The Impacts of Thermokarst and Burn History on the Leaching of Dissolved Organic Matter

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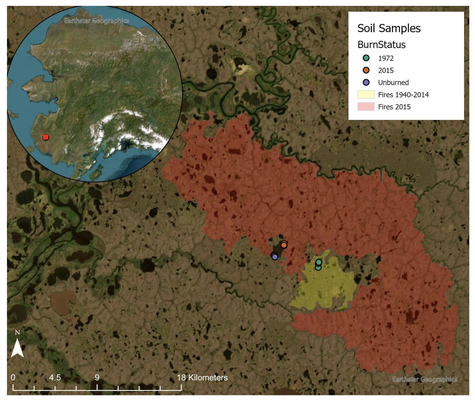
Introduction

As the climate rapidly warms across the Arctic, permafrost thaw can lead to thermokarst development-significantly altering biogeochemical linkages across the landscape with implications for global carbon cycling. These processes are also influenced by increases in fire frequency and severity. However, the combined impacts of thermokarst formation and burn history on soil carbon dynamics are not well understood. Here we compare the soil organic carbon content and leaching rate of dissolved organic carbon (DOC) in plots with different burn histories.

Study Site

Sample collection in the different burn sites in the Yukon-Kuskokwim Delta. We sampled from thermokarst areas, which we called “cracks”, and undisturbed areas, which we referred to as “control”.



Methods

- We collected soil cores in thermokarsted features (N=3) and three in non-thermokarsted (hereafter undisturbed; N=3) area using 30cm augers in the 1972 burn, the 2015 burn, and the unburned region.
- Cores were homogenized and subsampled in the field. ~50mg wet soil was leached with ~120mL of filtered lake water for about 24 hours, then GF/F filtered for lab analyses.
- Soil subsamples were analyzed for wet:dry ratio and organic matter content. Soil leachates were analyzed for DOC concentrations and chromophoric dissolved organic matter (CDOM).

Results

Fig. 1

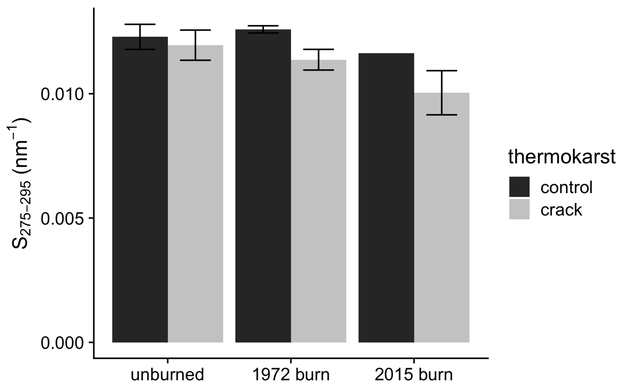


Figure 1. Average CDOM spectral slope ($S_{275-295}$) from soil leachates from landscapes of different burn histories. Color indicates whether the soil was from a thermokarst exposure or control site. Error bars show standard error. $S_{275-295}$ is inversely related to DOM molecular weight.

Fig. 2 A)

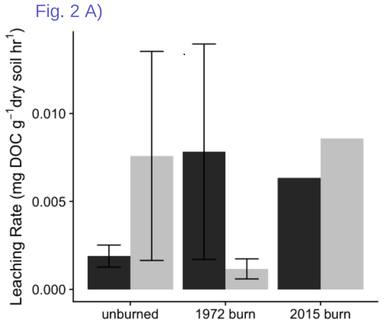


Fig. 2 B)

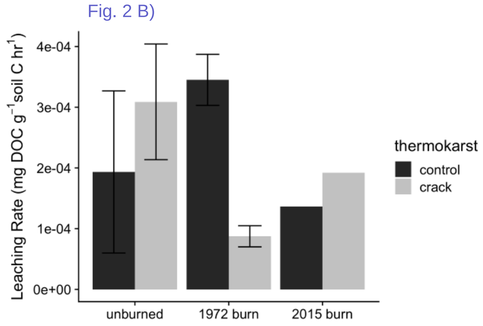


Figure 2. A Average leaching rate of soils sampled in landscapes that were not recently burned, burned in 1972, and burned in 2015. Leaching rates were normalized by (A) dry soil mass and by (B) soil organic carbon. Color indicates whether the soil was from a thermokarst exposure or control site.

Fig. 3

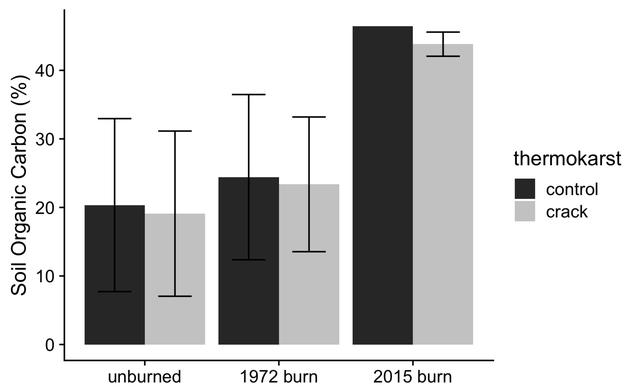


Figure 3. Average soil organic carbon (%) in landscapes that were not recently burned, burned in 1972, and burned in 2015. Color indicates whether the soil was from a thermokarst exposure or control site. Error bars show standard error.

An example of thermokarst cracking that occurs across the tundra as a result of thawing permafrost. As the permafrost beneath thaws, the soil slumps into itself. This results in previously buried soil being exposed to sunlight and the external terrestrial environment.

This is the landscape of the region the study took place in - the Yukon Kuskokwim delta

Discussion

- Soils from thermokarst features have slightly lower soil organic carbon (Figure 3).
- Our experiment demonstrates that DOC readily leaches from tundra soils. As run-off moves through the thawed permafrost in exposed cracks, soil organic matter is likely being leached and exported. However, there is no clear relationship between burn history or thermokarst cracks on leaching rates.
- CDOM data suggests that soil from burned regions leaches higher molecular weight dissolved organic matter (Figure 1) To improve the resolution of my results, more data needs to be collected.

Conclusion/Future Work

- Inclusion of vegetation leachates
- Gas wells for the gas concentration
- Flux dry soils
- Assess intact cores by each soil layer for leachability and organic carbon content
- Flux at each crack and undisturbed site to compare the dry vs wet portion of soil

Acknowledgments Tiffany Windolz, Noah Henkenius, David Davis; National Science Foundation (NSF 1915307) ;Yukon Wildlife Refuge; this study took place on Yup’ik lands.

50 Years since Burn

1972 Burn

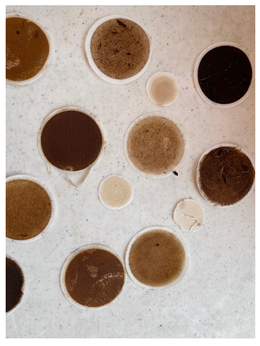
Unburned

7 Years since Burn

2015 Burn

Three soil cores taken in the thermokarst area and three taken in the undisturbed area using 30cm augers in the 1972 burn, the 2015 burn, and the unburned region. Cores were homogenized in field and stored for lab analyses

The soils were measured into ~50mg and were leached with ~120mL of filtered lake water for about 24 hours. Each sample after being leached was hand pump filtered with GFF filters into 30 20mL scint vials, one to assess CDOM, one for T0 of the bio incubation, and one for T28 of the bio incubation.



Run Total Organic Carbon (TOC) on Shimadzu for T0 and T28 and compare T0 to T28 to assess biolability of organic matter. Samples will then be ran on Fourier transform Ion Cyclotron Mass Spectrometry (FT-ICRMS) to assess the precise chemical composition changes from the bio incubation.