Templer's Sense of Snow

CAS BIOLOGIST PROBES THE IMPACT OF SNOW-CHALLENGED WINTERS
BY SUSAN SELIGSON

WHITE COLLARS measure rates of carbon dioxide exchange in trees in Pamela Templer's research plot at Harvard Forest.

When Pamela Templer muses about silver white winters that melt into springs, she is thinking beyond the photogenic snowfall of show tunes and poetry to the complex natural world hidden beneath. It is a world in delicate balance, with soil nourished by dead leaves and rich in insect and other life that thrives in part because of snow.

Now in the fourth year of field studies at experimental forests in Massachusetts and New Hampshire, the College of Arts & Sciences associate professor of biology is studying the way shrinking snow cover—consider this past

PHOTOGRAPHS BY MELODY KOMYEROV

In a cold winter with little snow, the normally protected soil freezes, along with tree roots and other flora and fauna.

nearly snowless winter—affects the robustness and future of New England forests. And while her biology department laboratory boasts state-of-the-art gas chromatographs and AutoAnalyzers, out in the field one of the main tools of Templer's trade is a standard snow shovel. Because snow acts as an insulating blanket, she has set out to measure what happens when that blanket is pulled back, exposing the soil to a deeper-than-normal freeze.

Last fall, in a 1,600-square-foot experimental plot at Harvard Forest in central Massachusetts, Templer padded through the undergrowth as she described the many variables—from soil temperature to carbon dioxide uptake—being monitored at plots she and her team of doctoral students and undergrads have staked out there.

The forest, a center for long-term ecological research encompassing a dozen institutions, is a 3,500-acre expanse of mostly red oak and maple trees, where scientists from all over the world investigate how forests respond to natural and human disturbances and environmental change. The first experimental forest of its kind to set up a tower to measure carbon exchange, it's a busy place until winter—the dormant season—arrives. But for Templer, that's when things get really interesting.

Although the trees are alive and respiring in winter, they are not taking up nutrients or photosynthesizing—the process, driven by sunlight, by which plants make carbohydrates (sugars) from carbon dioxide and water. "But recent studies have shown there's a lot going on," says Templer, who recently won a National Science Foundation five-year CAREER Award for her research on climate change in northern forests.

In winter, tree roots are protected by snow, which also provides insulation for insects and other organisms. Fresh, undisturbed snow is typically 90 to 95 percent air, trapped among the lattice structure of the amassed snow crystals and forming an insulating layer. In a cold winter with little snow, the normally protected soil freezes, along with tree roots and other flora and fauna.

By comparing undisturbed "reference" plots with test plots that Templer and her team shovel after each fresh snow, they hope to chart the effects of what might appear to be a passing seasonal quirk, but is in fact far more ominous. Since data show New England winters are growing warmer, the dwindling snow cover is more likely a manifestation of climate change. In the simplest terms, temperate-zone winter soil needs snow cover to keep it from freezing and allow it to carry on its role in plant growth, and ultimately, in the quality of the food we and other animals eat and the air we breathe.

According to Templer, in the temperate deciduous forests of New England, trees in winter lose their leaves to be more efficient in their nutrient retention.

"Forests are like big sponges," she says, because they store more than half the organic carbon on the planet. Climate change scientists are trying to determine which forests around the world absorb and store more carbon from the atmosphere than they release into it, a reassuring state known as net carbon sink. "In the northeastern United States, our forests hold onto only 15 percent of the total amount of carbon," she says, far less than the ideal.

SENSORS ATTACHED to sugar maples monitor sap flow, which has diminished with smaller snowpacks. The result is less maple syrup.

PAMELA TEMPLER points to sap flow sensors on a tree at Harvard Forest, with students Mary Farina (CAS'12) (from left), Keita DeCarlo (CAS'13), and Anna Ta (SAR'13).

"Whether it's caused by warming that increases respiration or winter change that damages trees and diminishes their ability to take up carbon, we could switch from being a carbon sink to a carbon source—that means more carbon released to the atmosphere, greater warming, and a smaller snowpack."

HOOKED UP LIKE INTENSIVE CARE PATIENTS

Call it a snowball effect—a smaller snowpack is likely to increase soil frost, causing root damage, reduced forest productivity, and lower rates of forests' removal of carbon from the atmosphere, says Templer, whose work is funded with grants from the Andrew W. Mellon Foundation and the U.S. Department of Agriculture. Her fieldwork, in which trees are hooked up like intensive care patients to syringe needles and sap flow sensors and plastic chambers with carbon dioxide analyzers, is complemented by in-depth laboratory examinations of plant and soil samples, measuring things from nutrient levels to microbial and insect life. To obtain late autumn samples of the last leaves clinging to the trees, she enlists the help of a forest employee, who hands out hearing protection headsets, aims a .22-caliber rifle at the canopy, and sends a few of the highest branches falling with a deafening pop.

WEB EXTRA Watch a video about Pamela Templer's research into the effects of climate change on New England forests at bu.edu/bostonia.

Previous studies at the Hubbard Brook Experimental Forest in New Hampshire's White Mountains have shown that periods of soil frost kill fine roots and result in greater-than-expected losses of carbon and nitrogen, Templer says. She hypothesizes that an increased depth and duration of soil frost also results in a decrease in forest productivity and a reduction in nutrient uptake by dominant woody plants. The environmental strains of decreasing snow levels are already surfacing. "Maple syrup producers around the Northeast have observed over time that the relatively smaller snowpack is causing a decrease in sap volume, which results in less maple syrup," she says. It takes about 40 gallons of sap to produce a single gallon of maple syrup. "So we're very interested in looking at sap levels," she says, adding that the BU team is collaborating with regional maple syrup producers to study their output.

The team also reported a significant decrease in the number of arthropods—mostly spiders—that live in the winter soil. "They're usually insulated by the snow above and don't have to worry about being frozen," Templer says. In addition to finding in two years of data collection that spider populations decline in plots with soil frost, the team observed a decrease in arthropod diversity.

Templer is also measuring levels of nitrogen, another marker of change in soil nutrients. A major building block of life, nitrogen is converted to a usable food for plants by microorganisms in the soil, and freezing can take a huge toll on these, too.

"As soon as the snow melted we were out there at the plots, collecting soil samples," says team member Annie Socci (GRS'12). "We'd find sugar maple roots in the soil, give them a nitrogen solution, and measure nitrogen uptake over time. After two years of doing that, during the early, middle, and late growing season, we found that compared with the plots we left alone, the plots we shoveled showed 46 to 55 percent less nitrogen uptake." One thing scientists studying climate change agree on is that air temperatures in the northeastern United States are expected to rise, Socci pointed out on one unseasonably balmy day in late November. "If there's no snow on the ground before the first freezing temperatures arrive in Boston, the soil will freeze, and forest productivity will be reduced."

As Socci puts it, people are skeptical about climate change, especially when a cold spell hits: "They'll look at me and say, 'I thought you said temperatures were going to rise.'" But the more the research of Templer and her team is publicized, "the more people understand and put the pieces together," says Socci, who wintered last year at Hubbard Brook. "We really focus on some indirect, and not necessarily intuitive, effects of climate change."

Among these, perhaps the most compelling is the likelihood that snow—for all its potential inconvenience—is a very good thing. ■