Environment Agency


Working with nature




Chief Scientist's Group report

July 2022

We are the Environment Agency. We protect and improve the environment.

We help people and wildlife adapt to climate change and reduce its impacts, including flooding, drought, sea level rise and coastal erosion.

We improve the quality of our water, land and air by tackling pollution. We work with businesses to help them comply with environmental regulations. A healthy and diverse environment enhances people's lives and contributes to economic growth.

We can't do this alone. We work as part of the Defra group (Department for Environment, Food & Rural Affairs), with the rest of government, local councils, businesses, civil society groups and local communities to create a better place for people and wildlife.

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"We are embedded in Nature. It is our home, and it provides us with a multitude of services we take for granted. So, even while we have enjoyed the fruits of economic growth, the demands we have made of Nature's goods and services have for some decades exceeded her ability to supply them on a sustainable basis."

Professor Sir Partha Dasgupta

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Foreword

Due to centuries of industrialisation, the intensification of agriculture and extraction of natural resources, the UK is now one of the most nature-depleted countries in the world. Demands on the land are set to increase: a growing population needs more water to drink, food to eat and places to live. In March, the government set out new proposals to halt the decline in species abundance by 2030. It also committed to designate and protect 30% of UK land by 2030, and Local Nature Recovery Strategies (a measure in the Environment Bill) will help drive action locally.

The activities outlined in this report are not enough to solve the nature emergency, but when the international community meets to discuss that at Nature COP15 they will need positive real-world examples to inform overarching future targets. Global systems must change in ways we can't yet imagine but we should start with what we can do, practically and locally, now.

Nature based solutions, though not possible everywhere, are a win-win. Take peatland for example. The Environment Agency works with local authorities, businesses and community groups to protect and re-wet peat. We created 531 hectares of blanket bog and restored a further 2,148 hectares across England in 2019/2020. Aside from protecting the intrinsic natural beauty of this landscape, this work represents value for money. Peatland filters water, meaning water companies can use less chemical treatment; it provides habitats for rare and declining species and it helps store carbon to mitigate the impacts of climate change.

Earlier this year, the Intergovernmental Panel on Climate Change cited the Environment Agency's Flood and Coastal Erosion Risk Management Strategy as an example of climate adaptation for its commitment to working with nature. In this report you will find many more good examples including tree planting, species re-introductions and natural flood management, but they all need finance.

Last month, along with Defra and Natural England, the Environment Agency announced the second round of projects funded through the Natural Environment Investment Readiness Fund (NEIRF). The fund provides grants of up to £100,000 to help organisations develop projects to the stage where they can demonstrate a return on investment.

One of the four pilot schemes is the Wyre Natural Flood Management project which reduces flood risk to downstream communities. Over several years, interventions in the Wyre catchment will include wetland creation, leaky barriers, sloped embankments, alongside peatland and river restoration. It uses a new financial model which will see the upfront investment repaid through contracts with organisations that benefit from improvements, including water and insurance companies. It is also the first environmental project eligible for Social Investment Tax Relief, which has helped bring in high net worth investment to the project. Tax relief of this kind could be extremely useful to finding finance for future projects.

Thank you to Natural England and the Forestry Commission for their support in the production of this report.

Emma Howard Boyd, Chair of the Environment Agency

Headline messages

- The complex ecosystems which society depends on for services such as clean water, climate regulation and food, are under threat globally due to loss of biodiversity and climate change.

- Since these services underpin our ability to survive and thrive on this planet, it should be viewed as an existential risk.

- England has experienced millennia of land use change by people and is one of the most nature depleted countries in the world, with impacts accelerating since the mid 20th century.

- Large areas of habitats have been lost, with 99.7% of fens, 97% of species-rich grasslands, 80% of lowland heathlands, up to 70% of ancient woodlands, and up to 85% of saltmarshes destroyed or degraded.

- The impacts on species have been severe, with a quarter of mammals in England and almost a fifth of UK plants threatened with extinction. A third of British pollinator species have declined.

- Demands on the land will increase in the next few decades as the population grows and we mitigate against and adapt to climate change.

- Working with nature, including tree planting, peat restoration, species reintroductions, and natural flood management, there are opportunities to restore biodiversity, while providing other benefits such as carbon sequestration, flood protection and clean and plentiful water.

- In order to maximise these opportunities, the choices we make must be appropriate to local conditions and ensure connectivity between different habitats to support biodiversity and help plants and animals adapt to climate change.

- The Environment Agency is working with others to make sure that we achieve multiple benefits for nature and people, wherever we can.

- The challenges are great, and the transitions needed are significant; it will take everyone playing their part and working together to address the dual climate and biodiversity crises.

Introduction

Biodiversity is defined by the Convention on Biological Diversity as "diversity within species, between species and of ecosystems."[1] It is the product of hundreds of millions of years of evolution, as species have adapted to and changed their environments. Species have carved out niches in a rich web of life, forming dependencies on each other in predatory and symbiotic relationships. What exists now is an incredibly complex network of up to 8.7 million different species.[2] Earth is the only planet known to be home to life and many regard biodiversity as having intrinsic value, which we have a moral responsibility to preserve.

Our economies are embedded within nature.[3] Nature provides us with a host of services which we depend upon, such as clean water, clean air and food. It's also vital in providing resilience to climate change by absorbing carbon dioxide, regulating local climatic conditions and providing flood protection. The natural environment is hugely important for our health and well-being; green and blue spaces benefit our mental and physical health.

Due to centuries of industrialisation and extraction of natural resources, the UK is now one of the most nature-depleted countries in the world.[4] Recent trends show a rapid decline in many species, and habitats such as wetlands and wildflower meadows have all but disappeared.[5] While it may appear like a green and pleasant land, there is in fact relatively little space left for nature in our cities and countryside. Land use change has encroached on natural habitats and produced pollutants which impact the quality of remaining habitats.[6] Climate change is also beginning to have an impact on species distributions, and is predicted to have a stronger effect in the future.

The latest climate change report from the IPCC emphasises the urgency of action to limit warming to 1.5 degrees. It states with high confidence that globally, some ecosystems have already reached their adaptation limits, and that others will soon reach theirs if immediate measures are not taken. Achieving net zero emissions as soon as possible is imperative.[7] The way in which we use the limited amount of land in England will be one of the main determinants in reaching this country's net zero carbon ambition in the next few decades. Climate mitigation through carbon sequestration and biofuel cultivation, as well as adaptation measures such as flood management, will require extensive amounts of land.[8] Combined with a growing population and the associated need for food, housing and infrastructure, there will be an exceptional demand on land to achieve all these goals. All these uses of the land fundamentally require diverse ecosystems to sustain them and therefore, biodiversity must be enhanced as part of this transformation.

This report will discuss the importance of nature in providing ecosystem services and present some recent and historical trends in biodiversity. It outlines some of the main pressures affecting England's habitats, wildlife and ecosystems: land use; climate change; pollution; invasive non-native species; and hydrological change. This report will focus on the opportunity we have to work with nature to tackle the climate and biodiversity crises in England, but will refer to the UK or Great Britain where information for England is unavailable.

We have worked closely with the Forestry Commission and Natural England in producing this report. Nature is vital to and inseparable from all our work. Much is gained from our collaborative approach to addressing the interlinked biodiversity and climate crises, and this will continue to be the case as the challenges become increasingly urgent.

Why nature is important

Human society exists within nature's web of life and ultimately, we depend upon ecosystems to provide us with essential services. These include clean air and water, fields for crops and livestock, forests for timber and fuel and the drawdown of greenhouse gases which threaten us through climate change.[9] Simply put, humanity would not be able to survive without these ecosystem services, which we receive free of charge.

Ecosystems are made up of complex networks of species which interact with each other and the wider environment in a multitude of different ways. Generally speaking, plants turn raw materials into biomass which is food for herbivores, which, in turn, provides food for predators. However there are other links between species, such as the symbiotic relationship between pollinating insects and plants. Some species are important in creating and maintaining habitats for other species, such as beavers, which create complex wetland habitats and reconnect rivers with their floodplains through their activity including creating dams. In some instances, altering the composition of species within an ecosystem can have wide-ranging and unexpected consequences, as those intricate connections may be disturbed.[9] These unexpected or unwanted changes can often be temporary while new niches and ecosystems form and adapt. Conversely, 'extinction cascades' can be triggered, whereby a species extinction causes secondary extinctions in the network. There is still much to learn about the intricate networks of species interactions within and between ecosystems.

While there are many factors involved, such as climatic conditions and nutrient availability, biodiversity is crucial to the effective functioning of ecosystems and in turn, the services we receive from them. There are 3 main reasons why biodiversity is important to the functioning of ecosystems.

The first is that each species has a set of characteristics, which determine how they obtain their resources and interact with other species within the ecosystem. It has been shown that ecosystems with a higher diversity of species have a higher diversity of characteristics and can therefore use a wider range of resources.[9] These ecosystems are more productive and produce more services for humanity.

The second way in which biodiversity supports ecosystems is through the 'sampling effect'. Ecosystems can be altered due to internal and external changes, such as changes to the climate. The more species there are within an ecosystem, the more likely it is that there will be species that have characteristics that will enable it to function and support other species in the altered ecosystem.[9]

The third way in which biodiversity supports ecosystems is by ensuring there is a large enough pool of species and characteristics, should a species be lost from the ecosystem. The more species there are in the ecosystem, the higher the chance that another species will be able to fill the gap of the missing species.[9]

Maintaining high levels of biodiversity protects ecosystem function and is essential for maintaining resilience, in the same way that diversity in skills and talents of people supports an economy.[3] Healthy functioning ecosystems, with their full complement of species, support ecological processes and services, which are vital for human well-being. The following highlights some of the ecosystem services that our economies rely upon.

Air quality: Vegetation removes pollutants such as PM2.5 and PM10 particles, ozone, sulphur dioxide, ammonia and nitrogen dioxide, and produces oxygen.[10] UK vegetation reduces sulphur dioxide, ozone and ammonia concentrations by 30%, 15% and 24% respectively, compared to a desert scenario.[11] Woodlands alone reduce the national health burden from PM2.5 pollution by 1,900 life years lost per year in the UK.[12]

Pollination: Globally, 35% of crops depend on animal pollination and these crops produce more than 90% of vitamin C and 70% of vitamin A.[13,14] In the UK, pollinators produced £615 million of benefits in 2015.[15]

Pest control: Diverse hedgerows and wildflower strips contribute to better pollination and pest control on farms by providing food and refuge for pollinators and pest predators.[16] Farmland birds are important regulators of many pests such as slugs and leatherjackets.[17]

Soil quality: In a gram of soil, there may be as many as a billion bacteria, and there can be up to 5 tonnes of organisms within a hectare of healthy soils.[18] It has been shown that diversity of organisms in soils leads to better outcomes for plants since different organisms play different roles in the maintenance of soils, as well as increasing the bio-availability of essential plant nutrients.[19]

Water quality: Ecosystems are important regulators of water quality by reducing soil erosion and limiting the run-off of sediment and nutrients into water bodies.[20] It has been shown that catchments with more diverse species on land and in the water are better at removing nutrients from sediment and water.[21]

Carbon storage: Plants draw down carbon dioxide through photosynthesis, storing the carbon within themselves and the soils in which they grow, while emitting oxygen back into the atmosphere. The total stock of carbon in UK forests is around 4,000MtC, [22] with forest soils accounting for around 70% of this stored carbon.[23]

Local climate management: Vegetation regulates local temperature, humidity and precipitation, mainly through evapotranspiration.[24] Vegetation also has an albedo effect, which reflects away radiative heat from the sun, reducing local surface temperatures. Temperatures in urbanised areas can be several degrees higher than the surrounding countryside, due to relative lack of vegetation.[25]

Flood management: A range of ecosystems such as woodlands, peatlands, wetlands and coastal habitats can provide natural flood management by slowing run-off following precipitation and by preventing coastal erosion and mitigating coastal surges.

Well-being and recreation: Human health is linked to the environment in complex ways and the scientific understanding of the importance of biodiversity is growing. At the microbial level, diversity is important in maintaining a healthy immune system, preventing allergic and respiratory diseases.[26,27,28] There is evidence that green spaces with more diverse species have a stronger effect on people's well-being. [29,30] Surveys during the Covid pandemic showed the benefits people found from engaging with nature.[31]

How we affect nature

Through the food and water we consume, the energy we use, the products we purchase and the housing and infrastructure we depend on, we each have an impact upon our environment and nature.[3] Many of the processes that provide the necessities and luxuries of our economy, produce waste and pollutants that end up in the environment or require space at the expense of natural habitats. At 432 people per square kilometre, England is one of the most densely populated countries in Europe.[32] The cumulative impact of such a concentration of people means that nature is currently suffering from significant pressure and consequently, the services we receive are under threat. With the population of England anticipated to increase by 5 million (9%) by 2043, these pressures will only increase.[33] This section gives an overview of nature as it is today and the pressures it is under.

Historical trends

Before considering modern trends, it is important to understand the historical context of nature in England. Conservation efforts are impacted by a phenomenon known as shifting baseline syndrome. This is a progressive decline in the perceived 'normal' state of biodiversity due to a lack of knowledge of its past state, and acceptance of less diverse environments. For example, it has been shown that compared to older residents, younger people in Yorkshire were less aware of changes in the abundance of common birds over the past 20 years.[34]

People have affected the environment in England for millennia. By the Roman conquest of Britain, it has been suggested that the countryside would have resembled modern conditions, with small natural areas within a landscape dominated by farming of different types. While most truly wild habitats had been lost, it is likely the emergence of diverse farming regions, as well as remaining forests and coppices in the 15th, 16th and 17th centuries increased the range of habitats on offer.[6]

Prior to the 1860s, the impact of industrialisation on the environment was likely limited, as settlements were still small and were often mixed with habitats such as farmland and market gardens. The most severe environmental impact of the Industrial Revolution prior to the 1860s was due to the diminishing importance of fuel-providing habitats, as coal increased in use and transportation via canals and railways became widespread.[6] Large areas of managed woodlands and heath were abandoned or claimed for agriculture instead, reducing the diversity of habitats in the countryside.

The period between the mid-19th and 20th centuries was a bad time for nature in England.[6] Large monoculture forests for timber demand, the decline in traditional land management practices, intensification of agriculture and the growing popularity of hunting led to large-scale degradation of habitats.

Recent trends

The Lawton Review concluded that England's habitats are too small and too fragmented to prevent further loss of species, with remaining priority habitats concentrated within protected areas and largely lost outside of these zones.[35]

Species-rich grasslands such as meadows and calcareous grasslands have decreased in extent in England and Wales by around 97% since 1930.[35] Lowland heathlands in England now cover only 20% of the area present in the 19th century.[35] The loss of wetlands has also been severe, with 99.7% of fens, 81% of grazing marsh and 44% of lowland bogs lost.[35] Much of England's blanket bogs have been lost since 1945.[36] Due to development and erosion, coastal margin habitats have declined in extent by around 10% in the last 60 years.[36] Up to 70% of ancient woodlands, which tend to have high biodiversity value, have been deforested or damaged, much of this during the past century.[37,38]

Habitats with good biodiversity value are now largely confined to small and isolated 'islands' within landscapes with poor biodiversity value.[39] Since these habitats are generally too small and too far apart from each other, they cannot support large-scale ecosystem services or support populations of species which require large habitats. For example, the fragmentation of wetlands has reduced their flood management effectiveness and biodiversity.[39] These changes in habitats have been reflected in trends in species.

Since the mid-20th century, there have been significant declines in many species in England.[40] Since 1970, 41% of species have decreased in abundance and 15% of species are now threatened with extinction from Britain.[5]

Priority species are the species of most conservation concern. Mammals, birds, butterflies and moths designated as priority species have all declined in abundance overall since the 1970 baseline data were collected (Figure 1). For 224 priority species assessed, the abundance indicator declined 61% between 1970 and 2019. The distribution indicator declined 4% between 1970 and 2018, and this is not considered a significant change.[41] However, this obscures the widespread distributional changes occurring in many individual species. Of all priority species analysed, 47% show increased or decreased distributions over the same time period.

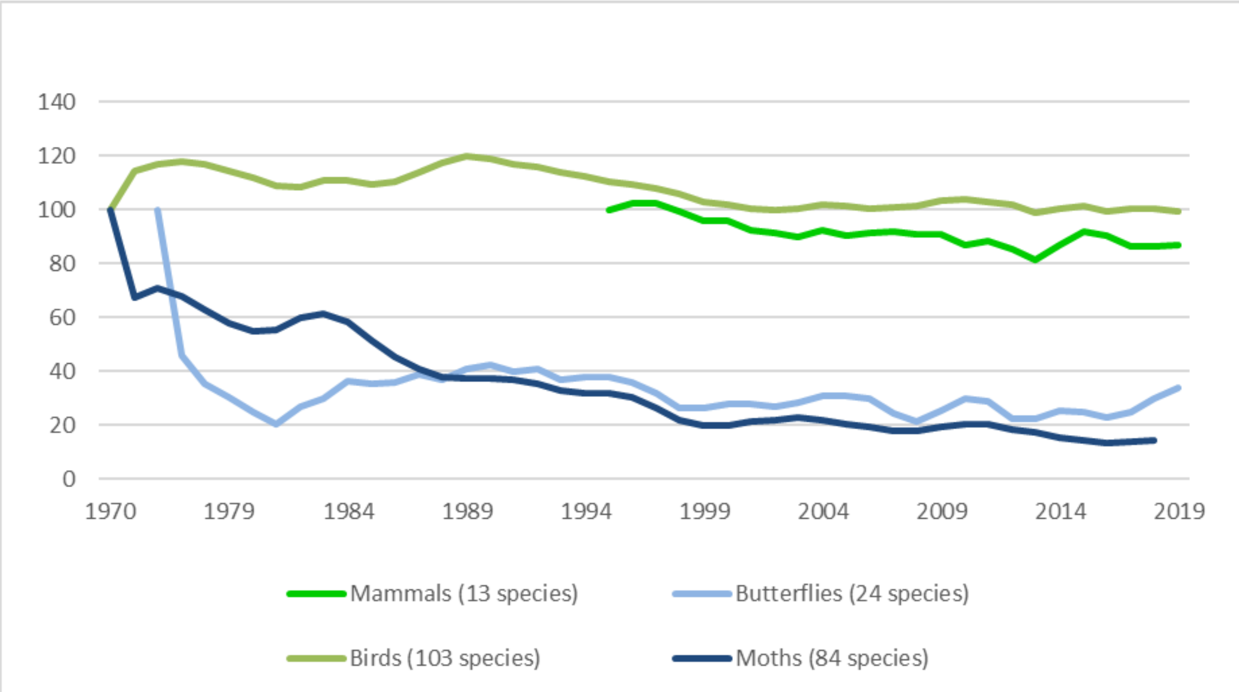

Figure 1: Abundance of priority species in the UK by taxonomic group from the 1970 baseline (100%) to 2019. Records for butterflies and mammals begin in 1976 and 1995 respectively. Source: JNCC 2021 Biodiversity Indicators, indicator C4a.[41]

Insects: Butterflies and moths decreased in average abundance by 16% and 25% respectively between 1970 and 2016.[5] A third of pollinator species have declined.[42]

Birds: From their 1970 baseline, the farmland bird index has fallen 55%, the woodland bird index has fallen 25%, the water and wetland bird index has fallen 14%. A third of farmland specialist species (grey partridge, turtle dove, tree sparrow and corn bunting) have declined more than 90% since 1970.[41]

Mammals: Several species have undergone drastic reductions in population sizes. Hedgehog numbers have fallen by approximately 66% since 1995 and water vole numbers have fallen 78%.[43] Overall, a quarter of mammals in England are threatened with extinction.[44]

Freshwater species: In 2019, 16% of rivers met minimum population targets for salmon conservation, which is the lowest score since monitoring began in 1993.[45] Meanwhile, freshwater invertebrates have shown a recovery in population range, having previously declined to a low in the mid-1990s.[46]

Plants, fungi and lichens: 18% of plants and 15% of fungi and lichens are at risk of extinction in Great Britain.[5] Since 1900, each county has lost one plant species every two years on average.[47]

Pressures on nature

Land use

Agriculture

With 70% of England's land area used to produce food, agriculture is the most extensive land use and it supports a range of species through the creation of diverse habitats. However, increases in demand for food and advances in agricultural technologies, which have doubled yields since the 1950s, have also led to practices that have removed or degraded habitats that agricultural practices previously supported.[48]

The area of England used to produce crops increased by 40% between 1940 and 1980.[36] Semi-natural habitats were converted or modified for agricultural use, resulting in the loss of most semi-natural grasslands in England and large areas of other habitats such as upland heathland.[36] The biggest factor affecting the amount of land required to produce food in the UK is consumer preferences. Livestock provide 18% of calories and 37% of protein consumed in the UK, but require over 80% of agricultural land.[49] When taking into account meat farmed abroad, the total amount of land used to supply meat in the UK, is larger than the total area of the UK.[50]

The farming practices over the past 50 years that have had the greatest impact on biodiversity include the increased use of fertilisers and pesticides, changing crop patterns; use of heavy machinery, extensive land drainage, and the removal of farm habitats such as hedgerows, field margins, ponds, and wooded areas.[5,51] There has been a reduction in landscape diversity, with fewer but bigger and more efficient farms.[52] The clearest impact that these changes have had on biodiversity is through declines in farmland birds and pollinating insects.[53,54]

With a growing population, domestic food demand will increase, although the exact nature of future demand from UK agriculture is uncertain due to changing consumer preferences and global commodity prices. It is unlikely that increased food demand will be met through an increase in the size of agricultural area and will need further intensification and better yields from current agricultural land.[55] Past increases in agriculture yields have largely been at the expense of nature, through reduced habitat size, connectivity and quality.[36] Future advancements in technology may reduce the impact of agriculture by better targeting application of nutrients and water. There is also growing interest and practice of nature-friendly farming approaches such as regenerative agriculture. The government's Environmental Land Management scheme[56] will lead to changes in the way that farmers manage their land, with major emphasis on nature recovery, the provision of ecosystem services and achieving net zero while supporting rural economies.

Urbanisation

Rising populations in the 20th century led to urbanisation. In terms of loss of habitat, the main effect has been due to coastal development, with a loss of 20% of sand dunes, saltmarshes and shingle since 1945.[36] The growth of urban populations has also had indirect impacts on habitats and ecosystems through increased consumption, which influences land use away from cities.

Projections suggest that the number of households in England will rise by 1.6 million (7.1%) between 2018 and 2028.[57] The majority of growth is expected to be in the south-east and south-west. The land area required for future homes will be relatively small compared to other land uses, particularly as new houses in the UK are the smallest in western Europe. Biodiversity Net Gain legislation will commit developers to achieving measurable improvements for biodiversity by creating or enhancing habitats in association with development.

Forestry

Woodland cover in England has risen from 5.8% in 1947[58] to 10.2% in 2022.[59] Annual rates of new planting rose to highs of 6,540 hectares (87% conifer) in 1971 and 6,360 hectares (90% broadleaf) in 1994. In 2021, 180 hectares of conifers and 1,870 hectares of broadleaves were planted.[60] In the past, plantations in inappropriate areas have put pressure on biodiversity and damaged some ecosystems. This was particularly the case where monocultures were planted.

Increasing population will also increase the demand on land for housing and infrastructure and the materials needed to construct them. In 2019, 81% of timber used in the UK was imported from abroad, with 33% of softwood and 4% of hardwood provided by UK forests.[61] 22% of new builds in England were constructed with timber frames in 2016 and the government's 25 Year Environment Plan commits to increasing timber use in construction.[62] Through the Trees Action Plan, the Forestry Commission will encourage demand for UK grown timber, reducing embedded emissions from imported timber.[63]

Climate change mitigation

Responding to climate change will require large-scale changes in land use. According to the Climate Change Committee (CCC), in order for the UK to become a net zero economy, which is resilient to climate change, a 'major shift' in land use is required in the coming decades. The way in which land is currently used is unsustainable, and in the future, will not be able to support future demand for settlement, meet current per capita food production or reduce emissions. [64]

The changes in land use which the CCC recommend in order to achieve net zero are a reduction in grassland and rough grazing by 26 to 36%,[65] and the use of around 30,000 hectares of additional land annually for woodland planting, and 23,000 hectares a year for biofuels.[66] Overall, the CCC recommends that one-fifth of agricultural land is released for actions which reduce emissions and sequester carbon.[64] The area required every year to meet these afforestation and bioenergy recommendations is approximately twice the size of Birmingham.

Climate change effects on biodiversity

Climate change has already impacted biodiversity in the UK. There is strong evidence that southern UK animal species have begun to exhibit shifts northwards.[67] Due to changes in climate, species of birds, butterflies, moths and dragonflies have moved north on average 23km every decade between 1970 and the 1990s and then 18km every decade between the 1990s and mid-2000s.[5] Upland species of bees declined by 55% between 1980 and 2013, compared to a reduction of 25% for lowland bees, in part reflecting the contraction of upland bee habitats due to climate change.[42]

As temperatures increase, climate zones will be moving northwards in Britain at 5km per year by 2050, which is one hundred times faster than during the last natural warming event at the end of the last ice age.[68] Species will have to move in order to remain in their climatic ranges. Risk assessments for species in England show that more species are expected to increase their ranges rather than decrease.[69] Upland habitat species are particularly vulnerable to climate change due to northwards and upwards range contraction. Due to dependencies between species, entire ecosystems will need to shift at similar rates, unless they alter in character.

Changes in seasonality of weather have led to changes in the timing of seasonal events. For plants and invertebrates, on average, seasonal events have changed by 4 days. This includes events such as flowering and leafing of plants and the emergence of invertebrates such as butterflies and moths.[70] For birds, events such as egg laying and spring migration have changed, on average, by 2 days.[5] Species which depend upon each other may no longer be aligned in the future. UK trends over 1976 to 2005 show that 83.8% of events occur earlier in the year now and there are considerable differences between levels of the food chain.[71]

Climate effects on water bodies will be through rising water temperatures and related effects on chemistry, as well as changes in river flows.[72] Rising temperatures have been shown to alter respiration and photosynthesis rates in aquatic species, increasing the risk of deoxygenation. Several species of fish are at risk from higher temperature waters. Salmon are a species known to be affected by increased water temperatures in both their marine and freshwater life stages. Their numbers are already in decline as a result of this and a range of other factors, and likely to fall further in some areas.

There will also be indirect effects to aquatic ecosystems through increased nutrient loads due to greater precipitation and mineralisation on land. Eutrophication will likely increase with climate change. Summer river flows may decrease as the climate warms.[73] Increased nutrient loads and lower summer flows would increase the likelihood of algal and cyanobacterial blooms and reduce dissolved oxygen levels. Many aquatic food webs are likely to change significantly as the climate changes, partly as a result of changes in the timing of the life cycles of different species.[74]

These are rapid changes which run the risk of crossing thresholds, beyond which natural ecosystems shift in their functioning. For example, above a water temperature of 17^{o}C, lakes are likely to suffer from algal blooms, which will lead to a deterioration in water quality and biodiversity.[75] This threshold is already exceeded for 3 months of the year in the south-east and may increase to 5 or 6 months a year by 2100 with climate change. By 2090, critical soil moisture deficits may occur in 85% of years for drought sensitive species. There will likely be reduced growth of broadleaved woodlands across much of England, while conifers will be less affected. This will impact the carbon sequestration of existing and future forests.[75]

Case study: Keeping Rivers Cool

Keeping Rivers Cool is an initiative created by the Environment Agency.[76] The project uses trees to shade small streams and prevent some of the warming that happens on hot sunny days, reducing some of the impact on trout and salmon. This provides both climate change adaptation and mitigation, and can provide other benefits; by improving river habitat for people and wildlife, reducing erosion and intercepting sediment and pollutants.

Shade from trees can reduce temperatures in small rivers on average by 2 to 4ºC (compared to unshaded streams), but demonstration sites in the Ribble catchment revealed shaded sites can be over 6°C cooler on hot days.

Since the programme began in 2012, the Environment Agency, Rivers Trusts and Wildlife Trusts have planted more than 500,000 riparian trees.

Pollution

Domestic sewage, farming, transport and industry produce the majority of pollutants which affect biodiversity. In addition, discharges from abandoned metal mines pollute over 1,500km of rivers in England with toxic heavy metals.[77] Diffuse pollution arises from pollutants spread over a wide area from multiple sources. Point source pollution occurs due to emissions from a single source and can include sewage from wastewater, storm overflows and spillage or leakage of toxic substances. Pollution via these routes can lead to eutrophication, acidification and toxic pollution of ecosystems.

Nutrient pollution caused by phosphorus and nitrate is a major cause of water bodies failing to achieve good ecological status. Farming contributes around 25 to 30% of phosphorous and around 70% of nitrate pollution in rivers.[78,79] Discharges of sewage contribute between 60 and 80% of phosphorous to rivers and 25 to 30% of nitrate entering surface waters.

No water bodies in England meet the Water Framework Directive (WFD) conditions for ‘good chemical status’, highlighting the prevalence of man-made chemicals in the water environment. The failures mainly reflect new tests and methodology for classifying water bodies for uPBT (ubiquitous, persistent, bioaccumulative and toxic) chemicals.[80] Microplastics have also become widespread in the environment and are contaminating wildlife.

There is evidence that airborne nitrogen deposition has caused a decline in plant species richness, with 62% of UK sensitive habitats exceeding recommended nitrogen levels.[5]

Most semi-natural habitats and over two-thirds of wildflowers are sensitive to excessive levels of nitrogen.[5] This has contributed to a decline in moth species which are dependent upon these sensitive plant species.[5]

Due to environmental regulation, the emissions of many forms of pollution have been falling over recent decades, with positive impacts on biodiversity. Emissions of many types of air pollutants, such as nitrogen oxides and sulphur dioxide have been falling since the 1970s.[81] It is likely that the increase in range of lichen and bryophyte species since the 1990s is in part due to this reduction in air pollution.[82]

Population growth and agricultural intensification will likely increase nutrient loading to rivers, particularly in south-east England. Urban expansion will increase pressures on sewage systems and increase run-off from impermeable surfaces in urban areas to waterbodies. It is also expected that a growing and ageing population will increase the levels of pharmaceuticals entering the water system.

Invasive non-native species

Invasive non-native species are those which are introduced to regions outside their natural range and pose a threat to native flora and fauna. They can outcompete or predate on native species, introduce diseases or lead to hybridisation where species are lost through interbreeding.

There are around 2,000 non-native species in the UK, with 250 of these classed as invasive due to their negative impacts. Each year, 10 to 12 new species establish themselves in Great Britain and around 12% of these species will go on to have impacts on native species.[5]

For example, oak processionary moths were accidentally introduced to the UK in 2005 and are now established in south-east England. Large populations of their caterpillars can strip a tree of its leaves, leaving it vulnerable to other stressors. Oak trees support a wide range of species. A total of 326 species in the UK are completely dependent on oak trees, including 257 species of invertebrate, and are at threat from continued oak declines.[83]

Ash dieback fungus was introduced to Europe 30 years ago and it is now predicted to kill 80% of ash trees in the UK.[84] There are 953 species in the UK associated with ash trees in some way, including 106 species which are highly or completely dependent on ash trees. These include 30 species of fungus and 53 species of invertebrate.[85]

The number of non-native species will continue to rise through the 21st century and it is likely that the rate of introductions will increase due to socio-economic factors, such as trade and travel.[86] Climate change is highly likely to encourage the settlement and spread of invasive non-native species, particularly those which come from continental Europe. Most established non-native species already in England will likely expand their ranges in the future. Plant pathogens and crop pests are among the species which are most likely to expand in range due to weather pattern changes.[87]

Case study: Check, Clean, Dry

Invasive aquatic plants can have a range of harmful effects, for example, floating pennywort, which forms very dense mats of vegetation across the surface of water. These can grow rapidly (up to 25cm per day), increasing flood risk, degrading amenity and changing the habitat for other native species.[88]

The Environment Agency has, for a number of years, promoted a national Check Clean, Dry campaign. Prevention, by thoroughly checking, cleaning and drying equipment (like boots, waders or nets) before leaving a site can dramatically reduce the risk of transferring unwanted and invasive species to a new location.

Hydrological and morphological change

Centuries of dam building, straightening, draining and abstraction of rivers, lakes, groundwaters and wetlands mean that there are few intact freshwater ecosystems remaining. Extensive drainage activity in the 20th century led to the loss of 300,000 hectares of lowland wet grasslands and 1.5 million hectares of upland peatlands.[5] Two-thirds of freshwater species rely upon ponds, but over 50% of these habitats have been lost since 1900 and 80% of the remaining ponds are in a poor state.[89] High quality ponds are now regarded as ecological hotspots, yet ponds in protected areas have lost 25% of their wetland plants since 1990.[90]

Urban, industrial and agricultural development has left a legacy of physical structures and modifications in and around the water environment, negatively affecting their ability to support biodiversity. Despite significant effort and investment over the last 10 years, 41% of surface waters in England are failing to meet ecological objectives because of physical modification.[91]

Current levels of abstraction in England are unsustainable in about 27% of groundwater bodies. Up to 15% of surface waters are affected by over abstraction.[92] Low flows can increase the concentration of pollutants and impact on water quality, alter geomorphology of rivers and disrupt species life cycles through more frequent dry spells.

There are approximately 200 chalk streams in the world, with 85% of these in south and east England. These unique habitats are located within areas which have experienced the highest population growth in the country and many suffer from over-abstraction. In 2019, 84% of chalk streams were failing to meet good ecological status.[93]

Increasing population and climate change will likely impact water bodies by increasing demand for water, and altering its availability. Winter river flows are predicted to increase and summer river flows are predicted to decrease, while increasing temperatures will likely increase summer water demand and evapotranspiration. The combination of these effects will have negative impacts on wetland ecosystems.

Addressing the climate and nature crises

With the widespread loss of many habitat types, such as wildflower meadows, wetlands and ancient woodlands, there is a need for more land dedicated to nature restoration. This is particularly the case for specialist species which require specific conditions in order to survive. The 2010 Lawton Review's recommendations that England needed more, bigger, better and joined up spaces for nature still apply today.[94] With climate change adding further pressures to nature, sites dedicated to nature will become even more important as refuges for plants and animals.

Biodiversity requires landscape-scale interventions in order to recover and become resilient to climate change. At the same time, land will also be required to provide mitigation against and adaptation to a changing climate. However, rather than these multiple demands on the land competing with each other, there is, in fact, an opportunity to make better use of land to meet multiple demands by working with nature. The government's commitment in September 2020 to protect 30% of the UK's land by 2030, provides a great opportunity to demonstrate this, with an additional 400,000 hectares protected to support the recovery of nature.[95]

In order to meet these different needs, land use in the future must be designed to achieve multiple benefits. The way of achieving this is through nature-based solutions (NbS); ways of working with natural processes to provide benefits to people and nature. These are solutions which help us mitigate against and adapt to climate change, while enhancing biodiversity and contributing to wider benefits such as food and timber production and human health and well-being.

NbS involve the protection, restoration and management of natural and semi-natural ecosystems.[96] The restoration of these ecosystems will help biodiversity recover and also help lessen the impacts of climate change. Working with natural processes encourages the sequestration of carbon from the atmosphere by creating productive ecosystems. At the same time, they provide adaptation benefits, primarily in the form of flood mitigation, microclimate regulation, agricultural productivity and the protection of water resources. It is important to monitor the impacts of NbS.

The International Union for the Conservation of Nature has developed an NbS framework, consisting of principles that form a common understanding of the solutions and their implementation.[97] NbS are not alternatives to nature conservation work, but complement these practices. They are developed and applied at the landscape scale, taking into account site-specific contexts, by including engagement with and decision making by local communities. An important benefit of using NbS across landscapes is to increase the connectivity between habitats. The degree to which species will be able to benefit from or adapt to climatic changes depends on available habitats and their connectivity in the landscape.[98] Isolated populations of species without networks of habitats are at higher risk from climate change since they will not be able to move their range with changing conditions.

NbS also need to take into account future changes in conditions and be resilient to these changes.[99] An important feature of NbS is improving the ecological resilience of the environment to shocks such as extreme weather or invasive species. For example, the Forestry Commission plants a wide range of tree species which thrive under different conditions, so that woodlands are resilient to climate change in the future.[100] Biodiversity is crucial for the long-term sustainability of the benefits we receive from NbS, as a wider range of species provides resilience against these shocks.[99]

Any intervention which does not intend to benefit biodiversity cannot be defined as an NbS, even if it uses natural processes.[97,99] The success of NbS in achieving climate mitigation and other benefits depends on biodiversity, since ecosystem services require a diverse range of species.[99] For this reason, the monocultural planting of biofuel crops and non-native plantations are not regarded as NbS.

While NbS alone will not prevent climate change and/or restore biodiversity, they will play a crucial role in limiting the impact of climate change, while improving biodiversity and providing a range of other social and economic benefits. Natural England, the Environment Agency, Forestry Commission and Royal Botanic Gardens, Kew are leading on a £12.5 million pilot project investigating how to integrate NbS into the landscape.[101] This project will identify the best way to optimise benefits for climate change and biodiversity. The project will inform the delivery of the national Nature Recovery Network with Local Nature Recovery Strategies (LNRS). [102] The Nature Recovery Network (NRN) is a major commitment in the government's 25 Year Environment Plan and will be a national network of wildlife-rich places across our towns, cities and countryside. The NRN will help us deal with 3 of the biggest challenges we face: biodiversity loss, climate change and well-being. LNRS are a new, England-wide system of spatial strategies that will establish priorities and map proposals for specific actions.

Working with nature

Tree planting

Trees and woodlands support the provision of clean air, timber, carbon storage, shade, health, water quality, flood alleviation and healthy soils. [103] They create essential habitats and support biodiverse landscapes. Enhancing tree coverage increases biodiversity and provides a resilient network of habitats that will enable the adaptation and movement of species affected by climate change. When planted in the right places, they improve water quality and soil health by reducing the amount of sediments and pollutants reaching rivers.[104] Trees and woodland also reduce river bank erosion and can support flood alleviation as part of catchment based natural flood management (NFM) solutions. NFM is a way of working with natural processes to reduce flood risk. Trees along rivers also provide shade and reduce summer water temperatures for fish.

Tree planting is probably the most well-known NbS intended to mitigate climate change. Trees draw down carbon from the atmosphere and store it in their vegetation and soils.

Different types of trees have different rates of carbon drawdown, biodiversity value and commercial value for forestry and other economic activities.[105] By planting the right type of tree in the right places, where they can thrive without compromising existing biodiversity interest or potential, we can maximise the benefits that trees provide. Increasing tree planting to 30,000 hectares per year to 2050, along with improved woodland management could sequester 14MtCO_{2e} per year.[64] The Forestry Commission has identified 5 million hectares of land which can be used for forestry while avoiding protected landscapes and productive agricultural sites.[106] The Forestry Commission has stated that England will have at least 12% woodland cover by mid-century, with conifer and broadleaved woodland managed for biodiversity and other benefits.[63] Better management of existing woodlands will create new habitats and ancient woodlands will be better protected.[63]

Different tree species support distinct communities of species so diversity in trees will have a positive biodiversity impact. Natural colonisation is a good way to achieve this and provides additional benefits such as helping to maintain local genetic diversity.[107] It is also cheaper, and requires no soil disturbance or use of tree guards (which are often plastic). However, mixed plantations of deciduous and coniferous trees can also have biodiversity benefits, particularly on sites with low biodiversity where natural regeneration is unlikely due to degraded soils and a lack of nearby seed sources.[108]

Case study: Wild Ennerdale, Valley Head tree planting

Wild Ennerdale is a partnership of people and organisations led by the principal landowners in the valley, The Forestry Commission, National Trust and United Utilities with the support of Natural England. The project is one of the largest in the UK, allowing the land and its ecosystems greater freedom to recover their natural processes and wildlife, with minimal human intervention. It includes tree planting, heathland creation and peat bog restoration, as well as extensive grazing of cattle, bringing new business to local farmers. This work is widely acclaimed and is being used to help inform similar projects elsewhere. Wild Ennerdale is also proposing, within its scope, to introduce Eurasian beaver to create new and diverse habitats, enhancing species diversity.[109]

A 34-hectare tree planting scheme underway in Valley Head, as part of the wider project, demonstrates the importance of understanding local landscape and its ecology in deciding what and where to plant. A range of native species including juniper, mountain willow, rowan, birch, Scots pine and oak are being planted. Trees are sensitively positioned to ensure that the glacial moraines at the head of the valley will continue to be visible. Forestry and farming will support and enhance the landscape and biodiversity value of the area.

Wetland restoration and natural flood management

Wetlands are diverse and constantly changing habitats that include fens, upland and lowland peat bog, reedbed and saltmarsh, wet woodland, wet grassland, and wet heathland. Wetlands are important carbon stores, are recognised for their importance as wildlife habitats, and provide a multitude of other ecosystem services to society. These include cultural and recreational value, water quality improvements and flood risk management.

Wetlands hold water in the landscape, making them important in reducing flood risk, and can be incorporated into wider NFM approaches. Biodiversity may also benefit from this work and, in some cases, nature itself will be providing the intervention needed to reduce flood risk. NFM can be an important component of climate change adaptation. There is significant evidence that restoring peatlands reduces downstream flooding by acting as a sponge, since they can store more water.[110] Restoring rivers to a natural state by reintroducing natural features such as meanders and removing human made features such as weirs can help slow the flow and reduce flood peaks.[110] Allowing this to happen naturally, by giving the degraded morphology of our rivers and coasts space and freedom to recover, can offer a cost effective nature-based approach. This process creates a more diverse environment, with a range of habitats, spawning sites and refuges for animal and plant species.[110] Including the restoration of floodplains and wetlands in NFM can have further benefits for flooding and biodiversity.[110] While the flood impacts of restoring floodplains are site specific, there are significant biodiversity benefits when the restoration of wetland habitats is involved.[110]

Globally, peatlands store more carbon than all of the world's forests combined, and can continue to draw down carbon for millennia.[111] However, once they are disturbed they become net sources of carbon as oxidation causes carbon dioxide and other greenhouse gases to be released. At least 75% of peat in the UK is damaged and emissions from peatlands were estimated at 23MtCO_{2e} per year in 2017.[64] Restoring peatlands through rewetting and reducing grazing is regarded as a low-cost method of reducing a significant source of carbon emissions, producing £3 to £4 of benefits for every £1 spent on restoration.[64] Peatlands also provide habitats for a range of specialist species such as sphagnum moss.[112] Restoring at least 50% of upland peat and 25% of lowland peat would reduce annual emissions from peatland by 5MtCO_{2e} by 2050.[64]

Freshwater ecosystems, including wetlands, are a crucial part of the water supply and need to be in good condition in order to provide services such as filtration and water storage. The British Isles are relatively highly dependent on peatlands for water security, with 72.5% of water in reservoirs in the UK being peat-fed.[113] Continued degradation of peatlands could threaten their ability to reliably provide the quantity and quality of water required in the future. Removing peat sediment and dissolved organic carbon due to degradation is a large cost in raw water treatment. Restoring peatlands mitigates peat loss by erosion and improves their capacity to store and filter water and so reduces the end of pipe costs to water companies.[113,114] The England Peat Action Plan details how 35,000 hectares of peatland will be restored by 2025, which is triple the rate of restoration between 1990 and 2013.[115]

Case study: Great Fen, Cambridgeshire[116]

Natural England, the Environment Agency, Huntingdon District Council, Middle Level Commissioners and Bedfordshire, Cambridgeshire and Northamptonshire Wildlife Trust are working with farmers and land managers to create 3,700 hectares of fen landscape on peatland soils between Huntingdon and Peterborough. The ultimate goal of the Great Fen is the recovery of nature and a wilder future for people and wildlife to fulfil a 100-year vision for the land. This is a long-term and ambitious project, requiring the work, expertise and support of many people and partners.

The restoration work contributes to the reduction of peat loss, capturing carbon and saving an estimated 325,000 tonnes of CO_2 from being released each year. Restoration of vegetation will also provide habitats for threatened fenland species, benefiting the local biodiversity. Actions to restore the area will also address climate-induced impacts on society. For example, implementation of floodwater storage helps to protect surrounding towns, villages and farmland from the risk of flooding after heavy rainfall. People’s well-being is enhanced through recreational use of the fen and by increasing connection to nature.

Coastal habitat restoration

Coastal wetlands such as saltmarshes are also important carbon sinks. They have one of the highest carbon sequestration rates among coastal habitats.[117] Up to 85% of saltmarshes are estimated to have been lost from England,[117] yet they are important sites for many migrating waders and wildfowl. The unique mix of fresh and saltwater provides habitats for many specialist invertebrate species. They have an important role as a nursery ground for many fish and are recognised for their role in sustainable fisheries.

Seagrass meadows are another coastal habitat with high carbon sequestration potential and biodiversity benefits. Up to 92% of these habitats have been lost in the UK.[117] Seagrass meadows are crucial habitats for species of conservation priority, such as seahorses. Restoring seagrass to historical extents could store 11.5Mt of carbon and support 400 million fish.[117]

The restoration of coastal habitats has been shown to have coastal erosion and flooding risk benefits as well as benefits for biodiversity.[111] Experiments in some coastal environments have shown that saltmarshes can help reduce the energy of waves, and their heights by 12 to 20%.[108]

Case study: Lower Otter Restoration Project (LORP)

The Lower Otter estuary in Devon has been shaped by human modification over hundreds of years. Embankments were built, and wetlands drained and reclaimed for agriculture and infrastructure, including a road and bridge, a railway, an aqueduct, a refuse tip and a cricket club. The river has become disconnected from its flood plain, and, as a result, flood water backs up, overtopping the embankment and filling the marshes behind. Prolonged and deep flooding affects the local community and wildlife. This situation is no longer sustainable in the face of our changing climate.

The Environment Agency is leading this project, in partnership with the landowner Clinton Devon Estates and East Devon Pebblebed Heaths Conservation Trust, working with local people and leading organisations to adapt and enhance the Lower Otter. It is restoring the area to more natural conditions; closer to those that existed 200 years ago, and it will need much less future management against the impacts of climate change.

By breaching an existing embankment approximately 55 hectares of mudflat and saltmarsh will be created, producing a new wildlife reserve of international conservation value, while also sequestering additional carbon.

Other expected benefits include:

- 2 hectares more broadleaf woodland
- an extra 1.6 kilometres of hedgerows
- increased ‘green tourism’ with an estimated value of £10 million by the end of the project
- significant public health benefits through better access to the natural environment via a network of footpaths

This work is expected to influence and inspire more adaptation projects.

Urban environments

Urban areas create temperature and weather effects that can exacerbate the impacts of climate change on people living in them. Green areas are usually cooler than built up areas. This temperature difference is called the ‘urban heat island’ effect. The effect varies but can be large, for example, London has experienced 10°C higher night time air temperatures than surrounding rural areas.[118] Urban green and blue spaces have been proposed as a means of managing intense heat events due to their cooling effects.[108] Greenery in urban areas is valuable for biodiversity due to the lack of natural habitats in cities. Green infrastructure designed to reduce temperatures and run-off, such as green roofs, is substantially more beneficial for biodiversity than grey infrastructure.

Vegetation can intercept and remove particulate matter and other pollutants, improving local air quality.[108] Trees can be particularly useful in this manner, but need to be selected carefully in order to avoid species that emit volatile organic compounds or allergens, which can negatively impact air quality. Young silver birch trees have been identified as an effective remover of particulates.[119]

Case study: Bradford Beck urban river restoration

Legislation requires that the water environment is improved and protected wherever possible. River restoration is the re-establishment of natural physical processes, features and physical habitats of a river system. Thousands of river restoration projects have been carried out across the UK.[120]

Bradford Beck is a highly industrialised and urbanised watercourse, often running underground or hidden in a steep channel. It has a legacy of canalisation and culverting since the Industrial Revolution, as well as ongoing pollution problems. The Environment Agency, in partnership with Bradford City Council, Friends of Bradford’s Becks and the

Wild Trout Trust, has worked to restore natural habitat along the river with a range of benefits to local communities and wildlife.

Work included planting 270 native trees and shrubs, installing bat and bird boxes, removing litter and debris, attaching vegetated coir rolls along the banks and constructing 4 fish easements. The restoration has meant that local people can now access the Beck area and enjoy the returning wildlife, improving their well-being and engagement with nature. Tree planting increases the carbon storage capacity of the area, and the trees and other native plants will support wildlife, including insects, fish, birds and mammals in and along the river. Additionally, the restoration will reduce levels of silt and polluted run-off entering the river and slow the flow of water into the catchment, reducing flood risk downstream. The partners will build on their successes by stepping up the scale of restoration in 2022/23.

Species-rich grasslands

Species-rich grasslands can store over 3 times more carbon in their soils than woodlands (where carbon is mainly stored in above ground vegetation).[121] They also provide significant benefits for pollinators. Flood-plain meadows, when allowed to flood naturally during the winter can help manage flood risk and improve water quality. Species-rich grasslands have the added advantage of retaining some agricultural productivity, since extensive grazing by livestock is essential to their management..

Case study: Species-rich floodplain meadows

Flood plain meadows provide an important ecosystem service by trapping sediments during floods. The fluvial floods of June/July 2007 were some of the largest on record in the UK. They deposited substantial amounts of sediment across many floodplains giving the Floodplain Meadows Partnership an opportunity to study the scale and impact of this across 5 catchments.[122] The steering group for this partnership includes the Environment Agency and Natural England along with others such as the Open University, Wildlife Trusts and Natural Resources Wales.

The study found that the meadows trapped up to 40 tonnes of sediment per hectare, preventing large volumes of this material from silting up channels or downstream structures. The meadows also trap phosphorus contained in the sediment and then gradually export it into the annual hay crop, at a rate of around 6kg/ha/yr for several decades. In this way, the meadows provide significant water quality benefits alongside a valuable agricultural product.

Rewilding

Restoring natural processes (such as grazing, succession and flooding) and allowing these to mediate outcomes by themselves can provide significant benefits for biodiversity and ecosystem services. This can be particularly beneficial where ecosystems have become significantly degraded and restoration at scale is considered feasible and desirable.[123] This will lead to the development of a mosaic of connected habitats which will provide a range of ecosystem services and allow species to move through the landscape and adapt to climate change. The resulting habitats that develop are less easy to predict, but they are likely to be more cost effective to establish and manage, and more resilient to future change.

Conclusion

Biodiversity is not just in decline in England, it is in crisis across the world. The consequences of allowing this decline to continue will be grave, threatening the provision of essential ecosystem services such as pollination and water filtration. Since these services underpin our ability to survive and thrive on this planet, it should be viewed as an existential risk. In order to reverse this decline and to ensure that nature is prepared for climate change, habitats which have been lost need to be restored at a large scale. There are a number of large scale nature based interventions happening right now. These include Local Nature Recovery Strategies, Peat Action Plans and the England Trees Action Plan, as well as commitments to protect 30% of land for nature by 2030 and the introduction of the Environment Bill.

Future land use decisions will be an important part of responding to climate change. Currently, the land use sector is a source of emissions, and shifts to less carbon intensive forms of agriculture, as well as increasing natural carbon drawdown by ecosystems, will be necessary. On top of this, there is a need to produce enough food and materials for a growing population, who require fairer access to better green and blue spaces.

Looking forward, land and water environments need to be managed in a more sustainable way in order to meet the government's pledge to reverse biodiversity loss by 2030 and prepare for climate change. The 25 Year Environment Plan sets out the government's goal to improve the environment within a generation.

The Environment Agency has a leading role to achieve the 25 Year Environment Plan goals and commitments. This includes helping to improve at least 75% of waters to be close to their natural state as soon as is practicable; contributing to 25 Year Environment Plan targets for new wildlife-rich habitat in England to be restored or created; and taking action to recover threatened, iconic or economically important species.

Internationally, the G7 leaders have committed to the global mission to halt and reverse biodiversity loss by 2030. The importance of nature and the application of nature-based solutions to achieving net zero and helping tackle climate change featured throughout the COP 26 climate conference in 2021. The COP 15 meeting of the UN Convention on Biological Diversity (CBD) in 2022 will review the progress towards previously agreed Biodiversity targets.[124] Global resourcing and capacity building to meet the challenges will be an important part of discussions.

Nature based solutions are a crucial tool in restoring nature and achieving multiple other benefits. When organisations, governments and citizens work together, there are substantial opportunities for collaboration, innovation and alternative funding. We are looking at how we can support these longer term approaches.

But other tools will also be needed if the crisis is to be properly addressed, and using them will transform the way humanity values, understands and interacts with nature. The Dasgupta Review, commissioned by the Treasury in 2021, sets out these tools, or 'options for change', in detail.[3] Demands on nature's services must not exceed its ability to supply them. The effects of consumption in wealthy countries on loss of biodiversity and habitats elsewhere in the world must not be overlooked. Part of addressing this will be the transition of consumption, production and supply chains. Transformation of current economic measures of success, and of finance and education systems were highlighted by Dasgupta as major opportunities to enable the changes that are needed.

Addressing the biodiversity crisis will require concerted and sustained efforts by many people and organisations, from individuals and communities, to global leaders and governments. By working with nature, we strengthen the roots which support our society, providing resilience against climate change and promoting a more sustainable economy.

References

[1] Convention on Biological Diversity. 1992. Text of the Convention. Available at: https://www.cbd.int/convention/text/ (Last accessed: 22/02/2022).
[2] Mora, C., et al. 2011. How many species are there on Earth and in the Ocean? *Plos Biology.* Available at: https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1001127 (Last accessed 22/02/2022).
[3] Dasgupta, P.S. 2021. Final report – The economics of biodiversity: The Dasgupta Review. Available at: https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review Last accessed: 16/02/2022
[4] Hayhow, D. et al. 2016. State of Nature 2016. Available at: https://www.rspb.org.uk/globalassets/downloads/documents/conservation-projects/state-of-nature/state-of-nature-uk-report-2016.pdf (Last accessed: 22/02/2022).
[5] Hayhow, D. et al. 2019. State of Nature 2019. Available at: https://www.rspb.org.uk/our-work/state-of-nature-report/ (Last accessed: 22/02/2022).
[6] Williamson, T. 2013. An environmental history of wildlife in England 1650-1950. Blooomsbury, London.
[7] IPCC. 2022. Climate change 2022. Impacts, adaptation and vulnerability. Summary for Policymakers. SPM C3.3. Available at: AR6 Climate Change 2022: Impacts, Adaptation and Vulnerability — IPCC (Last accessed: 03/03/2022).
[8] Committee on Climate Change. 2020. Sixth Carbon Budget. Available at: https://www.theccc.org.uk/publication/sixth-carbon-budget/ (Last accessed: 22/02/2022).
[9] Millennium Ecosystem Assessment. 2005. Ecosystem and human wellbeing. Available at: https://www.millenniumassessment.org/en/index.html (Last accessed: 22/02/2022).
[10] UNEP. 2015. Connecting global priorities: biodiversity and human health. Available at: https://www.who.int/publications/i/item/connecting-global-priorities-biodiversity-and-human-health (Last accessed: 22/02/2022).

[11] Nemitz, E., et al. 2020. Potential and limitation of air pollution mitigation by vegetation and uncertainties of deposition-based evaluations. *Phil Trans of Royal Society A.* Available at: https://royalsocietypublishing.org/doi/10.1098/rsta.2019.0320 (Last accessed: 22/02/2022).
[12] ONS. 2018. UK air pollution removal: how much pollution does vegetation remove in your area? Available at: https://www.ons.gov.uk/economy/environmentalaccounts/articles/ukairpollutionremovalhowmuchpollutiondoesvegetationremoveinyourarea/2018-07-30 (Last accessed: 22/02/2022).
[13] Nicholls, C. and Altieri, M. 2012. Plant biodiversity enhances bees and other insect pollinators in agroecosystems. A review. *Agronomy for Sustainable Development.* Available at: https://link.springer.com/article/10.1007/s13593-012-0092-y (Last accessed: 22/02/2022).
[14] FAO. 2019. The state of the world's biodiversity for food and agriculture. Available at: http://www.fao.org/state-of-biodiversity-for-food-agriculture/en/ (Last accessed: 22/02/2022).
[15] Defra. 2019. National Pollinator Strategy – supporting evidence. Available at: http://sciencesearch.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=20277 (Last accessed: 22/02/2022).
[16] Albrecht, M., et al. 2020. The effectiveness of flower strips and hedgerows on pest control, pollination services and crop yields: a quantitative synthesis. *Ecology Letters.* Available at: https://onlinelibrary.wiley.com/doi/full/10.1111/ele.13576 (Last accessed: 22/02/2022).
[17] Elliot, T. and Jarvis, P. 2016. Sustainable control of crop pests. Available at: https://www.agricology.co.uk/resources/sustainable-control-crop-pests (Last accessed: 22/02/2022).
[18] Environment Agency. 2019. State of the environment: soil. Available at: https://www.gov.uk/government/publications/state-of-the-environment (Last accessed: 22/02/2022).
[19] Natural England. 2012. Managing soil biota to deliver ecosystem services (NECR100). Available at: http://publications.naturalengland.org.uk/publication/2748107 (Last accessed: 09/03/2022)
[20] Kreye, M., et al. 2014. The value of forest conservation for water quality protection. *Forests.* Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0203909 (Last accessed: 22/02/2022).
[21] Brisson, J., et al. 2020. Plant diversity effect on water quality in wetlands: a meta-analysis based on experimental systems. *Ecological Applications.* Available at: https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/eap.2074 (Last accessed: 22/02/2022).
[22] Environment Agency. 2019. Internal briefing.
[23] FAO. 2020. Global forest resources assessment: United Kingdom of Great Britain and Northern Ireland. Available from: http://www.fao.org/forest-resources-assessment/fra-2020/country-reports/en/ (Last Accessed 22/02/2022).
[24] West, P., et al. 2010. An alternative approach for quantifying climate regulation by ecosystems. *Frontiers in Ecology and the Environment.* Available at: https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/090015 (Last accessed: 22/02/2022).
[25] Forest Research. 2010. Benefits of green infrastructure. Available at: https://www.forestresearch.gov.uk/research/benefits-of-green-infrastructure/ (Last accessed: 22/02/2022).
[26] Tasnim, N., et al. 2017. Linking the gut microbial ecosystem with the environment: does gut health depend on where we live? Frontiers in Microbiology 6th October 2017. Available from: https://doi.org/10.3389/fmicb.2017.01935 (Last accessed: 22/02/2022).
[27] Kirjavainen, P., et al. 2019. Farm-like indoor microbiota in non-farm homes protects children from asthma development. *Nature Medicine*. Available at: https://www.nature.com/articles/s41591-019-0469-4 (Last accessed: 09/03/2022)
[28] Sandifer, P., et al. 2015. Exploring connections among nature, biodiversity, ecosystem services, and human health and wellbeing: opportunities to enhance health and biodiversity conservation. *Ecosystem Services.* Available at: https://www.sciencedirect.com/science/article/pii/S2212041614001648 (Last accessed: 22/02/2022).
[29] Methorst, J., et al. 2021. The importance of species diversity for human wellbeing in Europe. *Ecological Economics.* Available at: https://www.sciencedirect.com/science/article/pii/S0921800920322084 (Last accessed: 22/02/2022).

[30] Cameron, R., et al. 2020. Where the wild things are! Do urban green spaces with greater avian biodiversity promote more positive emotions in humans? *Urban Ecosystems.* Available at: https://link.springer.com/article/10.1007/s11252-020-00929-z (Last accessed: 22/02/2022).
[31] Natural England. 2020. People and nature survey: How are we connecting with nature during the coronavirus pandemic. Available at: https://naturalengland.blog.gov.uk/2020/06/12/people-and-nature-survey-how-are-we-connecting-with-nature-during-the-coronavirus-pandemic/ (Last accessed: 15/04/2021).
[32] ONS. 2019. Population estimates for the UK, England and Wales, Scotland and Northern Ireland. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/annualmidyearpopulationestimates/mid2019#population-age-structure-and-density-for-local-authority-areas (Last accessed: 22/02/2022).
[33] ONS. 2021. Overview of the UK population. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/articles/overviewoftheukpopulation/january2021 (Last accessed: 22/02/2022).
[34] Papworth, S. 2007. Shifting baseline syndrome: an investigation. Available at: https://www.iccs.org.uk/wp-content/thesis/PapworthMSc.pdf (Last accessed: 22/02/2022).
[35] Lawton, J., et al. 2010. Making Space for Nature. Available at: https://www.gov.uk/government/news/making-space-for-nature-a-review-of-englands-wildlife-sites-published-today (Last accessed: 22/02/2022).
[36] UK National Ecosystem Assessment. 2011. UK National Ecosystem Assessment: Synthesis of the Key Findings. Available at: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx (Last accessed: 22/02/2022).
[37] Woodland Trust. 2021. Ancient woodland. Available at: https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/habitats/ancient-woodland/ (Last accessed: 22/02/2022).
[38] Forestry Commission. 2019. Keepers of time: a statement of policy for England's ancient and native woodland. Available at: https://www.gov.uk/government/publications/keepers-of-time-a-statement-of-policy-for-englands-ancient-and-native-woodland?msclkid=fdea4db6ab4d11ec96689e96cd595d87 (Last accessed: 24/03/2022)
[39] Natural England: 2020. Nature networks evidence handbook. Available at: http://publications.naturalengland.org.uk/publication/6105140258144256 (Last accessed: 22/02/2022).
[40] Defra. 2018. 25 Year Environment Plan: Supporting Evidence. Available at: https://www.gov.uk/government/publications/25-year-environment-plan (Last accessed: 22/02/2022).
[41] JNCC. 2021. UK Biodiversity indicators. Available at: UK Biodiversity Indicators 2021 | JNCC - Adviser to Government on Nature Conservation (Last accessed 03/03/2022).
[42] Powney, G. et al. 2019. Widespread losses of pollinating insects in Britain. *Nature.* Available at: https://www.nature.com/articles/s41467-019-08974-9 (Last accessed: 22/02/2022).
[43] Natural England: 2018. A review of the population and conservation status of British mammals: technical summary. Available at: http://publications.naturalengland.org.uk/file/6025076961181696 (Last accessed: 22/02/2022).
[44] Mathews, F. and Harrower, C. 2020. IUCN – compliant red list for Britain's terrestrial mammals. Available at: https://www.mammal.org.uk/science-research/red-list/ (Last accessed: 22/02/2022).
[45] CEFAS, Environment Agency and NRW. 2020. Assessment of salmon stocks and fisheries in England and Wales in 2019. Available at: https://www.gov.uk/government/publications/assessment-of-salmon-stocks-and-fisheries-in-england-and-wales-in-2019 (Last accessed: 22/02/2022).
[46] Vaughan, I. and Ormerod, S. 2012. Large-scale, long-term trends in British river macroinvertebrates. *Global Change Biology.* Available at: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2486.2012.02662.x (Last accessed: 22/02/2022).
[47] Natural England. 2010. Lost life: England's lost and threatened species. Available at: http://publications.naturalengland.org.uk/publication/32023 (Last accessed: 22/02/2022).
[48] GOS. 2010. Land Use Futures. Available at: https://www.gov.uk/government/collections/land-use-futures (Last accessed: 22/02/2022).

[49] Benton, T. 2019. Climate change and diets – a CCC discussion meeting. Available at: https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/ (Last accessed: 22/02/2022).
[50] The National Food Strategy: 2021. The National Food Strategy. Available at: https://www.nationalfoodstrategy.org/ (Last accessed: 22/02/2022).
[51] Chamberlain, D., et al. 2001. Changes in the abundance of farmland birds in relation to the timing of agricultural intensification in England and Wales. *Journal of Applied Ecology.* Available at: https://besjournals.onlinelibrary.wiley.com/doi/10.1046/j.1365-2664.2000.00548.x (Last accessed: 22/02/2022).
[52] Robinson, R. and Sutherland, W. 2002. Post-war changes in arable farming and biodiversity in Great Britain. *Journal of Applied Ecology.* Available at: https://besjournals.onlinelibrary.wiley.com/doi/10.1046/j.1365-2664.2002.00695.x (Last accessed: 22/02/2022).
[53] BTO. 2019. BirdTrends: Grey Partridge. Available at: https://app.bto.org/birdtrends/species.jsp?year=2019&s=grepa (Last accessed: 22/02/2022).
[54] Senapathi, D., et al. 2015. The impact of over 80 years of land cover changes on bee and wasp pollinator communities in England. *Proceedings of the Royal Society B.* Available at: https://royalsocietypublishing.org/doi/10.1098/rspb.2015.0294#d3e1356 (Last accessed: 22/02/2022).
[55] GOS. 2010. Land use futures. Available at: https://www.gov.uk/government/collections/land-use-futures (Last accessed: 22/02/2022).
[56] Environmental Land Management schemes: overview - GOV.UK (www.gov.uk)
[57] ONS. 2018. Household projections for England: 2018-based. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/householdprojectionsforengland/2018based (Last accessed: 22/02/2022).
[58] Forest Research. 2020. Forestry Statistics. Available at: https://www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/forestry-statistics-2020/1-woodland-area-and-planting/
[59] Forestry Commission. 2022. Key Performance Indicators, report for 2021-22. Available at: Forestry Commission Key Performance Indicators: Report for 2021-22 - GOV.UK (www.gov.uk) (Last accessed 22/06/2022).
[60] Forest Research. 2021. Woodland statistics. New planting and restocking for 1976 to 2021. Available at: https://www.forestresearch.gov.uk/tools-and-resources/statistics/data-downloads/ (Last accessed 22/02/2022).
[61] Forest Research. 2020. Forestry statistics. Available at: https://www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/forestry-statistics-2020/2-timber/ (Last accessed: 22/02/2022).
[62] UK government. 2018. 25 year environment plan. Available at: https://www.gov.uk/government/publications/25-year-environment-plan (Last Accessed 03/03/2022).
[63] UK Government. 2021. England trees action plan. Available at: https://www.gov.uk/government/publications/england-trees-action-plan-2021-to-2024 (Last accessed: 22/02/2022).
[64] CCC. 2020. Land Use: Policies for a net zero UK. Available at: https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/ (Last accessed: 22/02/2022).
[65] CCC. 2018. Land use: Reducing emissions and preparing for climate change. Available at: Land use: Reducing emissions and preparing for climate change - Climate Change Committee (theccc.org.uk) (Last accessed: 03/03/2022)
[66] CCC. 2020. Land use: Policies for a net zero UK. Available at: Land use: Policies for a Net Zero UK - Climate Change Committee (theccc.org.uk) (Last Accessed 03/03/2022).
[67] Pateman, R. and Hodgson, J. 2015. Biodiversity report card: The effects of climate change on the distribution of species in the UK. Available at: https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/ (Last accessed: 22/02/2022).
[68] Rewilding Britain. 2020. Adapting to climate heating. Available at: https://www.rewildingbritain.org.uk/news-and-views/research-and-reports/adapting-to-climate-heating (Last accessed: 22/02/2022).
[69] Pearce-Higgins, J., et al. 2017. A national scale assessment of climate change impacts on species: assessing the balance of risks and opportunities for multiple taxa. *Biological*

Conservation. Available at: http://dx.doi.org/10.1016/j.biocon.2017.06.035 (Last accessed: 22/02/2022).
[70] Sparks, T. and Crick, H. 2015. Biodiversity report card: The impact of climate change on biological phenology in the UK. Available at: https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/ (Last accessed: 22/02/2022).
[71] Thackeray, S. et al. 2010. Trophic level asynchrony in rates of phenological change for marine, freshwater and terrestrial environments. *Global Change Biology.* Available at: https://onlinelibrary.wiley.com/doi/10.1111/j.1365-2486.2010.02165.x (Last accessed: 22/02/2022).
[72] Moss, B. 2015. Biodiversity climate change impacts report card: Freshwaters, climate change and UK conservation. Available at: https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/ (Last accessed: 22/02/2022).
[73] Watts, G. and Anderson, M. (eds). (2016). Water climate change impacts report card 2016 edition. Living With Environmental Change. Available at: https://www.ukri.org/publications/climate-change-impact-on-water-lwec-impact-report-cards/ (Last accessed 22/02/2022).
[74] Woodward, G. et al. (2010). Climate change and freshwater ecosystems:impacts across multiple levels of organization. Phil. Trans. R. Soc. B. https://doi.org/10.1098/rstb.2010.0055 (Last Accessed: 22/02/2022).
[75] CEH. 2020. Climate driven threshold effects in the natural environment. Available at: https://www.ukclimaterisk.org/independent-assessment-ccra3/research-supporting-analysis/ (Last accessed: 22/02/2022).
[76] JNCC. (online). Keeping Rivers Cool | JNCC - Adviser to Government on Nature Conservation. (Last accessed: 15/02/2022)
[77] Environment Agency. 2019. 2021 River Basin Management Plan. Mine waters challenge. Available at: https://prdldnrbm-data-sharing.s3.eu-west-2.amazonaws.com/Challenge+narratives/Pollution+from+Abandoned+Mines+challenge+RBMP+2021.pdf (Last accessed 18/02/2022)
[78] Environment Agency. 2019. Phosphorous and freshwater eutrophication pressure narrative. Available at: https://consult.environment-agency.gov.uk/++preview++/environment-and-business/challenges-and-choices/user_uploads/phosphorus-pressure-rbmp-2021.pdf (Last accessed: 22/02/2022).
[79] Environment Agency. 2019. 2021 River Basin Management Plan. Available at: https://consult.environment-agency.gov.uk/++preview++/environment-and-business/challenges-and-choices/user_uploads/nitrates-pressure-rbmp-2021.pdf (Last accessed: 22/02/2022).
[80] Environment Agency. 2021. State of the water environment indicator B3: supporting evidence. Surface waters: ecological and chemical classification. https://www.gov.uk/government/publications/state-of-the-water-environment-indicator-b3-supporting-evidence/state-of-the-water-environment-indicator-b3-supporting-evidence
[81] Environment Agency. 2018. State of the environment: air quality. Available at: State of the environment - GOV.UK (www.gov.uk) (last accessed 17/02/2022)
[82] Outhwaite, C. et al. 2020. Complex long term biodiversity change among invertebrates, bryophytes and lichens. *Nature ecology and evolution.* Available at: https://pubmed.ncbi.nlm.nih.gov/32066888/ (Last accessed: 22/02/2022).
[83] Mitchell, R. et al. 2019. Collapsing foundations: the ecology of the British oak, implications of its decline and mitigation options. *Biological Conservation.* Available at: https://www.sciencedirect.com/science/article/pii/S0006320718317920?via%3Dihub (Last accessed: 22/02/2022).
[84] Woodland Trust. 2020. Ash dieback. Available at: https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/tree-pests-and-diseases/key-tree-pests-and-diseases/ash-dieback/ (Last accessed: 22/02/2022).
[85] Mitchell, R. et al. 2014. Ash dieback in the UK: A review of the ecological and conservation implications and potential management options. *Biological Conservation.* Available at: https://www.sciencedirect.com/science/article/pii/S0006320714001700 (Last accessed:/ 22/02/2022).
[86] Hulme, P. 2015. Biodiversity climate change impacts report card: Non-native species. Available at: https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/ (Last accessed: 04/05/2021).
[87] NERC. 201. Biodiversity report card: Non-native species. Available at: https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/ (Last accessed: 22/02/2022).

[88] Environment Agency. 2018. Press release – report floating pennywort this winter, says Environment Agency. https://www.gov.uk/government/news/report-floating-pennywort-this-winter-says-environment-agency (Last Accessed: 16/02/2022).
[89] Shropshire WWT. 2021. Shropshire Pond Creation Scheme. Available at: https://www.shropshirewildlifetrust.org.uk/pondscheme (Last accessed: 22/02/2022).
[90] Freshwater Habitats Trust. 2019. No let-up in the net loss of nature, and that includes ponds too!. Available at: https://freshwaterhabitats.org.uk/no-let-up-in-the-net-loss-of-nature-and-that-includes-ponds-too/ (Last accessed: 22/02/2022).
[91] Environment Agency. 2021. Physical modifications: challenges for the water environment. Available at: https://www.gov.uk/government/publications/physical-modifications-challenges-for-the-water-environment (Last accessed 11/02/2022)
[92] Environment Agency. 2021. State of the Urban Environment. Available at: https://www.gov.uk/government/publications/state-of-the-environment/the-state-of-the-environment-the-urban-environment (Last accessed: 22/02/2022).
[93] Analysis of 2019 EA data.
[94] Brotherton, P. 2020. Making space for nature – 10 years on. Available at: https://naturalengland.blog.gov.uk/2020/09/16/making-space-for-nature-10-years-on/ (Last accessed: 22/02/2022).
[95] UK Government. 2020. PM commits to protect 30% of UK land in boost for biodiversity. Available at: https://www.gov.uk/government/news/pm-commits-to-protect-30-of-uk-land-in-boost-for-biodiversity (Last accessed: 22/02/2022).
[96] Seddon, N. et al. 2020. Understanding the value and limits of nature-based solutions to climate change and other global challenges. *Philos Trans R Soc Lond B Biol Sci.* Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7017763/# (Last accessed: 22/02/2022).
[97] IUCN. 2016. Defining Nature-Based Solutions. Available at: https://www.iucn.org/theme/nature-based-solutions/resources/iucn-global-standard-nbs (Last accessed: 22/02/2022).
[98] Oliver, T. and Roy, D. 2015. Biodiversity climate change impacts report card: interactions between climate change and land use change impacts. Available at: https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/ (Last accessed: 22/02/2022).
[99] Seddon, N. et al. 2021. Getting the message right on nature-based solutions to climate change. *Global Change Biology.* Available at: https://onlinelibrary.wiley.com/doi/10.1111/gcb.15513 (Last accessed: 22/02/2022).
[100] Foresty Commission. 2019. Climate change and forestry: position statement. Available at: https://www.gov.uk/government/publications/climate-change-and-forestry-position-statement (Last accessed: 22/02/2022).
[101] Natural England. 2021. Nature-based solutions for climate change at the landscape scale: a new £12.5m pilot programme. Available at: https://naturalengland.blog.gov.uk/2021/07/23/nature-based-solutions-for-climate-change-at-the-landscape-scale-a-new-12-5m-pilot-programme/ (Last accessed: 22/02/2022).
[102] Natural England. 2021. Shaping the future of Nature Recovery: Developing Local Nature Recovery Strategies. Available at: https://naturalengland.blog.gov.uk/2021/08/27/shaping-the-future-of-nature-recovery-developing-local-nature-recovery-strategies/ (Last accessed: 22/02/2022).
[103] Forestry Commission. 2021. England Trees Action Plan. Available at: https://www.gov.uk/government/publications/england-trees-action-plan-2021-to-2024 (Last accessed: 22/02/2022).
[104] Woodland Trust. 2016. Keeping rivers cool: a guidance manual. Available at: Keeping Rivers Cool - Woodland Trust (Last accessed: 11/02/2022).
[105] Crane, E. 2020. Woodlands for climate and nature. Available at: https://ww2.rspb.org.uk/Images/Forestry%20and%20climate%20change%20report%20Feb%202020_tcm9-478449.pdf (Last accessed: 22/02/2022).
[106] Climate Change Committee. 2019. Net Zero technical report. Available at: https://www.theccc.org.uk/publication/net-zero-technical-report/ (Last accessed: 22/02/2022).
[107] Forestry Commission. 2020. Managing England's woodlands in a climate emergency. Available at: Managing England's woodlands in a climate emergency - GOV.UK (www.gov.uk) (Last accessed 11/02/2022)

[108] Stafford, R., Chamberlain, B., and others (Eds.) 2021. Nature-based Solutions for Climate Change in the UK: A Report by the British Ecological Society. London, UK. Available at: https://www.britishecologicalsociety.org/policy/nature-based-solutions/read-the-report/
[109] Wild Ennerdale. Online. https://www.wildennerdale.co.uk/managing/beavers/ (Last accessed: 10/02/2022)
[110] 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 (Last accessed: 22/02/2022).
[111] Ramsar. 2018. Wetland restoration for climate change resilience. Available at: https://www.ramsar.org/sites/default/files/documents/library/bn10_restoration_climate_change_e.pdf (Last accessed: 22/02/2022).
[112] Cris, R. et al. 2012. Peatland restoration – demonstrating success. Available at: https://www.iucn-uk-peatlandprogramme.org/resources/restoration-practice/demonstrating-success (Last accessed: 22/02/2022).
[113] Xu, J. et al. 2018. Hotspots of peatland derived potable water use identified by global analysis. *Nature Sustainability.* Available at: https://www.nature.com/articles/s41893-018-0064-6 (Last accessed: 22/02/2022).
[114] ONS. 2019. UK natural capital: peatlands. Available at: https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalforpeatlands/naturalcapitalaccounts (Last accessed 02/03/2022)
[115] Natural England. 2021. England Peat Action Plan. Available at: https://www.gov.uk/government/publications/england-peat-action-plan (Last accessed: 22/02/2022).
[116] JNCC. 2021. Great Fen. https://jncc.gov.uk/our-work/great-fen/ (Last accessed: 16/02/2022).
[117] Green, A., et al. 2021. Historical analysis exposes catastrophic seagrass loss for the United Kingdom. *Frontiers in Plant Science.* Available at: https://www.frontiersin.org/articles/10.3389/fpls.2021.629962/full#h5 (Last accessed: 22/02/2022).
[118] Vaz Monteiro, M. et al. 2019. The role of urban trees and greenspaces in reducing urban air temperatures. Available at: https://www.forestresearch.gov.uk/research/role-urban-trees-and-greenspaces-reducing-urban-air-temperatures/ (Last accessed: 22/02/2022).
[119] Wang, H. et al. 2019. Efficient Removal of Ultrafine Particles from Diesel Exhaust by Selected Tree Species: Implications for Roadside Planting for Improving the Quality of Urban Air. *Environmental Science and Technology*. https://doi.org/10.1021/acs.est.8b06629 (Last accessed 03/03/2022).
[120] The River Restoration Centre. [online]. River restoration in urban areas. Available from: https://www.therrc.co.uk/river-restoration-factsheets (Last accessed 22/02/2022).
[121] Anderson, P. 2021. Carbon and ecosystems: restoration and creation to capture carbon. Available at: https://cieem.net/resource/carbon-and-ecosystems-restoration-and-creation-to-capture-carbon/ Last accessed: 16/02/2022
[122] Floodplain meadows partnership. (online). Case study 6.1 - impact of summer flooding on floodplain biodiversity from nutrient deposition. Available at: https://www.floodplainmeadows.org.uk/content/case-study-files (Last accessed: 15/02/2022).
[123] CIEEM. 2020. Rewilding: position statement. Available at: https://cieem.net/resource/cieem-rewilding-position-statement/ (Last accessed 16/02/2022)
[124] Convention on Biological Diversity. Online. Aichi biodiversity targets 2011-2020. https://www.cbd.int/sp/targets/ (Last accessed 03/03/2022).

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