State of the Assets

A Technical Report for the State of Natural Capital Report for England 2024

October 2024

www.gov.uk/natural-england

About Natural England

Natural England is here to secure a healthy natural environment for people to enjoy, where wildlife is protected and England's traditional landscapes are safeguarded for future generations.

Further Information

This report can be downloaded from the Natural England Access to Evidence Catalogue. For information on Natural England publications or if you require an alternative format, please contact the Natural England Enquiry Service on 0300 060 3900 or email enquiries@naturalengland.org.uk.

Catalogue code: NERR137 TR2

Report Details

Authors

Jane Lusardi, Jenny Craven, Fiona Bell, Angharad Morgan, Miriam Dobson, Kirsty Martin, Patricia Rice, Caitlin Hinson

Project Manager

Eve MacKinnon

Keywords

Ecosystem, marine, coastal, freshwater, wetlands, woodlands, mountains, moorlands, heath, semi-natural grassland, enclosed farmland, urban, natural capital, risk, ecosystem services, benefits from nature, drivers of change

Acknowledgements

We would like to express our thanks to all those who have contributed during this study:

Project Advisory Group members

Clement Garcia, Frances Mynott and Lee Slater (Cefas); Chrissie Ingle, Lewis White and Robert Yarlett (Defra); John Stride and Ruth Hughes (Environment Agency); Andrew Canning-Trigg and Ben Ditchburn (Forestry Commission); Eleanor Tew and Jacob Waller (Forestry England); Chris Cheffings, Hannah Hoskins, Lauren Molloy, Lawrence Way, Niki Newton, Vicky Morgan (JNCC) and, Aisling Lannin and Leonie Robinson (MMO).

Natural England

Isabel Alonso-Rodriguez, JJ Buckle, James Bussell, Kristopher Carrigan, Stephen Chaplin, Caitlin Clark, Vilma Cortes, Ian Crosher, Alistair Crowle, Simon Curson, Emma Dear, Louise Denning, Joel Dixon, Dawn Enright, Melanie Fletcher, Matthew Funnell, Andrew Graham, Vashti Gwynn, Ruth Hall, James Highfield, Chris Hogarth, Tara Hooper, Jane Houghton, David Hunt, Louise Hutchby, Michelle Johnson, Joseph Jones, Fraenze Kibowski, Alice Kimpton, Michael Knight, Rosie Lear, Chris Mainstone, Maija Marsh, David Martin, Frances McCullagh, Sergio Milheiras, Rachael Mills, Martin Moss, Geoffrey Newman, Andy Nisbet, Ruth Oatway, Jakub Olewski, Ian Saunders, Sonja Schmidt, Anne Stefaniak, Katey Stephen, Dave Trigg, Becky Trippier, Peter Walker, Adam Waugh, Graham Weaver, Jessica Williams, Nell Williams Foley, Mike Young and Jo Ziemann.

Environment Agency

Jo Bayes, Vicky Beaumont-Brown, Susan Burton, Chris Cooper, Rachel Gibson, Catriona Hare, Alice Hiley, Owen Lewis, Glenn Maas, Jenny Marshall-Reed, Jonathan Ponting, Toni Scarr, Joanna Spink, Mike Summers, Nicola Terrett and Jenny Yarr.

Forestry Research

Elena Vanguelova.

Joint Nature Conservation Committee (JNCC)

Roma Banga.

UK Centre for Ecology and Hydrology

Lindsay Maskell, Lisa Norton, Ed Rowe, Kasia Sawicka and David Vowles.

With special thanks to

Alice Lord.

The team also acknowledges the contributions made by the following external contractors: Environment Systems and Natural Capital Solutions.

Citation

This report should be cited as: Lusardi, J. Craven, J. Bell, F. Morgan, A. Dobson, M, Martin, K, Rice, P. Hinson, C. (2024) State of the Assets: A Technical Report for the State of Natural Capital Report for England. Natural England, NERR137 TR2.

Executive summary

This is a technical report to support the State of Natural Capital Report for England 2024 (Lusardi and others, 2024). It sets out the state of eight ecosystem assets, collectively covering the whole of England:

- Marine
- Coastal margins
- Freshwaters and wetlands
- Woodlands and scrub
- Mountains, moorlands and heaths
- Semi-natural grasslands
- Enclosed farmland
- Urban

We report on the importance of each ecosystem asset, the benefits they provide and why they are at risk. We also identify priority actions to address the risks.

Using the findings of the Risk Register Technical Report (Morgan & Lusardi, 2024), we explore what is driving change in the eight ecosystem assets. This is based on the five main causes of nature loss, identified by the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES, 2016):

- Land and sea-use change
- Pollution
- Natural resource use and exploitation
- Climate change
- Invasive species

For each ecosystem asset we provide a dashboard with a selection of indicators for assessing change. A fuller set of indicators of ecosystem quantity and quality is provided in the Indicators and Data Appendix (Craven, Bell & Dobson, 2024). Data used is openly available national data, which is regularly collected and sensitive to change. Data gaps and limitations are detailed in this technical report. The Indicators and Data Methods Appendix sets out the methods used to measure the indicators (Bell & Craven, 2024).

The collation of evidence, indicators and data has enabled us to report comprehensively on the state of each ecosystem in this State of Assets Technical Report. This technical report is summarised in the State of Natural Capital Report for England 2024 (Lusardi and others, 2024).

Table of Contents

List of Figures

List of Tables

1 Introduction

This is a technical report to support the State of Natural Capital Report for England 2024 (Lusardi and others, 2024). Here we set out the state of the assets, the benefits they provide and explore what drivers are putting them at risk. These assets are ecosystems. The way that nature underpins society and the economy is through the living (e.g. plants, animals, bacteria) and non-living (e.g. soil, climate, water) components all interacting as a system, or ecosystem. In a natural capital framework, ecosystems are the assets that we want to protect and grow.

When ecosystems are healthy and biodiverse, they provide and sustain the benefits people depend on. This means that they work best when they have a full complement of species and aren't degraded. In the same way a sports team needs depth on the reserves bench to be able to overcome injury setbacks, ecosystems need a thriving population of species to give resilience to different environmental stresses. When they are intact with a full complement of species, they are more resilient to change, are adaptable and more productive. This is both in terms of their own regenerative properties and the benefits they provide to people. As with a financial portfolio, breadth and diversity ensures resilience and reduces risk.

Ecosystems are responsible for fundamental processes such as soil formation, the water cycle, and the flow of energy and nutrients through food webs. These are functions that cannot be substituted with other solutions such as technology. They are irreplaceable.

Loss of species reduces the ability of ecosystems to carry out their functions and increases the chance of exceeding tipping points. This is where ecosystems move from good working systems to poorer, less productive systems. Once tipping points have been exceeded, it is extremely difficult to recover them and the consequences for society are considerable. Because we do not know what many of these tipping points are, and many of our ecosystems are decreasing in area, degraded or declining (UK National Ecosystem Assessment, 2011), a focus on our ecosystem assets is essential and urgent.

1.1 Understanding the state of ecosystems

The state of our ecosystems affects how well they work and whether they provide benefits, or not, that in turn contribute to the economy. Using natural capital logic, figure 1 (taken from Lusardi and others, 2024) illustrates how much of an ecosystem we have (quantity), how good it is in terms of processes or cultural attributes (quality), and where it is (location) underpins the benefits people get from them. These three aspects together determine the state of our natural capital (Figure 1).

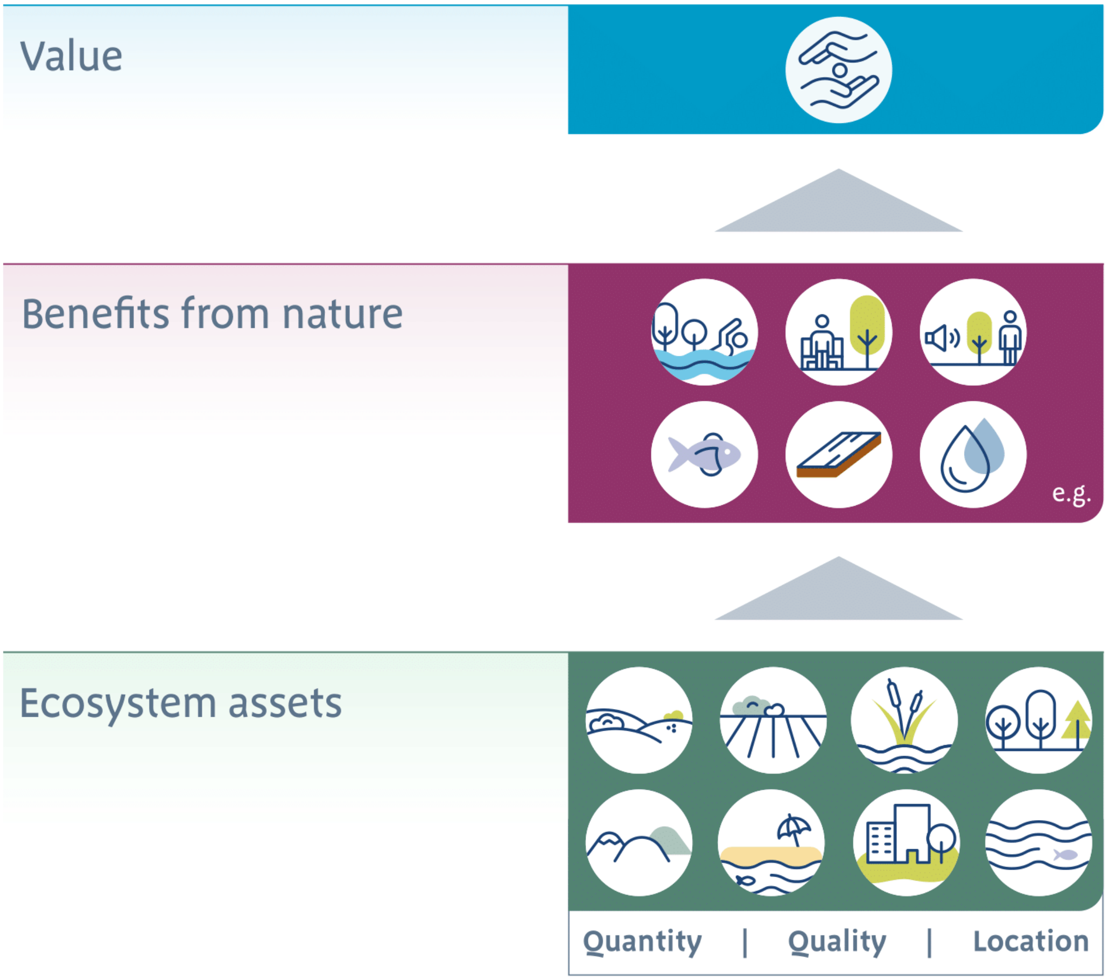


Figure 1. Natural capital logic chain. Ecosystems are the natural capital **assets** that underpin **the benefits on which society depends.** This figure shows example benefits from nature contributing to value to people and society.

Natural England has systematically identified which attributes of ecosystem quantity, quality and location underpin the provision of benefits (Lusardi and others, 2018), identifying indicators we can use to measure change. It is this evidence framework that has enabled the interpretation we offer in this State of the Assets Technical Report. We include a selection of indicators for measuring change in the asset state over time. Further indicators and information are provided in the Indicators and Data Appendix (Bell & Craven, 2024). Where indicators show progress against targets, or trends over time, these have been used to inform our assessment of natural capital risk: the Natural Capital Risk Register (the Risk Register) (Morgan & Lusardi, 2024) sets this out in detail.

Box 1. Indicators and data for measuring change

Indicators for the state of assets are based on Natural Capital Indicators: for defining and measuring change in natural capital - NERR076. This report identified indicators underpinning a full range of benefits. Our State of Natural Capital indicators cover ecosystem quantity (how extensive they are) and quality (what condition they are in). We would like to have more indicators for the location of ecosystems. However, where they are located spatially for the provision of benefits is complex and doesn't lend itself to simple indicators.

The number of indicators we report is limited by the availability of data. More data is available for marine, coastal and freshwater than for land-based ecosystems. We use the best available data, from a range of different sources. This data is openly available, transparent, consistently collected across England, usable at a national scale, collected regularly and sensitive to change. Where possible, we use indicators from the Defra Outcome Indicator Framework. The Indicators and Data Methods Appendix sets out the methods used to measure the indicators (Bell & Craven, 2024).

Further indicators and information are provided in the Indicators and Data Appendix, including:

- Linking indicators to different benefits
- Indicator trend direction (where available)
- Progress against targets (where available)
- Data used to measure the indicators
- Data gaps for measuring the state of natural capital

1.2 What assets do we report on?

We report on the state of eight broad ecosystem assets, collectively covering the whole of England. Figure 2 (taken from Lusardi and others, 2024) shows the extent of these ecosystems:

- Coastal margins and marine (reported together as an interconnected system)
- Freshwaters and wetlands
- Woodlands and scrub
- Mountains, moorlands and heaths
- Semi-natural grasslands
- Enclosed farmland
- Urban

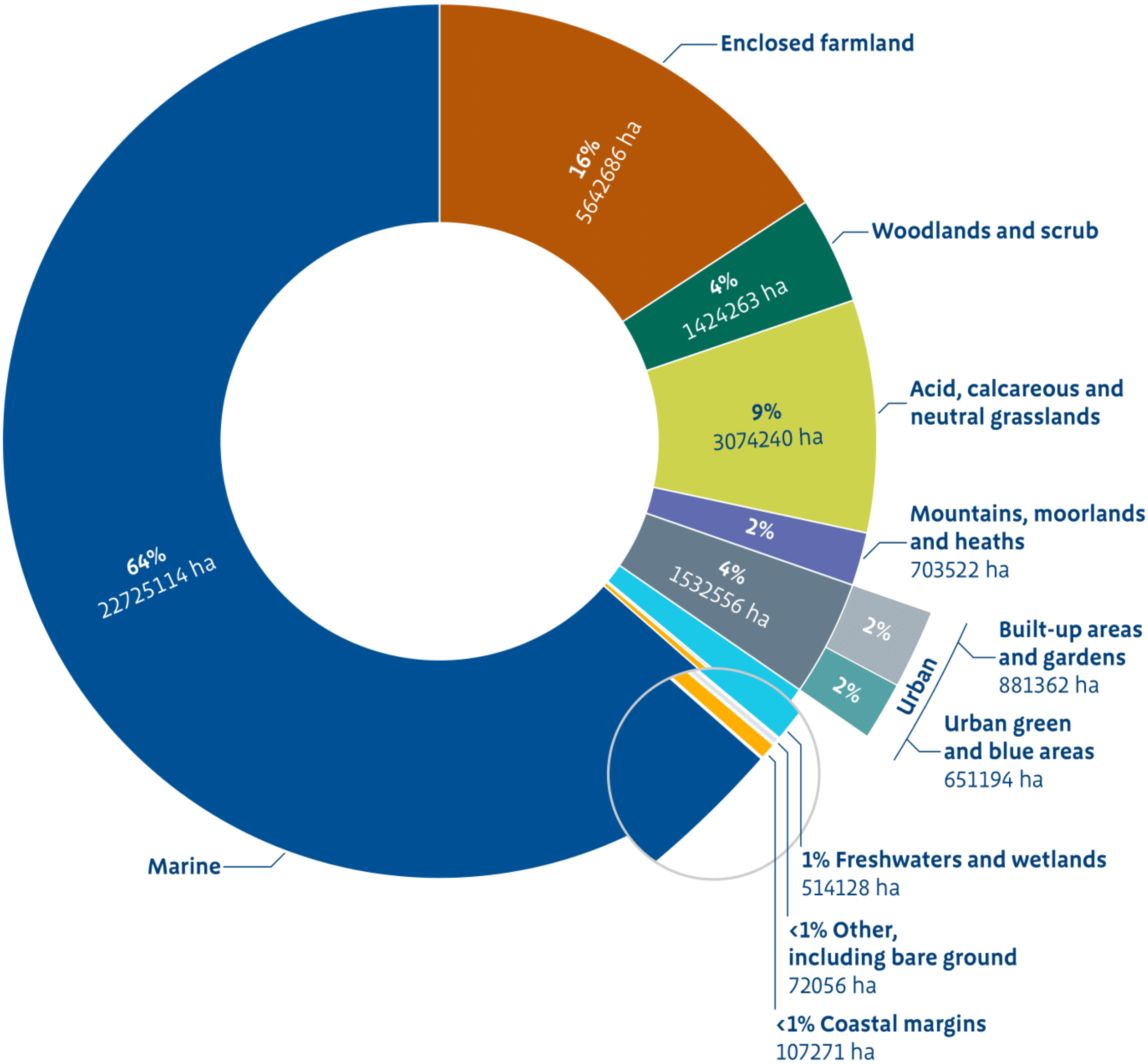


Figure 2. The extent of broad ecosystems in England. Terrestrial extents are measured using the Living England Phase IV dataset, which uses a predictive satellite-based habitat classification model. Please note that this figure shows the extent of acid, calcareous and neutral grassland, rather than semi-natural grassland. Marine extents are from Marine Habitats and Species Open Data.

1.3 What is driving risk to assets and benefits?

In this technical report we explore what is driving change in the assets and benefits. This is based on the five main drivers of change, or causes of nature loss, identified by the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES, 2016):

- Land and sea-use change
- Pollution

- Natural resource use and exploitation
- Climate change
- Invasive species

We also show our risk ratings for assets and benefits. Our assessment of risk is based on how impacted our ecosystems are already from the five main drivers of change, and the severity of these drivers now and going forward. The Risk Register provides further detail on the method and results for our assessment of risk (Morgan & Lusardi, 2024). Box 2 summarises how we have assessed risk.

Box 2. How have we assessed risk to natural capital?

We have assigned risk by assessing the severity of impact of past, current and ongoing drivers of change. This is based on an updated version of the UK National Ecosystem Assessment (2011) matrix of the impact of drivers on ecosystems. We have updated this using indicators trends and progress to targets, other evidence sources and the expert opinion of Natural England specialists.

Table 1. Impact and trend of direct drivers on the eight ecosystem assets

Ecosystem	Land- and sea-use change	Pollution	Natural resource use and exploitation	Climate change	Invasive species
Marine	↑	→	↗	↑	↑
Coastal margins	↗	→	↘	↑	↗
Freshwaters and wetlands	→	→	↗	↑	↗
Woodlands	↗	↗	↘	↗	↑
Mountains, moorlands and heaths	↗	→	↗	↑	→
Semi-natural grasslands	↗	↗	→	↗	→
Enclosed farmland	↗	→	→	↗	↗
Urban	↗	→	↗	↗	↗

Key to Table

Driver's impact on extent and condition of ecosystem assets

- Low
- Moderate
- High
- Very High

Driver's current (since the UKNEA[a]) and ongoing trend

[a] Exact timeframe over which trends were assessed differed across indicators depending on dataset availability

- ↘ Decreasing impact
- ↗ Increasing impact
- → Continuing impact
- ↑ Very rapid increase of impact

We have then assigned a risk rating to the impacts of drivers of change, shown in Table 2.

Table 2. Risk matrix, showing risk ratings for ecosystem assets based on the impact of drivers of change to date, plus current (since the UKNEA) and ongoing trends.

		Driver's current and ongoing trend (since the UKNEA[a])			
Driver's impact on extent and condition of ecosystem assets (1940-present)		↘ Decreasing Impact	→ Continuing Impact	↗ Increasing Impact	↑ Very Rapid Increase of Impact
	Very High	M	M	M-H	H
	High	L	M	M-H	H
	Moderate	L	M	M	M-H
	Low	L	L	M	M

[a] Exact timeframe over which trends were assessed differed across indicators depending on dataset availability.

Note: colour indicates the level of risk: red = high; orange = medium-high; yellow = medium; lemon = low risk.

We have applied this approach first to ecosystem assets and then to the benefits they provide. For the benefit risk ratings, we also take into account whether a driver impacts on a particular benefit or not. Further detail on the risk method and results is provided in the Risk Register (Morgan & Lusardi, 2024).

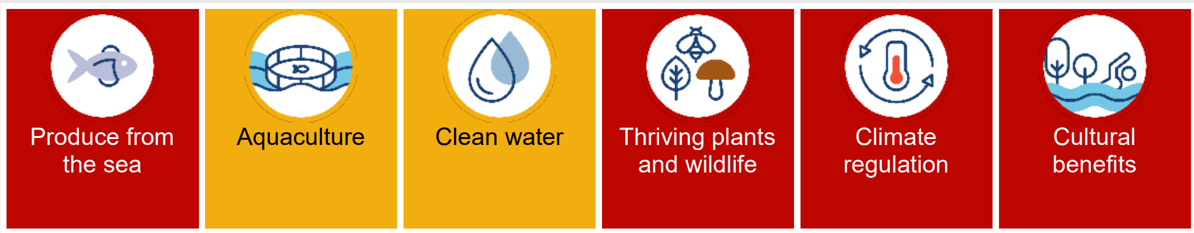
2 Marine and Coastal Margins

Box 3. Risk to marine and coastal margin ecosystem assets from main drivers of change

Our research has assessed how at-risk marine ecosystem assets are in England, and is summarised below.

	**Marine ecosystems** are at high risk due to:	
	Impact to date	Very high impact to date of **resource exploitation (fishing)** and **climate change** High impact to date of **land- and sea-use change**
	Trend – current and ongoing	Very rapid increase of impact from **climate change, land- and sea-use change,** and **invasive species** Increasing impact from **resource exploitation**

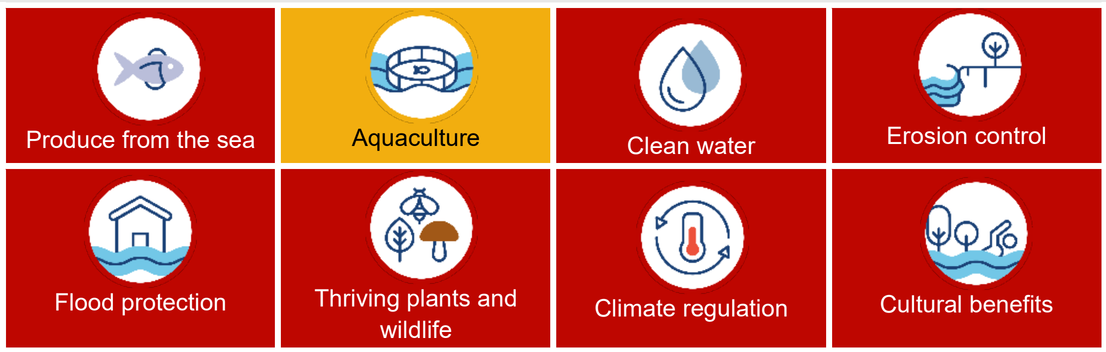
These drivers put the following benefits at risk (key: red = high risk, yellow = medium risk):



Our research has assessed how at-risk coastal margin ecosystem assets are in England, and is summarised below.

Coastal margins are at high risk due to:	
Impact to date	Very high impact to date of **land- and sea-use change, pollution and climate change**
Trend – current and ongoing	Very rapid increase of impact from **climate change** Increasing impact from **land- and sea-use change**, and **invasive species**

These drivers put the following benefits at risk (key: red = high risk, yellow = medium risk):



2.1 Why are marine and coastal margins important?

As an island nation, the coast and sea are a fundamental part of our national identity. With the UK Continental Shelf extending 200 nautical miles from the coast, English coastal and marine ecosystems cover 22,795,325 ha[†]. This is nearly twice the area of our terrestrial and freshwater ecosystems.

The coast and sea function together as a system driven by natural processes; tides, currents, climate and weather. As such, it is hard to draw a boundary between coastal and marine ecosystems. We are therefore considering them together in this section.

[†] For further detail, please see Appendix 1: Indicators and Data

Estuaries, sand dunes, saltmarshes, beaches and cliffs are found along our coastal margins. Sand dunes are ever changing, with different developmental stages supporting a huge diversity of plants, invertebrates and birds, as well as the rare natterjack toad. Saltmarshes are common along sheltered coastlines, including estuaries. Regularly flooded and drained by the sea, they provide important breeding and feeding sites for fish, waders and wildfowl.

The intertidal zone is covered and revealed by the tides. These ever-fluctuating conditions support mud, sand and coarser sediment intertidal flats and rocky shores. Seagrass beds are found in the intertidal and shallow sub-tidal areas, as are reefs created by mussels and worms. With increasing depth, rocky shores have zones of lichen, barnacles, limpets, and seaweed; below this is a deeper, darker, animal-dominated zone. In the deeper subtidal zone, soft bottom habitats, such as mud, mixed sand and coarser sediments, cover almost all of England's continental shelf.

This array of ecosystems supports a wealth of plant and animal life, from plankton and seaweeds at the bottom of the food chain to whales, dolphins and seals at the top. Seahorses and stalked jellyfish live in seagrass beds which, along with kelp, serve as refuge and nursery areas for mackerel, plaice and cod. The UK seas support over 330 different species of fish and around 100 seabirds, waders and wildfowl (Defra, 2019). This includes globally important numbers of breeding birds, as well as those wintering or on migration, such as pink-footed geese and red knot.

Our marine and coastal ecosystems support our sea fishing industry and communities. The total net profit of fish caught in UK waters was £284 million in 2018, with about a third of the catch from English waters (ONS, 2021). Aquaculture in our coastal waters includes salmon, shellfish (such as oysters, mussels, clams and scallops) and seaweed farming.

There is a major pollution burden on our estuarine and coastal waters, which receive 37% of England's treated sewage discharges (Environment Agency, 2023). While pollution is always best tackled at source, ecosystems help to dilute, detoxify and degrade pollutants to less toxic forms. For example, a single native oyster can filter up to 25 litres of water per hour, and in doing so removes nutrients, microplastics and bacteria (Green, 2016; Watson and others, 2020b).

Saltmarsh, seagrass, sand banks and dunes play a vital role in erosion control and flood protection for coastal communities. They dampen impacts of tidal surges, waves, storms and floods. The flood mitigation provided by English saltmarshes in 2019 has been valued at £62 million (ONS, 2022b).

Globally, ocean waters absorb a quarter of the carbon dioxide emitted annually by human activities (Watson and others, 2020a). Saltmarsh and seagrass are particularly important for capturing and storing carbon through photosynthesis and accumulation of sediments (Gregg and others, 2021). An estimate of between 10.5 and 60.1 million tonnes of carbon dioxide equivalent were sequestrated in UK waters in 2018 by saltmarsh and subtidal sand

and mud with an estimated value of between £742 million and £4,259 million (in 2019 prices) (ONS, 2021). This compares with gross carbon sequestration from terrestrial habitats of 28 million tonnes per year (ONS, 2020).

It is from the coast that people largely experience the sea. 25% of people had reported they visited the coast and sea in the month prior to being surveyed†. There were 423 million trips in 2018 and visitors' expenditure was estimated at £1,726 million (ONS, 2021). Swimming, playing, walking, wildlife watching, boating and other water sports, all contribute to a sense of freedom and escape. The rest and relaxation provided supports restorative physical and psychological benefits. A Surfers Against Sewage survey presented to the Environmental Audit Committee in 2022 found that people feel 'free, calm, alive and peaceful' when close to open water (Environmental Audit Committee, 2022).

2.2 Why are marine and coastal margins at risk?

The Risk Register (Morgan & Lusardi, 2024) has identified the level and trend of impacts of the five main drivers of change on marine and coastal margins in England, as summarised in Table 3.

Table 3. Impact of drivers of change on marine and coastal margins

	Land- and Sea-Use Change	Pollution	Natural Resource Use and Exploitation	Climate Change	Invasive Species
Marine	↑	→	↗	↑	↑
Coastal margins	↗	→	↘	↑	↗

Key to Table 3

Driver's impact on extent and condition of ecosystem assets

Low; Moderate; High; Very High

Driver's current (since the UKNEA[a]) and ongoing trend

[a] Exact timeframe over which trends were assessed differed across indicators depending on dataset availability

↘ Decreasing impact; ↗ Increasing impact; → Continuing impact; ↑ Very rapid increase of impact

---

† For further detail, please see Appendix 1: Indicators and Data

Historically there have been huge losses in coastal habitats. Over 30% of sand dunes in England have been lost since 1900 (Beaumont and others, 2014) and over 85% of saltmarshes since the 1800s (Jones and others, 2011). This is due to land reclamation for farming, construction of harbours and coastal defences, and the development of coastal towns. Further out to sea, trawl fishing, dredging and industrial infrastructure can damage the seabed. 75% of the English Channel and South Celtic Seabed are affected by high levels of disturbance from fishing[†].

Globally, 80% of marine pollution comes from land-based sources (United Nations Environment Programme, 2006) and in England, these sources include agriculture, storm overflows, wastewater treatment and industrial discharges (Environment Agency, 2023). A vast array of chemicals including pharmaceuticals, heavy metals and pesticides end up in our seas. Microplastics are present throughout the marine environment and have entered the food chain (Environment Agency, 2023). Strong regulation of industrial discharges and improvements in wastewater treatment have improved coastal water quality in many respects, including bathing water quality (Environment Agency, 2023). However, agricultural run-off and treated wastewater are causing excessive nutrient enrichment of estuaries (Malone & Newton, 2020). Storm overflows of untreated sewage are also a problem, particularly for recreation and shellfish production. 74% of shellfish waters failed to meet targets[†].

Fish in seas across Europe are estimated to be just 5% of the total mass present before commercial exploitation (Roberts, 2007). Since UK bottom trawling records began in the 1880s, fish numbers have decreased so steeply that 17 times the fishing effort is now required to catch the same number of fish (Thurstan, Brockington & Roberts, 2010). Although they fail to meet target levels, there are improvements in the numbers of commercial fish reaching breeding age for achievement of sustainable yields[†]. Length of fish gives an indication of whether they are being over-fished. This is increasing in some of our waters, such as the Bristol Channel and Irish Sea, while decreasing or remaining the same in others, such as the central and southern North Sea (Defra, 2023a).

Climate change is impacting on our thin strip of coastal ecosystems through increased storminess, sea level rise, increased saline intrusion, coastal erosion and accretion (Burden and others, 2020). Saltmarshes, particularly in East Anglia, are being squeezed through coastal erosion and a lack of space to spread further inland, due to sea defences and infrastructure (UK Climate Risk, 2021). Increases in our seawater temperatures and associated acidification (Environment Agency, 2023) have knock on effects on marine ecosystems, particularly plankton, seaweeds and seagrass (Winters and others, 2011; Robins and others, 2015). Changes in the distribution and seasonality of plankton blooms can mean that they are out of sync with organisms higher up the food chain, such as breeding birds (Austen and others, 2011).

[†] For further detail, please see Appendix 1: Indicators and Data

The number of marine invasive non-native species established across 10% or more of the coastline has increased from two species in the 1960s to 29 in 2020[†]. The current and future rapid increase in offshore wind farm and other development impacts on the seabed and provides habitat for invasive species to spread on the pilings.

Loss of nest sites, food, predation, disease and disturbance have impacted on breeding and non-breeding bird populations, which show declines since 1996[†]. With the banning of seal culling in 1970, numbers of both harbour seal abundance and grey seal pup production have increased since 1991[†], meeting long-term targets. However there have been localised decreases in populations in the last decade[†].

The combination of these past, present and future impacts puts the provision of produce from the sea, thriving plants and wildlife, climate regulation and cultural benefits from marine and coastal margins at high risk. Coastal clean water, flood protection and erosion control are also at high risk (See Box 3 for full list of benefits at risk).

2.3 Marine and coastal margin indicators

A selection of marine and coastal margin indicators is shown in Figure 3 on the next two pages. More indicators are available in the Indicators and Data Appendix, which also links indicators to benefits.

<u>Note on marine and coastal indicators:</u>

***Sabellaria* biogenic reefs** are formed by reef building *Sabellaria* worms.

Infralittoral rock is a zone of shallow subtidal rock closest to the shore, dominated by seaweed.

Circalittoral rock is a deeper, darker, animal-dominated zone below the infralittoral seaweed.

uPBT substances are ubiquitous, persistent, bioaccumulative and toxic chemicals, which persist in the environment, can be transported long distances, and pose long-term risks to human health and ecosystems. Tackling them is particularly challenging.

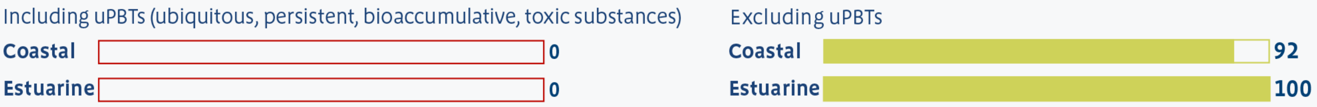
Figure 3. Selection of marine and coastal margin indicators. (next two pages)

[†] For further detail, please see Appendix 1: Indicators and Data

Marine & coastal margins indicators

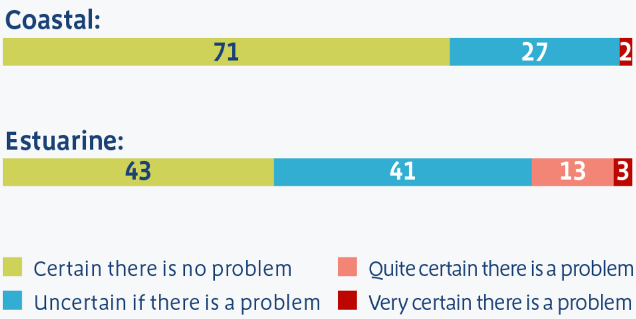
Nutrient & chemical status

% of coastal and estuarine waters with good chemical status



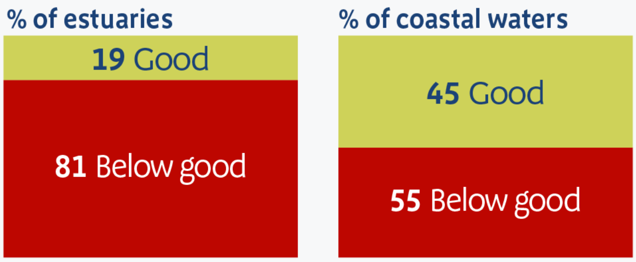
Nutrient & chemical status

% of coastal and estuarine waters with excessive nutrient enrichment



Species composition

Ecological status

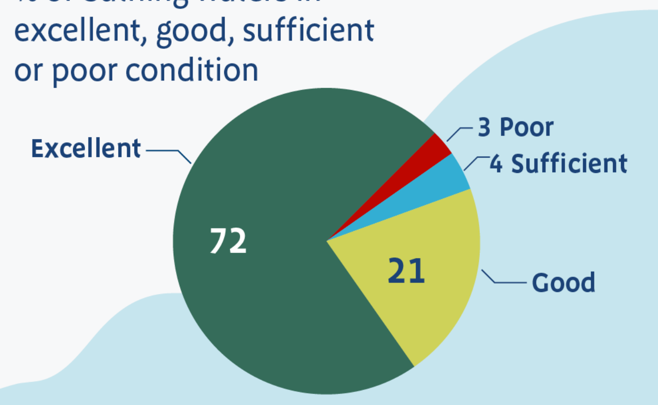


Species composition

Number of marine invasive non-native species established along 10% or more of Great Britain's coastline (cumulative net total of species 1969–2020)

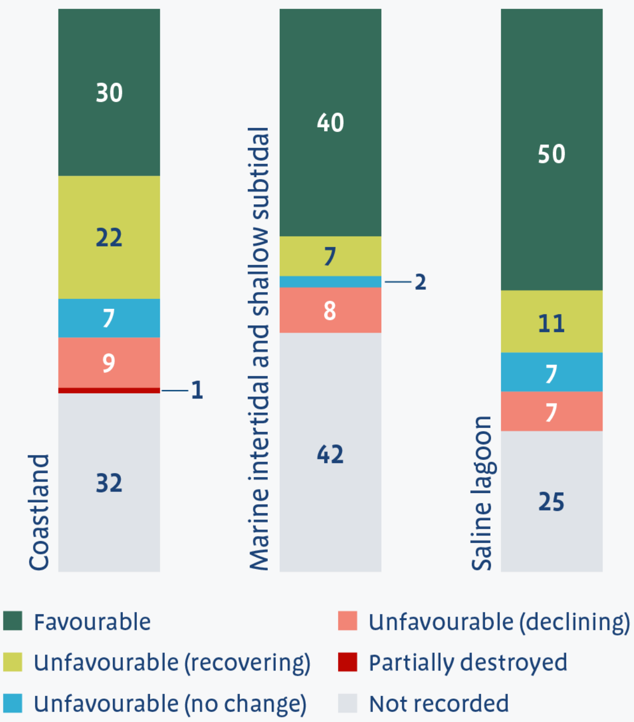
Cultural: nature

% of bathing waters in excellent, good, sufficient or poor condition



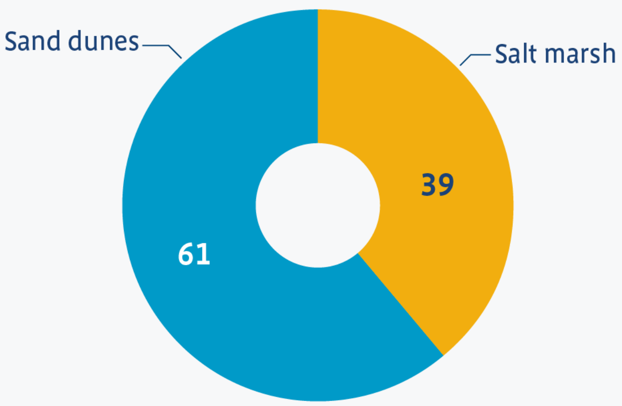
Species composition & Cultural: nature

SSSI feature condition (%)



Extent

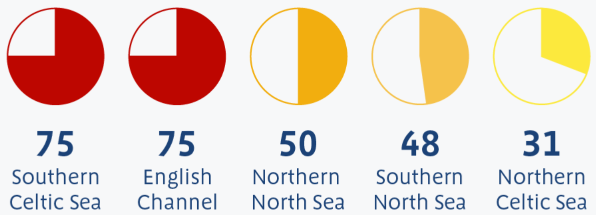
% of coastal margins



Figures are rounded to the nearest whole number, which means that percentages may not always add up to 100.
See the Indicators and Data Appendix for more detail on the data used.

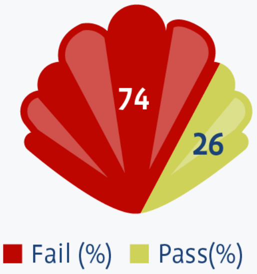
Species composition

% of total area of seabed habitat that is predicted to be subjected to higher levels of disturbance by fishing in English Sub-Regional Seas



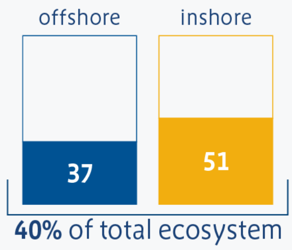
Nutrient & chemical status

Shellfish Water Protected Area condition assessment



Species composition & Cultural: nature

% of coastal and marine areas designated as Marine Protected Areas



Species composition & Cultural: nature

Seal populations

% change in harbour seal abundance

Long term **(1995–2020)**: +38, +87

Short term **(2015–2020)**: -15, +8

% change in Atlantic grey seal pup production

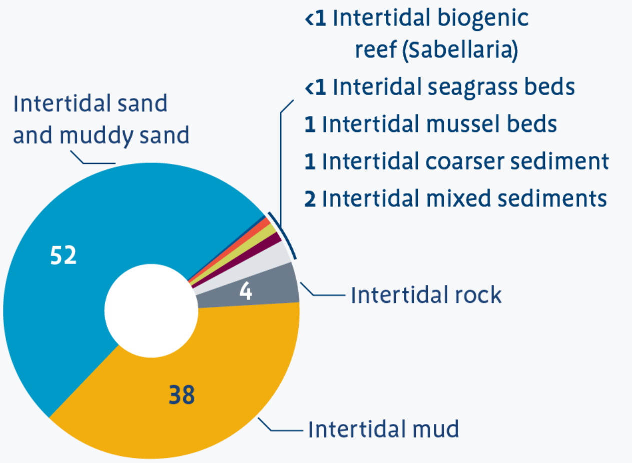
Long term **(1991–2018)**: +78, +51

Short term **(2013–2018)**: +2932, +171

SE England | NE England

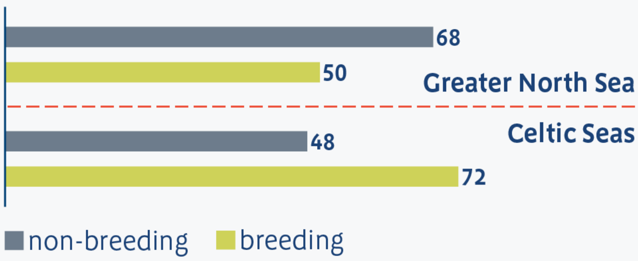
Extent

% of marine intertidal habitats



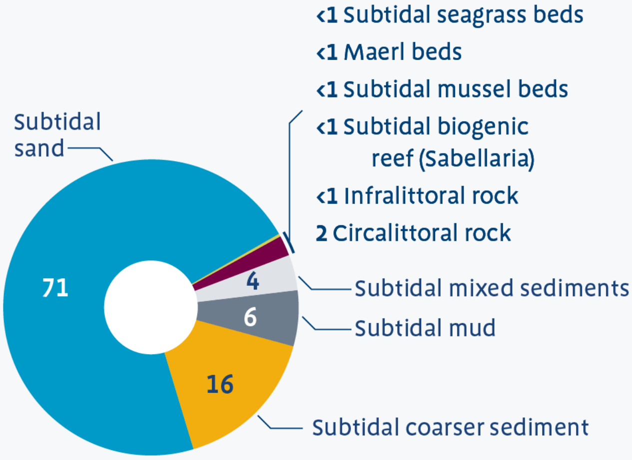
Species composition & Cultural: nature

% of marine bird species meeting population size targets for Good Environmental Status



Extent

% of marine subtidal habitats



Hydrology and geomorphology

% of coastal waterbodies with morphology significantly impacted by physical modifications

Species composition

% of fish stocks where biomass levels support sustainable reproductive capacity

Cultural: Experiential & physical use

% of people asked that had visited a beach, other coastline or sea in the month prior

Figures are rounded to the nearest whole number, which means that percentages may not always add up to 100.
See the Indicators and Data Appendix for more detail on the data used.

2.4 Priority actions for marine and coastal margins

Listed below are 10 priority actions to reduce risk to marine and coastal margins, with the benefits from nature supported by each action represented by icons. See Box 3 for names of benefits.

1. **Use marine spatial planning and mapping to minimise the impact of development on seabed ecosystems and seek restoration of damaged areas**
2. **Through land-use planning ensure the protection and enhancement of coastal ecosystems**
3. **Ensure space and natural sediment supply for landward migration of saltmarsh and sand-dune systems**, including through shoreline management planning
4. **Use blue carbon mapping to minimise the impact of development and activities on carbon stores and sinks**
5. **Adopt fishing practices and management which enable recovery of seabed and coastal ecosystems**, including reducing wildlife by-catch and entanglement
6. **Reduce water pollution from all sources to improve coastal water quality**
7. **Achieve Good Ecological Status of our seas**
8. **Ensure well-managed marine and coastal Protected Sites**
9. **Protect, recover and re-introduce species** to support naturally functioning ecosystems, resilient to change
10. **Identify, report, prevent and minimise the introduction, spread and impacts of invasive marine species**

3 Freshwaters and Wetlands

Box 4. Risk to freshwater and wetland ecosystem assets from main drivers of change

Our research has assessed how at-risk freshwater and wetland ecosystem assets are in England, and is summarised below.

Freshwaters and wetlands are at high risk due to:	
Impact to date	Very high impact to date of **land-use change, pollution, and climate change** High impact to date of **resource exploitation** and **invasive species**
Trend – current and ongoing	Very rapid increase of impact from **climate change** Increasing impact from **resource exploitation** and **invasive species**

These drivers put the following benefits at risk (key: red = high risk):

Plentiful water	Clean water	Erosion control	Flood protection	Thriving plants and wildlife	Climate regulation	Cultural benefits

3.1 Why are freshwaters important?

Freshwaters and wetlands are some of our most naturally diverse ecosystems. This reflects their dynamic and varied nature. Standing water bodies range in size from species-rich ponds to our largest lakes in the Lake District, as well as constructed canals, reservoirs, and gravel pits. Wetlands include reedbeds, fens, swamps, grazing marshes, and extensive floodplains. Groundwater is a major component of the flow of certain rivers and wetlands. Groundwater (abstracted from underlying aquifers) makes up around one third of England's drinking water supply (UK Groundwater Forum).

Freshwaters and wetlands support much-loved species such as kingfishers, water voles and dragonflies, as well as yellow flag iris and floating carpets of waterlilies. Our freshwaters are also of global importance, supporting internationally significant populations of species, such as Atlantic salmon, otters and wetland birds. Most of the world's chalk streams are found in England.

Water is what makes life possible on our planet. Clean and plentiful water is essential for us all, whether as drinking water, or for recreation, food production or other industries. Wetland and freshwater ecosystems trap, break down, process, and transform pollutants. Storing water on flood plains decreases downstream flood risk, while wetlands can act as natural flood defences (Bullock & Acreman, 2003). Active floodplains and other wetlands can be important carbon sinks (Walling and others, 2006). However, the UKNEA assessed that over 40% of floodplain extent in England and Wales had been lost to flood embankments (Maltby and others, 2011), and many are now carbon sources (Gregg and others, 2021). Freshwaters and wetlands also moderate temperatures in urban areas.

Valued for boating, fishing, swimming, art and other recreation, 29% of people reported that they had visited a freshwater or wetland habitat in the month prior to being surveyed[†]. There are 2331 ha of Scheduled Monuments on wetlands, of which 20% by area are considered to be at risk[†]. 88% of people surveyed agreed that the UK's rivers, lakes and streams are a national treasure and an important part of our heritage and culture (Troubled Waters, 2021). Living near or visiting the coast or rivers and lakes increases people's self-reported levels of mental health and wellbeing (Brown, 2020).

3.2 Why are freshwaters and wetlands at risk?

The Risk Register (Morgan & Lusardi, 2024) has identified the level and trend of impacts of the five main drivers of change on freshwater and wetlands in England, as summarised in Table 4.

[†] For further detail, please see Appendix 1: Indicators and Data

Table 4. Impact of drivers of change on freshwater and wetlands

	Land-Use Change	Pollution	Natural Resource Use and Exploitation	Climate Change	Invasive Species
Freshwaters and wetlands	→	→	↗	↑	↗

Key to Table 4

Driver's impact on extent and condition of ecosystem assets

Low
Moderate
High
Very High

Driver's current (since the UKNEA[a]) and ongoing trend

[a] Exact timeframe over which trends were assessed differed across indicators depending on dataset availability

↘ Decreasing impact
↗ Increasing impact
→ Continuing impact
↑ Very rapid increase of impact

Over millennia, as the human population and food production increased, freshwaters and wetlands were polluted, drained, fragmented and physically altered, including through the building of flood defences. The extent of UK wetlands has decreased by 90% since Roman times (Maltby and others, 2011). This has continued into the present day with over 1000 ha of wetland lost between 2006-2012 (Cole, Smith & Baltzer, 2018). 75% of ponds were lost between the late 19th century and the 1980s, although the number of ponds in England increased by 18% between 1998-2007 (Williams and others, 2010). There are no pristine freshwaters remaining in England (Maltby and others, 2011).

The intimate links between freshwater and land, mean that changes in catchments affect water levels and quality of nearby wetlands and water bodies. Point source and diffuse pollution enter freshwaters and wetlands from agricultural practices, storm overflows, wastewater treatment, industrial discharges, and road runoff. In rivers, water quality has improved markedly in recent decades, but these improvements have not continued in recent years (Malone & Newton, 2020). There have also been negative trends in the past decade in groundwater quality[†]. Since 1940, pressures from nutrients and pesticides have increased in many areas and diffuse-source pollution remains an issue (Whelan and others, 2022). At the same time, we are becoming increasingly aware of emerging pollutants, such as microplastics and chemicals, impacting our water system (Defra, 2023c).

Population growth and climate change impact further on water quality and resources, with house building particularly affecting the south and east. We use about 14 billion litres of

[†] For further detail, please see Appendix 1: Indicators and Data

water per day and will need 4 billion more by 2050 (Defra, 2023c). Although the quantity of groundwater[†] doesn't meet target levels, it does show improvement. Droughts will add to the pressure on surface and groundwaters. Our freshwaters and wetlands are among the most sensitive of our ecosystems to climate change (Staddon, Thompson & Short, 2023), which affects water levels and temperature, in turn exacerbating pollution and algal blooms.

Invasive species, such as signal crayfish, Himalayan balsam, Japanese knotweed and Australian stonecrop, have been introduced by humans and spread further by the flow of water. Between 1960 and 2019 the number of invasive freshwater species more than doubled from 21 to 46 (ONS, 2022a).

All these impacts affect the wildlife of wetlands and freshwaters. There have been declines in the past decade in the ecological status of rivers and lakes, although river fish and invertebrates are showing neutral or improving trends[†]. 24% of freshwater and fen Site of Special Scientific Interest features are in favourable condition[†]. From 2017 to 2022 the water and wetland bird index declined by 8%[†].

In combination, these impacts put the benefits from freshwater at high risk. The impacts of past land-use change, coupled with climate change, put plentiful water, clean water, erosion control, flood protection, thriving plants and wildlife, climate regulation and cultural services at high risk. Hotter, drier summers and droughts also put plentiful water and our wetland carbon stores at risk of drying out. Pollution levels have an additional impact on clean water, cultural services, thriving plants and wildlife (See Box 4 for full list of benefits at risk).

3.3 Freshwaters and wetlands indicators

A selection of freshwaters and wetlands indicators is shown in Figure 4 on the next page. More indicators are available in the Indicators and Data Appendix, which also links indicators to benefits.

> Note on freshwaters and wetlands indicators:
>
> **uPBT** substances are ubiquitous, persistent, bioaccumulative and toxic chemicals, which persist in the environment, can be transported long distances, and pose long-term risks to human health and ecosystems. Tackling them is particularly challenging.

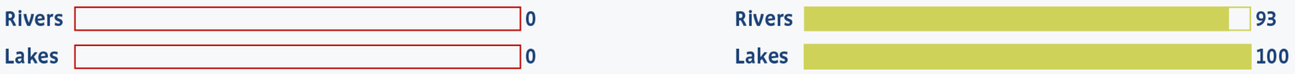
Figure 4. Selection of freshwaters and wetlands indicators. (next page)

[†] For further detail, please see Appendix 1: Indicators and Data

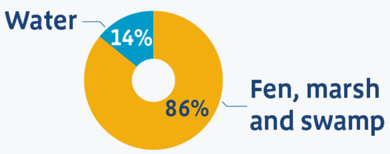
Freshwaters & wetlands indicators

Nutrient & chemical status

% of rivers and lakes with good chemical status

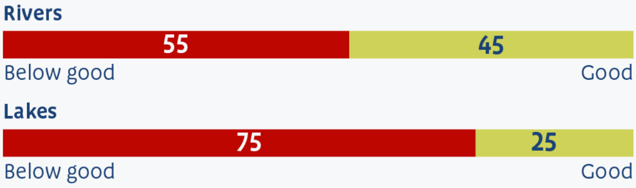


Extent



Nutrient & chemical status

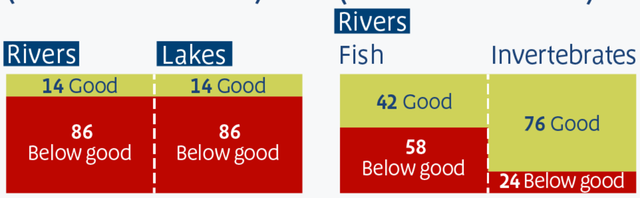
Phosphorus status (% of waterbodies)



Species composition

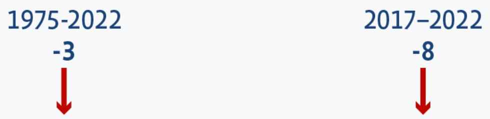
Ecological status (% of waterbodies)

Biological status (% of waterbodies)



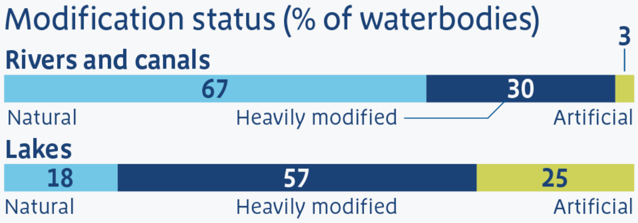
Species composition & Cultural: nature

% change in Water and Wetland Bird Index



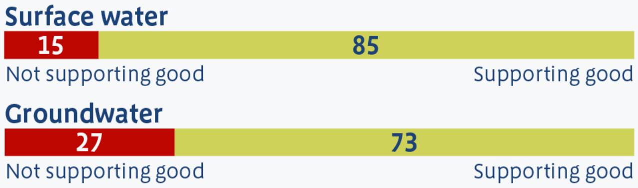
Hydrology and geomorphology

Modification status (% of waterbodies)



Morphology significantly impacted by physical modifications (% of waterbodies)

Quantity of flows supporting good ecological status (% of waterbodies)

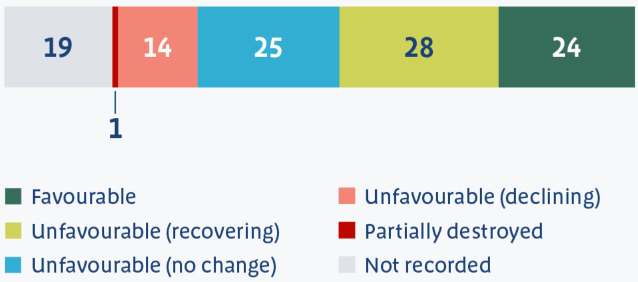


Nutrient & chemical status

Groundwater quality status (% of waterbodies)

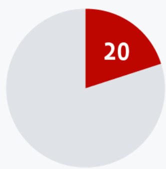
Species composition & Cultural: nature

Freshwater and fen SSSI feature condition (%)



Cultural: Culture & history

% area of Scheduled Monuments in freshwaters and wetlands that are on the Heritage at Risk Register



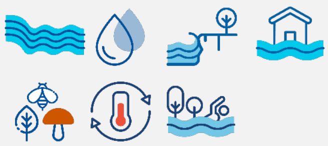
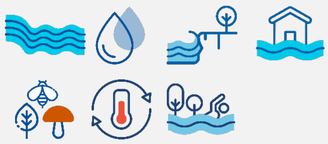
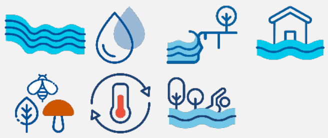
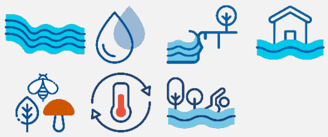
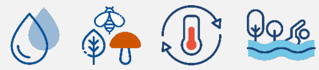
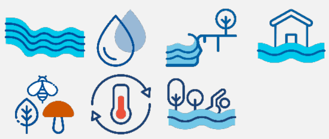
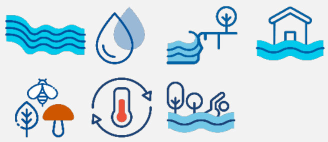
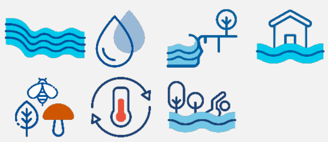
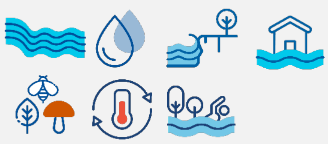
Cultural: Experiential & physical use

% of people asked that had visited a river, lake or canal in the month prior

Figures are rounded to the nearest whole number, which means that percentages may not always add up to 100. See the Indicators and Data Appendix for more detail on the data used.

3.4 Priority actions for freshwaters and wetlands

Listed below are 11 priority actions to reduce risk to freshwaters and wetlands, with the benefits from nature supported by each action represented by icons. See Box 4 for names of benefits.

1. **Work with natural processes in headwaters and catchments to slow flows, encourage infiltration and reduce soil erosion**	
2. **Create and restore large naturally-functioning and diverse wetland complexes**, including as part of flood management schemes	
3. **Restore naturally functioning river systems and re-connect rivers to flood plains**, increasing resilience to climate change	
4. **Create wetlands as part of large-scale wilder nature networks**, planned and located to provide multiple benefits	
5. **Reduce water pollution from all sources**	
6. **Reduce water demand and waste, from all uses**	
7. **Use land-use planning measures to reduce water use, pollution, surface run-off and flood-risk**, enhancing resilience to climate change	
8. **Improve the infiltration of rainwater to groundwater**, by restoring soil organic matter levels and avoiding soil compaction	
9. **Ensure well-managed freshwater and wetland Protected Sites**	
10. **Protect, recover and re-introduce species** to support naturally functioning ecosystems, resilient to change	
11. **Identify, report, prevent and minimise the introduction, spread and impacts of invasive freshwater species**	

4 Woodlands

Box 5. Risk to woodland ecosystem assets from main drivers of change

Our research has assessed how at-risk woodland ecosystem assets are in England, and is summarised below.

Woodlands are at high risk due to:	
Impact to date	Very high impact to date of **resource exploitation** High impact to date of **invasive species**
Trend – current and ongoing	Very rapid increase of impact from **invasive species (pests and diseases)** Increasing impact from **land-use change, pollution**, and **climate change**

These drivers put the following benefits at risk (key: red = high risk; orange = medium-high risk; yellow = medium risk):

4.1 Why are woodlands important?

Covering 11% of England†, woodlands constitute a highly distinctive, much-loved and spectacularly wildlife-rich component of our landscapes. They are very diverse and vary with climate, geology, soils and management, past and present. From ancient oak and ash woodlands carpeted with bluebells, through wet Atlantic oak woodlands burgeoning with mosses and ferns (our temperate rainforests) to the wild and swampy hollows of alder, willow and birch - no two woodlands are the same. They support large numbers of rare and often specialist species of plants, invertebrates, fungi and birds, and are home to many of our most cherished mammals such as red squirrels, pine martens and dormice.

Woodlands play a critical role in regulating our climate as they capture carbon at higher rates than any other semi-natural habitats. They are reliable carbon sinks that continue to take up carbon over centuries, although the rate varies greatly with tree species and age and is strongly influenced by soils and climate (Gregg and others, 2021). Over 125 million tonnes of carbon are stored in the trees of England's woodlands†. Woodland soils are second only to bog and fen peat soils for the amount of carbon they hold (Gregg and others, 2021).

Woodlands help people and nature adapt to climate change by providing shade and shelter from strong winds, reducing overheating, and decreasing soil erosion (Gardiner, Palmer & Hislop, 2006). They also help to reduce the risk of extreme flooding events as their leaves intercept water and their roots slow the flow through soil (Environment Agency, 2017; Stratford and others, 2017). Wood pasture, low-density, and young broadleaf woodland can tip the balance in favour of infiltration and replenishment of aquifers, over uptake by plants (Environment Agency, 2021). While pollution is best tackled at source, woodland also plays an important role in capturing pollutants from both water (Nisbet and others, 2011) and air (Powe & Willis, 2004).

Woodlands have supplied people with timber, fuel, nuts, and other products for millennia. England accounts for 25% of the total annual value of timber produced in the UK (ONS, 2023a). Timber removal levels have remained relatively stable in England over the last 50 years (ONS, 2023a).

Our People and Nature Survey shows that 31% of people when asked had visited woodlands in the month prior†. The peaceful and intimate settings of woodlands are highly valued for the wide variety of recreational opportunities they provide. The health benefits of recreation in woodlands were estimated to be £892.6 million for England for 2020 (ONS, 2022c). The educational value of woodland settings is now well recognised (O'Brien & Murray, 2006) and reflected in the increasing number of Forest School providers (Forest School Association).

---

† For further detail, please see Appendix 1: Indicators and Data

Woodlands have long provided inspiration for art, poetry, literature and music and the lives of those who have inhabited them are captured in folklore, traditions and the heritage that is still found within them (Quine and others, 2011). There are 7435 ha of Scheduled Monuments within England's woodlands of which 20% are considered to be at risk†.

4.2 Why are woodlands at risk?

The Risk Register (Morgan & Lusardi, 2024) has identified the level and trend of impacts of the five main drivers of change on woodlands in England, as summarised in Table 5.

Table 5. Impact of drivers of change on woodlands

	Land-Use Change	Pollution	Natural Resource Use and Exploitation	Climate Change	Invasive Species
Woodlands	↗	↗	↘	↗	↑

Key to Table 5

Driver's impact on extent and condition of ecosystem assets

Low
High
Moderate
Very High

Driver's current (since the UKNEA[a]) and ongoing trend

[a] Exact timeframe over which trends were assessed differed across indicators depending on dataset availability

↘ Decreasing impact
↗ Increasing impact
→ Continuing impact
↑ Very rapid increase of impact

After the last ice age, it is thought that woodland may have covered three quarters of England before clearance for agriculture and, more recently, urban expansion (Quine and others, 2011). By the beginning of the 20th century, woodland covered less than 5% of England (Rackham, 1986; Peterken, 1996). However, since 1945 England's woodland cover has doubled. High demand for timber after both World Wars led to large-scale tree planting, particularly of coniferous woodland and often on heathlands and bogs (The Conservation Volunteers, 2024). More recently broadleaved tree planting has been driven by efforts to combat the biodiversity and climate crises (Quine and others, 2011).

Woodland condition has declined with the abandonment of traditional practices such as coppicing and other management. Overgrazing by deer has reduced the structural diversity and natural regeneration of woodlands (State of Nature Partnership, 2019), and substantially changed the ground flora. Invasive species, pests and diseases pose a constant threat. Dutch Elm Disease decimated our woodlands in the 1970s, while Ash Dieback and Acute Oak Decline are seriously impacting them again today (State of Nature

† For further detail, please see Appendix 1: Indicators and Data

Partnership, 2019). Air pollution is also an issue, with the nitrogen critical load exceeded for 100% of nutrient-sensitive broadleaved woodlands in the UK†.

Consequently, despite the growth in total woodland area, many woodland species are in decline. In 2018 the woodland bird indicator for England was 28% lower than in 1970 and the woodland butterfly index had fallen by 46% since 1990, although there has been some recovery since the all-time low in 2012† (Defra, 2022b). 40% of woodland Site of Special Scientific Interest features are in favourable condition†.

Climate change is likely to result in further impacts on woodland from pests and diseases, drought, and winter waterlogging of roots (Climate Change Committee, 2021). While warmer temperatures and levels of carbon dioxide may increase tree growth rates, this is variable with not all species benefiting (Guerrieri and others, 2020).

These past, present and future impacts put woodland thriving plants and wildlife at high risk. Timber and wood products are also at high risk due to invasive species (See Box 5 for full list of benefits at risk)

4.3 Woodland indicators

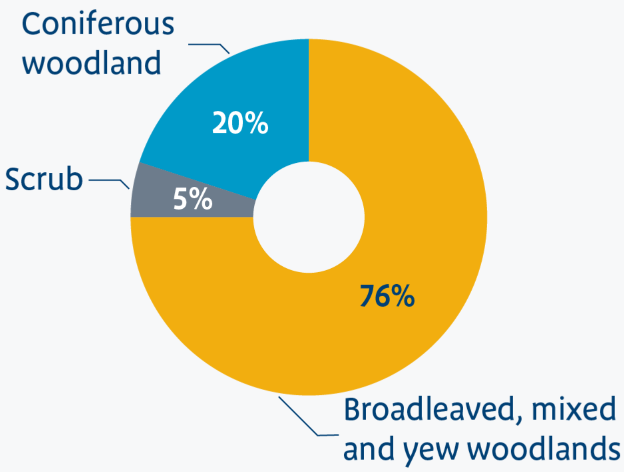
A selection of woodland indicators is shown in Figure 5, on the next page. More indicators are available in the Indicators and Data Appendix, which also links indicators to benefits.

Figure 5. Selection of woodland indicators. (next page)

† For further detail, please see Appendix 1: Indicators and Data

Woodlands indicators

Extent



Species composition & Cultural: nature

% change in Woodland Bird Index

1970-2018
-28 ↓

2013–2018
-6 ↓

Species composition & Cultural: nature

% change in Woodland Butterfly Index

1990-2021
-46 ↓

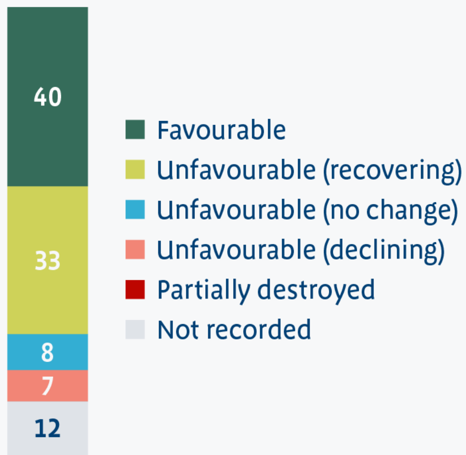
2016–2021
+3 ↑

Nutrient & chemical status

% of nutrient-sensitive habitat where nitrogen critical load is exceeded

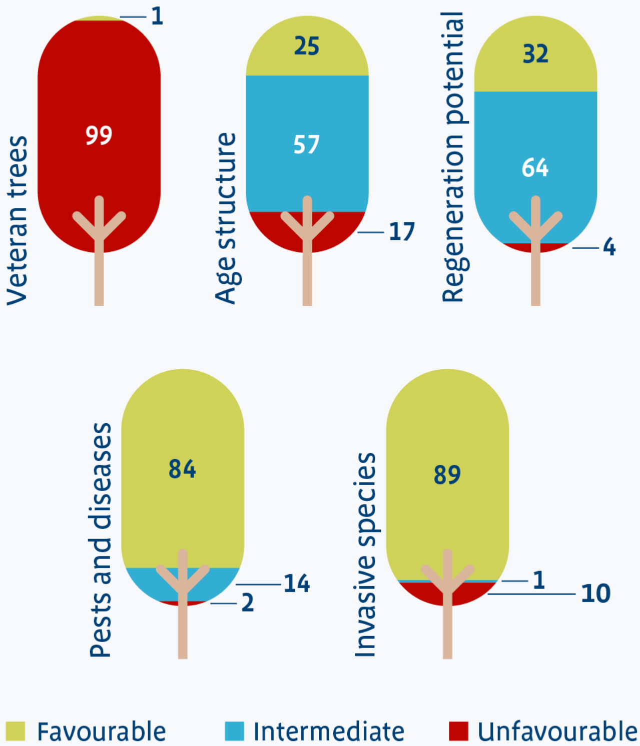
Species composition & Cultural: nature

Woodland SSSI feature condition (%)



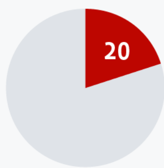
Vegetation & species composition

Native woodland condition (%)



Cultural: Culture & history

% area of Scheduled Monuments in woodlands on Heritage at Risk Register



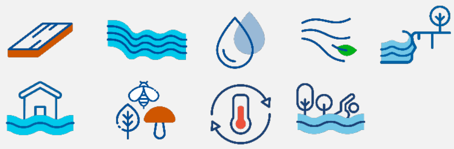
Cultural: Experiential & physical use

% of people asked that had visited a woodland or forest in the month prior

Figures are rounded to the nearest whole number, which means that percentages may not always add up to 100.
See the Indicators and Data Appendix for more detail on the data used.

4.4 Priority actions for woodlands

Listed below are 7 priority actions to reduce risk to woodlands, with the benefits from nature supported by each action represented by icons. See Box 5 for names of benefits.

1. **Create new woodland** through a “right tree in the right place” approach, which avoids existing nature or carbon-rich areas	
2. **Restore native woodland through management for wildlife**	
3. **Create woodland and scrub as part of large-scale wilder nature networks** planned and located to provide multiple benefits	
4. **Identify, report, prevent and minimise the introduction, spread and impact of tree pests and diseases**	
5. **Ensure well-managed woodland Protected Sites**	
6. **Protect, recover and re-introduce species** to support naturally functioning ecosystems, resilient to change	
7. **Use land-use planning to minimise the impact of development on woodlands and scrub**	

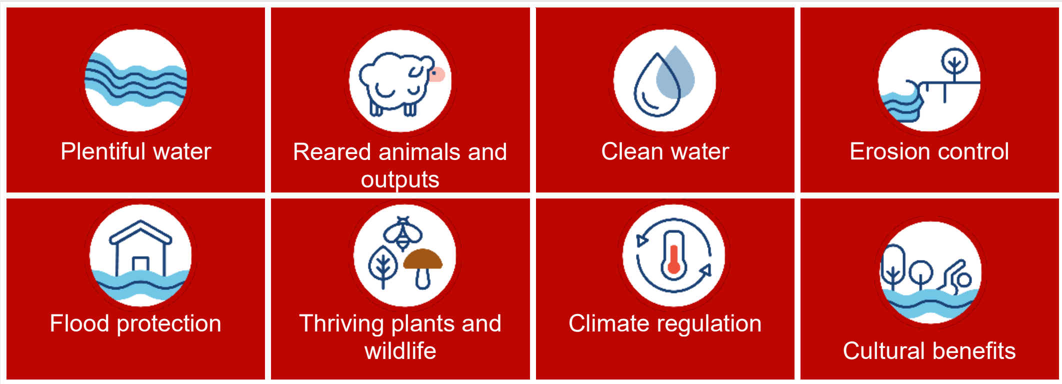
5 Mountains, Moorlands and Heaths

Box 6. Risk to mountains, moorlands and health ecosystem assets from main drivers of change

Our research has assessed how at-risk mountains, moorlands and heath ecosystem assets are in England, and is summarised below.

Mountains, moorlands and heaths are at high risk due to:	
Impact to date	Very high impact to date of **land-use change**, **pollution,** and **climate change**
Trend – current and ongoing	Very rapid increase of impact from **climate change** Increasing impact from **land-use change** and **resource exploitation**

These drivers put the following benefits at risk (key: red = high risk):



5.1 Why are mountains, moorlands and heaths important?

Mountains, moorlands and heaths ecosystems are remote, evocative, ‘wild’ landscapes. They form the largest unfragmented expanses of semi-natural habitats in England.

The majority of these bog, heath, bracken and rocky habitats are found in the harsher climatic conditions of the uplands, often in a mosaic with flushes, semi-natural grasslands and woodlands. The English uplands contain 1.5% of the world's blanket bog (RSPB, 2014) and represent England's largest land-based carbon stores (Gregg and others, 2021). Smaller areas of heathland and bog also occur in the lowlands. Whilst lowland heaths are more fragmented, they tend to be more biodiverse than their upland counterparts, supporting species such as the silver-studded blue butterfly, nightjar, sand lizards and Dartford warbler.

They are home to an extraordinary wealth of wildlife; from squelchy carpets of colourful sphagnum bog mosses to swathes of purple heather and cotton grass, inhabited by carnivorous plants, rare invertebrates, hen harriers and other birds of prey, and internationally important breeding populations of birds such as golden plover.

The unique biodiversity of bog, heath and upland habitats is responsible for the high density of carbon stored in their soils. Healthy peatlands hold the largest stores of carbon of any land habitats and actively lock up more, playing a critical role in regulating our climate. The degradation of England's peatlands means they are currently a net source of carbon and are having a warming effect (Gregg and others, 2021). Peatland restoration is essential to ensure our peatlands stop emitting carbon and become carbon sinks.

High rainfall and the natural storage capacity of these upland ecosystems means they are a vital source of drinking water: 70% of the UK's water supply comes from upland catchments (RSPB, 2014). The Peak District National Park alone holds 55 reservoirs and serves as a major water source to surrounding conurbations (Bonn and others, 2010). The vegetation and soils of these habitats also play an important role in intercepting and storing atmospheric pollutants that would otherwise contaminate drinking waters. Levels of soil compaction also affect the infiltration of rainwater and downstream flood risk. Upland water condition has improved in the last 30 years (1996-2018) in terms of concentrations of sulphate and the reduction of water acidity. However, the amount of dissolved organic carbon, which causes a brown staining to upland waters, roughly doubled between 1989 and 2018 as a result of peat degradation (ONS, 2022a).

The majority of National Parks are located within mountains, moorlands and heaths. The iconic imagery of these 'wild' landscapes and their open vistas provide inspiration for many, and a regional and national sense of identity. They are home to some of the most special National Trails, as well as large expanses of Open Access land where people can exercise their Right to Roam. Mountains, moorlands and heaths provide valued tourism and recreation opportunities. Our People and Nature Survey shows that 11% of people in England when asked, had visited hills, mountains or moorlands in the month prior[†].

The tightly woven histories of these habitats and the people that have shaped them are evident in the ancient landmarks, burial mounds and other historic features that are scattered across these landscapes. 5393 ha of Scheduled Monuments are found on

---

[†] For further detail, please see Appendix 1: Indicators and Data

mountains, moorlands and heaths, with 28% of these identified as being at risk†. The peat soils preserve records of species, environment, climate and land use over the millennia and are of considerable archaeological importance (Van der Wal and others, 2011).

5.2 Why are mountains, moorlands and heaths at risk?

The Risk Register (Morgan & Lusardi, 2024) has identified the level and trend of impacts of the five main drivers of change on mountains, moorlands and heaths in England, as summarised in Table 6.

Table 6. Impact of drivers of change on mountains, moorlands and heaths

	Land-Use Change	Pollution	Natural Resource Use and Exploitation	Climate Change	Invasive Species
Mountains, moorlands and heaths	↗	→	↗	↑	→

Key to Table 6

Driver's impact on extent and condition of ecosystem assets

Low | High | Moderate | Very High

Driver's current (since the UKNEA[a]) and ongoing trend

[a] Exact timeframe over which trends were assessed differed across indicators depending on dataset availability

↘ Decreasing impact | ↗ Increasing impact

→ Continuing impact | ↑ Very rapid increase of impact

Although often perceived as 'wild' and untouched, these ecosystems actually reflect thousands of years of human activity, with grazing by livestock and deforestation occurring since Neolithic times. Dramatic changes in the uplands have also occurred since the Second World War; a shift to more intensive grazing, commercial forestry and game management led to a significant reduction in the extent of peatlands and heaths and a deterioration in their condition due to drainage, grazing, burning and peat extraction (Van der Wal and others, 2011). Lowland heathlands have declined in extent and condition over the last century with only about 20% remaining of what was present in the 19th Century (Van der Wal and others, 2011). This has been due to urban development, agricultural intensification, abandonment of traditional practices, and afforestation (Van der Wal and others, 2011), leaving lowland heathland a rare and highly fragmented habitat.

Air pollution and wildfires have also contributed to declining condition. Virtually all bog, heath and montane habitats are subject to damaging levels of nitrogen deposition[†]. Wildfires are likely to be more damaging with drought events due to climate change (Albertson and others, 2009). In 2018, 1000 hectares of Saddleworth Moor burned in the 5 days it took to extinguish it (Glaves and others, 2020).

These changes are reflected in wildlife numbers too. The upland bird index is at 91% of its 1994 baseline level[†]. Between 2015 and 2020, 48% of upland bird species showed declines in their populations, 28% increased and 24% showed little change[†]. Only 21% of upland, bog and heath Sites of Special Scientific Interest features are in favourable condition[†].

Mountains, moorlands and heaths are among the most sensitive ecosystems to climate change (Staddon, Thompson & Short, 2023). Degraded bogs are highly sensitive (Staddon, Thompson & Short, 2023), especially to drying, with hotter and drier summers. Along with wildfire, this puts these major carbon stores at further risk. Peatland degradation and carbon losses also result from run-off during intense rainfall, with potential impacts for water quality. Thriving plants and wildlife in the uplands are at particular risk from climate change (Li and others, 2017). 75% of upland species face a decline by the end of the century under medium levels of warming (Pearce-Higgins and others, 2017). Climate change also puts further pressure on the provision of plentiful water, flood protection and erosion control. All of these past, present and future impacts put the benefits from mountains moorlands and heaths at high risk.

5.3 Mountains, moorlands and heaths indicators

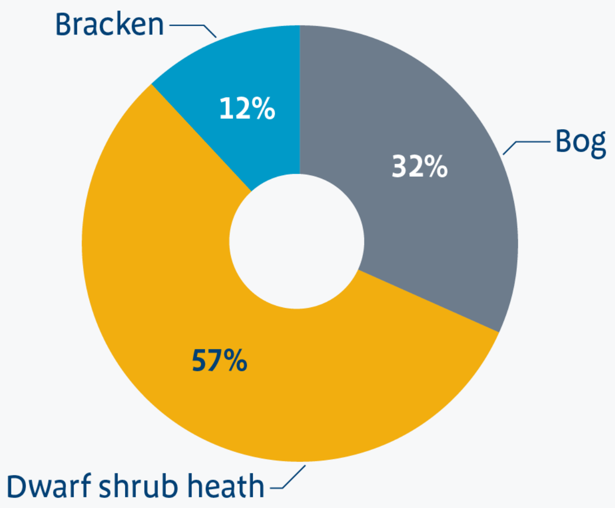
A selection of mountains, moorlands and heaths indicators is shown in Figure 6 on the next page. More indicators are available in the Indicators and Data Appendix, which also links indicators to benefits.

Figure 6. Selection of mountains, moorlands and heaths indicators. (next page)

[†] For further detail, please see Appendix 1: Indicators and Data

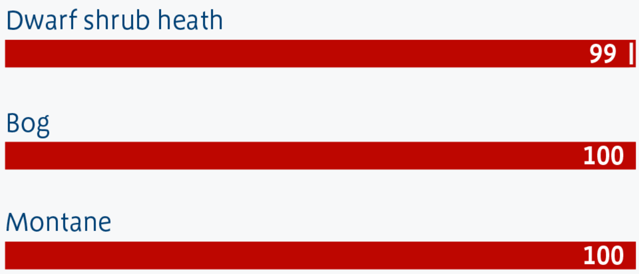
Mountains, moorlands & heaths indicators

Extent



Nutrient & chemical status

% of nutrient-sensitive habitat where nitrogen critical load is exceeded



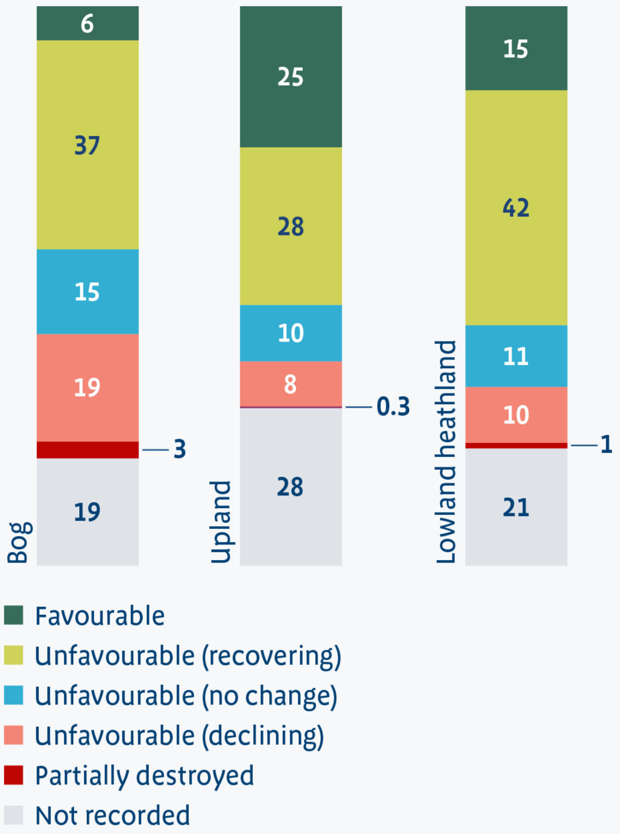
Species composition & Cultural: nature

% change in Upland Bird Index

1994–2022	2017–2022
-9 ↓	-5 ↓

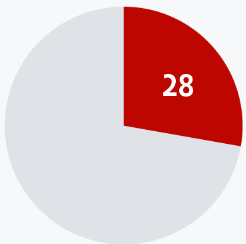
Species composition & Cultural: nature

SSSI feature condition (%)



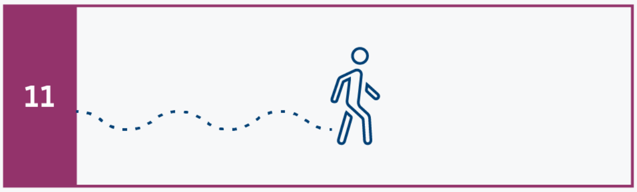
Cultural: Culture & history

% area of Scheduled Monuments in mountains, moorlands and heath on Heritage at Risk Register



Cultural: Experiential & physical use

% of people asked that had visited hills, mountain or moorland in the month prior



Figures are rounded to the nearest whole number, which means that percentages may not always add up to 100.
See the Indicators and Data Appendix for more detail on the data used.

5.4 Priority actions for mountains, moorlands and heaths

Listed below are 10 priority actions to reduce risk to mountains, moorlands and heaths, with the benefits from nature supported by each action represented by icons. See Box 6 for names of benefits.

1. **Create structurally diverse, naturally functioning upland mosaics**
2. **Sustainably manage existing lowland heaths**
3. **Work with natural processes in catchment and soil management**, slowing flows and encouraging infiltration of rainwater
4. **Develop fire prevention, management and contingency plans**
5. **Restore hydrology and peat formation**
6. **Cease extraction and use of peat**
7. **Reduce air and water pollution from all sources**
8. **Ensure well-managed mountains, moorlands and heaths Protected Sites**
9. **Protect, recover and re-introduce species** to support naturally functioning ecosystems, resilient to change
10. **Use land-use planning to minimise the impact of development on mountains, moorlands and heaths**

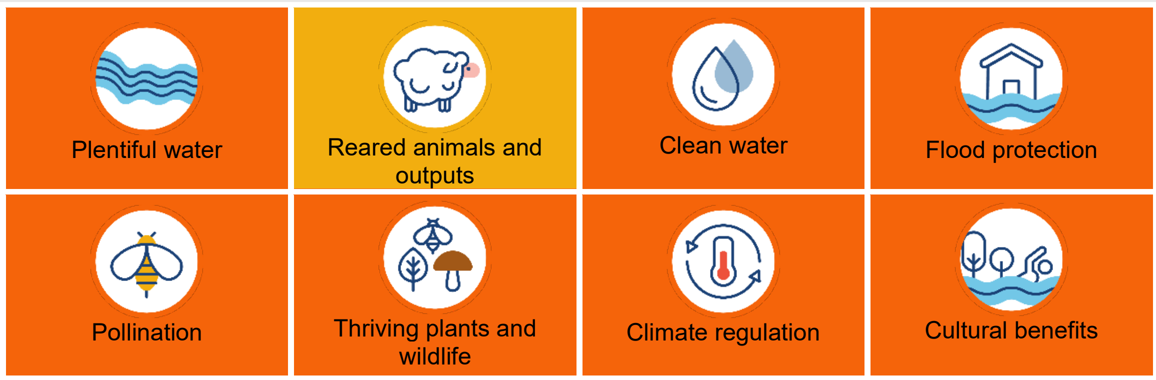
6 Semi-Natural Grasslands

Box 7. Risk to semi-natural grassland ecosystem assets from main drivers of change

Our research has assessed how at-risk semi-natural grassland ecosystem assets are in England, and is summarised below.

Semi-natural grasslands are at medium-high risk due to:	
Impact to date	Very high impact to date of **land-use change** and **pollution** High impact to date of **resource exploitation**
Trend – current and ongoing	Increasing impact from **climate change, pollution** and **land-use change**

These drivers put the following benefits at risk (key: orange = medium-high risk; yellow = medium risk):



6.1 Why are semi-natural grasslands important?

Semi-natural grasslands in summer can be a feast for the senses: a rainbow of flowers, the scent of thyme, bees buzzing and skylarks singing. These remnants of traditional livestock farming practices are rich in plant, invertebrate, mammal and bird life.

Semi-natural grasslands vary with geology, soil, climate, and management. In the lowlands they are often fragmented, although large swathes remain in places like Salisbury Plain.

Extensive areas are also found in our uplands. These are more species-poor, and often the result of degraded heath and bog.

The wealth of different species in these grasslands is a strength in many ways. Their diversity of flowering plants supports an abundance of bees, butterflies and hoverflies, which pollinate adjacent crops (Öckinger & Smith, 2006; Jauker and others, 2009). High biodiversity, especially in the soil (European Commission, 2010), strengthens the response to pests and diseases (Agriculture and Horticulture Development Board, 2021). Soil life, such as earthworms, help to reduce soil compaction (measured as bulk density). This boosts the infiltration of rainwater, helping to replenish aquifers and reduce flooding. Semi-natural grasslands are particularly important on floodplains, helping to reduce downstream flood risk. Infiltration is also critical for the aquifers below our chalk downs, which benefit in water quality terms too, from the low nutrient inputs to semi-natural grassland.

Semi-natural grasslands have one of the highest soil carbon densities, after woodlands, peatlands and saltmarsh (Gregg and others, 2021). Whether individual grasslands are a source or sink of carbon depends on a range of factors including soil type, management, climate change and pollution. Due to their more extensive management and less disturbed soils, semi-natural grasslands play a disproportionately important role in climate change mitigation (Gregg and others, 2021). Semi-natural grasslands sink and store more carbon than modern agricultural landscapes (enclosed farmland) (Gregg and others, 2021).

Semi-natural grasslands, created through traditional farming practices, are a product of thousands of years of interactions between humans and nature. This intertwining of culture, history and nature is still evident today, in art, literature and on the ground. “Lammas” meadows on floodplains are still managed through a communal farming system that dates back centuries. The absence of ploughing on semi-natural grassland has helped to preserve the historic environment too. Many of our species-rich grasslands are associated with historic sites, such as hill forts and tumuli.

6.2 Why are semi-natural grasslands at risk?

The Risk Register (Morgan & Lusardi, 2024) has identified the level and trend of impacts of the five main drivers of change on semi-natural grasslands in England, as summarised in Table 7.

Table 7. Impact of drivers of change on semi-natural grasslands

	Land-Use Change	Pollution	Natural Resource Use and Exploitation	Climate Change	Invasive Species
Semi-natural grasslands	↗ (Very High)	↗ (Very High)	→ (High)	↗ (Moderate)	→ (Moderate)

Key to Table 7

Driver's impact on extent and condition of ecosystem assets

Low | High | Moderate | Very High

Driver's current (since the UKNEA[a]) and ongoing trend

[a] Exact timeframe over which trends were assessed differed across indicators depending on dataset availability

↘ Decreasing impact | ↗ Increasing impact | → Continuing impact | ↑ Very rapid increase of impact

97% of lowland semi-natural grasslands in England and Wales were lost between the 1930s and 1984 (Fuller, 1987). This trend has continued, with a decrease in extent of nearly half between 1960 and 2013 (Ridding, Redhead & Pywell, 2015). With increases in agricultural productivity, farming practices have moved away from hay making, low intensity grazing and farmyard muck. Ploughing, drainage and applications of fertiliser and herbicide resulted in conversion to arable, horticulture and improved grasslands (which are covered in the Enclosed Farmland section).

Changing farming practices have also impacted on the quality of the remaining areas. While under-grazing can be an issue for lowland semi-natural grassland sites, over-grazing has impacted on upland areas (Bullock and others, 2011). Nutrient enrichment from fertilisers and slurry are particularly associated with losses in plant and invertebrate diversity (Bullock and others, 2011). Air pollution also plays a part, with the critical load for nitrogen deposition currently exceeded on 99% of acid and 87% of calcareous grasslands†. These combined changes affect other species too. There was a major decline in the distribution of grassland birds, both breeding and wintering, in the second half of the 20th century (Vickery and others, 2001). The decline in bumblebees since the 1960's has also been linked to the decline in semi-natural grassland (Goulson and others, 2005). Only 35% of lowland grassland Site of Special Scientific Interest features are currently assessed to be in favourable condition†. While there has been restoration and re-creation of semi-natural grasslands through agri-environment schemes, this is more than off-set by the current increasing losses to house building and agricultural intensification (Natural England habitat specialists, personal communication, 2023).

† For further detail, please see Appendix 1: Indicators and Data

The impacts of climate change are likely to change both the species composition of semi-natural grasslands, as well as the way in which they are managed. The fragmented nature of lowland grasslands leaves them vulnerable, as species distributions change with the climate (Bullock and others, 2011). The species richness of these grasslands makes them more resistant than other grasslands to droughts and floods (Isbell and others, 2015; Cole and others, 2019). However wet grasslands are at a greater risk from changes in rainfall patterns (Staddon, Thompson & Short, 2023). Degraded semi-natural grasslands, particularly upland hay meadows and wet lowland meadows, are more sensitive to climate change (Staddon, Thompson & Short, 2023).

These past, ongoing and future impacts, on the extent and condition of semi-natural grasslands, put the benefits they provide at medium-high risk. This includes risks to clean and plentiful water and flood protection, affected by pollution, lower rainfall infiltration and storage, and the increased severity of droughts and floods. These extreme weather events also put livestock grazing and the animals themselves at risk. Loss of species and their abundance impacts on thriving plants and wildlife, pollination and natural pest control. There's a risk of shifting this land from a carbon sink to a carbon source (See Box 7 for full list of benefits at risk).

6.3 Semi-natural grassland indicators

A selection of semi-natural grassland indicators is shown in Figure 7, on the next page. A fuller suite is available in the Indicators and Data Appendix, which also links indicators to benefits.

NOTE:

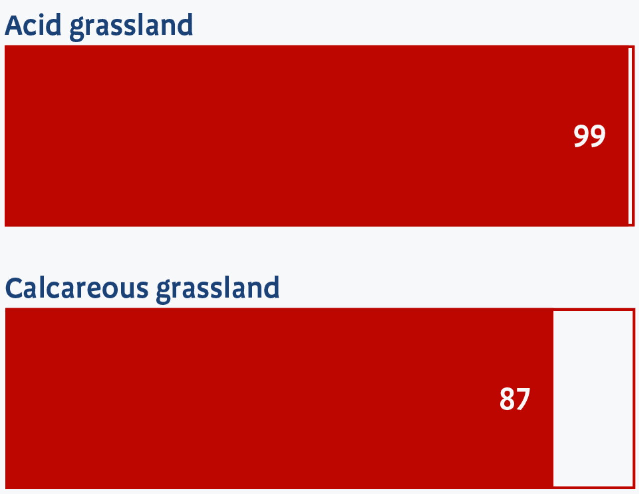
We do not include an extent indicator for semi-natural grassland. Overestimation of Acid Calcareous and Neutral grassland, due to misclassification of improved grassland, is a recognised limitation of Living England. The Scheduled Monuments at risk indicator is for Scheduled Monuments on Acid Calcareous and Neutral Grassland (Natural England, 2022).

Figure 7. Selection of semi-natural grassland indicators. (next page)

Semi-natural grasslands indicators

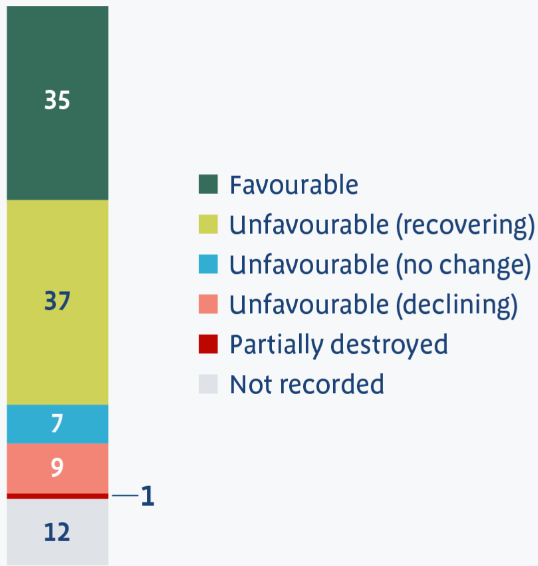
Nutrient & chemical status

% of nutrient-sensitive habitat where nitrogen critical load is exceeded



Species composition & Cultural: nature

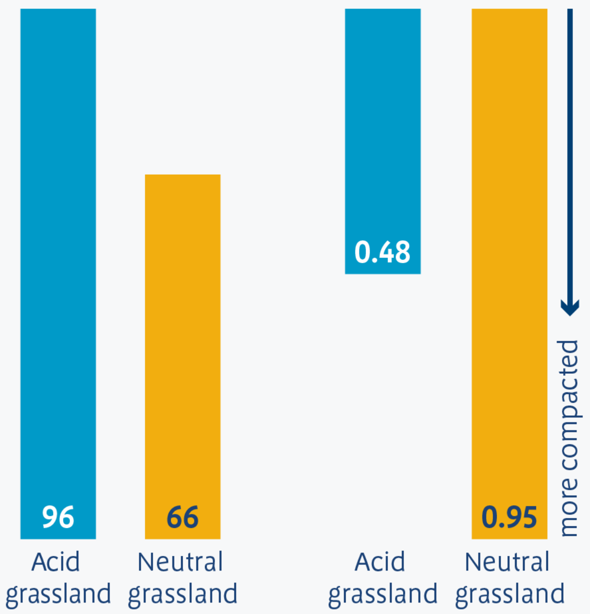
Lowland grassland SSSI feature condition (%)



Soil/sediment processes

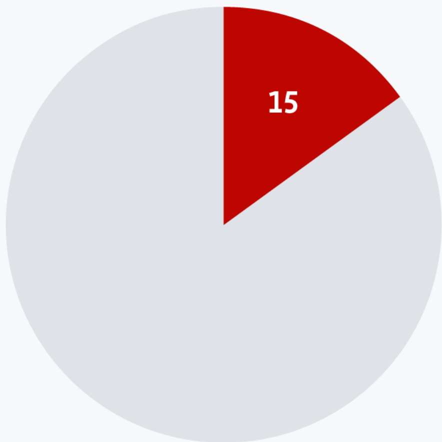
Topsoil carbon density (mean tonnes/ha)

Topsoil compaction: bulk density (mean g/cm³)



Cultural: Culture & history

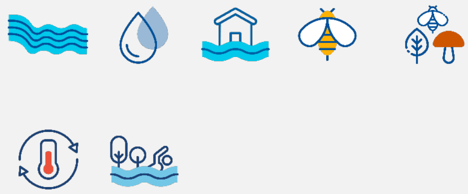
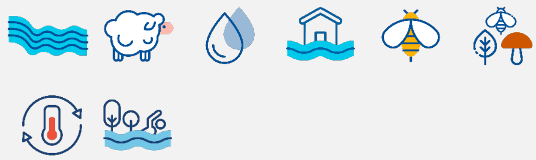
% area of Scheduled Monuments in acid, calcareous and neutral grasslands that are on the Heritage at Risk Register



Figures are rounded to the nearest whole number, which means that percentages may not always add up to 100.
See the Indicators and Data Appendix for more detail on the data used.

6.4 Priority actions for semi-natural grasslands

Listed below are 7 priority actions to reduce risk to semi-natural grasslands, with the benefits from nature supported by each action represented by icons. See Box 7 for names of benefits.

1. **Create semi-natural grasslands as part of large-scale wilder nature networks** planned and located to support multiple benefits	
2. **Sustainably manage existing semi-natural grasslands**	
3. **Reduce air and water pollution from all sources**	
4. **Work with natural processes in catchment management**, slowing flows and encouraging infiltration of rainwater	
5. **Ensure well-managed semi-natural grassland Protected Sites**	
6. **Protect, recover and re-introduce species** to support naturally functioning ecosystems, resilient to change	
7. **Use land-use planning to minimise the impact of development on semi-natural grasslands**	

7 Enclosed Farmland

Box 8. Risk to enclosed farmland ecosystem assets from main drivers of change

Our research has assessed how at-risk enclosed farmland ecosystem assets are in England, and is summarised below.

Enclosed farmland is at medium-high risk due to:	
Impact to date	Very high impact to date of **land-use change** and **pollution**
Trend – current and ongoing	Increasing impact from **climate change, invasive species** and **land-use change**

These drivers put the following benefits at risk (key: orange = medium-high risk; yellow = medium risk):

Cultivated crops	Plentiful water	Reared animals and outputs	Clean water	Erosion control	Flood protection
Pollination	Thriving plants and wildlife	Pest and disease control	Climate regulation	Cultural benefits	

7.1 Why is enclosed farmland important?

Arable, horticulture and improved grassland cover 43% of land in England[†]. Arable and horticulture are mainly in the drier east, with improved grassland in the wetter and milder west. However, this may shift with climate change. This land is primarily managed for food production. The UK is currently producing 58% of the food we eat (Defra, 2022a). Part of this is exported, which means just under half of the actual food on plates is produced in the UK, including the majority of grains, meat, dairy, and eggs (Defra, 2023d). In 2020, the

[†] For further detail, please see Appendix 1: Indicators and Data

total value of natural capital produced by agriculture in England was around £5.4 billion, according to 2021 prices (ONS, 2023a).

As well as the productive fields, the farmed landscape also includes field margins, hedges, banks of trees and scrub, plus walls and other boundary features. Small woodlands are scattered through it. Verges and ponds are part of this patchwork (along with the larger habitat patches covered in the other chapters of this report). This array of features is vital for supporting farmland wildlife and other benefits.

Food is the main benefit provided by enclosed farmland. Although we mainly farm one crop or animal species per field, this is supported by a host of other species in the soil and surrounding habitat patches. Hedgerows, banks of trees, scrub and other wilder areas are vital for supporting pollinators. Pollinator-dependent crops covered a fifth of the UK in 2007 (Breeze and others, 2011). Pollination by insects and other animals has been estimated to be worth £600 million annually in the UK (Steele and others, 2019).

Boundary and other field margin features provide habitats for species important in the control of agricultural pests and diseases. Globally, 20-40% of potential food production is lost each year to pests and diseases (Defra, 2021). Dense, single-species crops, and improved grassland are at highest risk (Agriculture and Horticulture Development Board, 2021), and this risk is likely to increase with climate change (Climate Change Committee, 2021). Greater species diversity increases the capacity to control pests and disease. This is especially true for soil biodiversity (European Commission, 2010).

Soil health and soil life are vital for farming. Soil organic matter (carbon), both alive and dead, aids water storage, nutrient cycling and chemical buffering of pollutants. It helps to bind particles and reduce soil erosion. Soil erosion has been estimated to affect 17% of arable land in England and Wales (Cranfield University, 2000). Production losses due to soil erosion have been estimated at around £40 million per year in England and Wales (Graves and others, 2015). Bare soil is more prone to both erosion and compaction. Compaction of soil from poor management, results in less infiltration of rainwater and more run-off, impacting on aquifer replenishment and flood risk.

Soil provides a critical carbon store. Enclosed farmland has the lowest carbon densities in England(Gregg and others, 2021). It is also a carbon source, with peatlands drained for agriculture having the highest greenhouse gas emissions, per hectare, of any UK land use (Gregg and others, 2021).

Our farmed landscapes are vital for our health and wellbeing, especially as places to visit close to where we live. Our People and Nature Survey shows that, when asked, almost a third of people had visited farmland in the month prior[†]. There are 17,784 ha of Scheduled Monuments on enclosed farmland, of which by area 21% are considered to be at risk[†].

[†] For further detail, please see Appendix 1: Indicators and Data

7.2 Why is enclosed farmland at risk?

The Risk Register (Morgan & Lusardi, 2024) has identified the level and trend of impacts of the five main drivers of change on enclosed farmlands in England, as summarised in Table 8.

Table 8. Impact of drivers of change on enclosed farmland

	Land-Use Change	Pollution	Natural Resource Use and Exploitation	Climate Change	Invasive Species
Enclosed farmlands	↗	→	→	↗	↗

Key to Table 8

Driver's impact on extent and condition of ecosystem assets

- Low
- Moderate
- High
- Very High

Driver's current (since the UKNEA[a]) and ongoing trend

[a] Exact timeframe over which trends were assessed differed across indicators depending on dataset availability

- ↘ Decreasing impact
- → Continuing impact
- ↗ Increasing impact
- ↑ Very rapid increase of impact

Agricultural productivity increased four-fold after the second world war (Defra, 2022a). Yields increased with mechanisation, pesticides, fertilisers, new varieties and breeds. This created the improved grassland, arable and horticultural fields we know today. Increases in productivity have been accompanied by a loss of more diverse mixed farming systems, with specialisation causing a concentration of arable in the east.

Wildlife has been affected by these changes too, with a loss in species richness in fields, margins and boundary features (Firbank and others, 2011). The farmland bird index shows a drop of approximately 59% between 1970 and 2018†. This includes declines in iconic farmland species such as skylarks, yellowhammers and lapwings (State of Nature Partnership, 2019). The farmland butterfly index also decreased by 12% on average between 1990 and 2021†.

Increasing nutrient levels have played an important role in the loss of species, going back to the advent of inorganic fertilisers in the 1900s (Firbank and others, 2011). Diffuse pollution from agriculture also impacts other ecosystems, especially freshwaters and wetlands. Atmospheric pollution from farming affects other sensitive habitats too. 87% of

† For further detail, please see Appendix 1: Indicators and Data

ammonia emissions in 2021 were from agriculture, mainly from cattle, poultry and fertiliser applications (Defra, 2023b).

Farmland has also been lost to urbanisation, roads and other infrastructure. Loss continues today with land-based renewable energy and the increasing demand on land for housing, particularly in the arable areas of the south-east.

Increasing summer temperatures, drought and extreme rainfall events are likely to increase soil erosion, desiccation, flooding, and agricultural pests and diseases (Climate Change Committee, 2021). Diseases such as blue tongue in cattle are spreading north with warmer summer temperatures (Szmaragd and others, 2010). Other invasive species such as New Zealand flatworms, which eat our native earthworms, have been introduced through garden centres and other human vectors (Cannon and others, 1999).

The combined past, present and future impact of these changes puts the benefits from enclosed farmland at medium-high risk. Loss of species diversity is a direct threat to thriving plants and wildlife, pollination and pest and disease control. Extreme weather events, plus diffuse pollution, put plentiful and clean water at further risk, and increase the likelihood of erosion. Crops and livestock are at risk from heat stress, drought, waterlogging, increased pests and diseases and loss of pollinators. Erosion and drying out of soil put farmland carbon stores at even greater risk of losing carbon to the atmosphere (See Box 8 for full list of benefits at risk).

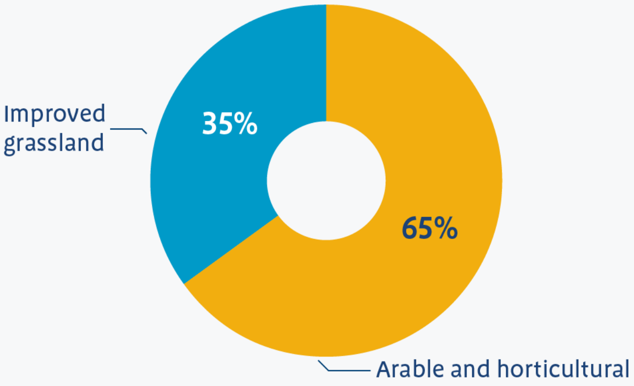
7.3 Enclosed farmland indicators

A selection of enclosed farmland indicators is shown in Figure 8, on the next page. A fuller suite is available in the Indicators and Data Appendix, which also links indicators to benefits.

Figure 8. Selection of enclosed farmland indicators. (next page)

Enclosed farmland indicators

Extent



Species composition & Cultural: nature

% change in Farmland Bird Index

1970–2018	2017–2022
-59 ↓	-6 ↓

Species composition & Cultural: nature

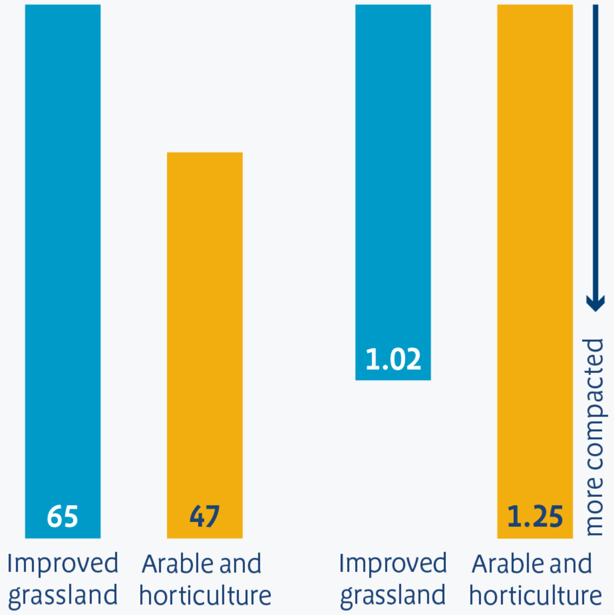
% change in Farmland Butterfly Index

1990–2021	2016–2021
-12 ↓	+6 ↑

Soil/sediment processes

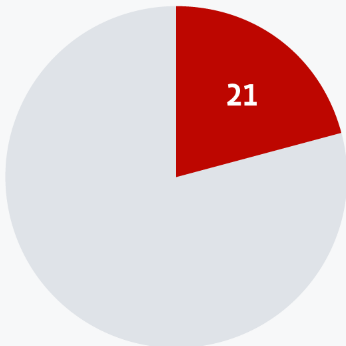
Topsoil carbon density (mean tonnes/ha)

Topsoil compaction: bulk density (mean g/cm³)



Cultural: Culture & history

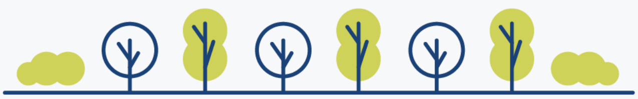
% area of Scheduled Monuments in enclosed farmland that are on the Heritage at Risk Register



Vegetation

Estimated length of hedgerows and lines of trees

← 547,000 km →



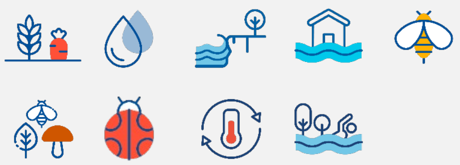
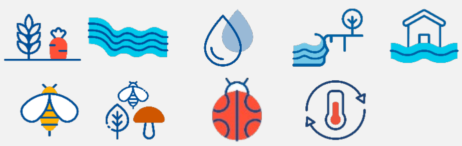
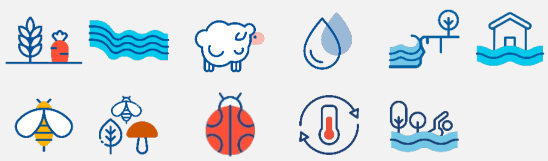
Cultural: Experiential & physical use

% of people asked that had visited fields, farmland or the countryside in the month prior

Figures are rounded to the nearest whole number, which means that percentages may not always add up to 100.
See the Indicators and Data Appendix for more detail on the data used.

7.4 Priority actions for enclosed farmland

Listed below are 7 priority actions to reduce risk to enclosed farmland, with the benefits from nature supported by each action represented by icons. See Box 8 for names of benefits.

1. **Work with natural processes in catchment and soil management**, slowing flows and encouraging infiltration of rainwater	
2. **Create species-rich nature networks within enclosed farmland** of field margins, boundary features and larger areas	
3. **Manage cultivated peat soils to reduce carbon emissions and retain their carbon stores**	
4. **Increase the carbon and biodiversity of all cultivated soils**	
5. **Reduce air and water pollution from all sources**	
6. **Reduce water consumption and waste**, adopting water conservation measures	
7. **Protect, recover and re-introduce species** to support naturally functioning ecosystems, resilient to change	

8 Urban Ecosystems

Box 9. Risk to urban ecosystem assets from main drivers of change

Our research has assessed how at-risk urban ecosystem assets are in England, and is summarised below.

Urban ecosystems are at medium-high risk due to:	
Impact to date	Very high impact to date of **land-use change** and **pollution**
Trend – current and ongoing	Increasing impact from **climate change, resource exploitation, invasive species** and **land-use change**

These drivers put the following benefits at risk (key: orange = medium-high risk):

8.1 Why are urban ecosystems important?

12% of England (not including our seas) lies within towns and cities[†]. 43% of this urban area is green and blue space[†]. This includes improved grassland in parks, sports pitches and amenity areas, as well as gardens, allotments, cemeteries, brownfield sites and green corridors. Our green and blue oases also include more nature-rich, semi-natural places such as woods, grasslands and wetlands. These vary from pocket woodlands, street trees and small ponds to large open spaces with a mosaic of different habitats. This green grid supports an array of urban wildlife, including birds, bats, bees and butterflies. Previously

[†] For further detail, please see Appendix 1: Indicators and Data

developed brownfield sites can be important, especially for urban wildflowers and invertebrates.

Urban green and blue spaces are particularly important for providing people with places to relax, unwind and interact with wildlife. As the places we visit most, closest to where we live, they play a vital role in supporting our physical and mental wellbeing and healthy child development (Davies and others, 2011). This includes reducing the prevalence of depression and anxiety (Callaghan and others, 2021). Outdoor exercise contributes to mental health and wellbeing (Brito and others, 2022). Lower rates of sick days are associated with increases in green and blue space (Moran and others, 2021).

Urban semi-natural places close to where people live make it possible to interact with wildlife on a regular basis. 50% of people surveyed had visited an urban greenspace, park, field, or playground in the last month[†]. As such, the location, distribution and accessibility of green and blue spaces is vital. The Accessible Greenspace Standards show that we are substantially below Government target levels of greenspace on our doorsteps, locally and in the wider neighbourhood[†]. We also need to feel safe visiting these places.

Access to green and blue space varies considerably across England. Deprived areas systematically fare worse in terms of the quantity and quality of greenspace (Commission for Architecture and the Built Environment, 2010). The most densely populated areas have the least greenspace (Commission for Architecture and the Built Environment, 2010). 7% of people have no access to personal greenspace such as a garden or allotment[†], particularly those living in areas of social deprivation, low-income households, ethnic minority groups, the unemployed and those suffering from poor health (Natural England, 2021).

Urban greenspaces allow rainwater to get into the soil, playing a vital role in reducing pollution, surface water flows and flooding. They also provide space for floodwaters. Sand dunes can be a barrier to coastal flooding, while saltmarshes can help to protect seawalls and reduce wave energy.

While all pollution is best tackled at source, plants and particularly trees can contribute to clean air, through both removing pollutants and keeping them away from people. The annual value of air pollution removal by urban vegetation was estimated at around £800 million in 2021 (ONS, 2023b). Vegetation also helps to buffer noise, with soft lawns decreasing noise more than paving (Bolund & Hunhammar, 1999).

As summer temperatures increase, so does the need for green/blue space and trees for urban cooling. Ecosystems help to counter the urban heat island effect. They provide shade and reduce temperatures through evaporation. Vegetation also absorbs and retains less heat than built surfaces. A 10% increase in tree cover in London could reduce surface temperature by 3-4°C (Forestry Commission, 2010). Woodlands, wetlands and other semi-natural urban habitats can also function as carbon stores and sinks.

8.2 Why are urban ecosystems at risk?

The Risk Register (Morgan & Lusardi, 2024) has identified the level and trend of impacts of the five main drivers of change on urban ecosystems in England, as summarised in Table 9.

Table 9. Impact of drivers of change on urban ecosystems

	Land-Use Change	Pollution	Natural Resource Use and Exploitation	Climate Change	Invasive Species
Urban	↗	→	↗	↗	↗

Key to Table 9

Driver's impact on extent and condition of ecosystem assets

Low

High

Moderate

Very High

Driver's current (since the UKNEA[a]) and ongoing trend

[a] Exact timeframe over which trends were assessed differed across indicators depending on dataset availability

↘ Decreasing impact

↗ Increasing impact

→ Continuing impact

↑ Very rapid increase of impact

Situated in the heart of our towns and cities, where most of us live, urban green and blue spaces are especially affected by social, demographic and economic change. Many (particularly brownfield sites) have been lost to housing, transport and other infrastructure (Davies and others, 2011). Vegetation has been replaced by concrete, tarmac and other non-permeable surfaces, including paving of front gardens over the last 50 years (Perry & Nawaz, 2008). This increases surface water run-off to our urban watercourses, which are largely canalised, or even buried underground in culverts. Urban freshwaters have been polluted by sewage and storm water discharges, run-off from roads and pollution from industry, past and present.

Climate change means we will place additional demands on our urban ecosystems. We need the benefits from our urban blue and greenspaces more than ever. This includes urban cooling plus outdoor greenspaces in heat waves, and flood protection from storms. Heat waves result in a further deterioration in air quality (HM Government, 2023). Drought, flooding, increased summer temperatures and demand for water, put clean and plentiful water at risk. All of these pressures (plus the spread of invasive species) impact on our urban plants and animals, ultimately putting our green and blue carbon stores at risk (See Box 9 for full list of benefits at risk).

8.3 Urban indicators

A selection of urban indicators is shown in Figure 9 on the next page. A fuller suite is available in the Indicators and Data Appendix, which also links indicators to benefits.

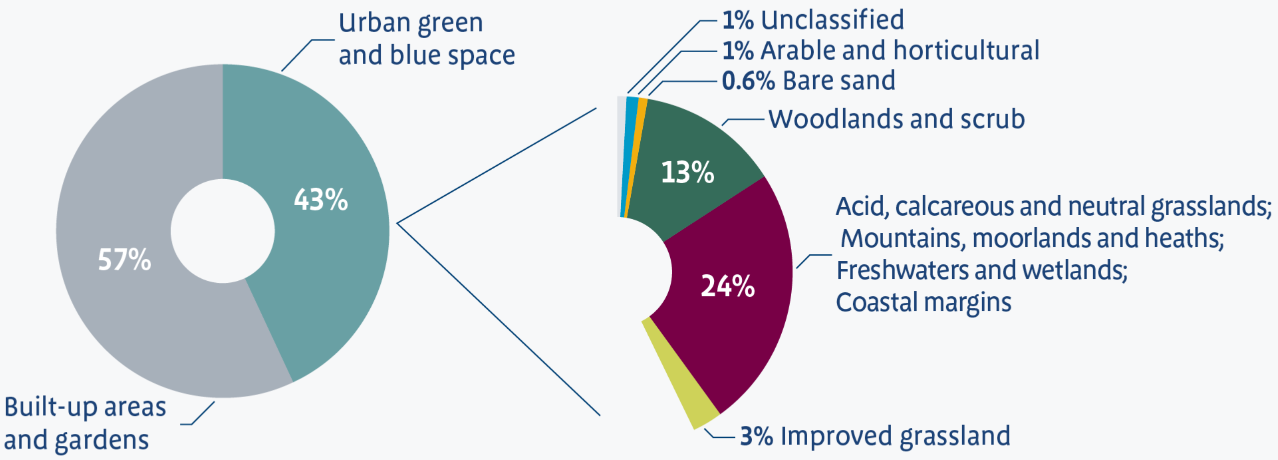
Figure 9. Selection of urban indicators. (next page)

Urban indicators

Extent

Urban areas

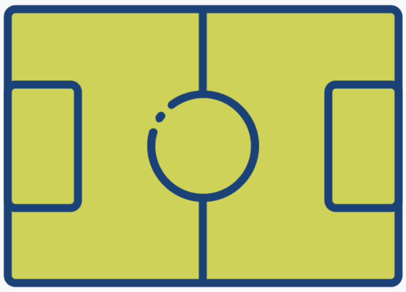
Urban green and blue space



Cultural: Accessibility

Local nature reserve provision

0.76 ha per 1000 people, which is approximately one football pitch

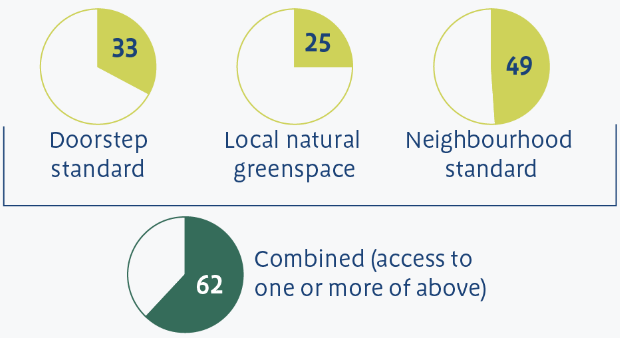


Cultural: Safety

Perceived safety of green space (% of visitors feeling safe/welcome)

Spatial configuration

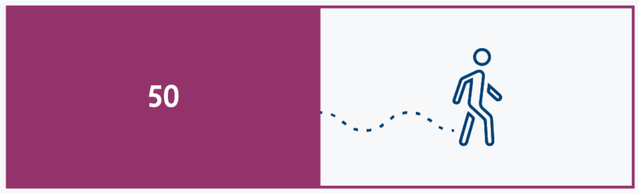
% of population meeting Accessible Greenspace Standard



Cultural: Experiential & physical use

% of people asked that had visited urban green spaces, allotments or community gardens in the month prior

Urban green space (park, field, playground)

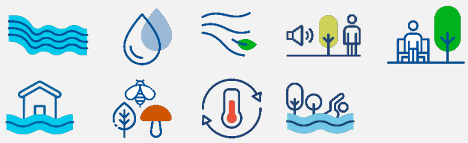
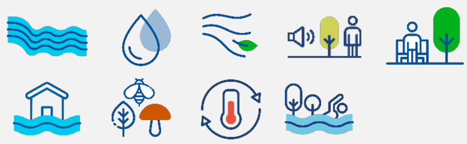


Allotment/community garden

Figures are rounded to the nearest whole number, which means that percentages may not always add up to 100.
See the Indicators and Data Appendix for more detail on the data used.

8.4 Priority actions for urban ecosystems

Listed below are 6 priority actions to reduce risk to urban ecosystems, with the benefits from nature supported by each action represented by icons. See Box 9 for names of benefits.

1. **Create multi-functional networks of accessible, wildlife-rich green and blue urban space**	
2. **Use land-use planning measures to embed climate adaption in new developments**, including reducing water use, surface run-off and flood-risk, as well as vegetation for cooling	
3. **Create, protect and conserve natural urban carbon sinks and stores**, including salt marshes, semi-natural grasslands, woodlands, bogs, peat and other soils	
4. **Reduce air and water pollution from all sources**	
5. **Protect and improve access to high quality natural greenspaces for people of all abilities** addressing inequalities in the current provision	
6. **Ensure well-managed urban Protected Sites**	

References

All online references were accessed between July 2023 and April 2024.

Agriculture and Horticulture Development Board 2021. Encyclopaedia of pests and natural enemies in field crops. Available at: https://ahdb.org.uk/pests

Albertson, K., Aylen, J., Cavan, G., and McMorrow, J. 2009. Forecasting the outbreak of moorland wildfires in the English Peak District. *J Environ Manage,* 90(8), 2642-2651.

Austen, M., Malcolm, S., Frost, M., Hattam, C., Mangi, S., and Stentiford, G. 2011. Chapter 12: Marine. *In: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment,* Cambridge: UNEP-WCMC. Available at: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

Beaumont, N.J., Jones, L., Garbutt, A., Hansom, J.D., and Toberman, M. 2014. The value of carbon sequestration and storage in coastal habitats. *Estuarine, Coastal and Shelf Science,* 137, 32-40.

Bell, F., and Craven, J. 2024. State of Natural Capital Report for England Appendix 2: Indicators and Data Methods, Natural England, NERR137 Appendix 2.

Bolund, P., and Hunhammar, S. 1999. Ecosystem services in urban areas. *Ecological Economics,* 29, 293 - 301.

Bonn, A., Holden, J., Parnell, M., Worrall, F., Chapman, P.J., Evans, C.D., Termansen, M., Beharry-Borg, N., Acreman, M.C., Rowe, E., Emmett, B., and Tsuchiya, A. 2010. Ecosystem services of peat – Phase 1.

Breeze, T.D., Bailey, A.P., Balcombe, K.G., and Potts, S.G. 2011. Pollination services in the UK: How important are honeybees? *Agriculture, Ecosystems & Environment,* 142(3-4), 137-143.

Brito, H.S., Carraca, E.V., Palmeira, A.L., Ferreira, J.P., Vleck, V., and Araujo, D. 2022. Benefits to Performance and Well-Being of Nature-Based Exercise: A Critical Systematic Review and Meta-Analysis. *Environ Sci Technol,* 56(1), 62-77.

Brown, S. 2020. The social benefits of Blue Space: a systematic review, Environment Agency. Available at: https://www.gov.uk/government/publications/the-social-benefits-of-blue-space-a-systematic-review

Bullock, A., and Acreman, M. 2003. The role of wetlands in the hydrological cycle. *Hydrology & Earth System Sciences,* 7(3), 358-389.

Bullock, J., Jefferson, R.G., Blackstock, T.H., Pakeman, R.J., Emmett, B.A., Pywell, R.J., Grime, J.P., and Silvertown, J. 2011. Chapter 6: Semi-Natural Grasslands. *In: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment.,* Cambridge: UNEP-WCMC. Available at: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

Burden, A., Smeaton, C., Angus, S., Garbutt, A., Jones, L., Lewis, H.D., and Rees, S.M. 2020. Impacts of climate change on coastal habitats relevant to the coastal and marine environment around the UK. *MCCIP Science Review 2020*, 228-255.

Callaghan, A., McCombe, G., Harrold, A., McMeel, C., Mills, G., Moore-Cherry, N., and Cullen, W. 2021. The impact of green spaces on mental health in urban settings: a scoping review. *Journal of Mental Health,* 30(2), 179-193.

Cannon, R.J.C., Baker, R.H.A., Taylor, M.C., and Moore, J.P. 1999. A review of the status of the New Zealand flatworm in the UK. *Annals of Applied Biology,* 135, 597-614.

Climate Change Committee 2021. Independent Assessment of UK Climate Risk: Advice to Government For The UK's Third Climate Change Risk Assessment (CCRA3). Available at: https://www.theccc.org.uk/publication/independent-assessment-of-uk-climate-risk/

Cole, A.J., Griffiths, R.I., Ward, S.E., Whitaker, J., Ostle, N.J., Bardgett, R.D., and Manning, P. 2019. Grassland biodiversity restoration increases resistance of carbon fluxes to drought. *Journal of Applied Ecology,* 56(7), 1806-1816.

Cole, B., Smith, G., and Baltzer, H. 2018. Acceleration and fragmentation of CORINE land cover changes in the United Kingdom from 2006-2012 detected by Copernicus IMAGE2012 satellite data. *International Journal of Applied Earth Observation and Geoinformation,* 73, 107-122.

Commission for Architecture and the Built Environment 2010. Urban Green Nation: Building the Evidence Base. Available at: https://webarchive.nationalarchives.gov.uk/ukgwa/20110118100054/http://www.cabe.org.uk/publications/urban-green-nation

Cranfield University 2000. Soil Protection in the UK, Cranfield University.

Craven, J., Bell, F., and Dobson, M. 2024. State of Natural Capital Report for England Appendix 1: Indicators and Data, Natural England, NERR137 Appendix 1.

Davies, L., Kwiatkowski, L., Gaston, K.J., Beck, H., Brett, H., Batty, M., Scholes, L., Wade, R., Sheate, W.R., Sadler, J., Perino, G., Andrews, B., Kontoleon, A., Bateman, I., and Harris, J.A. 2011. Chapter 10: Urban. *In: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment.,* Cambridge: UNEP-WCMC. Available at: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

Defra 2022a. Agriculture in the United Kingdom 2022. Available at: https://www.gov.uk/government/statistics/agriculture-in-the-united-kingdom-2022

Defra 2023a. C7: Healthy seas: fish and shellfish populations. Available at: https://oifdata.defra.gov.uk/themes/seas-and-estuaries/C7/

Defra 2023b. Emissions of air pollutants in the UK. Available at: https://www.gov.uk/government/statistics/emissions-of-air-pollutants/emissions-of-air-pollutants-in-the-uk-ammonia-nh3

Defra 2022b. England Biodiversity Indicator 6: Species in the wider countryside: Woodland.

Defra 2019. Marine Strategy Part One: UK updated assessment and Good Environmental Status. Available at: https://www.gov.uk/government/publications/marine-strategy-part-one-uk-updated-assessment-and-good-environmental-status

Defra 2023c. Plan for Water: our integrated plan for delivering clean and plentiful water. Available at: https://www.gov.uk/government/publications/plan-for-water-our-integrated-plan-for-delivering-clean-and-plentiful-water/plan-for-water-our-integrated-plan-for-delivering-clean-and-plentiful-water

Defra 2021. United Kingdom Food Security Report 2021. Available at: https://www.gov.uk/government/statistics/united-kingdom-food-security-report-2021

https://consult.environment-agency.gov.uk/water-resources/water-resources-priority-catchments/supporting_documents/CETJBAXXXXRPZ0019A6C02WRB_WWNP_final%2010catch.PDF

Environment Agency 2017. Working with natural processes to reduce flood risk. Available at: https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/working-with-natural-processes-to-reduce-flood-risk

Environment Agency, Chief Scientist's Group 2023. State of the environment: the coastal and marine environment. Available at: https://www.gov.uk/government/publications/state-of-the-environment

Environmental Audit Committee 2022. Water quality in rivers, HC 74 2021-22, WQR0031. Available at: https://committees.parliament.uk/writtenevidence/22367/default/

European Commission 2010. The factory of life: Why soil biodiversity is so important. Available at: https://ec.europa.eu/environment/archives/soil/pdf/soil_biodiversity_brochure_en.pdf

Firbank, L., Bradbury, R., McCkracken, D., and Stoate, C. 2011. Chapter 7: Enclosed Farmland. *In: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment,* Cambridge: UNEP-WCMC. Available at: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

Forest School Association What is Forest School? Available at: https://forestschoolassociation.org/what-is-forest-school/

Forestry Commission 2010. The case for trees in development and the urban environment. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/718033/eng-casefortrees.pdf

Fuller, R.M. 1987. The changing extent and conservation interest of lowland grasslands in England and Wales: a review of grassland surveys 1930–1984. *Biological Conservation,* 40(4), 281-300.

Gardiner, B., Palmer, H., and Hislop, M. 2006. Principles of using wood for shelter. Available at: https://www.researchgate.net/publication/237356779_The_Principles_of_Using_Woods_for_Shelter

Glaves, D.J., Crowle, A.J.W., Bruemmer, C., and Lenaghan, S.A. 2020. The causes and prevention of wildfire on heathlands and peatlands in England, Natural England. Available at: https://publications.naturalengland.org.uk/publication/4741162353295360

Goulson, D., Hanley, M.E., Darvill, B., Ellis, J.S., and Knight, M.E. 2005. Causes of rarity in bumblebees. *Biological Conservation,* 122(1), 1-8.

Graves, A.R., Morris, J., Deeks, L.K., Rickson, R.J., Kibblewhite, M.G., Harris, J.A., Farewell, T.S., and Truckle, I. 2015. The total costs of soil degradation in England and Wales. *Ecological Economics,* 119, 399-413.

Green, D.S. 2016. Effects of microplastics on European flat oysters, Ostrea edulis and their associated benthic communities. *Environmental Pollution,* 216, 95-103.

Gregg, R., Elias, J., Alonso, I., Crosher, I., Muto, P., and Morecroft, M. 2021. Carbon storage and sequestration by habitat: a review of the evidence (second edition). Natural England Research Report NERR094. York, Natural England. Available at: https://publications.naturalengland.org.uk/publication/5419124441481216

Guerrieri, R., Vanguelova, E., Pitman, R., Benham, S., Perks, M., Morison, J.I.L., and Mencuccini, M. 2020. Climate and atmospheric deposition effects on forest water-use efficiency and nitrogen availability across Britain. *Sci Rep,* 10(1), 12418.

HM Government 2023. National Risk Register 2023 edition. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1175834/2023_NATIONAL_RISK_REGISTER_NRR.pdf

IPBES 2016. The methodological assessment report on scenarios and models of biodiversity and ecosystem services. S. FERRIERand others. Bonn, Germany, Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 348pp. Available at: https://digitallibrary.un.org/record/3793989

Isbell, F., Craven, D., Connolly, J., Loreau, M., Schmid, B., Beierkuhnlein, C., Bezemer, T.M., Bonin, C., Bruelheide, H., de Luca, E., Ebeling, A., Griffin, J.N., Guo, Q., Hautier, Y., Hector, A., Jentsch, A., Kreyling, J., Lanta, V., Manning, P., Meyer, S.T., Mori, A.S., Naeem, S., Niklaus, P.A., Polley, H.W., Reich, P.B., Roscher, C., Seabloom, E.W., Smith, M.D., Thakur, M.P., Tilman, D., Tracy, B.F., van der Putten, W.H., van Ruijven, J., Weigelt, A., Weisser, W.W., Wilsey, B., and Eisenhauer, N. 2015. Biodiversity increases the resistance of ecosystem productivity to climate extremes. *Nature,* 526(7574), 574-577.

Jauker, F., Diekötter, T., Schwarzbach, F., and Wolters, V. 2009. Pollinator dispersal in an agricultural matrix: opposing responses of wild bees and hoverflies to landscape structure and distance from main habitat. *Landscape Ecology,* 24(4), 547-555.

Jones, L., Angus, S., Cooper, A., Doody, P., Everard, M., Garbutt, A., Gilchrist, P., Hansom, J., Nicholls, R., Pye, K., Ravenscroft, N., Rees, S., Rhind, P., and Whitehouse, A. 2011. Chapter 11: Coastal Margins. *In: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment,* Cambridge: UNEP-WCMC. Available at: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

Li, P., Irvine, B., Holden, J., and Mu, X. 2017. Spatial variability of fluvial blanket peat erosion rates for the 21st Century modelled using PESERA-PEAT. *Catena,* 150, 302-316.

Lusardi, J., Rice, P., Craven, J., Hinson, C., Bell, F., Morgan, A., Martin, K., Dobson, M., Sunderland, T., and Waters, R. 2024. State of Natural Capital Report for England 2024 - risks to nature and why it matters, Natural England, NERR137.

Lusardi, J., Rice, P., Waters, R.D., and Craven, J. 2018. Natural Capital Indicators: for defining and measuring change in natural capital, Natural England Research Report, Number 076. Available at: https://publications.naturalengland.org.uk/publication/6742480364240896

Malone, T.C., and Newton, A. 2020. The Globalization of Cultural Eutrophication in the Coastal Ocean: Causes and Consequences. *Frontiers in Marine Science,* 7.

Maltby, E., Ormerod, S., Acreman, M., Blackwell, M., Durance, I., Everard, M., Morris, J., and Spray, C. 2011. Chapter 9: Freshwaters – Openwaters, Wetlands and Floodplains. *In: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment,* Cambridge: UNEP-WCMC. Available at: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

Moran, D., Jones, P.I., Jordaan, J.A., and Porter, A.E. 2021. Nature Contact in the Carceral Workplace: Greenspace and Staff Sickness Absence in Prisons in England and Wales. *Environment and Behavior,* 54(2), 276-299.

Morgan, A., and Lusardi, J. 2024. Natural Capital Risk Register: A Technical Report for the State of Natural Capital Report for England 2024, Natural England, NERR137 TR1.

Natural England 2022. Living England: Satellite-based habitat classification- Technical User Guide (NERR108). Available at: https://publications.naturalengland.org.uk/publication/4918342350798848

Natural England 2021. The People and Nature Survey for England: Data and publications from Adults survey year 1 (April 2020 - March 2021) (Official Statistics) main findings. Available at: https://www.gov.uk/government/statistics/the-people-and-nature-survey-for-england-data-and-publications-from-adults-survey-year-1-april-2020-march-2021-official-statistics/the-people-and-nature-survey-for-england-data-and-publications-from-adults-survey-year-1-april-2020-march-2021-official-statistics-main-finding

Nisbet, T., Silgram, M., Shah, N., Morrow, K., and Broadmeadow, S. 2011. Woodland for Water: Woodland measures for meeting Water Framework Directive objectives. Forest Research Monograph. Surrey, Forest Research. 4, 156pp.

O'Brien, L., and Murray, R. 2006. A marvellous opportunity for children to learn: a participatory evaluation of Forest School in England & Wales, Forestry Commission. Available at: http://www.forestresearch.gov.uk/fr/INFD-5Z3JVZ

Öckinger, E., and Smith, H.G. 2006. Semi-natural grasslands as population sources for pollinating insects in agricultural landscapes. *Journal of Applied Ecology,* 44(1), 50-59.

ONS 2023a. England natural capital accounts: 2023. Available at: https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/englandnaturalcapitalaccounts/2023

ONS 2022a. Habitat extent and condition, natural capital, UK: 2022. Available at: https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/habitatextentandconditionnaturalcapitaluk/2022

ONS 2021. Marine accounts, natural capital, UK: 2021. Available at: https://www.beta.ons.gov.uk/economy/environmentalaccounts/bulletins/marineaccountsnaturalcapitaluk/2021

ONS 2022b. Saltmarsh flood mitigation in England and Wales, natural capital: 2022. Available at: https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/saltmarshfloodmitigationinenglandandwalesnaturalcapital/2022

ONS 2020. UK natural capital accounts: 2020, Office for National Statistics. Available at: https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalaccounts/2020

ONS 2023b. Urban natural capital accounts, UK: 2023. Available at: https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/urbannaturalcapitalaccountsuk/2023

ONS 2022c. Woodland Natural Capital Accounts: 2022. Available at: https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/woodlandnaturalcapitalaccountsuk/2022

Pearce-Higgins, J.W., Beale, C.M., Oliver, T.H., August, T.A., Carroll, M., Massimino, D., Ockendon, N., Savage, J., Wheatley, C.J., Ausden, M.A., Bradbury, R.B., Duffield, S.J., Macgregor, N.A., McClean, C.J., Morecroft, M.D., Thomas, C.D., Watts, O., Beckmann, B.C., Fox, R., Roy, H.E., Sutton, P.G., Walker, K.J., and Crick, H.Q.P. 2017. A national-scale assessment of climate change impacts on species: Assessing the balance of risks and opportunities for multiple taxa. *Biological Conservation,* 213, 124-134.

Perry, T., and Nawaz, R. 2008. An investigation into the extent and impacts of hard surfacing of domestic gardens in an area of Leeds, United Kingdom. *Landscape and Urban Planning,* 86(1), 1-13.

Peterken, G. 1996. *Natural woodland: ecology and conservation in northern temperate regions.*Cambridge: Cambridge University Press.

Powe, N.A., and Willis, K.G. 2004. Mortality and morbidity benefits of air pollution (SO2 and PM10) absorption attributable to woodland in Britain. *Journal of Environmental Management,* 70, 119-128.

Quine, C., Cahalan, C., Hester, A., Humphrey, J., Kirby, K., Moffat, A., and Valatin, G. 2011. Chapter 8: Woodlands. *In: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment.,* Cambridge: UNEP-WCMC. Available at: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

Rackham, O. 1986. *The history of the countryside: the classic history of Britain's landscape, flora and fauna.*London: Dent.

Ridding, L.E., Redhead, J.W., and Pywell, R.F. 2015. Fate of semi-natural grassland in England between 1960 and 2013: A test of national conservation policy. *Global Ecology and Conservation,* 4, 516-525.

Roberts, C.M. 2007. *The unnatural history of the sea.*London: Octopus Publishing Group.

Robins, P.E., Skov, M.W., Lewis, M.J., Giménez, L., Davies, A.G., Malham, S.K., Neill, S.P., McDonald, J.E., Whitton, T.A., Jackson, S.E., and Jago, C.F. 2015. Impact of climate change on UK estuaries: A review of past trends and political projections. *Estuarine, Coastal and Shelf Science,* 169, 119-135.

RSPB 2014. England's upland peatlands. Available at: https://www.iucn-uk-peatlandprogramme.org/sites/www.iucn-uk-peatlandprogramme.org/files/English%20upland%20peatlands%20report%20Jun14%20Final_1.pdf

Staddon, P.L., Thompson, P., and Short, C. 2023. Re-evaluating the sensitivity of habitats to climate change. Natural England Commissioned Report NECR478, Natural England.

State of Nature Partnership 2019. State of Nature. Available at: https://nbn.org.uk/wp-content/uploads/2019/09/State-of-Nature-2019-UK-full-report.pdf

Steele, D.J., Baldock, K.C.R., Breeze, T.D., Brown, M.J.F., Carvell, C., Dicks, L.V., Garratt, M.P., Norman, H., Potts, S.G., Senapathi, D., and Vanbergen, A.J. 2019. Management and drivers of change of pollinating insects and pollination services, Defra, UK. Available at: https://centaur.reading.ac.uk/88315/1/Steele%20et%20al.%202019%20NPS%20Evidence%20Update.pdf

Stratford, C., Miller, J., House, A., Old, G., Acreman, M., Dueñas-Lopez, M.A., Nisbet, T., Newman, J., Burgess-Gamble, L., Chappell, N., Clarke, S., Leeson, L., Monbiot, G., Paterson, J., Robinson, M., Rogers, M., and Tickner, D. 2017. Do trees in UK-relevant river catchments influence fluvial flood peaks?, UK Centre for Ecology and Hydrology. Available at: https://nora.nerc.ac.uk/id/eprint/517804/

Szmaragd, C., Wilson, A.J., Carpenter, S., Wood, J.L., Mellor, P.S., and Gubbins, S. 2010. The spread of bluetongue virus serotype 8 in Great Britain and its control by vaccination. *PLoS ONE,* 5(2), e9353.

The Conservation Volunteers 2024. The history of tree planting. Conservation Handbooks. Available at: https://conservationhandbooks.com/tree-planting-aftercare/why-plant-trees/the-history-of-tree-planting/

Thurstan, R.H., Brockington, S., and Roberts, C.M. 2010. The effects of 118 years of industrial fishing on UK bottom trawl fisheries. *Nature Communications,* 1(15).

Troubled Waters 2021. Troubled Waters: Why poor water quality is threatening some of our best places for nature and how we can fix it. Available at: https://www.pan-uk.org/site/wp-content/uploads/Troubled-Waters-Report.pdf

UK Climate Risk 2021. The Third Climate Change Risk Assessment: Technical Report. Available at: https://www.ukclimaterisk.org/wp-content/uploads/2021/06/Technical-Report-The-Third-Climate-Change-Risk-Assessment.pdf

UK Groundwater Forum Is the water in my tap groundwater? Available at: http://www.groundwateruk.org/Is-The-Water-in-my-tap-groundwater.aspx

UK National Ecosystem Assessment 2011. The UK National Ecosystem Assessment: Technical Report. Cambridge, UNEP-WCMC. Available at: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

United Nations Environment Programme 2006. UNEP 2006 Annual Report. Available at:

Van der Wal, R., Bonn, A., Monteith, D., Reed, M., Blackstock, K., Hanley, N., Thompson, D., Evans, M., and Alonso, I. 2011. Chapter 5: Mountains, Moorlands and Heaths. *In: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment,* Cambridge: UNEP-WCMC. Available at: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

Vickery, J.A., Tallowin, J.R., Feber, R.E., Asteraki, E.J., Atkinson, P.W., Fuller, R.J., and Brown, V.K. 2001. The management of lowland neutral grasslands in Britain: effects of agricultural practices on birds and their food resources. *Journal of Applied Ecology,* 38(3), 647-664.

Walling, D.E., Fang, D., Nicholas, A.P., and Sweet, R.J. 2006. River flood plains as carbon sinks. Sediment Dynamics and the Hydromorphology of Fluvial Systems, Dundee, UK.

Watson, A.J., Schuster, U., Shutler, J.D., Holding, T., Ashton, I.G.C., Landschützer, P., Woolf, D.K., and Goddijn-Murphy, L. 2020a. Revised estimates of ocean-atmosphere CO2 flux are consistent with ocean carbon inventory. *Nature Communications,* 11(4422).

Watson, S.C.L., Preston, J., Beaumont, N.J., and Watson, G.J. 2020b. Assessing the natural capital value of water quality and climate regulation in temperate marine systems using a EUNIS biotope classification approach. *Science of The Total Environment,* 744.

Whelan, M.J., Linstead, C., Worrall, F., Ormerod, S.J., Durance, I., Johnson, A.C., Johnson, D., Owen, M., Wiik, E., Howden, N.J.K., Burt, T.P., Boxall, A., Brown, C.D., Oliver, D.M., and Tickner, D. 2022. Is water quality in British rivers "better than at any time since the end of the Industrial Revolution"? *Science of The Total Environment,* 843, 157014.

Williams, P., Biggs, J., Crowe, A., Murphy, J., Nicolet, P., Weatherby, A., and Dunbar, M. 2010. Countryside survey: ponds report from 2007, Pond Conservation and NERC/ Centre for Ecology & Hydrology. (CS Technical Report No. 7/07 CEH Project Number: C03259). Available at: https://nora.nerc.ac.uk/id/eprint/9622/1/N009622CR.pdf

Winters, G., Nelle, P., Fricke, B., Rauch, G., and Reusch, T.B.H. 2011. Effects of a simulated heat wave on photophysiology and gene expression of high- and low-latitude populations of Zostera marina. *Marine Ecology Progress Series,* 435, 83-95.

www.gov.uk/natural-england