The Outside Story

Some Early Research on Climate Change and Soil

By: Rachel Sargent

For many of us, winter in the Northeast means cold temperatures and piles of snow, drifting through forests and across fields. It's hard to imagine that winter here could be different, but the prospect of climate change has scientists asking just what our winters might look like in the future – and how those changes might influence forest ecology.

At the U.S. Forest Service's Hubbard Brook Experimental Forest, scientists are thinking about the year 2100. How much warming will occur isn't certain, but some projections suggest that average air temperatures in our region may increase 5.5 to 9 degrees over the course of this century. The effects are likely to be complex and are difficult to predict, with benefits and costs for different organisms. Some tree species, for example, may benefit from longer and warmer growing seasons, but they may also sustain root damage from more frequent soil freezing.

It may seem counterintuitive that soils would freeze more often during warm winters. The reason is a projected lack of snow. The blanket of snow that usually accumulates during winter insulates the soil below, preventing it from experiencing the full, sub-freezing temperatures of the air. When warmer temperatures leave a thinner blanket of snow, or none at all, the soil is more likely to freeze when cold-snaps strike.

To tease apart the opposing effects of a warmer growing season and more soil freezing in winter, Hubbard Brook researchers have started the "Climate Change Across Seasons Experiment" (CCASE), to investigate cross-season effects on maple trees. Geoff Wilson, a research technician at Hubbard Brook, explained that there is a long history behind this project.

Since 1955, the U.S. Forest Service has maintained a long-term watershed monitoring project, taking daily or weekly measurements of environmental and meteorological conditions such as temperature, precipitation, snowpack, streamflow, and biogeochemistry. These data supported pioneering work on acid rain research, and also revealed, in the 1990s, another surprising change. There was something weird in the watershed records: unexplained spikes of high nutrient runoff in some years. Because they occurred after winters with less snow, researchers suspected the nutrient spikes were linked to the weather.

To investigate this phenomenon, in 1999, a research team led by Peter Groffman of the Cary Institute of Ecosystem Studies conducted a series of soil freezing experiments at Hubbard Brook. The researchers used shoveling to mimic reduced snowpack on 10 x 10 meter plots of mixed tree species at different elevations. This was not easy work – imagine drawing the short straw and trudging out to the study plots after every snowfall – but it yielded some clear consequences of soil freezing.

The shoveled plots that experienced soil freezing had higher levels of nutrients in the soil water collected from them – corresponding with the elevated nutrient runoff that researchers had first noticed following warm winters. These plots also exhibited more root damage than control plots that were insulated with snow. The team found that the trees most affected were sugar maples.

Like all good science, these studies led to yet more questions, which is why Hubbard Brook started the CCASE project.

This project, led by Dr. Pamela Templer of Boston University, tracks six 11x14-meter plots dominated by red maple. To prepare, in 2012, Templer's team buried 2.5 miles of electrical cable to warm the soil. "The electricity bill must be substantial!" Wilson commented.

In some plots, the soil is warmed an additional nine degrees during the April – November growing season, and an insulating blanket of snow is left for the winter. In other plots, the soil is warmed for the growing season, but the snow is shoveled off for the first several weeks of winter to let the soil freeze.

The CCASE experimenters measure nutrient and water uptake by trees, root growth and death, and competition for nutrients between plants and microbes. They also investigate the effect on soil arthropods, as Templer and her students have seen soil arthropod diversity drop after soil freezing events.

This is a multi-year study that's still in progress, but Wilson shared some early observations. They're seeing that the extra warming in summer plots does increase tree growth. Unfortunately, even if trees benefit from more growth in the summer, this benefit may be limited since the trees also experience root damage due to soil freezing in the winter. Studies like this one are early steps in exploring how climate change may impact forests, but there are still many questions to be answered.

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