THE ROYAL SOCIETY

Climate change and biodiversity
Interlinkages and policy options

Introduction

Climate change and biodiversity decline are major challenges of our time. Both are predominantly caused by human activities, with profound consequences for people and the ecosystems on which we depend. In 2021, major United Nations conferences on biodiversity (COP15[i]) and on climate change (COP26[ii]) will be held, providing an opportunity for Governments to focus international attention on the interconnectedness and interdependence of climate change and biodiversity.

Some policy measures are beneficial in both areas, helping to mitigate and adapt to climate change as well as conserve and restore biodiversity, while others can be positive in one sphere but negative in the other. This briefing examines these interconnections and outlines how measures that benefit biodiversity have the potential to support climate action, and how some aspects of climate action can support biodiversity. It also discusses instances where addressing one issue inappropriately can undermine efforts to enhance the other.

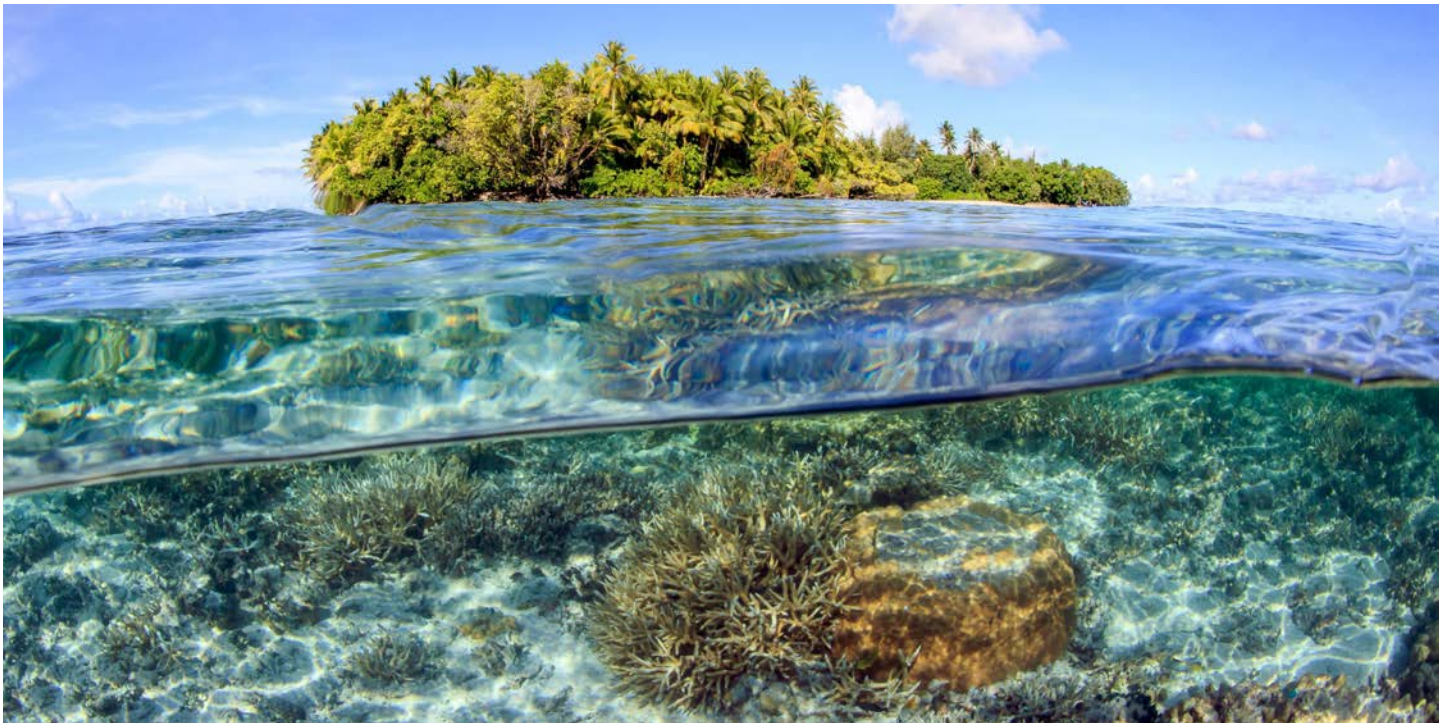


Image: Coral colonies growing in clear shallow waters surrounding a tropical islet in the Majuro Atoll of the Marshall Islands, Pacific Ocean © Tane Sinclair-Taylor

i Fifteenth meeting of the Conference of the Parties to the Convention on Biological Diversity.

ii Twenty-sixth meeting of the Conference of the Parties to the Framework Convention on Climate Change.

1. Understanding the interlinkages between climate change and biodiversity

1.1 Background – key science concepts

What is biodiversity and why is it important?

Biodiversity is the biological wealth of the Earth. The United Nations Convention on Biological Diversity (CBD) defines biological diversity as *"the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems".*

Countless interactions between organisms sustain human life on the planet, providing physical, cultural, recreational and spiritual benefits to society, often referred to as 'ecosystem services' or 'nature's contributions to people'. Loss of biodiversity can threaten these key benefits, including some as essential as supplies of food and clean water, or regulation of climate, pests and pathogens.

How does climate change affect biodiversity?

Aspects of climate change, such as rising temperatures, changing rain and snowfall patterns and extreme weather events, have a range of impacts on biodiversity. In the marine environment, climate change is causing intensified marine heatwaves, loss of oxygen and sea level rise, which lead to already observed alterations in biodiversity, ecosystem functioning and livelihoods such as fishing, particularly for coastal ecosystems[1]. The impacts of climate change are compounded by ocean acidification, which is also caused by increased atmospheric carbon dioxide concentrations. Many terrestrial, freshwater and marine species have shifted their geographic ranges, seasonal activities, migration patterns, abundances and way in which they interact with other species in response to ongoing climate change[2].

The rapid pace of twenty-first century climate change – currently, the world is on track for a temperature rise in excess of 3°C this century[3] – could mean that many species fail to adapt or migrate at sufficient speed, particularly in more fragmented landscapes. Some plant and animal populations will decline whilst others will increase, changing species interactions such as predation, competition and the spread of disease.

How do ecosystems affect the climate?

Ecosystems affect the climate in several ways, and their biodiversity secures these climate regulating functions. Biodiversity makes ecosystems more resilient to varying and shifting climates and other disturbances.

Ecosystems, through vegetation, sediments and soils are major reservoirs of carbon. The total amount of carbon stored in the terrestrial biosphere is around three times that found in the atmosphere as carbon dioxide. Changes in these carbon reservoirs, whether caused by direct human activity, climate change, or their interactions, can significantly affect the climate.

Ecosystems also influence the climate by altering the properties of the land surface and the flows of energy and matter in the oceans and on land. For example, vegetation increases the rate of water cycling to the atmosphere, which lowers surface temperatures, increases atmospheric humidity and affects local cloud formation and, in some cases, the rate or intensity of rainfall. At a larger scale, these features affect atmospheric circulation and, hence, regional and global climate patterns.

1.2 How is biodiversity changing and what role is climate change playing?

Wildlife worldwide has been influenced by human impacts with declines in abundance of many species in the last half-century[4, 5, 6]. Around one million animal and plant species are now estimated to be threatened with extinction as a result of human activity[7]. Local species richness, the number of different species in an ecosystem, is estimated to have fallen by around 14% on average due to human activity and more than 75% in the worst affected habitats[8].

The main driver of biodiversity change in the past 50 years has been alteration in land and sea use (including, prominently, tropical deforestation, the largest single cause of recent biodiversity loss), followed by direct exploitation of organisms, such as fisheries; climate change; pollution; and the invasion of species, especially on islands[7].

While climate change has yet to cause major species decline in some ecosystems, in others it has already resulted in severe falls in population size and changes in composition[9]. For example, warming-induced coral bleaching has caused declines of up to 90% in coral populations in some regions, leading to shifts to alternative types of organisms such as macroalgae, or broad-scale transformations in coral species composition[10, 11]. A 2°C warming is expected to cause a decline of greater than 99% of coral reefs. On land, the impacts of climate change on the diversity of plants and vertebrates are predicted to exceed those of land-use by 2050[12, 13].

As for the UK, a study of nearly 700 terrestrial and freshwater species showed that 41% of species had declined in average abundance since 1970[14]. Key drivers of this and associated trends include intensive management of agricultural land as well as climate change itself, which is causing range and population changes in sensitive species, alongside landscape-scale alteration to vulnerable habitats.

Species decline and other impacts of warming would be significantly lessened by limiting warming to 1.5°C. For example, a recent study suggests that whereas 4% of vertebrates, 8% of plants and 6% of insects have been projected to lose over half of their climate-determined geographic range at 1.5°C of warming, at under 3°C warming this rises dramatically to 26% of vertebrates, 44% of plants, and 49% of all insects. Under 3°C of warming, there may also be critical declines in some whole habitats, such as alpine, mountain, and high-latitude ecosystems and some tropical forests[2, 15].

1.3 How can biodiversity support climate adaptation and mitigation efforts?

Biodiversity can support climate action in many ways, particularly through well-designed 'Nature-based solutions' (NbS)[16]. These actions are intended to protect, sustainably manage, and restore ecosystems that address societal challenges such as climate change, while providing human well-being and biodiversity benefits. These are reasonably well understood and available for deployment in terrestrial systems, but less so in marine systems[17].

NbS supporting both climate change mitigation and adaptation include protecting and restoring ecosystems such as peatlands and seagrass meadows, and reforesting woodlands and mangroves, thus enhancing soil carbon sequestration whilst increasing resilience to climate change impacts[17].

Scaling up nature-based mitigation actions to their maximum possible extent has been estimated to result in a potential net absorption of around 11 billion tonnes CO_2-equivalent per year until the mid-century at least, equivalent to c.27% of current fossil-fuel carbon dioxide emissions, through enhanced sinks and reduced sources of greenhouse gas emissions (GHGs)[18, 19]. However, NbS will allow us to meet climate targets only in tandem with strict decarbonisation of the economy; the carbon-holding capacity of the biosphere is limited compared to current and potential fossil fuel emissions.

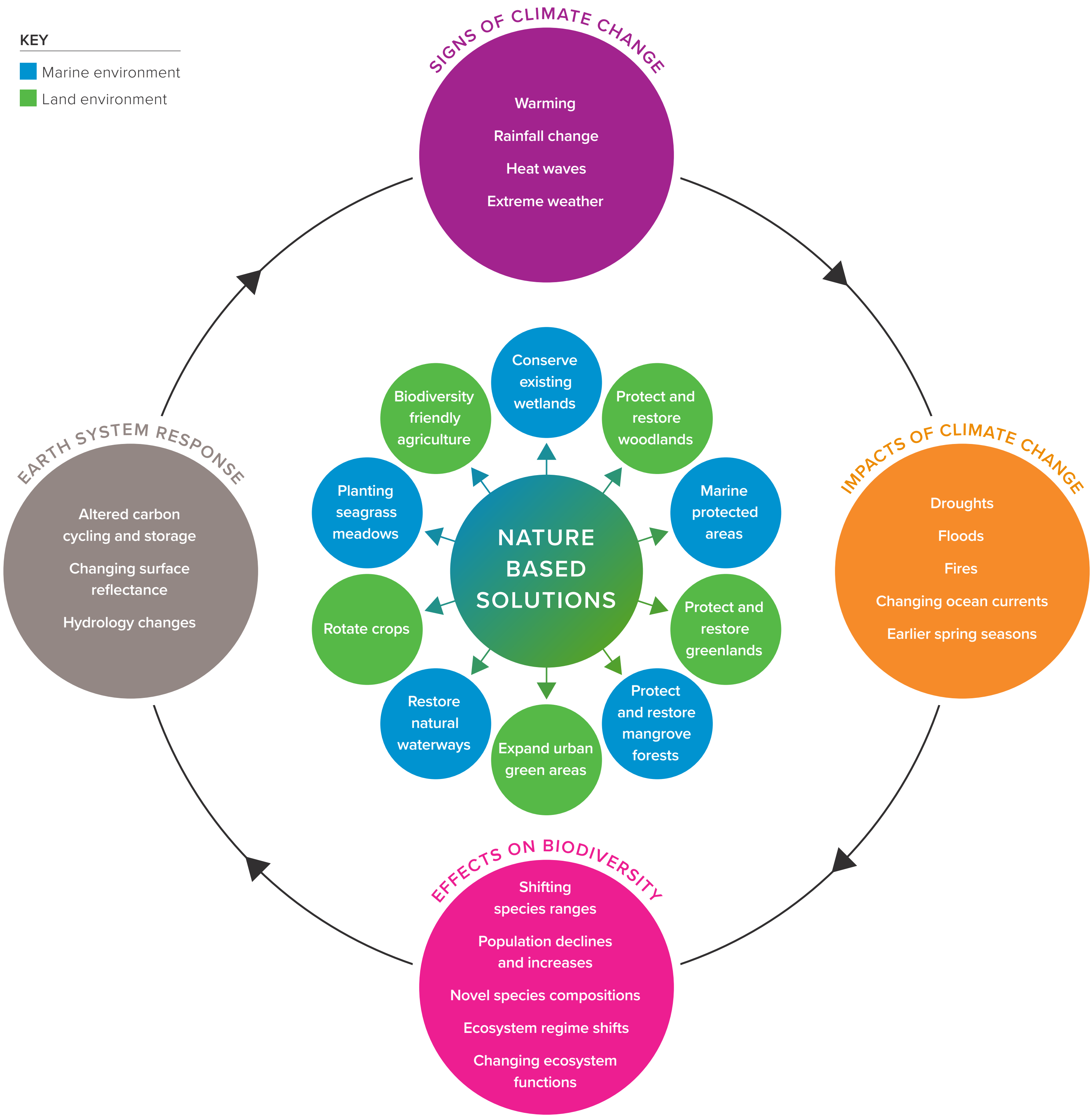
While some NbS, such as soil carbon sequestration, can be applied without changing land use, a key consideration for others is how much land conversion is required and potential trade-offs against existing uses and biodiversity.

Image: Appropriate nature-based solutions can help tackle climate change whilst also providing an opportunity for biodiversity protection and recovery. Bluebell wood at dawn © iStock / simonbradfield

FIGURE 1

Climate change impacts biodiversity through interactions with the Earth System.

Climate change induced factors such as earlier springs and changing ocean currents have consequences for all life on Earth. In turn, changes in biodiversity can impact the Earth System responses through changes to balanced cycles which further amplify climate change. Nature-based solutions (NbS) can help disrupt this cycle through the creation, restoration, management and protection of ecosystems to promote mitigation of and adaptation to climate change by altering the feedbacks between climate impacts and biodiversity, and Earth System responses. Examples of such NbS are outlined in the centre of the figure.



2. Integrated policy options for climate change and biodiversity

What is needed to mount a coordinated effort to combat both climate change and biodiversity decline? First, this section introduces the UK policy context and the scope for increasing integration in policy-making on both issues. Second, it proposes five principles that could guide the policy response. Third, it presents climate mitigation and adaptation measures that should be encouraged or discouraged based on their impacts on biodiversity. Lastly, it looks at what the UK can do at a global level to address climate and biodiversity issues in a mutually beneficial way.

2.1 UK policy context

What policies are in place in the UK to address climate change?

Climate change policy is framed by the 2008 Climate Change Act, under which carbon budgets are set 12 years ahead by Parliament on the advice of the independent Committee on Climate Change (CCC). In December 2020, the CCC recommended that the UK sets a Sixth Carbon Budget (i.e. the legal limit for UK net emissions of greenhouse gases over the years 2033 – 2037) at 965 $MtCO_2e$ (million tonnes of carbon dioxide equivalent) to achieve the net zero 2050 target, implying a 78% reduction from 1990 to 2035. The budget should cover all GHG emissions, including those from international aviation and shipping. This requires that emissions will have to fall more quickly than foreseen by the existing carbon budgets (i.e. the fourth and fifth, covering 2023 – 2027 and 2028 – 2032)[20].

The UK Government has already set net zero as its statutory target for 2050, requiring a 100% reduction of UK GHG net emissions compared to 1990 levels, with any remaining gross emissions needing to be offset by removal of GHGs from the atmosphere or by trading in carbon units[21]. On 12 December 2020, the UK communicated its new Nationally Determined Contribution (NDC) under the Paris Agreement which commits the UK to reducing economy-wide GHG emissions by at least 68% by 2030, compared to 1990 levels[22].

What policies are in place in the UK to address biodiversity decline?

UK biodiversity policy is currently based on a 'Post-2010 Biodiversity Framework' designed to achieve the global Aichi Biodiversity Targets, agreed in 2010 by 196 countries to halt the loss of biodiversity globally by 2020, at a UK level. The framework is supported by the Joint Nature Conservation Committee. Each of the UK's four nations has set out a biodiversity strategy with a common factor being an emphasis on integration of the strategy into a broad range of policies that have a direct or indirect link with biodiversity[23, 24, 25, 26]. As Northern Ireland's strategy, Valuing Nature, says: "A more integrated approach is required which recognises the need for sustaining ecosystems that are resilient to change."

In 2018, the UK Government published a broad 25-year plan called *Our Green Future*, with priority areas such as using land and seas sustainably and restoring nature[27].

The policy response to biodiversity decline has so far been inadequate at both international and national levels. The Fifth Global Biodiversity Outlook, published in September 2020, found that none of the 20 Aichi Biodiversity Targets had been fully achieved[28]. According to the UK Government's own assessment of performance, the UK has also failed in its contribution towards these targets. The UK's Sixth National Report, published in March 2019, showed the UK will miss most of its commitments for nature made in 2010. Particular challenges have been encountered in relation to targets on pollution, vulnerable ecosystems, conservation status of species and restoring degraded ecosystems where continuing pressures and other issues have counteracted progress[29].

In terms of marine policies, the UK has, since 2016, established some of the world's largest marine conservation areas with its 4 million km^2 'Blue Belt' network in the seas around some of its Overseas Territories[30]. These protected areas aim to safeguard biodiversity from the impacts of fishing, but the level of protection is not always very high, and investment in enforcement and management is limited. The UK ranks 94th out of 152 countries in the illegal unregulated and unreported fishing index (with the first country being the worst, and the last one the best)[31].

For several decades, the UK followed EU environment legislation, but with the decision to leave the EU, the UK Government is developing new environment and agriculture legislation and is establishing a new Office for Environmental Protection for England, while the devolved administrations of Northern Ireland, Scotland and Wales create their own counterparts[32, 33, 34].

2.2 Five principles to guide a joined-up climate and biodiversity policy response

Transformation

Modelling demonstrates that mitigation at the scale needed to keep the rise in global temperatures to 1.5°C, or to reverse global biodiversity decline, requires transformative change in the way our societies consume and produce resources[35]. Such change would include rapid and far-reaching transitions in consumption supply chains, energy production and use, land use, infrastructure, and lifestyle[2]. The 2021 Dasgupta Review and recent international climate change and biodiversity assessments have highlighted the need to transform the economic system, for example by: complementing GDP with measures that include multiple values for nature by reducing and redirecting some of the subsidies for, and financial investment in, fossil fuel, agriculture, fisheries, forestry, transportation, and mining towards sustainable policies and practices; internalising environmental and social externalities (according to IMF these amount to about US $5 trillion in 2017[36]); and embracing a circular economy[2, 5, 37, 38].

Collaboration

Governments alone cannot achieve the transformations needed – coordinated climate actions from multiple stakeholders, including the private sector and civil society are indispensable. Cross-government collaboration, for example between the ministries of treasury, energy, environment, agriculture, transportation, and harmonised policies are also necessary.

Integration

Greater understanding of the biodiversity-climate relationship may end the separation between the national and international policy frameworks that currently address climate change and biodiversity decline. It is important for policymakers to look at impacts in both areas when considering any intervention. Such integration will be furthered in the UK by environmental and agricultural legislation in line with CCC's recommendations on land use and measures to protect marine systems as set out in the UK's 25-Year Environment Plan[39].

Additionality

Where NbS are employed to help mitigate climate change, they should not delay or lower ambition to reduce carbon dioxide emissions from fossil fuels or reduce energy use through more energy efficient technologies[40]. Early projections indicate that even ambitious deployment of NbS worldwide can only provide 0.1 – 0.3°C of lowered global peak temperatures, a significant contribution but not a solution to climate change in the absence of fossil fuel emissions reductions[41].

Best practice

The success or failure of NbS is dependent on the adoption of best practice. In many cases best practice will involve place-based NbS: the appropriate solution for a specific location. The spread of best practice requires a well-defined framework for NbS that includes evidence-based standards and guidelines[42, 43] to avoid unintended or maladaptive outcomes[44, 45].

2.3 Guidance on policy measures through which the five principles can be applied

This section sets out policy measures that are beneficial for both biodiversity and climate change, and should therefore be encouraged, and measures which are harmful and should therefore be discouraged.

Policy measures to encourage:

Dietary shift and food waste reduction

In the UK, 38% of the total UK crop supply in 2010 was used for animal feed, with a significant footprint overseas[46], and 20 – 25% of food purchased by consumers in the UK is wasted[47]. Globally, animal agriculture is a major contributor to global biodiversity loss[48]. A reduction in meat and dairy consumption and a significant reduction in food loss and waste would not only significantly reduce greenhouse gas emissions, which itself benefits biodiversity through limiting climate change[49], it would also reduce pressure for deforestation and on other natural habitats abroad, and free land and resources for the wider use of NbS in the UK[46]. As such, dietary shifts and reduction in food loss and waste create the enabling conditions that make other actions outlined below more feasible.

Peatland restoration

Peatland restoration has multiple benefits for amenity, water resources, flood protection, biodiversity and climate. For example, restored peatlands show renewed growth of sphagnum moss species and attract invertebrates and birds[50]. The CCC has proposed restoring at least 50% of upland peat and 25% of lowland peat, which would reduce annual peatland emissions by 5 $MtCO_2e$ per year by 2050[51].

Expanded and improved forest cover

Expansion of cover of native woodland, through woodland restoration and natural regeneration, in a network that facilitates connectivity and species migration, will enhance biodiversity and carbon storage in UK ecosystems. The CCC has proposed increasing UK forest cover from 13% to at least 17% by 2050 by planting at least 30,000 hectares of woodland each year. With improved forest management, this is estimated to sequester 14 $MtCO_2e$ per year by 2050 in forests plus a further 14 $MtCO_2e$ per year from harvested materials[52].

Climate and biodiversity friendly agriculture

Farmers can be offered financial incentives in the form of 'public money for public goods', such as peatland restoration on their lands, or protection of pollinators that have an estimated value of £1 billion to UK farmers[53]. Such measures are included in the current Agriculture Bill in England, while Scotland, Wales and Northern Ireland have each made commitments to supporting sustainable farming[54, 55, 56, 57]. Other measures are also positive for biodiversity, such as protecting hedgerows that store carbon, provide wildlife habitats and greatly increase habitat connectivity[58, 59]. A next step could be to set targets for take-up of such incentives.

Marine protected areas

The UK has a network of Marine Protected Areas (MPAs)[60] including more than 90 Marine Conservation Zones that protect a range of important, rare or threatened habitats and species[61]. For example, because of the overseas territories, the UK is ranked the 12th largest coral reef custodian out of 80 nations[62]. As well as protecting biodiversity, many MPAs support climate resilience, either by protecting the coastline from severe weather events, for example through sandbanks or seaweed, or by absorbing carbon dioxide, seagrasses, salt water reedbeds and muddy habitats[61]. To be effective, MPAs should be extended with new investment in their management and enforcement of protection rules[63].

Green spaces in cities

Increasing green spaces in cities is vital for adaptation as they have a cooling effect, support biodiversity and its connectivity, and enable many biodiversity-associated mental, physical and cultural welfare benefits to people living in urban areas, as well as making a contribution to carbon storage and climate change mitigation[64].

Biodiversity-friendly renewables

Upscaling of renewable energy production should avoid negative impacts on biodiversity where possible. For example, engineers can design offshore wind farms to be biodiversity friendly and attract species under water[65]. Techniques include structures on which new reefs can grow along with fish habitats and sea grass settlements. Overall, marine sites where renewable energy technologies are being deployed should be managed to optimise the potentially positive effects, by adopting exclusion zones from other destructive activities such as bottom trawling and dredging and support the colocation of other industries such as mariculture that support wider benefits from nature[66]. On land, solar farms need to avoid fragmenting habitats or becoming barriers to the movement of wildlife species[67]. It is also important to source raw materials for renewables in a way that ensures minimal damage to biodiversity.

When using the policy measures listed above, the UK should adopt a holistic strategy. Multiple mechanisms can be used simultaneously to provide multi-layered benefits for biodiversity and climate, while enhancing environmental and socio-economic benefits. These benefits could be achieved through public time-bound incentives or through investment and trading mechanisms that reward emissions reduction through natural or engineered solutions. However, with many options available, more needs to be done on evaluating what constitutes success.

Policy measures to discourage:

Monocultures

Planting trees, either for bioenergy or as long-term carbon sinks, should focus on restoring and expanding native woodlands and avoid creating large monoculture plantations that do not support high levels of biodiversity. Simple targets such as 'numbers of trees planted' ignore biodiversity considerations, such as long-term survival of trees or stewardship, and can be misleading, potentially contributing to policy failure and misuse of carbon offsets[68].

Unsustainable energy crops

The modelled benefits of Bioenergy with Carbon Capture and Storage to mitigate climate change (the use of crops to generate power and fuel while capturing CO_2), for reducing emissions are significant. However, the scale of some modelled deployments would either take up large amounts of land now used for food production or have negative effects on the amount of land available for preservation or restoration of natural ecosystems. Policy should also limit use of fuelwood pellets and other feedstocks for bioenergy where it might intensify pressure on semi-natural ecosystems.

Peatland forestry

One specific challenge for the UK is to roll back the trend towards planting trees on peatlands. Such planting releases carbon from long-term soil reservoirs that have absorbed carbon for millennia and can continue to do so as wood is a shorter-term biomass store which is more likely to be converted back to carbon dioxide within years to decades. Nonetheless, estimates indicate that 18% of UK peatlands have been converted to forestry, according to the International Union for the Conservation of Nature. There is therefore a need to enforce the UK Forestry Standard's specific presumption against the conversion of priority habitats such as deep peat or active raised bogs[69].

2.4 What can the UK do at a global level?

The UK's role in environmental issues embraces both its own domestic policy and its influence over global policies. As well as acting nationally, the UK can become a leader in linking biodiversity and climate change policy as well as contributing to global agreements and initiatives. It has an opportunity to take the lead in bringing about the systemic change required to address the underlying drivers of biodiversity decline and climate change.

Connect biodiversity and climate policy

Given the growing focus on the interconnectedness of climate and biodiversity and the forthcoming United Nations conferences on both issues, the UK could prioritise the importance of systemic change to integrate policy making at the global level[17, 70].

Practical steps to this end could include:

- advocating for alignment of climate and biodiversity targets and identified actions;
- increasing collaboration between the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC) which includes joint work programs;
- promoting that the new global biodiversity goals to be adopted by the CBD for the next decade are holistic and ambitious[71];
- exploring funding for NbS, particularly via the United Nations Framework Convention on Climate Change (UNFCCC)'s planned forum on 'Finance for nature-based solutions'[72]; and
- strengthening the role of the Joint Liaison Group on the Rio Conventions[iii].

Other possibilities for UK action beyond the UK include:

Sustainable trade

The UK should lead by example in accounting for embodied carbon emissions and biodiversity impacts of its imported goods, and encourage action to avoid the destruction of natural habitats and biodiversity loss in supply chains; establish certification standards; and hold businesses to account who have said they will do this[73, 74]. When assessing both climate and biodiversity impacts, it is critical to take into account the whole life cycle of a product.

Forests and other ecosystems

The UK could lead, for example through the Commonwealth Charter, in supporting sustainable forest protection and expansion across the world, favouring ecologically intact forests, and avoiding planting trees in inappropriate landscapes. This should be complemented by additional focus on protection and restoration of non-forest landscapes, including peatlands, savannas, natural grasslands, freshwater and marine systems.

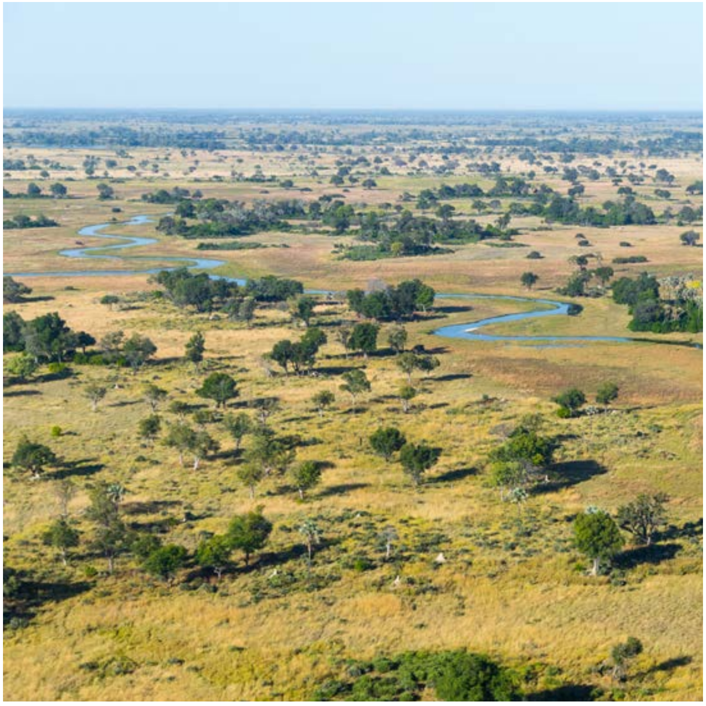


Image: Many ecosystems are naturally low tree cover systems. Increasing tree cover in such systems to meet climate mitigation goals is likely to lead to poor biodiversity outcomes. Aerial view over Okavango Delta © iStock / Gfed

iii The mandate of the Joint Liaison Group, which comprises the Executive Secretaries of the CBD, UNCCD and UNFCCC, is to enhance coordination among the three Rio Conventions and explore options for further cooperation.

Conclusion

Climate change and biodiversity are inherently connected and addressing them is central to achieving the UN Sustainable Development Goals. While a warming planet leads to biodiversity decline, biodiversity-based solutions can contribute to both climate change mitigation and adaptation. However, climate change and biodiversity tend to be governed separately at home and internationally, hindering solutions that could address both issues.

By better integrating climate and biodiversity policies at national and international levels, the full potential of biodiversity to support climate action could be leveraged, while at the same time helping to reverse the ongoing decline in biodiversity.

To create a fully sustainable future, the UK needs a rapid transition towards clean energy, large-scale ecological restoration of degraded ecosystems, a continued ramping up of biological conservation, and transformation of supply chains to reduce resource extraction and environmental impacts.

These actions, in turn, require transformation of economic and political structures and societal norms, including subsidies, incentives and international trade regulations, confirmation of the effectiveness and direction of interventions, and a significant shift in public opinion and lifestyles.

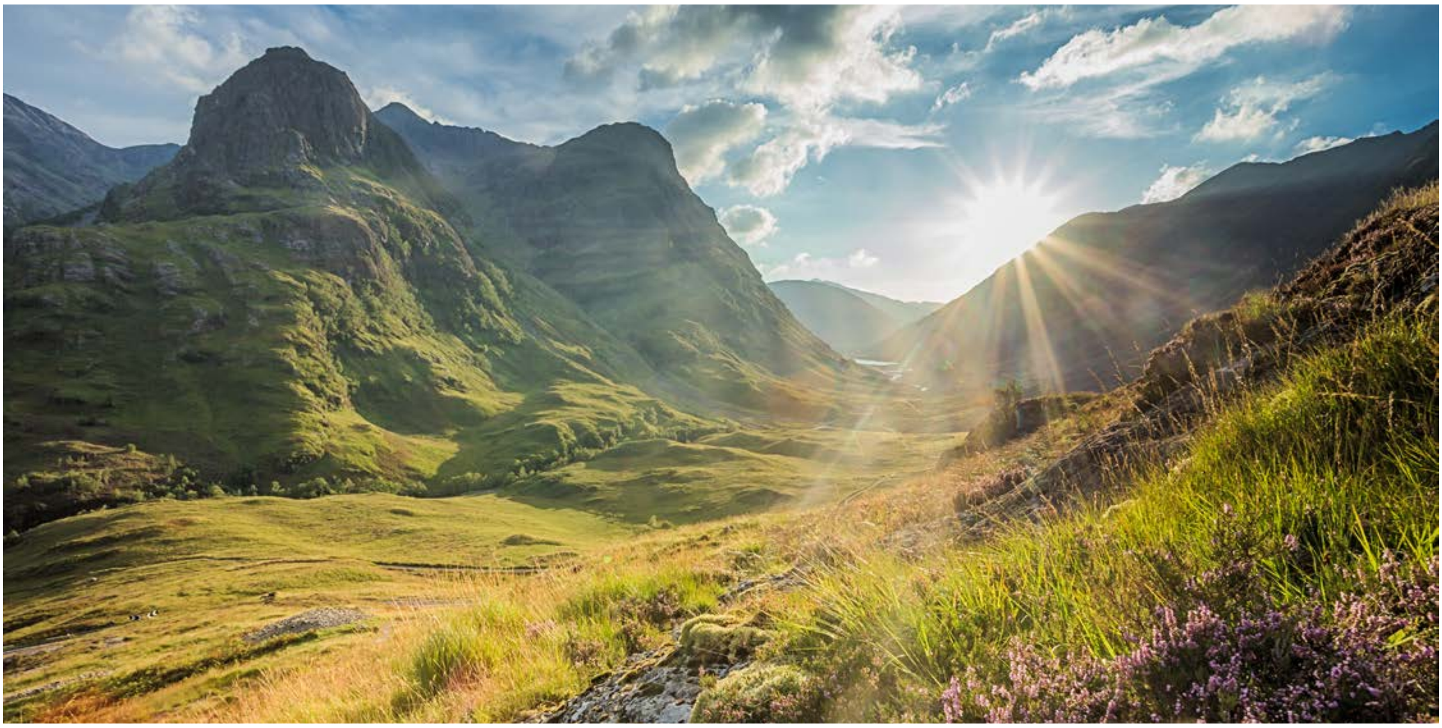


Image: Valley view below the mountains of Glencoe, Scotland, UK © iStock / FedevPhoto

Dedication to Dame Georgina Mace FRS (1953 – 2020)

This publication is dedicated to Dame Georgina Mace FRS who worked tirelessly through her research and advocacy for the causes of biodiversity and the environment.

Georgina Mace's research covered a range of topics that related to the trends and consequences of biodiversity loss and ecosystem change. She developed the criteria for measuring species extinction risk that are now used by the International Union for Conservation of Nature for their regular Red Lists of Threatened Species. Georgina also identified the factors that cause different species to be more or less vulnerable to extinction. She developed approaches to understanding climate change impacts and how this varies between species and in different ecosystems.

A second area of her research concerns ecosystem services and natural capital accounting, which she became interested in through her work on the Millennium Ecosystem Assessment and the UK's National Ecosystem Assessment. Georgina had been especially concerned with evaluating the links between biodiversity and ecosystem services, incorporating ecosystem services into biodiversity targets and examining trade-offs amongst ecosystem services. Most recently, she developed a new approach to measuring the loss of natural capital, using a risk register.

For her services to environmental science, Georgina was awarded an OBE in 1998, a CBE in 2007 and made a DBE in 2016.

At the time of her death on 19 September 2020, Georgina was fully committed to contributing to this briefing. She is greatly missed by all those involved with this project and the wider environmental science communities.

Annex A

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