USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

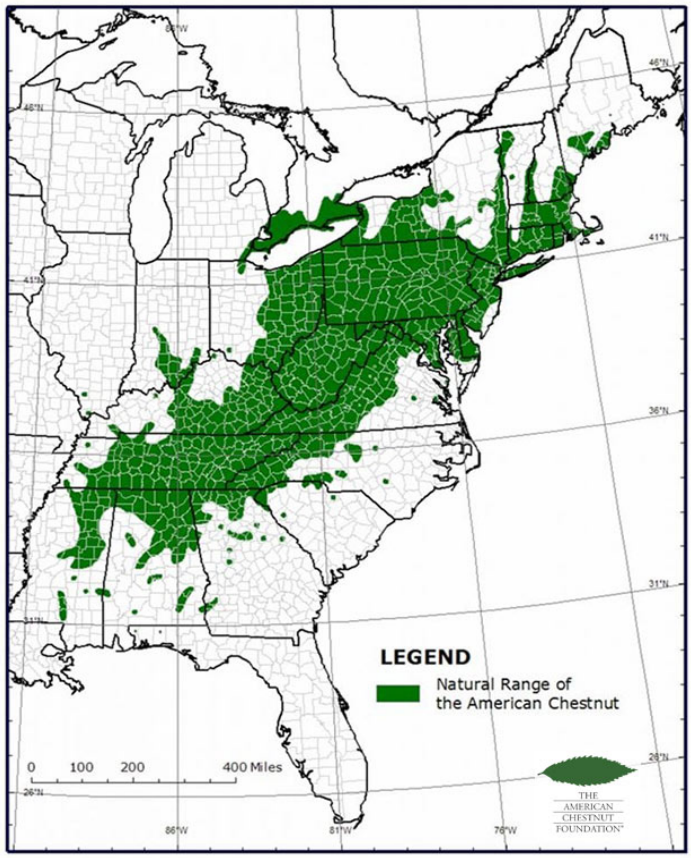
Northern Research Station

Rooted in Research

ISSUE 24 | JANUARY 2024

Chestnut Restoration Threatened by Root Rot

Once a dominant species in the eastern United States, the American chestnut (*Castanea dentata*) was largely wiped out by chestnut blight (*Cryphonectria parasitica*) in the early 20th century. Only 10 percent of the original population remains, and most of these trees are less than 1 inch in diameter. The ecological and economic value of chestnut has prompted extensive restoration efforts that have focused on developing blight-resistant chestnut trees and planting them in their native range.



The natural range of the American chestnut extended from Maine south to the northern parts of Georgia, Alabama, Mississippi, and west to the Ohio River Valley. Photo courtesy of the American Chestnut Foundation.

KEY MANAGEMENT CONSIDERATIONS

- Root rot infection by *Phytophthora cinnamomi* poses a considerable threat to chestnut restoration efforts, which underscores the importance of breeding chestnut for blight resistance and root rot resistance.
- Prioritizing locations where *P. cinnamomi* is less likely to occur may improve the success of American chestnut restoration efforts.
- LANDIS-II is a powerful tool that can be used to model forest change over time.

Until recently, restoration efforts have not considered another primary threat: *Phytophthora cinnamomi,* a pathogen that causes root rot in chestnut trees. *P. cinnamomi* is not a new threat, and it is likely that chestnut trees in the southern part of their native range were affected by the pathogen before chestnut blight arrived. Currently found in the southern two-thirds of the United States, the pathogen is limited by cold winter temperatures in northern latitudes. With a warming climate, however, the range of *P. cinnamomi* is likely to expand northward and threaten restored chestnut in areas where the pathogen has not been found before.

Forecasting Pathogen Disturbance

To better understand the risk that *P. cinnamomi* poses to chestnut restoration efforts, a research team led by Eric Gustafson, a research landscape ecologist with the U.S. Department of Agriculture Forest Service Northern Research Station, has used simulations that incorporate climate variability and root rot susceptibility to predict the effects of root rot.

In 2018, Gustafson and his team published a study that used LANDIS-II, a forest landscape modeling platform, to simulate chestnut restoration efforts under climate change. They found that active restoration efforts (e.g., clearcutting and planting chestnut hybrids) had the potential to restore American chestnut to the landscape.

The 2018 experiment did not consider root rot, so in 2020 the team created a Root Rot extension for LANDIS-II that simulates root rot disturbance (https://landis-ii-foundation.github.io/Extension-Root-Rot/). The Root Rot extension uses soil moisture and temperature, both reliable predictors of root rot, to classify forest sites as uninfected, infected, and diseased. LANDIS-II also takes other disturbances into account, such as infestation by other common forest pests. "The Root Rot extension adds to all the knowledge already in LANDIS about growth, competition, disturbances, and so on," says Gustafson, "and that is novel."

Although previous research has documented the substantial impact of *P. cinnamomi* on small-scale chestnut plantings, the Root Rot extension enabled the first study of the potential impact of the pathogen at a large scale. With LANDIS-II, scientists can model areas up to millions of acres in size. "And for long periods," Gustafson says, "because forest dynamics are relatively slow. We go out at least 50 years and sometimes up to 300 years into the future."

New Extension, New Results

Gustafson's team chose the Savage River State Forest and the Green Ridge State Forest in western Maryland for the simulation experiment. Both forests are at the northern edge of *P. cinnamomi's* current range, but they differ in rainfall and soil conditions. "Together, the two ecoregions account for 60 percent or more of the original American chestnut ranges," Gustafson says, "and they offer a nice variety of ecological and abiotic conditions."

During the simulation, researchers varied the climate and the susceptibility of chestnut to root rot over a 200-year period. For climate change, they used current and projected conditions. For root rot, they simulated four levels of chestnut resistance.

The American chestnut (*Castanea dentata*) was a dominant hardwood tree in the eastern United States. Licensed photo by Pabkov/Adobe Stock.

The results indicate that a warming climate will increase the population density of *P. cinnamomi* and decrease chestnut populations. Root rot could critically impair restoration efforts in areas where *P. cinnamomi* is currently found and in areas where the pathogen could spread in a warming climate. Even at an optimistically low susceptibility rate of 10 percent, the researchers predict that root rot will prevent American chestnut from regaining its former abundance in its natural range, even under aggressive planting efforts.

These findings underscore the importance of prioritizing suitable locations for chestnut restoration. The team suggests focusing restoration efforts on northern climates and, in areas where *P. cinnamomi* is found, prioritizing sites with conditions that are less conducive to root rot (i.e., undisturbed, well-drained sites). The researchers also note new efforts underway by others to begin breeding chestnut for resistance to *P. cinnamomi.*

Applying the Root Rot Extension

Gustafson describes the Root Rot extension as useful for anyone managing a forest where root rot already exists. "Managers will have to do their own testing and calibrating wherever they plan to use the model," he says, "but I expect it will be quite useful when someone is trying to decide what management strategy works best." In addition, the team's approach could inform how researchers develop LANDIS-II extensions for other pathogens, such as Dutch elm disease (*Ophiostoma novo-ulmi*) or oak wilt (*Bretziella fagacearum*).

"Climate change is on every land manager's radar," says Gustafson. "The law requires forests in the National Forest System to develop alternative management strategies, analyze how the management strategies will impact various characteristics of the forest, and choose one to go with. LANDIS-II is an extremely powerful and useful tool for land managers."

PROJECT LEAD

Eric Gustafson is a research landscape ecologist with the Landscape Ecology and Sustainability in the Lake States Forests research work unit at the USDA Forest Service Northern Research Station.

FURTHER READING

Gustafson, Eric J.; Miranda, Brian R.; Dreaden, Tyler J.; Pinchot, Cornelia C.; Jacobs, Douglass F. 2022. Beyond blight: Phytophthora root rot under climate change limits populations of reintroduced American chestnut. Ecosphere. 13(2): ecs2.3917. https://doi.org/10.1002/ecs2.3917.