UNDERSTANDING MECHANISTIC CONTROLS OF HETEROTROPHIC CO_2 AND CH_4 FLUXES IN A PEATLAND WITH DEEP SOIL WARMING AND ATMOSPHERIC CO_2 ENRICHMENT

Jason K. Keller, Chapman University (Principal Investigator)
Scott D. Bridgham, University of Oregon (Co-Investigator)
Qianlai Zhuang, Purdue University (Co-Investigator)

Peatlands are among the most important terrestrial ecosystems in the global carbon (C) cycle. These wetlands currently store roughly one-third of the terrestrial soil C and are a significant source of the potent greenhouse gas methane (CH_4) to the atmosphere. A pressing challenge in global change biogeochemistry remains whether or not a significant fraction of the large soil C pool in peatlands will be mineralized to CO_2 or CH_4 in future climates. Given that CH_4 has 28-times the global warming potential of CO_2, understanding the response of peatland CH_4 dynamics in response to global change is particularly critical for understanding peatland-climate feedbacks. Methane cycling in peatlands is complex. The production of CH_4 is the result of multiple, anaerobic microbial processes in which different groups of microbes 'cooperate' by sequentially producing substrates for one another and compete for those substrates. Once produced, a significant fraction of CH_4 can be oxidized to CO_2 within peatlands by different microbial processes. Currently, Earth system models do not adequately capture the complexity of CH_4 cycling in peatlands and are thus ill-equipped to predict the response of peatland CH_4 emissions to global change - including elevated [CO_2] and increased temperatures. ***The overall objective of this renewal is to expand our mechanistic understanding of how deep warming of peat and CO_2 enrichment in a bog affect C mineralization and CH_4 dynamics and to incorporate that understanding into Earth system models.***

We will utilize the ongoing DOE Spruce and Peatland Responses Under Climatic and Environmental Change (SPRUCE) experiment to test the following hypotheses: **H1:** *Warming will have a substantial positive effect on CH_4 production in surface peat but will have a smaller positive effect in deep peat due to its chemical recalcitrance.* **H2:** *Warming will cause a larger increase in anaerobic CO_2 production than CH_4 production due to stimulation of 'upstream' microbial processes, and this ratio will increase with depth.* **H3:** *Both warming and CO_2 enrichment will increase the prevalence of acetoclastic methanogenesis over hydrogenotrophic methanogenesis as a result of increased labile substrates and an increase in homoacetogenesis (acetate production from H_2 and CO_2). An increase in the importance of acetoclastic methanogenesis will be coincident with increased overall CH_4 production.* **H4:** *Both treatments will lead to transient accumulations of low-molecular-weight organic acids, including acetate, due to the slow growth of methanogens.* **H5:** *Anaerobic CH_4 oxidation will be an important process below the water table, adding to CH_4 consumption from aerobic CH_4 oxidation in surface soils as an important sink of CH_4.* We will explore these hypotheses using a combination of field measurements, including the quantification of key electron donors and acceptors in porewater collected from the SPRUCE treatments, thermodynamic modeling based on these dissolved constituents, and gross CH_4 consumption and production measured using $^{13}CH_4$. Concurrent mechanistic laboratory experiments will explore the temperature sensitivity of methanogenesis and other microbial processes over time in the SPRUCE treatments; changes in soil quality as potential C mineralization in response to climate treatments; the importance of and controls on anaerobic CH_4 oxidation; and the production and fate of low molecular weight organic acids during fermentation. Results of our field and laboratory experiments will be incorporated into our ongoing modeling efforts, and in particular will be used to improve algorithms associated with anaerobic processes and CH_4 cycling within the Terrestrial Ecosystem Model (TEM). Our data are also being used to parameterize anaerobic C cycling and CH_4 dynamics in the Community Land Model (CLM).