ECOLOGY

Avoiding the climate failsafe point

Although models of climate and vegetation change are greatly improving, they remain far from perfect. For example, on the one hand, recent modeling studies indicate that limiting temperature increase to 1.5°C will greatly reduce the impact on the ranges of insect, vertebrate, and plant communities. However, we also know that, since these models do not account for critical climate-sensitive relationships among species, their predictions are serious underestimates.

New research is allowing scientists to better understand the fine-tunings of climate-sensitive relationships among species, including how even very small changes of temperature can have devastating effects on ecosystems. We know, for example, that many coral bleaching events are due to temperature-based disruption of coral reef ecosystems. Even a subtle increase of temperature for a short period can cause coral animals to eject their symbiotic algae, a separation that quickly leads to coral bleaching and often to mortality and the collapse of the entire reef ecosystem. Another example of huge impacts resulting from small temperature changes is that slightly warmer temperatures in coniferous forests of western North America tipped a delicate ecosystem balance to favor native bark beetles, whose populations have exploded and led to widespread tree mortality from southern Alaska and northern British Columbia to southern Colorado.

Historical records of glacial-interglacial swings also help us understand that ecosystems do not move as a unit in response to climate change. Instead, individual species each move at their own rate, in their own directions, and in idiosyncratic responses to changes in climate including temperature. At a certain point, the divergence of responses leads ecosystems to literally disassemble and the species that survive reassemble in novel and unforeseeable biological configurations.

The essential unpredictability of nature in its response to climate change runs counter to the language of the UN Framework Convention on Climate Change, which says that greenhouse gas concentrations should be stabilized at a level at which ecosystems will be able to "adapt naturally" within a predictable time frame. However, as global temperatures increase, the designs of nature are not predictable; once disaggregated, they do not and will not reassemble in previous forms.

Policy makers have set the target of allowing no more than an increase of 2.0°C not for any intrinsic reason but more simply because that level was thought to be achievable. The implications of a 2.0°C rise for sea levels should have been enough to question that target since the last time the planet was 2.0° warmer, the oceans were 4 to 6 m higher as well. Today, many researchers are concluding that ecological systems around the planet will not be able to tolerate temperature rise much beyond 1.5°C. Although current trajectories in energy use and ecosystem destruction seem to be leading us relentlessly forward, a few paths to capping temperature increase at 1.5°C still exist, with the most important likely being ecosystem restoration.

According to new estimates, the proportion of CO_2 in the atmosphere that is generated by destruction and degradation of ecosystems turns out to be much larger than previously estimated. This gives us wonderful hope because that amount—now estimated to be between 450 and 500 Gton—is roughly equal to that remaining in extant ecosystems. What that means is that if we can restore 7.7 Gton of ecosystem services, then we can in turn reduce atmospheric loading by 1 ppm of CO_2. In short, focused and purposeful ecosystem restoration could help us keep global temperature rises at 1.5°C.

There are multiple reasons to engage in ecosystem restoration at scale beyond just the carbon/climate benefit. The amount of degraded lands in the world is vast, and restoring them to productivity as well as for biodiversity and ecosystem services is just plain common sense. Coastal wetlands provide protection from climate-enhanced storm surges. Agricultural systems that accumulate carbon gain in soil fertility. Forests not only protect watersheds but also represent great stocks of carbon and serve as safe havens for biodiversity. Restored grasslands store carbon underground even while being grazed by livestock or native herbivores.

However, the potential of ecosystem restoration to get us to no more than 1.5°C warming does not lessen the imperative to hasten—indeed to accelerate—changing our sources and use of energy. The potential power of ecosystem restoration means that we must take great care in how we balance ecosystem restoration and management with production of biofuels. We must better understand these tradeoffs and avoid clearing native ecosystems while remembering the imperatives of feeding a growing human population and conserving biodiversity.

Are we at the failsafe point? No. We still have time to act upon the recognition that our planet is an intricately linked biological and physical system that holds yet-to-be-understood capacity to heal and clean itself. We still have tools and opportunities to effectively manage the living planet and its biodiversity for the benefit of humanity and all life on Earth.

–Thomas E. Lovejoy and Lee Hannah

Thomas E. Lovejoy, University Professor, Environmental Science and Policy, George Mason University, Fairfax, VA 22030, USA. Email: tlovejoy@unfoundation.org

Lee Hannah, Senior Scientist, Climate Change Biology, The Moore Center for Science, Conservation International, Arlington, VA 22202, USA. Email: lhannah@conservation.org

10.1126/sciadv.aau9981

Citation: T. Lovejoy, L. Hannah, Avoiding the climate failsafe point. *Sci. Adv.* **4**, eaau9981 (2018).

Copyright © 2018 The Authors, some rights reserved; exclusive licensee American Association for the Advancement of Science. No claim to original U.S. Government Works. Distributed under a Creative Commons Attribution NonCommercial License 4.0 (CC BY-NC).

Downloaded from http://advances.sciencemag.org/ on September 27, 2020

Science Advances

Avoiding the climate failsafe point

Thomas E. Lovejoy and Lee Hannah

Sci Adv **4** (8), eaau9981.
DOI: 10.1126/sciadv.aau9981

ARTICLE TOOLS http://advances.sciencemag.org/content/4/8/eaau9981

PERMISSIONS http://www.sciencemag.org/help/reprints-and-permissions

Downloaded from http://advances.sciencemag.org/ on September 27, 2020

Use of this article is subject to the Terms of Service

Science Advances (ISSN 2375-2548) is published by the American Association for the Advancement of Science, 1200 New York Avenue NW, Washington, DC 20005. The title *Science Advances* is a registered trademark of AAAS.

Copyright © 2018 The Authors, some rights reserved; exclusive licensee American Association for the Advancement of Science. No claim to original U.S. Government Works. Distributed under a Creative Commons Attribution NonCommercial License 4.0 (CC BY-NC).