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Origins of color in boreal estuaries: Lessons from the biogeochemical responses of boreal forest landscapes to climate change.

Increases in water color attributed to dissolved organic matter (DOM) concentration and export in boreal catchments over the past few decades represents a potentially important impact on boreal estuaries yet the reason for these trends remains poorly understood. DOM source and composition typically explains much of the variation in estuarine bacterial growth and its efficiency. Therefore, an understanding of the source and impact of changes in terrestrial inputs is critical to predictive understanding of boreal estuarine responses including food web structure and carbon sink or source potential.

Ecosystem C fluxes respond positively to climate warming, however, the net impact of changing C fluxes on soil organic carbon stocks, the main source of terrestrial DOM, on decadal scales remains unclear. Natural climate gradient studies capture integrated ecosystem responses to climate on decadal time scales. Our research group has studied organic matter reservoirs, fluxes into and out of those reservoirs, and the chemical composition of inputs and dissolved and soil organic matter pools along a climate transect of mesic boreal forest watersheds. The terrestrial and headwater stream sites studied consist of similar forest composition, successional stage, and soil moisture but differ by 5.2˚C mean annual temperature.

Carbon fluxes through these boreal forest soils were greatest in the lowest latitude regions and indicate that enhanced C inputs can offset soil C losses with warming in these forests. Respiration rates increased by 55% and the flux of DOM from the organic to mineral soil horizons tripled across this climate gradient. The 2-fold increase in litterfall inputs to these soils coincided with a significant increase in the organic horizon C stock with warming, however, no significant difference in the surface mineral soil C stocks was observed. The shorter radiocarbon-based mean residence time of the mineral soil C (~70 versus ~330 y) provided further evidence for the greater turnover of SOC in the warmer climate soils. Increased mobilization of C in these forests was congruent with a ~10-fold greater annual flux of DOM from the forested headwater catchments in the warmest relative to coldest region.

Regional differences in soil organic matter composition did not result from significant differences in the degree of degradation, but rather resulted from chemically distinct vegetation inputs. The lower proportions of moss inputs in the warmer forests studied here signifies an important and understudied climate control on C cycling and organic matter composition in these, and likely other boreal forest soils and watersheds in a warmer future.

Collectively, these observations of within-biome C responses to climate demonstrate that the enhanced rates of soil C loss that typically occur with warming can be balanced by enhanced rates of C inputs. This suggests that in the wetter parts of the Boreal export of DOM may be supported by increased productivity, vascular relative to nonvascular plant inputs and hydrologic connectivity. The potential changes to light regime, food web structure and carbon source/sink capacity posed by increasing terrestrial DOM calls for an increased effort to better understand its quantity, composition and role in boreal estuaries.