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Preparing Trees for a Changing World

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Ponderosa pine and aspen seedlings nestle together in cherry red tubs in the John T. Harrington Forestry Research Center in northern New Mexico. The room smells damp and a fan buzzes at the ceiling. Owen Burney, superintendent of the research center and associate professor with New Mexico State University, stands over the fluttering rows, the pale and bluish green shades of new leaves and needles, describing the torture he puts them through.

Rather than pamper seedlings at the John T. Harrington Forestry Research Center in northern New Mexico, Owen urney puts them through stressful thirst. Photo by Elizabeth Miller.

"We really are bringing them to the edge of death," he says.

Typical nursery protocol pampers seeds, spurring fast and robust growth for forest replanting efforts. But then young trees leave those temperate and well-watered walls for an increasingly hot, dry world. The vast majority of them die. Research suggests this high mortality rate may be just one among many signals that forests are in trouble, and many could soon be lost altogether. So Burney — tall, loquacious, with strong opinions about trees based on the difficulty, patience, or itchiness involved in handling their seeds — tries to prepare trees for this changing world.

The seedlings he works with, individually planted in forearm-length, conical, black containers, are watered from below by filling those red tubs. Then, for days at a time, he'll lets them dry out. Even when they are so young and fragile as to be in what he calls the "birdcage stage," a handful of needles pinched together at the top in the bean-sized seed coat from which they burst, he puts them through what is, for a plant, stressful thirst. But later, while other seedlings wither, these thrive.

The persistent thread in studies of North American forests bodes of a grim future. While many of these forests adapted alongside recurrent wildfire — and some birds and beetles prefer burn scars and some plants only cast out seeds after being burned over — the balance is off now. A century of fire suppression left denser forests that burn more intensely, destroying thousands of acres of trees at a time instead of leaving behind a mosaic of unburned adult trees that can re-seed a new forest. Climate change is both increasing fire activity, as attested by the many fires currently burning in California, Colorado, Arizona, and New Mexico, and making for warmer, drier conditions that mature trees may endure, but seedlings can't survive. An article published in the journal *BioScience* in July found that after high-severity fires, a lack of tree seed sources, a warmer and drier climate, and recurrent wildfires are all limiting forests' abilities to recover. Landscape-changing events are likely to happen more often and on a larger scale. Some regions could lose a third to half of their traditional forests, reshaping the ecosystem and watershed for all life in and around it, including people downstream.

"We can't assume the future will resemble the past or the present, but what is sort of the end point of the changes that are unfolding now, we really have no idea," says Jonathan Coop, associate professor at Western Colorado University and lead author of that paper. "I'm looking at a ponderosa pine forest in New Mexico and I can say, in a hundred years, it's unlikely this area will support a ponderosa pine. Pinyon-juniper is more likely, and in some cases, it might not even be that."

There is already a significant need for expanded efforts to conserve functioning forest ecosystems, Coop says, and that need will grow. Their paper, among other efforts, prods forest managers not to simply walk away after a fire or a beetle-kill event and write that forest off as a loss.

But the situation raises questions about what to plant and where, both in terms of what science says and what ethics allows. Should humans help trees migrate? Does it make sense to replant the species that once lived in an area when they will face a hostile environment before, by a tree's standards, they reach middle age?

Replanting efforts often see just 25 percent of seedlings survive. Add fencing or other protection from browsing elk, deer, and pocket gophers, and that rate goes up to 65 percent, Burney says. In early tests, drought-conditioned seedlings suggest that number could bump up again to as high as 85 percent survival. Burney is looking for ways to increase these odds in an increasingly arid Southwest by supporting genetic and adaptive changes within tree species.

Research he conducted with Northern Arizona University professor Thomas Kolb and graduate student Allap Dixit checked the lifespan of ponderosa pine seeds collected from trees that had grown at warmer, drier sites against those from wetter, cooler sites, some of which were drought conditioned. Trees were planted in pinyon-juniper forest, a hotter, drier zone inhospitable to ponderosas.

“We killed them — on purpose,” Burney quips.

But they found that seeds from trees growing in hot, dry conditions lived longer, suggesting some inherited drought tolerance. Among those, the seedlings drought-conditioned in his nursery survived longest.

“Growing the seedlings with some stress can help precondition them to harsh conditions that they experience when they’re planted out in the forest,” Kolb says. “So this might be a fairly easy, low-cost way of increasing the survival, at least in the short term, of ponderosa seedlings that are planted in reforestation projects.”

Earlier this year, the National Science Foundation’s Centers of Research Excellence in Science and Technology (CREST) awarded New Mexico State University, partnered with New Mexico Highlands University and the New Mexico Forest and Watershed Restoration Institute in what’s called the Forest Restoration Triangle, a $5 million grant to study restoration activities. That research will dial in on questions like those around tree density, drought-conditioning, and shelter from browsing animals. Bottom line, Burney says: If we figure out — and fund — replanting trees, we don’t have to lose our forests.

The greenhouses Burney runs, which sit on 110 acres in the Mora River Valley, a lush, green corridor on the eastern face of the Sangre de Cristo Mountains in northern New Mexico, were built to fix a different problem. The nursery started in 1972 to support a buzzing timber industry. Then, precautions for endangered Mexican spotted owls shut down the harvest long enough to close lumber mills, adding to a list of challenges faced by the local timber industry, which soon collapsed. The focus shifted to replanting after mining and wildfires.

He started toughening up his seedlings after North Carolina State University forestry and environmental resources professor Barry Goldfarb prompted him to try stress treatments, which many nurseries use to some degree, when the plants were younger.

“If we begin stressing it early on, while those building blocks are being laid down, then we may be able to manipulate the morphology and the physiology to be better prepared for those stressful environments,” Burney says.

A tree’s internal components include what’s essentially an internal piping system called xylem. Some xylem move water through the trunk, while others provide structure. He suspects that drought-conditioning compels the tree to dedicate more xylem to moving water, an insurance policy against dry stretches that may kill off some of them. Kolb notes seedlings grown with periodic water stress tend to be smaller, and so might need less water for that reason. They also end up looking “extra rooty,” suggesting the stress might prompt them to direct more energy into their root system than their leaves.

The trouble in exporting the approach lies in how tailored it needs to be. Burney cuts off water not for a set time period, but just until the plant approaches the wilting point.

“We push those limits, and we want to push it as far as we can,” he says. But it’s delicate. Push too much, and the seedlings die.

Drought-conditioning is just one of many areas of forestry research and infrastructure that need added capacity and more funding, from seed collection and storage — a walk-in freezer in one of the NMSU greenhouses holds one of few seedbanks in the Southwest — to nursery capacity, replanting efforts, and follow-up measures. New Mexico State University’s greenhouses have the capacity to grow 300,000 seedlings annually, a fragment of what's needed with wildfires burning an average 6.8 million acres in the United States each year, even if only 5 to 10 percent of those acres need replanting.

Drought conditioning, he says, is "not a silver bullet, but it is a tool in the toolbox. There's models out there that are looking at climate change and basically saying, 'Oh, we're going to have all these failures of planted trees, because the climate at 2100 is going to be so hot and dry, that even planting now, we're going to have failures with reforestation.' But what's missing in these models is the inclusion of the variables."

They don't account for moving seeds from plants growing in hotter, drier areas to places that are becoming hotter and drier, or practices in nurseries like drought-conditioning seedlings, or changing the timing or sites selected for planting, or protecting them from animals, or taking care of the seedlings after they're planted.

"You incorporate that into a model," he says, "and it will change — drastically."

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