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U.S. DEPARTMENT OF AGRICULTURE

Rocky Mountain Research Station
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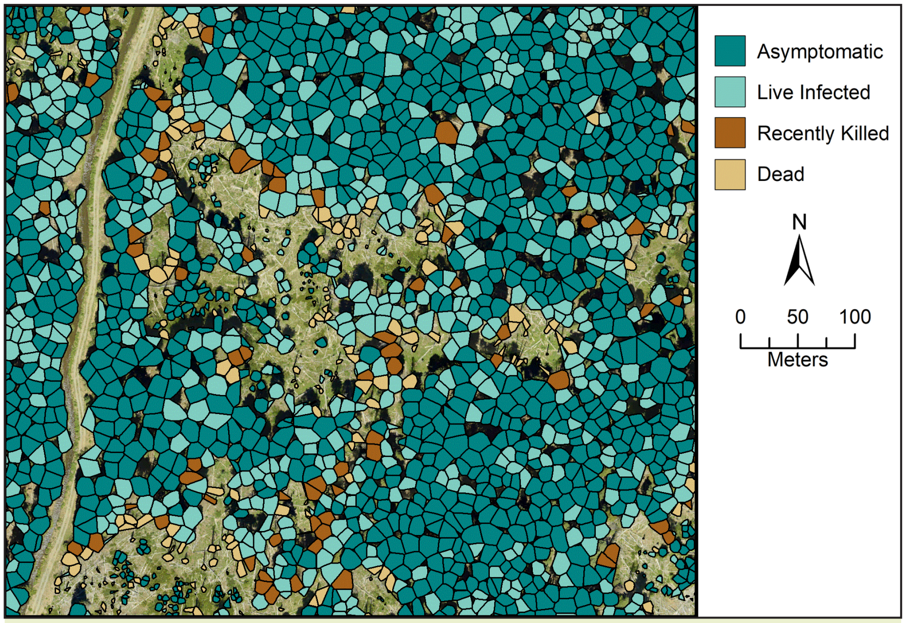
Unmasking an Underground Killer: Trees at High Risk of Root Disease Pinpointed with New Remote Sensing Methods

Conifer forests in the Interior Northwest are commonly affected by Armillaria root disease, an underground fungal infection that causes pockets of tree death. Gaps in the canopy that result from mortality caused by root disease change forests in significant ways: they alter the structure of the forest stand, changing how habitats evolve; they alter the distribution of fuel, changing the fire risk and potential fire behavior; and they lower tree density, reducing the productivity of timber operations.

"We don't know how widespread the damage from Armillaria root disease is because, until now, we didn't have a good method for mapping sites affected by root diseases," says geographer Benjamin Bright of the Rocky Mountain Research Station. "It's pretty easy to map large wildfires, and you can see the work of bark beetles from space, but root disease is trickier because it's so subtle and slow."

A research team that includes Bright and Brent Oblinger, a forest pathologist for USDA Forest Service Forest Health Protection, has developed a method to map conifer mortality due to Armillaria root disease by applying machine learning to remote-sensed data. "This is one of the first reliable remote-sensing methods for detecting mortality due to root disease at broad scales in the northwestern United States," Oblinger says. It is also one of the first methods to provide results at the level of individual trees.



This map reveals infected individual trees that could go undetected in a visual survey ("live infected" light green polygons). Lidar and visual data from an Oregon, USA, forest were processed to identify "tree objects"; then a machine-learning model assigned a tree-health condition category to each tree object. USDA Forest Service figure by Ben Bright.

The study combined two remote-sensing data sources: high-density light detection and ranging (lidar) and high-resolution images. The remotely sensed data were collected over a 3,100-acre study area on the Fremont-Winema National Forest in Oregon, USA. The study area included multiple stands where the disease has already been studied.

The lidar and visual data were processed to identify about 290,000 individual "tree objects." By comparing these tree objects with field data, the team was able to pair 150 trees with their tree-object counterparts. The researchers used these pairs to develop a statistical model for predicting tree health from the lidar and visual data. For the 150 test trees, the model correctly distinguished asymptomatic, live infected, recently killed, and dead trees with 83 percent accuracy. When the team applied the model to 27 stands already studied for Armillaria, it correctly identified patterns of root disease in all 27 stands. When tested on the full dataset, the model assigned a condition category to each of the 290,000 tree objects in only half an hour.

Maps produced by the model make it easy to see trees that are unhealthy but not yet dead. The method can also generate various "hotspot" maps, for example, to identify which stands to prioritize for surveys because they contain a certain number of dead or unhealthy trees. Such maps can help forest managers efficiently focus on mitigation work.

This newly developed method shows promise for detecting other fungal diseases that share the pattern of dead trees surrounded by canopy openings, such as laminated root rot (in mountain hemlock, Douglas-fir, or mixed-conifer forests) or Heterobasidion root disease (in conifer forests). "We believe our approach of combining lidar with high-resolution imagery could improve our overall ability to use remote sensing to detect disease incidence across broad scales," Oblinger says.

This conifer stand on the Fremont-Winema National Forest in south-central Oregon, USA, shows a characteristic pocket of ongoing tree mortality due to Armillaria root disease. Visible at the center are the yellowing needles that signal infection of live trees. USDA Forest Service photo by Ryan Hanavan.

KEY MANAGEMENT CONSIDERATIONS

- Researchers have developed methods for detecting areas affected by Armillaria root disease via patterns in tree mortality associated with canopy openings.
- Forest managers can use this approach during project planning to prioritize stands for ground surveys, select species for reforestation, and estimate future habitats for key wildlife species.
- Hotspot maps can provide estimates of snag densities and pinpoint areas of ongoing losses in canopy cover resulting from root disease. The method also makes it easy to see which trees are unhealthy but not dead, to assist in planning silvicultural prescriptions.
- This efficient approach is suitable for conifer forests for which high-quality lidar and imagery data have been acquired in approximately the same year.

FEATURED SCIENTISTS

Benjamin Bright is a geographer with the Rocky Mountain Research Station, based in Moscow, Idaho. In his research, he develops and evaluates methodologies that use remote sensing to measure vegetation and fuels in forests, especially following disturbance.

Brent Oblinger is a forest pathologist with U.S. Forest Service Forest Health Protection, working in the Pacific Northwest Region and based in Bend, Oregon. He specializes in tree disease identification and management, geographic information systems, and forest health assessments.

FURTHER READING

Webinar: Detecting sites with conifer mortality induced by root disease using airborne lidar and orthoimagery

Oblinger, B.W.; Bright, B.C.; Hanavan, R.P.; Simpson, M.; Hudak, A.T.; Cook, B.D.; Corp, L.A. 2022. Identifying conifer mortality induced by Armillaria root disease using airborne lidar and orthoimagery in south central Oregon. Forest Ecology and Management. 511: 120126.

Senf, C.; Seidl, R.; Hostert, P. 2017. Remote sensing of forest insect disturbances: Current state and future directions. International Journal of Applied Earth Observation and Geoinformation. 60: 49–60.

Wing, B.M.; Ritchie, M.W.; Boston, K.; Cohen, W.B.; Olsen, M.J. 2015. Individual snag detection using neighborhood attribute filtered airborne lidar data. Remote Sensing of Environment. 163: 165–179.

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