Response of Redox-Active Organic Matter Reduction to Long-Term Climate Change Manipulations in a Boreal Peatland

Jessica E. Rush[1,2], Jason K. Keller[3,4], Cassandra A. Zalman[4], Zachary S. Schwartz[1,2], Eve-Lyn S. Hinckley[1,2]

1. Department of Ecology & Evolutionary, University of Colorado, Boulder
2. Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder
3. Kravis Department of Integrated Sciences, Claremont Mckenna College
4. Schmid College of Science and Technology, Chapman University

Redox-Active Organic Matter at the Spruce and Peatland Responses Under Changing Environments (SPRUCE) site

Redox-active organic matter (RAOM) serves as an organic terminal electron acceptor (Fig. 1) that produces carbon dioxide (CO_2) as a byproduct and suppresses methane (CH_4) production.

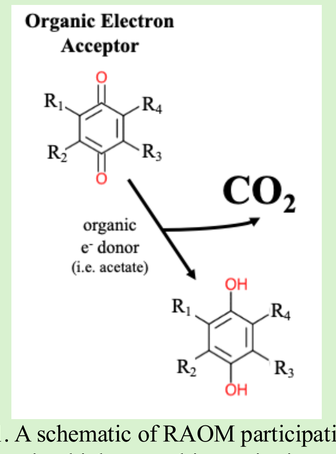

Fig. 1. A schematic of RAOM participating in microbial, anaerobic respiration.

- It is unclear how global climate change will directly and indirectly affect RAOM reduction and subsequent carbon cycling in boreal peatlands.
- Rush et al. (2021) found that ~2 years of warming at the SPRUCE site did not affect the potential for RAOM reduction.

How has almost 10 years of WEW and eCO_2 affected RAOM reduction at the SPRUCE site?

Fig. 2. The SPRUCE site has been exposing a peatland to whole-ecosystem warming (WEW) and elevated atmospheric CO_2 (eCO_2) since 2014.

How do WEW and eCO_2 directly affect *in situ* RAOM reduction along the peat profile?

Methods

- Incubated common substrate peat and plot peat in the experimental plots at SPRUCE using peat peepers (Fig. 3)
- Preserved *in situ* conditions and measured RAOM reduction via an electron shuttling capacity (ESC) assay

Fig. 3. Packets of peat (left) assembled and attached to a rod along specified depth increments and placed inside a peeper (right) within each experimental plot.

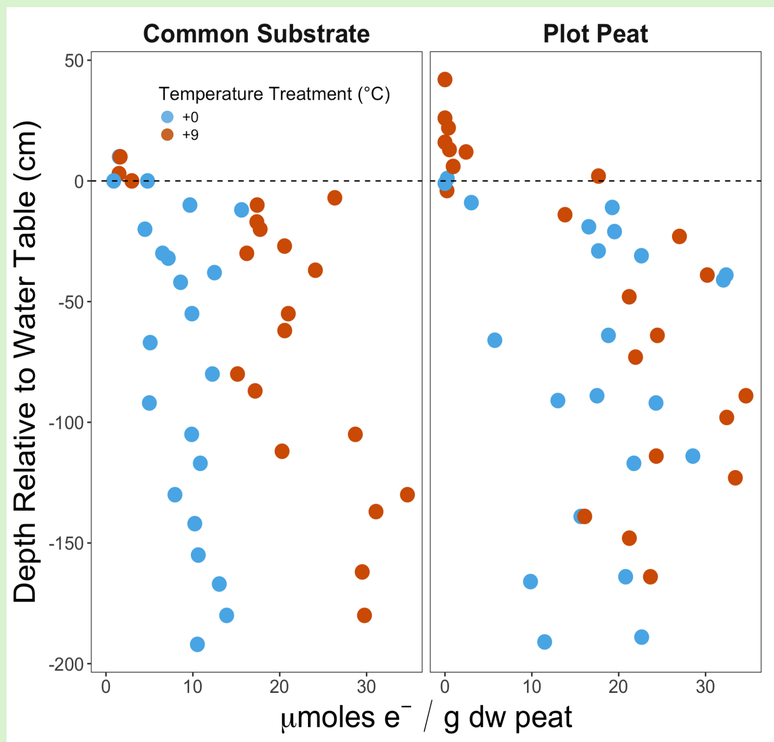

Fig. 4. Electron shuttling capacity of common substrate peat (left) and plot peat (right) incubated in the +0 or +9 °C experimental plots at the SPRUCE site. A higher ESC indicates more reduced RAOM. There was no significant effect of eCO_2, so plots are only separated by temperature treatment.

When controlling for peat heterogeneity with a common substrate, WEW treatments significantly ($p < 0.05$) stimulate more reduced RAOM.

There was no significant effect of WEW on RAOM in plot peat.

eCO_2 did not affect RAOM reduction in either peat type.

How has long-term WEW and eCO_2 changed the RAOM pool?

Methods

Following Rush et al. 2021…

- Oxidized peat collected at three different depths from each experimental plot; 10-20, 75-100, and 175-200 cm
- Incubated peat at 18 ºC over a 42-day anaerobic incubation and measured the potential for RAOM reduction.

Fig. 5. Peat was collected from each experimental plot using a Russian corer (left) and placed in bottles to create peat slurries (right).

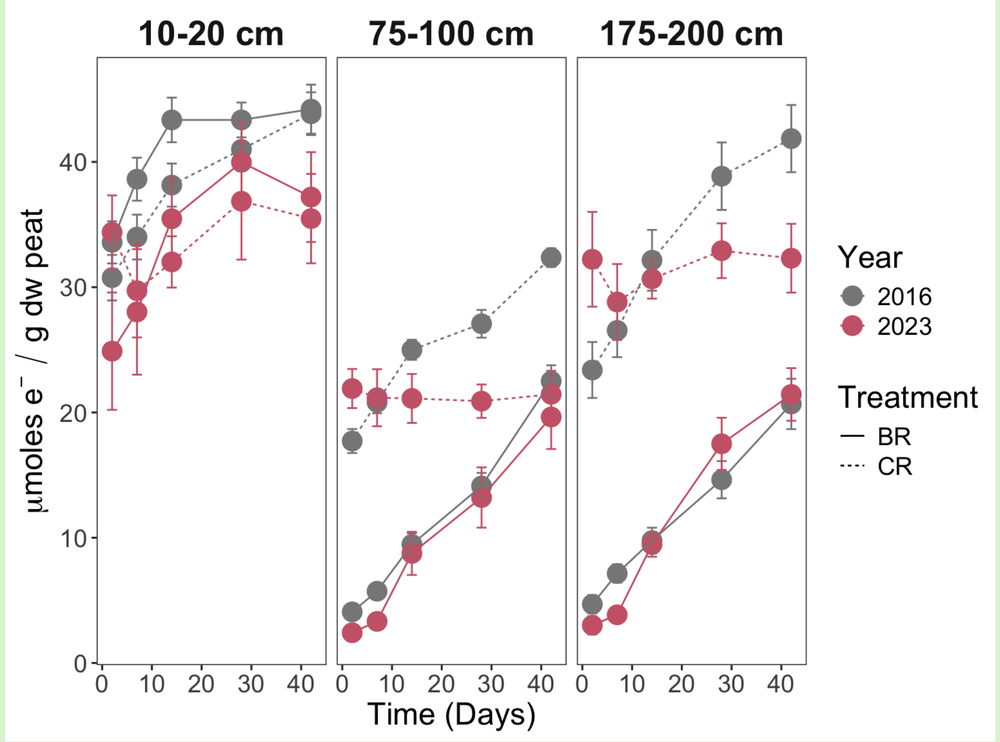

Fig. 6. Electron shuttling capacity averaged across all plots in 2016 (grey) vs 2023 (pink) in 3 different depths. Dashed lines represent chemically reduced samples (CR) where reduction of the RAOM pool was chemically forced. Solid lines represent biologically reduced (BR) samples that were reduced by the natural microbial community over the 42-day incubation period.

Treatments did not significantly change the rate of the biological reduction of the RAOM pool at any depth in 2016 vs 2023 peat.

The maximum RAOM pool (CR) was significantly lower in 2023 for the 75-100 and 175-200 cm depths ($p<0.05$).

References: Rush, J. E., Zalman, C. A., Woerndle, G., Hanna, E. L., Bridgham, S. D., & Keller, J. K. (2021). Warming promotes the use of organic matter as an electron acceptor in a peatland. Geoderma, 401, 115303.

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