The impact of fire on nitrogen availability during early and late succession on the Yukon Kuskokwim Delta

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B41I-2094

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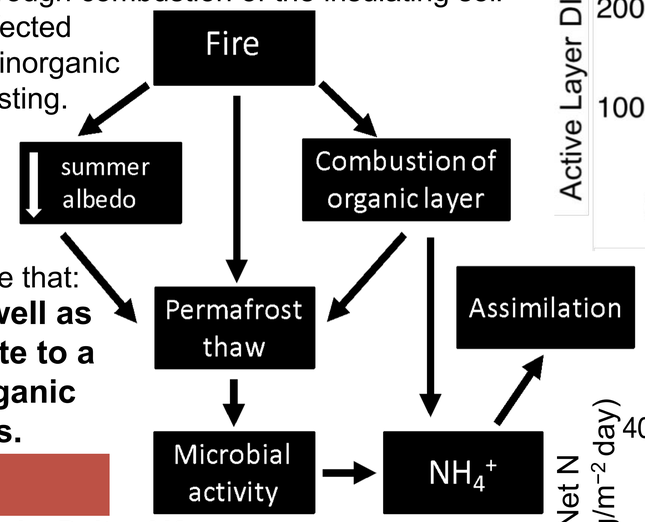
Introduction

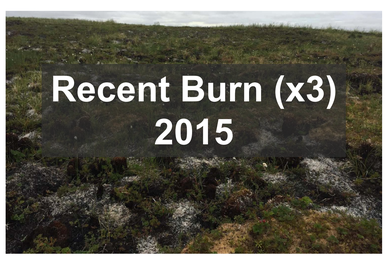
Tundra ecosystems are responding to more frequent and severe wildfires due to increasing lightning strikes (Veraverbeke 2017) in northern regions and warmer and drier conditions that promote more flammable biomass. In tundra ecosystems, fire increases soil's thermal conductivity through combustion of the insulating soil organic layer (Jiang 2015). In many fire-affected ecosystems, burns result in increased soil inorganic nitrogen pools, but this effect is not long-lasting. In arctic ecosystems, however, we could see a sustained increase in post-fire N pools because permafrost thaw can lead to increased pools of bioavailable nitrogen (Salmon 2016). As a result, we hypothesize that:

Both the direct impacts of fire as well as post-fire permafrost thaw contribute to a persisting increased pool of inorganic nitrogen in tundra ecosystems.



Methods

Study sites located in the Yukon Kuskokwim Delta, AK



Samples (x3) per site (July 2017)

Unburned
Old Burn (1972)
Recent Burn (2015)

Frozen cores were sectioned every 10cm and analyzed similarly to thawed soils.

Soils were homogenized, and analyzed for pH, %SOM, %C, %N, and extracted in 2M KCl to measure NH_4^+, NO_3^-, DOC, and DON. 30-day N mineralization experiments were performed.

Vegetation was sorted by species, dried, ground, and analyzed for %C & %N.

Results

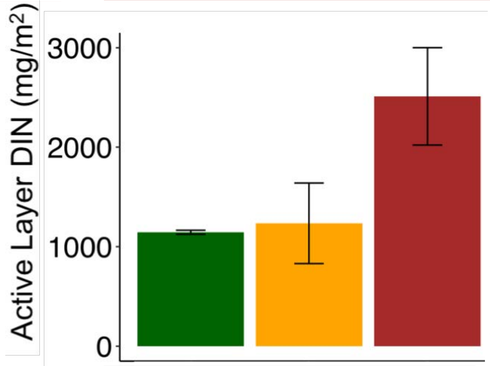


Figure 1. Average active layer dissolved inorganic nitrogen pool (mg/m²) calculated from thawed active layer and top 30 cm of frozen soil samples.

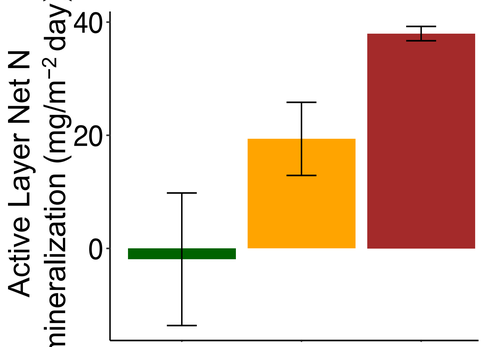


Figure 2. Average N mineralization rates calculated from thawed active layer and top 30 cm of frozen soil samples.

Table 1. Average thaw depth (cm).

Unburned	33.85 ± 0.7
Old Burn	36.54 ± 1.1
Recent Burn	36.85 ± 1.0

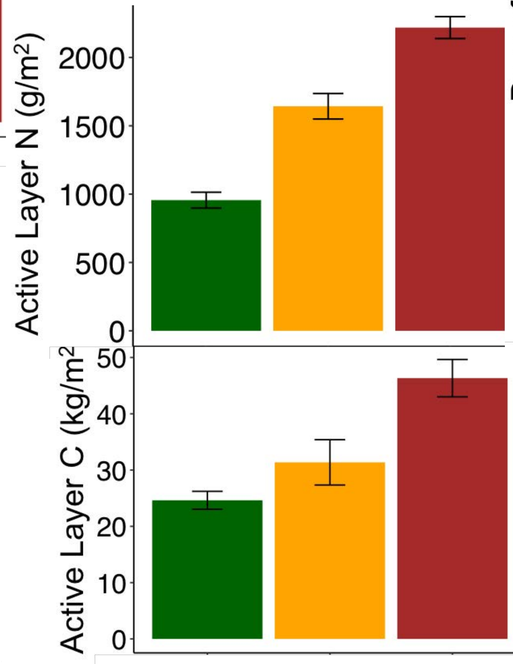


Figure 3. Average active layer N and C pools (g/m²) calculated from thawed active layer and top 30 cm of frozen soil samples.

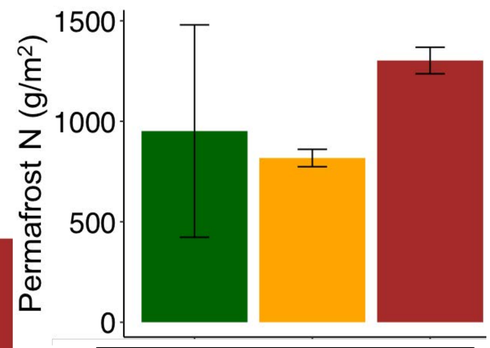


Figure 4. Total N (g/m²) in top 50 cm of permafrost.

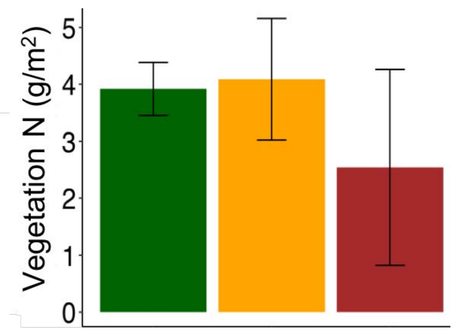


Figure 5. Average N (g/m²) in vegetation. Average biomass (g/m²) is 1343.38 (unburned), 607.56 (old burn), and 152.93 (recent burn).

(Error bars are standard error)

Conclusions

- The potential N contribution of 30 cm of post-fire permafrost thaw for the unburned sites was 1000 mg-N/m2 of DIN and 500 g-N/m2 of total N.
- The amount of inorganic N in the soil organic layer was greatest at the recent burn and was likely the result of fire mediated decomposition from incomplete combustion. (Fig. 1)
- N mineralization rates were elevated in the recent burn and continued to be elevated more that 40 years post-fire. (Fig. 2)
- Recent burn sites had larger C and N pools in the active layer, due to greater bulk density. Total N was elevated at the old burn compared to unburned sites. (Fig. 2 & 3)
- Vegetation N pool was similar at the old burn and unburned sites (Fig. 5)

These results underscore the effects of fire on N availability. Inorganic N returned to unburned levels within 45 years following a fire, but N mineralization rates remained elevated. The excess of mineralized inorganic N may be leached into aquatic systems and/or be lost through nitrification.

References

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Acknowledgements

We thank the Polaris Project 2017 team, particularly Anya Suslova, Edauri Navarro Perez, Sierra Melton, and Greg Fiske. This work was funded by the NSF.