Yale SCHOOL OF THE ENVIRONMENT

Ucross High Plains Stewardship

FELLOWSHIP BRIEF

Soil Greenhouse Gas Fluxes and Carbon Storage Across the Upper Green River Basin

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The Need.

Soil greenhouse gas budgets are a way to measure how much of a certain greenhouse gas (carbon dioxide, methane, nitrous oxide) is emitted relative to how much is offset through carbon storage in the soil. These budgets are critical both to informing our scientific understanding of ecosystem flux as well as to guiding policy in regard to carbon accounting and nature-based climate solutions. Estimates of budgets are mostly made at the regional scale and are based on the dominant ecosystem type in those locations. Dryland soils of the American West are often accounted for as having few greenhouse gas emissions and even as pulling methane out of the atmosphere. However, even in regions dominated by slow decomposition with relatively few emissions, there are "hot spots" where a disproportionate amount of greenhouse gas may be released relative to the area which they occupy in the ecosystem. In the rangelands of the West, these areas are mostly wetlands and sub-irrigated hay meadows which occupy a very small portion of the region but may be the primary contributors to emissions in the region and could potentially offset any mitigation effect the drier areas may have. Investigating the effect of these hot spots and how they change across time is critical to informing both our understanding of the carbon cycle as well as policy and land management decisions.

The Project.

To do this, Uthara uses the case study of the sagebrush-dominated region of the Upper Green River Basin located in western Wyoming. She selected sites representative of the four primary ecosystem types in this region: wetlands, sub-irrigated meadows, upland sagebrush, and sloping sagebrush. Replicated across three ranches in the region, she took weekly gas samples to get an estimate of how these fluxes changed across the summer. Uthara also measured soil moisture, soil temperature, nitrogen availability, and will measure soil organic matter, pH, and soil texture as these are important controls on microbial activity in soils. Using the gas sample data collected this summer as proxies for these ecotypes, she will scale these fluxes up to the area these landscapes represent within the region. Uthara can then investigate the balance between the predominant sagebrush landscape and the higher emitting areas which occupy a small portion of the region. In addition to the emissions of the area, she can also see the relative proportion of carbon stored in these different locations and how this affects the total carbon stored in this region.

The Findings.

At this time, Uthara is still processing soil samples and is working on scaling-up these fluxes to the geographic area they represent. However, there are initial observable differences in trace gas flux across landscape positions which can be seen in the figure below. The scale on the panels are different for each position as flux magnitude and direction is highly variable across these ecotypes. What can be observed here is that there is methane consumption in the dry, upland sagebrush but that these inward fluxes are much smaller than what is being emitted from the wetlands. Wetlands are inundated with water and because of this, microbial activity is dominated by anaerobic respiration. While negative flux consistently occurs in the upland sites, the magnitude of this flux is very small. However, once these fluxes have been scaled up to represent the proportional area of each landscape position within the region, we can better investigate how these small fluxes scale up across large areas and how they compare to the effect of hotspots within the region. These early observed differences make scaling-up these fluxes an exciting prospect, and Uthara is looking forward to sharing the regional budget once it is completed.

Figure 1.

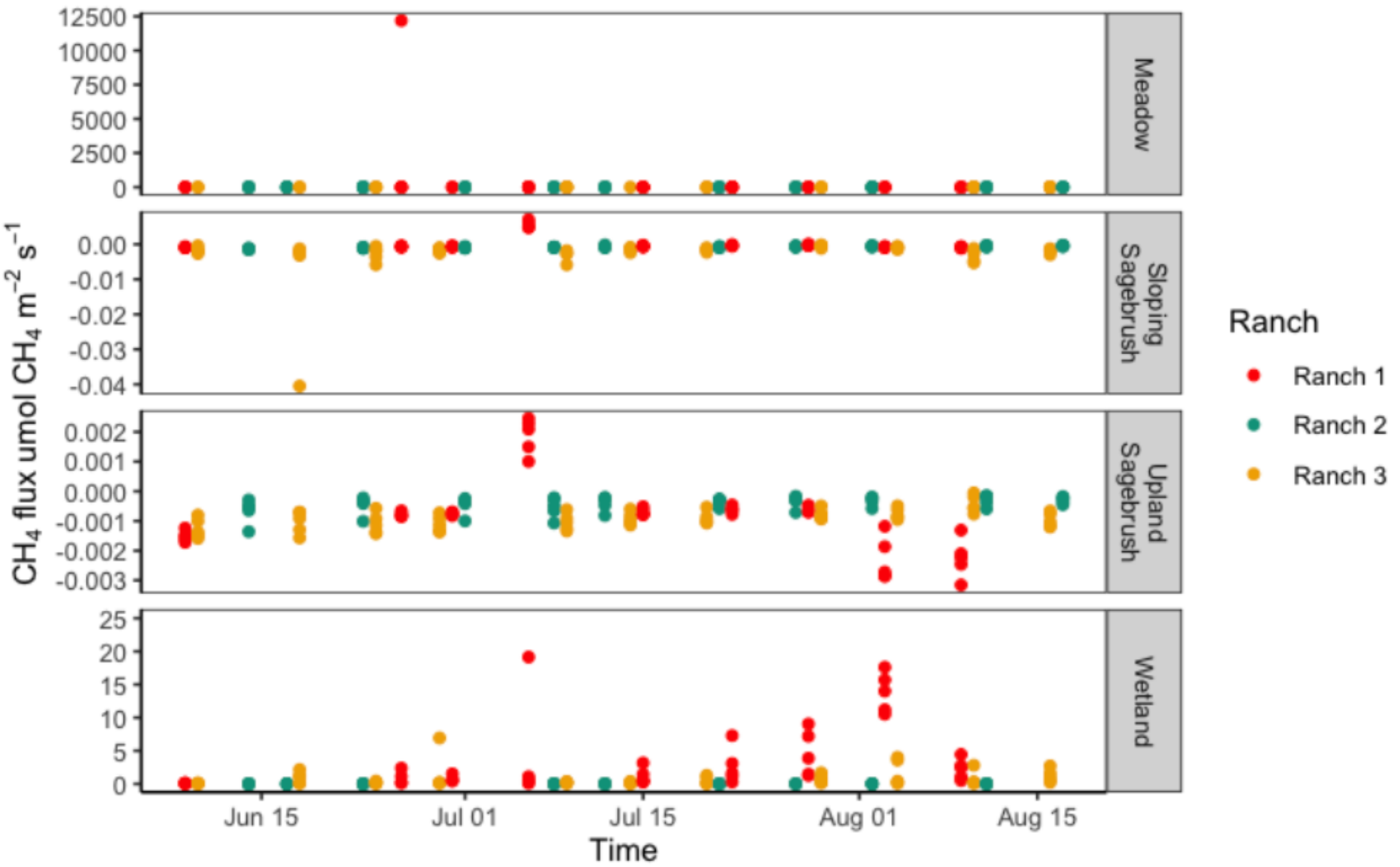

Figure 1. Soil methane fluxes across four landscape positions at three ranches in Sublette County, Wyoming during summer 2021.

The Impact.

These types of regional greenhouse gas budgets are frequently used to inform carbon sequestration policies and earth system models but rarely include the impacts of “hot spots” and “hot moments”. Particularly when looking at potent greenhouse gases like methane and nitrous oxide, it is important to consider how a few locations may have a disproportionate impact on contributions to global warming even if these emissions are sporadic and don’t occur everywhere in the region. As nature-based carbon sequestration becomes an increasingly important factor for policy makers and land managers to consider alongside eliminating fossil fuel emissions, it is critical that we understand and correctly account for ecosystem greenhouse gas emissions and carbon storage at the practitioner scale. Working on private ranches this summer has given Uthara the opportunity to continue with this project and she hopes to continue engaging with and discussing carbon conservation.

The Student.

Uthara Vengrai is a Master of Environmental Science candidate at the Yale School of the Environment. Her thesis research combines simulation modeling and field research to better understand the effects of land use practices and global change on biogeochemical fluxes and soil organic matter in dryland ecosystems. Originally from southern California, her academic interests are strongly motivated by a desire to produce research that helps inform and prepare communities in the West for the impacts of climate change. Uthara holds a Bachelor of Science degree in Environmental Sciences from the University of California, Berkeley.