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Editorial

Climate Change Impact on Ecology

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EDITORIAL

The Forum looked at a variety of recent scientific findings on how climate change affects terrestrial, freshwater, and marine ecosystems, sometimes in conjunction with other variables. It focused on current research frontiers such as the effects of changing climatic variability and extremes, connections between climate change and other human-induced stressors, thresholds and the possibility for rapid and irreversible change, and multi-trophic interactions. Ecosystems are quickly altering in response to climate change and other global change drivers, including changes in precipitation, atmospheric carbon dioxide concentration, water balance, ocean chemistry, and the frequency and amplitude of extreme events, among other things. Because of complex interactions among organisms, disturbance, and other stresses, ecosystems differ in their sensitivity and responsiveness to climate change.

Natural ecosystem changes pose a threat to biodiversity around the world and have ramifications for global food production. The works in this part contribute to our understanding of how climate change affects ecosystem features (biological diversity, trophic webs, or energy flux, nutrient cycling, or material flux) in various ecological communities (terrestrial plants, invertebrates in marine sediments, terrestrial soil microbes).

Link climatic variability and extremes to the potential for abrupt and permanent changes in ecosystems in the section's first study. Because extreme occurrences are unpredictable and rarely predicted, Abrupt Changes in Ecological Systems (ACES) are difficult to monitor empirically. Nonetheless, the authors advise scientists to place a high focus on identifying, explaining, and anticipating ACES as a result of climate change. We are beginning to see rising rates of change in the strength and frequency of individual drivers, rather than a "new normal" (equilibrium). The research uncovers key generalisations that lead to new questions and possibilities for future research. Some aspects of ecological systems are more vulnerable to sudden change than others; climate extremes may be more likely to cause rapid change than mean trends (e.g., coral bleaching is caused by extreme heatwaves rather than gradual ocean warming); Multiple drivers frequently interact to produce ACES (e.g., climate change-driven drought and extreme fire can cause abrupt changes in terrestrial ecosystems from forest to non-forest, introduced pathogens in combination with climate can cause populations of sensitive species to crash); historical contingencies (ecological legacies, frequency and order of disturbance, spatial context) are important drivers of ACES due to ecosystem memory; and strong positive feedbacks in a system are important drivers of ACES (tipping points).

Longer-term perspectives are needed to increase our knowledge of community reactions to change in ecological communities. During the Late Quaternary, temperate forests experienced long periods of stability and abrupt change in response to climate change and human activities (burning for land clearing), and a site-specific understanding of stability *versus* disequilibrium is needed to predict future ecological scenarios under rates of warming unprecedented in the Holocene and beyond.

Climate change ultimately leads to a loss of terrestrial biodiversity and has an impact on ecosystem carbon storage both directly and indirectly through land use change, such as farmland expansion due to climate change.

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