Site-specific, long-term research expanding understanding of climate change

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While science has often focused on big-scale, global climate change research, a study recently published in the journal *Bioscience* suggests that long-term, integrated and site-specific research is needed to understand how climate change affects multiple components of ecosystem structure and function, sometimes in surprising ways.

"Long-term ecological research is important to understanding the effects of a changing climate on our natural resources and so much more," said Michael T. Rains, Director of the Forest Service's Northern Research Station. "With a network of more than 80 experimental forests and decades of monitoring data from these forests, the Forest Service is contributing invaluable information to this and a wide-range of critical research topics."

Research at the Forest Service's Hubbard Brook Experimental Forest in New Hampshire's White Mountains forms the basis for the article "Long-Term Integrated Studies Show Complex and Surprising Effects of Climate Change in the Northern Hardwood Forest," by Peter Groffman of the Cary Institute of Ecosystem Studies with Forest Service scientists Lindsey Rustad and John Campbell and others. The paper describes how the interplay of climate, forest ecosystem dynamics, and past land use determines how an individual forest might respond to climate change. The paper is available online at: http://nrs.fs.fed.us/pubs/42303

At the Hubbard Brook Experimental Forest, that interplay has produced surprising effects on hydrologic variables such as evapotranspiration,

streamflow, and soil moisture and revealed the importance of changes in phenology on water, carbon, and nitrogen fluxes during seasonal transition periods. Scientists have also found surprises in winter climate change effects on plant and animal community composition and ecosystem services as well as the effects of anthropogenic disturbances and land-use history on plant community composition.

"The effects of climate change that we are documenting at the Hubbard Brook Experimental Forest truly affect all components of this forest," according to Rustad. "From winter recreation to Lyme Disease to changes in timber resources, what is happening in the forest is going to affect how people live, and science needs to address those questions."

Data from Hubbard Brook Experimental Forest show unequivocally that the climate has warmed, and temperature matters for species from the minute to the mighty. A warming climate is increasing the length of the growing seasons, as spring is advancing and fall is retreating. This extends the breeding season for birds, but also makes them more susceptible to late season frosts. Less snow in winter means more soil frost, which can damage tree roots and reduce the diversity and abundance of arthropods. Reductions in soil arthropods may directly affect the animals that feed on them, with ripple effects on the entire forest food web.

Warming winters also affect the distribution of pests and pathogens, such as the hemlock woolly adelgid, which are fundamental agents of disturbance in northeast forests. The insect's expansion north has been checked by its inability to tolerate temperatures colder than 13 degrees Fahrenheit, however researchers found that over the past 50 years Hubbard Brook Experimental Forest has experienced a 40 percent decline in days with a mean temperature of 13 degrees Fahrenheit, suggesting a potential for the hemlock woolly adelgid to affect hemlock throughout the tree's entire range within the next 30 years.

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