Researchers work to restore iconic West Virginia red spruce forests

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Lacy Rucker, a doctoral student at West Virginia University, searches for salamanders that inhabit red spruce ecosystems. Researchers at the Davis College of Agriculture, Natural Resources and Design are studying ways to restore the red spruce as it faces threats from warming temperatures. Credit: West Virginia University

Clearcutting and wildfires decimated the red spruce, once the dominant, high-elevation tree species in West Virginia, in the late 1800s and early 1900s. Nowadays, only 10% of the state's historic red spruce coverage

remains and it faces a new threat in climate change.

West Virginia University researchers Donald Brown and James Thompson with the Davis College of Agriculture, Natural Resources and Design are working toward restoring some of the original tree habitat by studying the long-term effects of warming temperatures on red spruce and the creatures that call that ecosystem home.

The animals within

Brown, a research assistant professor of wildlife resources, focuses largely on animal populations within the red spruce ecosystem. Notable species that inhabit the forest include the Virginia northern flying squirrel and the native brook trout. A herpetologist, Brown has also studied the threatened Cheat Mountain salamander, a federally protected species endemic to West Virginia. It lives only in the high-elevation spruce forest. As the climate warms, however, the eastern red-backed salamander, a lower-elevation species, has begun moving up into the Cheat Mountain salamander's range and competing for resources.

Brown's research on the Cheat Mountain salamander was recently published in the *Journal of Fish and Wildlife Management* and in *Forest Ecology and Management.*

As Brown has focused on the relationship between the Cheat Mountain salamander and its forest habitat, he's also looked at the role red spruce restoration plays in various species' success and whether a restored forest is as suitable a habitat as a virgin forest. He and his students also conducted a bird study to quantify birds that were specifically associated with red spruce forests, recently published in *Ecological Indicators*.

One finding is clear: climate change is a serious threat to red spruce because of where it grows.

The northern tree species follows the cool, wet Appalachian ridges down into North Carolina, but rising temperatures limit the chances for survival.

"They're already at the top of the mountain," Brown said. "There's nowhere to go. Some of the research has been pretty dire, essentially projecting that we're going to lose red spruce this century."

Current genetics research offers some hope. Researchers can identify seeds most likely to persist in warming temperatures and manipulate what is planted for the best chance for survival.

From the ground up

While Brown's research looks at red spruce forests as habitat for other species, Thompson takes a soil scientist's unique perspective. He works with the U.S. Forest Service and the Natural Resources Conservation Service to study soils in red spruce forests, and his research indicates a dynamic connection between the trees and the rich, spongy soil from which they grow, even at the southern end of their range.

"The soil types and our climate are right, so those red spruce are able to survive," he said. "But as the red spruce ecosystems persist, they start to change the soil even more and create certain characteristics that are unique within West Virginia. When we find a red spruce, we find certain types of soils."

Using this logic, Thompson and his colleagues postulate that the presence of those same soils elsewhere may indicate a former red spruce habitat. Similarly, the soils of both modern and historic spruce populations—the latter being locations where forests existed before clearcutting—form a map that can guide future restoration plantings.

"Soils are essentially a long-term record of the past," he said. "They carry the imprint of what's happened in the past and that imprint persists. Even though some of those areas haven't had spruce on them for 100 years or more, they remember that they used to support red spruce forests because they maintain that evidence in the soil."

Research indicates that a location suitable for red spruce a century ago would today be more likely to support a successful restoration effort.

"That's why I think using soils as a guide for red spruce restoration can be helpful," Thompson said. He added that consideration of soils is an important component of restoration efforts because red spruce soils store more carbon than non-spruce forest soils.

"If you're concerned about carbon sequestration and climate change, restoring red spruce forests will give you that carbon stock benefit," he said. However, the benefits of red spruce soils extend beyond carbon capture, as they have a higher water holding capacity. This changes the hydrology of the watersheds and limits downstream flooding.

A recipe for success

In addition to their own research, Brown and Thompson have partnered with the Central Appalachian Red Spruce Restoration Initiative. CASRI was formed to restore red spruce to the landscape. Over the past two decades, the initiative has become more focused and now consists of over a dozen government and non-government entities, including the Monongahela National Forest, West Virginia Highlands Conservancy and The Nature Conservancy. Many WVU scientists have contributed to the initiative's efforts; now, both Brown's and Thompson's research plays an important role in furthering restoration.

"Over the years, I've just become more and more involved with the

partnership," Brown said. "I've tried to find ways to conduct research that will inform their mission. The actual plantings that they've done have exponentially increased over that period."

He believes it's the collective effort that drives the organization's progress, and ultimately, the success of the volunteer initiative.

A restoration guidebook

Brown and Thompson are collaborating on a guide for red spruce restoration. The effort is a vital initiative between Davis College scientists, government entities and non-government organizations.

"The book has over 30 different contributors that are part of the partnership," Brown said. "We're trying to do an up-to-date synthesis of what we know about the ecology of red spruce, as well as the restoration actions that have occurred and will occur into the future."

Thompson and some of his former graduate students contributed to two chapters to the book. One covers the soils of the red spruce ecosystem and how they relate to identifying potential restoration sites. The second chapter considers the restoration potential that has come out of WVU's collaboration with the Forest Service and the Natural Resources Conservation Service. It draws connections between management decisions and how the ecosystem may or may not change in response.

While restoration efforts continue with input from researchers like Brown and Thompson, red spruce grow slowly compared to other trees. This means that today's seedlings will long outlive the hands that plant them.

"We won't see the results in our lifetime," Brown said. "We're really looking at decades to centuries to get to this mature forest stage that

we're ultimately interested in."

More information: Donald J. Brown et al, Microhabitat Associations for the Threatened Cheat Mountain Salamander in Relation to Early-Stage Red Spruce Restoration Areas, *Journal of Fish and Wildlife Management* (2022). DOI: 10.3996/JFWM-21-042

Lacy E. Rucker et al, Long-term occupancy dynamics of the threatened Cheat Mountain salamander and its competitors in relation to linear habitat fragmentation, *Forest Ecology and Management* (2021). DOI: 10.1016/j.foreco.2021.119847

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