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Peatland Ecohydrology: Water-vegetation-carbon Interactions in a Changing Climate

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As natural sources of methane (CH_4) and long-term sinks of carbon dioxide (CO_2), peatlands play an important role in the global carbon cycle. The position of the water table within a peatland can have a large effect on peatland-atmosphere carbon exchange. With climate models predicting enhanced evapotranspiration under a 2 x CO_2 scenario, and therefore a lower water-table position in peatlands, it has been suggested that peatland CH_4emissions will decrease while CO_2 emissions are expected to increase in the coming decades. This Fickian diffusion centric view of carbon exchange is overly simple and does not consider the effects of water-vegetation-carbon interactions and ecohydrological feedbacks that play an important role in peatland carbon cycling.

Here, we will present research from our field and modeling studies investigating the effects of drought and disturbances such as permafrost degradation on vegetation, carbon cycling, and ecohydrological processes in northern wetlands at multiple spatial scales. At local scales, our findings show that interactions among vegetation, soil, and hydrology can lead to unexpected and often complex changes in soil environments that often have consequences for carbon fluxes. For example, our ecosystem-scale water table manipulation experiments in Quebec and Alaska have shown that sustained drought typically leads to peat subsidence, increasing bulk density and decreasing saturated hydraulic conductivity and peatland storativity. In Alaska, the decrease in porosity and water content with drought reduced seasonal ice thaw, which also limited water table drawdown. In contrast, peatlands underlain by permafrost are increasingly experiencing thermokarst and soil flooding. Changes in moss productivity

post-thaw led to increased rates of organic matter accumulation, with very different hydrologic and soil properties than peat accumulated in permafrost settings. Through such changes in ecohydrology, responses in both CO_2 and CH_4 emissions can differ substantially from predictions based on simple increases or decreases in water table position.

We argue that carbon, water, and energy fluxes in northern peatlands can respond quickly to changes in climate and have the potential to influence atmospheric carbon concentrations. However, a comprehensive understanding of these responses and whether they will serve as positive or negative feedbacks to climate change require a comprehensive understanding of the relationships between, peat properties, ecohydrology, and carbon cycle processes. More robust approaches to modeling peatland hydroclimate and vegetation-water-carbon interactions are necessary to develop a true understanding of how northern wetlands will respond to climate change.