Early spring warming has greatest effect on breaking bud

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Research assistants Sarah Butler (left) and Lauren Nichols prepared one of the warming forest test chambers in the Duke Forest in May, 2009. Native tree species are grown in the open-topped chambers in North Carolina and Massachusetts that are heated to 3 degrees Celsius or 5 degrees Celsius warmer than ambient temperatures. Credit: Megan Morr

The timing of the first leaves on trees and plants can make or break an agricultural season. Too early, and the leaves might be blasted by the last frost. Too late and they miss out on maximizing the growing season.

But as climate change brings warmer-than-usual winters to the U.S., the plants may be more vulnerable to imprecise timing, and the tools traditionally used by farmers and horticulturists to predict the season may be inadequate.

"How do we do a better job of seeing the climate the way the plants see it?" asks James Clark, the Blomquist Professor of environment and biology at Duke University. With colleagues from the Marine Biological Lab at Woods Hole and the University of Georgia, Clark is working on building a statistical model of how trees make this decision.

The first takeaway from that work, now appearing online in the journal *Global Change Biology*, is that "there is a certain time of the year when warming has the most impact," Clark said. And that time would appear to be from mid-February to mid-March, a few weeks before the buds would be expected to open.

Unseasonal warming during that late-winter/early-spring period has more effect on the plant's timing than at any other time of the year, Clark said.

Farmers and horticulturists have long relied on the concept of degree days to have a ballpark sense of when the leaves will arrive and where it is safe to plant crops and ornamentals. Degree days are a measure of how many degrees above or below a mean the temperature has been over a period of time.

"The degree-day model makes most sense when the climate isn't changing," Clark said. But this new model is showing that it may become unreliable as temperatures depart from historical norms.

Data for the study comes from an experiment the researchers are running in the Duke Forest in North Carolina and in the Harvard Forest in Petersham, Mass. A mix of native trees are living in open-topped,

temperature-controlled chambers in natural forests. Some plots are unheated, others are heated to 3 degrees Celsius or 5 degrees Celsius higher than the ambient temperature.

In the case of the Duke plot, that meant that the +5C chamber experienced no below-freezing temperatures in the unusually mild winter of 2012, Clark said.

It was thought that the trees were "programmed to experience a certain amount of chilling and then warming," Clark said. But in this case, they wouldn't have met their usual requirement for chilling before experiencing the warming that signals it's time for spring. Yet they still budded very early. "The dormant season is more complex than we thought," Clark said.

Some species are more sensitive to an unusually warm winter than others, Clark said. Some will advance their budding to match the earlier season, while others cannot. "As the climate changes, can we see differences in how species track change through time?" Clark asks. "Averages don't work anymore because the plants aren't seeing the average."

More information: "The seasonal timing of warming that controls onset of the growing season," James S. Clark, Jerry Melillo, Jacqueline Mohan, Carl Salk. *Global Change Biology*, online Oct. 1, 2013. DOI: 10.1111/gcb.12420

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