Biodiversity risks to persist well beyond future global temperature peak

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Even if global temperatures begin to decline after peaking this century because of climate change, the risks to biodiversity could persist for decades after, finds a new study by UCL and University of Cape Town

researchers.

The paper, published in *Philosophical Transactions of the Royal Society B: Biological Sciences*, models the potential impacts on global biodiversity if temperatures increase by more than 2°C compared to pre-industrial levels, before beginning to decline again.

The Paris Agreement, signed in 2015, aims to limit global warming to well below 2°C, preferably to 1.5°C. However, as global greenhouse gas emissions continue to increase, many scenarios now feature a multiple decades-long 'overshoot' of the Paris Agreement limit, then factor in the effects of potential carbon dioxide removal technology to reverse dangerous temperature rise by 2100.

Climate change and other human influences are already causing an ongoing biodiversity crisis, with mass die-offs in forests and coral reefs, altered species distributions and reproductive events, and many other ill effects.

Co-author Dr. Alex Pigot (UCL Center for Biodiversity & Environment Research, UCL Biosciences) said: "We have investigated what will happen to global biodiversity if climate change is only brought under control after a temporary overshoot of the agreed target, to provide evidence that has long been missing from climate change research.

"We found that huge numbers of animal species will continue to endure unsafe conditions for decades after the global temperature peak. Even if we collectively manage to reverse global warming before species are irreversibly lost from ecosystems, the ecological disruption caused by unsafe temperatures could well persist for an additional half century or more. Urgent action is needed to ensure we never approach, let alone exceed, the 2°C limit."

The study examined more than 30,000 species in locations around the world and found that for more than a quarter of the locations studied, the chances of returning to pre-overshoot 'normal' are either uncertain or non-existent.

The paper focuses on one overshoot scenario where CO_2 emissions keep growing until 2040, then reverse their course and fall into negative territory after 2070 thanks to deep carbon cuts and massive deployment of carbon dioxide removal technology. This means that, for several decades in this century, global temperature rise breaches 2°C but returns to below this level around 2100. The researchers looked at when and how quickly the species in a particular location would get exposed to potentially dangerous temperatures, how long that exposure would last, how many species it would affect, and whether they would ever get de-exposed, returning back to their thermal niche.

In line with their previous research published in *Nature*, the research team found that, for most regions, exposure to unsafe temperatures will arrive suddenly as further warming means many species will simultaneously be pushed beyond their thermal niche limits. However, the return of these species to conditions comfortably within their thermal niches will be gradual and will lag behind the global temperature decline due to continually volatile climatic conditions within local sites and lasting changes to ecosystems. The effective overshoot for biodiversity risks is projected to be between 100 and 130 years, around twice as long as the actual temperature overshoot of around 60 years.

Tropical regions are most affected by these risks, with over 90% of species for many locations in the Indo-Pacific, Central Indian Ocean, Northern Sub-Saharan Africa, and Northern Australia pushed outside of their thermal niches. And in the Amazon, one of the most species-rich regions of the world, more than half of the species will be exposed to potentially dangerous climate conditions.

Concerningly, for about 19% of the total number of sites studied, including the Amazon, it is uncertain whether the share of exposed species will ever return to pre-overshoot levels. And a further 8% of sites are projected to never return to those levels at all. This means that the overshoot can cause irreversible impacts to nature due to species extinction and radical transformations of ecosystems.

Lead author Dr. Andreas Meyer (African Climate and Development Initiative, University of Cape Town) said: "In the Amazon, this could mean replacement of forests with grasslands, and as a consequence, the loss of an important global carbon sink, which would have knock-on effects on multiple ecological and climatic systems as well as our ability to curtail global warming."

The study underscores as the importance of looking at the complete picture of damage caused throughout overshoot scenarios, rather than focusing only on making sure the 'final destination' is within the agreed temperature limits, which could underplay the need for rapid and deep emissions reductions. Moreover, the authors note that carbon dioxide removal technology itself is also likely to have negative impacts on ecosystems: for instance, large-scale forest planting or biofuels production require a lot of land and water and may even have secondary effects on the climate system.

Lead co-author Dr. Joanne Bentley (African Climate and Development Initiative, University of Cape Town) said: "It is important to realize that there is no 'silver bullet' solution for mitigating climate change impacts. We have to rapidly reduce greenhouse gas emissions. Many carbon dioxide removal technologies and nature-based solutions, such as afforestation, come with potential negative impacts.

"Our study shows that should we find ourselves overshooting the 2°C global warming target, we could pay dearly in terms of loss of

biodiversity, compromising the provision of the ecosystem services that we all rely on for our livelihoods. Avoiding a temperature overshoot should be a priority, followed by limiting the duration and magnitude of any overshoot."

Co-author Christopher Trisos (African Climate and Development Initiative, University of Cape Town) said "Our findings are stark. They should act as a wake-up call that delaying emissions cuts will mean a temperature overshoot that comes at an astronomical cost to nature and humans that unproven negative emission technologies cannot simply reverse."

More information: Risks to biodiversity from temperature overshoot pathways, *Philosophical Transactions of the Royal Society B* (2022). DOI: 10.1098/rstb.2021.0394

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