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Climate Change—Biodiversity Interactions

There is increasing consensus among scientists and commentators for addressing conservation and climate change issues together, particularly through the development of intergovernmental agreements and targets. This POSTnote summarises the links between biodiversity loss and climate change, and outlines options for jointly addressing their drivers and effects on a global scale.

Overview

- While climate change and biodiversity loss are interlinked issues, they have largely been addressed through separate, rather than integrated, global policy frameworks.
- Changes in sea and land use are the main drivers of biodiversity loss and contribute to climate change. Climate change also drives biodiversity loss.
- Conserving biodiversity could also mitigate climate change by increasing capture and storage of carbon in ecosystems, and support adaptation to climate impacts.
- Ecosystems can be conserved, managed and restored to provide benefits for biodiversity, climate change mitigation and adaptation, and sustainable development.
- The effectiveness of ecosystem-based climate and conservation measures may be affected by the rate and magnitude of climate change.

Background

Intergovernmental agreements use the term biodiversity in place of nature, which refers to the abundance and variety of life on Earth.[1] Biodiversity is essential for human well-being (PN-341) because it provides benefits from the natural environment, such as: food, medicine, and clean water (ecosystem services or nature's contributions to people).[2] The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment found that humans have extensively altered 75% of the earth's land surface and 40% of the ocean. This may lead to the extinction of an estimated 1 million species within decades, leading to declines in ecosystem service benefits.[2]

Climate change is one of the largest drivers of biodiversity loss after changes in sea and land use, and direct exploitation of wildlife, such as fishing. These direct drivers of biodiversity loss are linked to underlying human drivers (Box 1). There are many complex interactions between these drivers. For example, deforestation and land conversion to agriculture are interacting contributors to climate change.[3] Climate change will also have large impacts on human well-being (PN-594).

The International Panel on Climate Change (IPCC) suggests that more protection and restoration of ecosystems is needed to meet the mitigation and adaptation objectives of the Paris Agreement (Box 2). This would increase the ability of plants, soils, and oceans to capture and store carbon, and also reduce biodiversity loss.[2,4] Most signatories to the Paris Agreement also committed to protecting and restoring ecosystems through the Convention on Biological Diversity (CBD, Box 2). In 2020, the CBD framework for the next decade will be agreed. Most existing targets will not be achieved globally, including in the UK.[2] One-third of the UK Biodiversity Indicators show long-term declines, such as in the abundance and distribution of species.[5]

Global biodiversity loss is projected to continue beyond 2050 in most IPBES modelling scenarios. These trends make achieving the UN Sustainable Development Goals less likely (Box 2).[6] Negative biodiversity trends can only be reversed by immediate reorganisation of technological, economic and social systems, and if the targets of the Paris Agreement are met.[2] This POSTnote summarises the interactions between biodiversity loss and climate change, the global opportunities and challenges for jointly addressing their effects and drivers, and their inclusion in international environmental frameworks.

Box 1: Addressing Underlying Drivers of Biodiversity Loss
IPBES states that the 'underlying drivers of biodiversity loss' are: unsustainable production and consumption patterns, human population trends, trade, technological innovations, and governance. These can lead to changes in sea and land use, direct exploitation of organisms, climate change, pollution, and invasion by alien species. For example, international supply chains for developed countries can cause biodiversity loss overseas.[7-10] The underlying drivers have not received much attention in the existing CBD framework.[11] IPBES suggests that ways to address these drivers include:

- **Reforming production and supply chains.** The UK Government recently established an independent Global Resources Initiative Taskforce.[12] The private sector has made supply chain commitments, but these have largely yet to be implemented.[13]
- **Consumption and dietary shifts.** Evidence suggests that changing food consumption patterns, improving agricultural production, and reducing food waste are required to address biodiversity loss; and can have a large climate mitigation potential.[2,14,15]
- **Economic and financial systems.** Financial support for biodiversity conservation and forest-based climate mitigation is currently much smaller than the value of commodities that drive deforestation.[14] IPBES states that perverse government incentives and subsidies for agriculture and energy that worsen biodiversity loss and climate change should be removed and redirected.[2]
- **Decarbonising the economy.** The ability of ecosystems to capture and store carbon does not reduce the need to decrease emissions. If all historic emissions from land-use change are reabsorbed, large fossil fuel emissions reductions will still be needed to meet the Paris Agreement objectives.[16]
- **Improved governance** enables other actions. For example, strengthening environmental laws and their implementation will integrate decision making across sectors and jurisdictions.[17]

Box 2: International Environmental Frameworks
Several UN-facilitated frameworks seek to address biodiversity loss, climate change and sustainable development.

The CBD Strategic Plan for Biodiversity 2011–2020
The CBD is an international treaty for biodiversity. The CBD Strategic Plan for Biodiversity 2011–2010 and associated Aichi Targets aim to:

- Halt biodiversity loss and reduce pressures from drivers;
- Restore resilient ecosystems for biodiversity and climate mitigation and adaptation;
- Use biological resources sustainably and share the benefits of genetic resources, such as crop varieties;
- Provide adequate financial resources, mainstream biodiversity issues and values; and,
- Effectively implement appropriate policies that are based on sound science and the precautionary approach.[28]

The UNFCCC Paris Agreement
The UN Framework Convention on Climate Change (UNFCCC) is an international treaty for climate change. The UNFCCC 2015 Paris Agreement is a legal instrument that aims to strengthen the global response by limiting average global warming to well below 2°C, aiming for 1.5°C above pre-industrial levels. In relation to biodiversity, the agreement aims to protect and increase forest carbon storage through policies and incentives for activities reducing deforestation and forest degradation emissions (PN-466), and sustainable forest management.[29]

The 2030 UN Agenda for Sustainable Development
17 Sustainable Development Goals (SDGs) were adopted in 2015 consisting of 169 targets across economic, social and environmental dimensions of sustainable development.[30] Conserving biodiversity is an explicit part of SDGs 14 and 15 and underpins most other goals.[31]

Biodiversity and Climate Change

Climate change and biodiversity are interdependent; climate change can contribute to biodiversity loss, and biodiversity loss can make climate change and its effects worse.

Effects of Climate Change on Biodiversity

Climate change will increasingly drive biodiversity loss in coming decades.[18] Human emissions of greenhouse gases (GHGs) have increased global average surface temperatures by 1.1°C since pre-industrial times.[19] The resulting climate change effects include increased frequency and intensity of extreme weather events, and rising sea levels.[3] These have widespread impacts on biodiversity, including:

- Shifting geographic ranges of species, including poleward, and reducing the extent of suitable habitat.[20-22] This can disrupt communities of species or create new communities.[23]
- Disrupting seasonal cycles leading to mismatch between otherwise co-dependent species, such as flowering and the emergence of pollinators.[24,25]
- Altering population dynamics, such as mass reindeer mortality due to abnormal weather affecting indigenous peoples.[26,27]
- Modifying land and marine ecosystem functions, such as carbon storage and productivity.[32] The combined effects of rising carbon dioxide (CO_2) and climate change on the productivity of land ecosystems are uncertain and likely varied.[2,33]

Climate change is affecting marine and coastal ecosystems through ocean warming, heatwaves, acidification, loss of oxygen and sea level rise (PN-604).[32] The oceans have stored 90% of the excess heat trapped by GHGs since the 1950s.[4] Climate impacts are accelerating, affecting agriculture, fisheries, and ecosystem services.[2,32] This has implications for human health, and economic and social wellbeing (PN-421).[2] By 2050, 5 billion people may be at risk from reduced provision of ecosystem service benefits. Global modelling shows declining provision of water quality regulation and coastal protection by ecosystems, and crop pollination by species.[34]

Impacts of Biodiversity Loss on Climate Change

Ecosystems can be both a store and a source of GHGs due to natural and human drivers. Globally, land stores around 29% of human CO_2 emissions and the ocean absorbs around 23%.[35] At the same time, human-driven changes, such as tropical deforestation, peatland degradation and loss of coastal habitats, release carbon. The net balance of this is an overall source of emissions (14% of CO_2 emissions) but reducing the loss and degradation of ecosystems could reverse this.[14,36]

Ecosystem Tipping Points and Feedbacks

Biodiversity loss and climate change make ecosystems more vulnerable to abrupt environmental changes, known as 'tipping points'.[37,38] Tipping points increase the risk that the Paris Agreement objectives will not be met, as they could cause irreversible feedbacks between ecosystems and the climate.[39] For example, Arctic and boreal permafrost (permanently frozen ground) stores twice as much carbon as the atmosphere. Temperature rise causes permafrost thaw, leading to the release of carbon; likely causing further temperature rise (PN-454).[18,40,41] Climate change is projected to make many forests warmer and periodically drier, with increased wildfire risk. This may result in tropical and boreal forests storing less carbon and potentially becoming a source of carbon to the atmosphere.[42-45]

Ecosystems in Mitigation and Adaptation

Biodiversity can mitigate climate change and support adaptation through ecosystem service provision, such as carbon storage. Mitigation refers to any intervention that reduces emissions from sources or enhances removal by sinks of GHGs. Forests, particularly tropical forests, have large mitigation potential, due to their rate of carbon uptake when growing, and capacity for carbon storage if deforestation is avoided.[46] Forests could provide a quarter of the emissions reductions currently pledged by nations under the Paris Agreement.[47] However, global forest extent would need to increase every year between 2019 and 2030 by an area equivalent to the size of the UK.[48]

Adaptation refers to any intervention that allows humans to adjust to climate change effects. For example, coastal ecosystems can aid climate adaptation by improving critical habitats for species to support fisheries and by protecting coastal communities from sea level rise and storms. However, the IPCC has highlighted that the rate of climate change and other pressures limits their adaptive capacity.[49,50] Many coastal wetlands are projected to be lost due to sea level rise.[32]

Policy strategies that conserve and restore biodiversity can also provide climate change mitigation and adaptation.[2,51] Such measures include retaining and protecting intact ecosystems and protecting and restoring degraded ones.[52] Nature-based Solutions (NbS) is an increasingly used term for actions that protect, manage and restore natural and modified ecosystems to address societal challenges and enhance human well-being.[53,54] NbS could be implemented globally to address biodiversity loss, climate change and sustainable development.[55] There could be large benefits in nations with highly biodiverse ecosystems with significant carbon storage that are being degraded, such as tropical rainforests.[56,57]

NbS are being included in countries' Nationally Determined Contributions (NDCs) to the Paris Agreement and in international funding programs such as the UK's Darwin Initiative.[55,58] The Forestry Commission, Environment Agency, and Natural England aim to use NbS to help meet the UK target of net zero emissions by 2050.[59] NbS policy measures need clear indicators of progress and cost-effectiveness, as well as monitoring and evaluation of mitigation, adaptation, biodiversity and socioeconomic outcomes, and consideration of the trade-offs and co-benefits that may arise.[60,61]

Managing Trade-offs

Simultaneously avoiding dangerous climate change, restoring biodiversity, and ensuring food security with limited land availability could result in trade-offs.[62-64] For example, most IPCC scenarios rely on large-scale, land-based mitigation (such as bioenergy crops and afforestation/reforestation) to meet the Paris Agreement objectives, which could negatively affect biodiversity, food production and water demand.[3,4] Managing such trade-offs will require an integrated approach that considers interactions between sectors and trade-offs among global environmental and sustainability goals, while recognising opportunities from interactions.[17,65] Land-use planning can deliver multiple objectives along with approaches such as Nature-based Solutions (NbS).[66]

Retaining and Protecting Intact Ecosystems

Most areas with both high biodiversity and carbon storage are unprotected.[57] Effectively protected lands and seas retain more biodiversity and have immediate mitigation and adaptation benefits.[2,67,68] Some studies suggest that 30–50% of the Earth's surface should be protected and restored, based on biodiversity importance and restoration potential.[69-72] However, increasing protected areas may have negative ecological, social and economic consequences if not integrated with human needs.[73-75] What is perceived as untouched wilderness has often been used by people for millennia (Box 3), yet there is evidence that human rights are sometimes violated as part of conservation interventions.[42,76,77] Others argue that halting all human impacts on ecosystems is unfeasible.[78]

Retaining intact ecosystems is likely to have greater biodiversity and mitigation benefits, and to allow ecosystems to adjust to climate change.[14,79,80] For example, maintaining mature forests that have higher biodiversity increases their ability to adjust to climate change impacts.[2] Preventing deforestation is also a low-cost approach to reducing land emissions and enhancing carbon sinks.[14,81] However, IPBES predicts conversion of natural ecosystems will increase, despite international commitments, improvements in monitoring deforestation, and the incentive mechanism REDD+ (PN-466).[2,82,83] Many protected areas are increasingly isolated and losing biodiversity due to internal and external human pressures, including the loss and downgrading of legal protections and their enforcement.[84-86] Isolated protected areas reduce the ability of species to move with climate change to more suitable areas.[87]

Box 3: Indigenous Peoples and Local Communities

Indigenous Peoples and Local Communities (IPLC) hold a large but uncertain proportion of the global land area through customary tenure systems, of which national governments formally recognise a small fraction, such as First Nations rights holders in Canada.[88-90] Recognising IPLC land rights may benefit biodiversity and climate:

- IPLC lands often score more highly on biodiversity indicators, with slower declines than in other lands.[2]
- IPLC hold a large proportion of the world's total tropical forest above ground carbon, much of which is in areas without secure tenure rights.[91]
- IPLC management may reduce deforestation and disturbance.[92,93]

Box 4: Restoring Coastal Habitats
Coastal ecosystems, such as mangrove forests, seagrass meadows and salt marshes contain large amounts of carbon per unit area.[50] Their global mitigation potential is around 0.4% of current yearly CO_2 emissions, but the mitigation potential of other marine ecosystems is under-explored.[50,94] Restoring coastal ecosystems could also help adaptation to climate impacts and provide other ecosystem services.[95] Seagrass meadows are one of the most widespread coastal ecosystems contributing to climate mitigation and adaptation, biodiversity protection and fisheries productivity.[96] The meadows store carbon, stabilise sediments and are nursery habitats for commercially important fish and other biodiversity.[42,97] However, global seagrass meadow area has declined considerably because of human activities.[98] An estimated 7,000 hectares of seagrass remain in UK waters, which is thought to be a small fraction of historic baseline levels.[99] There are some restoration efforts underway, although uncertainties exist around the protected status of restored seagrass under the UK legal framework for marine restoration.[99-102]

Forest Restoration and Creation
Restoring forest involves increasing tree cover on previously forested lands through active planting or natural regrowth.[103] There are no longer large intact or undisturbed temperate forests, and many tropical forests are degraded.[42] Restoring other high-carbon ecosystems, such as peatland, also has mitigation and biodiversity potential.[3,32,81] The UK Committee on Climate Change (CCC) and the Royal Society have separately published recommendations for the UK to restore peatlands, native forests and coastal habitats (Box 4).[95,104,105]

Natural and assisted regrowth of native forests, particularly in the tropics and subtropics, is likely to be highly effective in terms of biodiversity, carbon uptake and cost-effectiveness, despite the timescales involved (Box 5).[14,48,106] Mapping the potential for restoration in tropical forests suggests opportunities are large but variable.[107,108] Monitoring would be required to ensure carbon uptake and biodiversity outcomes are achieved.[60] Active replanting has higher costs per unit area than natural regrowth, but is needed where forests are unable to regrow naturally or if restoration of the community of under-canopy plants is required.[46,109]

Afforestation establishes new forests in naturally non-forest ecosystems such as savannah or grassland. Afforestation using species with low water needs can sometimes provide ecosystem service benefits.[3,110] However, non-native, single-species tree plantations negatively affect savannah and grassland biodiversity.[111-113] Afforestation could affect food and water security because of large land requirements, with desertification and land degradation risks.[3,30,114] Timber plantations also store much less carbon than restored natural forests and release carbon during wood harvest.[48,114] They are also more vulnerable to droughts, fire and disease outbreaks, reducing carbon storage permanency.[115] In higher latitudes, carbon benefits may be offset by increased warming as forests absorb more of the sun's energy than snow-covered land.[116]

Box 5: Timescales in Ecosystem Restoration
Some degraded, naturally regenerating tropical forests can accumulate significant carbon stocks and support biodiverse communities within 30 years.[117,118] Some reach mature forest-level carbon stocks within 70 years.[119-121] Ecosystems may recover even more rapidly under assisted restoration.[62] According to some mitigation scenarios, reforestation would capture carbon within the next few decades – the timeframe needed to limit global warming to 1.5°C.[122] However, after this period annual carbon removal would decline as trees mature and soil carbon reaches saturation.[3] Carbon stocks would be maintained, but with a risk of future loss of carbon from disturbance, poor management or weak governance.[123] Restored peatlands capture carbon for centuries; degraded peatlands are a source of emissions over similar timescales, but emissions reductions from restoration can take decades to be observed.[3,124] These timescales highlight the importance of protecting large existing stores of carbon in ecosystems from loss and degradation.[125]

Managing Forestry and Agricultural Land
Agricultural land and production forests can also be managed to reduce biodiversity loss, maintain ecosystem functioning, and address climate change.[81,126] As these lands provide food and other commodities, management also needs to support sustainable production and livelihoods.[127] For example, agroforestry (cultivated land with more than 10% tree cover) improves biodiversity, carbon storage and farm income, and protects soils.[14] Such agroecological approaches (PN-557, PN-589, and PN-600) make land more hospitable for wildlife moving between protected and restored ecosystems, helping it adjust to a changing climate.[87] Forestry management with longer rotation times and reduced harvest rates can significantly increase carbon storage in temperate and boreal forests.[14]

In 2020, the CCC estimated that 64% of agricultural emissions could be cut without reducing food production, by adopting low-carbon farming practices, improving productivity and setting aside 22% of farmland for natural carbon capture and storage. The CCC recommended that 30,000 hectares of new broadleaf and conifer woodland are planted annually, increasing woodland cover from 13% to 17%, to meet the legally-binding target of net zero emissions by 2050.[105]

Future Biodiversity and Climate Goals
Climate change-biodiversity interactions are increasingly included in discussions for international environmental frameworks. In the preliminary CBD post-2020 framework, a new target is intended to complement the Paris Agreement. The target calls for Nature-based Solutions for climate mitigation and adaptation to meet the Paris Agreement objectives.[128] To date, the UK Government is engaging with various stakeholders to develop the UK's position on the framework.[129] The UK will also host COP26, the UN Climate Change Conference, in December 2020. Paris Agreement signatories will be revising Nationally Determined Contributions towards the objectives, and biodiversity and Nature-based Solutions are expected to be key issues.[130]

(*References available online*)

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Endnotes

1 Biodiversity, or "biological diversity", is defined by the Convention on Biological Diversity (CBD) 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". CBD Secretariat (2006). *Convention Text. Article 2. Use of Terms*.

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