Linking biodiversity, conservation and climate change action

2022 Report

ROYAL PATRON
HRH The Duke of Cambridge, KG KT

UK Registered Charity No: 1186533

www.tusk.org

Acknowledgements

This report is a summary of a full academic paper titled 'The Role of Large Wild Animals in Climate Change Mitigation and Adaptation' published in Current Biology. Our thanks to all of the authors and organisations that contributed to this research; Yadvinder Malhi (Environmental Change Institute, School of Geography and the Environment, University of Oxford), Tonya Lander (Christ Church College, University of Oxford), Elizabeth le Roux (Environmental Change Institute, School of Geography and the Environment, University of Oxford/Center for Biodiversity Dynamics in a Changing World (BIOCHANGE) & Section for Ecoinformatics and Biodiversity, Department of Biology, Aarhus University), Nicola Stevens (Environmental Change Institute, School of Geography and the Environment, University of Oxford), Marc Macias-Fauria (School of Geography and the Environment, University of Oxford), Lisa Wedding (School of Geography and the Environment, University of Oxford), Cécile Girardin (Environmental Change Institute, School of Geography and the Environment, University of Oxford), Jeppe Ågård Kristensen (Environmental Change Institute, School of Geography and the Environment, University of Oxford/Center for Biodiversity Dynamics in a Changing World (BIOCHANGE) & Section for Ecoinformatics and Biodiversity, Department of Biology, Aarhus University), Christopher J. Sandom (Life Sciences/Sussex Sustainability Research Programme, University of Sussex), Tom D. Evans (Wildlife Conservation Society, Global Conservation Program), Jens-Christian Svenning (Center for Biodiversity Dynamics in a Changing World (BIOCHANGE) & Section for Ecoinformatics and Biodiversity, Department of Biology, Aarhus University) and Susan Canney (Department of Zoology, University of Oxford/WILD Foundation/International Conservation Fund of Canada). Our thanks also to ISPS Handa for generously supporting the development of this research.

Introduction

The climate crisis and the alarming downward trend in global biodiversity are two of the biggest challenges of our time. On one side, the global climate crisis is having a very real impact around the world, with drought, extreme weather events and famine becoming more and more common. On the other, ecosystems function through the interaction of elements across the complex web of life. When a species goes extinct, it poses a very real threat to the ecosystem and the species dependent on that ecosystem, including humans. The need to act, and the limited time and resources available to do so, mean that solutions tackling both crises are highly desirable. However, to date, most programmes aiming to achieve this have focussed on the protection and restoration of plants and soils. But what about the other elements of ecosystems?

Ecosystems function most effectively, and are most resistant to climate change, with a robust interplay of elements across the complex web of life. Removal of any trophic level from this interconnected system reduces the function and resilience of the system. With this in mind, Tusk commissioned a review of the links between the conservation of large wild animals and climate change mitigation and adaptation.

The incredible breadth of biodiversity across Africa is an excellent example of this. Africa is home to some of the planet's largest and most iconic animals, such as elephants and rhino. Research shows that they play a vital role in helping their ecosystems resist, recover from, and adapt to, the impacts of climate change. Despite this, the remaining populations of Africa's giants are under increasing risk. They face a number of threats to their survival, including habitat loss, poaching and human-wildlife conflict. Their loss could have significant consequences, including a severe impact on the earth's ability to respond and adapt to a changing climate.

This review, which has been published in Current Biology, describes the principles underpinning animal-climate interactions, identifies the most significant 'win-win' opportunities to tackle both biodiversity decline and climate change, and demonstrates the value of wildlife conservation efforts in reducing the impact of climate change, protecting species, and building resilient ecosystems.

How large wild animals affect the climate

There are three main ways that large animals can help mitigate climate change: increasing carbon stocks in plants, soils, and marine sediments; increasing Earth surface albedo (the amount of sunlight reflected by the Earth's surface), or directly affecting the intensity and frequency of fires.

Animals graze, browse, disperse seeds, trample, and fertilise vegetation, affecting the number, variety and spatial patterns of plant species, and maintaining or increasing overall ecosystem complexity. Complex ecosystems in which all trophic levels are present and robust tend to be more resilient to climate change impacts. These animal activities also usually protect and increase carbon stocks in plants and soils, driving reductions in atmospheric carbon, and reducing greenhouse effects. Large animal grazing and browsing can also moderate the impact of fires by reducing fuel availability and creating gaps in vegetation. This, in turn, reduces climate change impacts in ecosystems facing new or more intense patterns of wildfires. Finally, by shifting vegetation from closed to open shrub or forest, exposing pale grassy or open ground surfaces, or revealing snow cover at higher latitudes, large animals can increase Earth's surface reflection of solar radiation, and create strong cooling effects.

While mitigating and reversing the impacts of a changing climate would be the best possible outcome, we must also understand how ecosystems may be able to adapt to the pressures of climate change. Large animals can facilitate climate change adaptation by enhancing plant dispersal, shifting and diversifying the vegetation by browsing and grazing, and increasing habitat heterogeneity and ecosystem-wide complexity. Heterogenous systems tend to be more resilient to climate change impacts, and the diversity of species and micro-habitats also make the ecosystem as a whole better able to adapt to climate change. In some cases, large animal activity can facilitate ecosystem transformation; a shift from one ecosystem type to another (some species may go extinct, some may colonise).

Although resistance or resilience to climate change may be preferable to transformation under moderate climate change pressure, under higher levels of climate change transformation, adaptation could be a valuable and pragmatic strategy. A key difference between climate change mitigation and adaptation is that mitigation effects are only impactful if they are scalable to regional or global scales, whereas climate adaptation yields benefits even if only occurring at the local scale.

Where large wild animals have the greatest potential to affect the climate

Large animals are likely to have the greatest climate change mitigation impacts in ecosystems where they can affect carbon stocks, albedo, or fire regimes. The relevance of these processes depends on an individual ecosystem's 'abiotic constraints' (limited availability of light, water, or nutrients, or extreme temperatures), 'abiotic disturbances' (fire, wind, and flooding, for example), and primary productivity (amount of 'primary production', such as vegetation, plankton, and algae, produced over time). For example, animals can have large impacts on ecosystem carbon stocks when their grazing and browsing causes a shift from shrubby to grassy ecosystems. This shift reduces the carbon stored above-ground, in the plants' shoots and leaves, and increases the carbon stored below-ground in roots and soils. This process is especially relevant in ecosystems with moderate constraints and productivity, and moderate to high disturbance, such as temperate, sub-tropical and tropical grassland ecosystems (Figure C), and temperate floodplains (Figure B). Animals can also increase carbon stocks by accelerating nutrient cycling in abiotically constrained, cold or arid ecosystems, such as desert or tundra (Figure A).

Figure A

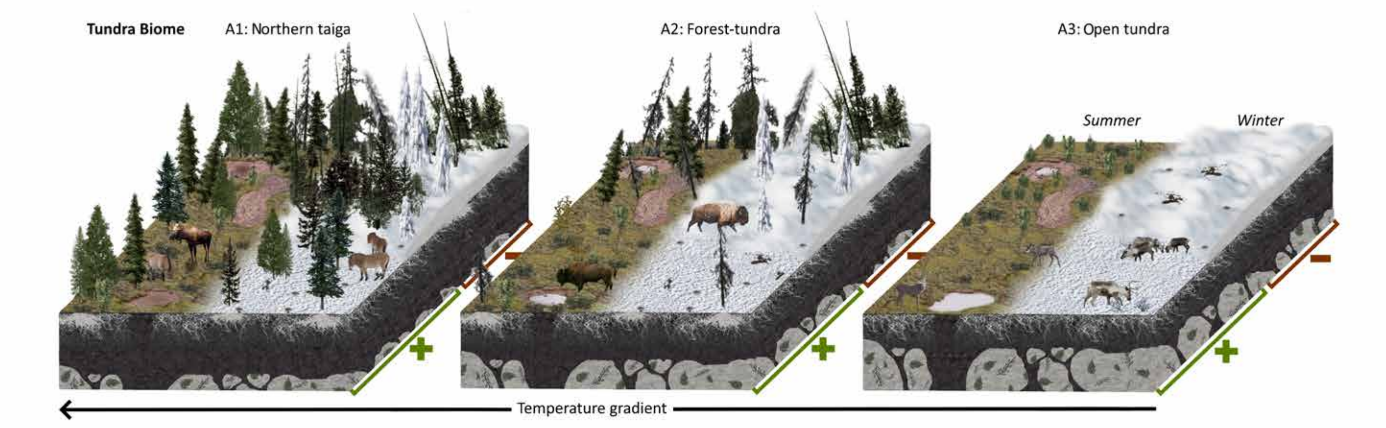
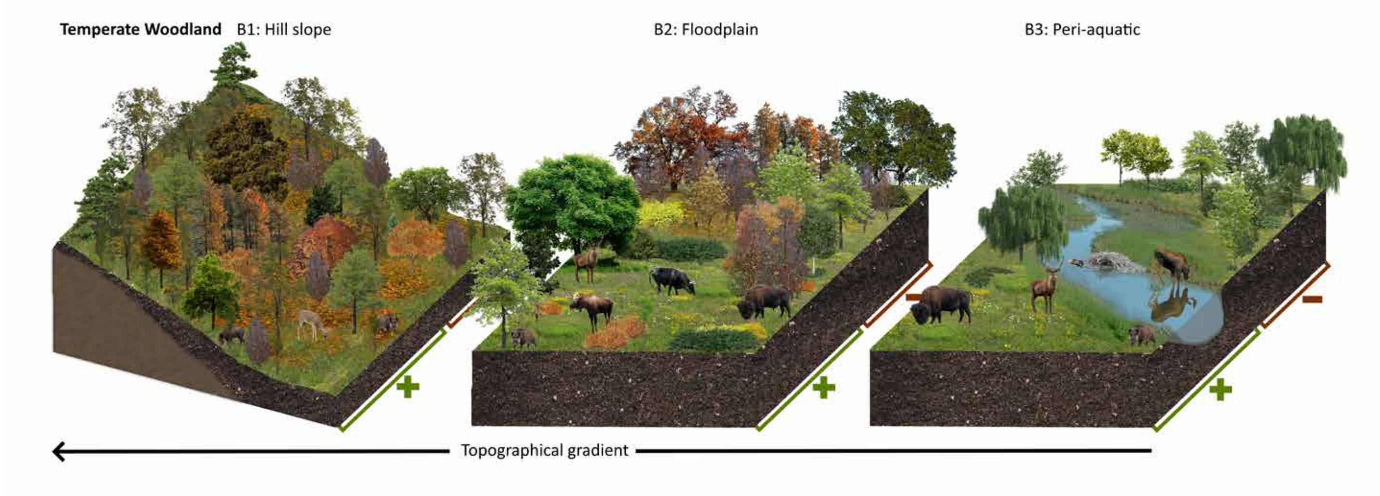


Figure B



Although clearly ecologically distinct from desert and tundra systems, the open ocean (Figure D) also experiences temperature, light, and nutrient limitations on productivity of plankton, algae, and plants. In the open ocean large animals affect productivity and carbon stocks by enhancing nutrient and carbon cycling through their movement between the deep ocean and the surface. In addition, when animals die in the open ocean, their carcasses deposit large quantities of organic matter on the seafloor. It has been estimated that sinking whale carcasses could export over 200,000 tonnes of carbon to ocean sediments annually, if populations were restored to pre-industrial levels.

In very high productivity systems, such as temperate woodland and some coastal ecosystems, animals have limited direct impact on vegetation, but they still have indirect, longer-term effects on ecosystem adaptation and carbon stocks through seed dispersal, nutrient transfer, and impacts on plant and animal community composition (Figure B and D).

The ecosystems most susceptible to animal-induced changes in albedo are low to moderate productivity ecosystems where there is the potential to shift from closed to open shrub and forest cover, such as grasslands, and ecosystems at higher latitudes with long periods of snow on the ground, such as tundra (Figure A,C). In the open ocean, large animals can affect albedo by increasing nutrient cycling, which stimulates plankton growth. Plankton, in turn, can affect the chemical composition of sea spray and encourage formation of clouds which reflect sunlight (Figure D).

Finally, new or intensifying fire regimes linked to climate change could be mitigated by animal grazing, browsing, and plant community shifts in grassy and arid ecosystems, and warm temperate woodlands (Figure B, C). It is important to note that interventions linked to carbon stocks, albedo, and fire regime, have the potential to provide substantial beneficial mitigation outcomes in the next few decades to half-century. This is a critical time period, as it is the estimated timescale of reaching peak warming under the 1.5°C and 2°C climate change scenarios modelled by the IPCC (Intergovernmental Panel on Climate Change, https://www.ipcc.ch/).

Figure C

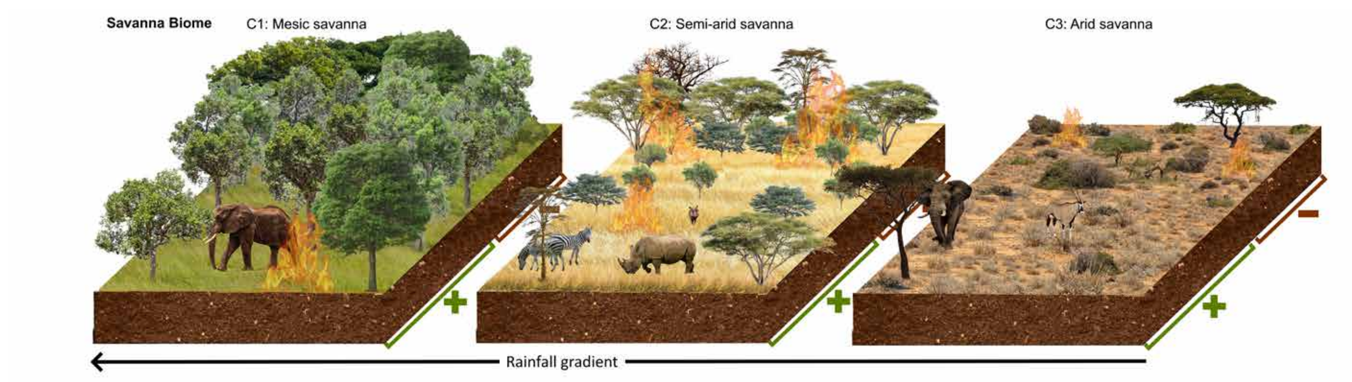
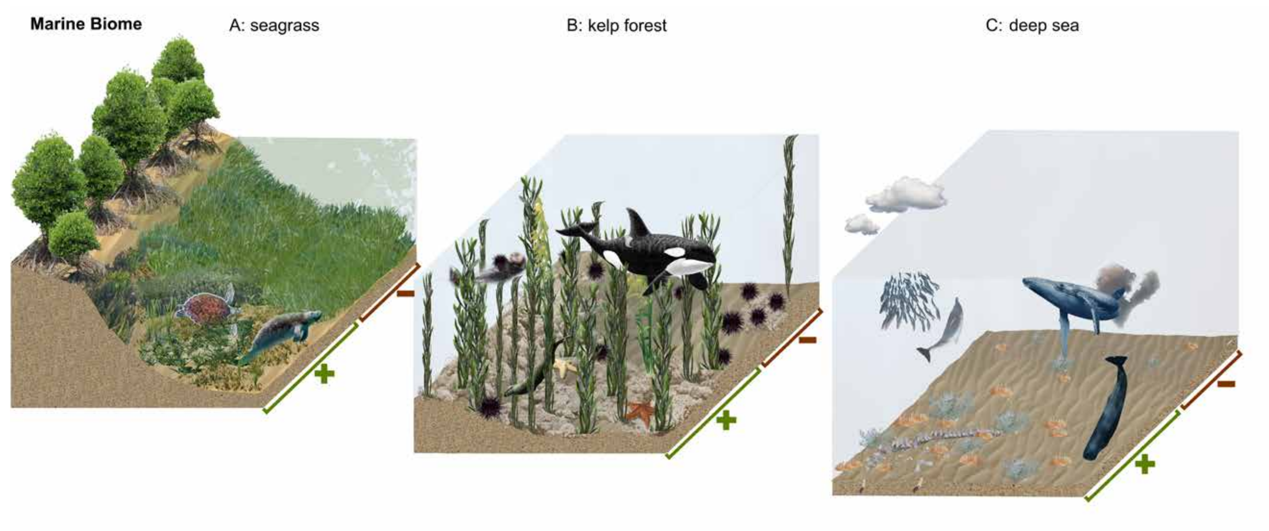


Figure D



‘Win–win’ conservation opportunities

Across ecosystems, ecological interactions, including predation, competition, facilitation, and pest and disease dynamics, are a key part of ecosystem function. Although the descriptions of animal-climate interactions described in this report, and shown in Figures A, B, C and D, largely focus on herbivores, the role of predators, competitors, mutualists, and pests and pathogens in maintaining healthy populations of herbivores and functional ecosystems is implicit and absolutely necessary. In the conservation opportunities described here we take a holistic and multitrophic view, and assume that protecting, restoring, or introducing functionally diverse, large wild herbivore communities is likely to require protecting or restoring whole, functional ecosystems.

Tundra - The tundra ecosystem has the potential for some of the strongest climate change mitigation and adaptation effects from large animal wildlife. When large herbivores are present, they limit woody plant encroachment and enhance flowering plant communities (including grasses). This mitigates climate change because it exposes soils to cold air which preserves permafrost and limits soil carbon release, reduces methane (greenhouse gas) emissions from wet soils, increases soil carbon stocks, limits the spread of fire in tundra peatlands, and increases albedo. Conservation interventions in this biome that aim to protect and increase large animal numbers have the potential to contribute to both biodiversity conservation and climate change adaptation at local scales and, if scaled, could contribute towards global-scale climate change mitigation.

Grasslands - Temperate, tropical and sub-tropical grassland ecosystems can show large climate change mitigation and adaptation effects from large animal wildlife. In particular, large animals can reduce fire spread and intensity and lower the frequency of fires in tree canopies (crown fires), especially in previously low-flammability biomes with a new or intensifying fire regime. Not only do these effects reduce carbon release from fire, increase albedo, and maintain and increase vegetation and soil carbon stocks, they can also increase habitat and microclimate heterogeneity, and contribute towards protecting and enhancing local biodiversity and complexity of trophic webs. As with the tundra ecosystem, these effects can contribute towards local climate change adaptation and, if scaled, could contribute towards global-scale climate change mitigation.

Marine systems - Large animals in marine systems appear to have important potential for climate change mitigation through their role in fertilisation of phytoplankton. Phytoplankton are estimated to capture 37 billion tonnes of CO_2 each year, and generate aerosols that contribute towards cloud formation. However, the size of these effects is poorly understood. This is an area where research is needed.

Soils - Large animals seem to have important effects on surface and deep soil carbon and mineral cycling, as well as soil compaction and disturbance. These impacts could have significant climate change mitigation or adaptation effects, but we have little evidence about how big the effects may be, especially away from temperate, open ecosystems. This is another area where research is needed.

Wildlife conservation does not always have to be a solution for climate change

Although the paper has identified a number of potential ‘win–win’ climate change and wildlife conservation interventions, it is important to note that there are also biodiversity, conservation and restoration outcomes that are not linked to, or that run counter to, climate change mitigation or adaptation. While it is valuable to highlight synergies where they exist, it is also vital to recognise that the responsibility for tackling climate change does not lie with the natural world. Misalignment with climate change mitigation or adaptation efforts does not mean that a biodiversity conservation goal should be abandoned. Moreover, it is imperative to consider the impact upon and welfare of the local human community when considering conservation interventions, including identifying direct benefits to people from wildlife, such as reduction of catastrophic fire or flood, as well as strategies for minimising human-wildlife conflict. When prioritising conservation action, we must evaluate projects on a wide range of metrics, including climate change mitigation and adaptation, biodiversity conservation and restoration, protection of ecosystem services, and Sustainable Development Goals.

Outstanding Questions and Ways Forward

Our research has shown that there are a number of areas where the climate benefits of large animals may be substantial. However, the complexity of ecosystem interactions and the large number of outstanding research questions highlight a clear need to build a more solid evidence base by establishing protocols for monitoring conservation interventions. A large number of animal restoration and protection initiatives claim to provide biodiversity and climate benefits, presenting an urgent opportunity to evaluate which interventions are effective, and which contexts provide the best chance of success.

Climate change and biodiversity decline are the two major environmental challenges of our time, and it is clear that they are interwoven. The linkages between these two challenges are usually only explored through the lens of vegetation. This report has explored how large wild animals, a particularly vulnerable and functionally important part of the Earth system, can influence climate change mitigation and adaptation. With a holistic and multitrophic view of ecosystem functioning, the evidence is clear: maintaining and restoring the diversity and abundance of large wildlife could play a game-changing role in how we save the planet, and thus ourselves.

The full paper is available at:
www.cell.com/current-biology/fulltext/S0960-9822(22)00101-4