IPBES-IPCC CO-SPONSORED WORKSHOP

BIODIVERSITY AND CLIMATE CHANGE

WORKSHOP REPORT

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

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Food and Agriculture Organization of the United Nations
UNDP

IPBES-IPCC CO-SPONSORED WORKSHOP REPORT ON BIODIVERSITY AND CLIMATE CHANGE

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IPBES-IPCC CO-SPONSORED WORKSHOP

BIODIVERSITY AND CLIMATE CHANGE

WORKSHOP REPORT

Disclaimer

In memoriam: Prof. Bob Scholes

This report is dedicated to the memory of Prof. Bob Scholes who passed away a few weeks before the finalisation of this meeting report. Bob co-chaired the scientific steering committee for the co-sponsored workshop, the workshop itself, and the overall production of this workshop report.

When contacted as a potential Co-Chair, Bob enthusiastically accepted. He immediately saw the importance of further bringing together the scientific community around biodiversity and climate change, to inspire policymakers in addressing these two issues together.

Bob's contributions and passions on ecosystem dynamics and global change sat squarely at the intersection of the IPBES and IPCC communities. Bob made major contributions to both, serving, for example, as Co-Chair of the IPBES Land degradation and Restoration Assessment (2018), and as an Author in the Third, Fourth and Fifth Assessment Reports of IPCC.

Bob was a colleague and a friend to many of the authors of this report. They all feel privileged for having been part, one last time, of the enormous legacy that Bob leaves behind, and will keep the memory of a world class scientist, and of a passionate admirer and lover of Nature.

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NB: The **Synopsis** presents the main conclusions of the workshop. In addition, a longer **Scientific Outcome** was prepared by participants including seven sections, a list of references and a glossary, and is posted here: https://ipbes.net/events/ipbes-ipcc-workshop

Preface

Climate change and biodiversity loss are two of the most pressing issues of the Anthropocene. While there is recognition in both scientific and policy-making circles that the two are interconnected, in practice they are largely addressed in their own domains. The research community dedicated to investigating the climate system is somewhat, but not completely, distinct from that which studies biodiversity. Each issue has its own international Convention (the UN Framework Convention on Climate Change and the Convention on Biological Diversity), and each has an intergovernmental body which assesses available knowledge (the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES)). This functional separation creates a risk of incompletely identifying, understanding and dealing with the connections between the two. In the worst case it may lead to taking actions that inadvertently prevent the solution of one or the other, or both issues. It is the nature of complex systems that they have unexpected outcomes and thresholds, but also that the individual parts cannot be managed in isolation from one another. The joint IPBES-IPCC workshop set out to explore these complex and multiple connections between climate and biodiversity. This workshop and its report represent the first ever joint collaboration between the two intergovernmental bodies and therefore a landmark activity in both of their histories.

The scientific community has been working for some time on the synergies and trade-offs between climate and biodiversity. Examples of a synergy include an action taken to protect biodiversity that simultaneously contributes to the mitigation of climate change; or an action increasing the capacity of species or ecosystems to adapt to those climate changes that cannot be avoided. In contrast, negative trade-offs can result, for instance, if an action taken to mitigate climate change by using the land or ocean to absorb greenhouse gases results in loss of biodiversity or the supply of other nature-linked benefits that flow from the affected ecosystems. Only by considering climate and biodiversity as parts of the same complex problem, which also includes the actions and motivations and aspirations of people, can solutions be developed that avoid maladaptation and maximize the beneficial outcomes. Seeking such solutions is important if society wants to protect development gains and expedite the move towards a more sustainable, healthy and equitable world for all. The role of science in addressing the current pandemic illustrates how science can inform policy and society for identifying possible solutions.

As members of the scientific steering committee, we are proud to have contributed to this first ever collaboration between IPCC and IPBES. Our first task was to select from our respective communities a diverse and world-class set of leading experts from around the world, and to then guide their work. It has been challenging to complete this process during the COVID-19 pandemic, and timelines were moved and revisited many times. What was originally going to be a physical workshop in May 2020 hosted by the United Kingdom with co-sponsorship from Norway, ended up being a workshop held on-line in December 2020. The experts have adjusted remarkably well to these changes and, to compensate for the inability to meet in person, have dedicated much time and effort to this project, and held vigorous and challenging remote discussions with one another, ahead and during the workshop and to prepare the workshop report and associated scientific outcome.

As explained in the disclaimer on the first page of this document, this is a workshop report, not an assessment. It is nevertheless a scientific document, which has been subject to peer-review by 24 external experts selected by the scientific steering committee of the workshop, providing an objective representation, synthesis and explanation of the published body of work. While being a workshop report and as such not fully comprehensive, the report summarizes the emerging state of knowledge to inform decision-making and helps to point the way towards solutions for society and also for scientific research by identifying knowledge gaps to be filled.

Our hope is that this co-sponsored workshop report and the associated scientific outcome will provide an important input into ongoing and future assessments by both IPCC and IPBES, and be of relevance to discussions held in the context of COP 15 of CBD and COP 26 of UNFCCC both, in principle, held in 2021. Connecting the climate and biodiversity spheres is especially crucial at this moment when the world seems to be gearing up for stronger actions on both. Urgent, timely and targeted actions can minimize detrimental trends and counteract escalating risks while avoiding costly and effort-sapping errors. Humankind has no time to lose and we hope that this report will inform such urgent actions toward “The Future We Want”.

Scientific steering committee for the IPCC-IPBES co-sponsored workshop:

Hans-Otto Pörtner and Robert Scholes, Co-Chairs

Edvin Aldrian, Sandra Díaz, Markus Fischer, Shizuka Hashimoto, Sandra Lavorel, Camille Parmesan, Ramon Pichs-Madruga, Debra Roberts, Alex Rogers, Ning Wu

Introduction

The Plenary of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), at its 7th session held in April/May 2019, adopted a new work programme up to 2030 and agreed to the preparation of a technical paper on biodiversity and climate change, based on the material referred to or contained in the assessment reports of IPBES and, on an exceptional basis, the assessment reports of the Intergovernmental Panel on Climate Change (IPCC), with a view to informing, inter alia, the Conference of the Parties to the Convention on Biological Diversity at its fifteenth meeting and the Conference of the Parties to the United Nations Framework Convention on Climate Change at its twenty-sixth session.

To that end, the Plenary of IPBES requested the Executive Secretary of IPBES to explore, with the secretariat of IPCC, possible joint activities relating to biodiversity and climate change, including the possibility of jointly preparing the technical paper mentioned above.

Following informal consultations, the option of a co-sponsored workshop with the Intergovernmental Panel on Climate Change (IPCC) emerged as a possible option.

The Bureau agreed to task Working Group II to engage with the IPBES secretariat to investigate the proposal further in terms of time and the type of scientific emphasis. Working Group II Co-Chairs in consultation with other Working Groups were requested to proceed with the preparations and present a plan to the IPCC Executive Committee. The concept note which sets out, among others, the objectives, outcomes, focus, timeline, and information about the scientific steering committee of the co-sponsored workshop was presented to the 52nd Session of IPCC for its information as document IPCC-LII/INF.7.

The workshop report will contribute to the scoping of and feed into the IPBES assessment of the interlinkages among biodiversity, water, food, health, in the context of climate change, and feed into the IPCC's Sixth Assessment Report (AR6) and Synthesis Reports.

Objectives

The objectives of the workshop, in accordance with the concept note for this workshop, are as follows:

In the light of the urgency of bringing biodiversity to the forefront of discussions regarding land- and ocean-based climate mitigation and adaptation strategies, this IPCC and IPBES co-sponsored workshop addresses synergies and trade-offs between biodiversity protection and climate change mitigation and adaptation. This includes exploring the impact of climate change on biodiversity, the capacity and limits to the capacity of species to adapt to climate change, the resilience of ecosystems under climate change considering thresholds to irreversible change, and the contribution of ecosystems to climate feedbacks and mitigation, against the background of an ongoing loss in the biomass of biota and associated risks to key species and biodiversity as well as ecosystem services (nature's contribution to people). The workshop report will provide information relevant to the implementation of the Paris Agreement, the Post-2020 Global Biodiversity Framework and the Sustainable Development Goals.

Focus of the workshop

The workshop aimed to provide an overview of the relationships between biodiversity and climate change including:

(a) The impacts and risks of plausible future changes in climate (e.g., on different time horizons and for different warming levels such as 1.5°C, 2°C, 3°C and 4°C compared to pre-industrial, considering non-linearities and associated thresholds for irreversible changes in the climate system and in ecosystems) for terrestrial, freshwater and marine biodiversity, nature's contributions to people and quality of life;

(b) The feedbacks of plausible changes in biodiversity on climate characteristics and change;

(c) Building on scientific as well as indigenous and local knowledge, the workshop then focused on opportunities to meet both climate change and biodiversity related objectives, and on the risks of considering these two issues separately, including:

(d) The opportunities, challenges and risks of climate change mitigation and adaptation options (e.g., bioenergy and carbon capture and storage and large-scale afforestation, reforestation and ecosystem restoration) for biodiversity, nature's contributions to people, and the quality of life;

(e) The impact of biodiversity conservation and sustainable-use practices on greenhouse gas emissions (i.e., climate feedbacks);

(f) An evaluation of the synergies, trade-offs and effectiveness of policies and governance structures that simultaneously address climate change and biodiversity loss at all scales, including in urban areas;

(g) Key scientific uncertainties.

Process

In light of the procedures for co-sponsored workshops (similar for both IPCC and IPBES), and taking into account delays due to the pandemic, the following steps were taken:

- A twelve-people scientific steering committee (SSC) was assembled, with six selected by IPBES, and six by IPCC.

- The SSC proposed an outline for an associated scientific outcome, consisting of seven sections, selected a group of 50 experts, taking into account gender, geographical and disciplinary balances, with 25 selected by IPCC, and 25 from IPBES. The SSC allocated these experts to the 7 sections, with each section having half of its experts from IPBES, and half from IPCC.

- To address the challenges posed by the pandemic, and in order to fully exploit the reduced number of hours available for a virtual workshop compared to a normal workshop, the Co-Chairs of the SSC oversaw a preparatory process, ahead of the workshop consisting of a series of teleconferences to start discussing the content of each section of the scientific outcome, drafting bullet points and some text for these bullet points. All selected participants took place in this preparatory process.

- The workshop, initially planned to take place in May 2020, hosted by the UK, with co-sponsorship from Norway, took place virtually 14-17 December 2020. The agenda is reproduced below. The workshop was opened by officials representing these two countries, followed by the Chairs of IPCC and of IPBES.

- Following the virtual workshop, experts worked virtually to finalize the texts of the respective sections of the associated scientific outcome and conducted an internal review across sections.

- The workshop report was peer reviewed during a three-week period, between 9 and 30 April 2021, by a group of 24 reviewers selected by the SSC, with half coming from the IPBES community and half from the IPCC community, and taking into account gender, geographical and disciplinary balances. The list of peer reviewers is reproduced in appendix 1 to this report.

- The workshop report was revised and finalized by the experts, under the guidance of the SSC, and released.

- Technical support to the co-sponsored workshop was provided by the IPBES secretariat, in collaboration with the technical support unit of IPCC Working Group II, and with the IPCC secretariat.

Agenda

14 DECEMBER 2020	
12:30–13:00	**OPENING SEGMENT**
	OPENING REMARKS BY CO-HOSTS OF THE WORKSHOP: – **Rt Hon Lord Goldsmith**, *Minister of State for Pacific and the Environment, Department for Environment, Food and Rural Affairs and Foreign, Commonwealth and Development Office, UK* – **State Secretary Holsen**, *Ministry for Climate and Environment, Norway* **WELCOME BY CO-SPONSORS OF THE WORKSHOP:** – **Anne Larigauderie**, *Executive Secretary IPBES, on behalf of* **Ana María Hernández Salgar**, *Chair of IPBES* – **Hoesung Lee**, *Chair of IPCC* **INTRODUCTION BY CO-CHAIRS OF THE WORKSHOP:** – **Hans-Otto Pörtner**, *Co-Chair IPCC Working Group II, Alfred-Wegener-Institute, Germany* – **Robert Scholes**, *Co-Chair IPBES Assessment of Land Degradation and Restoration, University of the Witwatersrand, Johannesburg, South Africa*
13:00–16:00	**PLENARY MEETING**
	– Presentation of draft outline for the workshop report – Discussion – Presentation of bullet points for the sections of the workshop report – Discussion – Plans for the week
15 DECEMBER 2020	
12:30–14:30	**SECTION 2** **(with Section 1 experts)**
	Section 2: Biodiversity conservation in light of a changing climate. This section focuses on how anthropogenic climate change has impacted biodiversity and is changing the goal posts for successful conservation into the future. – Discussion on content – Plans to complete section 2 draft – Figures options for section 2
14:30–15:30	**SECTION 1**
	Section 1: Climate and biodiversity are inextricably connected with each other and with human futures. This section explores the fundamental intertwining of biodiversity and climate and its impacts on people's quality of life, and makes a case for why considering climate and biodiversity policies jointly would help meet the challenge of achieving a good quality of life for all. – Discussion on content including alignment with other sections – Plans to complete section 1 draft – Figure options for section 1
18:00–20:00	**SECTION 6** **(with Section 1 experts)**
	Section 6: Interactions, limits, and thresholds at the interface of biodiversity, climate, and society. This section aims to help policy makers identify and analyze the interactions among actions implemented to address biodiversity, climate mitigation and adaptation, and good quality of life. – Discussion on content – Plans to complete section 6 draft – Figure options for section 6
20:00–22:00	**SECTION 6 AND 7** **(with Section 1, 3 and 5 experts)**
	– Discussion on possible overlaps in content between sections – Plans to complete drafts of sections 6 and 7 – Figure options including any joint figures or tables

16 DECEMBER 2020	
9:30–11:30	**SECTION 5 (with Section 1 and 3 experts)**
	Section 5: The effects of biodiversity conservation actions on climate change. This section focuses on the effects of actions to halt or reverse biodiversity loss on the climate system and, in particular, the relationships between conservation actions and climate change mitigation. – Discussion on content – Plans to complete section 5 draft – Figure options for section 5
12:30–14:30	**SECTION 3 (with Section 1 and 5 experts)**
	Section 3: The effects of climate mitigation actions on biodiversity. This section examines climate change mitigation actions harmful to biodiversity outcomes as well as actions that benefit both climate and biodiversity, and then explores these in the context of the Paris Agreement and the CBD Post-2020 Global Biodiversity Framework. – Discussion on content – Plans to complete section 5 draft – Figure options for section 5
14:30–15:30	**SECTION 3, 4, 5 (with Section 1 and 7 experts)**
	– Discussion on overlaps and content between sections – Plans to complete drafts of sections 3, 4 and 5 – Figure options including any joint figures or tables
18:00–20:00	**SECTION 4 (with Section 1 experts)**
	Section 4: Biodiversity and adaptation to climate change. This section highlights the capacity and limits of socio-ecological systems to adapt to climate change, examines the role of biodiversity in contributing to adaptation, and evaluates the impacts of a wide range of climate change adaptation measures on biodiversity. – Discussion on content – Plans to complete the first draft of the workshop report – Figure options for section 4
17 DECEMBER 2020	
9:30–11:30	**SECTION 7 (with Section 1 and 6 experts)**
	Section 7: Solutions at the climate-biodiversity-society nexus. This closing section examines the possibilities for integrated solutions that tackle multiple crises and delineates what these solutions might look like for the future of governance and policy options required at the climate-biodiversity nexus. – Discussion on content for section 7, and links with sections 1 and 6 – Plans to complete section 7 draft – Figure options for section 7
13:00–16:00	**PLENARY MEETING**
	– Presentation by sections (sections experts) – Draft synopsis of the workshop report: presentation of suggestions by Co-Chairs and scientific steering committee – Discussion – Wrap up, timelines and milestones

List of participants

Opening segment participants:

Rt Hon Lord Zac Goldsmith
Minister of State for Pacific and the Environment at the Department for Environment,
Food and Rural Affairs and the Foreign, Commonwealth and Development Office,
United Kingdom

Maren Holsen
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Ministry for Climate and Environment,
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Ana María Hernández Salgar
Chair of IPBES

Hoesung Lee
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Scientific steering committee:

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Co-Chair IPBES Assessment of Land Degradation and Restoration,
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Lysaker, Norway

Sandra Díaz
Co-Chair of the IPBES Global Assessment of Biodiversity and Ecosystem Services,
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Markus Fischer
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co-Chair of the IPBES Regional Assessment of Biodiversity and Ecosystem Services for Europe and Central Asia,
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Shizuka Hashimoto
Member of the IPBES MEP,
University of Tokyo,
Japan

Sandra Lavorel
Member of the IPBES MEP, French National Centre for Scientific Research, France, and Manaaki Whenua Landcare Research, New Zealand

Ning Wu
Member of the IPBES MEP,
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Selected workshop participants:

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Atmospheric Environmental Research

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British Antarctic Survey

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Christopher Trisos
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Adalberto Luis Val
Brazilian National Institute for Research of the Amazon

Jianguo Wu
Chinese Research Academy of Environmental Sciences

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IPBES Bureau (Vice Chair, Western Europe and Others Group)

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IPCC Bureau (Co-Chair Working Group I)

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IPCC Bureau (Vice Chair, South America)

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Katja Mintenbeck
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SY


YNOPSIS

IPBES-IPCC CO-SPONSORED WORKSHOP

BIODIVERSITY AND CLIMATE CHANGE SYNOPSIS

This workshop report is placed in the context of recent international agreements including the Paris Agreement, the Strategic Plan for Biodiversity 2011–2020 and on-going preparation for the Post-2020 Global Biodiversity Framework, the Sendai Framework for Disaster Risk Reduction and the 2030 Agenda for Sustainable Development that converge on solving the dual crises of climate change and biodiversity loss as essential to support human well-being. Simultaneously meeting these agreements relies on immediate and sustained efforts for transformative change which encompass technological and environmental policies as well as changes to economic structures and profound shifts in society. Climate change impacts and biodiversity loss are two of the most important challenges and risks for human societies; at the same time climate and biodiversity are intertwined through mechanistic links and feedbacks. Climate change exacerbates risks to biodiversity and natural and managed habitats; at the same time, natural and managed ecosystems and their biodiversity play a key role in the fluxes of greenhouse gases, as well as in supporting climate adaptation. The absorption of more than 50% of anthropogenic CO_2 emissions through photosynthesis and consequent carbon storage in biomass and organic material, as well as through CO_2 dissolution in ocean water, already reduces global climate change naturally (but causes ocean acidification). However, nature's contributions to attenuating climate change, partly provided by the underpinning biodiversity, are at risk from ecosystem degradation resulting from progressive climate change and human activities. In fact, ecosystem degradation through land-use changes and other impacts on natural carbon stocks and sequestration is a major contributor to cumulative CO_2 emissions, and, therefore, an additional driver of climate change. The ambitious implementation of land- and ocean-based actions to protect, sustainably manage and restore ecosystems have co-benefits for climate mitigation, climate adaptation and biodiversity objectives and can help to contain temperature rise within the limits envisaged by the Paris Agreement, provided that such actions support, and are not in lieu of, ambitious reductions of emissions from fossil fuels and land use change. In this broad context, the workshop explored diverse facets of the interaction between climate and biodiversity, from current trends to the role and implementation of nature-based solutions and the sustainable development of human society. A synopsis of the conclusions of the workshop is presented below:

Limiting global warming to ensure a habitable climate and protecting biodiversity are mutually supporting goals, and their achievement is essential for sustainably and equitably providing benefits to people.

1 **Increasing energy consumption, overexploitation of natural resources and unprecedented transformation of land-, freshwater- and seascapes[1] over the past 150 years have paralleled technological advances and supported better living standards for many but have also led to changes in climate and the accelerating decline of biological diversity worldwide, both negatively impacting many aspects of good quality of life**. A sustainable society requires both a stabilized climate and healthy ecosystems. However, 77% of land (excluding Antarctica) and 87% of the area of the ocean have been modified by the direct effects of human activities. These changes are associated with the loss of 83% of wild mammal biomass, and half that of plants. Livestock and humans now account for nearly 96% of all mammal biomass on Earth, and more species are threatened with extinction than ever before in human history. Climate change increasingly interacts with these processes. Anthropogenic release of greenhouse gases from fossil fuel combustion, industry, Agriculture, Forestry and Other Land Use (AFOLU), now overall exceeding 55 $GtCO_2e\,yr^{-1}$, continues to rise and

1. Extrapolating from the term landscape the term 'scape' is used in this report to represent the area and structural characteristics of terrestrial, marine and freshwater environments (land-, sea-, freshwaterscape), see glossary.

has already led to global warming above 1°C relative to pre-industrial times[2]. Climate change and biodiversity loss pose significant threats for human livelihoods, food security and public health, and such negative impacts are disproportionately felt by communities that are socially, politically, geographically and/or economically marginalized.

2 **The mutual reinforcing of climate change and biodiversity loss means that satisfactorily resolving either issue requires consideration of the other**. Climate change and biodiversity loss are closely interconnected and share common drivers through human activities. Both have predominantly negative impacts on human well-being and quality of life. Increased atmospheric greenhouse gas concentrations lead to increased mean temperatures, altered precipitation regimes, increased frequency of extreme weather events, and oxygen depletion and acidification of aquatic environments, most of which adversely affect biodiversity. Reciprocally, changes in biodiversity affect the climate system, especially through their impacts on the nitrogen, carbon and water cycles. These interactions can generate complex feedbacks between climate, biodiversity and humans that may produce more pronounced and less predictable outcomes. Ignoring the inseparable nature of climate, biodiversity, and human quality of life will result in non-optimal solutions to either crisis.

3 **Previous policies have largely tackled the problems of climate change and biodiversity loss independently. Policies that simultaneously address synergies between mitigating biodiversity loss and climate change, while also considering their societal impacts, offer the opportunity to maximize co-benefits and help meet development aspirations for all**. At the international level, greater synergies across multilateral environmental agreements such as the UN Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD) as well as with the Sustainable Development Goals could facilitate simultaneously halting global biodiversity loss and mitigating climate change. Cross-cutting issues, intersectoral policies and regulatory frameworks are areas where strong synergies could contribute to the transformative societal change that is needed to achieve ambitious goals for biodiversity, climate mitigation and good quality of life.

2. Carbon dioxide equivalent (CO_2e): A way to place emissions of various radiative forcing agents on a common footing by accounting for their effect on climate. It describes, for a given mixture and amount of greenhouse gases, the amount of CO_2 that would have the same global warming ability, when measured over a specified time period. (UNEP, 2020, see glossary). According to IPCC (2019) Agriculture, Forestry and Other Land Use (AFOLU) activities accounted for around 13% of CO_2, 44% of methane (CH_4), and 81% of nitrous oxide (N_2O) emissions from human activities globally during 2007-2016, representing 23% (12.0 ± 2.9 $GtCO_2e$ yr-1) of total net anthropogenic emissions of greenhouse gases during this period. The natural response of land to human-induced environmental change caused a net sink of around 11.2 $GtCO_2$ yr-1 during 2007–2016 (equivalent to 29% of total CO_2 emissions).

4 **As climate change progresses, the distribution, functioning and interactions of organisms, and thus ecosystems, are increasingly altered**. Ecosystems and species with restricted distributions, those close to their tolerance limits, or with limited ability to disperse and establish themselves in new habitats, are especially vulnerable to climate change. Extinction risks are highest on island-like biodiversity hotspots such as mountains, islands, coral reefs and coastal embayments, or fragments of formerly more extensive habitats, now separated by altered land-, freshwater- and seascapes less supportive of biodiversity. Human-caused climate change is becoming increasingly dominant as a direct threat to nature, and its contributions to people. Biodiversity loss disproportionately impacts those communities and societal groups that are most directly dependent on nature.

5 **The adaptive capacity of most ecosystems and social-ecological systems will be exceeded by unabated anthropogenic climate change, and significant adaptive capacity will be required to cope with residual climate change even under ambitious emissions reduction**. Tropical coral reefs (high sensitivity to present warming and ocean acidification), savannas (vegetation shifts due to increasing atmospheric CO_2), tropical forests (vegetation shifts due mainly to drying), high latitude and altitude ecosystems and Mediterranean-climate ecosystems (high vulnerability to the high levels of ongoing and projected climate warming), and coastal ecosystems (exposed to multiple factors) are among the most vulnerable ecosystems of the world, are already highly impacted, and require robust intervention to maintain and enhance their adaptive capacity. Actions to enhance the adaptive capacity of ecosystems are placed at risk by unabated climate change exceeding adaptation limits – highlighting the importance of keeping climate warming well below 2°C – and by high levels of other pressures, such as land use change, overexploitation or pollution.

6 **In a world increasingly affected by climate change, maintaining biodiversity relies on enhanced and well-targeted conservation efforts, coordinated with and supported by strong adaptation and innovation efforts.** Pressure on biodiversity is increasing as a result of multiplying, diversifying and interacting threats. These ultimately derive from the growing societal and economic demands on nature, driven by high levels of energy and material consumption, especially in wealthy countries, and will therefore continue to accelerate unless explicitly addressed, while allowing for more equitable outcomes in terms of a good quality of life. Global biodiversity targets set for 2020 (the Aichi Biodiversity Targets) were not met, increasing the urgency for biodiversity conservation to rapidly expand in ambition and scope.

7 **Biodiversity conservation approaches such as Protected Areas have been essential for successes to date, but, on aggregate, have been insufficient to stem the loss of biodiversity at a global scale.** The insufficiency is partly due to the inadequate fraction of the globe under protection, currently at about 15% of land and 7.5% of the ocean, but also because protective measures have been, in certain cases, poorly designed and/or insufficiently applied and enforced. Not only are protected areas too small on aggregate (and often individually), but they are also frequently sub-optimally distributed and interconnected, inadequately resourced and managed, and at risk of downgrading, downsizing, and degazettement. Ecological functionality outside of protected areas is also currently insufficient to adequately support either humans or nature in the future. Climate refugia, migration corridors, mobile conservation actions, adoption of Other Effective Area-Based Conservation Measures (OECMs) outside of protected areas, and planning for shifting climate belts will be essential components of future conservation approaches. Substantial upscaling of the strength of commitment and of resources, both technical and financial, is essential when developing, enabling and implementing conservation strategies to meet the challenges of the 21st century.

8 **A new conservation paradigm would address the simultaneous objectives of a habitable climate, self-sustaining biodiversity, and a good quality of life for all.** New approaches would include both innovation, as well as the adaptation and upscaling of existing approaches. For example, the search for viable multiple-benefit interventions focuses conservation on multifunctional 'scapes (which include land, freshwater and ocean scapes), rather than solely on a few of nature's component elements independently, such as critical or intact habitats or iconic species. The 'scape approach integrates functionally intact biodiversity with provisioning of material, non-material and regulatory benefits, from local to larger scales, linking 'sharing' and 'sparing' concepts. It includes networks of protected areas and corridors, 'working' or 'managed' 'scapes modified for human use, and profoundly transformed ecosystems, such as urban and intensively farmed areas. For these new approaches to be successful and sustainable, equitably planned and iterative participation of affected local communities and residents in their design and implementation will be essential in order to root solutions in local economies, needs, livelihoods and politics.

9 **The area of intact and effectively protected land and ocean required to meet the three objectives of a habitable climate, self-sustaining biodiversity, and a good quality of life is as yet not well established.** This area likely varies spatially, among biomes and with local contexts, but is substantially larger than at present, with global estimates ranging from 30% to 50% of both land and ocean surface areas. Sufficient intact habitat in critical carbon-rich ecosystems would provide substantial benefits for climate mitigation, but novel and inclusive approaches will be necessary to avoid potential risks to food security and to assure other benefit flows from nature. Maintaining or restoring 20% of native habitat in 'scapes inhabited/altered by humans may provide such opportunities, thus contributing to global climate and biodiversity targets, while also generating multiple benefits, through nature-based solutions and other ecosystem-based approaches.

Several land- and ocean-based actions to protect, sustainably manage and restore ecosystems have co-benefits for climate mitigation, climate adaptation and biodiversity objectives.

10 **Actions to protect, sustainably manage and restore natural and modified ecosystems that address societal challenges such as climate mitigation and adaptation are often referred to as nature-based solutions. Nature-based solutions (NbS)[3] can play an important role in climate mitigation, but the extent is debated, and they can only be effective with ambitious reductions in all human-caused greenhouse gas emissions. Nature-based solutions can be most effective when planned for longevity and not narrowly focussed on rapid carbon sequestration.** Estimates of potential contributions of nature-based solutions to climate mitigation vary widely and some proposed actions such as large-scale afforestation or bioenergy plantations may violate an important tenet of nature-based solutions – namely that they should simultaneously provide human well-being and biodiversity benefits. Ecosystems can aid climate change mitigation over time, but only when complementing rapid emissions reductions in energy production, transportation, agriculture, building and industrial sectors to meet the Paris Agreement's commitment to keeping climate change well below 2°C. In addition, failing to substantially reduce emissions from these sectors is projected to increase the climate-related risks for natural systems and reduce or limit

3. There is a variety of definitions of "nature-based solutions". This workshop report uses the IUCN (2016) definition: "Nature-based solutions are actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits." www.iucn.org/theme/nature-based-solutions. The definition encompasses the definition of ecosystem-based adaptation, "the use of ecosystem management activities to increase the resilience and reduce the vulnerability of people and ecosystems to climate change". It should be noted that the term "nature-based solutions" is not universally accepted in international policy (for example "ecosystem-based approaches" is the agreed upon term for these types of measures in the Convention on Biological Diversity), and that scientists have expressed concern about its use, among other reasons, because the term is sometimes used to refer to measures that have negative impacts on biodiversity and good quality of life.

their ability to contribute to climate change mitigation via nature-based solutions.

11 Implementing nature-based solutions also creates co-benefits for adaptation to climate change, for nature and its contributions to people. By enhancing ecosystem adaptive capacity nature-based solutions can also reduce exacerbation of climate change driven by ecosystem changes. In this context, protecting and restoring biodiversity plays an important role because higher genetic, species and ecosystem diversities help to reduce risk in the face of uncertain changes in climate and keep adaptation options open. Cost effectiveness and societal desirability of actions to increase adaptive capacity by implementing nature-based solutions vary in time and space, and there are examples of both lose-lose and win-win outcomes for biodiversity and climate.

12 Avoiding and reversing the loss and degradation of carbon- and species-rich ecosystems on land and in the ocean is of highest importance for combined biodiversity protection and climate change mitigation actions with large adaptation co-benefits. Significant reductions in the destruction and degradation of forest ecosystems; non-forest terrestrial ecosystems such as wetlands and peatlands, grasslands and savannas; and coastal ecosystems such as mangroves, salt marshes, kelp forests, seagrass meadows and deep water and polar blue carbon habitats can reduce greenhouse gas emissions from land- and sea-use change and maintain large carbon sinks if properly managed. For instance, reducing deforestation and forest degradation can contribute to lowering annual anthropogenic greenhouse gas emissions, with emission-saving estimates ranging from 0.4–5.8 $GtCO_2e\ yr^{-1}$. On a per area basis some ecosystems are even more important carbon sinks than forests; for example, mangroves may sequester four times more carbon than rainforest per unit area. Destruction and degradation are also the most important drivers of biodiversity loss in terrestrial and freshwater ecosystems and the second most important drivers of biodiversity loss in marine ecosystems. Substantial co-benefits with biodiversity are realizable by reversing destruction and degradation of natural ecosystems – building on ambitious reductions in fossil fuel emissions as a precondition – with adaptive co-benefits to people. For example, coastal wetlands and coral reefs provide coastal protection from storm surges and rising sea level, while wetlands help reduce flooding.

13 Restoring carbon- and species-rich ecosystems on land and in the ocean is also highly effective for both climate change mitigation and biodiversity, with large adaptation co-benefits. Ecosystem restoration provides opportunities for co-benefits for climate change mitigation and biodiversity conservation, which are maximized if restoration occurs in priority areas for both goals. Restoration is among the cheapest and rapidly implemented nature-based climate mitigation measures. Ecosystem restoration also enhances resilience of biodiversity in the face of climate change and provides multiple nature´s contributions to people such as regulating floods, enhancing water quality, reducing soil erosion and ensuring pollination. Ecosystem restoration can also provide multiple social benefits such as creation of jobs and income, especially if implemented taking into consideration the needs and access rights of indigenous peoples and local communities. Restoration with a variety of native species ensures ecosystem resilience in the face of climate change and has benefits for biodiversity, but also relies on novel species assemblages to match future climatic conditions.

14 Sustainable agricultural and forestry practices can improve adaptive capacity, enhance biodiversity, increase carbon storage in farmland and forest soils and vegetation, and reduce greenhouse gas emissions. Globally, it has been estimated that the food system is responsible for 21-37% of total net anthropogenic greenhouse gas emissions when including pre- and post-production activities. Measures such as the diversification of planted crop and forest species, agroforestry and agroecology enhance biodiversity and nature's contributions to people in landscapes focused on the production of food, feed, fibre, or energy. These measures can also reduce climate-induced losses of food or timber production by increasing adaptive capacity. This increased adaptive capacity is especially important in view of extreme events such as heatwaves, droughts, fires, insect, pest and disease outbreaks, which are expected to become more frequent and severe under climate change. Improved management of cropland and grazing systems such as soil conservation and reduction of fertilizer input is estimated to provide climate change mitigation potential of >3 to >6 $GtCO_2e\ yr^{-1}$. In forests, a potential to mitigate 0.4–2.1 $GtCO_2e\ yr^{-1}$ has been estimated through preserving and enhancing carbon stocks via sustainable management. Agricultural intensification can free land for biodiversity conservation by increasing productivity per unit of agricultural area (i.e., land sparing), but if not done sustainably the detrimental effects of intensification on the environment can outweigh the benefits of land sparing. The climate and biodiversity co-benefits of measures targeting production of food, feed, fibre or energy can be greatly enhanced by demand-side measures such as reduced loss and waste and dietary shifts, especially in rich countries, toward more plant-based diets.

15 The creation of green infrastructure in cities is increasingly being used for climate change adaptation and restoration of biodiversity with climate mitigation co-benefits. Urban greening, including the creation of urban parks, green roofs and urban gardens, reduces urban heat island effects, enhances urban biodiversity and improves quality of life including physical and mental well-being. Carbon sequestration and storage in urban trees and gardens vary considerably between cities and location. Urban gardens can provide important supplements to urban dweller's food supply. These measures are particularly important in light of the rapidly growing urban population.

16 **In both land and marine systems, options exist to combine nature-based and technology-based measures for climate change mitigation and adaptation, while contributing to biodiversity.** The combination of nature-based and technology-based climate change solutions on land and at sea is in its infancy but may provide co-benefits for climate mitigation, adaptation and biodiversity co-benefits. For example, grazing underneath solar panels can enhance soil carbon stocks, and grazing as well as cropping associated with solar farms could provide food. Studies also indicate that vegetation underneath the solar panels can provide pollinator habitat thereby benefiting nearby agricultural land. Solar photovoltaic cells supported on the surface of water bodies might reduce evaporation from the water bodies which could be beneficial to hydroelectric reservoirs in arid regions, but floating photovoltaics will also impact the water body's physical, chemical and biological properties, which should be considered when assessing their sustainability. Offshore wind in combination with hydrogen generation can be powerful for mitigation if negative impacts on migrating (e.g., bird) species can be minimized. Offshore turbines have also been found to create artificial reefs, with beneficial effects on marine biodiversity.

Measures narrowly focused on climate mitigation and adaptation can have direct and indirect negative impacts on nature and nature's contributions to people.

17 **Actions undertaken for climate change mitigation by enhancing ecosystem carbon sinks through biomass, planting large areas of forests or crops for biomass energy, may have other important consequences for the climate system.** It is important that the full climate consequences of land-based climate mitigation actions, in both the short and long-term are considered when evaluating their contribution. These consequences include effects mediated by changes in non-CO_2 greenhouse gas emissions, reflectivity of the surface to solar radiation (albedo), evapotranspiration, and the concentration of aerosols in the atmosphere, as well as indirect land-use change arising from large forest-area or bioenergy cropland expansion. These effects may either reinforce or counteract climate change mitigation depending on the details of the action taken, its geographic location and period over which it is implemented. There is currently a lack of formal recognition of many of these effects in UNFCCC mitigation project guidelines, compromising the full quantification of mitigation effectiveness.

18 **Planting bioenergy crops (including trees, perennial grasses or annual crops) in monocultures over a very large share of total land area is detrimental to ecosystems, reduces supply of many other nature's contributions to people and impedes achievement of numerous Sustainable Development Goals.** Negative impacts typically arise from competition for space — including displacement of other land uses locally or through indirect land-use change elsewhere, with associated carbon and biodiversity losses. Given the need to combat hunger and to feed a growing human population, scenarios that project annual bioenergy CO_2 uptake rates by 2050 (including carbon capture and storage) equivalent in magnitude to today's existing carbon sink in all land ecosystems exceed limits to the sustainable deployment of land-based mitigation measures, given the land area (which may exceed 1.5 times the size of India) required to do so. Intensive bioenergy crop production can negatively affect biodiversity and ecosystem services, including in adjacent land, freshwater and marine ecosystems through fertilizer and pesticide use or by increasing agricultural water withdrawals, thus also impacting on human capacity to adapt to climate change. When considering a range of sustainability criteria (including restricting bioenergy crops to 'marginal' land and/or excluding expansion into currently protected areas), studies suggest bioenergy deployment potentials between ca. 50 and 90 EJ yr^{-1} (compared to today's total global primary energy production of ca. 600 EJ yr^{-1}), equivalent to approximately 1-2.5 Gt CO_2 yr^{-1} in terms of mitigation potential. As part of a climate change mitigation portfolio, alongside pronounced and rapid reductions in fossil-fuel emissions, these levels of deployment of dedicated bioenergy crops for electricity production or fuels may provide co-benefits for adaptation and biodiversity**.**

19 **Afforestation, which involves planting trees in ecosystems that have not historically been forests, and reforestation with monocultures, especially with exotic tree species, can contribute to climate change mitigation but are often detrimental to biodiversity and do not have clear benefits for adaptation.** Large-scale tree planting can be harmful to biodiversity and food production due to competition for land. This can lead to displacement effects (indirect land use change) either within a region, or the land use forests replace is moved to other areas. Afforestation in particular may even reduce existing ecosystem carbon storage, cause further biodiversity loss and displace local people or curtail their access to land and its use. Single species plantations can increase pests and disease. Plantations of exotic species often have negative

impacts on biodiversity, on adaptive capacity and on many nature's contributions to people not related to timber production or carbon sequestration, especially if the planted species becomes invasive. Further, their climate benefits may be offset by local warming, especially in boreal and temperate regions, which is induced by different exchanges of water and energy compared to the land cover which it replaces. Recent claims of massive areas available for forest area expansion and associated large carbon uptake potentials are likely incorrect, and greatly exaggerate what is ecologically and socially achievable. Current scenarios used by the IPCC do not differentiate between natural forest regrowth, reforestation with plantations, and afforestation of land not previously tree-covered, which makes assessment of biodiversity impacts difficult and is a knowledge gap that needs to be addressed.

20 **Technology-based measures that are effective for climate change mitigation can pose serious threats to biodiversity.** They should be evaluated in terms of their overall benefits and risks. Renewable energies in the transport and energy sector are important options for mitigating climate change but currently rely on mining for minerals on land and in the ocean, for example rare-earth metals used in wind turbines, electric car motors and batteries, and may not have clean mechanisms for disposal and reuse. The large negative environmental and social impacts of land and seafloor mining could be mitigated by the development of alternative batteries and long-lived products, an efficient recycling system for mineral resources, together with mining approaches that include strong considerations for environmental as well as social sustainability. Renewable energy infrastructures such as onshore wind farms, offshore wind farms, and dams are often detrimental to biodiversity by interfering with migrating species, although much less so with modern wind turbines. Solar plants that require large land areas may lead to clearing or conversion of otherwise managed land, which can directly destroy natural habitats or increase pressure for agricultural intensification. To be holistically effective, renewable energy development will benefit from consideration of a circular economy and, ultimately, biodiversity (see also key finding 29).

21 **Technical and technological measures that are narrowly focused on climate adaptation can have large negative impacts on nature and nature's contributions to people but can also be complementary to nature-based solutions.** For example, technical measures for managing floods and droughts, such as building dams, or for protecting coasts from sea level rise, such as building sea walls, are of particular concern because they frequently have large impacts on biodiversity. Some technological measures can be of considerable benefit for biodiversity; for example, improvements in irrigation technology and water management techniques can enhance the capacity of agricultural systems to adapt to increased water stress, complement adaptive measures based on improving soil health and reduce demand for water abstraction from rivers and streams. There is an urgent need to better understand and account for the impacts of technical and technological measures and also for complementarities between nature-based solutions. Spatial shifts in human populations and activities such as agriculture and fishing as an adaptive response to climate change are also projected to have very large impacts on nature and nature's contributions to people that should be taken into account when developing adaptation strategies.

22 **Measures intended to facilitate adaptation to one aspect of climate change without considering other aspects of sustainability may in practice be maladaptive and result in unforeseen detrimental outcomes.** For example, increasing irrigation capacity is a common adaptive response for agricultural systems exposed to recent or projected increases in drought frequency and intensity. However, increased irrigation often leads to water use conflicts, dam building and long-term soil degradation from salinization. To avoid maladaptive responses, it is important to account for these unintended outcomes including when implementing nature-based solutions. It is also essential to take into account large uncertainties in projected future climate change and dynamics of socio-ecological systems. The need to address uncertainty argues in favour of approaches to climate adaptation that put a strong emphasis on risk management and strategies that can evolve over time. For example, there is high uncertainty in projections of future water stress for trees in many places due to uncertainties in precipitation, effects of rising atmospheric CO_2 concentrations on evapotranspiration and other factors, so promoting mixed species forests provides more flexibility than does planting monocultures of drought resistant tree species. Climate adaptation strategies too often focus on actions that lack flexibility if the climate projection or the projected response of the system to climate change turns out to be wrong.

23 **Where nature-based solutions are used as carbon offsets, they are most effective when applied subject to strict conditions and exclusions, and not used to delay mitigation actions in other sectors.** The concept of 'offsets' using natural climate solutions has been proposed to achieve early emissions reductions (particularly at lower cost) or to compensate for continued emissions from hard-to-decarbonize sectors; such offsets are increasingly part of 'net-zero' emissions pledges. However, the use of carbon offsets has come under increasing scrutiny because of the challenges of additionality, problems with overstated emissions reductions and double-counting, difficulty in monitoring and verification, and the unclear permanence of such actions, as well as potential social

equity impacts of actions like large-scale tree planting. Ideally, the appropriate use of offsets would raise ambitions, enhance financing for nature, and provide for the possibility of tackling residual emissions mid-century, but not create the conditions for a lack of urgency on greenhouse gas emissions reductions currently. This is particularly important given that nature-based solutions are likely less effective under increasing climate change and its impacts. Clear accounting standards applied consistently to verify any carbon offsets, as well as limits on their use, require international agreement. The inclusion of biodiversity requirements or safeguards, rather than climate mitigation targets alone, could help in defining those standards (for biodiversity 'offsets' see key finding 29).

Measures narrowly focusing on protection and restoration of biodiversity have generally important knock-on benefits for climate change mitigation, but those benefits may be sub-optimal compared to measures that account for both biodiversity and climate.

24 Protected areas are an important instrument to address biodiversity loss, with climate mitigation and adaptation co-benefits. The trend in conservation management is towards considering a continuum from areas with high levels of protection, through shared 'scapes, to highly human-dominated scapes. The implementation of appropriate mixed-use land- and seascapes through a holistic, integrated, consultative, and adaptive approach can maximize co-benefits in conserving biodiversity, mitigating climate change, and enhancing good quality of life. Optimal locations for protecting biodiversity are not necessarily fully coincident with optimal placement for land-based carbon capture, storage and sequestration, even though there is frequently a high correlation. For example, tropical rainforest and mangrove forests are two biologically diverse ecosystems that are typified by high rates of carbon sequestration.

25 Active management in conservation, such as through altering wildfire frequency or reintroducing key species can be beneficial for both biodiversity and climate mitigation and adaptation but can be antagonistic in some contexts. Reducing fuel loads with regular prescribed burning or increased thinning can reduce fire severity and maintain biodiversity in fire-dependent ecosystems, but fire suppression can strongly reduce endemic biodiversity. Reintroduction of keystone mammal species has been shown to be critical in reinstating ecosystem processes and biodiversity. Conservation management actions generally have more mutually synergistic benefits than antagonistic trade-offs with respect to climate mitigation, but there are important exceptions. For example, reversal of anthropogenic bush encroachment to maintain fire-dependent species in subtropical and tropical latitudes can have negative short-term impacts on carbon storage.

26 Achieving synergistic benefits and trade-offs between biodiversity conservation, ecosystem service enhancement and climate change mitigation is strongly dependent on which biomes, ecosystem uses, and sectoral interactions are under consideration. It may be impossible to achieve win-win synergies, or even manage the trade-offs between climate and biodiversity in every patch of a 'scape, but achieving multiple sustainable outcomes becomes progressively more feasible at the larger scale of a 'scape. This can be achieved through the use of spatial planning approaches that integrate multiple objectives with measures of spatial heterogeneity. On balance, the evidence suggests more mutually synergistic benefits than antagonistic trade-offs between conservation actions and mitigation objectives. National level reporting under UNFCCC and CBD frameworks provides a significant opportunity to align national mitigation and biodiversity goals.

27 Locally motivated biodiversity conservation actions can be incentivized, guided and prioritized by global objectives and targets, such as climate benefits. Every local initiative matters, since the benefits of many small, local biodiversity measures accumulate at the global level. For example, nature-based solutions in urban contexts can individually only make a small contribution to global mitigation and biodiversity protection but provide great benefits for local quality of life. Together, the seemingly small efforts made by cities and subnational governments to enhance biodiversity conservation and climate change mitigation can make a significant contribution. The restoration of mangroves in coastal urbanized areas is an example that fulfils multiple global biodiversity and climate objectives and enhances local nature's contributions to people. Overly simplified messages about large-scale nature-based solutions such as tree planting may risk adverse effects for biodiversity and human livelihoods when local context is not adequately considered. Eliminating subsidies that support local and national activities harmful to biodiversity can also add up to support climate change mitigation, e.g., halting deforestation, overfertilization or overfishing.

28 Changes in per capita consumption, shift in diets, and progress towards sustainable exploitation of natural resources, including reduced post-harvest waste, could make substantial contributions to addressing the biodiversity crisis, climate change mitigation and adaptation. Such demand-side measures free up land and ocean surface that can be used to protect biodiversity (e.g., reforestation, restoration of coastal habitats, protected areas) or provide climate mitigation benefits (e.g., re- and afforestation, bioenergy crops, wind farms). Large environmental and human well-being co-benefits arise, if dietary shifts have a strong focus on achieving globally larger equity in health, leading to a redistribution in consumption that reduces undernutrition as well as wasteful consumption, overweight and obesity. Demand-side choices can reduce grennhouse gas emissions globally for example through diminished demand for ruminant meat and dairy products. Changes in demand could also help to limit negative impacts of fishing on carbon-rich sea bottom vegetated habitats and sediments (trawling) and on the downward passive and active transport of carbon to the deep ocean (fish and krill biomass extraction). Globally, disturbance of previously undisturbed marine sediment carbon through trawling was estimated to release the equivalent of 15 to 20% of atmospheric CO_2 absorbed annually by the ocean. Such order of magnitude indicates a knowledge gap on ocean carbon storage capacity to be closed by further research.

29 **For biodiversity, the concept of offsets, the substitutability among a slate of possible actions, can introduce the flexibility required to achieve multiple competing objectives at regional scale, if applied subject to strict conditions and exclusions.** The concept of offsets is already widely applied to CO_2 removal measures (key finding 23), but less so for biodiversity protection. Biodiversity offsetting is the practice of mitigating the negative impacts of developments on biodiversity (e.g., mining, urban/housing development, agricultural expansion) by restoring the biodiversity, or setting aside areas for protection, elsewhere in remote sites. There are 12,983 listed biodiversity offsets implemented across 37 countries, however only one-third of biodiversity offsets demonstrably meet the "no net loss" (NNL) principle.[4] Furthermore, the trade-offs between biodiversity offsets, climate change mitigation and other nature's contributions to people have rarely been assessed. Unintended negative consequences of offsetting are likely to be avoided if the disconnects between local benefits from biodiversity, including capacities of adaptation to climate change, and nature's contributions with remote or global benefits are considered in the offsetting process along with the NNL objective. The conditions for effectiveness for biodiversity include no replaceability in biodiversity facets and action targets. Biodiversity conservation measures are specific, local, and regional, even when they contribute to global objectives such as mitigation of climate change (key finding 10). Substitution of one action for another in the biodiversity domain is more likely to be synergistic (rather than a pure compromise) if it is guided by complementarity principles.

Treating climate, biodiversity and human society as coupled systems is key to successful outcomes from policy interventions.

30 **The explicit consideration of the interactions between biodiversity, climate and society in policy decisions provides opportunities to maximize co-benefits and to minimize trade-offs and co-detrimental (mutually harmful) effects for people and nature.** The climate-biodiversity-social system is a 'nexus' most appropriately dealt with from a social-ecological systems perspective. Such an approach accounts for trade-offs, feedbacks, threshold effects and nonlinear relationships between biophysical and social variables across spatio-temporal scales. Social considerations feed into, and flow out of, the climate-biodiversity interactions. Additionally, all interventions to manage climate-biodiversity interactions pose differential effects on people's good quality of life, and these interactions have important implications for both intra- and intergenerational equity. The status quo has been for policy to show little cross-sectoral integration. However, progress in understanding the context-specific magnitude and direction of climate-biodiversity interactions, as well as their social determinants and implications, provides opportunities to consider these interactions routinely, rather than exceptionally, when making policy decisions.

31 **Under the effects of biodiversity loss and climate change, crucial (hard to reverse or irreversible) thresholds (tipping points) can be exceeded with dire consequences for people and nature, but positive social tipping interventions can help attain desirable biodiversity-climate interactions.** Surpassing thresholds can lead to changes in ecosystem function. For example, climate change can cause biophysical limits of corals to be exceeded or sea-ice ecosystems to disappear, leading to regime changes to algal-dominated communities with markedly different function. Biodiversity change and climate change can feedback on one another to alter the location of tipping points. For example, negative climate impacts on biodiversity, particularly in ecosystems that are already close to their tipping points, can diminish ecosystem function and carbon storage potential that contributes importantly to climate mitigation. Ignoring the potential for strong trade-offs between biodiversity and climate change resulting from a specific policy action further risks the surpassing of tipping

4. No Net Loss: The objective of "no net loss" policies for biodiversity are based on the aspiration to compensate for unavoidable biodiversity loss, most commonly due to impacts of infrastructure and land-use change, with balanced gains in biodiversity elsewhere, for example through ecosystem restoration or improved management practices.

points. For example, afforestation that focuses solely on replanting species with large carbon sequestration and storage potential can harm biodiversity and increase the likelihood of a change in ecosystem function. Exceeding biodiversity-climate tipping points can lead to the breaching of socially acceptable limits and thresholds, e.g., through reduced stability of crop yields that trigger food crises. However, social tipping points are not all detrimental. Positive social tipping interventions involve the rapid spreading of technologies, behaviours, social norms, and structural reorganization. Interventions with positive impacts on climate and biodiversity include the development of carbon-neutrality in cities, removal of fossil fuel subsidies, or the strengthening of climate and biodiversity education and civil society engagement in co-designing and implementing plans and strategies across sectors aiming at social-ecological resilience. Social tipping interventions can help transform social responses towards desirable biodiversity-climate interactions. The scaling up of positive social responses involves the consideration of power relations and rigidities typically inherent in political and economic decision-making contexts. The locations of tipping points are moving targets, owing partly to the interconnectedness of the climate-biodiversity-social system.

32 **When considering biodiversity-climate-society interactions, it is important to examine how the linkages between policy decisions and consequences unfold over time and how they act beyond the specific spatial context.** For example, the restoration of diverse ecosystems with high-carbon storage potential might improve biodiversity relatively quickly, while the carbon sequestration benefits might only be realized over longer time scales. Further, telecoupling properties, i.e., off-stage (distant, diffuse and delayed) effects that manifest away from the location of the intervention, are also common in intertwined biodiversity, climate and social contexts, and can result in unintended outcomes. For example, increasing demand for bioenergy under climate mitigation policies of one region, can drive significant changes in land use in other regions. Consequences may include expansion of the agricultural frontier with negative implications for biodiversity and the livelihoods of smallholder farmers.

33 **Assessing the range of viable solutions ('solution space') to achieve the intended climate mitigation, adaptation and biodiversity conservation outcomes, while positively contributing to people's quality of life, requires recognition of differences in social-ecological contexts.** As environmental characteristics differ from place to place, also motivations, interests, preferences and values differ across societies and cultures. It is crucial to identify interventions which are universal in terms of intent, but sufficiently flexible and adaptive to fit different social-ecological contexts, including governance structures. Policy interventions designed in the framework of equitable and just sustainability transitions can minimize the negative effects of policy actions, by including fair compensation mechanisms to promote the equitable distribution of the benefits and costs that may result from policy action. This, in turn, calls for robust and transparent deliberative and negotiation mechanisms including all relevant stakeholders that can address unequal power relations among stakeholders.

34 **In the presence of strong and apparently unavoidable trade-offs within the biodiversity-climate-society nexus, promoting social tipping interventions to modify the ways society and nature interact can be a viable joint solution.** This may involve the redistribution of benefits and costs of actions and even more profoundly, a collective shift of individual and shared values concerning nature. An example is moving away from a conception of economic progress based solely on GDP growth, to one of human development based on inclusive wealth and which considers the multiple values of nature for a good quality of life while not overshooting biophysical and social limits. Another example is the external recognition of indigenous peoples' and community conserved territories and areas (ICCA), initiated, designed, and governed by indigenous communities. While ICCA might be designed to support livelihoods, well-being, and cultural and spiritual values, they can lead to the conservation of natural and modified ecosystems and its biodiversity and associated benefits, including climate benefits.

Transformative change in governance of socio-ecological systems can help create climate and biodiversity resilient development pathways.

35 **While integrated solutions for the biodiversity-climate nexus exist that also have co-benefits in terms of sustainable development and meeting basic needs of the poor and vulnerable, governing and financing these nexus approaches is challenging.** Nature-based and other solutions are most likely to be effective when implemented in an integrated and socially equitable way but can present problems in terms of design and implementation. Existing governance systems often lack effective mechanisms to improve integration between climate and biodiversity, and between international and national to subnational scales. Overall, mainstreaming of biodiversity into climate policy and vice versa, and of both into initiatives to advance human development and good quality of life, remains limited at many scales and in many sectors, although there are some promising initiatives emerging, such as jurisdictional approaches, experimental policy mixes, and rights-based approaches.

36 **A key outcome for successfully integrated governance of climate, biodiversity and good quality of life will be to help identify solutions for stewardship that deliver the highest co-benefits while avoiding trade-offs.** Identifying how integrated approaches across actions to protect, restore, manage, create, adapt and transform can be fostered and supported is a primary concern. Many synergies and co-benefits exist across biodiversity and climate policies and actions, but potential negative trade-offs for nature, climate or human well-being and good quality of life are also possible. Governance systems that make use of a systems perspective can help to manage trade-offs and adapt to risk, through mechanisms such as adaptive management, reflexive evaluation, and social learning.

37 **Goal-based governance is now the norm for climate, biodiversity and sustainable development, but can create challenges in implementation.** For example, in the biodiversity domain, goal-setting that relies on achieving area-based protected area targets alone is unlikely to be successful, given climate change pressures. Flexible and adaptive mechanisms would work more successfully within goal-based approaches, such as the Sustainable Development Goals (SDGs) or the Paris Agreement. Global targets aligned with local contexts, values and abilities, and progressively adjusting the ambition of targets over time, can help strengthen governance.

38 **Multi-actor and multi-scale governance are appropriate approaches to the management of multifunctional 'scapes' at different scales.** The imperative for rapid action on both climate change and biodiversity loss argues for governance models to move beyond state-based approaches to embrace more collaborative solutions. For such constraints, the engagement of a broad range of actors, respect for multiple values, drawing on different knowledge systems, polycentric governance, and overcoming power imbalances across actors are all elements of a solution to the governance challenge and the need for transformative change.

39 **Transformative change can occur using leverage points in socio-ecological systems which alter future trajectories.** Critical leverage points include exploring alternative visions of good quality of life, rethinking consumption and waste, shifting values related to the human-nature relationship, reducing inequalities, and promoting education and learning. The global societal disturbances caused by the COVID-19 pandemic crisis have highlighted the importance of a more resilient, sustainable and transformative path forward, leaving no one behind.

40 **Better tools for multi-sectoral scenario planning and modelling can help map pathways to simultaneously achieve the goals in the SDGs, the Paris Agreement and the post-2020 Global Biodiversity Framework in the medium and long term.** In order to be robust, and for their identified pathways to be implementable, decision tools should acknowledge different visions of a good life and alternative positive futures for nature and climate. In light of the complexity of ecosystems and their responses and dynamics the scenarios that describe the future of nature and people are not as advanced as those developed for climate futures, and climate policies are not usually assessed in relation to biodiversity scenarios. This limits the confidence associated with the efficacy of conservation measures and adaptation possibilities, and the quantification of vulnerabilities, risks, trade-offs and synergies among different policies.

41 **Achieving the scale and scope of transformative change needed to meet the goals of the UNFCCC and CBD and the Sustainable Development Goals relies on rapid and far-reaching actions of a type never before attempted.** This builds on a commitment not only from countries through actions in their national territories, but also emergent coalitions and governance models at all levels. It includes new integrative agendas aligning all actors, private to public, in support of actions to protect biodiversity, reduce the impacts of climate change, and achieve sustainable development. Transformative change elements identified can include effective incentives and capacity-building, improved cooperation across sectors and jurisdictions, anticipatory and pre-emptive actions, inclusive and adaptive decision-making, and strengthened environmental policy and implementation. Climate and biodiversity resilient pathways that allow for directed, anticipatory, and iterative decision-making provide one such approach to achieve the long-term goals of the SDGs, the Paris Agreement and the Post-2020 Global Biodiversity Framework and to put society on the pathway to a positive vision of good quality of life in harmony with nature.

APPENDIX 1
List of peer reviewers

This appendix sets out a list of external scientists selected by the co-sponsored workshop scientific steering committee who reviewed both the Workshop Report and the Scientific Outcome.

Lilibeth Acosta-Michlik
Global Green Growth Institute

Ana Paula de Aguiar
Stockholm Resilience Centre

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Pam Berry
University of Oxford

Betsy Beymer-Farris
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Wolfgang Cramer
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Paula Harrison
UK Centre of Ecology and Hydrology

Valerie Kapos
UN Environment Programme World Conservation Monitoring Centre

Olaotswe Kgosikoma
Ministry of Agriculture, Botswana

Mahendra Kumar
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Debora Ley
United Nations Economic Commission for Latin America and the Caribbean

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