Research Highlights:

- We measured methane emission from nearly 500 trees at Yale-Myers Forest.
- We published methods for analyzing microbial communities in the wood of living trees.
- We are implementing these methods to explore the cross-domain microbiome inside trees.
- We are expanding our work to explore landscape dynamics at Harvard Forest, and working with the CT Agricultural Experiment Station to understand how plant pathogens influence methane production.

Research Summary:

Methane (CH₄) has a global-warming potential (GWP) 86 times higher than CO₂ over 20-year timescales, and some estimates place global CH₄ emissions from plants on par with the GWP of 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—whether it is produced by plants, soils, or microbes in the trees—and what environmental factors control those processes. In 2020-2021, we completed a one-year survey of CH₄ emissions and consumption by trees and soils across an upland to wetland gradient in the forest.
Research Summary cont.
In 2021-2022, we conducted sampling and microbial analyses of wood and soil to understand the origins of tree-emitted methane. CH₄ 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, developed laboratory methods, including how to extract microbial DNA from live wood tissues, and how to quantify small numbers of methanogens; we published our process in Methods in Ecology and Evolution this year. Using our method, we were 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 CH₄ in trees originating from microbes living inside the trees. Currently, we are further exploring the microbiome of these trees, examining not just the methane-cycling microbes, but the full bacterial, archaeal, and fungal communities, to explore the composition, structure, and function of these hidden ecosystems inside trees.

In 2023, we conducted new fieldwork at Yale-Myers, to further quantify lateral variation (i.e., differences across the landscape) in tree methane emissions. Three stellar undergraduates, in the Ingalls Field Ecology program, measured emissions from nearly 500 individual trees in order to determine how tree species and landscape positions affect the amount of methane emitted in the forest. We also expanded our work to Harvard Forest in Massachusetts, where we have focused on quantifying two other dimensions of variability in methane emissions: vertical (by measuring from the forest floor to canopy, using a bucket lift) and temporal (i.e., how methane emissions vary seasonally and in response to weather, by conducting repeat measurements on a cohort of long-term study trees).

In 2024, we will continue our exploration of variability in methane cycling at both forests, as we both continue our repeat measurements on our long-term study trees, and implement an automated measurement system—now several years in development—to measure diurnal variations in methane flux, and potentially links to tree processes such as sapflow. We will and work on linking microbial community dynamics to methane emissions at a larger scale, by exploring linkages between tree internal decay and methane emissions, using a new method called sonic and electrical resistance tomography—essentially, X-ray scans of the inside of trees. This work will continue to engage students through the Harvard Forest REU program, and build new collaborations in plant pathology with the Connecticut Agricultural Experiment Station. Overall, we hope to build our knowledge of pattern and process from individual trees and microbiomes at Yale-Myers to understanding landscape-level dynamics, developing management-relevant diagnostic tools, and furthering our understanding of connections between the plant-soil-atmosphere system and our changing climate.