Wild Science

2024

The Wildlife Trusts

Data, Research & Evidence in The Wildlife Trusts:
A Review & Prospectus

Contents

This report should be cited as:
Doar, N., Jamieson, A., Kingscott, J., Siggery, B., Barios O'Neill, D., Thomas, E. & K. Brown (2024) *Wild Science 2024: Data, research & evidence in The Wildlife Trusts - a review & prospectus*. The Wildlife Trusts, Newark.

The Wildlife Trusts

Cover photo: © Guy Edwardes / 2020VISION

© Mark Hamblin / 2020VISION

1. Foreword

As the nature and climate crises deepen, the work that goes on to understand the true value of the natural world to human beings, or to discover how best to bring about effective action for its recovery is more vital now than it has ever been.

It is increasingly important that people have a clear and accurate view of how things are changing, what the consequences are for human beings and the natural world, and how things can be improved. More than ever, we need good data and sound research to generate reliable evidence, and we need to test new ideas and emerging technologies.

Increasing the public's knowledge and understanding of wildlife and the natural world is a central purpose of The Wildlife Trusts. Nature conservation, scientific research and environmental education are the three pillars on which the work of most Wildlife Trusts has been built over the years. These are embedded in the charitable objects that spell out why our organisations exist; the public benefits that we're here to deliver and that give us the right to call ourselves charities.

We champion and deliver the protection of wildlife and wild places. We increase people's awareness, knowledge and understanding of wild plants, animals and the natural world. And we systematically study and explore the world around us, so we can understand it better, look after it more effectively and help others to do likewise.

Much of our success has rested on the meticulous collection and analysis of data; on the effort that has gone into recording and documenting the changes happening around us, on exploring what's going on and why things happen as they do, and on testing what works in practice (and what doesn't).

Often, Wildlife Trusts have provided the data for others to analyse, or our land has been made available as a natural laboratory where students and researchers have carried out their own investigations. We have helped to chart changes in much of the UK's wildlife, to identify the reasons for significant declines and to document some of the more positive trends; including what happens when positive action is taken. And we've worked with others to learn from them and to share what both they and we discover.

But are we doing enough? Are we doing it as well as we need to? Is our generation and use of evidence having as much positive impact as it could?

Internal consultation across The Wildlife Trusts, discussions and debates since 2020 have revealed huge support for an increased collective effort to strengthen our approach to

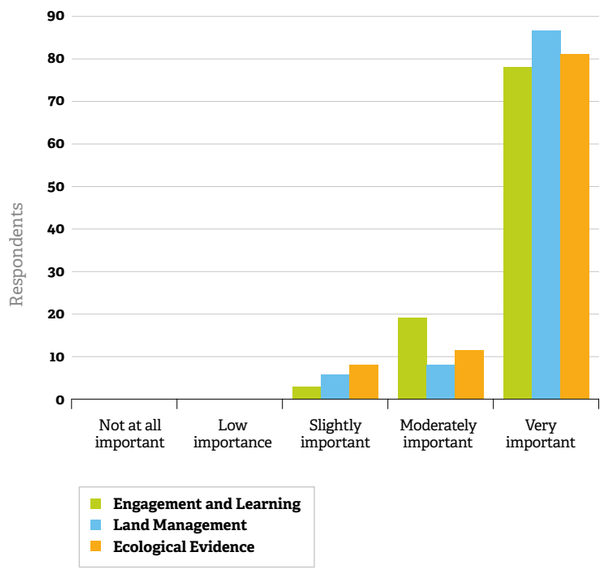
data, research and evidence. More than 80% of those involved (including specialists from all areas of our work) said that evidence is "very important", but only 35% felt that our work is currently "evidence-led"[1], with the majority of staff undecided. There was a strongly expressed view that collaborating more closely to address this together would help us to achieve more – to generate, access and share better data and evidence, to do this more easily and to communicate and apply it more effectively, so we can have a bigger impact.

From 2024, the Wildlife Trusts are bringing a new focus to this aspect of our work[2]. We have always done research and promoted it. We have always generated evidence and applied it. We recognise its value. But now, more than ever, we need to be solution-focused and evidence-led. We need to make the best use of technology to collect and process data to answer our most urgent and important questions. And we need to pool our efforts with those of others to make sure that we're using our limited resources as effectively as possible. We need to be asking the right questions, doing what's necessary to answer them and feeding what we discover back into what we do and how we do it.

This report summarises The Wildlife Trusts' collective approach to data, research and evidence across all areas of our work. It briefly explains why these are vital foundations for everything we do and how we intend to work together and with partners outside our federation to make them as strong as possible over the years to come. It highlights examples of data collection, research and analysis that have provided us with useful evidence in recent years and indicates the impact that these have had. It flags up some of our current initiatives that should produce further results and insight in the future. And it sets out an initial assessment of our emerging priorities for further data collection, research and evidence generation. We hope this will be the start of a process that will grow from strength to strength, year on year.

> "The objects of the Society are to promote the conservation and study of nature, the promotion of research into such conservation and to educate the public in understanding and appreciating nature, in the awareness of its value and in the need for conservation."
>
> **The Royal Charter of the Royal Society of Wildlife Trusts**
> March 2006

Figure 1: How important is evidence? Results of a survey of Wildlife Trust staff in 2021, broken down by work specialism[a].



[a] Reproduced from Parry *et al* (2022). See Endnote 1.

2. The Wildlife Trusts' Collective Strategy to 2030

The Wildlife Trusts exist to bring wildlife back, to empower people to take meaningful action for nature, and to create an inclusive society where nature matters.

We are working together with communities across the UK to achieve our shared vision of a thriving natural world, with our wildlife and natural habitats playing a valued role in addressing the climate and ecological emergencies, and everyone inspired to get involved in nature's recovery. We tell the truth about the state of nature and what needs to be done to put it into recovery[3].

The Wildlife Trusts are committed to working together to deliver a joint strategy to 2030, based on a clear common purpose and shared values. We are working together to achieve **three** shared strategic goals:

1

Nature is in recovery with abundant, diverse wildlife and natural processes creating wilder land and seascapes where people and nature thrive.

2

People are taking meaningful action for nature and the climate, resulting in better decision making for the environment at both the local level and across the four nations of the UK.

3

Nature is playing a central and valued role in helping to address local and global problems.

3. Our Approach to Data, Research and Evidence

To achieve these goals, we seek radical change and bold thinking. We base this on sound evidence and real-world solutions that work. We are convinced that working with partners and communities delivers the biggest positive impact for nature.

The Wildlife Trusts want to be, and to be seen to be, a federation that is evidence-led and solution-focused.

We will achieve more for nature and society if we develop better solutions, make better decisions and take more effective action, based on clear and accurate understanding.

This is why we are working together, and with many partners, to deliver easier access to more, better quality and more useful data and evidence.

It will help everyone take meaningful and effective action, so that together we can achieve more for the recovery of nature, a stable climate and the benefit of society.

We are evidence-led and solution-focused

We use facts to solve problems and drive effective change

4. Our Research and Evidence Work

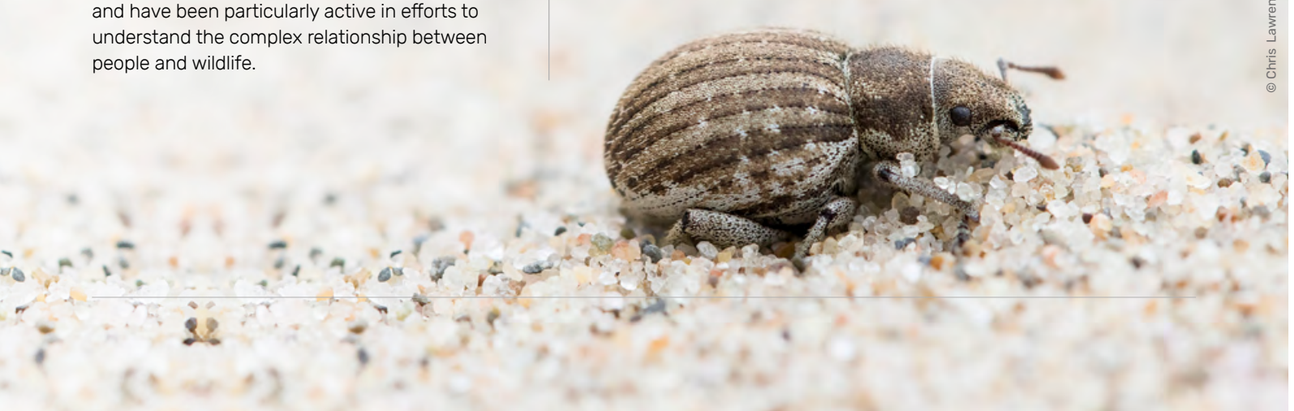
Across the federation of Wildlife Trusts, there are many scientists on our boards of trustees, sitting on our committees and taking part in working groups. Many of our staff and volunteers have PhDs and other research qualifications or substantial practical research experience.

We host local biological record centres and contribute to national monitoring programmes and recording schemes. Every day, our activities generate data that can be used to inform improvements to how we work and the advice we give to others.

In recent years, many staff and volunteers, working for individual Wildlife Trusts or for the federation as a whole, have commissioned, led or contributed to a very wide variety of data, research and evidence projects. In particular, we have led the development of evidence-based practical handbooks for the creation, restoration and management of habitats such as wetlands, peatlands and grasslands. We have identified, mapped and championed non-statutory Local Wildlife Sites across the UK and have been particularly active in efforts to understand the complex relationship between people and wildlife.

In recent years, we have contributed significantly to efforts to understand 'natural capital' and to develop effective mechanisms for green finance to be invested in nature-based solutions. We're increasingly interested in the best ways to reduce the greenhouse gas emissions generated by our work and the most effective ways to help natural systems to play an effective part in stabilising the climate and supporting our efforts to adapt with it as it changes. We have partnered with different expert researchers and research organisations and generated data that has been made available to others in order to achieve our goals for nature's recovery and strengthened relationships between people and the natural world.

Here is a small selection of the projects and initiatives we have helped to deliver and the impact they are having.



© Chris Lawrence

4.1 Space for Nature

It is critically important that nature recovers across the UK, amongst other things so that resilient, wildlife-rich, ecologically functioning landscapes and seas can adapt to climate change, help to stabilise future climate and help to solve the problems facing society.

Given the urgency and scale of the task, we need effective new tools to help us monitor, understand and plan change. A combination of citizen science, satellite-based collection of Earth Observation (EO) data and artificial intelligence (Machine Learning) may provide us with a transformational new way to plan, monitor and manage landscape recovery.

Space4Nature (S4N) was born out of the challenge of how to plan and monitor nature recovery at scale. It builds on earlier research undertaken by University of Surrey's Centre for Environment and Sustainability (CES) which assessed the potential role of Earth Observation (EO) data in implementing new agri-environmental grant schemes[4].

Surrey Wildlife Trust, CES and other partners are now developing a tool to remotely determine habitat types with enough certainty to inform decisions about habitat restoration and creation. Nothing can directly replace putting professional ecologists into the field to record the location, extent and condition of habitats, but this is expensive and dependent on the availability of suitably skilled individuals. Keeping ecological survey data accurate and up to date at the scale needed is time consuming. Given the magnitude of the biodiversity crisis and the urgency of the need for nature to recover, the availability of high-resolution satellite imagery and the use of new technological tools could make a very significant difference to nature's recovery in the UK.

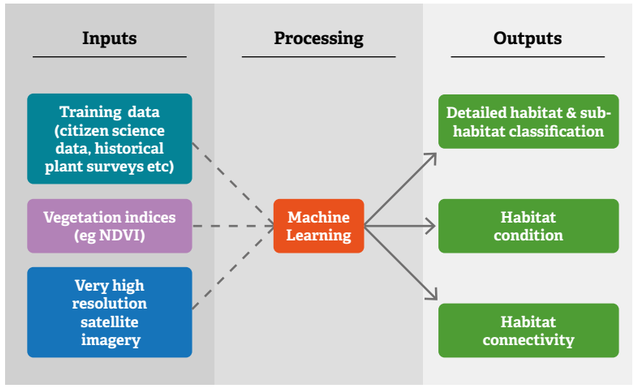
The S4N approach sets out to accurately automate the mapping of priority habitats across Surrey – and potentially further afield. It combines EO with citizen science field surveys, other data and artificial intelligence through Machine Learning.

Data from a number of sources, including citizen science data, historical plant surveys, local soil data and very high resolution satellite imagery, are combined with vegetation indices to train an Artificial Intelligence (AI). This then automatically generates digital maps which predict the presence of specific habitat types across Surrey, indicating their location, extent, distribution and condition. These are tested and refined through further rounds of data collection and Machine Learning.

The citizen science programme, delivered by Surrey Wildlife Trust, has included designing the field survey and recruiting, training and co-ordinating the citizen science volunteers. It provides training data which can be combined with other ecological data sets and variables to feed into the Machine Learning process.

Staff from Surrey Wildlife Trust's Research and Monitoring team developed a mobile S4N app on Esri's *Survey123* platform, with the survey design informed by *UKHab* habitat criteria[5]. Its data collection fields focus on key characteristics of each habitat – particularly vegetation composition and structure, and the presence of both positive and negative indicator species.

Figure 2: Teaching an Artificial Intelligence to map wildlife habitats. The use of Machine Learning to automatically generate accurate habitat maps for Surrey[b].



Data from a number of sources, including citizen science data, historical plant surveys, local soil data and very high resolution satellite imagery, are combined with vegetation indices to train an Artificial Intelligence (AI). This then automatically generates digital maps which predict the presence of specific habitat types across Surrey, indicating their location, extent, distribution and condition. These are tested and refined through further rounds of data collection and Machine Learning.

[b] Diagram © Surrey Wildlife Trust, 2023.

In the first season of fieldwork, Surrey Wildlife Trust's Citizen Science Officer trained 130 volunteers to use the app, including a mix of existing volunteers and newcomers. They have been using the app to collect field data at selected test sites[c], chosen to represent priority habitat types, to make good use of existing site-specific ecological datasets and to be sufficiently accessible to volunteer surveyors.

The citizen science field data is being shared with researchers at CES for use in the construction of the Machine Learning model. PlanetScope satellite imagery[d] of the test sites, at a resolution of 3m, is used to generate additional parameters for the model, including calculation of Normalized Difference Vegetation Index (NDVI) values. The spectral reflectance of the vegetation surfaces is key to interpreting the vegetation characteristics within individual pixels of the satellite imagery.

S4N's initial focus is on the correct identification of chalk grassland and lowland heath. An example of early outputs of the predictive modelling for lowland heath can be seen in Figure 4.

An iterative process of collecting additional survey data at other test sites and verification of predicted habitat parcels in the field will increase the accuracy of the predictions[7]. The approach is also being extended to other habitat types in Surrey, with test sites being selected for other grassland types and a range of wetland habitats. Further work will look beyond remote predictive habitat recognition to determine habitat condition and quality.

Whilst Space4Nature is a scientific research project, its overriding objective is to create a tool that has practical applications for nature recovery. In particular, Surrey County Council (the responsible authority for the county's Local Nature Recovery Strategy – LNRS) has already identified S4N as a potential tool for monitoring how Surrey's LNRS and the accompanying Nature Recovery Network (NRN) are delivered. If adopted, S4N would identify areas within the NRN where land restoration for wildlife can take place. It would then monitor the effectiveness of those interventions and their connectivity in the landscape.

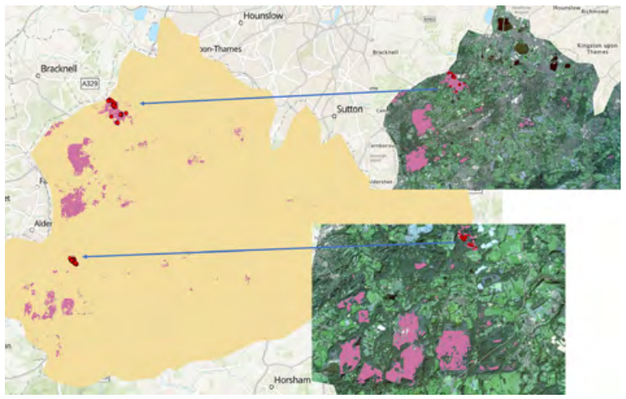
The S4N team is also working with partners Buglife to deliver "B-lines" in Surrey. These mapped 3km wide belts join the best permanent wildflower-rich habitat and help to prioritise where to target action to boost pollinator habitat. With the whole of the UK's B-lines now mapped there are clear opportunities for the S4N approach to be applied countrywide[8].

Learning from S4N is being shared with other practitioners who use satellite imagery and other remote sensing techniques for habitat restoration in a new online forum, "HaloHub". This was launched in April 2024 to share research, project updates, events and training opportunities[9].

Figure 3: Training Citizen Scientists. Teaching volunteer surveyors to use a mobile 'phone app to collect data for use in the *Space 4 Nature* Machine Learning process.

The citizen science element of S4N has proved to be an engaging way of increasing the public's active involvement in biological recording, through access to nature and a meaningful contribution to nature recovery.

Figure 4: Surrey's lowland heaths. Predicted areas of lowland heath habitat in Surrey, using Machine Learning (Random Forest Regression)[6].



Learning based on citizen science habitat data from two Space4Nature test sites and variables including soil type, soil pH, vegetation indices, topographic parameters and spectral reflectance.

[c] Mainly Wildlife Trust nature reserves and other designated sites.
[d] For further detail on PlanetScope satellite imagery, see here: https://developers.planet.com/docs/data/planetscope

4.2 The identification, designation & protection of marine protected areas

The successful protection of the UK's marine environment depends on the systematic accumulation of ecological survey data, much of which is collected by citizen science volunteers working through the Shoresearch and Seasearch programmes.

Data collected in this way since 2012 has contributed to the designation, protection and onward monitoring of hundreds of square kilometres of marine habitat within the marine protected area network, including one of the UK's most protective designations – Highly Protected Marine Areas – three of which were designated in 2023.

The onward monitoring of these and other marine protected areas is fundamentally important for nature's recovery at sea, particularly as ess than 30% of the UK's marine protected areas are currently in favourable condition.

After a decade of political campaigning by The Wildlife Trusts, supported by other environmental organisations, the Marine & Coastal Access Act, 2009, finally introduced statutory protection for Marine Conservation Zones (MCZs) around England and in UK waters not under the delegated jurisdiction of the Welsh, Scottish and Northern Irish governments. But it was widely recognised that having a legal obligation to designate protected sites, and the legal powers to do it, would only bring real protection to the marine environment if it was accompanied by evidence-based designation of the right sites and the active implementation of effective protective measures.

The process for designating sites divided England's marine territory into four regions and within each region, invited stakeholders to submit evidence-based proposals for suitable sites. These were then debated by a broad stakeholder community and reviewed by a scientific advisory panel before confirming them as recommendations for designation (and ultimately selection of the final set of designated MCZs).

High quality data concerning the location, quantity and quality of wildlife and its habitats was needed so that the right sites could be designated, they could be given the correct boundaries, and they could receive the right kind of protection for the natural features within them. Without this, it would be impossible to define precise boundaries of proposed sites, to justify designating one site rather than another, to defend proposals against objections within the stakeholder community, or to be sure that the whole network of sites was ecologically coherent.

It was clear that on the basis of evidence available at the time, many sites known anecdotally to be high quality marine areas worthy of protection might be unlikely to be designated as MCZs due to data paucity.

To ensure that proposals were consistently based on sufficiently high quality data, The Wildlife Trusts developed and agreed a standard data protocol (Technical Protocol E) with Natural England (NE) and the Joint Nature Conservation Committee (JNCC), which was adopted in 2012[10].

A considerable amount of data necessary to inform the MCZ designation process was then collected by volunteer divers working with The Wildlife Trusts through the Seasearch citizen science programme, using the agreed protocol. This was fed into the process.

In 2013, 27 MCZs were designated, in large part because of the data collected and provided by The Wildlife Trusts. But this was only a small part of what is needed to even start to ensure the protection of our marine ecosystem. The delays in designation of other MCZs were prolonging the exposure of these places to continuing damage and risked undermining the effectiveness of the network. There was a real risk that valuable sites would go undesignated, or would not adequately protect all their valuable features.

In response, from 2014, The Wildlife Trusts supported more high quality data collection by suitably trained and competent volunteers, working to further detailed guidance agreed between The Wildlife Trusts, NE and JNCC[11].

As several of the locations where data was most limited and most needed to provide defensible evidence for their designation were remote or hazardous (making them difficult for amateur divers to visit), during 2015, 2016 and 2017, The Wildlife Trusts also commissioned a team of professional divers to undertake targeted marine surveys at these sites.

In particular, The Wildlife Trusts' professional dive team surveyed The Manacles in Cornwall and Runswick Bay in North Yorkshire, which were designated as MCZs in 2016; and Beachy Head East and Goodwin Sands, which were both designated in 2019. Between them, these four MCZs alone cover 543 km^2. In all cases, the additional data generated provided the evidence necessary to support their effective protection, identifying and recording the presence of wildlife and habitats about which little was known previously.

In 2017, the professional dive team also identified a new and expansive maerl bed in the St Austell Bay. It was discovered too late to be designated within the agreed MCZ designation timetable, but Cornwall Wildlife Trust, working with the Cornwall Inshore Fisheries & Conservation Authority and Natural England, have now mapped the bed, which is believed to be one of the largest in England, covering an area of about 800 hectares. The Wildlife Trusts are now monitoring it with the intention to secure its future designation.


© Matt Slater / Cornwall Wildlife Trust

All of the additional data collected and submitted by The Wildlife Trusts contributed to the successful designation of a further 23 MCZs in 2016 and another 41 in 2019, completing England's contribution to the ecologically coherent network of marine protected areas in the North East Atlantic (in terms of the representation of species and habitats receiving protection within the network).

All of the new data generated is now openly available through the National Biodiversity Atlas[e], and will provide a readily available baseline against which the effectiveness of future conservation can be measured. The Wildlife Trusts were awarded the National Biodiversity Network (NBN) John Sawyer Open Data Award for this in 2018.

In October 2022, the UK Government consulted on the potential establishment of five pilot Highly Protected Marine Areas (HPMAs) in English waters. Data collected by volunteer divers through the Seasearch programme provided a significant part of the baseline information at two of the inshore candidate HPMAs, at Lindisfarne (Northumberland) and Allonby Bay (Cumbria). In July 2023, three of the five potential HPMAs were selected for designation, including Allonby Bay, which covers 28km^2 of inshore sediments, mussel beds and intertidal rocky habitats in the Irish Sea off the Cumbrian coast. These three sites will now be protected from virtually all potentially harmful activities, with the intention of achieving their full recovery to a more natural state. The baseline data collected at Allonby Bay will be vital in understanding and demonstrating how ecological recovery can be achieved, in measuring the success of these protected areas and making the case for further protection elsewhere.

More recently, staff within The Wildlife Trusts' central team have collated and analysed condition/vulnerability assessments for all the Marine Protected Areas (MPAs) across the UK, where these are available. These assessments have been standardised to allow a rating (red - declining, green - recovering, grey - unknown) to be assigned to each site as a proxy measure of how well the whole network is protecting and restoring marine biodiversity[f]. This analysis showed that only 15.3% of MPAs in England and 28.9% across the UK were in favourable condition at the time.


© Paul Naylor

Phase two of the work will be carried out during 2024. It is assessing individual features, looking for those features that are faring particularly well, those that are not, and any geographical patterns. The conclusions will be used to influence further policy-change and action to bring about the effective protection of the UK's MPA network.


© Matt Slater / Cornwall Wildlife Trust

[e] https://records.nbnatlas.org/#tab_simpleSearch

[f] This assessment, an explanation of the methods used and reasoning applied can be accessed online at the MPA Reality Checker website, here: https://experience.arcgis.com/experience/142a127f227f4481ae8f35e959046461

4.3 Beavers – a valuable part of the English landscape

Re-establishing populations of lost species to the wild is a vitally important part of nature's recovery, but can be very challenging. Basing decisions on sound evidence and verifiable facts has allowed many of these barriers to be overcome, with the re-introduction of beavers across the UK a prime example.

Eurasian beavers are now living wild and legally protected in England for the first time in 400 years. They will play a vital role in re-shaping and rewilding our landscapes, helping us to adapt to climate change and assisting in biodiversity recovery.

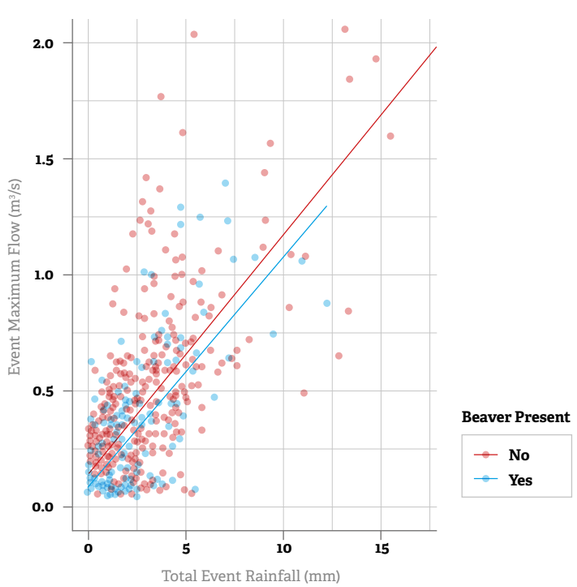
Eurasian beavers (*Castor fiber*) became extinct in England around 400 years ago, largely as a result of hunting for their meat, fur and scent glands (used in medicines and perfume). Their absence has made a significant contribution to major changes in the ecology of the English landscape over that time, especially concerning the distribution and nature of wetlands along the country's river systems.

There has been wild beaver activity on the River Otter in Devon since around 2008, though the origins of the beaver(s) were unknown. In 2014, young beavers (kits) were filmed on the river, providing evidence that the population was breeding successfully. Initially, because of the long absence of beavers from England's landscape, a lack of understanding of their needs and likely impacts, and doubts about whether they were Eurasian or North American beaver, the UK Government planned to remove them.

With support from the Royal Society of Wildlife Trusts, Devon Wildlife Trust opposed their removal. A significant amount had been learnt over the previous five years, from the pioneering trial reintroduction of wild beavers to Knapdale Forest, Argyll[g], led by Scottish Wildlife Trust, Forestry Commission Scotland and the Royal Zoological Society of Scotland[12]. After consulting with the local community, landowners and public bodies, an alternative plan was proposed for the wild beavers in Devon, to monitor the River Otter beaver population and their interaction with the local landscape and human population over a five-year period, in order to learn more about their impacts and ways of managing them.

The UK government agreed to this approach, which became the first project licenced by Natural England to re-release beavers outside a fenced enclosure. Devon Wildlife Trust led a group of organisations to deliver it, including experts from the Universities of Exeter and Southampton, Environment Agency, the Derek Gow Consultancy,

Figure 5: The effect of beaver dams on flow rates on the River Otter. The relationship between total rainfall and maximum flow for hydrological events[h].

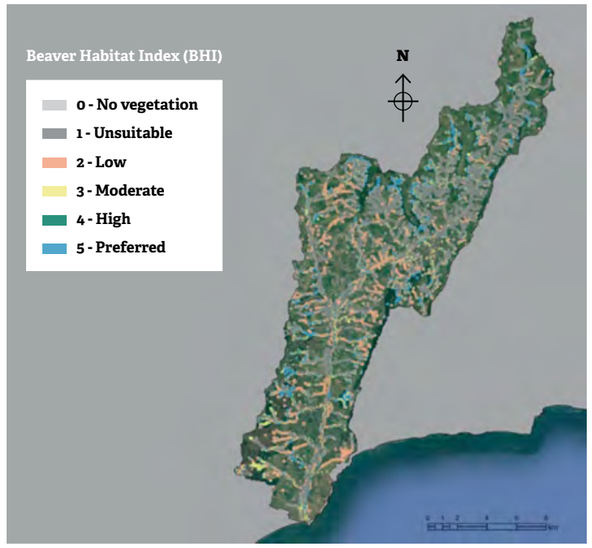


After beavers constructed dams, downstream flows were more likely to be lower for a given amount of rainfall.

[g] In a project which ran from 2009 to 2015, which was independently evaluated by Scottish Natural Heritage. After a decision by the Scottish Government to allow beavers to remain in Scotland, a further project was run to reinforce Scottish beaver population in Knapdale, generating further evidence of their impacts and insights into their integration back into the Scottish landscape. That project concluded in 2020, with the publication of a project report that can be accessed here: https://scottishwildlifetrust.org.uk/wp-content/uploads/2021/01/202011_Scottish-Beavers-Report_10-ONLINE-smaller.pdf

[h] Reproduced from Brazier *et al* (2020), See Endnote 13.

Figure 6: The Beaver Habitat Index. Suitability of habitat for beavers in the River Otter catchment[i].



the Royal Zoological Society of Scotland and Clinton Devon Estates. Consequently, between 2015 and 2020, the River Otter Beaver Trial collected data on the beavers, their habitats, other species in the catchment, river flows, water quality, the needs and opinions of farmers, land managers and other local people. Analysis of this data generated considerable evidence concerning the ecological, social and economic impacts of beavers. Impacts revealed by the data include:

- **Reduced peak-flows upstream of a village at risk of flooding;**
- **Increased fish biomass in some sections of the river;**
- **More trout, minnow and lamprey;**
- **Ecological benefits for amphibians, waterfowl and water voles;**
- **Creation of new riffle habitat, of benefit to dippers and bullhead;**
- **Extension and enhancement of scrub and wetland habitats, benefiting many species;**
- **Some obstruction of fish migration in small water courses during some flow conditions;**
- **Minor and readily manageable negative impacts on a water supply reservoir, some farmland, small riverside orchards and small country lanes (caused by dam-building, raised water levels and beaver feeding);**
- **Lower than previously feared risks to the health of humans, livestock and other wildlife;**
- **High and increasing levels of public support for beaver re-introduction and legal protection; and**
- **Overall economic benefits that are greater than the costs of beaver reintroduction.**

Subsequent ongoing monitoring and analysis carried out with the University of Exeter has demonstrated significant removal of suspended particulates and polluting nutrients as water flows through the ponds created by the River Otter's beaver dams.

This evidence was made available to the UK Government and published as *The River Otter Beaver Trial Science & Evidence Report*[13]. Natural England also published their own independent assessment of the Trial[14]. Subsequently, in August 2020, the Government announced that the River Otter beaver population would be allowed to remain living wild – the first officially

[i] Reproduced from Brazier *et al* (2020), See Endnote 13.

acknowledged wild population of beavers in England for 400 years.

Since 2020, the evidence generated by the River Otter Beaver Trial has helped to inform and shape government policy and practice in both England and Wales, as formal reintroduction programmes have multiplied, including fenced releases in Cornwall, Cheshire, Cumbria, Derbyshire, Dorset, Essex, London, Nottinghamshire and Surrey. Many of these have been informed by the evidence generated by the River Otter Beaver Trial, looking towards a future when beavers will be helping to build wildlife-rich, resilient landscapes across the UK. Most have been led by Wildlife Trusts, drawing on information communicated through the UK-wide network of Wildlife Trusts.

On 1st October 2022, beavers were added to Schedule 2 of the Conservation of Habitats and Species Regulations 2017, making it an offence to deliberately capture, injure, kill or disturb them, or to damage and destroy their breeding sites or resting places without a wildlife management licence from Natural England.

Wild-living beaver populations are now known in Devon, Kent, Somerset, Wiltshire, Cornwall and Herefordshire, as well as in Scotland, but despite this, no new wild releases have yet been licensed in England. The evidence generated and shared to date is also informing the preparation of a number of applications for licences to release beavers into the wild at suitable locations across the length and breadth of England. These will start to be submitted to Natural England during 2024.

By summer 2024, the partnership between The Wildlife Trusts and researchers at the University of Exeter had led to the publication of 24 peer reviewed papers on different aspects of beaver ecology and reintroduction.

4.4 Butterflies in a changing climate

Butterflies need dry, warm weather to thrive, but if it gets too hot they can easily overheat. In open places like chalk grasslands, specialist communities of butterflies need a range of different conditions to survive. As climate change causes extreme summer temperatures to become more frequent, land managers will need to provide more shelter and shade.

The 58 species of butterfly that still live wild in the UK are some of the most widely admired, closely studied and much-loved parts of our natural heritage. Half of these are currently considered to be of conservation concern[15]. Many are reliant on specific habitats such as chalk grassland, which are often restricted to only a few parts of the country and are frequently found in fragmented archipelagos of more-or-less isolated habitat patches, separated by land that is inhospitable to species with specific habitat needs.

Butterflies are reliant on the weather because they need to fly to disperse, feed and breed; rain, wind and either low or high temperatures can disrupt this. Drought can reduce the availability of foodplants for caterpillars and their lifecycle is closely tied to the changing weather from season to season. In particular, butterflies use variations in the microclimate in different parts of their habitats to regulate their body temperature – basking on sunny banks to warm up, resting in the shade to cool down. An ability to do this keeps their bodies functioning within a safe range; especially when temperatures are extreme.

Species such as the Duke of Burgundy (*Hamearis lucina*) are vulnerable to climate change as they live in isolated populations and don't disperse far. Extremes of temperature and changes in seasonal weather patterns are already with us and they will become more frequent and extreme as the climate continues to change. This poses many challenges for butterfly conservation and how butterfly habitats are protected and managed. It suggests that the availability of different microclimates – particularly the availability of cooler, shaded areas – will be particularly important in the future[16].

Over a number of years, the Bedfordshire, Cambridgeshire and Northamptonshire Wildlife Trust has developed a lasting relationship with the Insect Ecology Group at the Museum of Zoology, University of Cambridge. In 2021, they agreed to work together on the Butterfly Banks Project, which specifically set out to test the relationship between butterfly distribution and behaviour at different temperatures around artificially created experimental mounds built at two of the Wildlife Trust's chalkland nature

Figure 7: The possible significance of microclimate availability for butterfly conservation. The relationship between the long-term population trends of selected UK butterfly species and their reliance on microclimate for temperature regulation[j].

Correlation between species' published long-term UK population trend (taken from the UK Butterfly Monitoring Scheme[17] and the difference between each species' mean behavioural thermoregulation and mean microsite selection (higher values represent a greater ability to use behavioural mechanisms to buffer thoracic temperature, lower values represent greater reliance on local microclimate for thermoregulation). Points show data for individual species ±1 Standard Error for the mean difference between thermoregulatory strategies (standard errors for species' change in abundance are not published). Symbols and colours used represent species' taxonomic family. Lines represent fitted relationships for individual taxonomic families based upon the selected model in which no interaction term was retained.

[j] Reproduced from Bladon *et al* (2020) under the Creative Commons Attribution 4.0 International License – see Endnote 16.

reserves, Pegsdon Hills and Totternhoe (Figure 8). Similar butterfly banks have also been constructed by the Wiltshire and London Wildlife Trusts, for similar reasons.

Systematic butterfly monitoring surveys have been carried out around the butterfly banks during the summer, linked to the measurement of air temperatures, the thoracic temperatures of the butterflies themselves and the temperature of different substrates where butterflies were observed to be resting. Researchers are hoping to collect robust experimental data to answer the questions "*how significant is microclimate in the temperature regulation of chalk grassland butterflies?*" and "*how might land managers who want to conserve chalkland butterflies effectively change their approach as the climate changes?*".

The monitoring is ongoing and the final results of the research will not be available for a while, but it is already generating useful insights. In July 2022, the UK experienced a sustained period of extremely high temperature, during which a new UK record temperature (40.3°C) was recorded, on 19th July. This was reflected in air temperatures ranging from 30.1°C to 39.3°C at Pegsdon Hills nature reserve and allowed the project team to analyse the response of butterflies around the chalk banks, under conditions of extreme temperature that are likely to become more frequent in future.

On six survey-days between 19th July and 2nd August 2022, researchers found that at temperatures between 30 and 35°C butterflies flew more (feeding, mating and defending territories), but above that, flight activity fell rapidly as they sought shelter. At very high temperatures, there was a significant increase in the number of butterflies found in the shade provided by sheltering scrub and artificial butterfly banks. During surveys at lower temperatures, large patches of shade contained few, if any, butterflies, demonstrating that species only made use of the shade when experiencing very high temperatures[18].

Results comparing butterfly body and air temperature support the idea that butterflies were doing this specifically to cool down. At high air temperatures, butterfly body temperatures increased more slowly with increasing air temperature, than in lower air temperatures.

Figure 8: Experimental butterfly mounds to provide shade. The construction of new E-shaped mounds at Totternhoe nature reserve, Bedfordshire, to test the impact of providing shade and shelter to help chalk grassland butterflies survive as peak summer temperatures increase.

The vegetated 1.5 meter-high E-shaped chalk mounds were situated and constructed to provide a variety of different microclimates, with different amounts of shelter and aspects of slope. Each of the four E-shaped banks built at each reserve was 16m long and 7m wide, with an adjacent 16m by 5m area of cleared vegetation to act as a control area. Each was aligned to a different cardinal compass point (North, South, East, West) to provide a full range of different shade conditions throughout the day. Mounds re-vegetated naturally after construction, colonised by plants typical of the surrounding grassland.

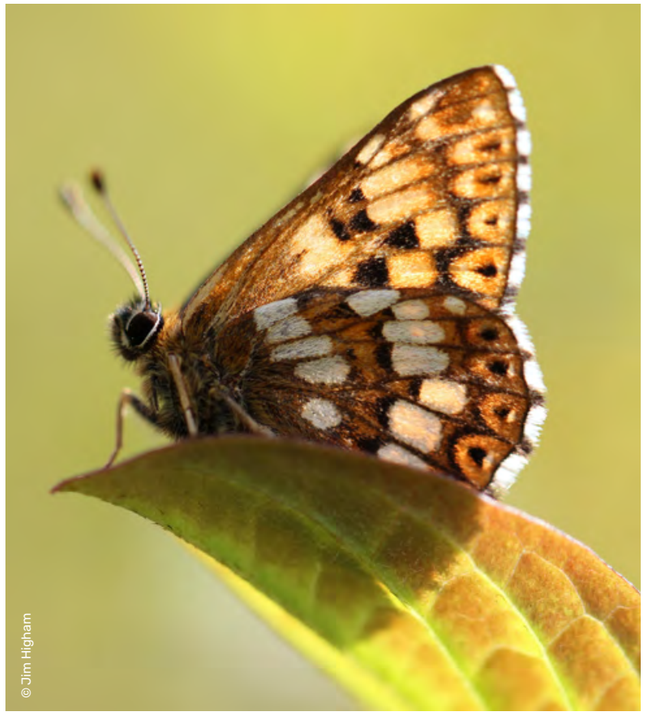
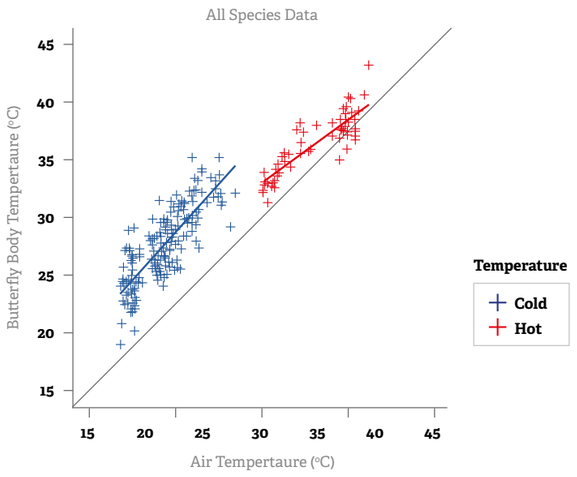


Figure 9: Response of butterfly body temperature to changes in air temperature. The difference in response on days experiencing extreme high temperature compared to on cooler days[k].



Butterfly body temperatures and air temperatures were recorded during the extreme high temperatures on 19th July 2022 (Hot, **red**) and five subsequent cooler days (Cold, **blue**) over a 15-day period on Pegsdon Hills nature reserve, Bedfordshire, UK. The relationship between the two, for all species detected during the survey period, is plotted.

These findings and others will feed into The Wildlife Trusts' efforts to adapt the management of our nature reserves to climate change.

It is likely that these results can reasonably be extrapolated to other invertebrates that have a similar need for a diverse range of microclimates. They also highlight the importance of protecting and restoring chalk grasslands that include shadier, north-facing slopes that are easily accessible to butterflies. They lend support to efforts to join up isolated chalk grassland fragments into ecologically connected landscapes within which a diverse range of microclimates (in this case shade) allow different species (in this case butterflies) to persist in a warming climate.

This work will allow the prioritisation of grassland management, to identify where physical interventions to alter microtopography, or changes to promote more scrub may be beneficial (and necessary) in the future.

[k] Reproduced from Hayes *et al* (2024) under the Creative Commons Attribution 4.0 International License – see Endnote 18.

4.5 Return of the Pine marten

Pine martens were once widespread across the UK, but they have been largely absent from England and much of Scotland and Wales since the early 20th century. As a native carnivore, they can play an important role in woodland ecosystems and may be an important part of efforts to control populations of invasive non-native grey squirrels.

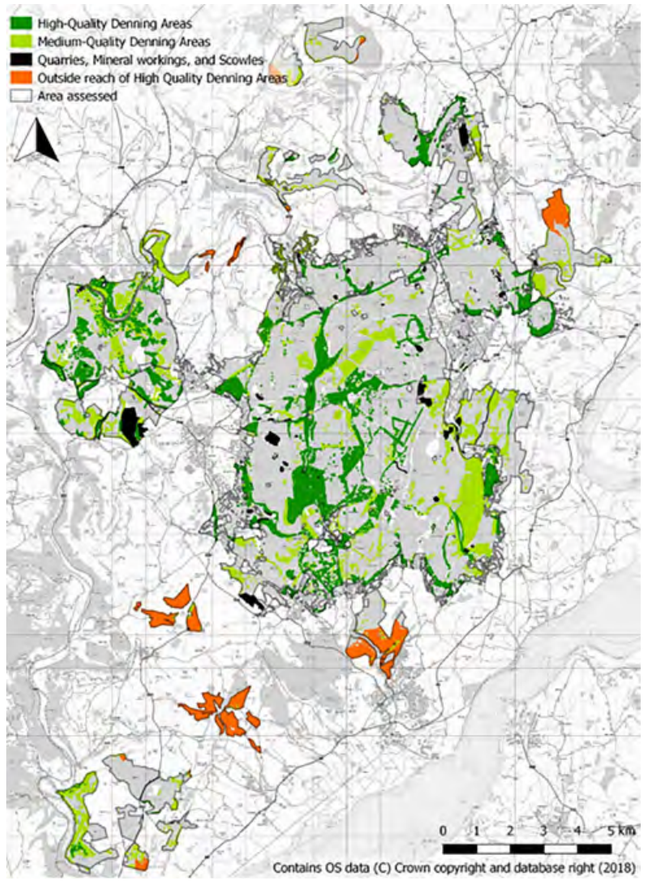
Understanding their ecological requirements and monitoring their numbers and distribution are critical in helping the population of pine martens to recover and spread. As a result of conservation work informed by detailed data collection and analysis, a new population of pine marten is now re-establishing itself in the Forest of Dean, after a long absence.

The European pine marten (*Martes martes*) is a native mustelid which was once widespread in the UK. It suffered widespread declines over several centuries, driven by habitat loss and fragmentation and compounded by predator control and persecution, particularly during the 19th Century, when Victorian gamekeepers trapped it to extinction in most of the wooded landscapes where it had persisted until then. By 1915, it was restricted to the north-western part of the Scottish Highlands and to a few isolated areas of north Wales and northern England[19].

Even with a considerable expansion of its population and range in Scotland, during the latter part of the 20th Century (pine marten are now found across much of northern, central and eastern Scotland), the pine marten is still the UK's second rarest native carnivorous mammal, with an estimated UK population of only 3,700[20]. Their presence in Wales and in particular in England is steadfastly patchy and restricted, despite some signs of recolonisation from the Scottish Borders into Northumberland.

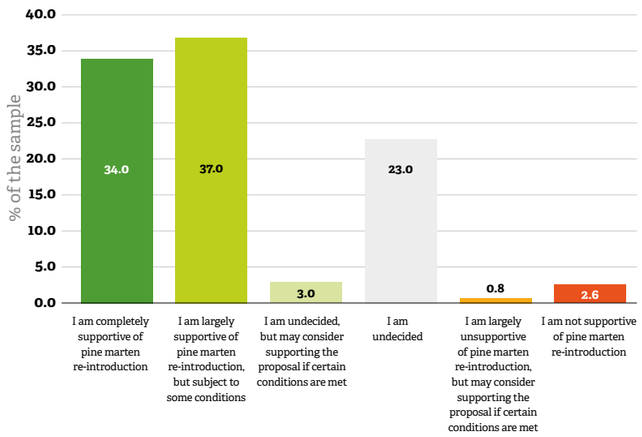
Low dispersal rates and the fragmented nature of remaining habitat make the pine marten a prime candidate for translocations to boost recovery across its former range. Pine marten translocations began In the UK in the 1980s, with a reintroduction to Galloway Forest in southern Scotland[21], and several similar projects have been undertaken since. The Forest of Dean and lower Wye Valley were identified as a potential release region[22]. In 2016 a partnership between Gloucestershire Wildlife Trust, Vincent Wildlife Trust, Forestry England and The Woodland Trust began a study to explore the ecological and social feasibility of reintroducing pine martens to the Forest of Dean.

Figure 10: Potential pine marten denning areas within the Forest of Dean. The mapped availability of suitable natal den sites within the Forest of Dean main block[l].



[l] Reproduced from Stringer *et al* (2018) – see Endnote 23.

Figure 11: Public support for pine marten reintroduction into the Forest of Dean. Results from a questionnaire survey of the general population (n=265)[m].



This chart was produced to present age/gender weighted data and is displayed with a confidence interval of +/- 5%. Overall, 34% of Forest of Dean residents were completely supportive of the proposal and 37% were largely supportive, subject to some conditions. Only 3% said they did not support the idea of a reintroduction. About a quarter (26%) were undecided.

Forestry Commission woodland datasets were used to assess habitat suitability and connectivity, den site availability, and likely road-related mortality. This ecological assessment identified over 17,000 hectares of Highly Suitable Woodland, with the total habitat area suitable for a viable population of 200 martens[23]. A Masters student at the University of Gloucestershire worked with the project team to study the abundance of rodent prey[24], which revealed a strong prey base with a higher number of small mammals than all other areas assessed[25].

Gloucestershire Wildlife Trust also worked with Forest Research and Litchfield Comms to assess the social feasibility of the proposed reintroduction. The research mapped the individuals and organisations with specific interests in pine marten reintroduction and explicitly identified their specific interests. Stakeholders and members of the public across the Forest of Dean were interviewed to establish their existing level of knowledge about pine martens, their ecology, and views on the potential reintroduction. Public opinion surveys were carried out in major population centres to provide a baseline for future tracking of public opinion[26]. The majority of those consulted were supportive of the reintroduction, citing the pine marten's native status, charismatic appeal and tourism potential among their reasons.

The interviews and survey responses highlighted the need for species reintroductions such as this to be accompanied by very good communications and community engagement, and the need to demonstrate that concerns raised have been taken seriously and addressed effectively.

Following the success of the detailed feasibility study, between 2019 and 2021, Gloucestershire Wildlife Trust worked closely with Vincent Wildlife Trust to move 35 pine martens from Scotland to the Forest of Dean, under license from NatureScot. Vincent Wildlife Trust brought considerable pine marten expertise and experience of previous translocations to the project, including sourcing and transporting martens, securing licences and overseeing veterinary assessments.

[m] Reproduced from Ambrose-Oji *et al* (2018) – see Endnote 26.

The pine martens were released into pens constructed across the Forest of Dean on land owned and managed by Forestry England and the Woodland Trust. Each marten was fitted with a VHF radio collar and a microchip to enable post-release monitoring by the Gloucestershire Wildlife project team, with support from volunteers. Each marten was radio-tracked for the first 6-12 months after release.

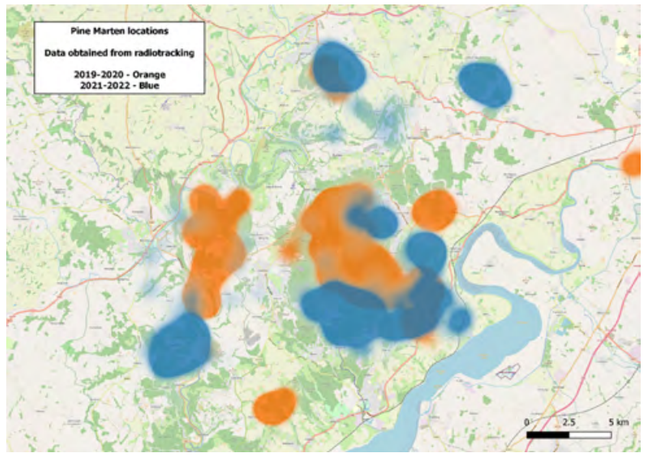
The majority of the first cohort (released in 2019 and 2020) established territories within the central area of the Forest. The second group (released in 2021 and 2022) settled in the surrounding areas with some venturing further afield, in a pattern similar to those observed previously in other translocation projects[27].

In addition to radio-tracking, the movements and distribution of the new Forest of Dean pine marten population have been monitored using trail cameras and systematic scat surveys. Together, these three monitoring methods have enabled the project team to track the restored population as it grows and expands into neighbouring counties, gaining insight into dispersal routes and highlighting areas where habitat connectivity may need to be improved.

In 2021, Gloucestershire Wildlife Trust set up a Camera Trap Loan Scheme (CTLS). The scheme provided volunteers with a trail camera and associated kit to enable each volunteer to bait and monitor their camera trap in an assigned area of the Forest. More than 100 volunteers have registered to assist with the camera trap monitoring programme across 60 survey squares (2x2 km each). Through this citizen science engagement programme, the project has been able to confirm breeding success every year since the martens' return.

In addition to the camera trapping, within each survey square a 1.5 km transect was established and systematically surveyed by volunteers each year[n], to record the location of scat[o]. From 2024, each potential scat has been assigned a score based on the presence or absence of key identifying features, to gauge the likelihood that the identification was accurate. The majority of scats were collected and are currently awaiting DNA testing (to confirm their identification) and analysis of their contents (to give an insight into the diet of the reintroduced pine martens).

Figure 12: The distribution of reintroduced pine martens. The radio-tracked locations of reintroduced pine martens in the Forest of Dean between 2019 and 2022.)



Areas marked in **orange** indicate the radio-tracked locations of reintroduced pine martens from the first cohort, in 2019 and 2020. Those marked in **blue** indicate the radio-tracked locations of pine martens reintroduced in the second cohort, in 2021 and 2022.

Alongside the monitoring of the pine marten themselves, Gloucestershire Wildlife Trust has been working with Forest Research and the Woodland Trust to monitor squirrel numbers and associated tree damage in 9 sub-compartments across the Forest of Dean, to assess the impact of the restored pine marten population on invasive non-native grey squirrels (*Sciurus carolinensis*). Pine martens have been observed to suppress populations of grey squirrels in other parts of the British Isles[28], leading to considerable interest in the potential for this in the Forest of Dean, with its likely implications for reduced damage to trees and reduced need for grey squirrels to be culled.

Learning from the Forest of Dean pine marten project has been shared widely. In 2024, similar pine marten reintroductions are planned in Dartmoor and Exmoor, delivered by a partnership of Wildlife Trusts (Somerset and Devon), National Trust, National Park Authorities, Vincent Wildlife Trust and Forestry Commission.

[n] with the main survey season undertaken in March.
[o] The blackish, sweet-scented, long (4-12cm), thin (1.2cm) droppings of pine martens are known as 'scat'. They typically contain hair and bone from the small mammals in their diet.

4.6 Learning from the past to create a wilder future

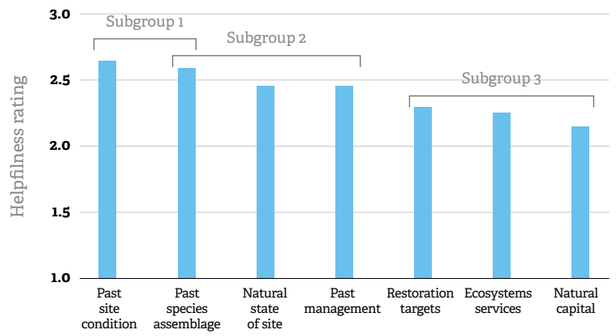
Palaeoecologists study the ecosystems and natural processes of the past. Their discoveries can teach us important lessons about what is happening now and what might happen in the future. Their expertise may be of great use in bringing about nature's recovery across the UK.

Understanding how best to enable palaeoecologists and those working for nature's recovery to work effectively together might transform the way our landscapes are planned, managed, valued and used in future.

It can be extremely useful for people working to conserve wildlife or bring about nature's recovery, to understand how ecosystems were in the past – what their 'natural' state might be; how they have changed over time and responded to influences such as climate, land use and land management. The study of past ecosystems – palaeoecology – is a science that provides unique insights into this. There is significant potential for palaeoecological research to answer nature conservation and environmental management questions, but its application within conservation practice has been hampered by a long-standing disconnect between the two[29]. At a time when practising evidence-based conservation is crucial in effectively addressing the growing biodiversity crisis, this disconnect is particularly unhelpful and bridging it is extremely important.

A PhD researcher working at Surrey Wildlife Trust is collaborating with academics at the University of Surrey and University College London (UCL) to develop the integration of palaeoecology into UK nature conservation. He is exploring ways to improve the accessibility of palaeoecology for conservation practitioners and to develop its practical application in support of nature's recovery. The first piece of research undertaken as part of this studentship set out to explore the perceptions of UK nature conservation practitioners and to establish the ways in which palaeoecological research can be framed and applied to align most usefully with conservation practice.

Figure 13: What is palaeoecological research most useful for? The potential uses of palaeoecology that nature conservation practitioners consider to be most helpful[p].



Mean rating of each potential use of palaeoecology, with 1 = "Not helpful", 2 = "Could be helpful", 3 = "Helpful". Black lines indicate statistically significant (at $P<0.05$) subgroups identified in the post-hoc Dunn-Bonferroni test.

[p] Reproduced from Siggery *et al* (2023) – see Endnote 30.

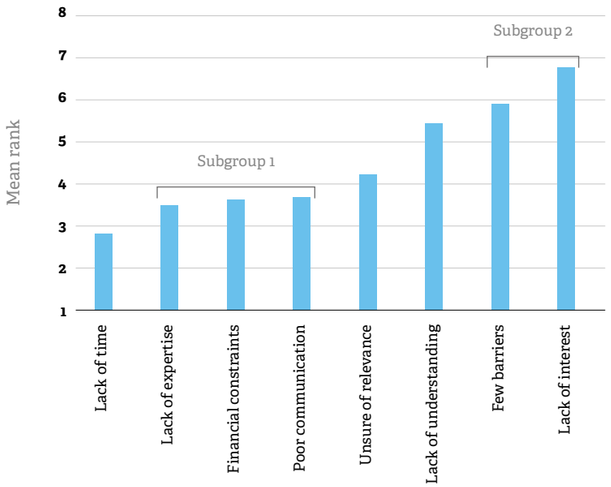

© Peter Cairns / 2020VISION

This research surveyed 153 UK-based conservation practitioners about their perceptions of palaeoecology. It concluded that the conservation community is keen and willing to embrace palaeoecological research and its members want access to applied case studies and databases that relate clearly to the practical issues they face. They considered that gaining a better understanding of the past condition of sites and of past assemblages of species would be particularly helpful[30].

The research also revealed that practitioners have reservations about the resource implications of this (especially in terms of time, but also expertise and money) and feel that the numerous and varied improvements are needed in the way palaeoecological researchers and conservation practitioners communicate, to make communication between them effective. All of these were seen as significant barriers to effectively bridging the researcher-practitioner gap.

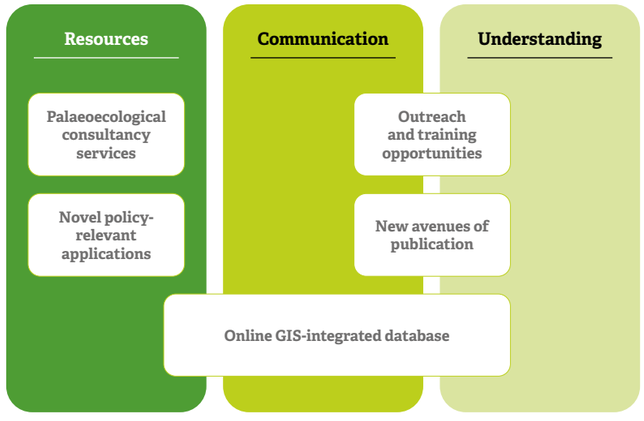
The next phase of work will focus on the development of case studies based on novel applications of palaeoecology that are of high relevance to practitioners active in nature conservation and nature's recovery. It will include work to explore what might be necessary to make palaeoecological data, expertise, knowledge and understanding more readily (and usefully) available to conservation practitioners.

Figure 14: Why don't conservation practitioners engage effectively with palaeoecological research? The most significant barriers to effective engagement[q].



Mean rankings of barriers with black lines indicating statistically significant subgroups identified in a post-hoc Dunn-Bonferroni test.

Figure 15: Improving the connections between palaeoecologists and nature conservationists. Some potential solutions to bridge the gap[q].



Key recommendations for better integration of palaeoecology and conservation practice and the relationship to key themes emerging from the survey.

[q] Reproduced from Siggery *et al* (2023) – see Endnote 30.

4.7 The Great Big Nature Survey

If we are going to bring about nature's recovery in the UK and to positively transform people's relationship with it, then decision-makers and action-takers need a far better understanding of human-nature relationships.

In 2023, *The Great Big Nature Survey* set out to provide this. It is the biggest survey of human-nature relationships covering all four nations of the UK, with over 23,000 respondents in its first year. It has already produced a comprehensive picture of the state of our collective relationship with the natural world in 2023.

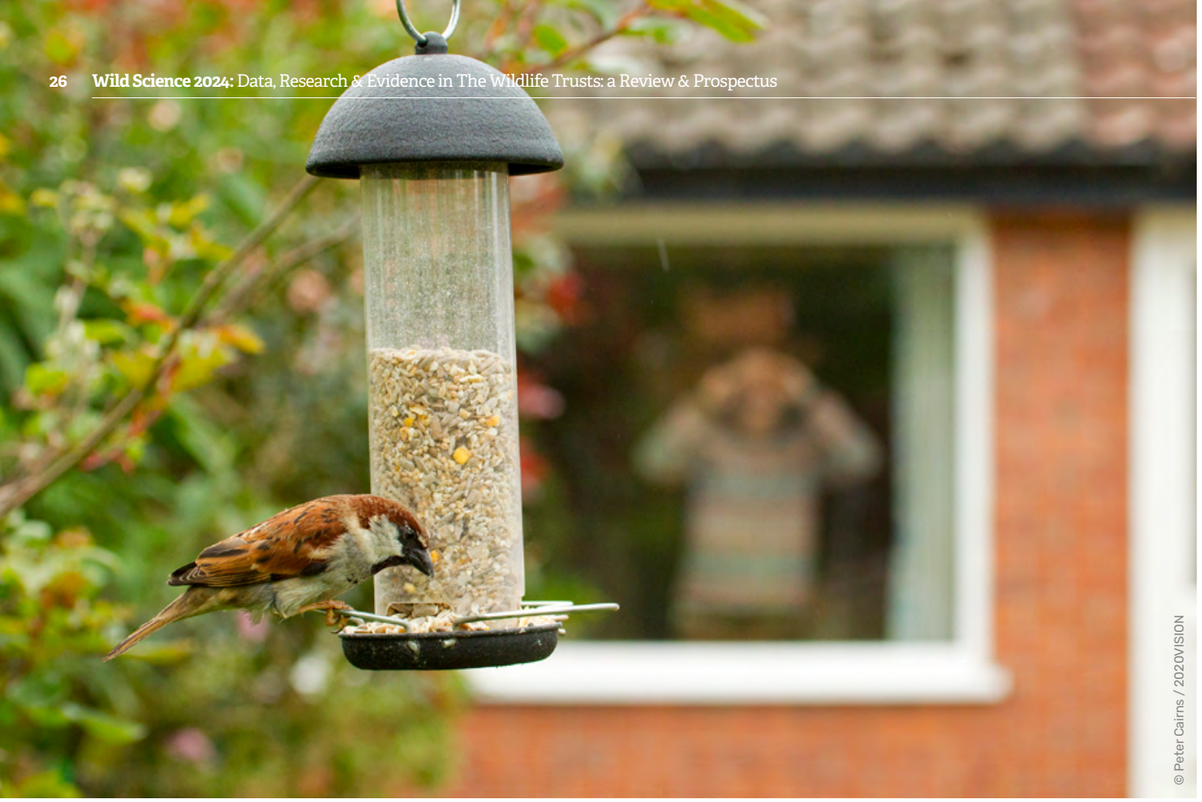
As it develops, it will generate a consistent longitudinal dataset that will enable changes to be tracked and a wide range of issues to be explored in depth, leading to better evidence and therefore better decisions.

People's relationship with nature matters because the causes of worldwide biodiversity declines are fundamentally social and political, and because the solutions to these declines will necessarily also be social and political. Our health, wellbeing, and prosperity all depend on people's ability and willingness to recognise this and to reflect the high value of nature in all its forms in the decisions we make and actions we take.

In the UK, understanding the state of our relationship with nature should be at the heart of any evidence-based approach to reversing biodiversity declines and securing environmental, social and economic sustainability. Despite this, the systematic collection of data on human-nature relationships in the UK is patchy and inconsistent. For example, regulatory bodies in the four nations of the UK take different approaches to measuring key variables — such as nature connection and pro-conservation actions — making it difficult to take a holistic view across the UK[r]. The challenges posed by this variability have recently been recognised by the UK Government, prompting a review to identify and clarify these inconsistencies[31].

The Wildlife Trusts developed *The Great Big Nature Survey* (GBNS) specifically to address some of these issues. Launched in March 2023, it aims to deliver the UK's largest consistent, longitudinal dataset on human-nature relationships across the UK. GBNS is a comprehensive look at the state of our collective

[r] Each of the four devolved nations has its own survey: the People and Nature Survey for England (PaNS), the Scottish People and Nature Survey (SPaNS), the People and Nature Survey Wales (PaNSW) and the People in the Outdoors Monitor for Northern Ireland (POMNI).



© Peter Cairns / 2020VISION

relationship with nature, derived from responses submitted by members and supporters of The Wildlife Trusts and members of the wider UK public. it is designed to collect baseline data on wellbeing, nature connection, access to nature, and pro-conservation actions, whilst also interrogating the values and attitudes underpinning nature conservation.

GBNS currently has six main sections:

1. **Pro-conservation and pro-environmental behaviours (2 questions)**
2. **Nature and wellbeing (10 questions)**
3. **Perceived threats to nature (3 questions)**
4. **Values and attitudes relating to nature and its protection (3 questions covering 30 items)**
5. **Support for environmental charities (2-7 questions)**
6. **Opt-in demographics (6 questions)**

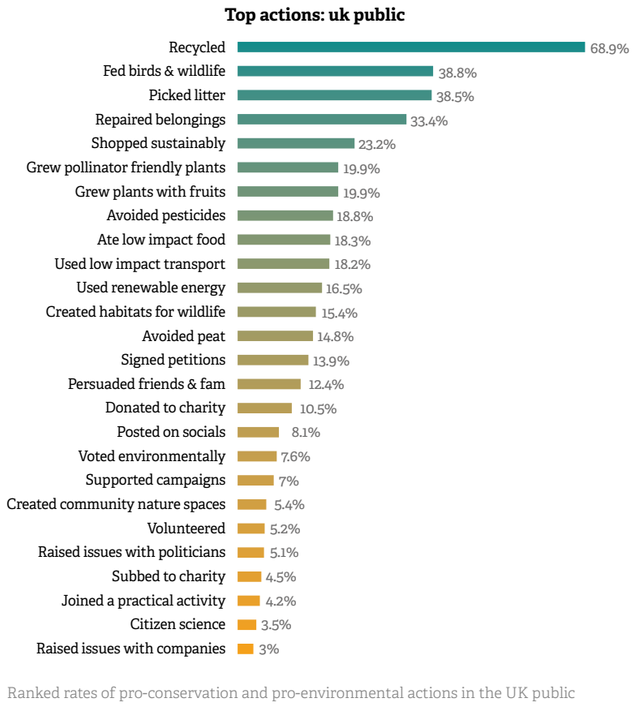
The survey is delivered online and receives opt-in responses as a result of advertising, as well as opt-in responses from members of participating Wildlife Trusts[5]. Additionally, the survey is augmented by a nationally representative UK public panel on an annual basis. Together, these responses allow us to compare a large sample of nature-engaged supporters with the public as a whole. Collectively, GBNS received over 23,000 responses across the four nations in its first year, making it one of the largest surveys of its kind in the UK, and the largest to cover all four nations.

Headline results in the Survey's first year (2023/24) included:

- **84% of the public have taken at least one pro-conservation or pro-environmental action in the past year (excluding recycling)**
- **Pro-conservation and pro-environmental actions in the public are skewed towards a small handful of all possible actions (see Figure 16)**
- **43% of the UK electorate have supported a UK-based environmental charity in the past year**
- **38% of the public (78% of Wildlife Trust supporters) agree that they are being affected by climate change**
- **37% of the public (73% of Wildlife Trust supporters) agree that they are being affected by the loss of nature**

[5] The online survey can be found on The Wildlife Trusts' website, here: https://www.wildlifetrusts.org/great-big-nature-survey#:~:text=What%27s%20it%20all%20for%3F,its%20environmental%20policies%20and%20priorities

Figure 16: Pro-Conservation and pro-environmental behaviours in the UK public. What people in the UK say they do for nature and the environment.



Ranked rates of pro-conservation and pro-environmental actions in the UK public over 12 months. Source data: Kantar OnLineBus omnibus survey, 2,476 UK adults (16+), interviewing conducted by online self-completion from 30/05/2023 – 05/06/2023.

The Wildlife Trusts are running follow-up surveys with an ever-growing panel of GBNS respondents across the UK, covering many issues in more detail. To date, these follow-ups cover topics that include environmental politics, attitudes to rewilding and species reintroductions, and green jobs. Follow-up responses can be linked across surveys, and also to GBNS, providing new ways to understand human-nature relations in more detail. Over time, GBNS will collate longitudinal data from repeat survey takers, providing new opportunities for research.

The Wildlife Trusts currently have well-developed research collaborations with the *Future of Conservation Survey* group of researchers at the universities of Edinburgh, Cambridge and Leeds. They are using GBNS data to fully explore the correlates of pro-conservation behaviour and to develop new validated scales of conservation-relevant ecocentrism and anthropocentrism, and related values. We are looking to extend access to the GBNS panel by other researchers wishing to explore issues of mutual interest.

Academic reports and papers are currently in preparation, based on the 2023 GBNS survey. Further rounds of GBNS will build on the first year's data collection and analysis, to generate a wide variety of useful evidence concerning the nature-related attitudes and behaviours of the UK population.

© Zsuzsanna Bird

4.8 The Mental Health Benefits of Activity in Nature

Being active in natural places and proactively taking notice of nature can significantly improve human mental health and wellbeing. Nature-based ('green') social prescribing not only improves mental wellbeing for a significant part of the population and delivers substantial wider benefits to society, it can also significantly reduce costs to the NHS.

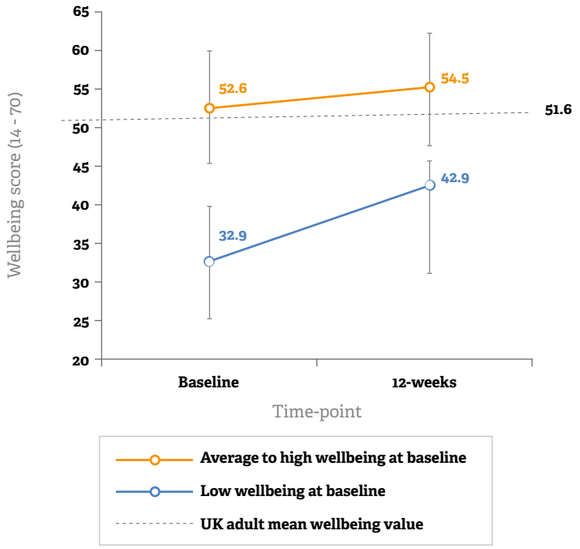
As long ago as 2000, there was interest in the public health benefits of contact with the natural world. The Trust for Conservation Volunteers (TCV) had been running and evaluating what they called 'Green Gyms' since 1997, with reports published in 1999 about their impacts on fitness and physical health, and in 2001 about their positive effects on mental health and wellbeing[32]. Over the following decade, several pioneers such as Dr William Bird and Professor Jules Pretty were promoting the idea that in the UK high quality natural greenspaces near to where people live and work could bring significant health benefits to local communities. Scientific research carried out mainly in The United States, Scandinavia, the Netherlands and Japan suggested that experiencing nature and exercising in natural places could be of significant benefit in terms of both physical and mental health. Some research in the UK also suggested that increasing the quantity and quality of greenspace near where people live could contribute effectively to efforts to tackle health inequality.

At the time, these ideas were often met with scepticism in government and public health circles and dismissed by politicians and those in charge of financial decision-making as "unproven". Even within environmental organisations, there was uncertainty and limited (though growing) enthusiasm for embracing a combined approach to the health of both people and the natural world – largely because of the perceived difficulty of overcoming resistance in the health system.

In 2014, RSWT commissioned researchers at the University of Essex to review the available scientific evidence relating to the mental health and wellbeing benefits of environments rich in wildlife[33]. This was then followed by data collection and analysis to assess the wellbeing benefits of nature conservation volunteering with The Wildlife Trusts.

© Jon Hawkins

Figure 17: How does volunteering with a Wildlife Trust affect mental wellbeing?
The impact of a 12-week period of nature-based volunteering on the wellbeing scores of participants with initial wellbeing above and below the UK average[u].



Data were collected from volunteers working with five different Wildlife Trusts[t], concerning the type of volunteer activities they undertook, where they did them, how frequently and how long for. Data was also collected to assess the mental wellbeing and 'nature relatedness' of all the volunteers – before they started volunteering, after 6 weeks of volunteering and again after 12 weeks. Analysis of the data revealed that across all the volunteers, mental wellbeing increased considerably. After 12 weeks of volunteering, the proportion of volunteers reporting wellbeing levels below the UK average fell from 39% to 19%. Over the same time period, 83% of volunteers who started with low wellbeing reported statistically significant improvement in their overall mental wellbeing, with other statistically significant increases in feelings of positivity, general health and 'nature relatedness'. The results of the analysis carried out on this data were published in 2017 and promoted widely with environmental and public health decision-makers, and with national and devolved governments across the UK[34].

In 2015, The Wildlife Trusts ran its month-long public engagement campaign '30 Days Wild', for the first time. It involved a concerted effort (including publications and other materials, online, social and other media communications) to encourage and enable members of the public to interact with nature in some way, every day for the month of June[v]. This was linked to a research project developed and delivered with researchers at the University of Derby, that explored various aspects of participants' circumstances, attitudes, behaviours, feelings and actions, before, during and after participation.

In its first year, of 12,400 people who formally signed up to take part in the month-long nature challenge during June, 2,305 also completed a baseline pre-participation survey. 344 of these also completed a post-participation survey in July, 269 completed a follow-up survey in September and 126 successfully completed surveys at all three time-points. Analysis of survey returns revealed that the self-reported health and happiness of participants were both significantly higher immediately after participating in *30 Days Wild* than they had been beforehand. These increases were shown to last at least until the follow-up survey, two months later[35].

As participation in *30 Days Wild* grew in subsequent years[w], more data was collected and further analysis revealed the same patterns, plus further detail about the wellbeing impacts of interacting with nature[36]. Analysis in 2017 concluded that the beneficial impact on participants' happiness was greatest for those with initially low happiness levels[37]. After 5 years, analysis of combined data from more than 1,000 participants demonstrated that on average, participation in *30 Days Wild* brought about a 30% improvement in their self-reported health[38].

Additional research was carried out during 2017 and 2018, delivered by researchers from University College London's Institute of Education, working with 451 children involved in projects with 12 individual Wildlife Trusts from across England. Amongst other things, it again revealed a statistically significant improvement in personal wellbeing and health as a result of participation in outdoor learning activities in natural places

[t] Avon, Gloucestershire, Lancashire, Nottinghamshire and Tees Valley Wildlife Trusts.
[u] From the Health Survey for England, 2015.
[v] 30 Days Wild has run every year since 2015 and is still running in 2024: wildlifetrusts.org/30dayswild
[w] Participation has increased steadily each year since 2015. In 2023, 124,487 individuals, schools, care homes and businesses signed up to take part and an estimated 593,720 people actively participated.

– especially amongst those children who had relatively low initial health and wellbeing[39]. Other similar independent evaluations of nature-based health and wellbeing interventions run by individual Wildlife Trusts have subsequently reached similar conclusions, for example, in Lancashire[40], Warwickshire[41], Derbyshire[42] and Montgomeryshire[43].

Further analysis of the wellbeing and activity data combined with financial information, by health economists at Leeds Beckett University, concluded that every £1 invested in normal Wildlife Trust volunteering programmes (aimed primarily at people with average to high wellbeing to start with) generated £8.50 of overall value to society (Social Return On Investment, SROI). Similarly, those Wildlife Trust programmes targeted specifically at participants with lower wellbeing, with the specific intention of bringing health and wellbeing benefits to them, generated £6.88 of social value for every £1 invested[x]. The results of this economic analysis were published in 2019[44] and used to further strengthen the evidence-based case for nature conservation activities to be provided as part of psychological wellbeing interventions funded from the public health budget.

Between 2016 and 2020, The Wildlife Trusts partnered with researchers from Sheffield, Derby and Heriot Watt Universities in the IWUN (Improving Wellbeing through Urban Nature) project[y]. It generated a considerable research output including 28 academic publications and a series of policy and practice briefs about how to bring the health and wellbeing benefits of nature more effectively to more people. Among other things, the project developed and applied a mobile phone app to monitor users' movements, perceptions and feelings in and around different urban greenspaces. Data generated by the app allowed researchers to explore the relationship between the biodiversity of urban greenspaces, people's perception of it and people's wellbeing.

One of the papers produced by the IWUN project team concluded that people readily and quite accurately identify whether or not a greenspace supports a diverse community of wild birds and plants, and that the diversity of wildlife and nature (especially birds) that people notice when visiting them is an important factor in how greenspaces affect their sense of wellbeing[45]. This data showed some of the strongest correlations between urban biodiversity and human positive emotions published to date. Larger, more diverse natural greenspaces in urban areas are home to a greater diversity of wild birds and also bring greater mental health and wellbeing benefits to people. This has significant implications for the planning and design of healthy urban areas, and the provision and maintenance of open spaces within them.

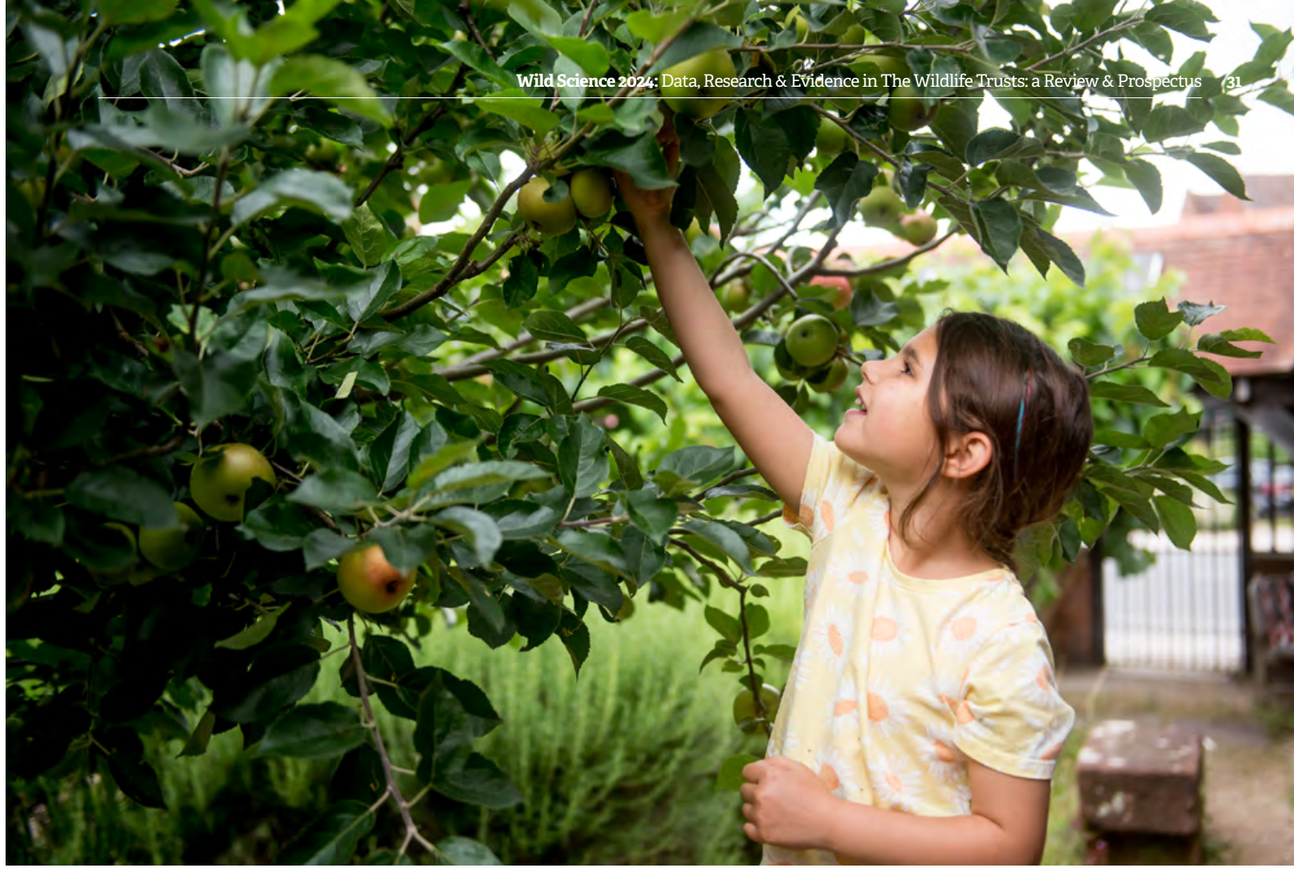
Independently of The Wildlife Trusts, analysis led by the University of Exeter and published in 2019 analysed nationally representative data collected by Natural England through the Monitor of Engagement with the Natural Environment survey (MENE). This indicated that spending a total of more than 2 hours per week in nature brings distinctly more mental wellbeing benefit than lesser amounts[46]. The researchers proposed that future longitudinal studies and intervention studies should inform development of weekly nature exposure guidelines for good mental health.

In 2021, the UK Government established seven Green Social Prescribing for Mental Health (GPMH) pilot initiatives across England to explore, test and demonstrate the potential for nature-based social prescribing to contribute effectively to improving

Figure 18: Does biodiversity affect people's mental wellbeing? The relationship between perceived biodiversity and human emotion ('How did you feel about this place?') in different urban greenspaces within Sheffield[z].

Circles are those Urban Greenspaces where biodiversity surveys were carried out in addition to perceived values from the App. Relationship for the main 10 sites represented by circles ($n \geq 10$) $r(df\ 9) = 0.813$, $p < 0.001$, $r2 = 0.661$. Relationship for 25 sites represented by circles and triangles ($n \geq 5$) $r(df\ 23) = 0.886$, $p < 0.001$, $r2 = 0.785$

[x] The lower SROI reflecting the higher cost of engaging and supporting participants with lower initial wellbeing levels through explicitly healthcare-related routes.
[y] Further information about IWUN, including access to the publications and other materials generated, can be found on the project's website: https://iwun.sites.sheffield.ac.uk/home.
[z] Reproduced from Cameron *et al* (2020) under the Creative Commons Attribution 4.0 International License – see Endnote 45.



England's mental health and wellbeing. Individual local Wildlife Trusts were involved in the delivery of all these pilots and many other Wildlife Trusts were also delivering nature-based social prescribing in various ways during this period, in other places.

In 2023, The Wildlife Trusts commissioned the Ricardo Energy & Environment consultancy with the Institute for Occupational Medicine, to undertake a Rapid Economic Assessment (REA) of some of the federation's green social prescribing ('Natural Health') services. Using data provided by The Wildlife Trusts and by some of the NHS Trusts with which they have been working, this REA concluded that not only do Wildlife Trust health-related programmes bring real health benefits and generate significant social return on investment (SRoI), they can also generate very significant real cost savings to the NHS.

Four out of the five projects assessed were shown to have the potential to generate direct net savings to the NHS, ranging from £1.03 in reduced costs to the NHS for every £1 invested (for long-term participants in the *Feed the Birds* project), to £1.19 in reduced costs to the NHS for every £1 invested (in the *Wild at Heart* project in South Yorkshire). On this basis, a UK-wide investment large enough to provide treatment to all those living with mental health conditions who would be likely to benefit from regularly spending time in nature (estimated at around 1.2 million adults[aa]) might reasonably be expected to result in between £16 million and £102 million of real (net) cost savings to the NHS each year[47].

These, and similar findings from elsewhere, are being actively promoted with national governments and health services across the UK, looking to secure a bigger and more explicit role for an accessible, healthy natural environment in publicly funded health provision. Insights into what works and what doesn't, and into the value of different approaches explored in these studies, is constantly being fed back into what Wildlife Trusts do and how they do it, to increase the effectiveness and efficiency of our natural health work. An extension to the GPMH pilots has been announced for 2024 to 2025, looking to turn previous learning into a compelling case for green social prescribing to be spread, scaled and embedded effectively across the NHS in England.

Table 1: Potential cost savings to the NHS from different Wildlife Trust green prescribing approaches. A summary overview of the benefit cost ratios achieved by seven different self-contained projects, using a variety of benefit calculation methods[bb].

Project	Annual benefit to NHS/ healthcare (2023 prices)	Annual total cost of running project (2023 prices)	Benefit Cost ratio (BCR)
Wild at Heart Clifton Park in Rotherham	£38,646 in reduced NHS healthcare costs	£32,427	For every £1 spent on the Wild at Heart Clifton Park in Rotherham session, £1.19 in benefit in terms of reduced costs to the NHS.
Feed the Birds	£15,460 in reduced NHS healthcare costs	£38,535	For every £1 spent on the Feed the Birds project, £0.40 in benefit in terms of reduced costs to the NHS (assuming participants spent only one year each time in the scheme). Where participants are assumed to have had a longer participation, ther payback is higher at £1.03 per £1 spent.
The Early Intervention project in Bury	£7,024 in reduced NHS mental health treatment costs	£3,250 (£6,500 if we include member of staff provided by NHS)	For every £1 invested into the Bury project, the project provides £2.16 of benefit in terms of reduced costs of treating mental health related conditions. If we include the NHS member of staff and double the costs the BCR would be for every £1 invested there would be a £1.08 benefit in terms of reduced costs of treating mental health related conditions.
Nature for Health in Greater Manchester	£8,460 in reduced NHS healthcare costs (method 1)	£47,891	For every £1 spent on the Nature for Health project, £0.18 – £0.93 in benefit in terms of reduced costs to the NHS.
	£44,745 in reduced NHS healthcare costs (method 2)	£47,891	
Wild Health	£35,474 in reduced NHS healthcare costs (method 1)	£60,644	For every £1 spent on the Wild Health project, £0.58 – £1.10 in benefit in terms of reduced costs to the NHS.
	£66,882 in reduced NHS healthcare costs (method 2)	£60,644	

[aa] In the latest release available in June 2023, 12.8% of respondents to The People and Nature Survey for England specifically reported that they visited natural places more than several times a month and also that they did this for mental health and wellbeing purposes. Assuming that this is representative of the UK population as a whole, if this percentage is applied to similarly credible estimates of the numbers of people suffering from depression, anxiety and other common mental disorders, it generates an overall estimate of 1.2 million adults.
[bb] Adapted from Sendall et al (2023) – see Endnote 47.

4.9 Farming Carbon

The decomposition of peat in the soils of damaged and degraded peatlands across the UK is a significant source of greenhouse gas emissions. Rewetting drained peatlands and restoring more natural peatland vegetation on them would have a very significant beneficial impact on the UK's carbon budget as well as helping native peatland wildlife to recover and providing an income to peatland farmers.

Testing the effectiveness of different peatland restoration techniques and assessing the economic implications of different approaches can guide restoration efforts towards those that work best for the climate, nature and people who make their living from the land. Farming carbon might be alternative to farming livestock across many peatland landscapes, at carbon prices as low as £50 t CO_2e^{-1}.

Peatlands are some of the UK's most important natural habitats, covering about 12.2% of the UK's land area[48]. The various types of peatland, including blanket bogs, raised bogs and fens, are home to communities of plants and animals that are highly specialised, thriving in places that are constantly waterlogged, some with very few nutrients and very acidic soils. As they grow, *Sphagnum* mosses found on blanket or raised bogs, remove carbon from the atmosphere and lock it up as living moss which blankets the peat surface. Much of this decomposes to release carbon back into the atmosphere, similar to other plants, but some never fully decomposes as it dies and is preserved in the low-oxygen, nutrient-poor, wet conditions of the bog, where it forms deposits of carbon-rich peat beneath the constantly growing moss surface. Consequently, peat bogs contain enormous stores of carbon that will slowly and steadily[cc] continue to grow for millennia, so long as they are maintained in good condition. UK peatlands have been estimated to contain at least 3.2 billion tonnes of carbon[49].

Wherever they are found, over the centuries, peatlands have been drained, ploughed, mined and damaged in other ways intended to make them more economically productive. Some of the most comprehensively drained and intensively farmed and productive agricultural land in the UK is in places with peat soils that historically were waterlogged peatlands. These activities have led to an enormous reduction in the area of high quality peatland


© Peter Cairns / 2020VISION

vegetation, particularly in low-lying areas such as floodplains. Fewer than 20% of the UK's peatlands are undamaged[50]. As a consequence, the remaining natural or near-natural bogs and fens have become increasingly protected and efforts to protect, repair and restore the rest have grown considerably in recent years, with varying degrees of success[dd].

Peatlands have become the focus of conservation and restoration efforts to sustain their unique ecological communities, and also because they have a very significant part to play

[cc] Typically at about 1mm of additional peat depth per year.
[dd] While specific efforts to protect peatlands have been significant since the 1990s and efforts to restore them are continuing, despite this, the condition of most of the UK's peatlands remains poor and much of it has declined in quality. No new peatlands have been designated in recognition of their nature conservation value and needs for several years. There is a continuing – and arguably growing – need to invest still more in protecting and restoring the UK's peatlands.

in efforts to stabilise the global climate. In good condition, peat bogs actively remove carbon dioxide from the air and lock it up for thousands of years, but the carbon stored in them in this way is readily released if they are damaged. Greenhouse gas emissions from degraded peat soils are some of the biggest contributors to the UK's land-based carbon emissions[51]; in 2019, they were estimated to contribute about 3.5% of the UK's total annual greenhouse gas emissions[52] Reducing these may be one of the most effective ways to reduce the UK's overall carbon emissions and rewetting drained peat soils is likely to be the most effective way to achieve this[53]. It may be possible to restore damaged and degraded peat bogs to a state where their existing carbon stores are secured and they are once again accumulating carbon and helping to reduce the amount of greenhouse gases in the atmosphere.

In the UK, many of the protected or restored peatlands that are currently in reasonable or good condition are small remaining fragments of formerly more extensive wetlands. They now often find themselves surrounded by farmland that is drained, ploughed and fertilised, or grazed with domestic livestock. As a result, while the soil carbon in the surrounding landscape continues to be lost to the atmosphere as the degraded peat there decomposes, the remaining pockets of more natural peatland vegetation struggle to stay wet and are increasingly difficult to sustain. This is particularly so where the remaining peatland is raised bog, rising as a wet dome of peat sitting above the adjacent drained land.

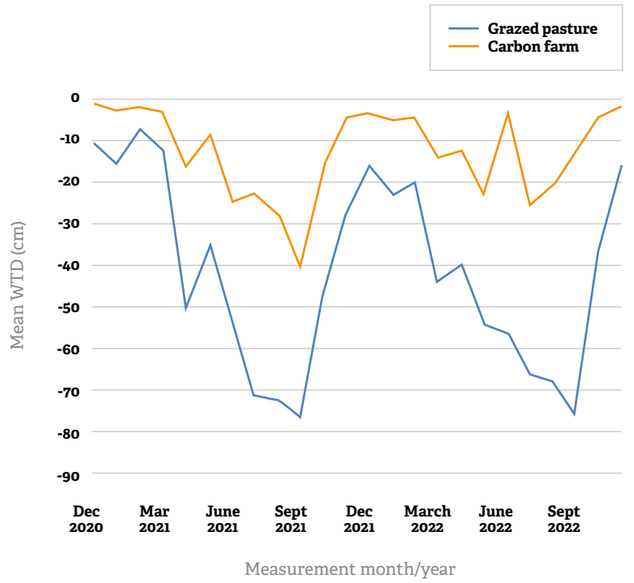
At one of these protected peatland fragments – the 89.5 ha Winmarleigh and Cockerham Moss Site of Special Scientific Interest (SSSI) in Lancashire – Lancashire Wildlife Trust have been exploring ways to raise water levels on adjacent grassland used at the time for livestock farming, and to re-establish *Sphagnum* vegetation on it. The expectation is that, if successful, this would help to protect the SSSI raised bog and the carbon stored within it, and also to reduce carbon emissions. In time, it may successfully reverse the net flow of greenhouse gases and restart the process of peat accumulation. By taking an experimental approach to the project, it was hoped to generate knowledge and understanding that could inform peatland restoration approaches elsewhere, and across a larger area of land in the surrounding area. The 4ha Winmarleigh Carbon Farm site was acquired in 2019 and a range of initial baseline data were collected and assessed to inform the approach to be taken. The pilot restoration area was prepared in May and June 2020. Soil chemistry analysis indicated signs of past lime application and high levels of inorganic nitrogen in the upper soil layers and that these levels reduced rapidly below a depth of 10cm, leaving about 1.5m of undisturbed high quality (low nutrient) peat beneath. Consequently, the turf and top 10cm of soil were stripped from three quarters of the site to provide a soil surface likely to be suitable for the establishment of *Sphagnum* moss.

Six of the bunded cells of the Carbon Farm were hand-planted with a variety of *Sphagnum* moss plugs (175,000 plugs in total) – five cells in September and October 2020 and the remaining cell in June 2022. The other two cells were planted with common reed (*Phragmites australis*), to filter water leaving the site before it entered the adjacent watercourse.

Figure 19: The Winmarleigh Carbon Farm. The newly created grid pattern of bunded cells, irrigation ditches and channels, with a protective layer of straw covering the newly planted plugs of *Sphagnum* moss (November 2020).

Two hectares of the stripped area was laser-levelled and divided into a grid-pattern of 8 peat-bunded cells with a regular series of water channels linked to a 1ha water-holding area. These provided automated irrigation of the re-vegetated cells, using solar-powered pumps. Water levels were raised and controlled using a series of valves and pipes to achieve optimum water levels throughout the experiment.

Figure 20: Water table depth. Comparison of water level fluctuations on the Winmarleigh Carbon Farm and adjacent farmland, 2020 to 2022[ii].



The water table was successfully maintained at less than 40cm deep and at all times it was between 5cm and 63cm closer to the surface than the water table in the adjacent (control) pasture[hh]. While it was not possible to consistently achieve the target 10cm water table depth required for favourable CO_2 balance, water table depth was significantly more consistent than on the control grassland plot and substantially smaller during the driest period of the year (from June to September). Ongoing monitoring since 2022 has indicated that increasing experience of managing the site has improved water level management, reducing fluctuations further and maintaining levels closer to the target 10cm depth.

***Sphagnum* moss cover increased consistently over the two year period, from 0% up to 57% within the greenhouse gas monitoring collars.** In some parts of the site (where nutrient and hydrological conditions were particularly good), *Sphagnum* hummocks were starting to join up and develop towards a continuous moss carpet. In other areas (where conditions weren't so good), Sphagnum establishment was more patchy and weedy vascular plants such as sheep sorrel and red shank were an issue.

There was a significant correlation between the measured water table depth (WTD) and the remotely sensed Normalised Difference Moisture Index (NDMI)[ii]. There were also positive correlations between measured growth of *Sphagnum* mosses and two other remotely sensed indices (Normalised Difference Vegetation Index – NDVI – and Enhanced Vegetation Index – EVI). Overall, relationships between on-site observations and remotely sensed indices indicated the potential of earth observation for monitoring the condition of peatland restoration areas.

Researchers from Manchester Metropolitan University and staff and volunteers from Lancashire Wildlife Trust monitored carbon dioxide (CO_2) and methane (CH_4) fluxes and a range of other parameters[ee], from December 2020 to December 2022 and analysed the data collected. They also investigated the use of remotely sensed optical satellite imagery[ff] to monitor change at the Carbon Farm, and developed an economic assessment tool to explore the financial feasibility of the carbon farming approach as an alternative to current land uses[gg]. Headline results were as follows.

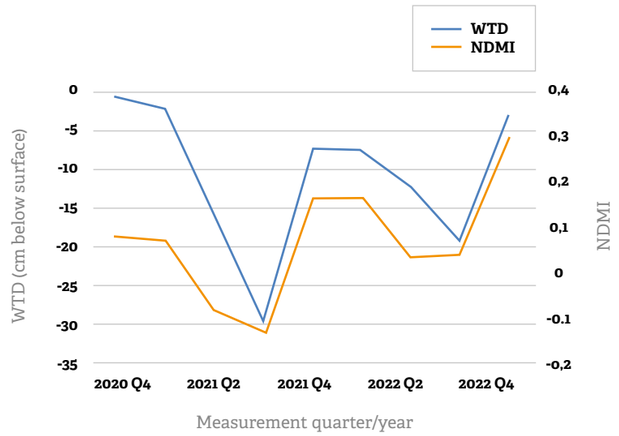
[ee] Water table depth; *Sphagnum* cover; presence of selected vascular plants, invertebrates, amphibians & birds.
[ff] From time series May 2018 to June 2023 Sentinel-2 image data obtained from the European Space Agency Copernicus programme, for sample points located on Carbon Farm restoration cells and across the adjacent grazed control areas.
[gg] Publications relating to the economic assessment tool and its application to the Winmarleigh Carbon Farm are currently in preparation by the Manchester Metropolitan University and National University of Ireland Galway researchers.
[hh] The water table depth on the Carbon Farm plot was only more than 30cm for a brief period in late summer 2021, following a period of sustained drought.
[ii] Reproduced from Kennedy et al (2023) – see Endnote 63.
[jj] A remotely sensed index of the water content in vegetation.

While both the Carbon Farm and the adjacent control site were net emitters of carbon-based greenhouse gases during both 2021 and 2022, across both years the Carbon Farm's emissions were about one tenth (10%) of those from the control site. Fluxes of carbon-based greenhouse gases (CGHGs: CO_2 and CH_4) were measured directly, using flux chambers and automatic GHG analysers. In year 1, emissions were 88.4% lower than those from the control site (a net emission reduction of 18.4 t CO_2e ha^{-1} yr^{-1}) and in 2022 they were 90.7% lower (a net emission reduction of 37.5 t CO_2e ha^{-1} yr^{-1})[mm].

Emissions of CH_4 were consistently very small, to the point of being negligible. On the carbon farm, they were at or extremely near to zero for the whole period; on the control grassland they were consistently higher, but still very small as a proportion of all emissions measured.

There were very high costs associated with establishing the Carbon Farm on this small, experimental scale, from scratch, on a short timeframe (£74,700 per hectare). Economic assessment of this pilot project as implemented makes it very clear why one-off project funding such as the EU Interreg grant that supported this project is necessary for the development and testing of new (as yet not economically viable) approaches such as this. Simply to break even over a 50 year period, direct replication of the Carbon Farm approach as implemented was estimated to require a carbon price of £128 per tonne CO_2e, even with no expectation of repaying loan finance or paying interest or dividends to investors. If return-generating investment or loans were needed to deliver the works, the break-even point over 50 years would be unlikely to be reached with carbon prices below £561 per tonne CO_2e.

Figure 21: Earth observation to monitor water table fluctuations in peatland restoration sites. The relationship between water table depth and Normalised Difference Moisture Index at Winmarleigh Carbon Farm, 2020 to 2022[ll].



Comparison of trends between measured water table depth (WTD) and remotely sensed Normalised Difference Moisture Index (NDMI) .

Table 2: Greenhouse gas emission reductions achieved. A comparison of the annual greenhouse gas emission reductions achieved in 2021 and 2022 at the Winmarleigh Carbon Farm, in comparison with an adjacent control plot of grazed agricultural grassland on peat soil[nn]

Annual Carbon Greenhouse Gas Emission Rates[oo]				
		2021	2022	Mean
Measured Total Emissions (t CO_2e ha^{-1} yr^{-1})	Grazed pasture (control)	20.76	41.30	31.03
	Carbon Farm	2.40	3.85	3.13
Emission Reduction	Quantity (t CO_2e ha^{-1} yr^{-1})	18.36	37.45	27.91
	Percentage (%)	88.4%	90.7%	89.9%

[ll] Reproduced from Kennedy *et al* (2023) – see Endnote 63.
[mm] Though the project team noted that this pilot didn't take account of the additional one-off emissions of greenhouse gases associated with the initial capital works – the removal of the surface soil layer and installation of the irrigation system. It is likely, given the measured greenhouse gas emissions from the control plot, that even though removal of the soil surface will have increased immediate and short-term emissions, over a longer time-frame those would still take place with a continuation of current land management practices.
[nn] Adapted from Kennedy et al (2023) – see Endnote 63.
[oo] That is emissions of carbon-based greenhouse gases, not nitrous oxide (N_2O). The grazed pasture (control) site is likely also to emit N_2O, which hasn't been measured, so overall emission reductions achieved by a conversion from pasture to recovering peatland are likely to be an under estimate.

A similar peatland re-wetting project delivered by Lancashire Wildlife Trust and funded through the Paludiculture Exploration Fund created a very similar mosaic of water-retention cells at a cost of £15,000 per hectare. The costs were significantly lower than at Winmarleigh Carbon Farm because surface layers of relatively nutrient-rich soil weren't removed (saving around £5,000 per hectare), land profiling groundworks were delivered by participating farmers (using their own machinery rather than relying on relatively expensive contractors) and the project didn't involve the high-cost purchase and planting of *Sphagnum* moss plugs (at a cost of £41,250 per hectare to purchase the moss plants and £11,000 per hectare to plant them). A slight re-design of the irrigation system and improvements to the solar water pumping arrangements brought improvements to performance at no additional cost.

Previous peatland restoration projects and experimental trials by other organisations (in Scotland, the Peak District , the Yorkshire Dales and elsewhere) have demonstrated the effectiveness and costs of implementing various peatland restoration approaches, including drain-blocking to retain water and the re-establishment of *Sphagnum* mosses. While these have often been in upland situations not requiring (or allowing) significant ground works or complex irrigation, they give a very good idea of the realistic price at which different aspects of peatland restoration can be delivered. The introduction of new *Sphagnum* moss vegetation onto bare peat, for instance, can range in cost from as little as £845 per hectare (£1,037 at 2023 prices) reported in 2019[55], to as much as £104,400 per hectare (£131,300 at 2023 prices) reported in 2018[56], depending on circumstances, the form of *Sphagnum* used, application methods and the timescale over which land managers are willing to wait for full *Sphagnum* cover to be re-established.

The results of the Winmarleigh Carbon Farm pilot project suggest that successful *Sphagnum* moss

Table 3: The financial viability of lowland carbon farming. The relationship between peatland restoration costs, the price of investment finance, the price of carbon and the business models of average English lowland grazing livestock farms in 2023[PP].

https://www.farmbusinesssurvey.co.uk/regional/reports /FBS-Lowland-Report-2022-23.pdf		**Carbon Investment** (assumed restoration cost – £/ha)	**2022-23 Actual** (£/ha)			**Model 1:** Remove all livestock and crop production. Reduce fixed costs to be comparable to those of the lowest cost farm type (performance band). Retain public subsidies and grants, and non-farming income. Switch whole farm to carbon farming.			**Model 2:** Reduce livestock and crop production by a third. Retain public subsidies and grants, and non-farming income. Switch a third of farm area to carbon farming.		
Performance Level of lowland livestock farm			**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Farm Output, Costs, Margins and Income without carbon	Total Farm Output (£/ha)		994.00	1,301.00	1,810.00	405.00	462.00	708.00	797.67	1,021.33	1,442.67
	Total Variable Costs (£/ha)		307.00	415.00	417.00	0.00	0.00	0.00	204.67	276.67	278.00
	Total Gross Margin (£/ha)		687.00	886.00	1,393.00	405.00	462.00	708.00	593.00	744.67	1,164.67
	Total Fixed Costs (£/ha)		858.00	751.00	863.00	729.00	729.00	729.00	858.00	751.00	863.00
	Net Farm Business Income (£/ha)		**-171.00**	**135.00**	**530.00**	**-324.00**	**-267.00**	**-21.00**	**-265.00**	**-6.33**	**301.67**
Target net annual Income from carbon farming, to generate the same total farm business income per hectare as 2022-23 (£/ha)						**153.00**	**402.00**	**551.00**	**94.00**	**141.33**	**228.33**
Carbon price necessary to acheve sufficient net annual Income from carbon farming to generate the same total farm business income per hectare as 2022-23 (as indicated above). Assuming payment of 5% interest on investment finance, over 50 years.(£/t CO_2e)		£6,000.00				66.60	76.60	82.70	64.20	66.10	69.60
		£15,000.00				111.12	121.20	127.20	108.80	110.70	114.20
		£20,000.00				135.90	146.00	152.00	133.60	135.50	139.00
		£33,000.00				200.30	210.40	216.40	197.90	199.90	203.40
		£74,700.00				406.90	416.90	422.90	404.50	406.40	409.90
Carbon price necessary to acheve sufficient net annual Income from carbon farming to generate the same total farm business income per hectare as 2022-23 (as indicated above). Assuming payment of 3% interest on investment finance, over 50 years.(£/t CO_2e)		£6,000.00				59.30	69.40	75.40	57.00	58.90	62.40
		£15,000.00				93.10	103.10	109.10	90.70	92.60	96.10
		£20,000.00				111.80	121.90	127.90	109.40	111.30	114.80
		£33,000.00				160.50	170.60	176.60	158.10	160.00	163.50
		£74,700.00				316.70	326.80	332.80	314.40	316.30	319.80
Carbon price necessary to acheve sufficient net annual Income from carbon farming to generate the same total farm business income per hectare as 2022-23 (as indicated above). Assuming no requirement for investment finance.(£/t CO_2e)		£6,000.00				41.70	51.80	57.80	39.30	41.20	44.80
		£15,000.00				49.00	59.00	65.00	46.60	48.50	52.00
		£20,000.00				53.00	63.10	69.10	50.60	52.50	56.10
		£33,000.00				63.50	107.20	79.60	61.00	63.00	66.50
		£74,700.00				97.20	73.60	113.20	94.80	96.70	100.20

[PP] Adapted from Doar (2024) – see Endnote 62.

re-establishment can be achieved quite rapidly (likely to achieve 100% Sphagnum cover within 4 years, at the rates measured and reported in the trial) using the relatively high-cost approaches applied there. They also confirm that significant greenhouse gas emission reductions can be achieved within one year just from raising the water table to re-wet the peat, long before a new covering of *Sphagnum* moss has been established. Given this, shaping the peat surface and installing the irrigation system necessary to manage water levels effectively may be sufficient to achieve substantial emission reductions at far lower cost than those of implementing the whole scheme as delivered at Winmarleigh. Lower cost (and typically slower) approaches to re-establishing a *Sphagnum* moss carpet may then be used on the re-wetted peat surface, leading to the establishment of a re-wetted and re-vegetated peat bog, likely to be over the course of a decade, rather than 4 years.

According to the 2022-23 Farm Business Survey of lowland grazing livestock production in England[57], a typical English lowland livestock farm with 'medium productivity' had a total (net) farm income of £135 per hectare in that year, including public funding of £250 per hectare (from agri-environment type schemes and Basic Payment Scheme). Typically larger, higher

Key:

Carbon price below £40 per t CO_2e - within the range of current voluntary schemes currently reflected in UK voluntary carbon markets (2024)

Carbon between £40 per t CO_2e and £80 t CO_2e - within reasonable expectation likely by 2025 (may already be viable)

Carbon price between £80 per t CO_2e and £100 t CO_2e - possible likely by 2030 (between 2025 and 2035)

Carbon price between £100 per t CO_2e and £120 t CO_2e - possible but unlikely likely by 2035 (between 2025 and 2038)

Carbon price between £120 per t CO_2e and £300 t CO_2e - very unlikely likely beyond 2035 (possibly from 2030)

Carbon price over £300 per t CO_2e - currently entirely infeasible unlikely until after 2050 (if ever)

Output, Cost, Margin and Income values for farms at different performance levels (low, medium, high) derived from the Farm Business Survey 2022-23, for lowland grazing livestock farms in England. Indicative necessary carbon prices (£ / t CO_2e) modelled for peatland restoration cost scenarios ranging from £6,000 to £74,700 per hectare, with three different assumed rates of payment on investment finance (0%, 3% and 5%) and two different assumptions concerning the amount of each farm switched to carbon farming (33%, 100%). Carbon prices modelled using the financial feasibility and pricing tool for carbon credits developed by Manchester Metropolitan University and National University of Ireland Galway as part of Interreg North-West Europe Care-Peat project (with Lancashire Wildlife Trust as a partner).

performance lowland livestock farms had a total (net) farm income of £530 per hectare in that year, including public funding of £270 per hectare.

The economic modelling tool developed by Manchester Metropolitan University and the National University of Ireland Galway, as part of the Care Peat project (see above) indicates that over a 50 year period, with carbon prices at £80/t CO_2e and above, and low-cost peatland restoration methods (costing up to about £6,000 per hectare), it is already feasible for farmers to generate as much income from farming carbon as they currently do from farming livestock. Application of the tool to a range of scenarios based on average 'low performance', 'medium performance' and 'high performance' lowland grazing livestock farms in England (using financial data from the Farm Business Survey for 2022-23[58]) allowed the potential for carbon farming to be incorporated into farm businesses to be explored.

At the low carbon prices currently being paid for credits issued in the UK under either Woodland Carbon Code or Peatland Carbon Code (typically less than about £40/t CO_2e, averaging at about £24/t CO_2e[59]), carbon farming would only be a viable economic choice for lowland livestock farmers if peatland restoration works could be delivered extremely cheaply (at below £6,000 per hectare) and only on part of a farm's total area, without payment of interest on any investment finance required.

The 2024 price for carbon in the UK Emission Trading Scheme is £64.90[60]. UK Government projections of future carbon prices to 2050, used for economic planning purposes, forecast steadily rising prices through to a peak of between £106 and £171 per t CO_2e (mid-range £145) in 2039, then settling down to a fluctuating rate of about £138 (between £95 and £172) per t CO_2e through to 2050[61].

On this basis, modelling carried out by The Wildlife Trusts suggests that within the next one to five years, the economics of lowland peat farming is likely to be such that even high performing (typically larger) lowland grazing farm businesses in areas with peat soils would be able to justify commercial investment in


Red fox planting Spagnum plugs at Winmarleigh.


An area next to the carbon farm has remains drained and used for grazing as a control.

rewetting and restoring *Sphagnum* moss cover to a third of their total farm area. **Doing this might realistically achieve a farm business income at or above the income achieved from producing livestock and crops in 2022-23[62].** Low interest and/or philanthropic investment in peatland restoration would make this an immediately viable economic option with peatland restoration costs up to about £20,000 per hectare – particularly for low performance (typically smaller) farms, where even whole-farm conversion to carbon farming may be economically viable at a carbon price of £112 or less.

Realistically low-cost peatland restoration techniques could already make carbon farming an economically viable alternative to livestock production for some lowland grazing livestock farms. Even with a requirement for **commercial financial investment to be repaid over 50 years at 5% interest per year**, most lowland grazing livestock farm businesses could generate as much net annual income as they did in 2023 from the production of livestock and crops, if they were to restore a third of their farm area to reduce carbon emissions and generate saleable carbon credits from those reductions while maintaining their current level of financial support from government.

If **low-cost finance** is made available, or for farm businesses where external investment finance isn't required to carry out the necessary capital works, even relatively high-cost restoration approaches (up to £33,000 per hectare) would become economically viable as an alternative to lowland livestock farming at carbon prices below the current UK Emission Trading Scheme carbon price for 2024 (£64.90). Further work is underway to refine the initial economic analysis and explore its implications in greater depth.

The full results of the Winmarleigh Carbon Farm Pilot were published as part of the outputs from the North West Europe Interreg Care-Peat Project[63]. Further details of The Wildlife Trusts' supplementary economic modelling exercise can be obtained from evidence@wildlifetrusts.org. They will be used by The Wildlife Trusts and others to inform how we proceed with the restoration of lowland peat habitats and the development of financial mechanisms to fund it.

4.10 Peat-Fix

Peatland restoration is always challenging, but on some exposed upland sites, restoring vegetation cover on the steeply sloping bare peat surfaces on the flanks of peat 'hags' can be especially difficult.

Established techniques often fail because the seeds and mulches used are simply blown away. Experimental testing of a new technique – hydroseeding – has demonstrated that it can successfully overcome these challenges. It may now prove to be a valuable new tool for the restoration of particularly difficult peatland sites.

Just as the Winmarleigh Carbon Farm (see Section 4.9, above) is testing the practicalities and economics of peatland restoration in the lowlands, other Wildlife Trust projects are exploring better ways to restore upland blanket bogs.

Yorkshire Peat Partnership (YPP), led by Yorkshire Wildlife Trust, is restoring peatlands across the north of Yorkshire. Restoration is nearly always challenging, but an especially taxing problem is how to re-establish vegetation on steep slopes of bare peat, often on the sides of eroded mounds known as 'hags'. These bare features expose the peat to the atmosphere, compounding erosion and increasing carbon emissions; covering them in vegetation prevents this. This is normally addressed by the application of mulch and seed to the exposed peat areas, using a technique known as 'brashing'. Unfortunately, this typically fails on exposed sites (of which there are many across the upland peat areas of the UK), as the restoration materials are removed by the wind.

Alternative peatland revegetation techniques to the established technique of 'brashing' are needed to re-establish vegetation on the steep bare flanks of seriously eroded peat hags – particularly on exposed sites.

Figure 22: The challenge of restoring vegetation on steep-sided eroded peat 'hags'. The damaged peatland landscape at Oughtershaw, where established peatland restoration techniques are unlikely to succeed.

Alternatives peatland revegetation techniques to the established technique of 'brashing' are needed to re-establish vegetation on the steep bare flanks of seriously eroded peat hags – particularly on exposed sites.

Figure 23: Collecting the peat eroded from test plots. Innovative new sediment traps were designed to collect sediment falling to the bottom of slopes on the flanks of peat hags.

Trapped sediment was collected once a month, dried and analysed.

Figure 24: Enabling the revegetation of bare peat using hydroseeding. All the different Peat Fix treatments tested enable vegetation establishment and significantly reduce peat erosion.

Peat-Fix test plots at Oughtershaw, showing vegetation growth with different Peat-Fix treatments compared to a control plot (to the left of the picture)

YPP collaborated with researchers in the University of Manchester's Geography department (UoM) to establish a government-funded Knowledge Transfer Partnership project intended to develop a solution to the problem. The Peat-Fix project set out to test the application of a technique that is already widely used in more easily accessible and less demanding – predominantly lowland – situations, in the upland environment. The technique being tested – hydroseeding – uses a slurry of seed, mulch and a plant-based tackifier (glue) to attach the materials necessary for establishment of new vegetation securely onto the peat surfaces.

The joint YPP / MoU project team established an experimental test site at a particularly challenging location at Oughtershaw, over 500 metres up on an exposed ridge south of the Yorkshire Dales town of Hawes. Restoration had started on a large area of bare peat in 2018, but due to its exposed location all the hags facing the prevailing wind were still bare in 2022.

Four different mixes of Peat-Fix were applied in trial plots, each with different amounts of seed and ingredients in the mulch (wool, straw, paper). If the treatment is effective, then vegetation should establish better than on the control plots and less erosion should occur on the treated slopes. Eroding sediment was collected from each plot; vegetation surveys were also carried out and fixed point photos taken using an unmanned aerial vehicle (UAV).

Initial data have been analysed by the UoM researchers, working towards the project's conclusion in July 2024. The project has already generated greater understanding of how hydroseeding can be applied in practice in challenging upland environments. Initial analysis shows that Peat-Fix works; all the different treatments tested are able to significantly reduce peat erosion. The data also indicates that Peat-Fix's role in enabling vegetation growth is less driven by the seed mix than by the mulch materials.

Once the analysis is complete, the final aspect of the research will focus on scalability and economic benefit of applying this innovative new approach. Plans are being developed to expand the experiment, further develop the treatments to be more effective and to be used in different landscapes. It is expected that YPP and other peatland restoration programmes will be able to use hydroseeding as an effective new tool for the restoration of very challenging sites.

5. The Wildlife Trusts' Collective Research and Evidence Priorities

The Wildlife Trusts have a federated structure. Each individual Wildlife Trust is an independent organisation in its own right, with its own resources, networks, priorities and governance arrangements – all tailored to its particular circumstances and needs and those of the wildlife, people and places where it works.

These include individual approaches to the generation and communication of evidence that are tailored to local need and priorities[qq].

At the same time, all Wildlife Trusts share a long history, common strategy and set of strongly held values. Consequently, they work closely together as a united federation of 46 geographically distinct individual Wildlife Trusts, plus a central charity, the Royal Society of Wildlife Trusts, which co-ordinates, supports and helps to develop the federation as a whole. Many of the opportunities, challenges and risks that different Wildlife Trusts face are the same, and so are many of the ecological, political, social and economic conditions that influence change. Pooling our data and sharing our evidence needs across The Wildlife Trusts and with others enables us to make better use of the data we already have, to ask more relevant questions and discover better answers to them.

From 2024, as part of a shared evidence framework, The Wildlife Trusts will be working more proactively and strategically to identify and address some of the evidence and data needs that we collectively think are most important in our efforts to bring about nature's recovery, to stabilise the climate and to strengthen people's relationship with the natural world.

[qq] For example: Surrey Wildlife Trust has published its own research prospectus, here: https://www.surreywildlifetrust.org/sites/default/files/2021-11/Research%20Prospectus%20v.2.2.pdf

Similarly, London Wildlife Trust makes its own research reports available to the public here: https://www.wildlondon.org.uk/about/research-and-reports

Other Wildlife Trusts periodically publish documents that include a significant element of research and evidence content, such as Bedfordshire, Cambridge & Northamptonshire Wildlife Trust's '*Towards a Wilder Future*' report, here: https://www.wildlifebcn.org/sites/default/files/2022-02/Wildlife%20Trust%20BCN%20Wilder%20Future%20Report%202022.pdf

or Kent Wildlife Trust's *Nature' Sure Connected* framework for evidencing landscape-scale conservation, here: https://www.kentwildlifetrust.org.uk/sites/default/files/2021-09/KWT_CE_Nature%27s%20Sure%20Connected%20practical%20framework_FINAL%20PROOF_v3_website.pdf

and their *Bugs Matter Citizen Science Survey* of invertebrate abundance, here: https://www.kentwildlifetrust.org.uk/sites/default/files/2024-04/KWT%20Bugs%20Matter%20Technical%20Report%202023%20A4%20PRESS.pdf

Our initial list of research themes and areas of interest, which we intend to refine and update annually, is as follows. An evolving full list of research questions and ideas sits behind these.

5.1 Nature is in recovery...

1. How are nature's recovery, 'wilding' and 'rewilding' changing biological abundance across different landscapes and what is the consequence of this for their ecological function and the delivery of nature based solutions?
2. How can we best harness and manage natural processes to increase biological abundance, restore biodiversity and provide nature-based solutions?
3. How is current planning policy affecting the natural environment and how should it change to improve protection for nature and support its recovery in the UK?
4. What actions can we take to maximise the effectiveness of ecological networks, in both urban and rural areas?
5. What role are nature reserves and Wildlife Sites playing in nature recovery networks and how can their positive contribution be maximised?
6. How effective are the UK's marine protected areas at protecting marine biodiversity?
7. How can marine biodiversity best be protected in the face of significant offshore development and industrial activity?
8. How can we best harness digital and other emerging technologies to support nature's recovery?
9. How can we best measure and demonstrate the effectiveness of conservation management actions on Wildlife Trust landholdings?
10. How can we best improve and coordinate biodiversity monitoring across the UK?
11. How can we best measure and track the changing condition of specific habitats and natural assets, such as soils?

5.2 Nature is adapting resiliently to climate change...

1. How is climate change driving land use and marine changes across and around the UK, and how will it do so in future?
2. How are our habitats and species responding to climate change on land and sea, and how can we make them more resilient?
3. What is the worst-case future for the UK's wildlife and natural systems under likely climate change scenarios?
4. What are the implications of climate change for the acquisition or allocation of land for nature conservation and nature's recovery?
5. What are the biggest climate change risks to the operations and landholdings of The Wildlife Trusts and how can they be managed most effectively?

5.3 People are taking meaningful action for nature's recovery and a stable climate...

1. How and why do attitudes and approaches to nature and climate action vary across different communities and sectors?
2. What are the most effective ways to inspire and enable more people, organisations and communities to take action for nature?
3. What interventions work best to motivate and enable young people to understand and take action for nature, including through the education system?
4. How can The Wildlife Trusts best measure our own greenhouse gas emissions from our operations and land, and reduce them to net zero?

5.4 Nature is providing valued solutions for society and the economy...

1. What are the most significant risks to the UK and global economy from nature loss and how can they be addressed most effectively?
2. What are the best ways to scale up nature markets across the UK?
3. How can nature-based interventions to promote health and wellbeing best be scaled up?
4. What are the best ways to minimise conflicts between people and wildlife arising from recreational, leisure and wellbeing-related use of natural spaces?
5. How can farmed landscapes become more environmentally and socially sustainable whilst maintaining their economic value and potential?
6. How could we improve our understanding of the costs and benefits of initiatives to restore nature, engage people and deliver nature-based solutions?

6. The research partnerships in this report

Collaboration with partner organisations is a fundamental part of the way The Wildlife Trusts address our evidence needs. We are particularly interested in developing lasting relationships with long-term partners with whom we can develop and deliver meaningful programmes of research to answer the questions that are of greatest importance to us. The sample of projects in this report has been delivered working with the following partners.

The Evidence Emergency Phase 1,
Section 1
- The Conservation Evidence Team, University of Cambridge
- National Biodiversity Network (NBN) Trust

Space4Nature,
Section 4.1
- University of Surrey's Centre for Environment and Sustainability
- Buglife

Seasearch and Shoresearch Surveys for Marine Protected Areas,
Section 4.2
- Natural England
- Joint Nature Conservation Committee
- Cornwall Inshore Fisheries & Conservation Authority
- Marine Conservation Society

River Otter Beaver Trial,
Section 4.3
- University of Exeter
- University of Southampton
- Environment Agency
- Derek Gow Consultancy
- Royal Zoological Society of Scotland
- Clinton Devon Estates

Butterfly Banks,
Section 4.4
- Insect Ecology Group at the Museum of Zoology, University of Cambridge

Forest of Dean Pine Marten Reintroductions,
Section 4.5
- Vincent Wildlife Trust
- Forest Research
- Forestry England
- The Woodland Trust
- University of Gloucestershire

Paleoecology and Nature Conservation,
Section 4.6
- University of Surrey
- University College London

Great Big Nature Survey,
Section 4.7
- University of Edinburgh
- University of Cambridge
- University of Leeds

Health and Nature,
Section 4.8
- University of Essex
- University of Derby
- University College London's Institute of Education
- Leeds Beckett University
- University of Sheffield
- Heriot Watt University
- Ricardo Energy & Environment Consultancy
- The Institute for Occupational Medicine

Care Peat,
Section 4.9
- Manchester Metropolitan University
- National University of Ireland Galway

Peat-Fix,
Section 4.10
- University of Manchester

7. Funding the research & evidence work highlighted in this report

The various data, research and evidence projects included in this review have been funded by (in alphabetical order):

Evolution Education Trust Knowledge-Exchange Studentship, administered by the Cambridge Conservation Initiative (Butterflies in a changing climate)

Forest Holidays (Project Pine Marten)

Garfield Weston Foundation (Space 4 Nature)

A **Harding Distinguished Postgraduate Scholarship** (Butterflies in a changing climate)

EU I**nterreg North-West Europe** (Care Peat)

Innovate UK Knowledge Transfer Programme (Peat-Fix)

Natural Environment Research Council (River Otter Beaver Trial, Improving Wellbeing through Urban Nature)

The players of **People's Postcode Lottery** (Space 4 Nature, Butterfly Banks, Palaeoecology & nature conservation, Children & Nature)

Peter de Haan Charitable Trust (River Otter Beaver Trial)

The Wildlife Trusts' **Strategic Development Fund** (The Evidence Emergency Phase 1 Project, River Otter Beaver Trial, Marine Protected Area surveys, Health & Nature)

The **Tale Valley Trust** (River Otter Beaver Trial)

The **Wellcome Trust** (River Otter Beaver Trial)

The **Woodland Trust** (Project Pine Marten)

Yorkshire Peat Partnership (Peat-Fix)

8. References

[1] Parry, G., Tomlin, P., Fitzmaurice, A. & N. Doar (2022) The Evidence Emergency. Stage one summary report. The Wildlife Trusts, Newark. [available on request from evidence@wildlifetrusts.org]

[2] The Wildlife Trusts (2024) Data, Research & Evidence: The Wildlife Trusts' Framework 2030. A collective framework for data, research & evidence in The Wildlife Trusts. The Wildlife Trusts, Newark. [available on request from evidence@wildlifetrusts.org]

[3] The Wildlife Trusts (2022) Bringing Nature Back. The Wildlife Trusts' Strategy 2030. The Wildlife Trusts, Newark. https://www.wildlifetrusts.org/sites/default/files/2022-04/TheWildlifeTrustsStrategy2030.pdf

[4] Andries, A., Murphy, R.J., Morse, S. & J. Lynch (2021). Earth observation for monitoring, reporting, and verification within Environmental Land Management Policy. *Sustainability* **13(16)**, p. 9105. https://doi.org/10.3390/su13169105

[5] UK Hab. (2024) UK Habitat Classification. Available at: https://ukhab.org/ (Accessed: 26 March 2024).

[6] Andries, A. (2024) Predicted areas of lowland heath habitat in Surrey using Random Forest Regression. Unpublished manuscript, University of Surrey.

[7] Surrey Wildlife Trust (2024) Space4Nature Machine Learning Predictions. Available at: https://storymaps.arcgis.com/collections/a5e54b4f458046ffbde4c0ad2ce0ece2?item=5 (Accessed: 26 March 2024).

[8] Buglife (2024) B-Lines. Available at: https://www.buglife.org.uk/our-work/b-lines/ (Accessed: 26 March 2024).

[9] Ecosystems Knowledge Network (2024) Learning Hubs. Available at: https://ecosystemsknowledge.net/hubs/ (Accessed: 26 March 2024).

[10] Vina-Herbon, C. & B. Stoker (2012) SNCB MCZ Advice Project – Assessing the scientific confidence in the presence and extent of features in recommended Marine Conservation Zones (Technical Protocol E). Version 5.0 https://data.jncc.gov.uk/data/723cec60-558d-43b0-88b5-74f38ea437b0/E-Assessing-scientific-confidence-in-presence-and-extent.pdf

[11] Richardson, L. (2014) Collecting and submitting data to support designation of Marine Conservation Zones (MCZs). Best practice guidelines for data providers. Version 0.7

[12] Gaywood, M., Stringer, A., Blake, D., Hall, J., Hennessy, M., Tree, A., Genney, D., Macdonald, I., Tonhasca, A., Bean, C., McKinnell, J., Cohen, S., Raynor, R., Watkinson, P., Bale, D., Taylor, K., Scott, J. & S. Blyth (2015) *Beavers in Scotland: a report to the Scottish Government*. Scottish Natural Heritage, Inverness. ISBN 978-1-78391-363-3. https://digital.nls.uk/pubs/e-monographs/2015/BeaversinScotlandAreporttoScottishGovernment.pdf

[13] Brazier, R.E., Elliott, M., Andison, E., Auster, R.E., Bridgewater, S., Burgess, P., Chant, J., Graham, H., Knott, E., Puttock, S.K., Sansum, P. & S. Vowles (2020) *River Otter Beaver Trial Science and Evidence Report*. https://www.wildlifetrusts.org/sites/default/files/2020-05/River%20Otter%20Beaver%20Trial%20-%20Science%20and%20Evidence%20Report.pdf

[14] Howe, C. V. & S. E. Crutchley (2020) *The River Otter Beaver Trial: Natural England's assessment of the trial and advice on the future of the beaver population*. Natural England Evidence Review **NEER018**. Peterborough: Natural England. https://publications.naturalengland.org.uk/publication/6537677127286784

[15] Fox, R., Dennis, E.B., Brown, A.F. & J. Curson (2022) A revised Red List of British butterflies. *Insect Conserv. Diver.* **15(5)**:485-495. https://resjournals.onlinelibrary.wiley.com/doi/10.1111/icad.12582

[16] Bladon, A.J., Lewis, M., Bladon, E.K., Buckton, S.J., Corbett, S., Ewing, S.R., Hayes, M.P., Hitchcock, G.E., Knock, R., Lucas, C., McVeigh, A., Menéndez, R., Walker, J.M., Fayle, T.M. & E.C. Turner (2020) How butterflies keep their cool: Physical and ecological traits influence thermoregulatory ability and population trends. *J. Animal Ecol*. **89(11)**:2440-2450. https://doi.org/10.1111/1365-2656.13319

[17] Brereton, T.M., Botham, M.S., Middlebrook, I., Randle, Z., Noble, D., Harris, S., … & D.B. Roy (2018) *United Kingdom Butterfly Monitoring Scheme report for 2017* (p. 24). Centre for Ecology and Hydrology, Butterfly Conservation, British Trust for Ornithology and Joint Nature Conservation Committee. Retrieved from http://www.ukbms.org/reportsandpublications

[18] Hayes, M.P., Ashe-Jepson, E., Hitchcock, G.E., Clark, R., Hellon, J., Knock, R.I., Bladon, A.J. & E.C. Turner (2024) Heatwave predicts a shady future for insects: impacts of an extreme weather event on a chalk grassland in Bedfordshire, UK. J. *Insect Conserv*. https://doi.org/10.1007/s10841-024-00556-5

[19] Langley, P. & D. Yalden (1977) The decline of the rarer carnivores in Great Britain during the nineteenth century. *Mammal Review* **7(3-4)**: 95-116. https://doi.org/10.1111/j.1365-2907.1977.tb00363.x

[20] Sainsbury, K.A., Shore, R.F., Schofield, H., Croose, E., Campbell, R.D. & R.A. McDonald (2019) Recent history, current status, conservation and management of native mammalian carnivore species in Great Britain. *Mammal Review* **49(2)**: 171-188. https://doi.org/10.1111/mam.12150

[21] Shaw, G. & J. Livingstone (1992) The pine marten: its reintroduction and subsequent history in the Galloway Forest Park. *Transactions of the Dumfries and Galloway Natural History and Antiquarian Society*, third Series, **67,** 1-7.

[22] MacPherson, J., Croose, E., Bavin, D., O'Mahony, D., Somper, J. & N. Buttriss (2014) Feasibility assessment for reinforcing pine marten numbers in England and Wales. The Vincent Wildlife Trust, Ledbury. https://www.vwt.org.uk/wp-content/uploads/2015/04/Feasibility-Assessment-for-Reinforcing-Pine-Martens-in-England-and-Wales.pdf

[23] Stringer, A.P., MacPherson, J., Carter, S., Gill, R., Ambrose-Oji, B., Wilson, R., Kelsall, P., Feirn, W.G., Galbraith, L.C., Hilário, C.M., Parry, G. & A. Taylor (2018) The feasibility of reintroducing pine martens (*Martes martes*) to the Forest of Dean and lower Wye Valley. Gloucestershire Wildlife Trust, Gloucester. https://www.gloucestershirewildlifetrust.co.uk/sites/default/files/2022-09/Full%20pine%20marten%20feasibility%20and%20study%20report%20-%20GWT%202022.pdf

[24] Feirn, W. (2018) Pine marten prey abundance in the Forest of Dean. Masters thesis. University of Gloucestershire.

[25] Zalewski, A. & W. Jedrzejewski (2006) Spatial organisation and dynamics of the pine marten *Martes martes* population in Bialovieza Forest (E Poland) compared with other European woodlands. *Ecography*, **29(1)**: 31-43. https://nsojournals.onlinelibrary.wiley.com/doi/epdf/10.1111/j.2005.0906-7590.04313.x

[26] Ambrose-Oji, B., Dunn, M. & M. Atkinson (2018) Pine martens in the Forest of Dean: stakeholder and public attitudes. Forest Research report to the Pine Marten Reintroduction Feasibility Project. Gloucestershire Wildlife Trust, Gloucester. https://cdn.forestresearch.gov.uk/2022/02/pine_marten_fod._social_science._final.pdf

[27] McNicol, C.M., Bavin, D., Bearhop, S., Bridges, J., Croose, E., Gill, R., Goodwin, C.E.D., Lewis, J., MacPherson, J., Padfield, D., Schofield, H., Silk, M.J., Tomlinson, A.J. & R.A. McDonald (2020) Postrelease movement and habitat selection of translocated pine martens *Martes martes*. *Ecol Evol*. **10(11)**: 510-6-5118. https://doi.org/10.1002/ece3.6265

[28] Sheehy, E. & C. Lawton (2014) Population crash in an invasive species following the recovery of a native predator: the case of the American grey squirrel and the European pine marten in Ireland. *Biodivers Conserv* 23, 753-774. https://link.springer.com/article/10.1007/s10531-014-0632-7

[29] Clarke, S. & A. Lynch (2016) Palaeoecology to inform wetland conservation and management: some experiences and prospects. *Marine and Freshwater Research*, **67(6)**: 695-706. Available at: https://doi.org/10.1071/MF15031. Free at https://www.researchgate.net/publication/301719944_Palaeoecology_to_inform_wetland_conservation_and_management_some_experiences_and_prospects

[30] Siggery, B., Bennion, H., Morse, S., Murphy, R. & M. Waite (2023) Practitioner perspectives on the application of palaeoecology in nature conservation. *Frontiers in Ecology and Evolution*, **11**. Available at: https://www.frontiersin.org/articles/10.3389/fevo.2023.1304510 (Accessed: 12 January 2024).

[31] Montana, J., Ferguson, C., Marshall, T., Barrios-O'Neill, D., Bavin, S., Cardinal, I., Crockatt, M. Gent, J., Hafferty, C., Hirons, M., Hughes, J., Janda, E., Maxwell, S., Mailley, J., McDermott, M., Mitchell, M., Owen, R., Rydlewski, J., Sheffield, D., Simms, C., Slessor, J., Veríssimo, D., & K. Wilhelm (2023) *Large-scale social surveys on people and nature relations: Report on the state of the art in the UK*. Oxford: Leverhulme Centre for Nature Recovery, University of Oxford. https://www.naturerecovery.ox.ac.uk/wp-content/uploads/2024/02/LCNR-large-scale-social-surveys-v4.pdf

[32] TCV (2012) Green Gym research summary. The Conservation Volunteers. https://www.tcv.org.uk/wp-content/uploads/2012/04/green-gym-summary.pdf

[33] Bragg, R., Wood, C., Barton, J. & J. Pretty (2015) Wellbeing benefits from natural environments rich in wildlife. The Wildlife Trusts/University of Essex. https://www.wildlifetrusts.org/sites/default/files/2018-05/r1_literature_review_wellbeing_benefits_of_wild_places_lres_0.pdf

[34] Rogerson, M., Barton, J., Bragg, R. & J. Pretty (2017) The health and wellbeing impacts of volunteering with the Wildlife Trusts. The Wildlife Trusts/University of Essex. https://www.wildlifetrusts.org/sites/default/files/2018-05/r3_the_health_and_wellbeing_impacts_of_volunteering_with_the_wildlife_trusts_-_university_of_essex_report_3_0.pdf

[35] Richardson, M., Cormack, A., McRobert, L. and R. Underhill (2016) 30 Days Wild: Development and evaluation of a large-scale nature engagement campaign to improve well-being. PLOS ONE **11(2)**: e0149777. https://doi.org/10.1371/journal.pone.0149777

[36] Richardson, M. and K. McEwan (2018) 30 Days Wild and the relationships between engagement with nature's beauty, nature connectedness and well-being. *Front. Psychol*. **9**:1500. doi: 10.3389/fpsyg.2018.01500 https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2018.01500/full

[37] Richardson, M., McEwan, K. and G. Garip (2018) 30 Days Wild: who benefits most? *Journal of Public Mental Health*, **Vol. 17 No. 3**, pp. 95-104. https://doi.org/10.1108/JPMH-02-2018-0018

[38] The Wildlife Trusts (2020) 30 Days Wild: a Five Year Review. The Wildlife Trusts/The University of Derby. https://www.wildlifetrusts.org/sites/default/files/2020-05/30%20Days%20Wild%205%20YR%20Summary%20Review.pdf

[39] Sheldrake, R., Amos, R. & M.J. Reiss (2019) Children and Nature: A research evaluation for The Wildlife Trusts. University College London Institute of Education and The Wildlife Trusts http://www.wildlifetrusts.org/sites/default/files/2019-11/Children%20and%20Nature%20-%20UCL%20and%20The%20Wildlife%20Trusts%20Full%20Report.pdf

[40] The Evaluator (2019) My Place: An independent review carried out by The Evaluator, for the Wildlife Trust for Lancashire, Manchester and North Merseyside and Lancashire & South Cumbria NHS Foundation Trust. https://www.lancswt.org.uk/sites/default/files/2019-12/An%20Independant%20Evaluation%20Review%20of%20Myplace%20October%202019.pdf

[41] Warwickshire Wildlife Trust (2019) The Environment and Me (TEaM) Project Year 2 report. Warwickshire Wildlife Trust, Coventry. [available on request from evidence@wildlifetrusts.org]

[42] Harvey, C., Holland, F. & R. Furlong (2022) Wild Wellbeing Hub: An evaluation report for Derbyshire Wildlife Trust. Nature Connectedness Research Group, University of Derby. https://repository.derby.ac.uk/item/9y29w/wild-wellbeing-hub-an-evaluation-report-for-derbyshire-wildlife-trust

[43] Sellars, P., Crone, D., Mercer, J. & D. Clayton (2024). Wild Skills, Wild Spaces project - evaluation report. Cardiff Metropolitan University for Montgomeryshire Wildlife Trust. https://doi.org/10.25401/cardiffmet.25003607.v1

[44] Bagnall, A.-M., Freeman, C., Southby, K. & E. Brymer (2019) Social Return on Investment analysis of the health and wellbeing impacts of Wildlife Trust programmes. The Wildlife Trusts/Leeds Beckett University. https://www.wildlifetrusts.org/sites/default/files/2019-09/SROI%20Report%20FINAL%20-%20DIGITAL.pdf

[45] Cameron, R.W.F., Brindley, P., Mears, M., McEwan, K., Ferguson, F., Sheffield, D., Jorgensen, A., Riley, J., Goodrick, J., Ballard, L. & M. Richardson (2020) Where the wild things are! Do urban green spaces with greater avian biodiversity promote more positive emotions in humans? *Urban Ecosystems* **23**:301–317 https://doi.org/10.1007/s11252-020-00929-z

[46] White, M.P., Alcock, I., Grellier, J., Wheeler, B.W., Hartig, T., Warber, S.L., Bone, S., Depledge, M.H. & L.E. Fleming (2019) Spending at least 120 minutes a week in nature is associated with good health and wellbeing. *Sci Rep* **9**, 7730. https://doi.org/10.1038/s41598-019-44097-3

[47] Sendall, J., Leake, A. & H. Cowie (2023) The Wildlife Trusts' Natural Health Services: A rapid economic assessment of The Wildlife Trusts' Natural Health Services. Ricardo Energy & Environment, the Institute for Occupational Medicine and The Wildlife Trusts. https://www.wildlifetrusts.org/sites/default/files/2023-07/23JUN_Health_Report_FINAL%20%281%29.pdf

[48] Evans, C., Artz, R., Moxley, J., Smyth, M.-A., Taylor, E., Archer, N., Burden, A., Williamson, J., Donnelly, D., Thomson, A., Buys, G., Malcolm, H., Wilson, D., Renou-Wilson, F. & J. Potts (2017) *Implementation of an emissions inventory for UK peatlands. A report to the Department for Business, Energy & Industrial Strategy.* Centre for Ecology and Hydrology, Bangor. https://naei.beis.gov.uk/reports/reports?report_id=980

[49] Bain, C.G., Bonn, A., Stoneman, R., Chapman, S., Coupar, A., Evans, M., Gearey, B., Howat, M., Joosten, H., Keenleyside, C., Labadz, J., Lindsay, R., Littlewood, N., Lunt, P., Miller, C.J., Moxey, A., Orr, H., Reed, M., Smith, P., Swales, V., Thompson, D.B.A., Thompson, P.S., Van de Noort, R., Wilson, J.D. & F. Worrall (2011) *IUCN UK Commission of Inquiry on Peatlands*. IUCN UK Peatland Programme, Edinburgh. ISBN 978-0-9570572-1-0 https://www.iucn-uk-peatlandprogramme.org/sites/default/files/IUCN%20UK%20Commission%20of%20Inquiry%20on%20Peatlands%20Full%20Report%20spv%20web_1.pdf

[50] Bain, *et al*. (2011). See endnote 49, above.

[51] Department for Energy Security & Net Zero (2024) *2022 UK greenhouse gas emissions, final figures*. National Statistics. DESNZ, London. https://assets.publishing.service.gov.uk/media/65c0d15863a23d0013c821e9/2022-final-greenhouse-gas-emissions-statistical-release.pdf

[52] UCN UK Peatland Programme (2021) *Peatland addition to the UK GHG inventory adds 3.5% to national emissions*. February 4, 2021. IUCN UK Peatland Programme, Edinburgh. https://www.iucn-uk-peatlandprogramme.org/news/peatland-addition-uk-ghg-inventory-adds-35-national-emissions

[53] Gunther, A., Barthelmes, A., Huth, V., Joosten, H., Jurasinski, G., Koebsch, F. & J. Couwenberg (2020) Prompt rewetting of drained peatlands reduces climate warming despite methane emissions. *Nat Commun* **11**:1644. https://doi.org/10.1038/s41467-020-15499-z

[54] Evans, C.D., Peacock, M., Baird, A.J., Artz, R.R.E, Burden, N., Callagham, N., Chapman, P.J., Cooper, H.M., Coyle, M., Craig, E., Cumming, A., Dixon, S., Gauci, V., Grayson, R.P., Helfter, C., Heppell, C.M., Holden, J., Jones, D.L., Kaduk, J., Levy, P., Matthews, R., McNamara, N.P., Misselbrook, T., Oakley, S., Page, S.E., Rayment, M., Ridley, L.M., Staney, K.M., Williamson, J.L., Worrall, F. & R. Morrison (2021) Overriding water table control on managed peatland greenhouse gas emissions. *Nature* **593**, 548–552. https://doi.org/10.1038/s41586-021-03523-1

[55] Okumah, M., Walker, C., Martin-Ortega, J., Ferré, M., Glenk, K. & P. Novo (2019). *How much does peatland restoration cost? Insights from the UK*. University of Leeds - SRUC Report. https://environment.leeds.ac.uk/downloads/download/57/cost_of_peatland_restoration_in_the_uk

[56] Crouch, T. (2018) *Kinder Scout Sphagnum Trials: 2018 Update Report*. Moors for the Future Report, Edale. https://www.moorsforthefuture.org.uk/__data/assets/pdf_file/0027/93933/MFFP-Kinder-Scout-Sphagnum-Trials-Update-Report-2018.pdf

[57] Promar International (2023) *Farm Business Survey: lowland livestock farming in England – lowland grazing livestock production in England 2022-23*. Department for Environment, Food & Rural Affairs, London. https://www.farmbusinesssurvey.co.uk/regional/reports/FBS-Lowland-Report-2022-23.pdf

[58] Promar International (2023). See Endnote 57, above.

[59] IUCN UK Peatland Programme (2023) UK carbon Price Index. Published online here: https://www.iucn-uk-peatlandprogramme.org/peatland-code/uk-carbon-price-index

[60] Department for Energy Security & Net Zero (2023a) *Guidance: UK ETS: Carbon prices for use in civil penalties, 2024*. Published online; updated 29 November 2023. https://www.gov.uk/government/publications/determinations-of-the-uk-ets-carbon-price/uk-ets-carbon-prices-for-use-in-civil-penalties-2024#:~:text=%2D%20the%20carbon%20price%20for%20the,January%202024%20is%20%C2%A364.90

[61] Department for Energy Security & Net Zero (2023b) *Research & Analysis: Traded carbon values used for modelling purposes, 2023*. Published online; updated 29 November 2023. https://www.gov.uk/government/publications/traded-carbon-values-used-for-modelling-purposes-2023/traded-carbon-values-used-for-modelling-purposes-2023

[62] Doar, N. (2024) *Some economic aspects of peatland restoration*. Data and calculations relating to the economic feasibility of peatland restoration approaches on lowland grazing livestock farms. Internal working note. The Wildlife Trusts, Newark. [available on request from: evidence@wildlifetrusts.org]

[63] Kennedy, J., Johnson, S., Longden, M., Bennion, J., Tzoulas, K., Wright, N., Baker, F., Keightley, A., Caporn, S. & C. Field (2023) *Winmarleigh Carbon Farm case study*. The Wildlife Trust for Lancashire, Manchester & North Merseyside and Manchester Metropolitan University, for the Interreg North West Europe Care Peat Project. https://vb.nweurope.eu/media/21500/care-peat_main_output_carbonfarm_wpi3.pdf

Acknowledgements

The authors would like to thank the following for providing background materials and expert input to earlier drafts of the report and for their various comments on and contributions to its contents as they have developed:

Jane Akerman, IUCN UK Peatland Programme;

Ana Andries, University of Surrey;

Liz Ballard, Sheffield & Rotherham WT;

Lissa Batey, RSWT;

Andrew Bladon, Museum of Zoology, University of Cambridge;

Ross Cameron, University of Sheffield;

Ben Cook, RSWT;

Joan Edwards, RSWT;

Helen Harper, IUCN UK Peatland Programme;

Matt Hayes, Museum of Zoology, University of Cambridge;

Angelika von Heimendahl, RSWT

Dom Higgins, RSWT;

Gwen Hitchcock, Bedfordshire, Cambridgeshire & Northamptonshire WT;

Matt Holden, Devon WT;

Anna Jorgensen, University of Sheffield;

Eleanor Johnston, RSWT;

Jo Kennedy, Wildlife Trust for Lancashire, Manchester & North Merseyside;

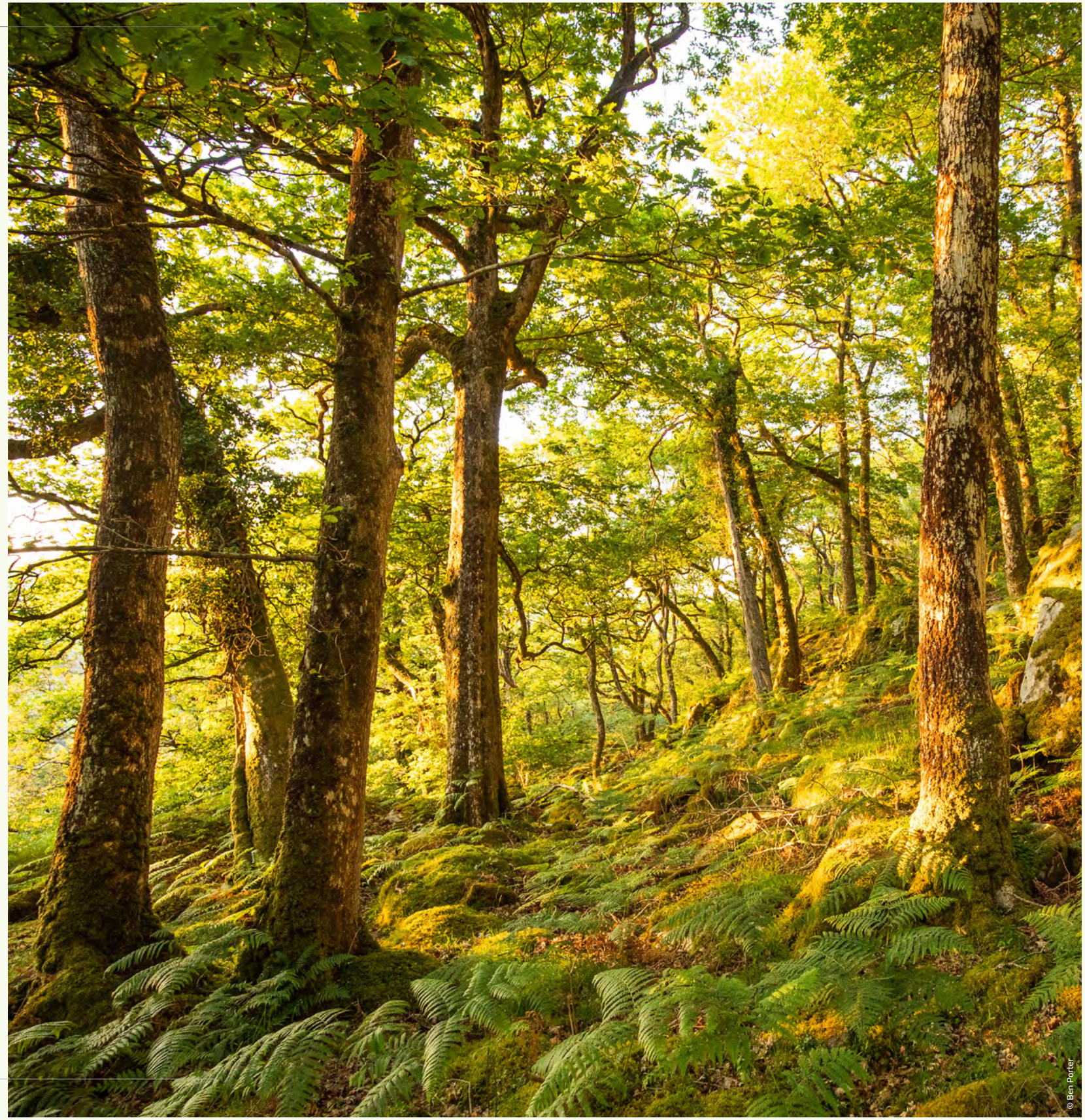
Mike Longden, Wildlife Trust for Lancashire, Manchester & North Merseyside;

Rob Stoneman, RSWT;

Ruth Swetnam, RSWT;

Jessica Williams, IUCN UK Peatland Programme

Further information about anything in this report, or about other aspects of The Wildlife Trusts' collective approach to data, research and evidence, please contact **evidence@wildlifetrusts.org**



© Ben Porter

The Wildlife Trusts
The Kiln
Mather Road
Newark
Nottinghamshire
NG24 1WT

www.wildlifetrusts.org
evidence@wildlifetrusts.org
01636 677711

Follow us

wildlifetrusts
@wildlifetrusts
@thewildlifetrusts
thewildlifetrusts