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Climate Change and Biodiversity Loss: Two Sides of the Same Coin

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Upon hearing that climate change will have serious impacts on our planet's rich storehouses of biodiversity, many people likely conjure up an image of a polar bear trapped on shrinking ice, or perhaps of rescuers saving soot-blackened koalas from Australia's 2019 bushfires. But the impact of rapidly increasing global temperatures is hardly confined to dangers to iconic animal species. We are altering the globe in far more complex ways, involving unprecedented changes in how ecosystems function, the accelerated spread of alien invasive species, and even extraordinary disruptions to the process of evolution itself. This poses a danger not only to the abundance of nonhuman life all around us, but ultimately to ourselves.

Scientists with the Intergovernmental Panel on Climate Change (IPCC)—the international body that provides regular assessments of the state of climate science, present and future impacts, and possible pathways for mitigation—have long warned that biodiversity, which includes species, ecosystems, and their functions and productivity, is at risk from climate change. Two degrees Celsius of warming above pre-industrial temperatures would risk "shifts of species to higher latitudes, damage to ecosystems (e.g., coral reefs, and mangroves, seagrass and other wetland ecosystems), loss of fisheries productivity (at low latitudes), and changes to ocean chemistry (e.g., acidification, hypoxia and dead zones)," the IPCC warned in 2018.

If we reach the 2°C threshold, it is projected that 18 percent of insects, 16 percent of plants, and 8 percent of vertebrate species will lose over half of their geographic range, and localized extinctions are a near certainty. Beyond this threshold, total extinction of thousands of vulnerable species is a real risk later in the twenty-first century.

The alterations to ecosystems occurring over recent decades as the planet has warmed are increasingly visible not just to scientists but also to average citizens who see their garden plants blooming earlier, or fewer lightning bugs on summer evenings, or the spread of invasive species, like the spotted lanternfly that is currently spreading ominously across my home state of New Jersey, threatening the state's agricultural economy. As many of our landscapes and ecosystems become less diverse, they are rendered even more vulnerable to temperature changes. This puts at risk the many benefits these systems provide to us, like clean freshwater from vegetated lands or pollination of many of our most valuable crops by bees, birds, and other creatures. Changes in ecosystems and higher temperatures also increase our vulnerability to emergent diseases, at a time when the COVID-19 pandemic has revealed the fragility of our preparedness and our inability to coherently respond.

Recent disasters and extreme events have made it even clearer that biodiversity loss and climate change are two sides of the same coin. One of the most vulnerable and threatened ecosystems, tropical coral reefs, are bleaching regularly, and many species within them are dying off. This occurs not only because of warming ocean temperatures. These reefs were overfished, overharvested, or overtouristed in the first place, creating more fragile reef complexes that cannot survive the added stressor of warming water.

When wildfires rage out of control due to extended dry seasons, we lose more than just the

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many animals and plants that cannot move away from the blazes. The combustion of millions of acres of trees releases more carbon into the atmosphere, which is normally counterbalanced by revegetation—but if it is not, it can accelerate the greenhouse process in what scientists dispassionately call a "positive feedback cycle." It could instead be described as a terrible circular Catch-22.

If we want to fix climate change, we cannot ignore its links to biodiversity. Climate change is not just a technical problem requiring shifts in energy systems, as billionaires like Bill Gates and Elon Musk would have us believe. Tackling climate will require a holistic approach and transformations not only in what we drive or how we heat our homes, but also in how we produce food, how we procure water and timber as well as energy, and even where we live.

Given that we have already locked in further warming even if our greenhouse gas emissions drop to zero tomorrow, we need to think of ways to help species and ecosystems adapt to the temperature changes that are already under way. This may involve assisted species relocations, extensive restoration work to remove invasives and restore native biodiversity, genetic manipulation of species like corals and fish to increase their chances of survival, and even reanimating species that have already been extirpated. These adaptation measures can help buy time and prevent some extinctions and ecosystem collapses, though scientists warn that we have very little wiggle room and much to do.

Multiple interventions will be needed to help species and ecosystems adapt.

There is a further catch: while most policies that we put in place to protect biodiversity are either neutral or positive for climate change—like expanding protected areas around the globe, or helping species recover through restoration efforts—we cannot say the same about climate policies, many of which will require considerable trade-offs. Imagine the expansion of solar panels into ever-larger areas, disturbing some species' habitats or disrupting fragile ecosystems like deserts. Or deep-seabed mining for metals required in renewable energy technologies or electric car batteries. Or large-scale afforestation with fast-growing trees that may maximize carbon sequestration but often may displace local vegetation. In other words, failing to consider climate and biodiversity together risks making an already bad situation worse.

LINKED FATES

Climate and biodiversity are linked in multiple ways. Rising global temperatures caused by emissions of greenhouse gases have a number of important and related effects. The average changes in temperature we have experienced thus far (around 1.1°C of warming above the pre-industrial era) are felt unevenly across the globe and across ecosystems. The average warming on land has already exceeded 1.5°C globally, while in some polar regions, average temperature anomalies are now closer to 4°C and rising.

An unprecedented "heat dome" that blasted the North American West Coast with temperatures as high as 115°F in July 2021 was quickly attributed by climate modelers to global warming; such extremes simply could not have happened in the absence of anthropogenic emissions. The ecosystem impacts of the heat dome event are only beginning to be accounted for and will take years of study to understand. But biologists have initially estimated that billions of sea creatures, ranging from mussels to sea stars and barnacles, were literally cooked to death in the scorching temperatures.

Oceans are storehouses of incredible biodiversity in coastal, offshore, and deep-sea ecosystems, as well as an important buffer for atmospheric carbon concentrations. They now face multiple threats: warming waters and rising oxygen depletion that affect sea creatures' ability to survive, along with increased acidification. The latter occurs because of the exchange of carbon in the atmosphere with the sea surface, which enables the ocean to act as a sponge and draw down nearly a third of all anthropogenic CO_2 emissions. Without this ocean exchange, atmospheric carbon concentrations would likely be much higher than they are now. However, there is increasing evidence that the oceans' ability to absorb our CO_2 emissions may be slowing.

Although it is beneficial to us, the absorption of CO_2 reduces the pH of the oceans. This acidification is increasing at a rate that is "unprecedented for at least the last 65 million years," according to the IPCC. Marine organisms that rely on carbonates in seawater to make their shells are less able to do so in more acidic waters. Other species' physiologies are also sensitive to changes in pH: for example, some crabs and sea urchins respond to rising acidity inside their bodies by dissolving their exoskeletons, literally melting into the seawater.

Global temperature changes also alter precipitation regimes, bringing more unseasonable rains and risk of floods to some areas, as we saw in Germany and China in July 2021, while drying up other regions, like California and the US Southwest. Extreme weather events like wildfires, hurricanes (including unusual appearances in the Southern Hemisphere), and drought all adversely affect biodiversity in different ways. Too frequent and hotter-burning wildfires can inhibit ecosystem recovery, favoring colonization by invasive species and causing permanent loss of habitat for some species. Hurricanes can inflict structural damage on forest canopies, while rising sea levels and increased salinity in root systems have given rise to the phenomenon of "ghost forests," where decaying trees poisoned by brackish water serve as sentinels warning of the damage we are doing.

At the same time, changes in biodiversity also affect the climate system: what we do with ecosystems can alter carbon cycles, water exchange, and nitrogen circulation. When forests are converted to agriculture, for example, the natural sink capacity of trees, roots, and soil to absorb anthropogenic CO_2 is altered. There is increasing evidence that deforestation and degradation in the Amazon Basin, once considered the largest and richest storehouse of biodiversity on the planet, have led to a tipping point whereby the system now releases more carbon than it stores.

All these impacts associated with climate change alter the "distribution, functioning and interactions of organisms," according to the first-ever joint report by the IPCC and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), released in June 2021, for which I was one of fifty expert scientists. The report noted that the most vulnerable species and ecosystems are ones that have limited distribution (such as those found only in specific or small areas); those that have limited ability to move into new habitats (organisms that are immobile, like corals, or that move slowly, like most plants); and those that are already close to their physiological tolerance limits (species like fish that already live in waters as warm as they are able to survive in).

Certain ecosystems were singled out by the report as being most at risk of irreversible losses: mountains, islands, high-latitude ecosystems, Mediterranean climate systems (including California and South Africa as well as the Mediterranean proper), and coral reefs, along with ecosystems already fragmented by land-use change and overexploitation. It is entirely possible that my six-year-old daughter will live in a world facing the complete extirpation of the majority of tropical coral reefs before she turns thirty, if warming trends continue.

With the loss of these vulnerable ecosystems, we lose not only the species complexes that inhabit them, but also direct benefits to humans. IPBES has called the services that ecosystems provide to us "nature's contributions to people." The collapse of rich sources of food, fiber, and other important economic assets threatens human well-being, especially among vulnerable and poor populations. As the IPCC/IPBES report noted, "Biodiversity loss disproportionately impacts those communities and societal groups that are most directly dependent on nature."

Coastal ecosystems, for example, support food and water provisioning for many island populations and form the backbone of their economic systems, particularly through tourism and fishing. One estimate has suggested that loss of coral reefs alone would cause $1 trillion in economic damage globally. The uneven impacts of climate change and biodiversity loss will be felt far more acutely in some areas than others. Often the communities and nations most at risk are the ones that have emitted the least carbon emissions: poorer countries, small island states, Indigenous peoples, and polar regions.

Damage drivers

The drivers of biodiversity loss and climate change are related, but are not exactly the same. For biodiversity loss, a 2019 report by IPBES identified five primary drivers, ranked in order: land use change, direct exploitation of wild species, climate change, invasive alien species, and pollution. These trends are all shaped by other indirect drivers, such as demographic and social changes and economic pressures.

For climate change, the primary drivers of rising CO_2 emissions are increasing fossil fuel use in transportation, industry, and other sectors, alongside land use change and agriculture. These in turn are driven by rising affluence and the increasing number of people on the planet.

Each of these sources and drivers is difficult to tackle on its own, but designing policies that reach across both problems has posed particular challenges. Currently, the primary international agreements that govern global climate policy, the UN Framework Convention on Climate Change

(UNFCCC) and the associated Paris Agreement, and the pact that covers biodiversity, the Convention on Biological Diversity (CBD), operate mostly separately from one other. While some nations have explicitly addressed the need for including ecosystem management and restoration within the climate pledges required by the Paris Agreement, most countries have tended to focus their promised climate policies on the energy sector.

The CBD is working to finalize a post-2020 global biodiversity framework (delayed since last year due to COVID-19), and currently only one of its twenty goals (Target 8) is linked to climate. The UN's Sustainable Development Goals, adopted in 2015, address both climate (in goal 13) and biodiversity (in goals 14 and 15), but these targets are poorly integrated, with few identified actions that might tackle both problems. Overall, as the recent IPCC/IPBES report noted, "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."

It is also clear that what has worked in the past is unlikely to work in the future. For example, species conservation in a warming world cannot follow the tried-and-true strategy of designating protected areas, given the ways that species are rapidly shifting across landscapes: some protected areas may someday enclose zones in which few original species are able to live. Multiple interventions will be needed to help species and ecosystems adapt to present and future changes. Such interventions may include integrating conservation throughout landscapes and corridors to enable species movement; more aggressive management of invasive species threats; and even technological interventions to help nonhuman species survive extreme events—as Australia has done by installing sprinklers in one protected area to help flying foxes cool off in severe heat.

Billions of sea creatures were cooked to death in the heat dome's scorching temperatures.

Overall, the healthier an ecosystem is, the more resilient it is to climate change. This argues for precautionary and active approaches to managing our lands and oceans. As the IPBES/IPCC report notes, "Higher genetic, species, and ecosystem diversities help to reduce risk in the face of uncertain changes in climate and keep adaptation options open."

DUBIOUS SOLUTIONS

Beyond helping species and ecosystems adapt, we also need to avoid the costly trade-offs and negative consequences of some policy "solutions." Certain proposed actions to mitigate climate change are likely to have very detrimental impacts on biodiversity if not managed properly.

These include large-scale tree planting proposals, which might displace native vegetation or local food production, and extensive reliance on bioenergy crops, which often harbor little biodiversity. Such proposals have become increasingly popular, since they make use of plants' incredible ability to turn CO_2 into food through photosynthesis. One report in 2017 suggested that "natural climate solutions" like conserving and expanding forests, restoring wetlands, and protecting peatlands could provide up to 30 percent of the carbon sequestration needed by 2030 to hold the global temperature increase to 2°C.

While these are all promising approaches that recognize the links between climate and biodiversity, ecosystems alone cannot save us. All too often, nature is being seen as a "get out of jail free" card to make up for our failure to reduce fossil fuel use. Witness the many countries and companies rushing to issue "net-zero" pledges, primarily by using tree planting or other measures to offset their carbon emissions, rather than by fully decarbonizing their production and supply chains or national economies. For example, Shell Oil recently announced a plan to make its petroleum products "carbon-neutral" by offsetting some greenhouse gas emissions with tree planting, an absurd proposition worthy of Dr. Seuss.

Numerous initiatives have focused on the miraculous benefits of forests, from the Trillion Tree worldwide reforestation program to a proposal for a Great Green Wall of new trees in the Sahara, but their claims are often overstated. Although trees are enormously important assistants in sequestering carbon, they are not equally helpful everywhere. Trees planted in the northern latitudes can affect albedo (reflectivity of the land surface to solar radiation), increasing warming potential. Trees also affect processes like evapotranspiration and aerosol exchange with the atmosphere, which in turn have both regional and global climate effects. These multiplier effects can diminish the effectiveness of trees' role in carbon removal, given the complexities of the biosphere.

Trees also compete with other land uses, whether for food, fiber, or other benefits. If trees replace food production in one area, agriculture may be displaced to another area, leading to rising deforestation overall. Food production will need to continue to increase to feed a growing global population. Overly optimistic projections of the amount of land available for tree planting usually underestimate how much will be needed for agriculture. And as the 2021 IPBES/IPCC report noted, "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." In other words, tree planting can be extremely counterproductive if not done correctly.

Particularly problematic are plans for rapid and extensive expansion of bioenergy with carbon capture and storage (BECCS) initiatives. In these projects, large-scale bioenergy sources—either crops like corn for ethanol, or trees like willow and grasses such as Miscanthus—are planted (so they absorb CO_2 while growing) and then used for power generation. The CO_2 emitted by the latter is captured and stored, resulting in net "negative" emissions. Although there is little evidence for the current feasibility of BECCS, it has become increasingly of interest to modelers and policymakers as a way to avoid the worst outcomes of warming.

A little-known fact is that all integrated assessment models that show the world limiting warming to well below 2°C require the inclusion of substantial land-based mitigation, with different combinations of reforestation, afforestation, reduced deforestation, and BECCS. But BECCS would greatly increase demand for land conversion if applied at the scale necessary to make a difference—several million square kilometers, up to 1.5 times the size of India. That would mean adverse consequences in the form of water scarcity, land degradation, food insecurity, and biodiversity losses.

Instead, a much more realistic approach would be to focus on supporting and protecting ecosystems that already aid in climate mitigation, namely natural systems that store large amounts of carbon. These include forests (especially tropical ones and coastal mangroves), peatlands, coastal wetlands, and "blue carbon" stocks like kelp forests and seagrass meadows. Ecosystem restoration can improve the resilience of biodiversity to climate change, as well as provide additional benefits to people in the form of soil erosion control, reduced flood risks, and buffers against coastal storms.

Restoration also provides jobs and income, a fact recognized by the Biden administration in its proposal for a new Civilian Conservation Corps to help restore the health of federal lands. Such investments have been proven to work. Marine restoration projects funded as part of the 2009 US stimulus bill in the wake of the global financial crisis generated more jobs per million dollars invested than most other sectors.

A POST-PANDEMIC PATH

Many voices have been making the case for a low-carbon recovery from the COVID-19 pandemic, but much less attention has been paid to biodiversity. Only a few countries have identified nature-based investments or policies in their economic recovery proposals, and even then, green funding has been well under 10 percent of the total. Several countries, the United States and China among them, have allocated essentially zero stimulus funds to biodiversity or ecosystems. In other countries, post-pandemic recovery packages include steps backward on climate, such as subsidies for national airlines or bailouts of fossil fuel producers.

Yet there are a number of policies that would aid in post-COVID reconstruction while addressing many of the root causes of climate change and biodiversity loss. At a minimum, recovery packages should do no harm to ecosystems and climate. At their most ambitious, longer-term efforts could be transformative in addressing the interlocked biodiversity, climate, and well-being challenges.

One area that could be prioritized encompasses nature-based solutions—the use of natural systems to aid in both climate mitigation and adaptation. For example, parks and gardens, trees, and green roofs in cities have multiple positive impacts: they reduce the urban heat-island effect (inner cities are hotter than surrounding areas), and they can help prevent flooding, control stormwater runoff, enhance local biodiversity, and improve residents' quality of life. Numerous studies have shown that urban green spaces contribute to healthier populations through recreation opportunities and psychological benefits, as well as increased property values and even reduced crime rates. These green spaces in turn help store carbon and can encourage reduced automobile use, lowering emissions even further.

Other types of nature-based solutions can involve using nature, rather than concrete, to protect coastal zones. Such projects include restoring wetlands and protective mangroves instead of dredging and building seawalls to keep out rising seas and storms. Many experts have noted that green infrastructure is more effective than hard structures and cheaper to boot.

Some novel policies and projects combine nature and technology. Pilot projects have shown that grazing cattle and goats under solar panels increases soil carbon storage by encouraging turnover and growth of vegetation. Some solar array operators are experimenting with restoration of native grasses to improve pollinator habitat. Solar photovoltaic cells can also be floated on water, which not only reduces the need for land but also provides shade that helps address the increasing evaporation from water surfaces, an inevitable result of climate change. While some offshore wind installations have run into conflicts with fishing communities and conservationists, well-designed systems can imitate reefs and provide habitat for marine biodiversity.

The need for more funding for nature-based solutions and conservation actions for threatened ecosystems has been made more urgent by the COVID-19 pandemic. Rising unemployment and food insecurity in the global South have added to the pressure on local landscapes, leading to expansion of agriculture or the illegal wildlife trade, which in turn can increase the risk of future epidemics. There is already evidence that falling ecotourism income and reduced ranger activity as a result of COVID-19 have had negative consequences in many conservation areas around the world. This calls for a more concerted effort to address these problems in pandemic recovery packages.

Ecosystem restoration can improve the resilience of biodiversity to climate change.

Fixing our food system is another priority. Overall, producing, transporting, and consuming food generates between 21 and 37 percent of total anthropogenic greenhouse gas emissions. Improving how we produce food, with steps such as soil conservation measures and better fertility management in croplands and pastures, can yield substantial reductions in greenhouse gas emissions from this sector. Using agroforestry and agroecology to diversify food systems would also help, while providing more adaptive capacity to handle extreme events like heat waves, droughts, fires, and pest and disease outbreaks. Demand-side policies are needed as well—such as reducing food loss and waste and encouraging dietary shifts away from excessive meat consumption, especially in richer countries.

ANTHROPOCENE REALITIES

The dual effects of climate change and biodiversity loss have irrevocably altered the composition of life on our planet. From changing weather patterns and increasingly frequent extreme events to melting polar and glacial ice and rising sea levels, shifting geographic distribution of plants and animals, and the loss of rich storehouses of both carbon and species in peatlands and tropical forests, the Anthropocene is upon us. Human activity has had a heavy impact on the planet.

Recent scientific assessments have laid out the choice starkly. We must make rapid reductions in emissions from fossil fuel use, across energy, transport, agriculture, and other sectors, to keep from exceeding 2°C of global warming, the red line established by the Paris Agreement. If we fail to meet this goal, we will make things much riskier for both nature and ourselves.

Policymakers and scientists increasingly discuss the need for "transformative change" in the way we relate to nature to address these dual crises. While there is not yet consensus on what this would look like, a diverse range of bodies, from the European Union to the World Economic Forum to major Fortune 500 corporations, all recognize that the current approach is unsustainable and risks the long-term welfare of nature and humanity. Achieving the long-term targets of the Sustainable Development Goals, the Paris Agreement, and a post-2020 global biodiversity framework will require us to address the problems of climate change and biodiversity simultaneously and in an integrated manner. As the Convention on Biological Diversity puts it, the goal must be "living in harmony with nature."

Whether the COVID-19 pandemic has provided a reset button to put us on this better pathway remains to be seen. Nonetheless, the urgency and scale of the problems we face demand that our relationship with nature be placed at the forefront of all our economic, social, and political agendas moving forward. ■