Following the Tundra's Water:
Factors that influence water movement from plateaus to fens in Yup'ik territory of the Yukon-Kuskokwim Delta, Alaska

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Introduction

Background

The upland tundra of the Yukon-Kuskokwim Delta (YKD) consists of relatively flat landscapes, yet it is connected by a complex mosaic of peatland plateaus and interconnected lakes, fens, and streams.

Permafrost thaw and tundra wildfire may alter surface and subsurface water flow paths, altering water and/or solute transport across the landscape.

To better understand the influence of fire on subsurface water flow in the YKD, we characterized soils and measured subsurface water levels on peat plateaus and fens in unburned controls sites as well as sites impacted by a 2015 wildfire.

Study Area

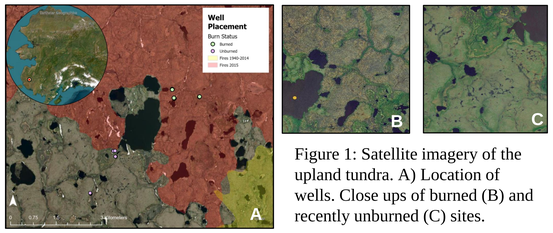

Figure 1: Satellite imagery of the upland tundra. A) Location of wells. Close ups of burned (B) and recently unburned (C) sites.

Methods

- Wells (N=19) were installed in the thawed soils above permafrost, on gradients from plateaus, to slopes and fens in the tundra with (2015) and with no recorded fire history.
- Wells (N=15) had Hoboware water level loggers that recorded absolute pressure. Water level loggers were left during the summer of 2022, to collect data from two (2) to six (6) weeks.
- We used pressure and precipitation data from a weather station to calculate water height (thickness of the water table) and identify precipitation events.
- Soil cores (N=14) were collected where wells were installed and used to characterize soils.

Results

Water level

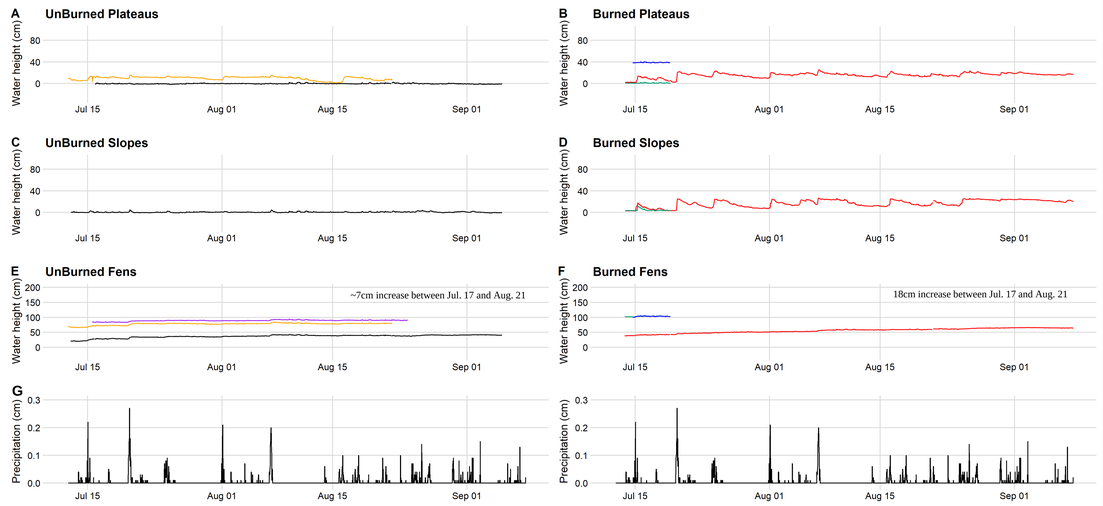

Figure 2: Surface and subsurface water level of three landscape features of the tundra compared to the precipitation during the same timeframe. The transects from Peat Plateaus (A and B) to Slopes (C and D) and Fens (E and F) are represented by the same color. The precipitation graph (G) is duplicated to facilitate recently burned (2015) and unburn comparison. For C and D, only one (1) and two (2) wells were sampled respectively.

Soil Characterization

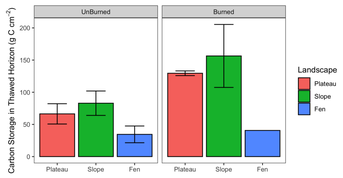

Figure 3: Carbon storage of thawed active layer of three (3) connected landscape features in burned and unburned areas.

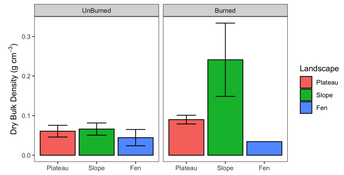

Figure 4: Dry bulk density of thawed active layer of three (3) connected landscape features in burned and unburned areas.

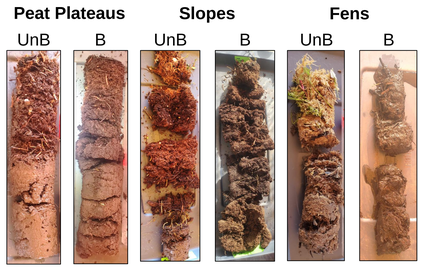

Figure 5. Examples of soil cores of two (2) transects: Unburned (UnB) and recently burned (B)

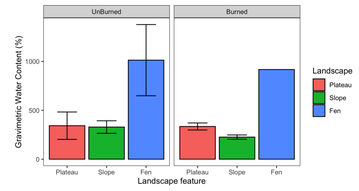

Figure 6: Gravimetric water content of soils of three (3) connected landscape features in burned and unburned areas.

Conclusion

Results and Discussion

- Following major precipitation events, subsurface water on the plateau moved rapidly into the fen, with little water storage above the frozen layer on plateaus and slopes and within < 1 hour following precipitation events (Fig. 2).
- Thawed active layers were much shollower on the peat plateaus and slopes (depths up to ~30 cm) compared to the fens (>1m).
- Soils in peat plateaus and slopes were dominated by organic rich fibric and humic soils, whereas fens were mostly fibric soils composed of sphagnum (Fig. 5).
- Average soil depths for characterization: Plateaus 30.7 ± 3.0 cm, Slopes 30.2 ± 4.1 cm, Fens 27.6 ± 8.3 cm. Only one sample available for burned Fen. (Fig. 3, 4, 5)
- Thaw soil carbon pools were higher on the plateaus and slopes compared to the fens. The higher soil carbon in the burned sites is due to combustion of the lower bulk density surface soils in the fire (Fig. 3, 4).
- Gravimetric Water Content was greater in fens than plateaus and slopes regardless of recent fire activity (Fig 6).

Conclusions and Future work

We found that surface and subsurface water moves rapidly from peat plateaus to fens, and that precipitation patterns, bulk density, and fire history are factors that may influence that movement and solute transportation.

To further understand how water moves across the tundra landscape, we suggest studying subsurface water for longer periods of times and at more locations to assess spatial heterogeneity in physical and biological features such as slope gradient and shrubification that are likely important drivers of water movement.

Due to the significant changes the tundra is experiencing caused by climate change, such as increase of wildfires, permafrost thaw, and changes in precipitation patterns, future research could identify how changes in water movement and solute transportation influence physical and biological carbon fluxes in peat plateaus and slopes.

Acknowledgements: The land we conducted this research on is Yup'ik territory, which is a community of people that hold strong ties and knowledge to this land that spans thousands of years.