Long-term research reveals how climate change is playing out in real ecosystems

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Around the world, the effects of global climate change are increasingly evident and difficult to ignore. However, evaluations of the local effects of climate change are often confounded by natural and human induced factors that overshadow the effects of changes in climate on ecosystems. In the December issue of the journal *BioScience*, a group of scientists writing on long-term studies of watershed and natural elevation gradients at the Hubbard Brook Experimental Forest in New Hampshire and in the surrounding region report a number of surprising results that may shed more light on the complex nature of climate change.

According to Peter Groffman, one of the lead authors and a principal investigator at the Hubbard Brook Long Term Ecological Research (LTER) program, these studies highlight the value of long-term integrated research to assessments of the subtle effects of changing climate on complex ecosystems.

"This analysis shows the power and value of long-term ecological research," says Groffman. "The ability to use long-term data streams as a platform for asking detailed questions about complex changes in the environment is the only way that society will be able to grapple with how climate change is playing out at the local scales that most directly affect people."

While the scale and pervasive nature of climate change can motivate scientists to try approaches that depict atmospheric and ecosystem processes at regional and global scales, these approaches may not give a

complete and accurate assessment of the effects of climate change on ecosystem structure, function, and services at local scales.

Because climate change plays out on a complex and dynamic landscape with intertwined patterns of soils, vegetation, and hydrologic flowpaths and interacts with many human and natural factors over many areas and time periods, the report says the various effects of climate change cannot be predicted purely from the broad effects of temperature and precipitation on ecosystem properties. The authors argue that long-term integrated studies, such as those conducted over the past 50 years at Hubbard Brook, should be an essential component of climate change research and assessment. In their estimation, a combination of long-term and in depth measurements is essential for understanding the interplay between climate and forest ecosystem dynamics.

At Hubbard Brook, that interplay has produced surprising effects on hydrologic variables such as evapotranspiration, streamflow, and soil moisture; the importance of changes in periodic biological occurrences on water, carbon, and nitrogen fluxes during critical transition periods; climate change effects on plant and animal community composition and ecosystem services in winter; and the effects of human induced disturbances and land-use history on the composition of plant communities.

The report recommends further research on how climate change affects multiple components of ecosystem structure and function at specific sites to investigate what determines the composition of plant and animal communities, the rate of flow of water, and other natural and human elements that impact ecosystems in many areas of the globe.

Groffman says the results from these detailed studies should be incorporated into broader approaches that include modeling, experiments and long-term monitoring at multiple scales. The report

suggests that coordination of long-term research efforts and development of common approaches will improve the scientific understanding and response to the overarching challenge that climate change presents to science and society.

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