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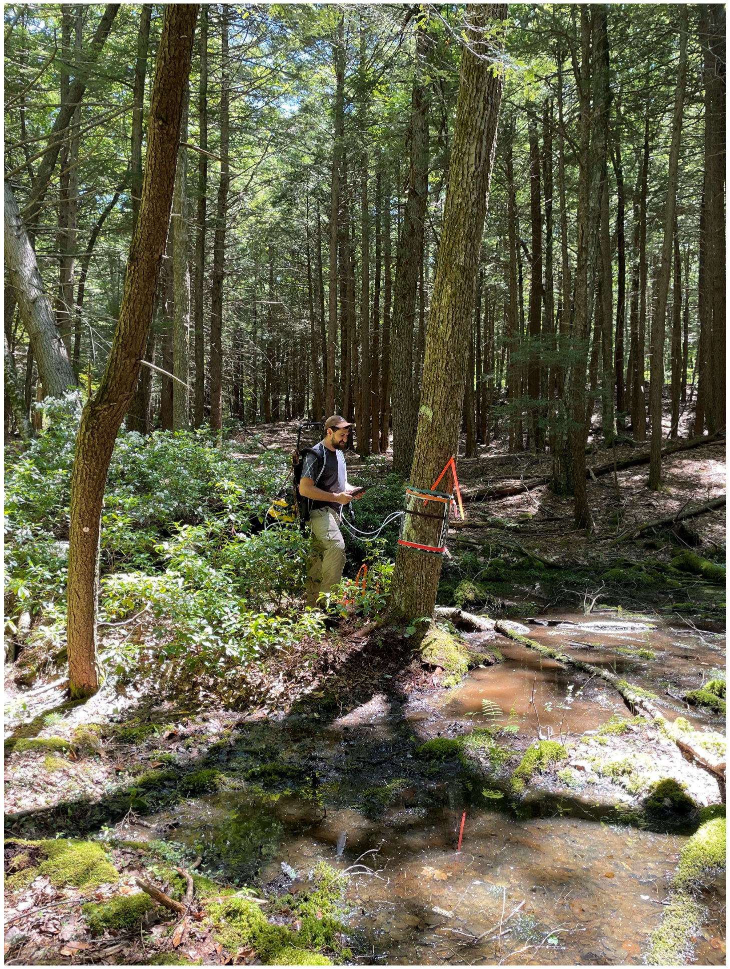
Measuring methane emissions from tree stems



Research Highlights

- Tree stems are a source of methane in every species we measured at Yale-Myers.
- Methane-producing microbes (methanogens) inhabit the wood of living trees.
- Methanogens are only one part of diverse, distinct, and undescribed microbial communities harbored by living trees.

Research Summary

Methane (CH_4) has a global-warming potential (GWP) 86 times higher than CO_2 over 20-year timescales, and some estimates place global CH_4 emissions from plants on par with the GWP of CO_2 emissions from combined U.S. industrial, residential and commercial sources Despite this, considerable uncertainty exists in the global methane budget, particularly for emissions from natural sources, such as biological processes in forests. In this project, I am working on understanding the amount of methane emitted from trees at Yale-Myers Forest, as well as how that piece of the puzzle fits into the overall amount of methane taken up and released from the forest. I am also working on understanding the sources of the methane coming out of the trees—such as whether it is produced by plants, soils, or microbes in the trees—and what environmental factors controls those processes.

Last year, we completed a one-year survey of CH_4 emissions and consumption by trees and soils across an upland to wetland gradient in the forest. We found large CH_4 emissions from wetland soils and consumption by upland soils. However, we found that trees in both the upland and wetland areas were both sources of CH_4 emissions. Until recently, people have thought of upland forests as being only CH_4 sinks, or areas where methane is consumed, due to soil uptake. However, we are now trying to understand how much of this soil uptake is cancelled out by tree emissions. This year, we measured emissions from over 150 trees across 16 different species in order to understand how different species and individual plants vary in their rates of emissions. We found relatively consistent emissions across species—and emissions from all species in the forest—although under certain conditions, like inundated soil or visible signs of tree disease, the emissions rates are much higher.

Research Summary cont.

Our next goal was to understand who in the forest was producing this methane. CH_4 production is the result of microbes called methanogens, which usually live in anoxic environments such as flooded soils. We sampled soils and took tree cores from each of the trees where we measured fluxes, to see whether methanogens were living in either or both of those environments. In order to make those measurements, we needed to develop a few new laboratory methods, including how to extract microbial DNA from live wood tissues, and how to quantify small numbers of methanogens, which can be a very small portion of the total microbial community depending on the sample. After lots of testing, we found a method to extract DNA from wood by freeze-drying, cryo-grinding (pulverizing it in liquid nitrogen), and then modifying a chemical DNA extraction kit usually used for soils. We were then able to detect methanogens living inside the wood of nearly all of the trees we sampled, giving good evidence for at least some of the CH_4 emitted by trees originating from microbes living inside the trees.

Now, we are working on understanding more about what conditions lead to different levels of methanogen abundance inside the trees. Specifically, are using amplicon sequencing, a method of identifying all species/taxa of microbes present in a sample, to understand the bacterial, archaeal, and fungal communities living side by side with the methanogens. We are also describing the microbial habitat conditions, or environment inside each tree, by measuring the moisture, pH, oxygen, sugar and starch availability, and the physical structure of the wood. We are collaborating with groups in Yale's School of Engineering to complete the microbiome analyses, with an international network to measure wood traits and their relationship with stem emissions, and with multiple undergraduate students at Yale to complete the laboratory analyses of wood chemistry. We will continue this work, as well as new fieldwork and sampling, back at Yale-Myers next summer.