How biodiversity is both impacted by and a solution for climate change

The field of climate change biology has changed a lot over the years. It began in one sense in 1987 with a conference at the Smithsonian funded by the National Science Foundation, although there was a 1985 conversation with Stephen Schneider when I inquired how what I studied (biological diversity) fitted with his focus (climate change). Steve later characterized that as a eureka moment.

The conference ultimately turned into the 1992 book *Global Warming and Biological Diversity* (Peters and Lovejoy, 1992). At that point one could mostly just try to project from changes engendered by past climate change to the current day and future. By 2005, Lee Hannah and I produced a new volume titled *Climate Change and Biodiversity* (Lovejoy and Hannah, 2005), and at this point one could see the fingerprints of climate change virtually everywhere.

Yet there was only one mention of ocean acidification in that volume. Only during that very year (long after the book had gone to press) had that suddenly become noticed, even though in the end it was a matter of simple high-school chemistry – that some of the CO_2 absorbed by the oceans was altering the acidity of the oceans. Today the oceans on average are about 0.1 of a pH unit more acid: in absolute terms that is 30% more acid than in pre-industrial times.

Now we are in 2019 and Lee Hannah and I have produced a completely new book – *Biodiversity and Climate Change: Transforming the Biosphere* (Lovejoy and Hannah, 2019). It hadn't taken long for us to realize that so much had changed since the previous volume that there was no point in a revision: a completely new book was in order.

Changes in the annual cycles of plants and animals are ubiquitous. More importantly, geographic distributions are changing as species move to track their required conditions, among other things moving upward in altitude or poleward (northward in the northern hemisphere), tracking their preferred conditions. Marine organisms seem to be changing in distribution even more rapidly than terrestrial ones.

Decoupling events are also occurring when one member of a pair of closely synchronized species depends on temperature for its cycle, while the other uses day length. An example would be the snowshoe hare, which changes its pelage from winter white to summer brown using a relatively immutable response to day length, as opposed to the vegetation it inhabits, which loses its white snow cover earlier in the spring. Another example is that of migratory organisms (*e.g.* birds), which may arrive in their summering grounds after the spring flush of key food supplies.

Organisms moving upward will run out of upslope opportunities, in what has been termed an 'elevator to extinction'. Sea level rise is imperilling some species. The first extinction from sea level rise is a mammal, the Bramble Cay melomys, a small rodent that was native to a single Australian island (clearly, island species face a particular challenge). The salt marsh sparrow in eastern North America is vulnerable as it must nest successfully between two spring tides. The key deer of the Florida Keys will only have a future if translocated elsewhere.

Basically, these individual cases are only minor adjustments in the fabric of life. Nonetheless, it is a statistically robust finding that nature is responding to climate change anywhere it is studied.

What is more worrying is what things will be like looking ahead.

Thomas E Lovejoy

About the author

Thomas is a professor in the Environmental Science and Policy department at George Mason University (Fairfax, VA, USA) and a Senior Fellow at the United Nations Foundation.

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We know that glaciers came and went in the past with little apparent loss of biodiversity. What is different today is that as species attempt to track their required conditions, they mostly must do so in highly fragmented landscapes, which have essentially become obstacle courses for dispersing organisms. That challenge can be alleviated if we restore natural connections in landscapes. Restoring riparian vegetation is a good place to start but obviously not sufficient.

It is also clear from past climate change events that as climate shifts increase, individual species move each in their own direction and at their own velocity. Ecosystems essentially disassemble, and new assemblages take place which are hard to imagine in advance.

This relates to abrupt changes in ecosystems that can occur when some particular aspect of biology proves more sensitive than climate or vegetation modelling can forecast. For example, muskoxen are today raising underweight calves because their winter forage is now covered more frequently with frozen rain than with snow, which is easily brushed aside (Berger *et al.*, 2018).

Sometimes climatic shifts can lead to abrupt ecosystem changes. A prime example is when not very much warming for not very long causes coral bleaching: the symbiotic relation between the coral animal and the alga with which it partners breaks down and the entire coral reef, with all its diversity and productivity, collapses. Sixty per cent of the Great Barrier Reef bleached last year. In another example, in North America's coniferous forests, longer summers and warmer winters have tipped the balance in favour of native bark beetles, with massive tree mortality from southern Alaska to southern Colorado.

At an even greater scale, Earth system change is taking place, such as the aforementioned acidification of the oceans.

The future of biodiversity looks very grim if warming goes beyond 1.5°C above pre-industrial levels. The climate movement 350.org and others advocate a reduction from current carbon dioxide levels of 415 to below 350 parts per million. Use of fossil fuels – actually the remains of ancient ecosystems and photosynthesis – should stop immediately, but that would only halt further rise in carbon dioxide concentrations in the atmosphere.

Largely overlooked is the immense amount of carbon dioxide in the atmosphere from destroyed and degraded nature. It is shocking that it is roughly equal to the carbon that remains in extant nature – about 450 to 500 billion tons of carbon (Erb *et al.*, 2018). Ecosystem restoration has the potential to pull enormous amounts of carbon dioxide from the atmosphere and convert it to living organisms and ecosystems (Lovejoy and Hannah, 2018). If we stopped fossil fuel emissions this instant, ecosystem restoration could bring us back to 350 parts per million through sequestration in living ecosystems of 143 billion tons of carbon.

To do something of that scale is not impossible. It basically requires recognizing that we inhabit a living planet that works as a linked biological and physical system. Ecosystem restoration always brings immediate tangible benefits (*e.g.* an agricultural system that accumulates carbon gains greater soil fertility).

People tend to think of forests first because they do in fact sequester enormous amounts of carbon, but all kinds of ecosystems can contribute to carbon sequestration while simultaneously providing wildlife habitat and other benefits. Restoration is also an activity to which individuals can contribute, alleviating the kind of helplessness that some people feel about climate change. Anyone can help plant a tree, restore a wetland or support agroecology.

In the geological past the planet has twice reduced very high carbon dioxide levels from geological activity like volcanic eruptions to pre-industrial levels of carbon dioxide. We know it works – in fact it has worked twice. That took tens of millions of years, which we cannot afford, but we are quite capable of re-greening the emerald planet. ■

References

Berger J, Hartway C, Gruzdev A and Johnson M (2018) Climate degradation and extreme icing events constrain life in cold adapted mammals. *Scientific Reports* **8**: 1156.

Erb KH, Kastner T, Plutzar C *et al.* (2018) Unexpectedly large impact of forest management and grazing on global vegetation biomass. *Nature* **553**: 73–6.

Peters RL and Lovejoy TE, eds (1992) *Global Warming and Biological Diversity*. Yale University Press, New Haven, CT, USA.

Lovejoy TE and Hannah L, eds (2005) *Climate Change and Biodiversity*. Yale University Press, New Haven, CT, USA.

Lovejoy TE and Hannah L (2018) Avoiding the climate failsafe point. *Science Advances* **4**: eaau9981.

Lovejoy TE and Hannah L, eds (2019) *Biodiversity and Climate Change: Transforming the biosphere*. Yale University Press, New Haven, CT, USA.