and about across Scotland. I love seeing your pictures on LinkedIn and Twitter.

It was great to get back to in-person Member Network events with a visit to Black Law Windfarm looking at 10 years of peatland restoration. Thanks to Rachel Short and Peter Robson from ScottishPower Renewables. Prior to that we held the brilliantly entitled Member Network event – 'Can you hear me? Oh, I'm muted!' Thanks to Ashleigh Kitchiner and Claudia Gebhardt for giving us a fascinating insight into bioacoustics and echolocation by cetaceans and bats. See Member Network news (page 79) for write-ups from both events. We are busy planning lots of events for our Scottish members this autumn/winter so hope to see you there.

Our Scotland Policy Group members have been busy inputting to consultation responses on Environmental Standards Scotland Draft Strategic Plan and Scotland's Biodiversity Strategy consultation.

We are looking forward to seeing you at the CIEEM Autumn Conference – Delivering a Nature Positive, Carbon Negative Future – in Edinburgh on 23 and 24 November 2022. Find out more at www.cieem.net/events.

Thanks, Annie

Contact Annie at:
AnnieRobinson@cieem.net

Elizabeth O'Reilly – Ireland Project Officer

Hello CIEEM members

I hope you all had a good survey season and that quieter times are ahead. CIEEM has recognised the additional strains on you at the minute as the sector experiences a capacity crisis across all nations. Here in Ireland, we have been making some efforts towards addressing this. We have written to Minister Varadkar to request ecologists and environmental managers are added to the Critical Skills List, and have been working with other organisations on the possibility of establishing an apprenticeship for the sector. In addition, we have been communicating with the Department of Further and Higher Education, Research and Science on other support that we can access. We hope to have further details on these activities by the next edition, but don't hesitate to get in touch with me if you have any questions or input.

In addition to this, we have been working on pulling together some events and activities for our Irish members this autumn. Our Lunchtime Chat Series will return at the end of the month, and we are looking forward to hosting more in-person events before the year is out.

As the Irish Section grows, we look forward to working with our members to support and build a stronger sector in Ireland.

Until next time, goodbye from Ireland,

Liz

Contact Elizabeth at:
Elizabeth@cieem.net

Mandy Marsh – Wales Project Officer

S'mae pawb/Hello everyone

The bryophyte and lichen theme of this edition of *In Practice* reminded me that in 2009 I was briefly part of the Lichen Apprentice Scheme Wales. This was set up by Welsh Government following a suggestion by Ray Woods of Plantlife, as a solution to the dearth of expert (and younger!) lichenologists, not just in Wales but generally. Some went on to become experts, others gained a general grounding in the importance of lichens. We know that there is a skills shortage in ecology and environmental management and that many of our members have been extremely busy over the summer season. It's worth looking at the Welsh Government's apprenticeship scheme, covering all professions, with a view to training up the next generation. Find out more at https://gov.wales/apprenticeships.

With so many of our volunteers, both organisers and speakers, busy surveying throughout the summer, there's been a lull in Member Network events. Keep an eye out on the website for a renewed Autumn and Winter programme, and don't forget that CIEEM members can access all past recorded talks via the My CIEEM section of our website. We also have many publicly available talks on our YouTube channel – just search for CIEEM.

Our Wales Policy Group members continue to input responses to the Welsh Government's Deep Dive into Biodiversity, the Ofwat Price Review 24 process, and the Sustainable Farm Scheme and National Minimum Standards proposed by the Agriculture Bill. The Bill is expected to be laid by the end of September.

Hwyl, Mandy

Contact Mandy at:
MandyMarsh@cieem.net

British Ecological Society

The Interdisciplinary Future of Ecological Forecasting

Charlotte Harrison-Littlefield

Bringing together ecologists and climate scientists has always excited Dr Vicky Boult. With the climate and ecological crises looming, now is the time to unite these historically separate disciplines.

The fields of climate science and ecology are clearly interconnected: climate affects the presence and abundance of species in an ecosystem, while ecological processes feed back into the climate. Yet these disciplines have been kept apart in the past. A joint meeting between the British Ecological Society (BES) and the Royal Meteorological Society (RMetS) in May provided a new opportunity to establish interdisciplinary connections between ecologists, meteorologists and climate scientists. Researchers and practitioners united under one roof to discover a way forward for this emerging field.

Dr Vicky Boult, Knowledge Exchange Fellow from the University of Reading's Meteorology Department, was one of the conference's pivotal organisers. She shares her passion for incorporating climate science modelling into ecological forecasting.

"Anyone interested in the future of ecology and biodiversity should put ecological forecasting on their agenda," she says. "Funding is moving towards applied science, science with impact. Now is the opportunity to bring together these interdisciplinary networks."

The journey so far

The power of ecological forecasting is elevated when fed with the knowledge and expertise of climate scientists, Vicky explains. "In the USA, harmful algae blooms are an increasing concern for lake management," she says. Sophisticated forecasting models have been developed to predict the

BES 2022 Symposium, Climate Science for Ecological Forecasting. Photo credit Grace Foulds.

emergence, flow and movement of blooms. The models consider temperature and ocean currents as well as the impacts of environmental conditions on ecological factors. "The predictive model provides an early warning system to forewarn visitors of the dangers of swimming during bloom events."

Having always been interested in ecological forecasting and predictive ecology, Vicky explains the opportunities that interdisciplinary collaboration brings. "Climate science has been doing this for decades: weather forecasting informs everyday decisions we all make, while climate projections are increasingly used in decision-making, planning and conservation."

"When I first moved into a meteorology department it was a massive learning curve. I had no idea these data were available. As a PhD student in ecology, I used some climate projections for modelling elephants, but there was so much more I could have done that I didn't know was even possible. There is a real need to share knowledge and data across disciplines."

Facilitating interdisciplinary research

Interdisciplinary science, bringing people with diverse backgrounds together, has enormous potential to improve our understanding of the world. Yet it is often seen as a challenge. There was little history of collaboration between climate scientists and ecologists – the Climate Science for Ecological Forecasting conference had to be pulled together from scratch. So how did Vicky and the other organisers set about bringing communities together to kickstart conversations and breakdown barriers? Part of the answer is drawing on the power of societies like the BES to bring people together and increase the reach of such efforts.

At the BES annual meeting last year, Vicky and colleagues ran a workshop to identify the main barriers preventing collaboration. "Going into that first experience it's crucial not to make any assumptions, you must be open to listening," she says. "One of the big barriers that comes out is language. We are all talking different languages and throwing around different fragments of scientific jargon."

Since the May conference with RMetS, work is underway to address these barriers through the development of an introductory seminar series, glossaries of key terms, and a 'database of databases' to improve access to the decades of knowledge and data available in both ecology and climate forecasting.

"Ecological forecasting has value in practical ecology," says Vicky. "We're already seeing the impact of climate change and increasing extreme weather events on species around the world. A better understanding of the forecasting models and data available will be increasingly valuable to ecologists in ensuring the best mitigation and management strategies are in place."

By joining these discussions, researchers and practitioners can play a crucial part in bringing ecological forecasting to the forefront of future management and policy decisions.

Find out more about Vicky and her work at: https://vickyboult.com/

By Members ForMembers

Election season in approaching, and Member Networks need your help. Be part of something amazing!

Our CIEEM Member Networks and Special Interest Groups require enthusiastic and proactive CIEEM members to remain active in supporting members and influencing the sector. This autumn, please take an active part in the Member Network regional elections, and be the spark that inspires your local CIEEM group to go further!

Volunteering for your regional or national CIEEM Member Network can deliver a great number of advantages for you personally including contributing towards your CPD requirements, helping you stand out from the crowd when looking for employment opportunities, as well as providing you with the chance to get involved with lots of great initiatives and projects. There will be opportunities to share your knowledge and learn new skills along the way. You will be able to network with lots of different people involved in many areas of ecology and environmental management, and also be able to help influence the future of CIEEM and the ecology and environmental management profession.

CIEEM Member Networks are a vital part of the Institute's work because they enable networking between professionals in the sector linked together by region/country. Member Networks can showcase the very best case studies illustrating positive work on specific species, habitats and hot topics within ecology and environmental management, through the medium of webinars, workshops and site visits. They can influence the next generation of ecologists and environmental managers by engaging with universities, delivering talks to students and having 1:1 discussions at careers fairs about life in the sector. They can even get involved with policy work with assistance from the Secretariat, and share their passion for specific topics with members via *In Practice* magazine and writing online blogs for the CIEEM website.

Does the above sound good to you? If so, please do not hesitate to take part in the autumn elections this year to recruit new members to your local Member Network committee. Remember, as a committee member, you will be able to take an active role in the work of the committee in the subjects and focus areas that are most important to you. To discover which Member Network roles are available in your area, please visit the Volunteer Opportunities page in the My CIEEM area of our website.

North East England Geographic Section

Woodland Creation Challenges

Back in April 2022, held in conjunction with the Institute of Chartered Foresters, the North East England Section held a successful event delivering relevant presentations and visits to two large-scale productive woodland creation projects in the Rothbury area of Northumberland, to foster a healthy discussion on meeting the Government's tree planting targets while also meeting environmental constraints. The area hosts multiple Sites of Special Scientific Interest (SSSIs), particularly due to the wealth of rare flora found there.

The day provided an opportunity to debate the current situation, for members of both organisations to air their perspectives on the issue of creating both a biodiverse and commercially viable forestry, and help build constructive working relationships so that such schemes can also meet the challenge of the climate crises.

Scotland Geographic Section

Can you hear me? Oh, I'm muted!

At this Scotland Member Network event, we heard from experts examining bioacoustics and echolocation by cetaceans and bats. It focused on the process and mechanisms of echolocation, and the impacts that anthropogenic activities may have on these fascinating creatures.

The group was treated to an excellent talk by Claudia Gebhardt, the Scottish Bat Officer with the Bat Conservation Trust. In her role as Scottish Bat Officer Claudia is supporting bat groups in Scotland, providing training for bat surveys skills, as well as enthusing and engaging people about bats and taking part in bat surveys.

They also heard from the brilliant Ashleigh Kitchiner, a Senior Marine Mammal Consultant at APEM Ltd. Ashleigh works with many organisations to create marine mammal risk assessments, monitoring survey plans, mitigation protocols and much more.

Noctule bat (*Nyctalus noctula*)

Ten years of peatland restoration at Black Law Windfarm

The Scottish Section welcomed back the opportunity for in-person events again with a much overdue visit to Black Law Windfarm to see the results of peatland restoration carried out there over 10+ years. The site visit was very informative and a big thanks to Peter Robson for talking us through the various operations, results and research undertaken at the site. Having seen the ex-forestry sites in such poor condition prior to restoration, I thought the results were particularly impressive over a relatively short space of time. In addition to the technical discussions, I heard comments from various attendees at how good it was just to be back mixing and networking with like-minded people and that is such an important part of these events.

Thanks to everyone who attended and a big thanks to Peter, Rachel Short and the other ScottishPower Renewables staff for hosting our first in-person event for over 2 years.

Matt Pannell, Scotland Committee Convenor

East Midlands Section

A summer stroll through Bunny Old Wood

The East Midlands Member Network met up at Bunny Old Wood, Nottinghamshire, for an evening walk on one of the hottest days of the year! Bunny Wood is an ancient, coppiced woodland referred to in the Domesday Book and was probably used by Saxon settlers as a source of wood. In 1487, Henry VII and his army camped nearby on their way to the Battle of East Stoke.

It was an insightful evening walk with a fantastic opportunity for sharing knowledge, networking, learning about woodland management and enjoying the beautiful surrounds. The Member Network were joined by Dr Chris Terrell-Nield, who manages the woodland on behalf of Nottingham Wildlife Trust. Chris shared the history of the woodland as well as how the woodland is managed in the present day. Great and lesser spotted woodpeckers are among the 50 bird species recorded at the site, while field maple, dogwood, foxglove and bluebell make up some of the diversity of flora of the woodland.

From the CIEEM Patrons

Creative Cultural Encounters Towards a Collaborative World

Judy Ling Wong
Painter, Poet and
Environmental Activist

There is no such thing as a purely environmental initiative. A so-called purely environmental initiative is one that has rejected its social, cultural and environmental context. When we think locally and globally, issues of diversity, equality and inclusion necessarily come to the fore. There are issues of diversity, equality and inclusion within nations, and there are issues of diversity, equality and inclusion set within the relationship between nations. Purposeful cultural encounters can contribute to building better multicultural collaboration nationally and internationally, fueling innovative and culturally appropriate sustainable solutions.

There is a world of diversity in every country. The people that we call ethnic minorities in the UK are in continuity with global ethnic majorities. White people make up only 11% of the world population. By giving a focus to cultural encounters and building working relationships with ethnic communities, members of dominant populations can look forward to acquiring an ease of cultural contact, and gaining intercultural skills that can facilitate the effective negotiations and collaborations that we wish to see locally and on the world stage. Our ethnic minorities are like the living world news. Their stories are told from a place of heart, through day-to-day connections with family and colleagues across the world. These can bring us closer to what we need to know in order to work well cross-culturally.

Besides bringing all of us closer to the world-wide lived experiences that can move us and help us to work from a place of identification, there is also the inspiration of cultural visions of nature that can inspire us to work from a place of deep visceral, emotional and spiritual connections. In the early days of Black Environment Network, a group of Bangladeshi women asked us to look for a space for them to grow some vegetables. At the end of the project, there was the usual evaluation and we asked, "What is the best thing about this project?" Typical answers would have been the pleasure of fresh food, being in the outdoors or making friends, but their answer blew me away. They said, "The best thing is that our bare feet are once more upon our Mother, the Earth." A few years ago, when I was in Mexico, I met people from the Huichol tribe and one of them said to me, "In the West you talk about Mother Earth, seeing her as mother just because she is seen to feed you, but for us, there is also Grandmother Moon. There is Father Sun and Brother Deer…. When we take care of the environment, we are only taking care of our family." Many cultural visions of nature carried by our ethnic minorities inspire and challenge us to rethink our connection to nature. The impact of cultural visions is not about receiving something completely new. It is more about reawakening something we too felt a long time ago on our developmental journey and that we have lost as society in the Global North has become more mechanistic and science-based.

We can invest in cultural encounter and in the building of working relationships between environmental professionals and ethnic minorities, paying particular attention to supporting both parties' capacity for creativity. Creativity opens out expression, communication and the ability to re-imagine scenarios. Bringing in creatives to work alongside environmental professionals can help to unlock the power that may be released when those who are affected are included, supported and enabled to contribute from their lived experience towards the transformative solutions that we need to address climate change.

I look to environmental professionals to purposefully engage with ethnic minorities, building capacity and shaping the processes, to create a quality of energy that moves us within a multicultural context, so that we can re-imagine the world together, moving it towards the culturally informed transformative ideas that we need so much right now, locally and globally, for meaningful collaboration. When we are richly engaged, we are inspired to work hard together towards a sustainable green future for all of us.

About the Author

Judy is a painter, poet, environmentalist and expert advisor on multicultural environmental participation. She is probably best known as the Honorary President of Black Environment Network (BEN). For 27 years she was the UK Director of BEN, with an international reputation as the pioneer and creator of the field of multicultural environmental participation in the built and natural environment. Judy is a major voice on policy and practice towards social inclusion. She is recognised as a visionary advocate for diversity and equality. She was awarded an OBE for pioneering multicultural environmental participation in 2000, and a CBE for services to heritage in 2007. Recently, she was included in the BBC Power Women List 2021, and the Forbes List of 100 Leading Environmentalists in the UK 2021, Climate Reframe List of 100 best-known UK BAME activists.

Student Hub

Foot in the Door:
Step into the Sector

Drew Lyness
Volunteer Engagement Officer, CIEEM

In late June, CIEEM were pleased to host a student and early career webinar, focusing on top tips for applying for jobs in the sector. Members of the CIEEM Secretariat – Krystie Hamilton, Drew Lyness and Saz Hayward – were joined by professional recruiter Catherine Bunting, from Hill and Jago Recruitment, who specialise in the environment sector. Usually focusing on more senior level positions, Catherine works with leading small- to medium-sized environmental consultancies across the UK. She is a passionate environmentalist who enjoys supporting graduates and early careers professionals with careers advice and coaching. Here is a summarised version of the advice that Catherine and CIEEM provided during the webinar, to help driven individuals to break into the ecology and environmental management sector.

Finding the perfect opportunity

Before taking any of the processes below any further, it is vitally important you consider what you want from a career. Think about practicalities and potential impacts on your life outside of work. Choose the correct working environment for you. Work may involve reaching remote outdoor locations, nature reserves or remaining office-based, at home and everything in-between. Some roles may require working anti-social hours and considerable travel time, so before committing to anything, consider whether this fits with your weekly life. Talk to lecturers and course leaders at your higher education institution, as they can provide insight into life in the sector, or put you in touch with those who know about specific areas and career types.

Once you have decided, do your research into which organisations and companies are based in your desired area. You can often reach out to them through LinkedIn, or if not, contact them by email to find out more about them and their mission. Seek further information about a specific role if you have one in mind. Focus on how the role might fit into the bigger picture. You could search for past and present employees on LinkedIn too, to ascertain opportunities for development. You may even get an idea of staff turnover.

Attracting attention: all eyes on you

When applying for a job, take time to ensure your CV stands out from the crowd. Remember, all graduates have a degree. Think about what sets you apart, and what drives you to pursue a particular job. Keep your CV concise (two pages at the most) and split into clear sections. Recommendations for structuring a CV can be found in the CIEEM Resource Hub. Writing a cover letter is strongly advised, even if the application does not specifically require one. Your letter and CV should be structured to answer why you are getting in touch, why you are suitable for the job and what you feel you can bring to the company/organisation. At the end, reiterate how your ambitions link to the mission of the role being applied for.

While being able to demonstrate impactful volunteering for a related organisation or project is highly valuable, not everyone has the time or resources to do this. Remember to consider transferrable skills from paid jobs which may apply, and mention these in your application. If you are able to volunteer, be wise about where you do this and how it might help you build a network of useful connections or gain new skills. Volunteer for something you are passionate about! This will help you remain interested and motivated. Organisations will recognise high motivation, and that may lead to an offer of paid employment down the line.

Stay focused, stay true

Be organised when applying for jobs. Keep a log of roles you have applied for. If you can, find out who key decision-makers might be, and add them to your LinkedIn profile if you have one. If you don't hear a response from an organisation, follow up and find out why. Remember to tailor your CV and covering letter to each role, so that it remains targeted and relevant. Call

companies to ensure your application has been received, if applying online. Personal communication gets you noticed and illustrates a proactive approach. If an application is rejected, don't let it get to you! Each rejection just means you are one step closer to the role that you want. If you need further advice as you feel you might be getting something wrong, seek further help and guidance. In the sector we are all one team and will support each other when asked.

Thriving under interview

If your interview is online, ensure you have a strong internet connection. Keep your background clear so attention can be kept on you. Complete your research on the organisation interviewing you. Be aware of what you can bring to the table, and also what you might like to get out of the role. Think about relevant scenarios where you have demonstrated the skills required on the role profile, especially where a positive impact can be shown. Think about how your examples show an ability to learn and adapt. At the end of the interview, confirm you are still interested in the role (assuming you still are) and ask the interviewers what the next steps will be.

Honest review post-interview

Before you hear back, send an email to interviewers to thank them for their time. If you receive a job offer, fantastic! Take the time to read through the terms of the role, and ensure you understand everything you need to know before responding. If you receive a rejection, don't be disheartened. Contact the organisation to ask for feedback, and (if you can) find out what made the chosen candidate stand out. Keep going, but make sure you take an occasional day off so you can relax and check in with yourself. If you are still struggling after several applications, ask for further advice from experts in the sector. Consult with the careers service at your university or college (if you have one) as they may be able to provide further useful information.

Further support from CIEEM

Make use of CIEEM's Continuing Professional Development (CPD) tool, and keep track of the skills and knowledge you build from training, volunteering and other activities. CIEEM can offer great opportunities for networking, so be sure to get involved with regional Member Networks and Special Interest Group activities. You could also get involved with CIEEM's mentoring scheme as a mentee, where you would be matched with a suitable volunteer mentor based on your personal and professional development goals (for more about the mentorship scheme, see page 75 of this issue). Additionally, if you are a student CIEEM member, you can apply to receive one of five free places to attend a national CIEEM conference. There are lots of opportunities here, so don't miss out. Once you've taken the first step on the career ladder, do join up with the newly created CIEEM Early Careers Special Interest Group. This group exists to support you as you settle into life in the sector, so do get involved where you can.

About the Author

Drew develops and assists CIEEM's brilliant volunteer community, so that they can continue to make positive impacts in all areas of our Institute. Drew is an Ecology BSc(hons) graduate from UEA and has previously worked for the RSPB supporting its volunteers and community groups in Eastern England. He is a highly passionate birder and naturalist, based in Norfolk.

Contact Drew at: DrewLyness@cieem.net

BOOKS, JOURNALS AND RESOURCES

Compiled by the Academia Special Interest Group

Paper Review OPEN ACCESS

Nutrient fertilization by dogs in peri-urban ecosystems

De Frenne, P., Cougnon, M., Janssens, G.P. and Vangansbeke, P.

Ecological Solutions and Evidence, 2022, 3(1): e12128

https://doi.org/10.1002/2688-8319.12128

These authors calculated the nutrient input from the dogs visiting four peri-urban nature reserves around the city of Ghent in Belgium over an 18-month period. The research was prompted by the recent dramatic increase in dog ownership combined with the access to nature agenda acknowledging the health benefits of outdoor exercise. The research involved observing the number of dogs visiting the areas combined with data in the literature urinary and faecal output to calculate that nutrient input could be as high as 11 kg nitrogen and 5 kg phosphorous per hectare per year, with the later mostly from solid waste. The potential impact on vegetation, with this input additional to atmospheric nitrogen, is significant although deposition is not evenly spatially distributed but likely to be concentrated along pathways and in high-use areas. The authors stress the importance of considering this issue in management plans and discuss the implications for management. If dogs are kept on the lead rather than allowed to roam freely the likelihood of owners collecting poo and disposing of it responsibly is increased and this is estimated to remove over 50% of the nitrogen and 97% of the phosphorus. Communicating the implications of failing to do this for wildlife, rather than the health and hygiene messages commonly used, may be a more effective encouragement.

Paper Review OPEN ACCESS

Principles for the production of evidence-based guidance for conservation actions

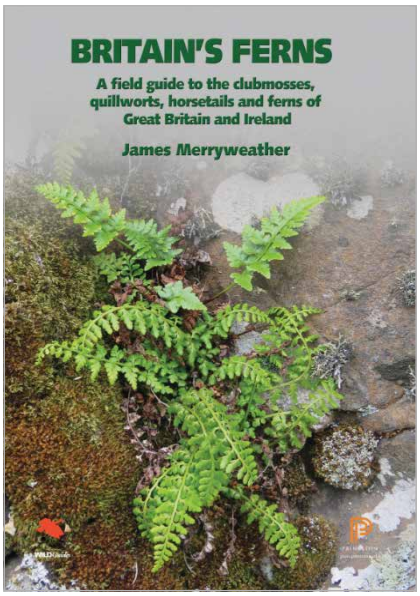
Downey, H., Bretagnolle, V., Brick, C. *et al*

Conservation Science and Practice, 2022, 4: e12663

https://doi.org/10.1111/csp2.12663

Conservation guidance documents can offer consolidated advice, and its adherence can often form part of licensing or other aspects of regulatory compliance in relation to protected species or habitats. This research involved a review of conservation guidance for mitigation and management of species and habitats in the United Kingdom and Ireland. The study identified and reviewed 301 examples of guidance, of which only 29% provided a reference list, and only 32% (9% of all the guidance reviewed) had references that were relevant to justify the recommended actions. Much of the guidance also lacked methodology for production, did not list uncertainty of, or lack of evidence and was often outdated. The review concludes that a lack of up-to-date and evidence-based guidance can lead to misguided and ineffective conservation action and policy as well as poor decision making and wasted resources. To combat this and enable more effective conservation practices, the paper presents a set of principles to follow that would ensure relevant evidence is incorporated into future conservation guidance.

Book



Britain's Ferns: A Field Guide to the Clubmosses, Quillworts, Horsetails and Ferns of Great Britain and Ireland

Merryweather, J., 2020. (Vol. 15).

Princeton University Press, Woodstock.
ISBN: 978-0-691-18039-7

A useful field guide for those interested in identification of British and Irish ferns and their allies. This book includes attractive illustrated keys and a significant range of coloured photographs, often showing morphologically similar species side by side and tabulating critical features. For anyone who has struggled with identification of *Dryopteris* species, the text offers psychological support in the justification of 'walk on by' specimens, individual ferns that through apomixis and hybridisation may defy identification. In biology, not everything can be readily determined but it is rare to see that admitted in a field guide. Such honesty makes it easy to warm to this book; it offers encouragement. Coverage of seasonal variation and unusual habitats such as drainpipes also make this guide fun to read.

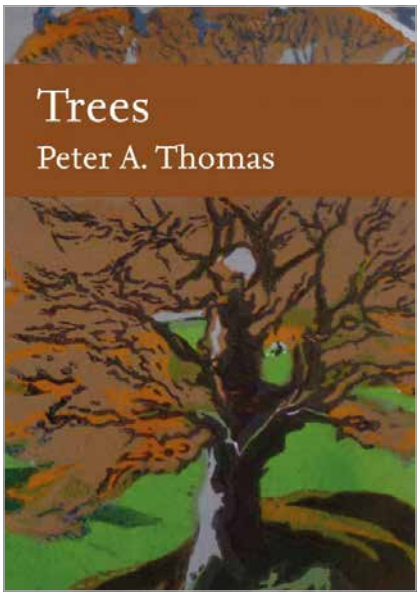
Paper Review OPEN ACCESS

Nature's contributions to people and peoples' moral obligations to nature

Piccolo, J.J., Taylor, B., Washington, H. *et al*
Biological Conservation, 2022, 270, 109572
https://doi.org/10.1016/j.biocon.2022.109572

In this timely article the authors reflect on the second session of COP15 (now confirmed for December 2022), which aims to implement ambitious measures to stop biodiversity loss with the ultimate goal of establishing harmony between humans and nature by 2050. They argue that achieving these aims is currently hampered by the separation of humans from nature, citing conservation scientists as responsible for continuing this paradigm. They are specifically critical of the ecosystem services approach, challenging the notion that this helps to make conservation activities more socially and culturally inclusive. They argue that in order for conservation initiatives to move forward and effectively address the extinction crisis neither technical advances nor policy measures will be enough without challenging anthropocentric assumptions and radically changing the way we view and value nature and other species. While most of us will agree wholeheartedly it was perhaps surprising – and illuminating – to be reminded just how embedded anthropogenic values are in high-level organisations. The authors concluded by urging the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), to address this issue in future work and focus on promoting a more inclusive approach based on intrinsic values and ecocentrism. For those without the time to read the full article a summary has been published in *The Conversation,* available at https://theconversation.com/conservation-science-still-rests-on-how-animals-can-benefit-humans-184671.

Book

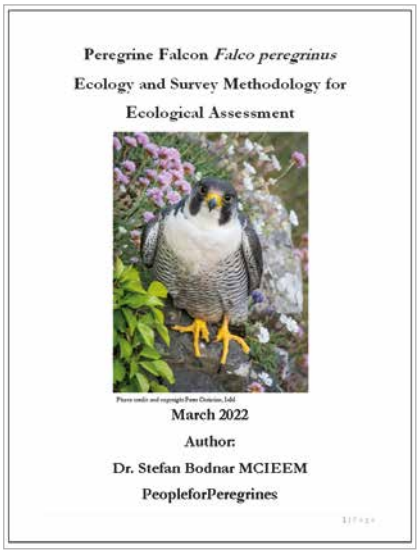


Trees

Thomas, P.A., 2022.
(The New Naturalist Library #145)
HarperCollins. ISBN: 9780008304539 (pbk), 9780008304515 (hbk)

This much awaited latest edition of the New Naturalist Library follows on from Rackham's (2006) Woodlands (book #100). In Chapter 1 'setting the scene' Thomas explains the inclusive approach of the book, which includes shrubs and non-native species from outside of Britain. The text is accessibly written, amassing a huge wealth of new published research (sources are given), accompanied by tables of data, diagrams and colour photographs of trees. The core of the book loosely follows a tree's journey through the seasons (spring flowers, summer droughts, autumn seeds, winter storms), with break-out chapters examining tree biology in more depth, such as how a tree defends its wood (Chapter 8) and gets to be 5000 years old and 100 m tall (Chapter 12). The book closes with an assessment on 'what is the future of trees' (Chapter 16), highlighting the need to slow deforestation and improve forest quality to counteract the 32% of the world's forests we've lost since the industrial era and that 40% of what is left is high in quality and without human modification. Thomas is optimistic and hopeful that this can be done in a variety of local to global ways, such as the Tree-lined Streets Bill currently passing through the House of Commons that would require new developments to have tree-lined streets. Throughout the whole book there are fascinating case studies. For example, in Chapter 2 on 'the value of trees', Thomas reports on how trees can be used to protect cities from terrorist bombs, with accompanying images showing intact *Thuja* hedges (smaller leaves) and ripped-apart cherry laurel (large leaves). It's this kind of information that makes this book a must-read for those involved in land management and it provides some great anecdotes for tree enthusiasts. This is the definitive book on trees!

BOOK REVIEW



New Guidance for Survey and Mitigation for Peregrine Falcon

The new guidance *Peregrine Falcon Falco peregrinus Ecology and Survey Methodology for Ecological Assessment*, written by Stefan Bodnar MCIEEM, provides comprehensive and up-to-date guidance for surveys and mitigation for developments.

Introduction

The peregrine falcon, *Falco peregrinus*, is now a familiar and iconic bird of inner cities and towns in the UK, with an expanding population. The peregrine is renowned for its speed, reaching over 320 km/h during its characteristic hunting stoop (high-speed dive). In the 1950s and 1960s, the population suffered a catastrophic decline from the effects of pesticide contamination in its food chain and neared extinction. Its rarity as a breeding bird was the reason for its inclusion on Schedule 1 of the Wildlife and Countryside Act (1981) as amended. Following certain pesticides being banned and increased legal protection for the birds, the recovery of the peregrine is a conservation success story. The population is now estimated to be more than 1505 breeding pairs in the latest national survey by the British Trust for Ornithology.

Development

Once a species that was rarely (if ever) encountered by most ecological consultants, with continued expansion of the peregrine population, particularly in urban areas, there is increased need for survey and appropriate assessments in terms of development. However, there has been limited guidance on surveying and mitigation available, and the related behavioural and ecological information for this species is fragmented, difficult to find and, at times, out of date.

This guidance brings together the body of research and evidence in relation to timings of breeding, causes of disturbance, the process of site colonisation and the degree of post-fledging dependence.

The guidance provides detailed advice for professional ecologists undertaking surveys in different habitats, assessing the impacts of development and appropriate mitigation. It bridges the gap between practical conservation work of peregrine groups and research evidence on behaviour and ecology and focused advice for ecological consultants. The aim was to create a coherent, accessible resource of all relevant information on peregrine status and ecology. The guidance develops and describes best practice for consultant ecologists in relation to development. Where appropriate, existing guidance has been incorporated, amended, developed and expanded based on more recent data and experience. In particular, the focus is urban situations, which is where professional ecologists are most likely to encounter the species. It covers such issues as potential disturbance and licensing, when to recommend boxes and other mitigation structures and the potential impacts of new developments on resident birds, and it aims to provide appropriate approaches and, where possible, offer pragmatic and realistic solutions.

Content

The guidance is 94 pages long, and contains nine chapters split into two main sections. The first (Chapters 1–3) deals with peregrine falcon identification, conservation status and ecology in relation to surveying and mitigation. The second section (Chapters 4–9) comprises desk and field survey guidance, the planning process and development/mitigation, including the creation and efficacy of artificial nest sites. Lastly there are comprehensive appendices of legislation, recommended reading and references. The text is illustrated throughout with tables and images for clarity.

Future and availability

In publishing this guidance, the aim is to improve on our collective knowledge through the learned experiences of others. It is our intention to revise the text regularly and amend the guidance in the light of further knowledge and experience. To obtain the document, please contact the author at the email address given below.

Thanks

As with all such endeavours, we stand on the shoulders of others in developing this guidance and it is the sum of our collective knowledge, developed by many experts and enthusiasts alike, who are gratefully acknowledged here. I have met many peregrine workers who have shared their knowledge and insights and have helped to fill in any omissions or errors. In addition, useful comments and observations on the draft guidance was provided by the London Peregrine Partnership, Ed Drewitt, Keith Betton, Richard Foss and the Professional Standards Group of CIEEM, to whom I am grateful. Photographic images were provided by several talented individuals and are reproduced with their kind permission and their copyright acknowledged.

About the Author

Stefan Bodnar MCIEEM runs an independent ecological consultancy, having previously worked for a range of statutory and voluntary sector conservation organisations. His interest in peregrines involves holding a Schedule 1 licence and being a founding member of PeopleforPeregrines.

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14–15 September **Undertaking Dusk/Dawn Bat Roost Surveys** South East England	15–16 September **UK Habitat Classification for Practitioners** Online	21 September **Peregrine Falcon: Ecology, Survey and Mitigation** West Midlands	28 September **Eurasian Beaver Ecology and Restoration** Online
03–04 October **Water Vole Mitigation** Online	04–05 October **Train the Trainer for Ecologists** South East England	05–06 October **Identifying and Managing Non-native Invasive Plant Species** Online	06–07 October **Plant Identification and Botanical Keys** Online
11 & 12 October **Introduction to Bat Ecology and Bat Surveys** Online	11–14 October **Beginners QGIS for Ecologists and Conservation Practitioners** Online	12 & 13 October **Ecological Report Writing** Online	12 & 19 October **Introduction to Nature Conservation Legislation in the UK (England)** Online
17–19 October **Bats: Assessing the Impact of Development on Bats, Mitigation & Enhancement** Online	18, 19 & 21 October **QField for Ecologists and Environmental Practitioners** Online	19 October **Conifer Identification for Ecologists** West Midlands	20–21 October **Using UKHab for Biodiversity Net Gain** Online
03 & 04 November **Developing Skills in Ecological Impact Assessment (EcIA) (England & Wales)** Online	03 & 04 November **Eurasian Beaver Ecology and Restoration** Online	07-–09 November **Intermediate QGIS for Ecologists and Environmental Practitioners** Online	23–24 November **2022 Autumn Conference: Delivering a Nature Positive, Carbon Negative Future** Edinburgh

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