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Climate change, other factors may reshape central Appalachian forests

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The hardwood forests of the central Appalachians are a bastion of biodiversity, providing protective habitat for some 6,000 species of plants and animals. They support a $5 billion forest products industry in Pennsylvania alone. But these forests face stresses that could change their character substantially over the next hundred years.

One of these stresses is climate change. Given current forecasts for rising temperatures and increased precipitation, the suitable habitats for many individual tree species are expected to migrate north. But forest ecologist Margot Kaye says the impact on actual trees is hard to predict.

"Trees persist for so long on the landscape, they have to be able to tolerate a wide range of conditions," Kaye says. "If you just took a species on its own and looked at its physiological limits, that's one question. But you can't take that species away from the environment it's growing in. You have to look at the whole forest."

In the Northeast in particular, that's a challenging task. "The forests here are very complex," Kaye says. "There is no single smoking gun like precipitation that acts as a limiting factor. There are many contributing factors."

To begin to sort things out, Kaye and her students conducted a three-year experiment on a small plot of land near Penn State's nature center in Stone Valley. They cleared the land and then, using heat lamps and irrigation, set up conditions to mimic the warmer and wetter projections for the future. "We wanted to see the effects of these changes on the successional environment," Kaye says.

With regard to tree regeneration, she reports, perhaps their most significant finding was that the direct effects of warming were not as important as some of the indirect effects that were observed.

Northern red oak, for example, managed to germinate and grow just fine under conditions of two degrees warming. "Moderate warming, by itself, is not going to be the bottleneck," Kaye concludes. "But then you have to look at things like competition."

Young trees, she explains, rely heavily on the shoulder seasons—spring and fall—to grab the light they need. "There are these little windows of opportunity, especially in spring, where they can get a lot of light, and fix a lot of carbon, before other, faster growing plants start to block the sun."

Kaye and her team found that under warming conditions, trees and tall shrubs began to put their leaves out significantly earlier. Where under normal conditions the forest's greening is staggered by species, with simulated warming, it all pops out at once.

"What you start to have is an issue with some species losing that window of time," Kaye says. "And that will then eventually have cascading effects on biodiversity. If you look at how well any given group of plants is doing, what's actually most important is not temperature and precipitation, but how much of everything else is around. That's what determines most of their success."

A complex picture

Another indirect effect plays out below the surface. "In a warmer, wetter environment, you'd expect increased soil respiration"—the critical production of carbon dioxide by soil microorganisms. "But there was no increase," Kaye says. "Respiration was no different from the ambient—it actually was less than with warming or wetting alone." Her graduate student, Marshall McDaniel, suggested in his Ph.D. dissertation that the repeated cycles of wetting and drying put stress on the soil's microbial community, and some of the microbes couldn't handle it. Those that remained couldn't break down carbon as efficiently.

Beyond its impact on microbes, increased precipitation seemed to have no effect on regeneration. "This is a pretty wet area," Kaye reasons. "Maybe the amount of water we added was not enough to make a difference." But if the predictions of climate modelers come true—fewer but more intense storms with longer periods of mini-drought between them—"that could change things very much, especially when we're talking about saplings with shallow roots," she says.

The difficulty of simulating precipitation change shows the limits of small-scale experiments, she says. "They're great for answering some questions, but they give us only one piece of the puzzle. Now we need to look at what's really happening on the landscape."

To do that, Kaye and graduate student Christy Rollinson are collecting tree-ring samples from all across the central Appalachian range, and comparing them against temperature and precipitation records for the last hundred years.

Climate change is not the only concern, Kaye notes. Land-use practices, including the widening footprint of Marcellus shale drilling, invasive plant species and insect pests like the woolly adelgid and the emerald ash borer, and a large and growing deer population could cause significant changes in forest composition.

"I can't tell you right now what these forests will look like a hundred years from now," she says. "We will need a better understanding of all these influences, and of how they fit together."

Provided by Pennsylvania State University

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