EXECUTIVE SUMMARY

Applicant: University of Oregon, c/o Office of Research Services and Administration

Project Title: UNDERSTANDING THE MECHANISMS UNDERLYING HETEROTROPHIC CO_2 AND CH_4 FLUXES IN A PEATLAND WITH DEEP SOIL WARMING AND ATMOSPHERIC CO_2 ENRICHMENT

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Peatlands are an important global source of atmospheric methane (CH_4). Additionally, peatland soils currently store roughly one-third of the terrestrial soil carbon. Thus, the response of peatland carbon cycling to ongoing environmental change will have global implications. Given the high global warming potential of CH_4, our ability to predict climate forcing by peatlands in the future hinges on our ability to incorporate CH_4 dynamics into earth system models. However, CH_4 dynamics are regulated by a complex set of controls, including plant and microbial activities, and the response of these controls to warming and elevated [CO_2] are not well understood. This lack of appropriate mechanistic understanding of peatland CH_4 dynamics represents a fundamental knowledge gap in our ability to predict if CH_4 flux from peatlands will represent a positive feedback to anthropogenic global change. ***The overall objectives of this proposal are to provide a mechanistic understanding of how deep warming of peat and CO_2 enrichment in a bog affect carbon mineralization and CH_4 production, consumption, and transport (which together control CH_4 emissions) and to incorporate that understanding into a biogeochemistry model, the Terrestrial Ecosystem Model (TEM), which will then be used to improve predictions of CH_4 emissions from boreal peatland ecosystems.***

Our proposed work will leverage ongoing DOE research at the Spruce and Peatland Responses Under Climatic and Environmental Change (SPRUCE) experiment taking place in a black spruce-*Sphagnum* bog in northern Minnesota to address the following hypotheses: **(H1)** CO_2 enrichment will enhance CH_4 fluxes substantially because of an increase in root exudations. **(H2)** Warming will enhance CH_4 production, but the mechanistic controls will be a complicated mix of the direct positive effects of warming on methanogens and indirect warming effects on interacting and competing anaerobic processes. **(H3)** Warming will seasonally reduce CH_4 fluxes to the extent that it draws down the water table and thus increases CH_4 oxidation. Alternatively, warming and a drawdown in the water table will increase the vascular component of the plant community over time. This will increase root exudation, the carbon quality of the surface peat, and plant transport of CH_4, all of which will increase CH_4 fluxes and partially offset the increase in CH_4 oxidation due to a lower water table. We will address these hypotheses through a combination of controlled laboratory experiments as well as field measurements of key electron acceptors and carbon sources in porewater; stable isotope signatures ($\delta^{13}C$ and δD) of CH_4 and CO_2 to quantify CH_4 production and oxidation pathways; and measurements of $^{14}CH_4$ and $^{14}CO_2$ to quantify the age of mineralized carbon. This increased mechanistic understanding of CH_4 dynamics, and how they respond to key global changes, will be explicitly linked to the Terrestrial Ecosystem Model (TEM) in this proposal. Thus, this project will deliver valuable scientific data and models about the mechanistic controls of anaerobic carbon cycling, and CH_4 dynamics in particular, in peatlands, a globally important ecosystem, in response to elevated temperature and [CO_2].