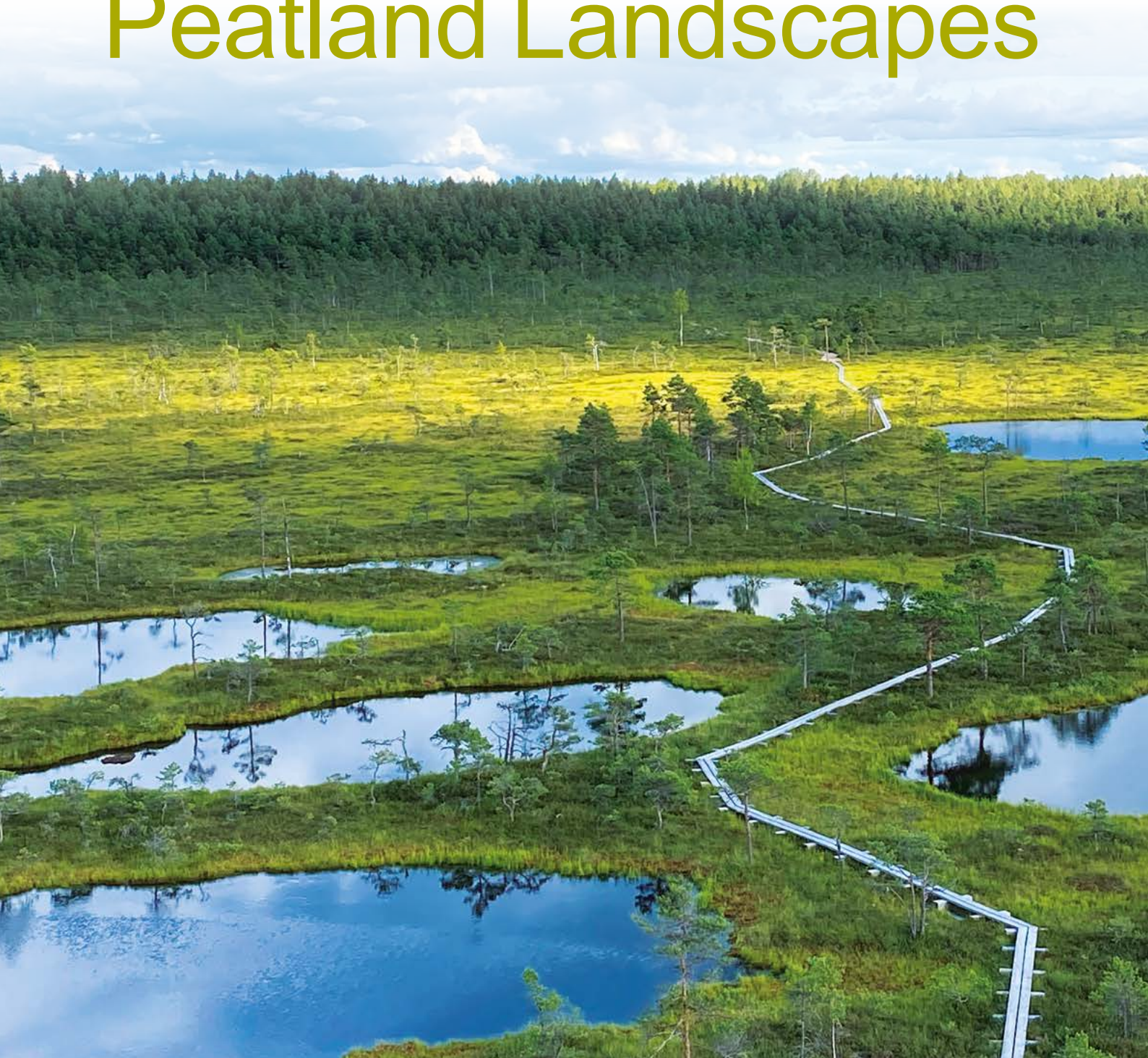
IUCN | National Committee United Kingdom

Peatland Programme

National Trust

Native Trees in Peatland Landscapes



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Native Trees in Peatland Landscapes.
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Cover image: Mukri Bog, Estonia by Martin Hallang

Design by Alan J. Tait

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Summary of key points

Stunted Scots pine in Marimetsa bog, Estonia by Martin Hallang

Native Trees in Peatland Landscapes
Summary of key points

1. Peatlands and native trees are both critical but historically treated in silos

Peatlands and native trees have significant climate, biodiversity, water and heritage value, yet UK policy, restoration practice and conservation culture have tended to treat them separately, creating tensions and missed opportunities.

2. Tree planting or establishment can seriously damage peatlands *when hydrology is compromised*

Afforestation and naturally regenerating trees on drained, degraded peat can lower water tables, accelerate carbon loss and hinder restoration.

3. Native trees *do* have a natural place in many peatland landscapes

Examples include wet or bog woodland, fen carr, slopes or ecotones. This nuance is often lost in policy and land use planning.

4. Peatland restoration requires restoring hydrology *first*

Stable, high water tables are essential for all peatland restoration trajectories. Trees must be considered relative to hydrological recovery, not the other way around.

5. UK statutory frameworks create complexity

Different targets for peatlands and trees, varying definitions of peatlands, designated site requirements and devolved approaches create inconsistent incentives and sometimes contradictory outcomes.

6. Landscape-scale, process-led approaches work best

Examples from across the UK and internationally demonstrate the value of reconnecting peatlands, trees and catchment systems based on natural processes rather than rigid habitat boundaries.

7. The ‘right tree in the right place’ requires evidence and monitoring

Decisions must weigh hydrological condition, natural regeneration versus planting, biodiversity and species-specific risks and trade-offs, landscape context and long-term climate resilience.

8. There are still major evidence gaps

Especially around hydrological impacts of trees at different stages of peatland recovery, and species assemblages and long-term climate resilience in more heterogeneous ‘restored’ mosaics.

This document aims to stimulate discussion and consideration of the role and importance of native trees in peatland landscapes, advocating for a holistic approach to ecosystem restoration which favours context- and site-appropriate habitat mosaics. Although the authorship group largely brings a peatland conservation perspective, the document aims to break down the barriers between those working in 'habitat silos' and discuss how native trees can be integrated into peatland restoration planning to create a more resilient approach to conservation. Where possible, we provide evidence and examples of practical experience whilst acknowledging different approaches and knowledge gaps.

Acknowledgements

This document developed from the National Trust hosted webinar 'Trees and Peat – Interactions in Ecosystem Recovery' and the IUCN UK Peatland Programme Conference workshop 'Native trees, peat and dynamic landscapes'. It was produced jointly by the National Trust and IUCN UK Peatland Programme, with input from the following organisations: South West Peatland Partnership, Forestry and Land Scotland, RSPB, UK Centre for Ecology & Hydrology, Natural England, Defra, DAERA, Natural Resources Wales, NatureScot, University of Exeter, Royal Holloway, University of London, Lancashire Wildlife Trust, Forest Research and Rewilding Britain.

Definitions used

For clarity, the following definitions are used in the document which reflect the authors' intended framing of the terms used:

Peatland

There are a variety of peatland definitions in use across the UK, many of which are based on the depth of peat. For the purposes of this document, peatland is where there is a presence of peat soil of any depth. We include naturally shallower peat soil areas as these often connect different habitat types: they represent an opportunity for supporting unique biodiversity but may be at risk when establishing a balanced dynamic between peat and trees.

Native trees and shrubs

Trees and shrubs which occur naturally in the UK and established after the Last Glacial Period. Typical tree species growing on or around peatland habitats include Scots pine, native willows, alder and downy birch. Typical shrubs include dwarf birch, juniper, mountain willow. Smaller shrub species also occur across these landscapes e.g., native heathers, bog-myrtle, crowberry and cranberry but are largely excluded from discussion in this document.

Trees are woody perennials typically defined by having a single, dominant main stem or trunk and a height often over 3-5 meters, creating a distinct crown. Shrubs, or bushes, are woody perennials characterized by multiple self-supporting stems arising at or near ground level.[1]

Species such as common juniper can function as a small tree in sheltered habitats and reach several metres in height, but is most often characterised as a shrub, particularly in the context of British upland ecology. Conversely, typically large trees such as Scots pine may have limited growth in waterlogged or exposed places: these stunted examples are shrub-like in appearance.

This document focuses largely on native trees whilst acknowledging the related ecological roles and importance of native, habitat-appropriate shrubs.

Woodland

Can be self-sown or planted. This term differentiates the variable and often smaller extent of native trees, generally with more open canopy than commercial forestry plantations. Plantation forestry is discussed in the IUCN UK Peatland Programme's position statement on 'Peatlands and Trees'.

Wet woodland

Woodland that is either subject to almost continuous waterlogged conditions and accumulates peat (including **bog woodland** and **fen carr**) or subject to intermittent floods that restrict the accumulation of organic material (e.g. floodplain forest).[2]

Introduction

Dorback Estate by Mark Hamblin/2020VISION

Nature in decline

Over the past 50 years, the UK has implemented a range of nature conservation measures, including the establishment of protected areas, species recovery programmes, and biodiversity action plans. These efforts have had some success in halting or reversing declines for certain species and habitats, particularly where targeted interventions were well-resourced and sustained. However, the overall picture remains concerning: the UK is now one of the most nature-depleted countries globally, with an average 19% decline in species abundance since 1970 and one in six species at risk of extinction,[3] driven by intensive agriculture, pollution, climate change, and habitat loss or fragmentation.

In 2010 Lawton advocated a fundamental shift in conservation strategy, emphasising the need for effort to go beyond isolated interventions and embrace landscape-scale restoration framed around his principles of more, bigger, better and joined habitats.[4] Progress has been made in some areas, such as the creation of new habitats and landscape-scale projects but overall, the ecological network is not coherent or resilient enough to halt biodiversity decline by enabling species to move or adapt to pressures.

There are diverse views and policies on how to deliver nature conservation, from high-level land use frameworks to farm-level management plans; biodiversity roadmaps to species-specific action plans, and budget-constrained small-scale approaches to large-scale interventions. This diversity of strategies, funding and ideological constraints influences conservation action, driving partnership and landscape-scale working but also at times causing division between those who broadly fall under a ‘pro-conservation’ umbrella.

There are two fundamental things to recognise when considering native trees and peatlands:

1. We have drastically altered tree cover and peatland systems in the UK.
2. Change in these fragmented and degraded habitats is accelerating due to climate change and other pressures.

There is recognition and a growing consensus that we must restore resilient ecosystems, and that this requires a shift towards reestablishing natural processes. For peatlands, this means enabling the hydrological and ecological functions that allow habitats to recover, adapt and persist over time, rather than relying solely on repeated human-led interventions.

The importance of peatlands and trees

Peatlands are among the UK’s most valuable ecosystems, covering around 12% of the land[5] and storing an estimated 3.2 billion tonnes of carbon.[6] They are critical for climate regulation and achieving net zero targets. Healthy peatlands support rare wildlife, regulate water flow, reduce flood risk and filter drinking water. Peatlands also contain important historic and environmental heritage, providing a unique archaeological and palaeoecological record. However, around 80% of UK peatlands are degraded, largely due to drainage for agriculture, managed burning, forestry, and peat extraction.[6,7] This damage turns them from net carbon sinks into net carbon sources, releasing approximately 20 million tonnes of CO_2 annually to the atmosphere,[7] and compromising their wildlife and heritage value. Restoring peatlands is essential for reversing biodiversity loss, mitigating climate change and supporting the multiple services they provide.

Native woodlands and associated woody habitats are similarly vital for biodiversity, with native trees supporting thousands of species: in England, native trees support a fifth of the UK's priority species.[8] They also provide ecosystem services such as carbon sequestration, flood protection, air purification, and soil health. Forests in the UK (including non-native plantations) store around 1 billion tonnes of carbon across trees, soil and deadwood.[9] Native woodlands are central to nature recovery and net zero ambitions, yet UK woodland coverage is amongst the lowest in Europe. Of the UK's extant woodlands, many are in poor ecological condition due to lack of management, invasive species, and climate pressures.[9] Enhancing woodland health and expanding tree cover are key to restoring ecological networks and building climate resilience.

Working towards a more integrated approach

Significant work is ongoing to restore peatland vegetation and the hydrological function of damaged peatlands, and to extend our woodland and tree cover across the UK through both planting and natural expansion. Typically, these initiatives have been thought of in isolation. This binary approach has arisen for three main reasons:

1. Trees and shrubs and the practices involved in establishing them can and do pose a threat to peatlands, particularly their hydrological function and biodiversity.

- Commercial afforestation of peatlands, which involves comprehensive drainage and planting of usually non-native trees has led to severe damage and decline of peatland habitats and species in the UK, including some of our richest and most extensive peatland areas. Ground preparation accelerates degradation and carbon loss from the peat through physical disturbance.[10,11]
- Forestry plantations established upslope of and within peatland catchments have caused diversion and interception of water that should feed the peatland. In many cases forestry activities have also led to significant downwash of sediment into the peatland, causing nutrient enrichment and loss of typical species.
- Where forestry plantations occur on or adjacent to open peatland habitats, 'edge effects' can cause changes in predator populations which have negative impacts on peatland species such as dunlin and European golden plover.[12]
- Establishment of native and non-native trees on a damaged peatland increase water removal from the system through evapotranspiration, lowering the water table and increasing the air-filled pore volume in the rooting zone.[13] Water tables that remain at least 30-40 cm below the peat surface during most of summer are favourable for tree growth on peat, and increasing tree stand volume has been shown to further increase water table depth.[13] Tree establishment on hydrologically compromised peatlands therefore causes further drying and degradation, increasing the risk of catastrophic events such as wildfires that can negate any woodland carbon gains and release large amounts of carbon from the peatland carbon store.[14]

2. There are distinct UK and devolved national targets and legislation for tree cover and peatland condition. Habitat condition assessments are based on specific designated features and can either incentivise tree cover or tree removal on peatlands, depending on the site and the designation. The preservation of designated features may inhibit habitat interventions such as tree planting or peatland re-wetting. Trees have had government agency coordination and supporting regulatory structures in place for almost a century. Peatlands lack centralised coordination of this nature and historically have not been at the forefront of land use decision making as much as trees.

3. The intensity of historic land use on peatlands, and significant modifications due to drainage, grazing, cropping or burning have resulted in simplified landscapes lacking in structural diversity including that provided by native trees and shrubs. Fragmented peatland and woodland habitats often have hard edges without connecting habitat mosaics and adjacent habitat parcels may have conflicting management priorities.

Felled plantation by Peter Cairns/2020VISION

These factors and the need to avoid further damage to degraded peatlands have tended to dominate the narrative on native trees, shrubs and peatlands, with comparatively little attention focused on situations where the intimate associations between them provide rich opportunities for nature recovery and provision of other public benefits.

There is growing recognition of the desirability and need to consider peatland and woody habitat restoration more holistically. If natural ecosystem processes operated throughout the UK, peatlands and woodlands would form dominant interconnected ecosystems across much of the country.

Creating conditions for natural processes to operate across a variety of scales is pivotal to re-establishing natural environmental gradients and biodiversity-rich ecotones: areas where different ecological communities or ecosystems coincide.[15] For peatlands, restoring the hydrological processes which created and sustained the habitat prior to damaging drainage and other modifications is fundamental to effective restoration and the ability to support a naturalistic native tree and shrub component.

Trees and shrubs on peatlands are increasingly being considered at site-specific and landscape scales:

1. As natural components of healthy, functioning peatland systems – encouraging trees and shrubs where they would naturally occur. For example:
    - Not automatically removing native trees when they establish naturally but considering whether they will negatively impact peatland restoration objectives.
    - Planting habitat-appropriate species such as creeping willow or dwarf birch on upland blanket bogs, or willows and alder as carr woodland species associated with fens.
2. As buffering or stabilising features at the edges of peatland habitats. For example, establishing trees and shrubs in valleys that intersect with the edge of a blanket bog plateau where their roots and stems could act to stabilise degrading peatland edges.

It is challenging to think and act more flexibly about trees in peatland landscapes, but understanding their ecology and natural distribution can support informed decisions.

CASE STUDY

Uwch Conwy Project:
Restoring nature and inspiring people

Restoring a landscape, together

The Uwch Conwy Project is a collaborative conservation initiative led by National Trust Cymru and Natural Resources Wales (NRW). Based in Eryri National Park, it aims to restore and enhance the natural environment for the benefit of both people and wildlife.

Focusing on the Afon Conwy catchment, the project has restored degraded peatland in the uplands of Yr Migneint, planted hedgerows and trees across ffridd pastures (the transition between moorland and farmland) and riverbanks, created wildflower meadows, and reinstated natural river processes. Its two main objectives are to improve the condition of nature and increase public involvement in restoration.

Through school programmes, e-bike initiatives, volunteer days, community events, and improved footpaths, the project connects people with their local environment. Supported by NRW and the National Lottery Heritage Fund, it exemplifies effective partnership and community engagement.

A collaborative approach has been key to success. Early, consistent engagement through joint site visits, shared plans, and open dialogue enabled effective decision-making. The partnership between National Trust, Eryri National Park Authority, and RSPB fostered flexible knowledge-sharing and helped overcome challenges around consents, logistics, and restoration in difficult terrain. Strong relationships with farm tenants also led to new land management agreements benefiting both graziers and nature, while community events built understanding and long-term support.

A landscape in balance

The project reconnects upland peatlands, ffridd habitats, and the wider valley landscape. Over 375 km of artificial drains on the peatland of Yr Migneint have been blocked to re-wet the blanket bog - improving carbon storage, reducing sediment, and enhancing water quality in the Afon Conwy.

Peatland re-wetting and dam closing on Y Foel, Migneint in 2024 by Abbie Edwards

CASE STUDY

Local primary school engagement work on how healthy peatlands reduce flooding by Abbie Edwards

"Seeing upland peatlands recover while communities embrace their local landscape is incredibly rewarding. It's about people and nature thriving together - that's what makes Uwch Conwy so special."

Abbie Edwards, Project Officer

Rewetted areas and restored river channels slow water flow, reducing downstream flood risk. Further downslope, restoration of ffridd habitats strengthens habitat connectivity and climate resilience. Over 50,000 trees have been planted, adding surface roughness and creating habitat for species such as curlew, which rely on connected upland and ffridd habitats for nesting and chick foraging.

Access and engagement remain central: nine bridges have been restored in Dyffryn Mymbyr, two new paths created in Cwm Penmachno, and a nature education programme has reached over 40 primary and two secondary schools. More than 100 volunteer days, guided walks, and community events have inspired lasting stewardship.

Challenges and opportunities

Tree planting has been broadly welcomed, though some initial concerns arose within the farming community about land use. Open communication helped clarify where trees are most suitable, and where peat restoration offers greater long-term climate benefits.

Balancing restoration with biodiversity priorities also required care, such as avoiding trees on the plateau to protect nesting curlew from predators. Local land managers leading extensive tree planting across nearby ffridd areas demonstrate how community-led action supports wider landscape goals.

Looking to the future

Since 2015, Uwch Conwy has evolved through multiple phases and funding streams, enabling large-scale habitat restoration and new ways for people to connect with nature. Local engagement has been vital, building trust and shifting perceptions around peatland, wetland, and treed habitats.

Community drop-ins, volunteer sessions, and school and university partnerships have raised awareness of peat's role in climate regulation, water quality, and flood mitigation. Regular dialogue with farmers and land managers continues to foster openness to re-wetting and adaptive grazing, embedding long-term stewardship across the landscape.

Peatland ecology

Abernethy by Mark Hamblin/2020VISION

Where could trees naturally feature in peatland landscapes?

There is evidence of some historic tree cover beneath UK blanket bogs and on lower lying ground or where peat was marginal to other soil types. These tree remains typically represent woodland before human tree removal and climate change allowed expansion of peat some 4-5 thousand years ago. Palaeoecological evidence suggests that wet woodland colonisation was widespread on floodplains after the Last Glacial Period,[16] but these woodlands were almost completely deforested by the Iron Age.[17] Wet woodlands cover less than 1% of the UK land area today, due to long-term drainage and land conversion rather than a lack of suitable habitat.[2]

The UK's relatively recent glacial past has left a mosaic of different soil types in proximity which means woodlands could grow naturally on non-peat soils within peatland landscapes. In the present climate era, woodland cover could naturally occur on hillslopes and stream cloughs associated with thinner peat and mineral soils on bog margins. Indeed, there is some evidence that these naturally wooded slopes helped to support the mass of blanket peat in the uplands.[18,19]

The boundaries, or ecotones, between these habitats can be sharp or gradual, often changing over time in response to underlying hydrological or geological conditions. Ecotones are often species rich[15]: the combination of native trees on and around peat can produce rare habitats supporting many priority or uncommon species.[2]

Past land management has led to the loss of ecotones and their associated habitat connectivity and biodiversity. Land ownership patterns and variation in land management regimes have created hard boundaries in the landscape, such as fence lines and invisible management boundaries drawn on maps.

Wet woodland in winter, Wheatfen by Phil Harbord

CASE STUDY

Integrated blanket mire and temperate rainforest landscapes of Tierra del Fuego

A landscape where trees and peat combine to maximise mutual ecosystem stability and function.

Environmental context

To the south of the dry pampas region, Tierra del Fuego forms the southern tip of South America and is a landscape dominated by forest and mire systems. It lies at the southern hemisphere equivalent of the northern Pennines (54 degrees) and though somewhat cooler because of its proximity to Antarctica, it experiences a relatively mild oceanic climate throughout the year. Regular precipitation in the form of rain, snow and fog amounts to as much as 3,000 mm annually. Climate conditions are thus similar to those giving rise to extensive blanket mire landscapes in the UK, and while the mountains of central Tierra del Fuego resemble the more rugged peaks of the Scottish Highlands with only scattered opportunities for blanket mire formation, the gentler hills and plains of the Mitre Peninsula in eastern Tierra del Fuego offer extensive vistas of blanket mire landscape.

Southern beech and Sphagnum

The most striking difference between the blanket mire landscapes of the UK and Tierra del Fuego is the ubiquitous presence of trees within the landscapes of the latter. Viewed from the wide tracts of open bog, stands of Southern beech (*Nothofagus*) can be seen everywhere, cloaking hill slopes and forming wooded ribbons along stream-courses. Venture into the temperate rainforests of the slope woodlands, however, and the forest floor will be found to consist of peat-forming vegetation, thinner and more sparse on the steepest slopes but becoming more vigorous with deeper peat whenever the slope becomes more gentle, with a concomitant reduction in tree height and density, until upon emerging onto a broad summit plateau the *Nothofagus* scrub gives way to open *Sphagnum*-rich blanket bog.

Summit on the Mitre Peninsula, Tierra del Fuego, where the forest edge meets the blanket mire landscape by Richard Lindsay

CASE STUDY

Tierra del Fuego peatland landscape, with woodland on slopes and following streams by Google Maps

Ecosystem integration provides stability

This integrated landscape of peat bog and temperate rainforest means that there is a seamless transition from one habitat to the other. There is no sharp unstable edge to peat bodies draping plateau summits but instead a gradual transition from open deep peat to increasingly shallow peat as hillslopes become steeper, but all held in place by the presence of the increasingly dense woodland cover. Meanwhile the rainforest ecosystem benefits from the high humidity maintained by the peat-forming forest floor shaded beneath the evergreen *Nothofagus*.

The lost landscapes of the UK represent multiple losses

The precariously small extent of temperate rainforest in the UK means that such stable ecosystem configurations as are found in Tierra del Fuego but also in other parts of the world such as British Columbia, Newfoundland and Kamchatka, are now all but absent from the UK landscape. Integrated blanket mire/rainforest landscapes represent double carbon capture, much increased flood control, anchored, stable peatland margins, as well as supporting the distinctive biodiversity associated with these globally rare environments. Temperate rainforest has been attracting considerable attention in the UK recently, but the case for re-establishment of our lost integrated blanket mire/rainforest landscapes is ultimately even more compelling.

Healthy and naturally 'treed' peatlands

The waterlogged nature of functioning peatlands restricts the growth rate and density of trees, which in turn hinders the ability of trees to dry out the peat or interfere with peat accumulation. Trees will grow on peat where water tables naturally fluctuate (e.g. floodplain/wet woodland such as alder carr) and raised bogs with high and stable water tables can have fen carr woodland around the edge on thinner peat or areas flushed with groundwater.[2] There are also areas where stunted trees grow on the surface of bogs as bog woodland.

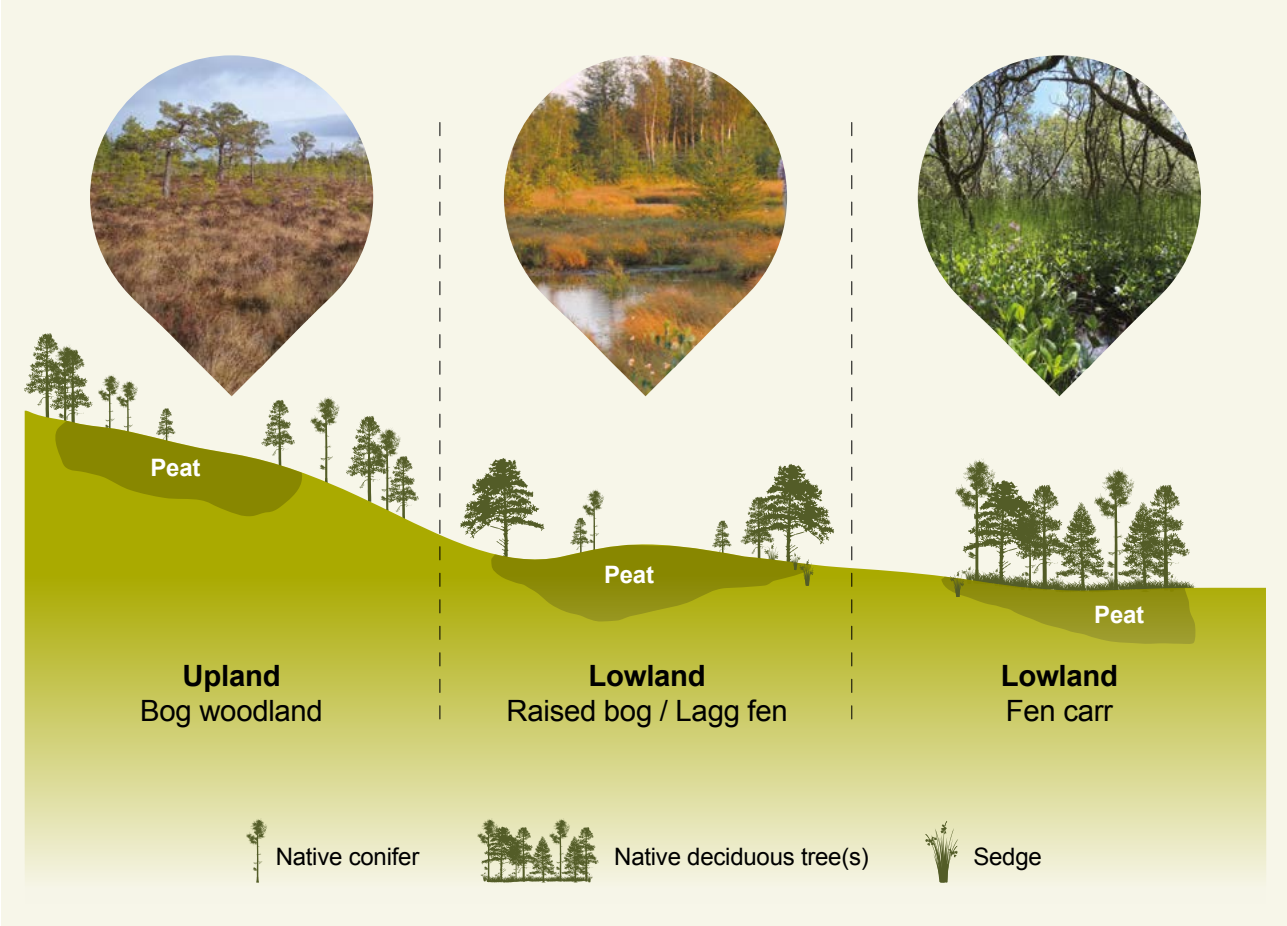


Figure 1. A simplified illustration of where native conifers and deciduous trees would naturally occur on (and around) upland and lowland peatlands.

Bog woodland

Bog woodland (Habitat 91D0, JNCC[20]) has a clear definition under the EU Habitats Directive in terms of tree species and structure: these are generally small non-intrusive groups of trees and shrubs that occur in a relatively stable ecological relationship as open woodland **without the loss of bog species or disruption to peatland hydrology**.

Bog woodlands develop on acidic peat in ombrotrophic (precipitation-fed) peatlands. The dominant tree species - often sparse and stunted due to waterlogged, nutrient-poor conditions - are Scots pine (*Pinus sylvestris*) and downy birch (*Betula pubescens*); less common are broadleaved species such as willow (*Salix* spp.) and alder buckthorn (*Frangula alnus*) that sometimes occur in the peripheral, minerotrophic zones (laggs) surrounding the bog. Standing and fallen dead trees are common. The trees grow over typical open bog vegetation dominated by *Sphagnum* mosses, interspersed with cottongrasses (*Eriophorum* spp.), bilberry (*Vaccinium myrtillus*) and heather (*Calluna vulgaris*).

True bog woodlands are rare in the UK due to habitat loss from drainage, and the habitat is protected as an Annex I habitat under the EU Habitats Directive (91D0 Bog woodland) due to its unfavourable conservation status.[20] Old growth bog woodland in the UK is limited to Scotland, such as sites in Abernethy and Mineral Well in the Cairngorms, and Monadh Mor in the Highlands and Islands. Bog woodlands are more common in other parts of Europe, particularly in Fennoscandia, where the climate is drier and where bogs are less modified and more extensive.

Abernethy bog woodland in Cairngorms, Scotland by Emma Hinchliffe

CASE STUDY

Inshriach pine bog woodland

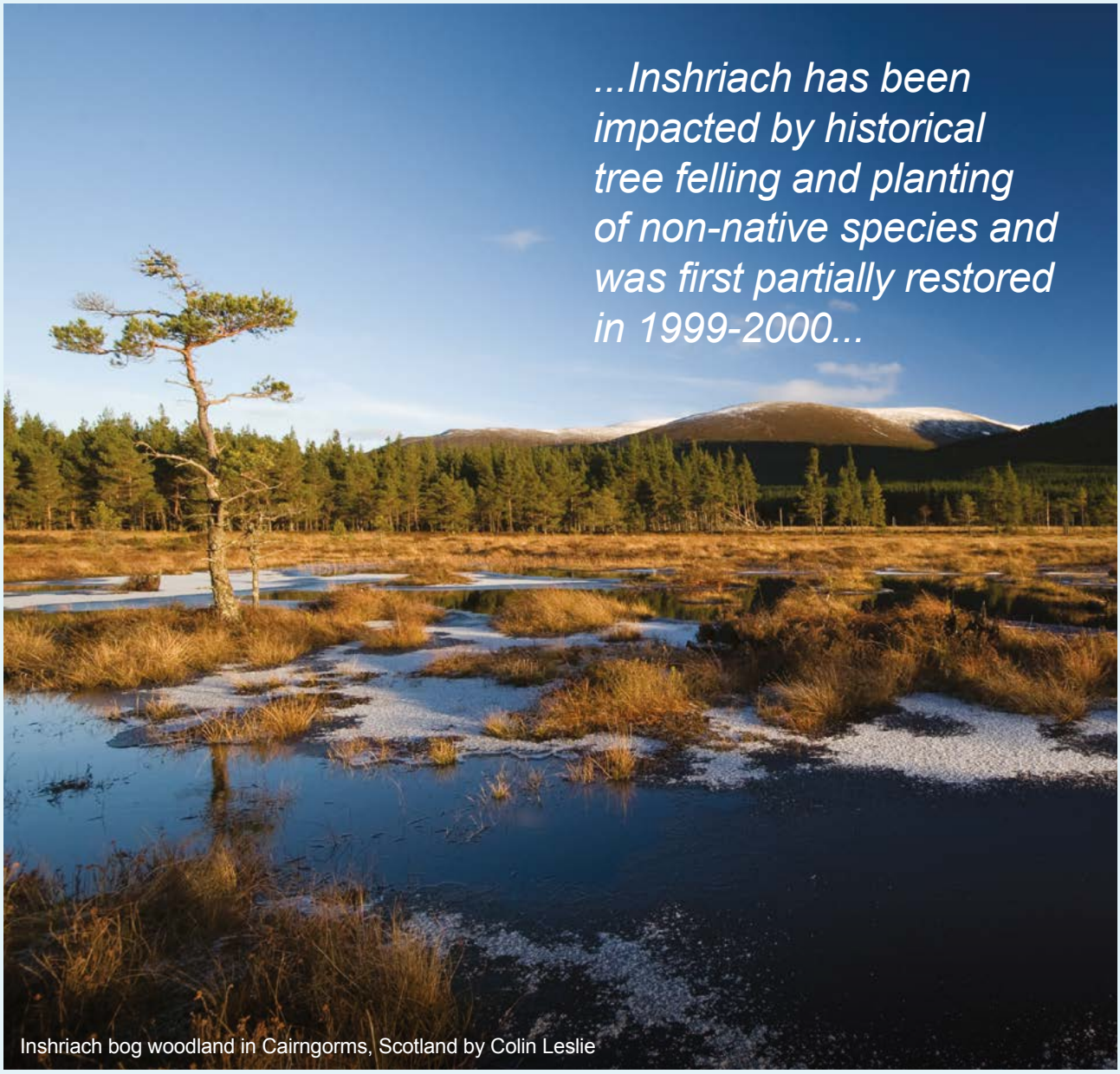
Bog woodland is an important but very rare habitat in Scotland, although it was once more widespread in Cairngorms. At the end of the Last Glacial Period, retreating glaciers moulded the landscape and formed a topography of mounds and hollows. Pine woodland developed on the drier slopes, and bog woodland in the wet hollows between. Bog woodland started to decline in the 16th and 17th centuries when commercial timber extraction saw drainage implemented in many parts of the forest to improve growing conditions for pine plantations and to allow timber extraction down major watercourses.[21]

Today, the Invereshie and Inshriach National Nature Reserve in Cairngorms contains small areas of Scots pine bog woodland where summer drying allows for the growth of tree roots in the upper peat layers. While much of the surrounding forest has been planted, the trees in the bog are remnants of the native Caledonian Forest that once covered this site.

Scots pines in Inshriach bog woodland are widely spaced and severely stunted (<3 m tall) due to the severely restricted volume of rootable, drier soil; the few taller pines are likely over a hundred years old. The site supports diverse wildlife, including ospreys who nest in taller pines towards the centre, benefiting from good all-round visibility. The site attracts numerous dragonflies including the occasional rarity (such as the northern emerald and white-faced darter), and a large population of Scotland's rarest damselfly, the northern damselfly.

Inshriach bog woodland in Cairngorms, Scotland by Helen Harper

CASE STUDY



Inshriach bog woodland in Cairngorms, Scotland by Colin Leslie

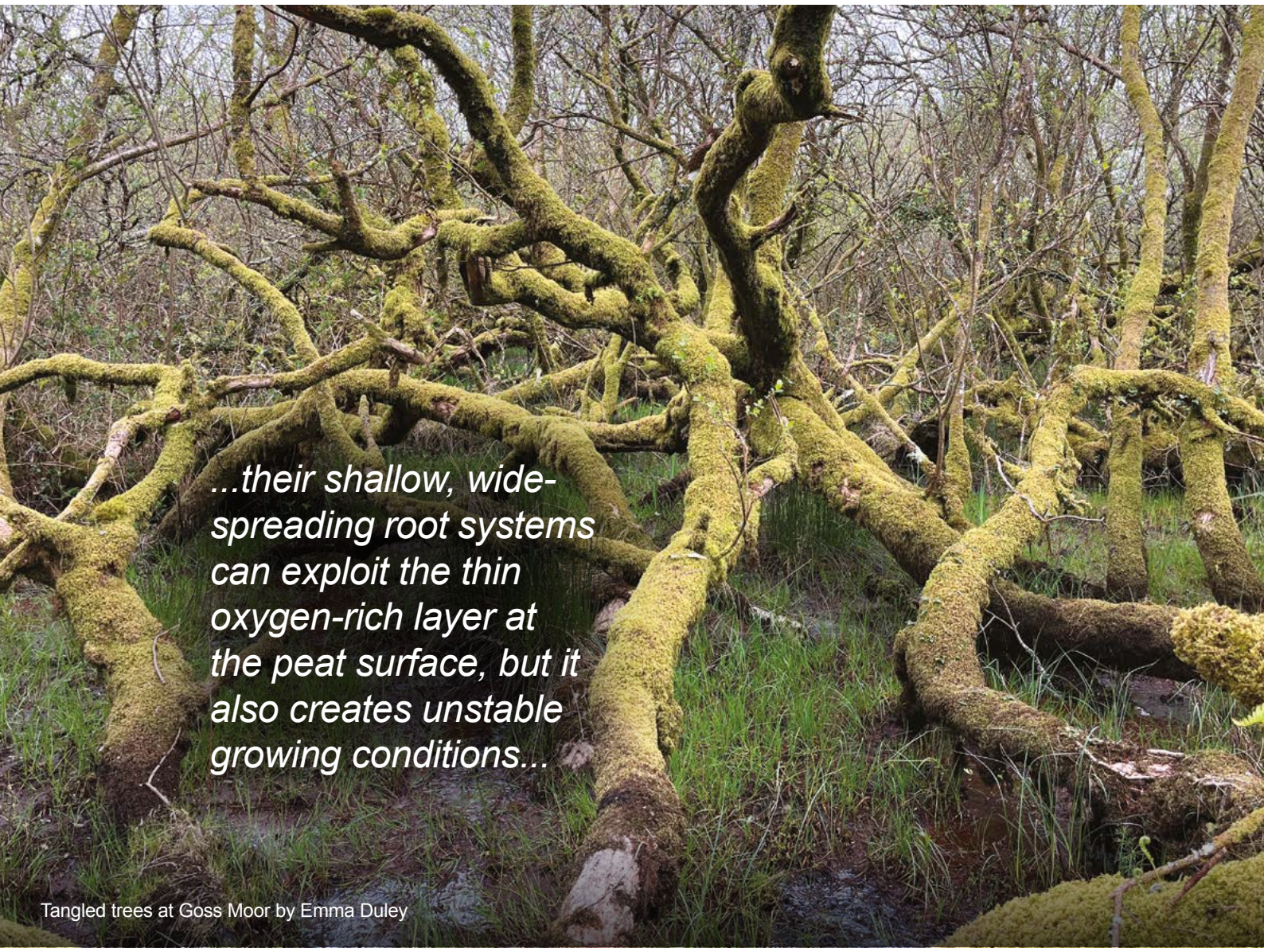
Inshriach has been impacted by historical tree felling and planting of non-native species and was first partially restored in 1999-2000 under the EU LIFE Wet Woods Project, when 52 hectares of the Inshriach forest were restored to forest bog. The restoration project included the removal of non-native trees, as these (particularly lodgepole pine, *Pinus contorta*) can seed onto peat from adjoining land, so a buffer zone beyond the bog edges should be kept free of these. Heavy thinning of planted Scots pine and the blocking of key drains to rewet the area were also undertaken. Most brash was raked and burned, but some heaps were left to encourage invertebrates and as cover for birds and animals. Follow-up work has involved revegetating an area of exposed peat and naturalising the main watercourse through the site.

Fen carr

Temperate broadleaved wet woodlands, or fen carrs, are characterized by seasonally or permanently waterlogged soils fed by mineral-rich groundwater and surface water, which facilitate the rapid accumulation of organic matter and the formation of peat. Fen carrs are usually dominated by willow (*Salix* spp.), alder (*Alnus* spp.), or birch (*Betula* spp.) and appear dense and tangled. Their shaded herbaceous understory consists of rich vegetation of shrubs, brambles, ferns, tall herbs, reeds, sedges, mosses and liverworts interspersed with pools of standing water. The high humidity under the canopy and the abundance of deadwood creates microhabitats for specialist fungi, epiphytic bryophytes, lichen, and a high diversity of invertebrates.

Trees in fen carrs have developed adaptations to allow them to grow in waterlogged conditions, including the formation of pores and channels that help transport oxygen to submerged roots, adventitious roots that emerge above the waterlogged zone, anaerobic metabolisms and the ability to host nitrogen-fixing bacteria. Their shallow, wide-spreading root systems can exploit the thin oxygen-rich layer at the peat surface, but it also creates unstable growing conditions. The trees often lean at odd angles, topple over and re-sprout, which creates a tangle of stems, standing snags and fallen trunks.

Fen carr at Goss Moor in Cornwall, England by Emma Duley



Tangled trees at Goss Moor by Emma Duley

Peat-forming minerotrophic fen carrs have significant potential for carbon sequestration, both in the form of peat and in the biomass of trees; they can also contribute to flood regulation and water quality enhancement.[2] Despite these prospective benefits, the ecological processes and biogeochemical cycles of wet woodlands, along with their biodiversity value, remain under-researched and underappreciated.[2]

Fen carrs are found across the UK, with concentrations in the Norfolk and Suffolk Broads and the West Midlands Meres and Mosses, but also in Loch Lomond National Nature Reserve, Gordon Moss, and the Speyside Way in Scotland. Prior to widespread drainage and woodland clearance for grazing, many valley peatlands would have supported large areas of trees.

CASE STUDY

The Broads wet woodland

An estimated 3,000 hectares of wet woodland can be found in the Broads National Park - Britain's largest protected wetland, covering 303 km^2 in Norfolk and Suffolk. The region is a mosaic of habitats, from open water through reedswamp, open fen and wet woodland (carr). Carr is dominated here by alder and willow species. The trees grow on the permanently waterlogged peat that can be several metres deep, and form dense, low canopy woodlands as well as more open stands.

The shrub-rich understory features guelder rose, buckthorn, dog rose, red- and blackcurrant, large tussock sedges, reeds, mosses, water mint and royal fern. The atmosphere is humid under the canopy, with an abundance of deadwood that hosts fungi, bryophytes, lichen and invertebrates. These woodlands host heronries for breeding colonies of herons, and support marsh tits, treecreepers, Cetti's warblers and otters year-round; blackcaps and chiffchaffs join in summer, siskins and redpolls in winter.

Deadwood is abundant due to frequent tree fall and it contributes to peat accumulation and carbon storage. The undrained, peat-forming wet woodlands in the Broads accumulate peat from leaf litter, understorey debris and from deadwood. This contrasts with bogs where trees might provide some initial scaffolding for Sphagnum but ultimately do not form a significant part of the peatland vegetation nor peat accumulation, which is primarily composed of moss.

Evidence from palaeoecology shows that almost all the fens in this region have valley infill of "brushwood" peat that is rich in wood fragments, which can be several meters thick. The accumulation of this wood peat in the pre-Roman period represents a long phase of wet woodland development where the "natural" vegetation across the Broads was dominated by wet woodland.[22] The wet woodland persisted until saline flooding associated with the Romano-British sea level rise shifted conditions towards salt marsh and deposited estuarine clays, silts and muds. The peat accumulations after this point contain alternating woody, herbaceous and aquatic layers controlled by local hydrological conditions and land-use changes – including medieval peat diggings that eventually created the Broads and widespread drainage and conversion to agriculture.[22]

Wet woodland in winter at Wheatfen in Norfolk by Phil Harbord

CASE STUDY

Dense wet woodland vegetation at Wheatfen by Phil Harbord

The chief threats to wet woodlands in the Broads region are drainage and nutrient enrichment from surrounding farmland, which can replace the rich ground-flora and ultimately lose the 'wet' that makes wet woodlands a valuable part of our landscapes.

Adding complexity, some wet woodlands across the Broads have developed because of recent colonisation of previously open fen, accelerated by drainage and nutrient enrichment.[2] Wet woodland development can therefore be seen as a threat to open fen. Historical ecological records suggest there was a dynamic equilibrium between fen vegetation and woodland, often alternating between the two as water levels changed and gaps opened in the canopy from tree fall or from herbivore activity creating open areas and pools. This relationship is still observable today but with insufficient land available with appropriate hydrological conditions, selective clearance of recently established wet woodland is needed to re-create open fen that would once have been maintained by large herbivores and natural changes in hydrology, to help retain landscape diversity in the Broads.

Brushwood peat, showing wood fragments in a peat core, Broadland, Norfolk by Alice Milner

Statutory frameworks and other guidance

Laxford Mire by Tim Allot

Statutory frameworks and other guidance

Greater understanding of the ecology of trees in peatland landscapes can help inform ecosystem restoration which supports greater connectivity and diversity of habitat mosaics. This approach sits against a backdrop of ambitious national targets, statutory frameworks designed to conserve protected areas or species and help meet these targets, and a wide range of additional guidance which supports the restoration of natural ecosystem function.

In the UK, each nation has established specific targets and initiatives for peatland restoration and woodland creation (Table 1), and much statutory guidance is published at the devolved level. However, greenhouse gas targets and reporting occur at the UK level, alongside additional guidance such as the UK Forestry Standard, creating a complex environment for practitioners to navigate.

The following section summarises the approach in each nation and highlights some of the key guidance available to support decision making in relation to native trees and peatland.

UK forestry guidelines and peat conservation

The UK Forestry Standard (UKFS) is the statutory technical standard for sustainable forest management in the UK, including native woodland and non-native plantation forestry. It states that new forests should not be established on soils with peat exceeding 50 cm in depth (or a depth specified in country guidance) or on sites that would compromise the hydrology of adjacent bog or wetland habitats.[47]

Northern Ireland, Wales and Scotland use the UKFS definition (<50 cm) for new tree planting.[48] Additionally, in Scotland, ploughing to plant trees on peat deeper than 10 cm is prohibited.[49] Forestry Commission Scotland (FCS) proposed “Peatland Edge Woodland” as a management option in 2014 for plantations on deep peat – this option would see afforested deep peat sites being converted to low-density woodland after clear-felling, to allow partial peatland recovery whilst retaining some woodland benefits.[50] This idea has been considered controversial and is not currently a mainstream management option; however, it is still referred to in the FCS guidance.[51]

In England, The Forestry Commission and Natural England have developed a statutory decision support framework to guide landowners and regulators on where to establish trees and where to restore peat. This specifies that woodland creation will not be approved on areas of peat (or soil with organic matter content greater than 30%) greater than 30 cm deep and hydrologically linked to surrounding areas. ‘Low density trees’ may be appropriate with the Forestry Commission’s approval. A decision support framework is also provided to determine whether it is appropriate to replant or naturally regenerate existing woodland after felling on peat.[52]

In 2020, the IUCN UK Peatland Programme (IUCN UK PP) published their position statement on peatlands and trees.[53] This highlights that both native woodlands and peatlands are crucial for climate regulation and biodiversity, and that sustainable management of both ecosystems is essential without compromising one for the other.

While the UKFS, country specific guidance and the IUCN UK PP position statement focus on protecting peatlands from commercial forestry, the Woodland Trust’s position statement on trees and peat, published in 2023, focuses exclusively on the potential role and suitability of open native wooded habitats on peat soils.

The Woodland Trust suggest that, across the UK, suitable native trees and scrub should be recognised as a valuable and often missing component of many peatland landscapes, especially where they complement existing priority habitats and species.[48] While the primary focus for all peat soils should be restoring natural hydrological function and addressing the causes of degradation, native trees and scrub may return naturally where conditions allow or be assisted via tree planting where appropriate.[48]

Table 1. Peatland restoration and woodland creation targets and progress towards delivery targets across the four countries. Note that the targets listed are for all trees, including commercial forestry, unless stated otherwise.

England		
	Peatland	**Woodland**
National target	Restore 280,000 ha by 2050; Restore 40,000 ha by April 2030 supported by Nature for Climate Peatland Grant Scheme.[23]	Increase tree canopy and woodland cover from current level of 14.5% to 16.5% of total land area by 2050, adding around 250,000 ha of tree cover, with an interim target of 34,000 ha added by 2028.[24]
Progress	30,000 ha restored since 2020 under Nature for Climate Peatland Grant Scheme; a further 35,000 ha expected to be delivered through Environmental Land Management scheme under Landscape Recovery.[25] Interim restoration targets are 6,900 ha by 2025, 7,943 ha by 2030, 9,208 hectares by 2035.	England Woodland Creation Offer launched in 2021; future delivery through Environmental Land Management scheme including Sustainable Farming Incentive, Local Nature Recovery, and Landscape Recovery.[26] 2023/24: 5,529 ha of new trees and woodland were planted.[27] In 2024/25: 7,164 ha of new trees and woodland were planted.[28]
Northern Ireland		
	Peatland	**Woodland**
National target	Restore / sustainably manage 150,000 ha by 2050.[29]	9% (124,000 ha) by 2030; 12% by 2050; Woodland Trust recommends 14% by 2050.[30]
Progress	Environment Fund and Peatland Challenge Fund (£3M in 2024)[31]; Nature Recovery Challenge Fund (2025–2028) to offer grants of £50,000+[32]; PEACEPLUS Special EU Programmes Body (2025-2029) to provide investment.[33]	Afforestation rates: 540 ha in 2021/22; 290 ha avg (2018–2022); 3,100 ha/year needed by 2023, 4,100 ha/year by 2039.[30]
Scotland		
	Peatland	**Woodland**
National target	Restore 250,000 ha by 2030 (20,000 ha/year).[34]	Increase from 18.5% to 21% by 2032; 10,000 ha (2018) to 15,000 ha/year (2024/25).[35]
Progress	Peatland ACTION have restored 51,000 ha (2012–2024); over £250M committed by government up to 2030.[36]	Forestry Grant Scheme is main mechanism[37]; 13,111 ha of new woodland approved in 2023 – including 6,456 ha classed as Native species, 497 ha as New natural regeneration, and 4,771 ha as Conifers, which mainly refers to non-native Sitka spruce.[38,39]
Wales		
	Peatland	**Woodland**
National target	45,000 ha in favourable condition by 2050 (1,800 ha/year).[40,41]	Plant 2,000 ha/year (2020–2030).[42]
Progress	National Peatland Action Programme (2020–2025) led by Natural Resources Wales has restored 5,473 ha since 2020.[43-46]	Funded by schemes provided by Welsh Government.[42]

Woodland creation and upland breeding waders

Woodland creation in upland landscapes, including peatlands, needs to consider the presence of breeding waders as a suite of species are sensitive to increased tree cover. Evidence shows that species such as curlew, lapwing and redshank tend to avoid nesting near woodland and may experience reduced breeding success where trees increase predation risk or reduce open habitat.[54]

To support decision-making, Defra, the Forestry Commission and Natural England have produced guidance for England to help inform when surveys may be needed and when woodland creation is likely to be appropriate. This guidance applies to upland farmland and moorland in the north of England and focuses on curlew, lapwing and redshank.

Equivalent formal guidance is not currently available for Northern Ireland, Scotland or Wales, but the same principles, recognising the habitat requirements of open-ground species and assessing potential displacement or predation impacts, should be applied when planning woodland creation in these landscapes.

Other guidance that supports natural ecosystem function

There are several research and monitoring reports written by Natural England that support natural ecosystem function.

Natural England (2016) Research Report NERR064 'A narrative for conserving freshwater and wetland habitats in England'[55] summarises a hierarchical approach to decision-making that is:

1. Landscape-led, natural process-aware
2. Natural process-led, habitat aware
3. Habitat-led, species aware

Natural England (2018a) Research Report NERR071 'Generating more integrated biodiversity objectives – rationale, principles and practice'[56] discusses in more detail the ecological position, function and relationships, current level of natural function, and potential for restoration of natural function for a range of habitats including woodlands, fen and bog habitats and upland habitats.

Lapwing by Pete Quinn

CASE STUDY

Marsden Moor: navigating peat, breeding birds and other barriers to woodland creation

Landscapes for Water, a partnership between the National Trust and Yorkshire Water, is creating 350 ha of native broadleaf woodland and installing 3,500 leaky dams in the South Pennines, much of which lies within SSSI, SPA, and SAC areas. Using the Forestry Commission's Woodland Creation Planning Grant (WCPG), the project follows a structured process to assess biodiversity, geology, soils, climate, landscape, water, historic environment, and stakeholders - ensuring Forestry Commission and Natural England involvement and smoother consenting.

Challenges and opportunities, including lessons learned

The WCPG has two stages: Stage 1 funds a desk-based assessment to identify constraints and opportunities - here focused on biodiversity, historic environment, peat soils, and stakeholders (Table 2).

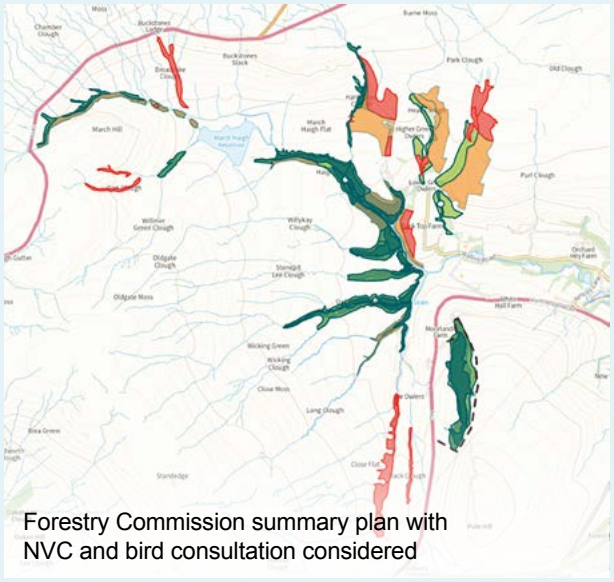
Stage 1 findings highlighted the need for further assessment. In Stage 2, detailed surveys were conducted for peat depth, breeding birds, and habitats. Peat depth was measured on a 50x50 m grid (WCPG methodology). Woodland planting was excluded from areas with peat >30 cm to avoid hydrological impacts. Planting density decreased upslope to prevent colonisation of deeper peat.

Breeding bird surveys were conducted (WCPG methodology), as well as bespoke twite surveys at sites known to be important for this red listed species. Planting plans were adjusted based on impact level: major impact sites were reconsidered; moderate sites redesigned; minor impact sites proceeded. Areas important for twite were excluded from planting.

Table 2. Constraints and opportunities affecting the proposed planting.

Topic	Constraint	Opportunity
Biodiversity	Potential impact on blanket bog, European dry heath and grassland fungi habitats, and protected bird species, particularly curlew, golden plover and twite.	Protect and enhance existing habitats and connectivity, creating wildlife corridors between woodland blocks on the Yorkshire Water estate.
Historic Environment	Potential impact on archaeological features from the Mesolithic period (c. 4000-8000 BC).	Include archaeologically relevant species identified within the pollen record.
Soil	Avoid tree planting within 100 m of peat over 30 cm deep unless approved by the Forestry Commission.	Tree planting, combined with reduced grazing pressures may reduce peatland and soil erosion on steep cloughs.
Stakeholders	Stakeholder concerns about changing land use to woodland, including potential loss of grazing. The need to consult multiple parties adds complexity and may slow the project.	The climate emergency and flood alleviation potential unite stakeholders in support of the project.

CASE STUDY



Forestry Commission summary plan with NVC and bird consultation considered

Marsden Infants & Junior School planting on Pule Hill, West Yorkshire by Nick Singleton

Habitat, vegetation and grassland fungi surveys identified areas of impact (e.g., Blanket Bog, Dry Heath). Woodland plans were reduced to avoid these areas. Natural England input refined designs; for example, omitting heather-rich areas at Deanhead Reservoir and adding scrub patches to boost structural diversity.

Key successes and future ambitions

Partnership working at landscape scale led to planting 65,000 trees on Marsden Moor. Community involvement included 300 volunteers - school children, locals, Scouts, and asylum seeker groups - who planted 3,600 trees and *Sphagnum* mosses. The National Trust and Yorkshire Water provided school assemblies to explain tree importance. Collaboration with Colne Valley Tree Society volunteers supported community sessions, additional planting, bracken clearance, and fire recovery.

Tree planting on Marsden Moor, West Yorkshire by Paul Harris

The Government funding we can provide to all landowners across North and West Yorkshire is helping to plant trees where they are needed the most. Trees and woodland are vital for our environment, biodiversity, economy, industry, and the health and wellbeing of our communities. Trees give us oxygen, store carbon, stabilise the soil and provide essential habitats for wildlife. New woodland carefully placed in a rural river valley will, over time, help reduce flooding in the towns and cities further downstream."

Guy Thompson, Programme Director for the White Rose Forest

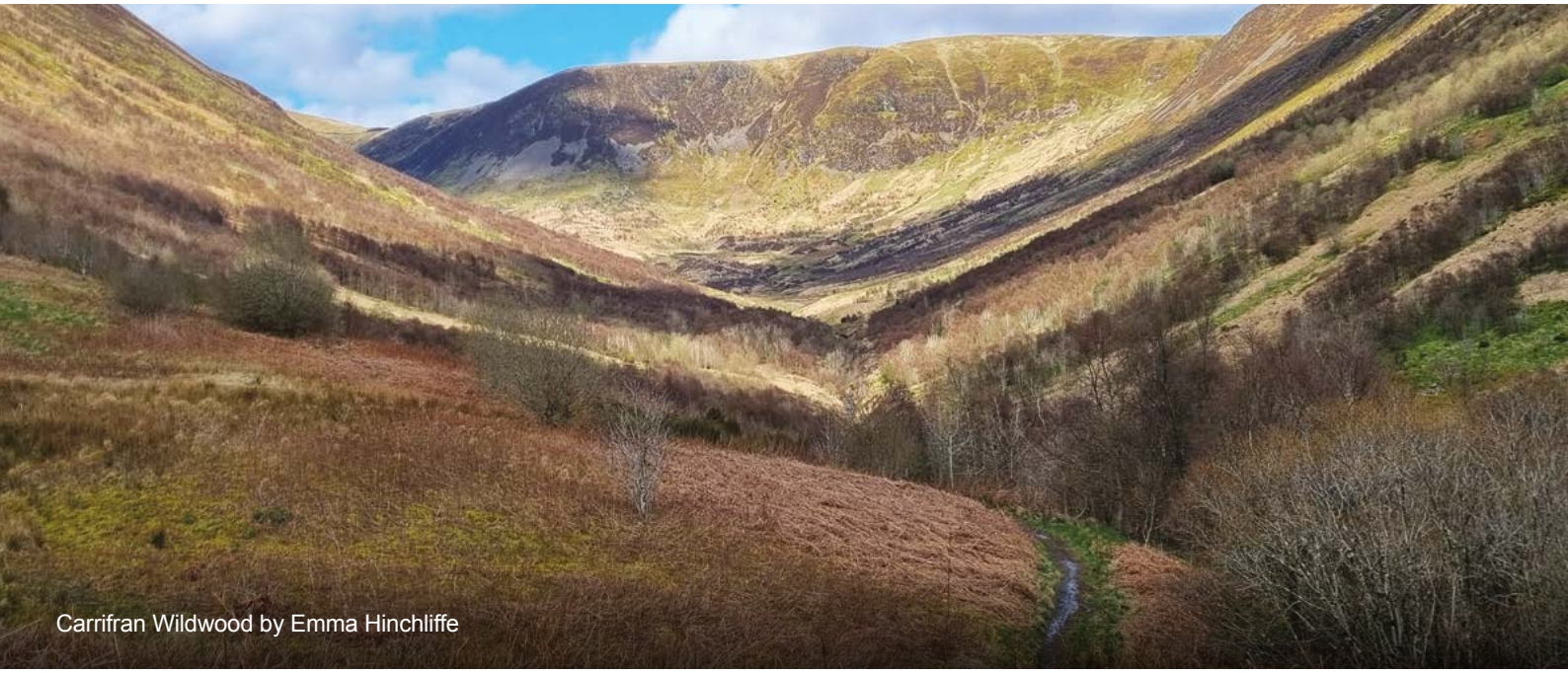
Voluntary carbon finance standards

The Peatland Code and Woodland Carbon Code are UK-based standards that support and ensure the integrity of land-based carbon crediting projects for peatland restoration and woodland expansion. The Peatland Code recognises that the removal of commercially planted trees is an important peatland restoration opportunity, but plantation forest to bog restoration projects are currently not eligible, as there is a need for reliable estimates of carbon impacts before it can be formally included in the scheme. The Woodland Carbon Code currently allows planting of trees on shallow peat (<50 cm; <30 cm in England).

Whilst individual projects are usually certified under one code, some landowners may manage multiple projects across their landholdings, some of which may fall under the Woodland Carbon Code and others under the Peatland Code. One such location is the Talla, Gameshope and Carrifran site in Scotland that combines native woodland planting with peatland restoration at a landscape scale.

However, the implementation of both codes in the context of current policy could reinforce the divide between “trees” and “peat.” Hard boundaries can introduce significant risks: densely planted woodland species right up to the edge of damaged or recovering peatlands can negatively affect those peatlands in ways that are uncertain in scale. The magnitude of this risk depends on factors such as the water table height of the peatland, condition of surface vegetation, additional environmental stressors (e.g., high atmospheric pollution), and the likelihood and speed of tree dispersal onto the damaged peatland.

Although the two schemes can work together to enable landscape-scale action, existing woodland creation policy and guidance, along with the peat definitions used across the four nations (where soils deeper than 50 cm qualify as peat and anything shallower does not), can result in missed opportunities to work with natural processes and recreate important habitat mosaics and ecotones.



Carrifran Wildwood by Emma Hinchliffe

What do statutory nature conservation and heritage bodies need to know to be able to consent proposals for new or innovative interventions, techniques or trials for native trees adjacent to peatlands?

Several factors are important in the decision-making process by statutory agencies when considering tree planting or establishment in peatland landscapes, which demonstrate the proposal has been carefully thought through and forms part of an overall vision for the site. For advice on proposals involving innovative peatland restoration techniques on statutory sites, see Section 4.

1. Baseline site data on peat depth, peat condition, and the temporal variability in water table if available, and historic environment

This will allow statutory bodies, who might not have a detailed understanding of the site, to understand its extent, depth, condition and features.

2. Vision and management plan for the site

This will allow advisors, who might not have a detailed understanding of the site, to understand what your objectives are for the site as a whole and how the approach you are requesting contributes towards these site objectives.

3. Include a completed Habitats Regulation Assessment

If your site is designated as a SAC, SPA or RAMSAR site, include a completed Habitats Regulation Assessment. If your site is an ASSI or SSSI, include an assessment of the impacts on the features of the ASSI/SSSI. This will demonstrate that you have considered any risks from your proposed approach.

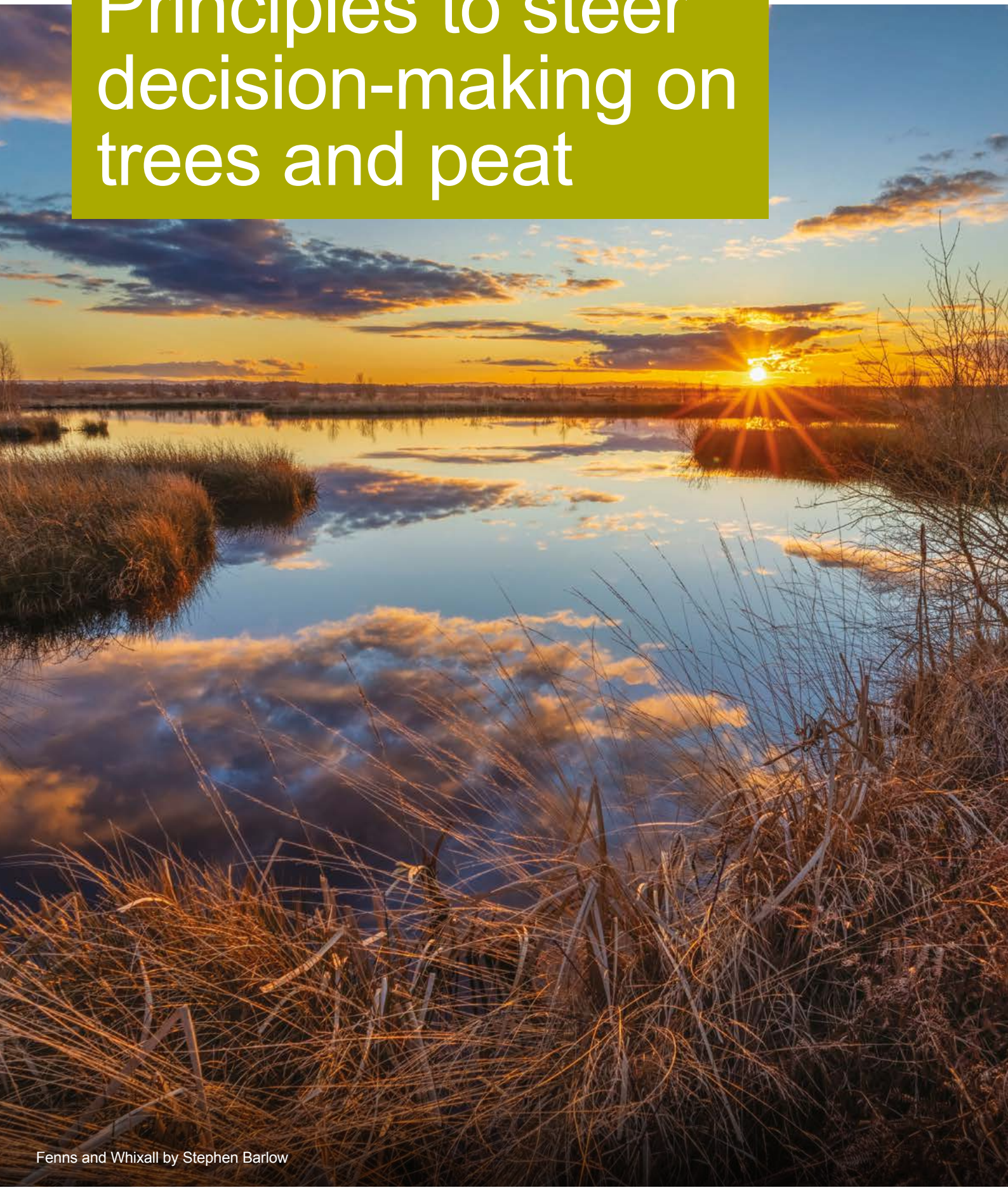
4. Demonstrate that historic environment features and palaeoenvironmental remains are not affected

Always seek to avoid or minimise damage to historic environment features and peat deposits. See Peatlands and the Historic Environment: Guidance for Carrying out Peat Restoration and Guidance for Peatland Restoration and the Historic Environment in Scotland. In Northern Ireland proposals should be aligned with the Historic Environment Division guidance on Peatland Restoration and may include peatland-specific Heritage Impact Assessment. For guidance contact Scheduling@communities-ni.gov.uk. There is currently no equivalent guidance for Wales.

5. Include plans to manage risk, monitor impact and include an exit plan

Include a plan for how you will minimise or mitigate any risks interventions pose; demonstrate how you will implement monitoring to track impact and what you will do if mitigation measures are not effective, e.g., could the technique/intervention be reversed or removed if it doesn't have the desired effect? Explain what controls are in place to mitigate additional risks such as grazing pressure or the existing presence of trees within the seed risk zone of areas where trees are undesirable, or the trees are non-native.

Principles to steer decision-making on trees and peat



Fenns and Whixall by Stephen Barlow

Principles to steer decision-making on trees and peat

When considering native trees and shrubs during peatland restoration, there are several core principles that can help guide decision-making:

Think long-term: consider the past and the future

When degraded peatlands are under restoration, reduction of carbon emissions to the atmosphere[57], increased water storage[58] and increasing diversity of a range of peatland species[59] ('desirable' and 'undesirable') can occur rapidly, but trajectories of change towards resilient ecohydrological function operate at decadal timescales or longer.[58,59,60]

When considering if and how we apply habitat restoration interventions with the aim of restoring natural processes, it is essential to reflect on the historical context of each site and recognise that today's practitioners may not live to see the desired long-term outcomes. This long-term thinking is critical to guide decision-making which is realistic about likely short-term outcomes while facilitating longer-term trajectories of positive change.

Using palaeoecology (the study of biological remains such as tree pollen preserved in peat) can inform our understanding of where trees, shrubs and peat coexisted in the past, and the conditions associated with this.[61] Archaeological records also indicate how humans have shaped landscapes over time. Whilst it may not be appropriate or possible to recreate such past environments due to changes in climate or land use, this evidence can inform our understanding of natural habitat mosaics and the role of trees, shrubs and people in peatland landscapes. Palaeoenvironmental and archaeological insight is also a powerful tool for communicating how landscapes change over time.

Future climate change may alter the hydrology, species composition and disturbance regimes (e.g., drought and water table fluctuations) of peatland habitats. Decisions involving native trees and shrubs should therefore be made with an understanding of how climate pressures, such as drought, extreme rainfall and fire risk, may affect peatland recovery and long-term ecosystem function.

Peatlands differ in their sensitivity and adaptive capacity. In some locations, native trees and shrubs may help buffer climate pressures by stabilising peat surfaces, increasing humidity or supporting diversity, while in others, they may intensify water stress or competition, particularly where hydrology remains compromised. Assessing future risks and benefits is therefore important when deciding whether woody vegetation has a role in a peatland's restoration trajectory.

This requires consideration of the site's past and present hydrological conditions and its likely future climate pressures, whether projected climate scenarios may alter peat-forming conditions, that some interventions may need to be adaptive over time, and that an evidence-led, precautionary approach may be needed where uncertainty is high. This will help to ensure that peatlands are restored in ways that support long-term climate resilience.

CASE STUDY

Applying palaeoecology to restore peat with wet woodland at Alderman's Barrow Allotment, Exmoor

Alderman's Barrow Allotment is a 67-ha site on the National Trust Holnicote Estate, Somerset. Located at the top of the Horner Water catchment, peatland is associated with the waterway and extends across the gently sloping combe bottom. Hydrological restoration was required to recover the water level in the valley mire and promote more natural function. During winter 2022/23, the South West Peatland Partnership (SWPP) carried out peatland restoration interventions that included the creation of over 500 blocks in erosion channels and gullies, the installation of 6 culverts and over 4 ha of tree planting in the valley. Work was funded through Natural England's Nature for Climate Peatland Grant Scheme (NCPGS), South West Water and the National Trust.

Peatland 'time capsule' discovered

The SWPP employs in-house Historic Environment Officers to help protect peatland archaeological monuments during works and carry out further research into palaeoecology, previous land use and previously undiscovered features. Investigations carried out as part of the planning and feasibility stage of works helped inform the peatland restoration design and woodland creation. Peat cores taken to depths of 1.5 – 2 m revealed woodland and insect remains dating between the Neolithic and Bronze Age (3,500 to 6,000 years ago). This 'time capsule' revealed the presence of historic woodland in the, at the time, treeless site and recorded species that would have lived there – many still present in similar wet woodland areas today. The prehistoric woodland floor composed of fragments of trunks and branches revealed the presence of alder and willow onsite and birch and oak in the wider area 3,500 - 4,500 years ago. Plant remains indicated sedges and rushes grew within this wet woodland habitat.

Remains of Bronze Age woodland revealed during archaeological work by Sander Aerts, Wessex Archaeology

CASE STUDY

Willow and alder stems planted into enclosure on restoration site by South West Peatland Partnership

We're really excited about these findings. It's great to think that the discovery of the prehistoric insect and woodland remains provides an opportunity to understand the vegetation and the natural processes which helped establish this thriving wet, peaty environment many thousands of years ago. Crucially, all this information will help inform how we manage the landscape now and in the future. During this phase of restoration work we have created larger areas of wetland pools with woody dams and added woody species back into the environment."

National Trust Area Ranger

Historic record informed a restoration scheme that delivered multiple benefits

Full-scale hydrological restoration – a raised and stable water table creating the conditions for peat-forming sphagnum mosses to colonise - is the primary focus of SWPP's restoration work. To make works holistic and positive for wildlife, the historic environment and local land users, restoration plans are informed by consultation with relevant local parties, and research findings. Drains were blocked and leaky log dams installed to raise and slow the flow of water. The woody remains found further validated the reintroduction of stems of willow and alder into the landscape. The addition of small areas of deer-fenced woodland on the slopes of the combe helped maximise the carbon and water regulation benefits of the scheme, trap sediment runoff and stabilise eroding edges of the peat whilst adding important structural and habitat diversity. Rewetting the peatlands and reducing erosion of the carbon-rich peat helps ensure the valuable palaeoenvironmental record will be preserved, and added to, into the future.

Long term views and looking to the future

The discoveries provide a unique and tangible way of connecting with Exmoor's past and illustrate the changing nature of the landscape over time, helping take a long-term view about future land management and land cover changes. Monitoring the vegetation, water levels and local species will track the restoration's impact.

Remove pressures and restore peatland hydrology as a preparatory action

The aim of peatland restoration is to reinstate peatland ecosystem function, i.e., facilitate the return of the natural processes which enabled peat formation in the first place, and its wider natural hydrological and ecological function. This may include seeking to restore natural watercourse and outflow channels running between peat masses. Functioning or 'active' peatlands are defined by waterlogged conditions controlled by hydrological processes that retain a high and stable water table, allowing peat-forming vegetation to dominate. Damaged peatlands are characterised by altered hydrology which typically results in drier conditions, in turn leading to the reduction or loss of peat-forming vegetation.

Tree and shrub colonisation can impinge on restoration of hydrologically compromised sites by lowering the water table through increased transpiration and rainfall interception, potentially creating a positive feedback loop that encourages further colonisation and drying of the surface of the peat.[62] Therefore, **as a general principle, hydrology should be corrected before trees are actively introduced or managed on a recovering peatland site**. This is not a black and white prescription; in some cases, young trees or shrubs might help to stabilise degraded peat and hold moisture close to the soil surface. Site-specific judgement should balance known risks and uncertainties.

Full ecological restoration of damaged peatlands is dependent on removing or mitigating the pressures which caused the damage, then stabilising the peatland by preventing water loss, preventing penetration of air into the peat and reestablishing peat-forming vegetation.[63] Unless damaging pressures such as high grazing levels or burning are removed and hydrology is properly restored, the functional capacity of the peatland will remain compromised, and any efforts to introduce or control native tree or shrub establishment will be impacted by sub-optimal hydrological regimes. Where sites are severely damaged and degraded, restoration may require a multi-phase approach or rewetting may not be fully successful.

Pressures such as overgrazing, pollution and proximity to plantation forestry can prevent both peatland restoration and tree and shrub regeneration or planting success. Understanding and mitigating unwanted impacts of wild herbivores and livestock is essential to support the re-establishment of natural processes.

Restoration at Blackpitts, Exmoor by Exmoor National Park Authority

There is no ‘one size fits all’

Peatlands are exceptionally diverse ecosystems, with hydrological processes that operate at multiple temporal and spatial scales creating a wide range of peatland habitat types which are functionally connected to other peatlands and non-peatland habitats. The range of damaging pressures is equally diverse, and damaged peatlands are often part of a wider landscape of unsustainable land management practices and urbanisation.

When considering the role of trees in peatland restoration and ongoing sustainable management, it is critical to consider each site individually and holistically, developing a detailed understanding of past and present impacts and the geography, hydrology and ecology of the site within the wider landscape including opportunities for establishing native tree and shrub cover in situations where they may have been lost. The raised bog at Little Woolden Moss subject to commercial peat extraction required very different interventions to the pine bog woodland at Inshriach impacted by plantation forestry. Decision-making based on the principles outlined here must always be place-based and informed by the best possible understanding of each individual site.

There is a spectrum of approaches that can be taken for dealing with the degraded landscapes that we have and the dichotomy of trees and peat: from full blown ‘rewilding’ to closely managed ‘gardening’ approaches where every action and outcome is deliberate and human controlled. The management of native trees and peatlands will exist along this spectrum, and we are not advocating for one approach or the other. The conditions that exist at each site as well as access, resources and knowledge limitations will mean that a variety of levels of intervention will be desirable.

The right tree (or shrub) in the right place

Mosaics of different peatland habitats and native trees and shrubs can enhance the structural complexity of landscapes, increasing their resilience to environmental perturbations and supporting greater biodiversity at multiple scales. However, extensive tree and shrub cover can benefit generalist or non-peatland species to the detriment of peatland specialists, especially those with poor dispersal ability which require connectivity of open habitats.[64] This is especially important when considering planting contiguous areas of native trees or shrubs.

When considering habitat restoration at landscape scale over decadal timeframes, trees and peat may form part of a shifting balance towards a resilient equilibrium adapted to prevailing environmental conditions. Natural establishment of trees and shrubs will occur during restoration trajectories towards ecohydrological stability. Effective hydrological interventions which achieve a high and stable water table are critical to limit the growth of this vegetation and prevent it from drying out the recovering peat and this should be carefully monitored to inform whether removing this vegetation is the best course of action.

Decisions regarding whether to allow or support natural regeneration or engage in active planting must be based on an understanding of habitat-appropriate species and evidenced assessments of the positive impacts of native trees and shrubs versus risks to ecohydrological restoration and peatland biodiversity.

CASE STUDY

Little Woolden Moss: Challenges of scrub control on a lowland raised bog damaged by peat extraction practices

Little Woolden Moss is a 115-ha site close to the centre of Irlam, Greater Manchester that has a long history of industrial-scale peat extraction. Formed at the end of the Last Glacial Period, this is a fragment of the Chat Moss peat mass, which was once one of the largest raised bogs in England. Today, the majority of that 20 km^2 of peat is under agriculture.

The land was purchased by Lancashire Wildlife Trust in 2012, and restoration work on the eastern half of the site commenced, including the creation of peat bunds and a large-scale programme of revegetation. The peat extraction license expired in 2017, and all extraction practices ceased a year later, when work to restore the rest of the site began.

Little Woolden Moss is a site that was described as 'unrestorable' due to the degraded peat, shallow peat depth – reduced to 50 cm in places – and complete loss of vegetation. However, ten years on, the water table is stable across large parts of the site and Sphagnum and cotton grasses have re-established. Despite this progress, the presence of scrub remains a major issue that will need long-term investment to control.

The degraded nature of the peat has resulted in it taking longer to stabilise site hydrology, allowing trees and scrub to gain a foothold across large areas of the landscape, despite management. On neighbouring Cadishead Moss, where peat extraction was less intensive and cut by hand, the peat depth and quality are significantly greater, resulting in faster stabilisation of water levels across the site and reducing scrub encroachment.

Little Woolden Moss before rewetting by Lancashire Wildlife Trust

CASE STUDY

Little Woolden Moss in 2024 by Lancashire Wildlife Trust

The presence and management of trees is supported as part of the restoration trajectory of Little Woolden Moss due to its proximity to the M62 motorway: it is hoped that nitrogen deposition from vehicle emissions will be buffered by the presence of trees. Bog oaks continue to be found preserved in the peat, suggesting that trees have historically been a part of the landscape.

Little Woolden Moss boasts a wide range of raptors, including marsh harrier, hobby, buzzard, and kestrel, for which trees are an important feature. Ospreys continue to spread their range across the UK and, should we ever want to see these birds breeding at Little Woolden Moss, trees would have to be present. Stewardship regulations, which restrict tree cover on lowland raised bog to 10%, place pressure on staff and funds to meet this strict criterion.

> *"Wet woodlands would have played an important part of the mossland mosaic in Chat Moss, both in terms of hydrological buffer and biodiversity. Having them on site in small, controlled numbers will help to restore this landscape mosaic and in the long term provide key shelter for species such as the white-faced darter dragonfly and important corridors for species including willow tits."*

Mike Longden, Peat Programme Technical Lead

Apply evidence and monitoring

A clear, well-informed and well-defined vision, supported by a management plan which outlines the steps towards achieving that vision, are essential. Baseline data which evidence the history of sites and their condition are essential for proper site characterisation, planning interventions and understanding impacts. This approach will support funding applications; help navigate consent on designated sites; help to address existing knowledge gaps and identify research priorities.

The management plan must include how interventions will be monitored, as well as identifying opportunities for collaboration with research organisations to maximise and prioritise the data collected.

A significant challenge in understanding the impacts of different interventions is the relative newness of peatland restoration compared to the timescales needed to properly assess change, and the lack of standardised long-term monitoring protocols.Space-for-time substitution can be used to infer future trajectories by comparing sites at different stages of recovery, but interpretation is difficult due to the site-specific differences previously emphasised.Data collection is usually funded by specific short-term grants for restoration activity or academic research, making it financially and logistically challenging to implement long-term monitoring of metrics associated with multiple ecosystem functions. Continuity of monitoring from one grant to the next is challenging, but could be achieved by building simple monitoring techniques into business as usual for site managers.Training volunteers or land managers to collect and review data helps embed long-term monitoring and engage local communities.

Monitoring at a glance

1. **Recognise that an area is peatland**. To understand, manage and restore peatlands, we need to know where our peatlands are, and the type of peatland it is. If we don't recognise our peatland habitats, we risk managing them in a way that is harmful to their peatland characteristics and services, or risk inadvertently converting them to other, less favourable, habitat types. In the UK, there are various datasets which identify peatlands and peaty soil extent and depth. These include the England Peat Map, Welsh Peatlands Data Portal, and Scotland's Peatland ACTION Data Portal.
2. **Understand your peatland**. Carry out baseline surveys (including vegetation, peat depth and ecohydrological investigations) and understand the hydrological environment the peatland developed in, the likely reference state, how it's been modified and how this has affected its function and biology before making any decisions about management, restoration and tree establishment / planting.
3. **Monitor long-term**. As well as collecting data to understand the baseline condition of our peatlands, we also need to collect data to help us understand how condition changes because of interventions we deliver and continually assess risks to peatland recovery from native tree or shrub planting or establishment. Monitoring should be considered at the project planning stage to ensure sufficient resources are available. Simple, low-cost, long-term monitoring solutions, such as the IUCN UK Peatland Programme's Eyes on the Bog methodology, should be implemented as a minimum requirement, and supported by additional higher-level data collection activities as resources allow.

Dent Head Eyes on the Bog monitoring by staff at Yorkshire Peat Partnership by Beth Thomas

CASE STUDY

Dove Stone: the potential of trees and scrub to support ecosystem recovery

Dove Stone is a 4000-hectare site in the Peak District National Park, including 2,500 hectares of deep peat. The site is owned by United Utilities and managed in partnership with RSPB, who are tenants. With some of the most damaged peat in Europe, restoration works since 2010 have aimed to revegetate bare peat, reduce erosion and raise the water table, with significant and internationally recognised success. However, the site is still at an early stage of a long trajectory towards fully functioning peatland.

Understanding the interplay between plant composition and hydrology

As with many other UK peatlands where intensive sheep grazing has been removed, scrub including dwarf tree species is now returning on the peat mass itself, and this may be welcomed as part of the recovery process. From small-scale observations so far, the roots of these trees lie predominantly in the litter layer, and the site managers are keen to understand if this is having a drying effect, and how that compares to the root growth and related hydrological impacts of more commonly accepted plants on peatlands such as heather and cotton grass.

Natural establishment of complex vegetation communities

Restoration interventions such as peat dams aim to saturate the remaining peat from the bottom up, facilitating a return to Sphagnum dominance. Naturally establishing scrub could be a valued part of a complex vegetation community which intercepts rainfall, increases surface roughness (slowing water flow) and supports biodiversity such as the bibionid flies so important as a food source for wading birds.

Scrub potentially enabling revegetation of a bare peat edge at RSPB Dove Stone by Tom Aspinall

CASE STUDY

Could our uplands be fuzzier and more complex? Allowing migration in altitude for species impacted by a warming climate, developing resilience to fire, slowing overland flow by Tom Aspinall

"We need to step away from our typically British view of conservation (where we have a need to control and map and measure and predict outcomes to the minutest degree) and embrace natural process-led land management (where our job is to restore basic natural function) and then let the land lead the way."

Kate Hanley, Site Manager, RSPB Dove Stone

The potential of tree planting to stabilise eroding edges

Like many other degraded blanket peats in the UK, the peat masses at Dove Stone sit like a toupee on top of the hills, with remnants on hillsides in places – a result of centuries of degradation which started with the removal of trees and scrub. These peat masses are shrinking from the outside in, with large drawdown of water drying the edges and resulting in cracking, collapse and increased vulnerability to fire. The peat edges are complex and tortuous, following the valley sides and leading into the peat interior. There is potential for dense planting of habitat-appropriate and fast-growing scrub species such as dwarf and creeping willows into the mineral substrate adjacent to these peat edges. This could act to stabilise these eroding slopes, providing shade and humidity, intercepting eroding peat and slowing water, with the aim of eventual paludification and outward growth of the peat mass.

The appropriateness of such interventions is dependent on successful rewetting of the interior peat mass: bottom-up through raising the water table, and top-down through reintroducing Sphagnum. There is also the potential to introduce Sphagnum species which are adapted to somewhat drier conditions, where bottom-up approaches can't yet be delivered.

Changing attitudes

There are increasing numbers of people from across land management and statutory agencies willing to talk positively about peat, trees and dynamic upland landscapes viewed as whole systems rather than component parts. Better understanding of the potential of our upland landscapes and the role of scrub within them is an urgent need. Trials must be landscape scale and delivered now, as the window of opportunity to make our peatlands resilient to future climate pressures is closing rapidly.

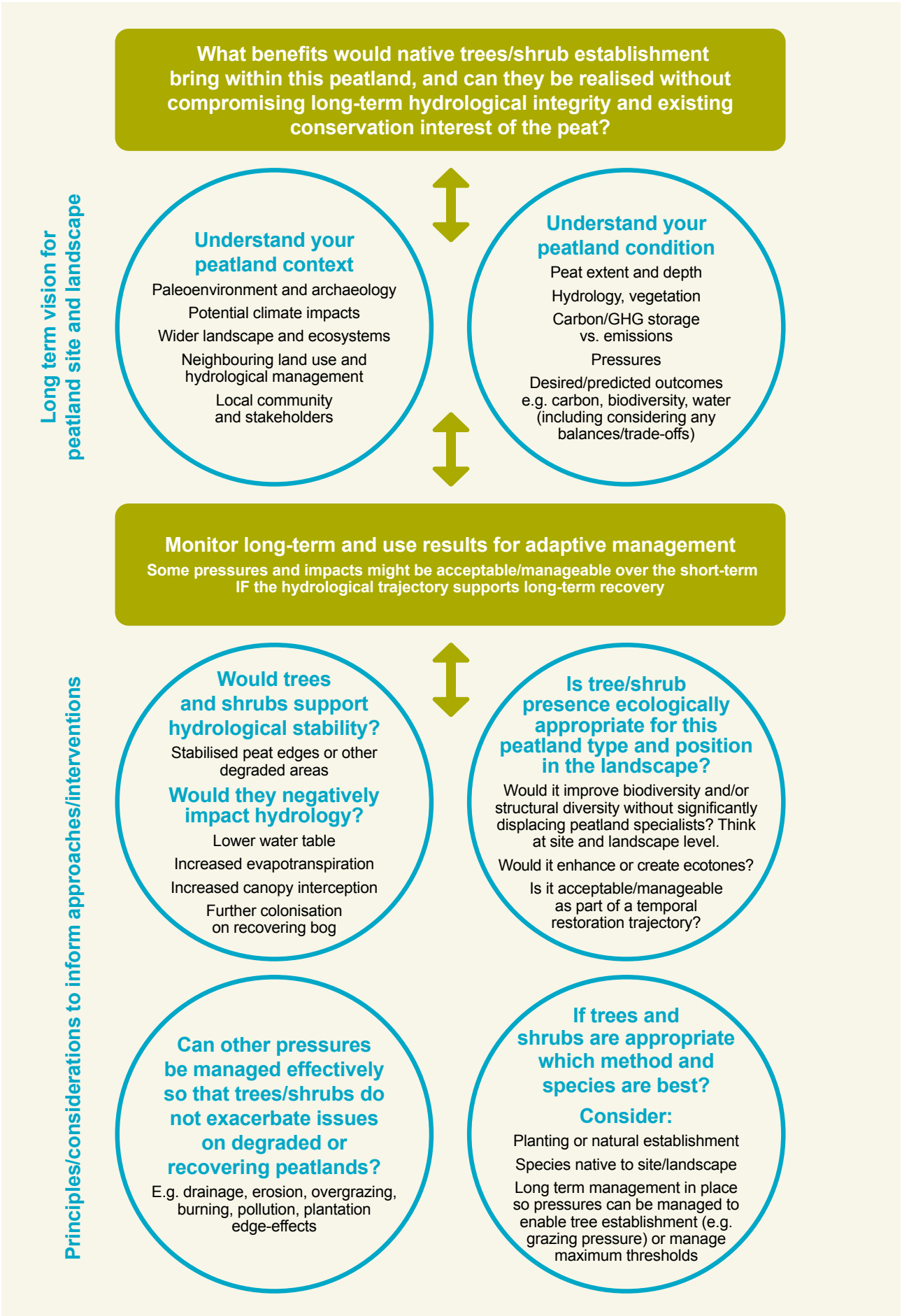


Figure 2. Principles to steer decision-making on trees and peat

Knowledge gaps and recommendations for further research

Flux tower in southern Scotland by Emma Hinchliffe

Knowledge gaps and recommendations for further research

To understand the role of native trees and shrubs in peatland ecosystem restoration, there are several priority areas for research:

- What is the depth of root penetration and shading by trees and shrubs in peatland habitats at different stages of recovery versus natural and semi-natural peatlands? How does this impact hydrological function, particularly the interplay between evapotranspiration and water level dynamics, and the stability of the peat?
- How do trees and shrubs respond to peatland restoration and over what period? Do certain species reduce in number or growth rate to be replaced by wet-adapted species as hydrological integrity recovers, do they inhibit restoration of hydrological function, and what are the drivers of these scenarios?
- What is the true range of suitable habitats/niches for species commonly associated with open peatlands, such as certain breeding waders? How do they respond to changes in native trees and shrubs?
- Do trees and shrubs inhibit or support peatland ecosystem resilience to climate change, fire, invasive species and pests and diseases? What evidence is there from the UK versus functioning temperate peatland ecosystems elsewhere in the world?
- How do native trees and shrubs influence greenhouse gas dynamics in peatland ecosystems?
- How do native trees and shrubs in the wider landscape impact degraded and recovering peatland and how is this related to dispersal ability and peatland condition?

Long-term investment in ecosystem restoration and associated ecological and hydrological monitoring are essential to support evidence-based decision-making in relation to native trees, shrubs and peat. This should be supported by policies which recognise the importance of holistic approaches to ecosystem restoration, valuing and focusing on the re-establishment of natural processes and complexity. Ecosystem services rely on ecosystem function, and it is only when that function is valued and restored, that the full benefits of native trees and peatlands will be realised.

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Creag Meagaidh National Nature Reserve by NatureScot

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