Death of hemlock trees yields new life for hardwood trees, but at what cost to the ecosystem?

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This shows a dead hemlock forest in Appalachians. Credit: University of Illinois

Due to the introduction of exotic pests and pathogens, tree species are being eliminated one by one from forest ecosystems. In some cases, scientists can observe immediately how their loss affects the environment, whereas in other cases, creative puzzle solving and analysis reveal unexpected repercussions. In the case of the loss of the hemlock tree, University of Illinois landscape and ecosystem ecologist Jennifer Fraterrigo uncovered a surprising benefit to hardwood species.

Throughout much of the eastern United States, a pest called the hemlock woolly adelgid has decimated hemlock tree populations. While

researching how hemlock mortality affects nitrogen retention in the soil and vegetation, Fraterrigo noticed that other components of the ecosystem were changing.

"Our findings were unexpected," Fraterrigo said. "We hypothesized that in this area of the southern Appalachians, where there is a lot of nitrogen available due to high rates of atmospheric nitrogen deposition, hemlock mortality would increase nitrogen leaching from the soil because the trees were no longer taking up that nitrogen, but we found the opposite. We found less nitrogen leaching from the soil because hardwood trees had compensated by increasing their productivity."

The hardwood trees were able to grow because, when the hemlock trees died, phosphorus was released and became available to the hardwood species in the area. The increase in available phosphorus stimulated the growth of existing hardwood trees, which then increased tree demand for nitrogen. As a result, we saw less nitrogen being leached from the soil. Without hemlock mortality, the hardwood trees could not take up the excess nitrogen in the soil because their growth was limited by a lack of phosphorus, Fraterrigo said.

"We believe chronically high nitrogen availability is actually driving the accumulation of phosphorus in vegetation and soil organic matter in this area. Without disturbance, however, the phosphorus stays locked up in these pools and is unavailable to support new growth," Fraterrigo said.

Fraterrigo explained how the balance of nutrients operates in the environment.

"Nitrogen and phosphorus are among the most important elements for growth and carbon storage," she said. "Plants fix carbon in the atmosphere, but if they don't have enough of either of these elements, they're limited as to how much carbon they can actually fix. It is the

relative, not the absolute, amounts of nitrogen and phosphorus that limit growth and carbon storage."

Although this would seem to be beneficial, at least for the hardwood industry, Fraterrigo said it's important to look at the entire ecosystem and the ramifications of losing a species such as hemlock. Fraterrigo said hemlock is significant ecologically. "It's a foundation species in this ecosystem. It provides structure because it's an evergreen so wildlife depends on it year round for shelter. It also influences many biophysical processes, including those that affect ecosystem hydrology. Losing a species such as hemlock that is biologically active all year can alter stream flow, which could affect aquatic organisms," she said.

Fraterrigo said that disturbances created by exotic pathogens and pests such as the hemlock woolly adelgid are increasing. "An introduced fungus is decimating oak populations in the West, and there's the emerald ash borer in the Midwest. We need to study how the loss of tree species is affecting forest ecosystems," she said.

The only places that hemlock stands can still be found in the Southeast are where an insecticide called Imidacloprid has been sprayed, Fraterrigo said. "But that's just a temporary solution. You'd have to continue to apply it again and again in order to deter the hemlock woolly adelgid."

The hemlock woolly adelgid is host specific, meaning it only infests hemlock trees. The aphid-like insect attaches itself to a needle, sucks the sap from it, and the tree dies.

"Although the hemlock woolly adelgid doesn't do well in cooler climates, it is clearly affecting hemlock populations in the Northeast as well. It's just taking longer to see the impact," Fraterrigo said. "We're seeing warmer temperatures at night across the nation and warmer winter temperatures in some places. Those two factors together could allow the

insect to move slowly farther north.

"It's difficult to anticipate how species loss will affect forest ecosystems," she said. "Our research demonstrates that it is important to consider other drivers of global change, such as air pollution, to reveal ecosystem-level changes."

Fraterrigo said she'd like to continue the work in the Great Smoky Mountain National Park, which has also lost hemlock and has even higher rates of atmospheric nitrogen deposition. "We're curious if we'll see similar changes in hardwood productivity and ecosystem nitrogen retention," she said.

Interactive effects of disturbance and nitrogen availability on phosphorus dynamics of southern Appalachian forests was published in a 2012 issue of *Biogeochemistry*.

Impacts of hemlock loss on nitrogen retention vary with soil nitrogen availability in the southern Appalachian Mountains was published in a 2012 issue of *Ecosystems*.

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