UK Parliament
POST

POSTbrief

By Rachael Holmes,
Jonathan Wentworth

3 October 2022

Restoration and creation of semi-natural habitats

post.parliament.uk

Contents

Glossary

- **Biodiversity Net Gain** (BNG) will require all developments from November 2023 in England to deliver a minimum 10% increase in biodiversity from that present at a site beforehand (the baseline) (PN 369, PB 34).[1] The **BNG metric** has been developed to calculate the baseline of biodiversity at a site and the number of biodiversity 'units' needed to achieve this increase.[2] Units are calculated based on habitat type, size and condition.

- **Calcareous grasslands** can occur over limestone and chalk geology where soils are often alkaline with a pH more than 7 as well as occurring upon calcium rich sands.[3]

- **Compact Airborne Spectrographic Imager** (CASI) is a small hyper-spectral sensor that can be attached to an aircraft and is used in remote sensing to record wavelength data on a spectrum from visible to the longwave infrared.[4]

- Defra defines **habitat creation** as 'establishing a wildlife-rich habitat where it is currently not present'.[5]

- The UN **Convention on Biological Diversity** (CBD) defines an **ecosystem** as a 'dynamic complex of species and their non-living environment, interacting as a functional unit'.[6,7] An area of habitat (e.g., pond) could contain an ecosystem, but an ecosystem (e.g., forest), can also contain multiple habitats within it.

- **Ecosystem services** are the benefits provided to people by healthy ecosystems.[6]

- The EU Habitats Directive defines a **habitat** as 'terrestrial or aquatic areas distinguished by geographic, abiotic (non-living) and biotic (living) features, whether entirely natural or semi-natural'.[8,9] Habitats are classified into **habitat types** with shared characteristics (section 1.1)

- The **Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services** (IPBES) is an independent intergovernmental body established to strengthen the science-policy interface for biodiversity and ecosystem services for the conservation and sustainable use of biodiversity, long-term human well-being and sustainable development.[10]

- **Light Detection and Ranging** (LiDAR) is a form of laser scanning sensor that can be attached to an aircraft and used to calculate distance between the Earth's surface and the receiver and is used for surveying.[4]

- **Recovery** has been defined as the rate and process of an ecosystem returning to a pre-disturbance state.[11] However, the term is also used to broadly refer to an improvement in environmental condition towards a projects target state.
- **Resilience** has multiple definitions but in ecology can be described as the ability of an ecosystem to recover from disturbance.[12,13]
- **Restoration** is the process of promoting ecosystem recovery from a degraded state.[14]
- IPBES define **semi-natural habitat(s)** as 'an ecosystem with most of its processes and biodiversity intact, though altered by human activity in strength or abundance relative to the natural state'.[15]

Introduction

This POSTbrief describes approaches to, and challenges of, restoring different semi-natural habitat types in England including native woodlands, heathlands, grasslands, wetlands, and coastal habitats.

This brief complements the key points summarised in POSTnote 678, which focuses on terrestrial habitats and their restoration for the wider habitats target in England. Terrestrial habitats are usually described as including freshwater and coastal habitat types.

The UK has lost more of its nature than most countries globally.[16] The UK's devolved nations are setting out various approaches to nature recovery in plans and strategies.[17–21] Of the four UK countries, England is the most nature-depleted.[16] Species listed as conservation priorities that are most threatened under Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 ('priority species') continue to decline.[22,23] A major driver of this decline is the degradation, fragmentation and loss of habitats that species depend on.[24] Agricultural intensity, development of built infrastructure and pollution are major causes of this loss.[24–26] No habitat in the UK is completely 'natural' as humans have modified them for thousands of years.[27–29] However, 'semi-natural' habitats still retain most of their natural biodiversity (the variety of ecosystems and species within nature and the interactions between them, PN 617).[15] Semi-natural habitats cover around 32.6% of UK land area.[30] However, the condition of many semi-natural habitat types (such as grasslands) continues to decline, despite legal protections.[22,31]

Ecological restoration is the process of promoting the recovery of an ecosystem from a degraded state.[14] Restoration can deliver for ecosystems, habitats, and species; or it can prioritise outcomes for each. UK policy and legislation on restoration and conservation currently prioritises outcomes for habitats and species.[1,21,32]

Ecological restoration can improve the condition of habitats, expand their size, and connect them with other habitat patches as suggested in the 2010 Lawton review. This was commissioned to make recommendations on improving England's wildlife ('bigger, better and more joined up').[33]

Habitat creation is where habitats are re-established on land where that habitat type no longer exists because of historic land-use change. The practice of restoring habitats began in the early 20th Century.[34] In England, early habitat restoration and creation projects were conducted at sites such as Wicken Fen[35] and the Upper Nene Valley Gravel Pits,[36] which are now internationally significant for wildlife. However, further restoration work is required at Wicken Fen as over 50% of the site's protected area (Site of Special Scientific Interest – SSSI) is currently in unfavourable condition due to continuing drainage of the wetland.[37]

Habitat restoration usually has a range of co-benefits for humans ('ecosystem services') but there may be short-term trade-offs with, for example, agricultural production (PN 678) or other beneficial ecosystem services.[38] Benefits include removing CO_2 from the atmosphere and into stores such as soil (carbon sequestration, PN 668; PN 656, PN 636) and providing spaces for recreation, access to which can be important for human health and wellbeing (PN 538).[39,40] Bodies such as IPBES, have stated that restoring habitats and ecosystem services is critical to address the 'biodiversity and climate crises'.[41,42]

The Government has consulted on environmental targets for England. These are part of the framework which sets the direction for achieving the 25 Year Environment Plan (25YEP) goals.[21] They include a 'long-term wider habitats target' to create or restore 500,000 ha of wildlife-rich habitat outside legally protected conservation sites by 2042.[5] Increasing the area of good quality habitat for wildlife would contribute to the key target to halt the decline in species abundance (the number of individuals per species) by 2030 (with further longer-term targets proposed on species abundance and extinction).[5] Other complementary targets to restore and create specific habitat types are also being set.[5,43,44]

1 Habitat restoration and creation

1.1 How habitats are classified in the UK

Habitats are distinguished by geographic, living (such as species) and non-living (such as geology) features.[8,9] UK habitats are classified into different types based on their shared characteristics. These can include having similar physical conditions like soil type, and similar vegetation.

Different habitat classifications are used in UK regulations and biodiversity monitoring, including:[45]

- **Phase 1 Habitat Classification,** which groups semi-natural vegetation and wildlife habitats into 155 habitat types. This means that large areas can be assessed quickly.

- **National Vegetation Classification (NVC)** is a detailed classification that groups habitats based on their vegetation into 12 main types, which can be further split into 578 categories. It is used to define areas for regulatory purposes. These include specifying Sites of Special Scientific Interest; UK Common Standards Monitoring Guidance; and the UK Interpretation of Annex I habitats listed under the Habitats Directive.[46]

- **UK Biodiversity Action Plan (BAP)** groups semi-natural habitats into 'priority habitats'.[47] Priority habitats are those which are threatened and require conservation. This classification informed the selection of 56 habitat types and 943 species of principal conservation importance in England as outlined in the UK Post-2010 Biodiversity Framework.[48]

- **European Nature Information System (EUNIS) habitat classification** covers all natural and artificial habitat types found across Europe.[49] Habitats are grouped in three hierarchical levels based on their physical characteristics and vegetation. EUNIS, is similar in scope to NVC but its main purpose is to harmonise between different habitat classification systems used across Europe. In the UK, Scotland has adopted the EUNIS habitat classification system.[50]

- **UK Habitat Classification System (UKHab)** is an independent system privately developed by practitioners to unify existing classifications, seeking to cover all UK habitat types and land uses from the natural to artificial.[51] UKHab will underpin the habitat data used in a measure to assess and monitor sites to calculate the Biodiversity Net Gain (BNG) metric (PN 678) in England.[52] However, licensing issues may prevent some organisations, such as Natural England, from using UKHab in other aspect of their work.[53]

The International Union for Conservation of Nature (IUCN) have a habitat classification scheme, which is widely used in ecological analyses.[54] However, ecosystem-level classifications have also been developed, like the IUCN Global Ecosystem Typology. This classification was developed to monitor trends in biodiversity more efficiently at larger scales (PN 644). It is a hierarchical classification system that, in its upper levels, defines ecosystems by their convergent ecological functions and, in its lower levels, distinguishes ecosystems with contrasting assemblages of species engaged in those functions.[55]

The type of classification used will influence how the habitat type is surveyed, protected, and restored. Restoration and creation at a site often involve many different habitat types that form a mosaic with transitional habitats between them. Over time, both natural and restored habitats are dynamic and will change. For example, sand dunes shift position over time but will become more stable and vegetated unless disturbed naturally or artificially (see section 2.5). This dynamism is important to consider when planning restoration activities and further management.

1.2 The process of habitat restoration and creation

Restoration is a process (Figure 1) rather than a defined endpoint. This process begins through assessment of past and current conditions by an experienced ecologist, alongside consultations with the landowner and relevant stakeholders to understand their interests, values and objectives. Further assessments of past management and identification of nearby sites to act as a reference site may also be undertaken.

This information is used to determine the restoration aims, for which appropriate target states and goals can be set.

Key management actions are then identified that will achieve restoration goals. Many habitat types have guides or standards for their restoration developed by practitioners, researchers and public bodies.[56–63] Typical interventions may include:

- implementing the correct type and level of management;[64]
- creating a diverse vegetation structure;[65]
- reintroducing species;[66–68]
- reducing pollution;[69]
- creating disturbance;[70] and
- altering water levels at a site.[71]

However, differences in the context for projects, such as their location and condition, mean that bespoke restoration plans are usually developed for each site.[72]

After the completion of initial work, a costed management plan outlining required actions to be developed and delivered to support recovery and prevent the habitat reverting to a degraded condition is created.[73] This could involve a range of possible interventions along a continuum from active (intensively managed) to passive management (where human involvement in the restoration process is reduced or absent).[74] It should be noted that the passive management approach can result in the further degradation of some types of semi-natural habitats, such as for some grassland and heathland habitats (see sections 2.2 and 2.3).

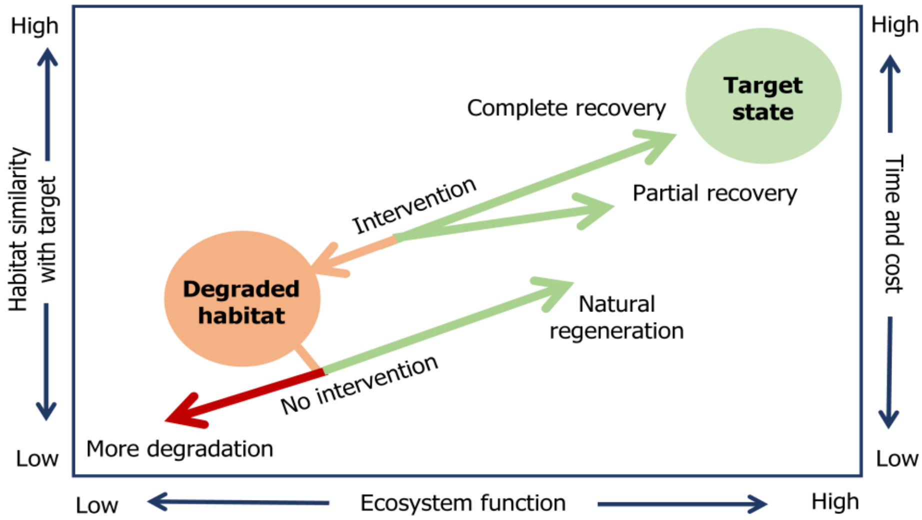

Figure 1. Depending on the type and level of degradation, a habitat may continue to degrade or naturally recover if no steps are taken to intervene. If sufficient interventions are taken to restore a habitat, there can be several outcomes from partial to complete recovery. Modified after Wilson et al. 2019[75]

An increasing number of projects use rewilding approaches (PN 537),[76] which involve minimal direct human interventions to restore habitats. Multiple definitions of rewilding exist,[77] but it can be broadly described as reinstating natural processes degraded by human activities that would have occurred in the absence of these human impacts (PN 537). This usually involves some level of intervention at the beginning to restart processes (some of which can be major and prolonged in duration), such as blocking drains and raising water levels to restore peat soils (PN 668) or removing non-native or invasive species. It can also be achieved through reintroducing plants, herbivores or predators that play a critical role in the ecology of habitats, such as trees, beavers or pine martins.[67,78–83]

The focus is on restoring natural processes so these become self-sustaining rather than meeting a specific goal such as restoring a habitat to a specific target state or increasing the number of individuals of a rare species. Rewilding Britain lists 48 active terrestrial rewilding projects in England.[84] These are a mix of networks and independent projects which range from rewilding on ex-agricultural land to restoring semi-natural habitats.[85–87]

There is little evidence directly comparing the outcomes of active and passive management approaches for restoration. Defra has stated that a mix of the two, where appropriate, will be applied to deliver the Government's wider habitats target.[5]

More heavily degraded habitats can be harder to restore. Restoration may have less successful outcomes when, for example:[88]

- Soils are polluted with contaminants, such as metals (PB 45), or enriched with nutrients, such as phosphates and nitrates from fertiliser use or through atmospheric deposition (PN 662 and PN 601)[89,90]
- Major work is required to restore the physical environmental conditions at a site, such as changing water levels or removing built infrastructure, as this can be expensive and time intensive.

Degradation can make the restoration and creation of semi-natural habitats more challenging, costly and unpredictable. However, there are well-established methods to improve chances of success for some habitat types, such as the creation of semi-natural grassland on former arable farmland (section 2.2) or for restoring habitats on quarried land (section 2.3, Box 3).

The time taken for distinct aspects of habitats to be restored varies from years to centuries, and differs between habitat types, degree of degradation and restoration approaches (Table 1).[91,92] The Natural Capital Committee conducted a systematic review of recovery times but Table 1 can only be indicative of potential recovery times as these will depend upon site-specific contexts, which will vary greatly. Many of the times reported refer to only partial recovery of a habitat component and recovery times for the same habitat type and components can be highly varied due to several factors including the initial level of degradation and the restoration interventions applied.

Pressures on wildlife in the future, such as the introduction of new non-native invasive species (PN 673), spread of pests and diseases and climate change impacts (PN 678), could affect the time taken for habitats to recover and their ability to reach desired outcomes (referred to as the 'target state').[93]

After assessing starting conditions at the site, projects often monitor progress towards their goals by surveying species, habitat condition and other environmental attributes or factors (PN 678) against standard criteria.[94] The length and frequency of monitoring will depend on the desired objectives, but it may take many years before the target state is achieved. Good monitoring data enables land managers to practice 'adaptive management', where restoration activities are altered if habitat recovery starts to show undesirable trends (PB 42). This data can also be used to better understand ecosystems and their functions, enable identification of effective restoration methods and provides a way of reporting how successful restoration activities have been at achieving project goals. The RestREco project has been set up to establish methods for measuring recovery of ecosystem complexity (Box 1) which is not commonly monitored.[95]

Table 1. Overview of reported recovery times for a selection of different habitat types identified in a report for the Natural Capital Committee in 2014.[91]

Habitat type	Recovery time (years)	Habitat component
Native woodland	80-160	Complete habitat recovery

	>100	Partial recovery of soils after at least 75 years but most sites will need much longer for full recovery
Heathland	>4	Dwarf shrub species showing structural and botanical diversity
	11-15	Pollinators function recovered
	>2	Partial recovery of vegetation
	>10	Partial recovery of soil
Peatland	1-2	Partial recovery of site hydrology (blanket bog)
	~2	Initial vegetation re-colonisation/ establishment
	>3	Improved carbon sequestration
	20-50	Development of appropriate vegetation
Grasslands	4-5	Acid & neutral grassland
	10*-100	Calcareous and species rich grassland
	4-15	Pollinators
	>10	Partial recovery of soil (if damage was not severe)
Lakes	10-15	Water quality
	10-20	Insects
	2-50	Aquatic plants
	2-10	Fish
Rivers	15-25	Biodiversity & function
Wetlands	1-2	Partial recovery of site hydrology & mobile species such as birds arriving
	<10	Beneficial changes seen for vegetation & insects
	>60	Complete habitat recovery (for some wetlands)
Sand dunes	~33	Initial vegetation colonisation of bare sand
	5-20	Semi-fixed dunes
	>40	Fixed dunes and dune slacks
Saltmarsh	~5	Vegetation cover established (but typically not the same as non-restored community)

	~5	restoration of degraded invertebrate communities
	Up to 100	Full recovery of coastal processes, and ecological function

*Some species rich grasslands plant communities have been restored in 10 years.[96]

Box 1 Restoring ecological complexity

Complexity is commonly defined as the number of components and connections in a system.[97] In ecology, components could include species or habitat patches within a site or landscape. For example, how many species interact with each other are a component of ecosystem complexity. A degraded ecosystem has fewer species and less interaction and complexity. For example, a less complex, degraded, heathland might only have 2-3 plant species and support 5 species of insect. By contrast, a restored or existing high-quality complex heathland ecosystem may include 50 species of plants, including healthy populations of rare plants, plus high numbers of native insects, birds, reptiles and amphibians as well as having a diversity of habitat patches such as streams, ponds, and scrub. A complex ecosystem supports a far higher number of diverse species that interact more.

High levels complexity and interaction may confer key ecosystem properties. For example, an ecosystem with lower complexity may be less resilient to environmental change and may provide fewer ecosystem services in future.[98,99] Monitoring ecological complexity should provide better understanding of the state of ecosystems as a whole but may be more time consuming than current approaches (PN 644).[100] The RestREco project is a partnership between Cranfield University, the National Trust, University of Stirling, UK Centre for Ecology & Hydrology (UKCEH) and Forest Research, which is investigating ways to measure ecological complexity to better understand how to restore functioning ecosytems.[95] They suggest ecological complexity could be measured by quantifying:[97]

- differences in the structure of vegetation or the physical environment (the physical complexity of the habitat);
- the number of species within the area (species richness);
- tracking food web connections (interactions);
- soil microbial community complexity; and,
- soundscape complexity (the sounds in the environment).

2 Semi-natural habitat types

2.1 Native woodlands

There are a range of native woodland types in England. Section 41 of the NERC Act lists 6 types of woodland: lowland mixed deciduous woodland, lowland beech and yew woodland; upland mixed ashwoods, upland oakwood, wet woodland, and wood pasture and parkland.[101]

Across England only 9% of native woodlands are in 'favourable condition'.[102] Native woodlands that have been degraded may have low levels of deadwood and veteran trees; lack open habitats within the woodland; contain trees of a similar age; and have low diversity of tree species.[103] Drivers of native woodland degradation and loss are similar to other habitats and include built development and infrastructure, climate change, pollution, invasive species and disease.[103] According to National Forest Inventory herbivore damage, such as overgrazing, is a major cause of native woodlands being classed as in an 'unfavourable condition' in England.[102]

Woodland in England that has existed since at least the 1600s is referred to as an Ancient Woodland. This is considered an irreplaceable habitat due to its distinct wildlife and landscape context that cannot be restored within human timeframes (PN 465). There are 215,156 ha of Ancient Semi Natural Woodland (ASNW) within the 914,000 ha of native woodland in England.[44] A further 149,733 ha of Plantations on Ancient Woodland Sites (PAWS) in England occur on Ancient Woodland sites.[44] These PAWS, have the potential to increase semi-natural ancient woodland area in England by around 16%.[44] [104] Over time this would increase the area of restored ASNW with semi-natural characteristics.[105]

Defra is consulting on a Government target to increase tree cover from 14.5% to 17.5% by 2050 in England.[43] This is in addition to existing UK Government targets like restoring PAWS sites to ASNW by 2030 in England.[44] Defra has suggested that around 150,000 ha of native woodland will be created by 2042, to contribute towards the wider habitats target.[43] The Government has set stretching woodland creation targets such as planting 30,000 ha of woodland (including non-native plantations) every year by the end of this parliament,[106] but it is unclear whether these will be met.[107]

There are a range of guides by bodies such as the Forestry Commission and the Woodland Trust, for restoring, creating, and managing native woodlands.[63,104,108,109] Two common approaches to native woodlands habitat creation are directly planting trees and allowing natural regeneration or natural colonisation of woodlands (PN 636).

The Woodland Trust has highlighted that management priorities for woodland restoration and expansion are removing non-native species, managing browsing pressure by deer and reducing nitrogen air pollution.[103,109] For example, overgrazing by deer can prohibit natural regeneration of woodlands and has been linked with declines of biodiversity in some woodlands,[110] and fewer small mammals within restored woodlands.[111] Deer fencing is a common approach to reduce grazing and browsing pressure but can be expensive and rarely covers the whole wood.[110] Controlling deer population sizes is preferred by some, who see it as a more effective approach because fencing deals with individual areas but culling tackles the whole issue.[110,112,113] The two management approaches can be carried out together and Defra are currently producing a strategy on sustainable approaches to deer management across England with stakeholder consultation.[114]

Other woodland restoration activities can include tree felling and coppicing (cutting trees to stumps and allowing them to regrow)[115] in dense woodlands or opening up woodland rides (open spaces or pathways providing access).[116–118] Creating openings within some types of woodlands can be important to produce different microhabitats (a small area differing from the surrounding area) that has different temperatures and levels of light exposure that provide varied groups of wildflower resources, supporting insect and bird species.[116,118–120] These management approaches may mimic natural processes of disturbance that in the past may have been performed by large herbivores, such as bison or boar.[121,122] However, there remains debate about the role of large mammals within woodlands in the past.[123–126] Carefully introducing cattle grazing to some woodlands can help to mimic the benefits of disturbance and nutrient cycling previously achieved via wild herbivores. Such wood-pasture systems can be incredibly rich in wildlife,[127] although this may not suitable for all woodland types.[128]

It can take between 80 and 160 years for restored woodlands to begin to attain characteristics similar to mature woodland in good condition.[129,130] However, this will be dependent upon the starting condition, i.e., level of degradation and whether the native woodland has been restored or created.

The unpredictable impacts of climate change (PN 68x) as well as new tree pests and diseases (PN 636) could impact the recovery of woodlands. Proximity to existing woodland is important for the availability of tree seeds and presence of species that disperse seed, such as mice, jays, and squirrels.[130] Preliminary results from the WrEN project have revealed that creating or restoring even small patches of native woodland and individual trees can also be an important resource for wildlife across a landscape.[131]

2.2 Grasslands

In England, semi-natural grasslands can be separated into six priority habitat types: lowland calcareous grassland, lowland dry acid grassland, lowland meadows, purple moor-grass and rush pasture, upland calcareous grassland and upland hay meadows.[132] The communities of plant species found in grasslands can vary significantly due to differences in:

- underlying geologies affecting how acidic or alkaline they are (for example, grassland on chalk or limestone will have alkaline soil);

- whether they are in the uplands or lowlands;
- climate and drainage; and,
- their location (such as north or south-facing slopes and whether they occur in the North, South, East, or West of the country).

However, all semi-natural grasslands are comprised of a mix of grasses and other herbaceous plants (flowering plants without woody stems). Semi-natural grasslands cover around 10% of UK land area, with an estimated area of 611,000 ha reported in 2015, in England.[133] Between 1960 and 2013, 47% of semi-natural grassland sites surveyed in England (846 sites in total) were lost mostly by conversion to agricultural uses (either growing arable crops or treated with herbicides and fertiliser and reseeded with commercially bred forage grasses for livestock grazing, PB 42).[134]

Some grassland types have been more widely degraded and destroyed than others. For example, 97% of wildflower rich grassland has been lost in the UK since the 1930s.[135] Wildflower rich grasslands are particularly important for insect communities (PN 67X, Box 5; PN 619). Floodplain meadows have also been subject to historic declines (Box 2).[136]

The UK Government has set no specific targets for the restoration of semi-natural grasslands. However, present agri-environment schemes and the new Environmental Land Management schemes (ELMs) promote and fund grassland restoration activities on agricultural land.[137,138] Aspirational figures for restoration of different grassland habitats have been published by Natural England, including:

- restoring around 149,000 ha of semi-improved grassland, arable and dense scrub to lowland calcareous grassland,[139]
- increased the extent of lowland dry acid grassland by 49,000 ha,[140]
- restoring around 65,000 ha of semi-improved grassland, forestry plantation or dense scrub to purple moor-grass and rush pasture,[141]
- increase the extent of upland hay meadows by 24,000 ha, which should include expanding the size of existing patches of upland hay meadow.[142]

Restoration approaches are well established across semi-natural grassland types.[132] Restoration typically includes actions such as: managed grazing, traditional hay cutting, and turf stripping or selective planting to reduce soil nutrients.

Sourcing high quality, genetically diverse, native plant material is often necessary for grassland restoration or creation (and restoration of most habitat types).[143,144] In England, these plant materials are either collected from existing habitats such as through seed brush harvesting or green hay,[143] or produced by small scale suppliers and specialists' institutions like Kew's UK Native Seed Hub.[145]

This can be expensive when conducted at scale. For example, at the Wendling Beck Environment project (PN 678, Box 3) the reintroduction of rare native plants by sowing high quality seed cost ~£1,000 p/ha.[146] However, techniques such as green hay harvesting have been effective and can be much cheaper but will involve additional labour to collect the plant material.[147–149] As the scale of restoration activities increase, an increase in production, alongside training for harvesting, processing, and sowing to reduce costs may help meet demand.

Box 2 Case study: Floodplain Meadows Partnership

Floodplain meadows have developed in the UK over hundreds of years, through traditional agricultural practices to produce hay for overwintering animals.[136,150–152] With up to 40 plant species per m^2, traditionally managed floodplain meadows are home to a high diversity of plants.[136,153] They can also play a significant role in flood management.[154]

Historic loss of floodplain meadows has been estimated at around 90,000 ha.[155] Changes in drainage, climate, and nutrients (such as from the application of fertilisers) from agricultural uses and development of built infrastructure on floodplains have driven this decline in their area since the early 20th Century.[136]

Species-rich floodplain meadows now cover 2,980 ha in England and Wales.[136] Some of these sites have legal protection, but some remain in poor condition and under threat. Actions used to restore floodplain hay meadows such as mowing for hay cutting, applying 'green hay,' reducing nutrient levels in the soil, sowing seed mixes and plug planting are similar to those for other grasslands, but it is sometimes necessary to amend the soil-water regime too.[96]

Floodplain meadow sites such as Priors Ham, Wiltshire; Clattinger Farm, Gloucestershire;[156] and Somerford Mead, Oxfordshire;[157] have been, or are being, successfully restored. However, not all restoration actions at other sites have resulted in successful outcomes. A review of floodplain meadow restoration in England and Wales of 163 restoration sites covering 733 ha, found that only 25% of sites met an expected restored state, with 15% designated as failed.[96]

Private landowners were more likely to have successfully restored floodplain meadows than charitable organisations and public bodies, which may reflect type of management.[96] The ability of experienced restoration managers to adapt their management approach for the context of the specific site was also important for success.[96] The Floodplain Meadow Partnership (FMP)[158] is supporting manager-to-manager demonstrations of best practice to improve rates of successful restoration of floodplain meadows.

2.3 Heathlands

Heathlands occur in the uplands and lowlands and are characterised by the presence of a range of dwarf-shrubs. These include various types of heather and gorse, as well as bilberry, cowberry and crowberry.[159] They expanded in the UK when forests were cleared around 5,500 years ago and have persisted with subsequent human land management for food, timber, fuel, livestock grazing and game.[160–163] Without grazing most heathlands, in the UK, naturally become scrub or woodland. In the UK grazing is normally provided by domestic animals, but in the past would have been wild herbivores. Heathlands occur on infertile acidic soils that are either dry and sandy, or wet and peat rich, and can occur in conjunction with peatlands and other wetlands including fens (section 2.4), grasslands (section 2.2), woodlands (section 2.1) or as part of the natural succession of older sand dunes that have low calcium levels (section 2.5).

Heathlands have been degraded by: afforestation (planting trees), inappropriate burning regimes, urban development, overgrazing in the uplands, drainage of wet heath, disturbance by people and pets, and under-grazing and agricultural development in the lowlands.[164]

Mapping by Natural England suggests that around 237,790 ha of heathland remains in England.[53] Across England, the total loss of heathland area has not been well quantified, but loss of lowland heathland in some English counties has been well monitored, such as Dorset.[165–167] Lowland heathlands in Britain are estimated to have declined by 78% between 1830 and 1984.[168]

The UK Government has not set specific targets for the restoration of heathland habitats and there is a lack of data on their condition outside protected sites. Some current agri-environment schemes promote and fund heathland restoration.[169–171] Heathlands on peat soils may also benefit from peatland restoration projects (section 2.4).

Techniques for heathland restoration can include:[172]

- allowing natural regeneration (when conditions are met e.g., after conifer clearance),
- transplanting topsoil from intact heathland,
- spreading seed-rich heathland vegetation,
- controlling bracken or non-native species,
- tree felling,
- controlled grazing, and
- controlled burning.

A study in Dorset over a 17-year period tested five of these approaches for restoring lowland heathlands on former farmland and found that ecological outcomes varied with different techniques and original situation.[173] The study found that spreading seed-bearing heathland vegetation was one of the best approaches for successfully restoring the community of plant species that are typically found in nearby heathlands in good condition.[173] Restoration and creation of heathland has also been achieved at heavily degraded quarry sites, such as Rugeley Quarry within the Special Area for Conservation at Cannock Chase (Box 3).

Box 3 Case study: Restoration of quarry sites

The quarry industry in England has a legacy of habitat creation and restoration on their sites that extends over 50 years.[174] Currently, quarries occupy around 64,000 ha in England. These will be restored in the future.[174] Many quarries are excavated on agricultural land, and some will be restored for that or for other uses such as housing or recreation. However, on a large proportion of sites, wildlife-rich habitats have been created or restored. By 2020, members of the Mineral Products Association (MPA) had created over 8,300 ha of priority habitat, with over 11,000 ha committed to in approved restoration plans. This was often as part of collaborations with NGOs such as the RSPB through their Nature After Minerals project.[174,175]

Quarry restoration is often associated with wetland habitat creation, but other semi-natural habitat types like heathlands, woodlands and grasslands are also being restored (Figure 2). For example, Rugeley Quarry in Staffordshire is run by CEMEX, which extracts sand for construction.[176] Before becoming a quarry, the site was lowland dry heathland in poor condition. Restoration of heathland habitat outside of the quarried area primarily involved removal of trees, scrub and bracken, and controlling gorse. Habitat was also created within the quarried area. Following this award-winning restoration, 475 species of insects, 41 species of bees and wasps, and rare species like the woodlark and great crested newt are now present. However, full ecological recovery to good condition will take much longer.[176,177]

As more industries and infrastructure providers are obligated to restore or create habitats as part of biodiversity net gain policies (PN 678, PN 369, PB 34), similar awards programmes to that of the MPA could promote best practice approaches to restoration.

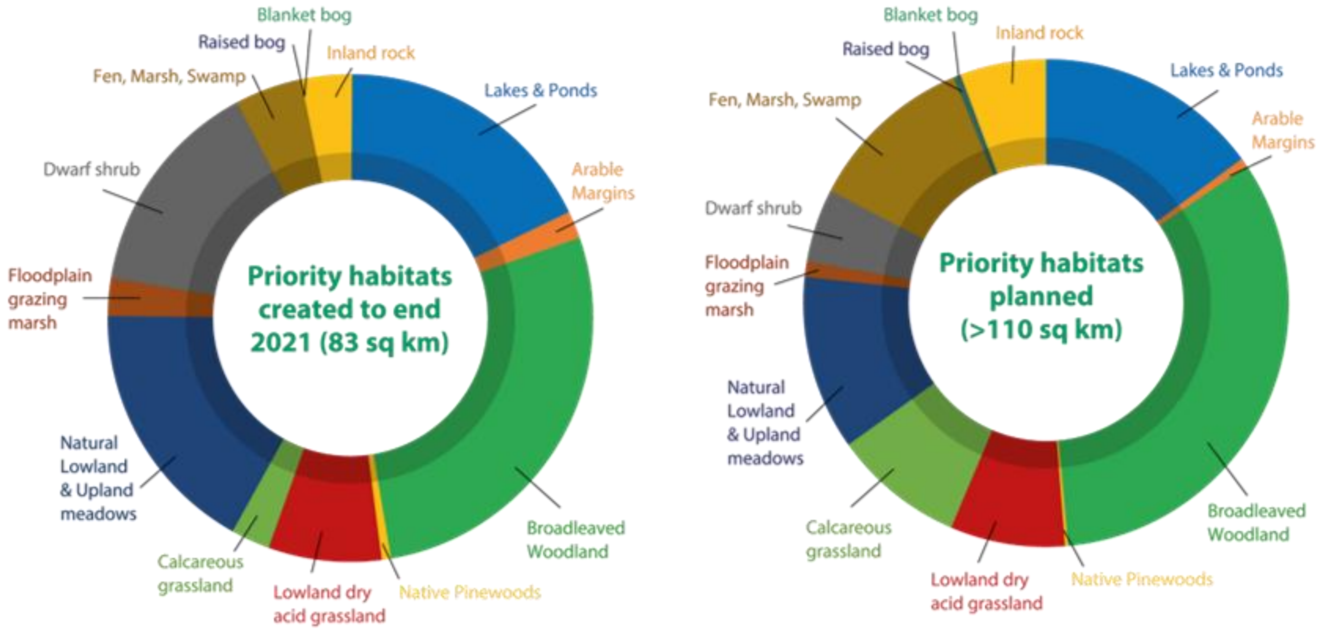

Figure 2 Area of priority habitat types created (left), and planned (right), by members of the Mineral Products Association as of 2021.[174]

2.4 Wetlands

Wetlands are ecosystems that are either permanently or seasonally flooded with water.[178] There are several priority wetland habitat types in England, including blanket bog, coastal and floodplain grazing marsh, lowland fens, lowland raised bog and reedbeds. Wetlands can also overlap with other semi-natural habitats described here, such as woodlands (such as wet woodland) and grassland (such as floodplain meadow (Box 2)). Along with freshwater habitats (Box 4), wetlands have been subjected to a range of pressures, such as development of floodplains for housing or agriculture.[179]

Freshwater and wetlands sites currently cover around 1,330,499 ha in the UK.[31] They support a diverse range of nationally and internationally significant wildlife, are an important carbon store, and can play an important role in flood defence.

Wildlife-rich wetland habitats can be complex and expensive to restore,[180] because wetland restoration can often require cooperation across different sectors, such as agriculture and the water industry, to prevent further degradation at the scale of a whole catchment (PB 40).[181] Restoration may require restoration of natural water levels and water regimes, and other physical and chemical conditions at a site level to reverse degradation, which can also be expensive. But a range of approaches have been developed and successfully applied to restore and create wetland habitats, such as at former quarry sites (Box 3).

Box 4 Freshwater habitats

The condition of wetland habitats is highly interlinked with the condition of adjacent freshwater habitats such as lakes, ponds, rivers, and estuaries. Degradation of the freshwater water environment has been primarily driven by sewage discharge, physical and chemical pollution (agricultural fertiliser run-off, PN 661, pesticides, mining pollutants, plastics and pharmaceuticals), and physical modification (such as constraining rivers in artificial channels).[182,183] Based on data collected between 2016 and 2019, the Environment Agency reported that only 14% of rivers, 14% of lakes, and 19% of estuaries could be considered as having 'good ecological status' (an assessment of the state of waterbodies based on biological, physical, chemical and environmental criteria as defined in the Water Framework Directive[184] PB 40).[185]

In addition to peatland restoration targets (below), which support the recovery of wetland habitats, the UK Government is setting other targets to improve the water environment. These include targets to reduce water consumption and pollution in the water environment.[186]

Defra has noted that meeting these targets will partially depend upon wetland, lake and river habitat creation and restoration (PB 42).[186] However, the IUCN National Committee UK, has suggested that to improve restoration outcomes there is a need for more information about how best to restore rivers and streams and to monitor and appraise the success of projects.[187] But there are well established methods for restoring and creating other freshwater habitats, such as ponds (PN 661).[188–190] Restoring and creating wetland habitats including freshwater habitats such as ponds, lakes, and reedbeds is likely to be supported by ELMs as part of Local Nature Recovery when it is launched in 2024.[191]

In addition to the wider habitats target, as part of the 25YEP, the UK Government has set overarching goals for wetland and freshwater habitat restoration:[21]

- Improving at least three-quarters of England's 'waters' (including wetlands, rivers and the marine environment) to be close to their natural state (or 'good ecological status').
- Reaching or exceeding objectives for rivers, lakes, estuaries, coastal and ground waters that are specially protected, whether for biodiversity or drinking water. These are set out in a policy called river basin management plans which document how organisations, stakeholders and communities will work together to improve the water environment (PB 40).

- Restoring 750,000 ha of terrestrial and freshwater protected sites to favourable condition (as defined in Common Standards Monitoring),[94] securing their wildlife value for the long term.

Peatlands

Peatlands are characterised by their partially decomposed organic soils which form under waterlogged conditions (PN 668).[192,193] In England, there is around 1.42 million ha of deep (>40cm) and shallow (10-40cm) peatland habitat.[194] These can be split into three peatland types, two types of which occur in upland and lowland areas, blanket bog and fens, as well as raised bog which only occurs in lowlands.[195] An estimated 13% of deep peats are in a good condition in England.[194] Peatland degradation has been driven by activities such as draining peats for agriculture, afforestation, peat extraction for fuel and overgrazing as well as by the effects of air pollution (PN 668).

Via the Nature for Climate Fund,[196] the Government committed to funding the restoration of 35,000 ha of peatlands by 2025;[21] the Net Zero Strategy outlines a policy to restore approximately 280,000 ha of peatland by 2050;[197] and they have also published the England Peat Action Plan laying out plans to protect, prevent degradation and restore degraded peatlands.[194] Further financial support for peatland restoration will come from ELMs when they begin in 2022 and 2024 (PN 678).[194] Defra is expecting that around 99,000 ha of peatland restoration would be delivered through England's Peat Action Plan by 2042 to contribute to delivery of the Governments wider habitats target.[5] This assumes that restoration of peatlands will be constant and at the 'maximum level' of 4,950 ha/y.[5] However, the Government did not meet its targets for peatland restoration in 2020 – 2021.[198]

The aim of peatland restoration is to restore peat forming habitats and may require a variety of actions depending on the site condition.[199] Often the main requirement is raising of the water table to promote peat formation. On severely degraded peatland such as on previous peat extraction sites or on eroded blanket bogs, there may be extensive areas of bare peat and here revegetation is sped up by introduction of bog plants often following a stabilisation phase where nurse plants are sown.[200] On some other damaged peatlands, native peat forming communities have been replaced by less desirable vegetation such as plantation forests or by the strongly competitive purple moor grass. Others may have diminished communities of common peatland plant species that provide key surface features for the functioning of peatlands, such as areas of bare and eroding peat (PN 668). In these areas, intensive management such as restoring natural hydrology, may be needed to recover the peat-forming bog habitat.[200,201]

In northern England, projects over the past 20 years have applied successful restoration works to substantial degraded areas particularly in the Pennines and have yielded improved habitat condition and benefits in ecosystem services .[202] Since its start in 2003, the Moors for the Future Partnership has transformed 34 km^2 of bare eroding peatland and this has included introduction of 4.6 million sphagnum plug plants. Peatland partnerships in northern England now have ambitions for a linked up 'Great North Bog' landscape-scale restoration project across nearly 7,000 km2 of upland peatland.[203]

Another type of restoration is targeted in the lowlands where substantial areas of peat have been drained and turned to agriculture. Winmarleigh Carbon Farm in Lancashire is an EU Care-Peat project in collaboration between the Wildlife Trust, Manchester Metropolitan University and Beadamoss.[204] They are trialling restoration of improved grassland to lowland raised peat bog with a primary aim to reduce carbon emissions and over the longer term improve biodiversity. Restoration actions have included stripping grassland, rewetting and planting several species of sphagnum moss. The project is investigating ways to make peatland restoration financially viable for farmers and landowners, which can be a barrier for restoration success.[205] In some lowland peatland areas, lack of peat depth has been used as an argument against restoration. However, recovery of peatland habitat has been possible even on peats under 2m deep on for example, parts of Little Woolden Moss, a lowland raised peat bog in Manchester.[206]

2.5 Coastal habitats

Coastal habitats occur at the intersection between terrestrial and marine environments. In England, priority coastal habitats include: maritime cliff and slopes, coastal vegetated shingle, machair, coastal saltmarsh and coastal sand dune. The two latter habitat types (saltmarsh and sand dune) are provided below as examples of coastal habitat restoration and creation. Transitional water habitats that occur beyond the coastline, such as seagrass beds and reefs (PN 651), have been included within the Governments wider habitats target, although their restoration will likely only contribute marginally to the overall target area.

Saltmarsh

Saltmarshes are coastal habitats that occur in estuaries, or in areas sheltered by barrier islands and coastal bays.[207] Salt-tolerant plants such as species of grass, rush and sedge, are characteristic of saltmarsh.[58] Saltmarshes were reported to be in a slightly better condition when compared with other freshwater and wetland habitats (Box 4) with 36% of estuary and 50% of coastal saltmarsh reported by the Environment Agency to be at ‘good status’.[185]

The Environment Agency reported that saltmarsh currently covers around 35,5055 ha in England (based on data collected between 2016-2019).[208] This is an increase by 7% in total area compared with the first published inventory (collected between 2006-2009). These recent increases follow on from historic national losses largely due to the conversion of saltmarsh for agriculture and coastal development, and longer term monitoring will be necessary to determine if this is a real positive trend.[207,208] Much of the recent increase (870 ha or 37%) can be attributed to gains in managed/ unmanaged realignment (PN 647) and regulated tidal exchange sites (where barriers that block tidal waters from entering saltmarsh are removed and agriculture is abandoned).[58] In particular, the large-scale projects at Steart Marshes (PN 651), Alkborough Flats, Medmerry and Hesketh Out Marsh.

However, care is needed in interpreting this data, as there have been declines in many regions over the same period. For example, around Poole

Harbour, saltmarshes have declined by 18 ha over a 6-year period[208]. The reason for this decline is complex but can be attributed in part to high levels of nitrogen causing eutrophication, coastal squeeze (see below), die-back of one of the principal plant species and a loss of sediment from the system.

The RSPB's Wallasea Island, in Essex, is the largest coastal wetland site created in the UK at 740 ha.[209,210] The project involved moving 4.5 million tonnes of sediment to the site to create a wetland mosaic of mudflats, saltmarsh and saline lagoons on former farmland, at a cost of around £50 million.[209,211,212] The majority of the sediment needed for the project was leftover sediment produced as a by-product of tunnelling work in London by Crossrail. Use of sediment that has already been dredged or excavated as part of other projects is important for the sustainability of wetland restoration.[213] It took almost 20 years from the original project conception to completion of all major restoration activities.[212]

Wallasea Island forms part of 8,750 ha of wetland (or future wetland habitat) that the RSPB has acquired for habitat creation or restoration between 1990 and 2015.[214] These restored wetlands support significant proportions of the UKs breeding bird population as well as other important wildlife.[214]

Based on this experience, the RSPB reported that challenges for future wetland restoration, creation and management include, the high cost of wetland management, reducing levels of predation, the need to increase available resources and being able to adapt site management to cope with the effects of climate change.[214]

Climate induced sea-level rise could cause a projected loss of 3,777 ha of saltmarsh in England between 2010-2060 through 'coastal squeeze'.[58] Coastal squeeze occurs when coastal habitats, like saltmarshes, cannot migrate inland when sea-levels rise as they may be blocked by built infrastructure like sea defences or developments like hotels (PN 647).[215] However some management methods, like introducing fenced areas which slow the flow of water and promote an increase in sediments, may be suitable for increasing the area of some saltmarshes impacted by coastal squeeze.[58]

The UK Government has set no specific targets for restoring saltmarsh habitat in England. However, many saltmarshes in England are protected for their conservation importance, and any losses due to coastal squeeze in front of flood defences must be compensated for.[58] Habitat potential maps are being produced that show areas where coastal and estuarine habitats could be created (i.e., where coastal processes still exist but the habitat has been degraded or lost). These maps will be used in the future in deciding where habitats could be created and where to target funding.

Sand dunes

Sand dunes are dynamic, mobile habitats that form along coastlines.[216] They are created as sand is blown and trapped by vegetation, forming ridges and depressions that can support rare species of plants and animals like the natterjack toad.[217] Sand dunes can be bare or covered by a range of plant species that can be categorised as dune heath, dune scrub, and dune grassland.

The Sand Dune Survey of Great Britain in the early 1990s, reported that sand dunes covered ~11,897 ha in England.[218] Although estimates differ, it is thought that the UK has lost 30% of its dune area since 1900.[219] English dunes may have experienced an even higher rate of loss: between 1875 and 1975 the area of sand dune almost halved from just under 20,000 ha to a more stable level from the 1970s onward.[219] A recent review of the conservation status suggested that ~1000 ha of modified habitat (where coastal process such as wind-blown sand remain) could be restored to functioning sand dune.[220]

Human activities such as sand fencing and tree planting, nutrient enrichment (from air pollution and agricultural run-off) alongside changes in climate have caused many dunes in the UK to become more stable,[61,221] which can reduce their biodiversity.[222] However, some older more static dunes can be a valuable archive of past environmental or archaeological information.[223] A range of younger, less stable shifting sand dunes through to older more stable sand dunes are needed to provide a spectrum of habitats and functions.

Sand dunes can also act as a natural coastal defence, acting as a buffer against the impacts of predicted sea level rise. However, this is only if they are not constrained by engineered coastal defences and are able to migrate inland with rising sea levels (PN 647).[224]

Dune habitats are one of the habitats in Europe that commentators highlight as most in need of restoration.[225] In the UK, Natural England and the Environment Agency undertake regular monitoring of sand dune extent and condition using remote sensing (Lidar and CASI, PN 628) and ground-truthing, but geographical coverage is incomplete particularly outside of protected sites.[226] This data is useful to monitor change and target restoration interventions. Natural England have published an aspirational target for England, to restore 1000 ha of modified sand dune habitats to good quality and functioning.[220]

Dynamic Dunescapes is a Natural England project with Natural Resources Wales, Plantlife, the Wildlife Trusts and the National Trust.[227] The project is restoring 34 sand dune sites covering 7,000 ha across England and Wales. Outcomes from the project are improving understanding the dynamics of natural dune habitats as well as informing best practice for restoration.[61]

Restoration measures for sand dunes can involve:

- removing scrub (Figure 3) and invasive species;
- re-establishing grazing (new 'NoFence' technology can be used to control grazing patterns);
- turf stripping (stripping the top layer of vegetation and organic matter to reach the underlying sand creates bare sand and removes accumulated nutrients), and;
- creating 'notches' (cutting a notch in the foredune allows windblown sand to reinvigorate over-stabilised dunes).[228–231,61]

These measures can re-establish movement of sand in dune systems and favour species that can colonise bare sand dunes.[61] Public perception has been an important challenge for restoring sand dunes as some interventions can initially be perceived to be damaging. To address this, the project has run an extensive engagement and communications programme alongside the conservation works to build an understanding and appreciation of sand dunes as a naturally dynamic habitat requiring conservation interventions.

Figure 3. Restoration work by the Dynamic Dunescapes Team at Cleethorpes sand dunes in Lincolnshire (reproduced after Dynamic Dunescapes).[230] Left, shows an area of dune before scrub clearance in 2018 and right, demonstrates an area of dune following from scrub clearance work in 2019 that is carpeted with orchids.

References

1. Environment Act 2021. Queen's Printer of Acts of Parliament.
2. Defra *et al.* (2021). Biodiversity metric: calculate the biodiversity net gain of a project or development. *GOV.UK*.
3. Save Our Magnificent Meadows (2022). Calcareous Grasslands.
4. Harding, L. W. *et al.* (2001). Aircraft Remote Sensing. in *Encyclopedia of Ocean Sciences (Second Edition)*. (ed. Steele, J. H.) 138–146. Academic Press.
5. Defra (2022). Biodiversity Terrestrial and Freshwater Targets. 154. Department for Environment, Food and Rural Affairs.
6. The Biodiversity information system for Europe (2022). Ecosystems and their services.
7. United Nations (1992). Convention on Biological Diversity - Article 2. Secretariat of the Convention on Biological Diversity.
8. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. *OJ L*.
9. European Environment Agency (2022). An introduction to habitats.
10. IPBES (2020). IPBES Home page. *IPBES secretariat*.
11. Kelly, J. R. *et al.* (1990). Indicators of ecosystem recovery. *Environ. Manage.*, Vol 14, 527–545.
12. Dakos, V. *et al.* (2022). Ecological resilience: what to measure and how. *Environ. Res. Lett.*, Vol 17, 043003. IOP Publishing.
13. Chambers, J. C. *et al.* (2019). Operationalizing Ecological Resilience Concepts for Managing Species and Ecosystems at Risk. *Front. Ecol. Evol.*, Vol 7,
14. Gann, G. D. *et al.* (2019). International principles and standards for the practice of ecological restoration. Second edition. *Restor. Ecol.*, Vol 27, S1–S46.
15. IPBES (2018). Semi-natural habitat(s).
16. RSPB (2021). Biodiversity loss: the UKs global rank for levels of biodiversity loss.
17. The Department of Agriculture, Environment & Rural Affairs (DAERA) (2021). Environment Strategy Consultation.
18. NatureScot (2022). Scotland's Biodiversity Strategy 2022-2045. *NatureScot*.
19. Scottish Government (2020). Scottish biodiversity strategy post-2020: statement of intent.
20. Welsh Government (2020). Nature recovery action plan.
21. Defra (2018). 25 Year Environment Plan. HM Government.
22. Defra (2022). 25 Year Environment Plan Annual Progress Report - April 2021 to March 2022. 63.
23. Natural Environment and Rural Communities Act 2006.
24. Hayhow, D. *et al.* (2019). State of Nature 2019. The State of Nature partnership.
25. Ridding, L. E. *et al.* (2020). Ongoing, but slowing, habitat loss in a rural landscape over 85 years. *Landsc. Ecol.*, Vol 35, 257–273.

26. Gibson, R. *et al.* (2007). Loss, Status and Trends for Coastal Marine Habitats of Europe. *Annu. Rev.*, Vol 45, 345–405.
27. Woodbridge, J. *et al.* (2014). The impact of the Neolithic agricultural transition in Britain: a comparison of pollen-based land-cover and archaeological 14C date-inferred population change. *J. Archaeol. Sci.*, Vol 51, 216–224.
28. Fyfe, R. M. *et al.* (2015). From forest to farmland: pollen-inferred land cover change across Europe using the pseudobiomization approach. *Glob. Change Biol.*, Vol 21, 1197–1212.
29. Roberts, N. *et al.* (2018). Europe's lost forests: a pollen-based synthesis for the last 11,000 years. *Sci. Rep.*, Vol 8, 716. Nature Publishing Group.
30. Office for National Statistics (2021). Semi-natural habitat natural capital accounts, UK: 2021.
31. Office for National Statistics (2022). *Habitat extent and condition, natural capital, UK: 2022*.
32. The Conservation of Habitats and Species Regulations 2017 (S.I. 2008/301.). Queen's Printer of Acts of Parliament.
33. Lawton, J. *et al.* (2010). *Making Space for Nature: A review of England's Wildlife Sites and Ecological Network*. 119. Report to Defra.
34. Jordan, W. R. *et al.* (2011). *Making nature whole: a history of ecological restoration*. Island Press.
35. National Trust (2019). Wildlife thriving at Cambridgeshire fenland oasis.
36. Ramsar Sites Information Service (2011). Upper Nene Valley Gravel Pits | Ramsar Sites Information Service.
37. Natural England (2022). Site: Wicken Fen SSSI Condition Summary.
38. Walmsley, D. C. *et al.* (2021). Ensuring the Long-Term Provision of Heathland Ecosystem Services—The Importance of a Functional Perspective in Management Decision Frameworks. *Front. Ecol. Evol.*, Vol 9,
39. Martin, L. *et al.* (2020). Nature contact, nature connectedness and associations with health, wellbeing and pro-environmental behaviours. *J. Environ. Psychol.*, Vol 68, 101389.
40. Roberts, A. *et al.* (2020). Nature activities and wellbeing in children and young people: a systematic literature review. *J. Adventure Educ. Outdoor Learn.*, Vol 20, 298–318. Routledge.
41. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, IPBES. (2018). The IPBES assessment report on land degradation and restoration. Zenodo.
42. IPBES (2019). Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Zenodo.
43. Defra (2022). Woodland cover target. HM Government.
44. Defra (2022). *Keepers of time: ancient and native woodland and trees policy in England.* 25. HM Government.
45. JNCC (2019). Terrestrial habitat classification schemes.
46. JNCC (2020). National Vegetation Classification (NVC).
47. HM Government (1994). *Biodiversity: The UK Action Plan.* 192.
48. UK Post-2010 Biodiversity Framework (2012–2019) | JNCC Resource Hub.

Defra and Natural England (2022). Habitats and species of principal importance in England.

49. European Environment Agency (2022). EUNIS habitat classification.
50. NatureScot (2017). NatureScot Commissioned Report 766: Manual of terrestrial EUNIS habitats in Scotland.
51. UKHab Ltd. (2018). UK Habitat Classification.
52. UKHab Ltd. (2018). BNG.
53. McCullagh, F. (2022). Personal communication. Natural England.
54. Jung, M. *et al.* (2020). A global map of terrestrial habitat types. *Sci. Data*, Vol 7, 256. Nature Publishing Group.
55. Keith, D. A. *et al.* (2020). IUCN Global Ecosystem Typology 2.0: descriptive profiles for biomes and ecosystem functional groups. IUCN, International Union for Conservation of Nature.
56. Blakesley, D. *et al.* (2016). *Grassland Restoration and Management*. Pelagic Publishing Ltd.
57. Natural England (2010). Planning river restoration - STREAM01.
58. Hudson, R. *et al.* (2021). Saltmarsh restoration handbook: UK and Ireland. Environment Agency.
59. Natural England (2008). Seed sources for grassland restoration and re-creation in Environmental stewardship - TIN038.
60. Natural England (2008). Soil sampling for habitat recreation and restoration - TIN035.
61. Jones, L. *et al.* (2021). The sand dune managers handbook. Produced for the Dynamic Dunescapes (DuneLIFE) project: LIFE17 NAT/UK/000570; HG-16-086436.
62. Buglife (2018). Wildflower-rich Grassland Restoration.
63. Woodland Trust (2021). Woodland Creation Guide. 330.
64. Rieger, J. *et al.* (2014). *Project planning and management for ecological restoration*. Island Press.
65. Ruiz-Jaén, M. C. *et al.* (2005). Vegetation structure, species diversity, and ecosystem processes as measures of restoration success. *For. Ecol. Manag.*, Vol 218, 159–173.
66. Rieger, J. *et al.* (2014). Plant Material. in *Project Planning and Management for Ecological Restoration*. (eds. Rieger, J. et al.) 115–134. Island Press/Center for Resource Economics.
67. Law, A. *et al.* (2017). Using ecosystem engineers as tools in habitat restoration and rewilding: beaver and wetlands. *Sci. Total Environ.*, Vol 605–606, 1021–1030.
68. Smith, P. L. (2014). Lichen translocation with reference to species conservation and habitat restoration. *Symbiosis*, Vol 62, 17–28.
69. May, L. (2012). Loch Leven: a UK Lake Restoration case study. UKCEH.
70. Management Case Study: Notch creation and slack scrapes. *Dynamic Dunescapes*.
71. Acreman, M. C. *et al.* (2007). Hydrological science and wetland restoration: some case studies from Europe. *Hydrol. Earth Syst. Sci.*, Vol 11, 158–169. Copernicus GmbH.
72. Rieger, J. *et al.* (2014). Design. in *Project Planning and Management for Ecological Restoration*. (eds. Rieger, J. et al.) 83–98. Island Press/Center for Resource Economics.
73. Rieger, J. *et al.* (2014). Maintenance and Stewardship. in *Project Planning and Management for Ecological Restoration*. (eds. Rieger, J. et al.) 179–188. Island Press/Center for Resource Economics.
74. Chazdon, R. *et al.* (2021). The intervention continuum in restoration ecology: rethinking the active-passive dichotomy. *Restor. Ecol.*,

75. Wilson, J. W. *et al.* (2019). *Conservation biology in Sub-Saharan Africa*.
76. Perino, A. *et al.* (2019). Rewilding complex ecosystems. *Science*, Vol 364, eaav5570. American Association for the Advancement of Science.
77. Pettorelli, N. *et al.* (2018). Making rewilding fit for policy. *J. Appl. Ecol.*, Vol 55, 1114–1125.
78. RSPB (2022). Beaver Reintroduction in the UK.
79. Rewilding Britain (2022). What's so special about beavers?
80. Sandom, C. *et al.* (2019). Rewilding a country: Britain as a case study. in *Rewilding*. 222–247. Cambridge University Press.
81. White, C. *et al.* (2015). Cost-benefit analysis for the reintroduction of lynx to the UK: main report. 1–47. AECOM.
82. Schweiger, A. H. *et al.* (2020). Analogous losses of large animals and trees, socio-ecological consequences, and an integrative framework for rewilding-based megabiota restoration. *People Nat.*, Vol 2, 29–41.
83. The Vincent Wildlife Trust (2015). Pine Marten Recovery Projects.
84. Rewilding Britain (2022). Rewilding projects and local groups.
85. Wild Ennerdale (2022). Shaping the Landscape Naturally.
86. Cairngorms Connect (2022). Home.
87. Tree, I. (2017). The Knepp Wildland project. *Biodiversity*, Vol 18, 206–209. Taylor & Francis.
88. Maron, M. *et al.* (2012). Faustian bargains? Restoration realities in the context of biodiversity offset policies. *Biol. Conserv.*, Vol 155, 141–148.
89. Walker, K. *et al.* (2004). The restoration and re-creation of species-rich lowland grassland on land formerly managed for intensive agriculture in the UK. *Biol. Conserv.*, Vol 119, 1–18.
90. Goossens, E. P. *et al.* (2022). Phosphorus puts a mortgage on restoration of species-rich grasslands on former agricultural land. *Restor. Ecol.*, Vol 30, e13523.
91. Maskell, L. *et al.* (2014). Restoration of natural capital: review of evidence. 20. Final Report to the Natural Capital Committee.
92. Watts, K. *et al.* (2020). Ecological time lags and the journey towards conservation success. *Nat. Ecol. Evol.*, Vol 4, 304–311. Nature Publishing Group.
93. Harris, J. A. *et al.* (2006). Ecological Restoration and Global Climate Change. *Restor. Ecol.*, Vol 14, 170–176.
94. JNCC (2019). Common Standards Monitoring.
95. RestREco Project (2022). Restoring Resilient Ecosystems.
96. Rothero, E. *et al.* (2020). Recovering lost hay meadows: An overview of floodplain-meadow restoration projects in England and Wales. *J. Nat. Conserv.*, Vol 58, 125925.
97. Bullock, J. M. *et al.* (2022). Future restoration should enhance ecological complexity and emergent properties at multiple scales. *Ecography*, Vol 2022,
98. Pearsons, T. *et al.* (1992). Influence of habitat complexity on resistance to flooding and resilience of stream fish assemblages. *Trans. Am. Fish. Soc.*, Vol 121, 427–436.
99. Rogers, A. *et al.* (2014). Vulnerability of Coral Reef Fisheries to a Loss of Structural Complexity. *Curr. Biol.*, Vol 24, 1000–1005.
100. Moreno-Mateos, D. *et al.* (2020). The long-term restoration of ecosystem complexity. *Nat. Ecol. Evol.*, Vol 4, 676–685.
101. Natural Environment and Rural Communities Act 2006 - S41.

102. National Forest Inventory (2020). NFI woodland ecological condition in England: classification results. Forestry Commission.
103. Lee, B. *et al.* (2021). State of the UK's Woods and Trees 2021. 245.
104. Forestry Commission England (2010). *Managing ancient and native woodland in England.* Forestry Commission England.
105. Thompson, R. *et al.* (2003). Restoration of native woodland on ancient woodland sites: practice guide. Forestry Commission.
106. Defra (2021). England Trees Action Plan 2021 to 2024.
107. Environment, Food and Rural Affairs Committee (2022). Tree planting. House of Commons Environment, Food and Rural Affairs Committee.
108. Woodland Trust (2021). Restoring your ancient woodland: Guidance and training.
109. Woodland Trust (2020). How we restore ancient woodland.
110. Dolman, P. *et al.* (2010). Escalating; ecological impacts: Of deer in lowland woodland. *Br. Wildl.*, Vol 21, 242–254.
111. Fuentes-Montemayor, E. *et al.* (2020). Small mammal responses to long-term large-scale woodland creation: the influence of local and landscape-level attributes. *Ecol. Appl.*, Vol 30, e02028.
112. Wäber, K. *et al.* (2013). Achieving landscape-scale deer management for biodiversity conservation: The need to consider sources and sinks. *J. Wildl. Manag.*, Vol 77, 726–736.
113. Pollock, M. *et al.* (2022). *Overcoming deer management challenges*. Scotland's Rural College (SRUC).
114. Defra (2022). Consultation on proposals for the deer management strategy.
115. Woodland Trust (2022). Types of woodland management.
116. Buckley, P. (2020). Coppice restoration and conservation: a European perspective. *J. For. Res.*, Vol 25, 125–133. Taylor & Francis.
117. Kirby, K. J. *et al.* (2017). Restoration of broadleaved woodland under the 1985 Broadleaves Policy stimulates ground flora recovery at Shabbington Woods, southern England. *New J. Bot.*, Vol 7, 125–135.
118. Kirby, K. J. *et al.* (2017). Biodiversity implications of coppice decline, transformations to high forest and coppice restoration in British woodland. *Folia Geobot.*, Vol 52, 5–13.
119. Weiss, M. *et al.* (2021). The effect of coppicing on insect biodiversity. Small-scale mosaics of successional stages drive community turnover. *For. Ecol. Manag.*, Vol 483, 118774.
120. Fartmann, T. *et al.* (2013). Effects of coppicing on butterfly communities of woodlands. *Biol. Conserv.*, Vol 159, 396–404.
121. de Schaetzen, F. *et al.* (2018). The influence of wild boar (Sus scrofa) on microhabitat quality for the endangered butterfly Pyrgus malvae in the Netherlands. *J. Insect Conserv.*, Vol 22, 51–59.
122. Wilder Blean | Kent Wildlife Trust.
123. Evans, M. N. *et al.* (1992). Coppicing and natural disturbance in temperate woodlands — a review. in *Ecology and Management of Coppice Woodlands*. (ed. Buckley, G. P.) 79–98. Springer Netherlands.
124. Hodder, K. H. *et al.* (2009). Can the mid-Holocene provide suitable models for rewilding the landscape in Britain? *Br. Wildl.*, Vol 20, 4–15.
125. Mitchell, F. J. G. (2005). How open were European primeval forests? Hypothesis testing using palaeoecological data. *J. Ecol.*, Vol 93, 168–177.

126. van Asperen, E. N. *et al.* (2017). Dietary traits of the late Early Pleistocene Bison menneri (Bovidae, Mammalia) from its type site Untermassfeld (Central Germany) and the problem of Pleistocene 'wood bison'. *Quat. Sci. Rev.*, Vol 177, 299–313.
127. Maddock, A. (2011). UK Biodiversity Action Plan Priority Habitat Descriptions: Wood-Pasture and Parkland. JNCC.
128. Armstrong, H. *et al.* (2003). A survey of cattle-grazed woodlands in Britain. Forest Research.
129. Fuentes-Montemayor, E. *et al.* (2022). The long-term development of temperate woodland creation sites: from tree saplings to mature woodlands. *For. Int. J. For. Res.*, Vol 95, 28–37.
130. Broughton, R. K. *et al.* (2021). Long-term woodland restoration on lowland farmland through passive rewilding. *PLOS ONE*, Vol 16, e0252466. Public Library of Science.
131. Park, K. (2022). Personal Communication. WrEN.
132. Bullock, J. *et al.* (2011). Semi-natural grasslands. UNEP-WCMC.
133. Office for National Statistics (2018). UK natural capital: developing semi-natural grassland ecosystem accounts.
134. Ridding, L. E. *et al.* (2015). Fate of semi-natural grassland in England between 1960 and 2013: A test of national conservation policy. *Glob. Ecol. Conserv.*, Vol 4, 516–525.
135. Plantlife (2018). Action now for species-rich grasslands. Plantlife.
136. Rothero, E. *et al.* (2016). *Floodplain meadows beauty and utility: a technical handbook*.
137. Rural Payments Agency *et al.* (2022). GS7: Restoration towards species-rich grassland. *GOV.UK*.
138. Rural Payments Agency *et al.* (2021). Environmental Land Management schemes: overview. *GOV.UK*.
139. Natural England (2020). Definition of Favourable Conservation Status for Lowland Calcareous Grassland - RP2944.
140. Natural England, N. (20202). Definition of Favourable Conservation Status for Lowland Dry Acid Grassland - RP2945.
141. Natural England (2020). Definition of Favourable Conservation Status for Purple Moor-grass & Rush Pastures - RP2947.
142. Natural England (2020). Definition of Favourable Conservation Status for Upland Hay Meadows - RP2948.
143. Kiehl, K. *et al.* (2010). Species introduction in restoration projects – Evaluation of different techniques for the establishment of semi-natural grasslands in Central and Northwestern Europe. *Basic Appl. Ecol.*, Vol 11, 285–299.
144. Stevenson, M. J. *et al.* (1995). Re-creating Semi-natural Communities: Effect of Sowing Rate on Establishment of Calcareous Grassland. *Restor. Ecol.*, Vol 3, 279–289.
145. RBG Kew (2022). UK Native Seed Hub.
146. Anderson, G. (2022). Personal Communication. WBEP.
147. Forest of Bowland AONB (2021). Meadow Makers Project.
148. Coverdale, D. (2021). Tees-Swale hay meadow restoration. *North Pennines AONB*.
149. Save Our Magnificent Meadows (2020). Restoration using green hay.
150. Pearson, A. W. *et al.* (2018). Meadowlands in time: re-envisioning the lost meadows of the Rother valley, West Sussex, UK. *Landsc. Hist.*, Vol 39, 25–55. Routledge.

151. Brian, A. *et al.* (2002). *The History and Natural History of Lugg Meadow.* Logaston Press.
152. Natural England (2017). Conserving Historic Water Meadows. Historic England.
153. Wallace, H. *et al.* (2015). *Clattinger Farm SSSI: report of monitoring in 2014.* Report to Wiltshire Wildlife Trust.
154. Cook, H. f. (2010). Floodplain agricultural systems: functionality, heritage and conservation. *J. Flood Risk Manag.*, Vol 3, 192–200.
155. Stevens, K. (2022). Personal Communication. Natural England.
156. Hosie, C. *et al.* (2019). Restoration of a floodplain meadow in Wiltshire, UK through application of green hay and conversion from pasture to meadow management. 6.
157. Woodcock, B. A. *et al.* (2011). Can long-term floodplain meadow recreation replicate species composition and functional characteristics of target grasslands? *J. Appl. Ecol.*, Vol 48, 1070–1078.
158. the Floodplain Meadows Partnership (2022). Welcome to the Floodplain Meadows Partnership Website.
159. Loidi, J. *et al.* (2020). Heathlands of Temperate and Boreal Europe. in *Encyclopedia of the World's Biomes*. (eds. Goldstein, M. I. et al.) 656–668. Elsevier.
160. Groves, J. A. *et al.* (2012). Long-term development of a cultural landscape: the origins and dynamics of lowland heathland in southern England. *Veg. Hist. Archaeobotany*, Vol 21, 453–470.
161. Webb, N. r. (1998). The traditional management of European heathlands. *J. Appl. Ecol.*, Vol 35, 987–990.
162. Bunting, M. J. (1996). The development of heathland in Orkney, Scotland: pollen records from Loch of Knitchen (Rousay) and Loch of Torness (Hoy). *The Holocene*, Vol 6, 193–212. SAGE Publications Ltd.
163. Fyfe, R. M. *et al.* (2008). Historical context and chronology of Bronze Age land enclosure on Dartmoor, UK. *J. Archaeol. Sci.*, Vol 35, 2250–2261.
164. Office for National Statistics (2017). UK natural capital: developing UK mountain, moorland and heathland ecosystem accounts.
165. Rose, R. J. *et al.* (2000). Changes on the heathlands in Dorset, England, between 1987 and 1996. *Biol. Conserv.*, Vol 93, 117–125.
166. Webb, N. R. (1990). Changes on the Heathlands of Dorset, England, between 1978 and 1987. *Biol. Conserv.*, Vol 51, 273–286.
167. Hooftman, D. A. P. *et al.* (2012). Mapping to inform conservation: A case study of changes in semi-natural habitats and their connectivity over 70years. *Biol. Conserv.*, Vol 145, 30–38.
168. Ratcliffe, D. A. (1984). Post-Medieval and Recent Changes in British Vegetation: The Culmination of Human Influence. *New Phytol.*, Vol 98, 73–100.
169. Rural Payments Agency *et al.* (2022). LH1: Management of lowland heathland. *GOV.UK*.
170. Rural Payments Agency *et al.* (2022). LH2: Restoration of forestry and woodland to lowland heathland. *GOV.UK*.
171. Rural Payments Agency *et al.* LH3: Creation of heathland from arable or improved grassland. *GOV.UK*.
172. Shellswell, C. *et al.* (2016). Rehabilitation of existing lowland heathland - timescales to achieve favourable condition. Plantlife.

173. Pywell, R. F. *et al.* (2011). Long-term heathland restoration on former grassland: The results of a 17-year experiment. *Biol. Conserv.*, Vol 144, 1602–1609.
174. Mineral Products Association (2021). Quarries & Nature: A 50 year success story. Mineral Products Association.
175. RSPB (2022). Home - Nature After Minerals.
176. CEMEX UK (2022). Heathland restoration at Rugeley Quarry.
177. Bellow, H. (2017). Condition of wildlife habitat to be assessed through insect DNA. *The RSPB*.
178. WWT (2022). Wetlands.
179. Entwistle, N. S. *et al.* (2019). Recent changes to floodplain character and functionality in England. *CATENA*, Vol 174, 490–498.
180. Keating, K. *et al.* (2015). Cost estimation for habitat creation - summary of evidence. Environment Agency.
181. House of Commons Environmental Audit Committee (2022). *Water Quality in Rivers*. 139.
182. RSPB *et al.* (2021). Troubled Waters Report.
183. Brooker, M. P. (1985). The ecological effects of channelization. *Geogr. J.*, Vol 151, 63–69.
184. The Water Environment (Water Framework Directive) (England and Wales) Regulations 2017. Queen's Printer of Acts of Parliament.
185. Environment Agency *et al.* (2021). State of the water environment indicator B3: supporting evidence. *GOV.UK*.
186. Defra (2022). Water targets Detailed Evidence report.
187. Addy, S. *et al.* (2016). River restoration and biodiversity. the IUCN National Committee UK.
188. Suffolk Wildlife Trust (2022). Pond restoration and management.
189. Aquatic Restoration Partnership (2014). Ponds.
190. Robson, H. *et al.* (2022). Restoring lost farmland ponds. *WWT*.
191. Defra (2022). Sustainable Farming Incentive: full guidance. *GOV.UK*.
192. Bonn, A. *et al.* (2016). Peatland Restoration and Ecosystem Services: Science, Policy and Practice. Cambridge University Press.
193. International Peatland Society (2020). What are peatlands?
194. Defra (2021). England Peat Action Plan.
195. IUCN UK Peatland Programme (2022). UK Peatlands. *IUCN Peatland Programme*.
196. Clarke, S. (2021). Restoration Grants awarded to restore thousands of hectares of peatland. *Natural England*.
197. Department for Business, Energy & Industrial Strategy (2022). Net Zero Strategy: Build Back Greener. HM Government.
198. Defra (2021). Annual reports and accounts 2020-2021. Defra.
199. Thom, T. *et al.* (2019). Conserving Bogs: The Management Handbook. IUCN UK Peatland Programme.
200. Pilkington, M. *et al.* (2021). Diversification of Molinia- dominated blanket bogs using Sphagnum propagules. *Ecol. Solut. Evid.*, Vol 2,
201. Hancock, M. H. *et al.* (2018). Vegetation response to restoration management of a blanket bog damaged by drainage and afforestation. *Appl. Veg. Sci.*, Vol 21, 167–178.
202. Alderson, D. M. *et al.* (2019). Trajectories of ecosystem change in restored blanket peatlands. *Sci. Total Environ.*, Vol 665, 785–796.
203. The Great North Bog (2022). The Great North Bog – The UK's Peatland Restoration Partnership.

204. The Wildlife Trust for Lancashire, Manchester and North Merseyside (2020). Pioneering Winmarleigh carbon farm is fighting climate change.
205. Bonn, A. *et al.* (2014). Investing in nature: Developing ecosystem service markets for peatland restoration. *Ecosyst. Serv.*, Vol 9, 54–65.
206. Osborne, A. W. *et al.* (2021). From bare peat desert to nature reserve within ten years: a review of restoration practice on Little Woolden Moss, Manchester, UK. *North West Geogr.*, Vol 21, 31–48. Manchester Geographical Society.
207. Adnitt, C. *et al.* (2007). *Saltmarsh management manual.* Environment Agency.
208. Environment Agency (2022). The extent and zonation of saltmarsh in England: 2016-2019.
209. Ausden, M. *et al.* (2015). *WALLASEA: a wetland designed for the future*. RSPB.
210. RSPB (2022). Wallasea Island Nature Reserve, Essex. *The RSPB*.
211. BBC (2012). Wallasea Island nature reserve project construction begins.
212. RSPB (2022). Wallasea Island Wild Coast Project | Our Work.
213. Manning, W. *et al.* (2021). Restoring estuarine and coastal habitats with dredged sediment: a handbook. Environment Agency, CEFAS, ABP Mer.
214. Ausden, M. *et al.* (2019). Wetland restoration by the RSPB – what has it achieved for birds? *Br. Birds*, Vol 112,
215. Pontee, N. *et al.* (2021). What is coastal squeeze? Environment Agency.
216. The Wildlife Trusts (2022). Sand dunes.
217. Philip Smith (2019). Effects of environmental factors and conservation measures on a sand-dune population of the natterjack toad (Epidalea calamita) in north-west England: a 31-year study. *Herpetol. J.*, 146–154.
218. Radley, G. (1994). *Sand Dune Vegetation Survey of Great Britain: A National Inventory*. JNCC.
219. Jones, L. *et al.* (2011). *Coastal Margins. In: UK National Ecosystem Assessment Understanding nature's value to society*. UK National Ecosystem Assessment.
220. Rees, S. (2020). Definition of Favourable Conservation Status for Coastal Sand Dunes - RP2942. Natural England.
221. Provoost, S. *et al.* (2011). Changes in landscape and vegetation of coastal dunes in northwest Europe: a review. *J. Coast. Conserv.*, Vol 15, 207–226.
222. Rhind, P. *et al.* (2013). The Impact of Dune Stabilization on the Conservation Status of Sand Dune Systems in Wales. in *Restoration of Coastal Dunes*. (eds. Martínez, M. L. et al.) 125–143. Springer.
223. Pye, K. *et al.* (2020). Is 're-mobilisation' nature restoration or nature destruction? A commentary. Discussion. *J. Coast. Conserv.*, Vol 24, 10.
224. Defra *et al.* (2021). Sand dune processes and management for flood and coastal defence. *GOV.UK*.
225. European Environment Agency (2020). State of nature in the EU — European Environment Agency. 101.
226. Environment Agency, E. (2022). CASI and LIDAR Habitat Map.
227. Dynamic Dunescapes (2021). Home.
228. Dynamic Dunescapes (2021). Management Case Study: Notch creation and slack scrapes.

229. Dynamic Dunescapes (2021). Management Case Study: Invasive Species (Clematis) Removal.
230. Dynamic Dunescapes (2021). Management Case Study: Scrub Coppicing, Cleethorpes, Lincolnshire.
231. Dynamic Dunescapes (2021). Management Case Study: UXO, Scrub Clearance and Scrapes, Braunton Burrows.

Contributors

POST is an office of both Houses of Parliament, charged with providing independent and balanced analysis of policy issues that have a basis in science and technology. POST is grateful to Rachael Holmes for researching this briefing, to NERC for funding this parliamentary fellowship. For further information on this subject, please contact the co-author, Dr Jonathan Wentworth.

POST is also grateful to all contributors and reviewers:

Bethany Chamberlain, BES Policy

Dr Daniela Russi, BES Policy

Peter Shepherd, BSG Ecology

Jamie Robbins, Buglife B-lines

Rachel Richards, Buglife B-lines

Jason Reeves, CIEEM

Harry Greenfield, Country Land and Business Association (CLA)*

Professor Jim Harris, Cranfield University/RestREco

Freya Dixon van-Djik, Defra*

Eleanor Andrews, Defra*

Hugh Loxton, Defra*

Judith Stuart, Defra*

Henrietta Appleton, Game and Wildlife Conservation Trust/Allerton Project

Alastair Leake, Game and Wildlife Conservation Trust/Allerton Project

Dr Ted Chapman, Kew/UK Native Seed Hub

Dr Christopher Cockel, Kew/UK Native Seed Hub

Professor Simon Caporn, Manchester Metropolitan/CARE PEAT Project*

David Payne, Mineral Products Association (MPA)*

Dr Rosie Hails, National Trust

James Grischeff, Natural England

Verity Pitts, Natural England/Dynamic Dunescapes*

Dr Louise Denning, Natural England/Dynamic Dunescapes*

Katey Stephen, Natural England*

Frances McCullagh, Natural England*

Emma Goldberg, Natural England*

Dr Louise Denning, Natural England*

David Glaves, Natural England*

Dr Alice Noble, Natural England*

Dr Isabel Alonso, Natural England*

Clare Pinches, Natural England*

Poppy Sherborne, NFU*

Professor David Gowing, Open University/Floodplain Meadows Partnership*

Jenna Hegarty, RSPB

Nigel Symes, RSPB/Nature After Minerals

David Edwards, Sheffield University

Professor Kirsty Park, Stirling University/RestREco/WrEn

Dr Emma Toovey, the Environment Bank

Dr Jo Treweek, Treweek Environmental Consultants/UK Hab/eCountability/Wendling Beck Environment Project

Professor James Bullock, UKCEH/RestREco

Dr Nick Isaac, UKCEH

Katie Powell,UKCEH/BES Policy

Professor Richard Pywell, UKCEH/RestREco

Bob Edmunds, UKHab

Professor Douglas Yu, University of East Anglia/Nature Metrics

John Martin, University of Plymouth

Glenn Anderson, Wendling Beck Environment Project

Richard Benwell, Wildlife and Countryside link

Christine Reid, Woodland Trust*

Dr Nathalie Pettorelli, ZSL/IUCN Rewilding Working Group *denotes people and organisations who acted as external reviewers of the briefing

The Parliamentary Office of Science and Technology (POST) is an office of both Houses of Parliament. It produces impartial briefings designed to make scientific information and research accessible to the UK Parliament. Stakeholders sometimes contribute to and review POSTbriefs. POST is grateful to these contributors.

POST's published material is available to everyone at post.parliament.uk. Get our latest research delivered straight to your inbox. Subscribe at post.parliament.uk/subscribe.

post.parliament.uk

@POST_UK