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Seed Banks Provide a Peek into Past and Future Fire Adaptation

Seed banks can provide insight into a forest's past and give land managers valuable information to help them plan for the forest's future. For example, knowing which species may germinate after future fires is valuable, especially when non-native invasive species in the seed bank could proliferate quickly following disturbances. Short-term studies comparing seed banks and vegetation before and after burning do not reliably predict how fire could impact seed banks over a long period of time. Instead, researchers can turn to witness trees—trees used historically to mark property or boundaries—for insights into which areas might have been historically burned.

Researchers Cynthia Huebner and Melissa Thomas-Van Gundy (U.S. Department of Agriculture, Forest Service, Northern Research Station) and Chris Underwood (University of Wisconsin) studied the species composition of buried seeds and extant vegetation present in areas that have faced differing fire conditions over many years on the Monongahela National Forest in West Virginia. Study sites were selected using an estimate of past fire importance based on the presence of fire-related witness trees.

A seed bank in a greenhouse setting. USDA Forest Service photo by Cynthia Huebner.

KEY MANAGEMENT CONSIDERATIONS

- Scientists investigated seed banks and current vegetation along a hypothesized gradient of past fire importance based on trees listed in deeds from the 1800s in West Virginia.
- The seed bank from the high zone site—with the greatest abundance of fire-related witness trees—exhibited the greatest species richness and differed most from the current vegetation at the site.
- Although the high zone seed bank contained the greatest number of fire-related species, one of its top indicator species was not fire related: tulip tree (*Liriodendron tulipifera*).
- The high zone sites may be reaching a state in which they may be unlikely to return to fire-adapted conditions without human intervention.

Study Methods

The research team identified three sites in forests that were at least 80 years old. They used a previously published map showing the distribution of witness trees from grants dating from 1752 to 1899 to select the study sites. The sites ranged in abundance of fire-related witness tree species from low (0 to 10 percent fire-related species), to medium (40 to 50 percent fire-related species), to high (80 to 90 percent fire-related species).

To determine the composition of species in the seed bank, they placed soil samples from the sites in a greenhouse, allowed the seeds from the soil samples to germinate under controlled conditions for three months, and identified all plant species that germinated. They measured soil nutrient concentrations and analyzed soil samples for charcoal content, which could help confirm that fire was more or less prevalent at the site as predicted by the witness-tree species abundance. They also surveyed the current vegetation of the site and recorded the herb, shrub, and vine abundance.

Past and Present Vegetation

When the seeds germinated from the seed banks, the researchers discovered that the current vegetation in the sites differed substantially from the past vegetation revealed by the seed banks. For example, the seed banks included species like woodland bluegrass (*Poa sylvestris*) and prairie wedge grass (*Sphenopholis obtusata*) that require open forest conditions and sunshine, which indicate that the forest was less dense and that more light reached the forest floor. Because these and similar species are present in the seed bank, they might be expected to grow after a disturbance, such as a fire, that would open the forest canopy.

The researchers identified remnant woodland plants in the seed bank that were not found currently growing at the site and considered the implications for the forest's future. If the current vegetation contains fewer fire-related species than nonfire-related species each growing season, the proportion of fire-related species in the seed bank would decrease over time. "There is a decreasing likelihood that fire-adapted species can be restored to these high zones as our seed bank loses these species over time and gains more nonfire-related species," Huebner says. "Time could be running out for these sites."

Studying the High Zone

The high zone seed bank contained the greatest species richness but had the lowest total seed density. The high zone seed bank's species composition also differed more from the current species composition at the site than the medium and low zone seed banks differed from their current species composition at each site. Although the high zone was expected to have the most fire-related species in its seed bank compared to other zones, the nonfire-related tulip tree (*Liriodendron tulipifera*) was one of its top indicator seed bank species. According to Huebner, "tulip poplar is common to seed banks of more mesic forests and its presence in the high zone is telling."

The researchers also found that the high zone may have reached a state of mesophication, which occurs when a forest that was historically subject to fire at somewhat regular intervals, but due to fire suppression and the increase in nonfire-related species, is now less amenable to the growth and maintenance of fire-related tree species and somewhat resistant to fire. Consequently, the high zone appears to be reaching a potential threshold where passive recovery to fire-adapted conditions may be unlikely.

Management Implications

Seed bank studies, such as this one, can inform restoration. To encourage the growth of certain species in an area, for example, knowing whether the species are still in the seed bank can help prioritize locations for prescribed burning. Land managers on the Monongahela National Forest use fire as a tool to regenerate oak woodlands and forests and increase understory grasses and forbs for wildlife. These managers rely on the seed bank as a source of many of these species to germinate after prescribed burns. Noncommercial timber harvesting can also increase the light reaching the forest floor and encourage seeds in the seed bank to germinate.

Despite the potential benefits of a more open canopy, the researchers warn that encouraging germination from the seed bank may not yield the desired results. Huebner points out that seeds of certain species in a forest may have not been regularly added to the seed banks through the years "because the plants have not been able to reproduce either due to a lack of light or due to deer herbivory." More than one hundred years of fire suppression and deer herbivory have also made these systems vulnerable to seed bank depletion. "Adding fire now might help reverse the trajectory," she adds, "but more research is needed to know if the remnant fire-prone seeds in the seed bank would be sufficient."

FURTHER READING

Huebner, Cynthia D.; Thomas-Van Gundy, Melissa; Underwood, Chris A. 2023. Comparison of seed bank composition over a gradient of pyrophilic vegetation. The Journal of the Torrey Botanical Society. 150(3): 409–436. https://doi.org/10.3159/TORREY-D-22-00026.1.

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PROJECT LEADS

Cynthia Huebner is a research botanist for the Ecology and Management of Invasive Species and Forest Ecosystems research work unit at the Northern Research Station.

Melissa Thomas-Van Gundy is a project leader and research forester for the Ecological Sustainability of Central Appalachian Forests research work unit at the Northern Research Station.

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