Poster #28

Direct Measurements of Permafrost Soil Carbon Loss in an Experimentally Warmed Tundra Ecosystem

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New estimates place 1330-1580 billion tons of soil carbon in the northern circumpolar permafrost zone, more than twice as much carbon than in the atmosphere. Permafrost thaw and the microbial decomposition of previously frozen organic carbon is considered one of the most likely positive feedbacks from terrestrial ecosystems to the atmosphere in a warmer world. Understanding the magnitude, rate, and form of greenhouse gas release to the atmosphere is crucial for predicting the strength and timing of this carbon cycle feedback to a warming climate. Here we report results from an ecosystem warming manipulation —the Carbon in Permafrost Experimental Heating Research (CiPEHR) project—where we increased air and soil temperature, and degraded the surface permafrost. We used snow fences coupled with spring snow removal to increase deep soil temperatures and thaw depth (soil warming) and open top chambers to increase growing season air temperatures (air warming). The soil warming treatment has successfully warmed soils by 2-3ºC in winter, has increased growing-season depth of ground thaw by up to 25-50%, and has degraded an increasing amount of surface permafrost each year of the project. Our previous reports have focused on measurements of carbon dioxide exchange as a metric of changes in ecosystem carbon storage, and these are ongoing. Here we report direct measurements of changes in soil carbon storage at the study site. Repeat soil measurements are not typically part of planned Arctic research and observation networks. This is largely because of ground subsidence that occurs as high-ice permafrost (perennially-frozen) soils begin to thaw. Physical alterations to the soil profile (ground subsidence) confound the application of traditional methods for quantifying carbon pool changes to fixed depths or using soil horizons. We overcame these issues by quantifying carbon in relation to a fixed ash content, which uses the relatively stable mineral component of soil as a metric for pool comparisons through time. Using this approach, we show a 26% loss in soil carbon over five years across both experimentally warmed and ambient tundra ecosystems at the research site. While the warming treatment had lower mean carbon pool amounts, this difference was not significantly different from changes in carbon pools in the ambient tundra. These surprisingly large losses overwhelmed increased plant biomass carbon uptake and were not fully detected by measurements of ecosystem-atmosphere carbon dioxide exchange. Assimilating experimental data into an ecosystem model indicated that

parameter adjustment was needed for the model to simulate carbon cycle dynamics under experimental warming. In particular, parameters for light use, gross primary production allocation, as well as transfer coefficients from litter to soil pools showed the greatest change, suggesting that there was acclimation in ecosystem behaviour in response to warming. This research highlights the potential to directly detect changes in the soil carbon pool of this rapidly transforming landscape, and that current methodologies for quantifying ecosystem carbon dynamics may be underestimating soil losses.