Study of individual soil organic horizons cannot predict the elevated temperature sensitivity of respiration observed in warmer climate boreal forests

FRANCES A. PODREBARAC[1], JÉRÔME LAGANIÈRE[1,2], SHARON BILLINGS[3], KATE EDWARDS[4], AND SUSAN ZIEGLER[1]

1. Department of Earth Sciences, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador A1B 3X5, Canada ¶ 2. Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Centre, Québec G1V 4C7, Canada ¶ 3. Department of Ecology and Evolutionary Biology, Kansas Biological Survey, University of Kansas, Lawrence, Kansas 66045, USA ¶ 4. Natural Resources Canada, Canadian Forest Service, Atlantic Forestry Centre, Corner Brook, Newfoundland and Labrador A2H 6J3, Canada

Soil is the largest reservoir of terrestrial carbon compared to the atmosphere and vegetation. To predict the impact of climate warming on the global carbon cycle and possible feedbacks, we must address the dynamics of soil organic carbon (SOC), particularly in high latitude ecosystems where >31% of Earth's SOC reservoir resides. Previous studies have demonstrated a relationship between soil bioreactivity (respiration per unit C at constant temperature) and the temperature sensitivity of SOC mineralization (typically reported as Q_{10}, which represents change in C decomposition rate to a 10°C temperature increase). Few studies, however, have addressed the role of in situ climate warming or the influence of soil profile substrate availability or exchange on the temperature sensitivity of soil respiration. Does a warmer climate history yield SOC that elicits a more temperature sensitive respiratory response? Can the respiratory response of individual organic soil horizons or their bioreactivity be used to predict the response of an organic soil profile?

To address these questions we conducted three parallel incubations experiment with (a) intact organic profiles, (b) isolated organic horizons of the same soil, and (c) profiles rebuilt from the isolated organic horizons. Soil samples were collected from podzolic boreal forest sites in two regions similar except a mean annual temperature difference of 5.6°C. The soils were incubated at 5°C, 10°C, and 15°C for 438 days with soil respiration measured at 6 time points. The experiments provided a way to compare respiratory responses of soil horizons with (intact and rebuilt) or without (isolated horizons) the exchange of substrate across horizons typical of an intact soil profile.

Cumulative respiration was greater in the cooler relative to the warmer region soils, regardless of incubation temperature or experiment type indicating that the warmer climate soils were indeed less bioreactive. We found that Q_{10}, however, was influenced by how the organic horizons were incubated suggesting that microbial access to different soil C pools, represented by the different organic horizons, can regulate the Q_{10} of soil respiratory losses. The respiratory response of the individual horizons incubated in isolation could not predict the significant climate history effect observed in the more realistic rebuilt and intact organic profiles. This indicates that factors beyond soil C composition, or its bioavailability, regulate the Q_{10} of soil respiration in these boreal organic soils. Therefore, future investigations need incorporate the study of intact soil profiles as well as factors, other than the "quality" of individual soil pools, such as soil microbial substrate availability when assessing the temperature responses of soil respiration.

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