

Researchers discover tree trunks act as methane source in upland forests

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Credit: Notneb82, Wikimedia Commons

A new study from the University of Delaware is one of the first in the world to show that tree trunks in upland forests actually emit methane rather than store it, representing a new, previously unaccounted source of this powerful greenhouse gas.

Methane is about 25 times stronger than carbon dioxide, with some estimates as high as 33 times stronger due to its effects when it is in the atmosphere.

Because of [methane](#)'s global warming potential, identifying the sources and "sinks" or storehouses of this greenhouse gas is critical for

measuring and understanding its implications across ecosystems.

Upland forest soils usually take up and store methane, but this effect can be counteracted by methane emissions from tree trunks, the research team from UD's College of Agriculture and Natural Resources found. Their work is published in the scientific journal *Ecosystems*.

"We believe our work can help fill in some gaps in methane budgets and environmental processes in global ecosystem models," said the study's leader, Rodrigo Vargas, assistant professor in the Department of Plant and Soil Sciences in UD's College of Agriculture and Natural Resources.

Shreeram Inamdar, professor of watershed hydrology and biogeochemistry, is co-investigator on the project with Vargas, and doctoral student Daniel Warner is the lead author of the paper. The research was funded by the U.S. Department of Agriculture, with additional support from Delaware's Federal Research and Development Matching Grant Program.

Maryland study site

In a 30-acre area of upland forest at Fair Hill Natural Resources Management Area in nearby Cecil County, Maryland, the researchers tested a cluster of [trees](#), soil and coarse woody debris (CWD)—dead wood lying on the forest floor in various stages of decomposition—to measure fluxes of methane and carbon dioxide.

The researchers used a state-of-the-art greenhouse gas analyzer based on laser absorption technology, called Off-Axis Integrated Cavity Output Spectroscopy (OA-ICOS), which looks similar to a proton pack from the movie "Ghostbusters."

Warner visited the site over the course of one growing season, April to

December, and measured the carbon dioxide and methane fluxes of the soil, tree trunks and CWD to determine whether those three components were sources or sinks of these greenhouse gases.

Soils and CWD fluxes

In terms of carbon dioxide, research on the fluxes of tree trunks, known as stem respiration, and soil, known as soil respiration, has been done for decades, but research to determine the importance of carbon fluxes with regard to CWD still lags behind.

For methane, however, it's a different story. While studies have been done on methane fluxes in connection to soils, which usually consume the methane and are considered methane sinks, there are very few that deal with CWD and tree trunks in upland soils.

"What research has been done is generally lab incubations of wood where they measure how much methane is released over time. What we've found in this study is that some coarse woody debris acts kind of like the soil and consumes methane while other pieces of coarse woody debris emit small amounts of methane, which is also what we saw with living tree trunks," said Warner.

To understand the differences between the actions of the CWD, Warner and colleagues found that fresher CWD has a positive methane flux, which is similar to how a living tree behaves.

"When a tree falls over, it's still functionally the same in terms of methane emissions. Over time, as it decays, my theory is that it gets colonized by soil bacteria that consume methane and it shifts to behave more like the soil, resulting in a methane sink," said Warner.

The researchers also found that CWD had a high rate of variability when

it came to methane emissions.

"As it decays it becomes a lot more variable. Some of the super-decayed wood was still releasing methane but a lot of it was consuming methane," said Warner. "If you have a CWD pool with less diversity regarding the degree of decomposition, you can expect it to play a more uniform role in terms of methane emissions or sinks."

Tree trunks and methane fluxes

While tree trunks have been known to release carbon dioxide, this research showed that they were also releasing methane.

"The tree trunks constantly have low but detectable emissions of methane. Soils are providing an environmental service of sequestering this potent greenhouse gas, but the trunks are releasing methane equivalent to 4 percent of what could be captured by CWD and soils at the ecosystem scale," said Vargas.

Overall, the tree trunks acted as a source of carbon dioxide and as a small source of methane, but the magnitude of gases emitted varied with the species.

Tulip poplar was one species that released a lot of methane and carbon dioxide, whereas beech trees released the most methane within the forest but emitted very little [carbon dioxide](#).

"It might be some species-specific trait that's controlling the flux," said Warner.

Temperature threshold

Temperature also played a key role in regulating the magnitude of the fluxes.

"Methane in soils seem to follow a temperature gradient where higher temperatures are related to higher uptake of methane but that's not necessarily the case for CWD or for tree trunks," said Vargas.

Warner said it's hard to develop a temperature relationship with methane because there are two processes that oppose each other.

"You have things in the soil producing methane—known as methanogenesis—things consuming it—known as methanotrophy—and so as you warm up, it's more kind of like a shot gun where the magnitudes of methane scatter out more as it gets warmer; suggesting that other factors beyond temperature regulate [methane emissions](#)," said Warner.

They found that beyond a threshold of 17 degrees Celsius for soil temperature, the variability of methane consumption expands dramatically.

"Under 17 degrees, temperature is a key driver of methane flux but above 17 degrees, there are other drivers that will influence methane production," said Vargas.

Soil hot spots

As for where the methane originated, Warner said it's still a science frontier, but this study provides enough clues to give the researchers some theories.

The first one is that methane is produced in hot spots in the [soil](#).

"By hot spot, we mean a place where conditions are conducive to methane production and then that methane is sucked up by the tree roots, transported through its vascular system and released out of its [trunk](#)," said Warner. "We know that happens in wetlands but in uplands, maybe it happens in one specific spot and nowhere else."

The other mechanism that could be causing methane fluxes from trunks is internal rotting or infection inside the tree, which produces an environment where methanogenic bacteria can survive and then methane diffuses out of the tree.

"At this moment, the mechanisms of methane production in upland forests are not clear. Methane can be either transported from the soils upward inside the stem and diffused to the atmosphere or produced inside the stem by fungi or archaea—single-celled microorganisms," said Vargas.

Next steps

Both Warner and Vargas agreed that the next steps should be to test the generality of these observations across different forests, and identify the mechanisms of [methane production](#) and transport in tree trunks. Finally, they suggest that global and ecosystem models should take into account methane produced from tree trunks as a new source of methane to the atmosphere.

"When people develop ecosystem to global scale methane budgets, there's always a chunk in which it is uncertain from where that methane is coming. Methane emissions by vegetation and [tree trunks](#) are seen as a newly-considered source that might bring that budget closer in to our estimates. It's good to keep chipping away at that," said Warner.

More information: Daniel L. Warner et al, Carbon Dioxide and

Methane Fluxes From Tree Stems, Coarse Woody Debris, and Soils in an Upland Temperate Forest, *Ecosystems* (2017). [DOI: 10.1007/s10021-016-0106-8](#)

Provided by University of Delaware

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