Frost, Fire, and Flora in Nunatsiavut, Labrador

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INTRODUCTION

Permafrost characteristics are strongly linked to vegetation cover, which is changing rapidly throughout the Arctic. This study examines the state of ground thermal characteristics in Nunatsiavut, in response to surface changes caused by shrub growth and fire disturbance. The main research objective is **to measure and model the impacts of surface change on discontinuous permafrost in Nunatsiavut**.

The formation of permafrost in coastal Labrador was likely climate-driven. Today, most lowland permafrost is ecosystem-protected, with persistence relating to boreal forest cover. Much of this ecosystem-protected permafrost is projected to degrade due to the removal of overlying vegetation and organic soil by forest fires and the snow-trapping and ground-insulating effect of shrubs.

STUDY AREA

Nunatsiavut is a subarctic coastal region with a mean annual air temperature of around -3.0°C and some of the highest precipitation levels in the North American boreal forest. The communities of Nunatsiavut are located in sporadic discontinuous and isolated permafrost zones.

A total of 13 transects were performed at 3 fire-disturbed sites (Beaver River, BR; Tikkoatokak Bay, TB; Webb Bay, WB) and 3 non-fire-disturbed sites (Nain Foreshore, FOR; Nain Hill 1, NH1; Nain Hill 2, NH2), located near or in Nain and Postville.

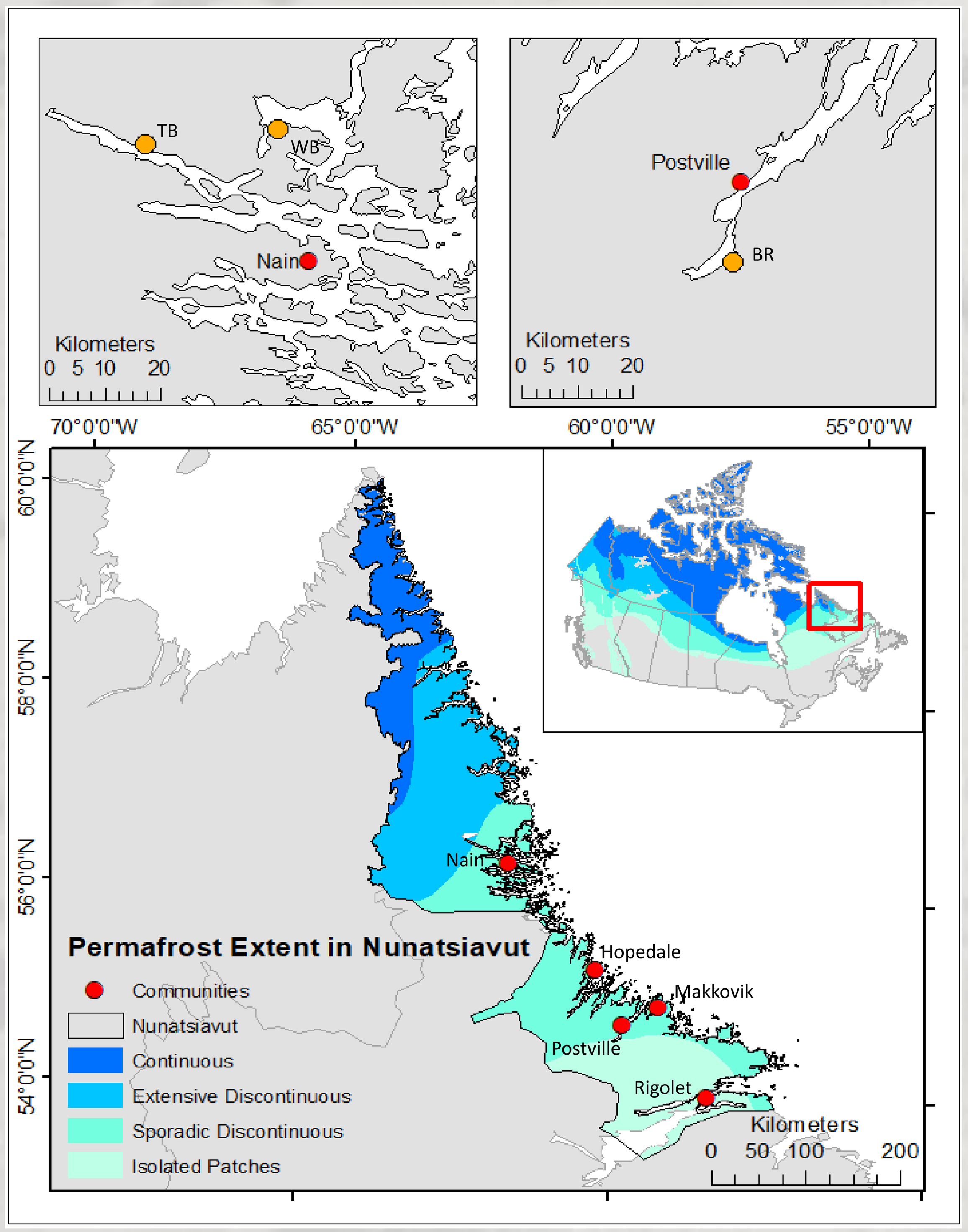

Figure 1. Permafrost extent and distribution in Nunatsiavut, Labrador. The Beaver River (BR), Webb Bay (WB), and Tikkoatokak Bay (TB) forest fires, located near the communities of Nain and Postville, are located within sporadic discontinuous permafrost zones. The 3 non-fire-disturbed sites (Nain Foreshore, FOR; Nain Hill 1, NH1; Nain Hill 2, NH2) are located in the community of Nain. Permafrost zones are based on the Circum-Arctic Map of Permafrost and Ground Ice Conditions, Version 2, from the National Snow and Ice Data Centre.

METHODS

This project includes both field and modelling investigations. In-field methods include the following:

- Direct current Electrical Resistivity Tomography (ERT)
- Frost probing (120-cm-long probe) and ground temperature measurements
- Soil characteristics and organic layer depth measurements
- Air and ground temperature monitoring
- Snow depth monitoring and surveys
- Shrub height and density surveys and canopy cover estimates
- Low-altitude Unmanned Aerial Vehicle (UAV) surveys

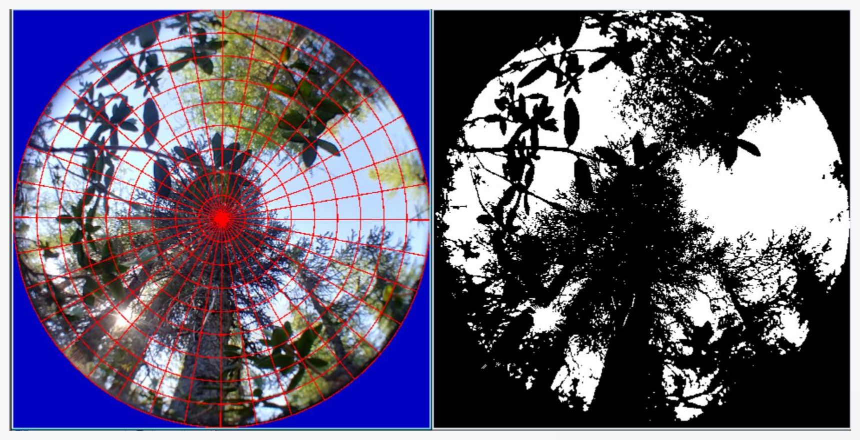

Figure 2. Original and working hemispherical images processed through the Gap Light Analyzer 2.0. A threshold for pixel classification is applied to the working image to estimate canopy cover within the hemispherical photograph.

RESULTS

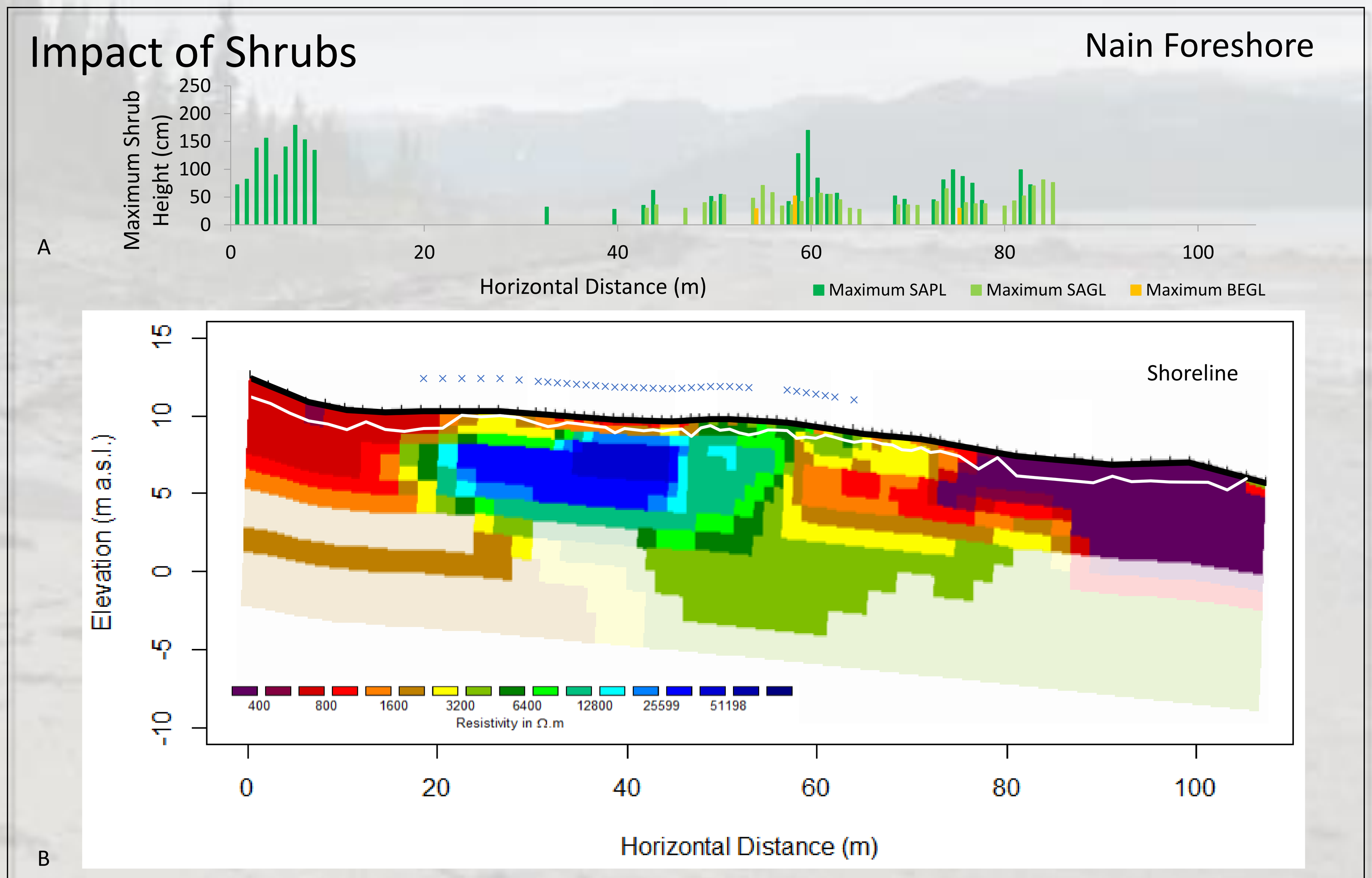

Figure 3. A) Maximum height of shrubs in 0.25 m² plots along ERT profile. Maximum height of each observed species was recorded, including *Salix planifolia* (SAPL), *Salix glauca* (SAGL), and *Betula glandulosa* (BEGL). B) A 106-m-long ERT transect, perpendicular to the shore (at 106 m), collected on a south-east-facing slope at the Nain Foreshore site. Depths of return from frost probing at electrode positions are displayed ( ). Confirmed frost tables are marked (*).

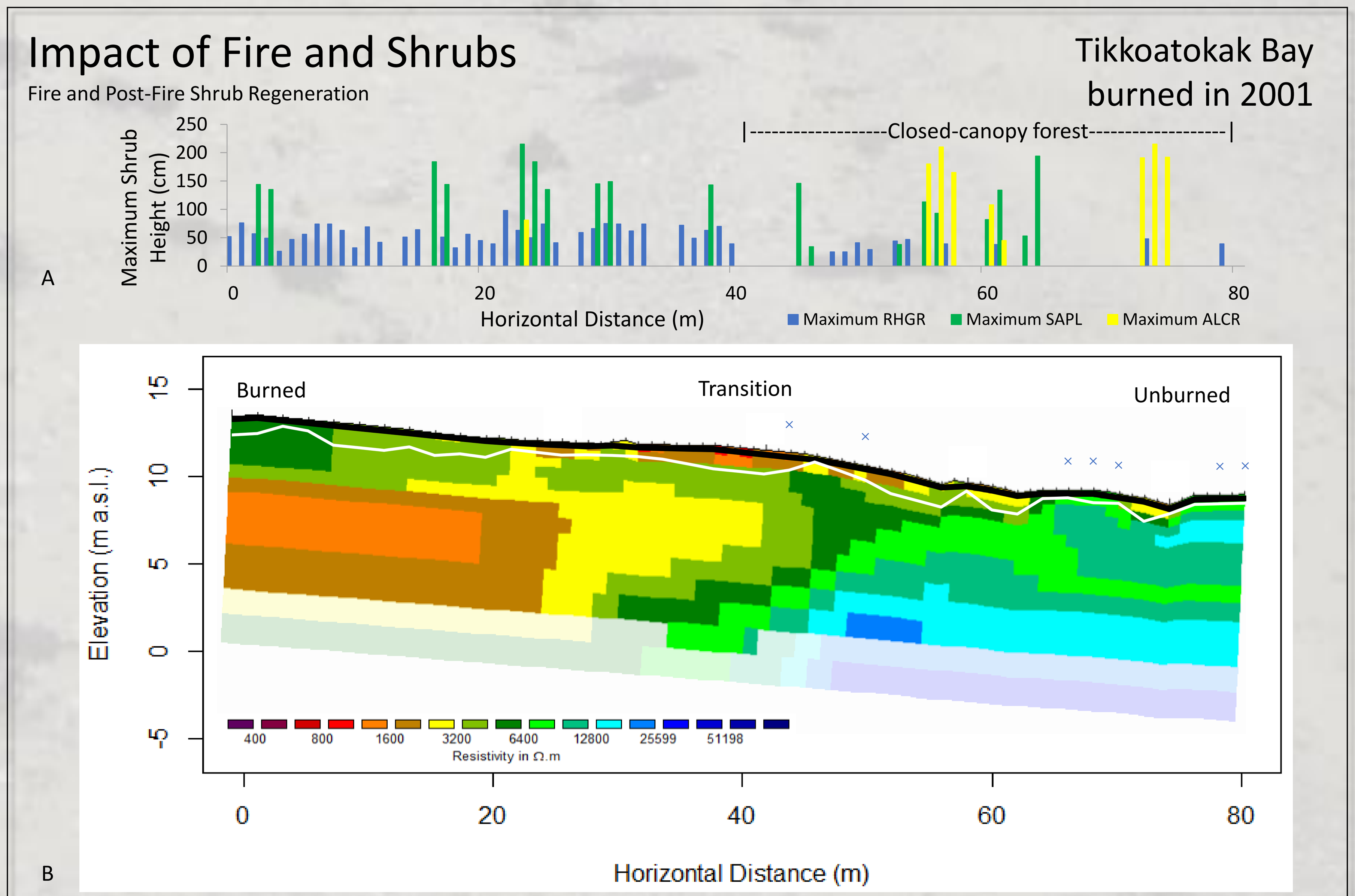

Figure 4. A) Maximum height of shrubs in 0.25 m² plots along ERT profile. Maximum height of each observed species was recorded, including *Rhododendron groenlandicum* (RHGR), *Salix planifolia* (SAPL), and *Alnus crispa* (ALCR). B) An 80-m-long ERT transect from the burned area to the unburned forest, collected on a south-west-facing slope at the Tikkoatokak Bay burn of 2001. Depths of return from frost probing at 2-m intervals are displayed ( ). Confirmed frost tables are marked (*).

RESULTS (continued)

Impact of Shrubs:

At the Nain Foreshore site:

- A body of permafrost is present. This body of permafrost measures ~7m in thickness.
- Frost tables are deeper near taller and denser shrubs than in areas with fewer shrubs.

Impact of Fire and Shrubs:

At the Webb Bay site:

- The transects can be separated into 3 distinct regions:
    - a burned area (Cluster 4)
    - an unburned area (Cluster 3)
    - a transition area (Cluster 1)
- A fourth cluster (Cluster 2) contains cases along the ERT lines in which no shrubs are present.
- The variance of the burned area is greater than that of the unburned area.

This pattern occurs at all 3 fire-disturbed sites.

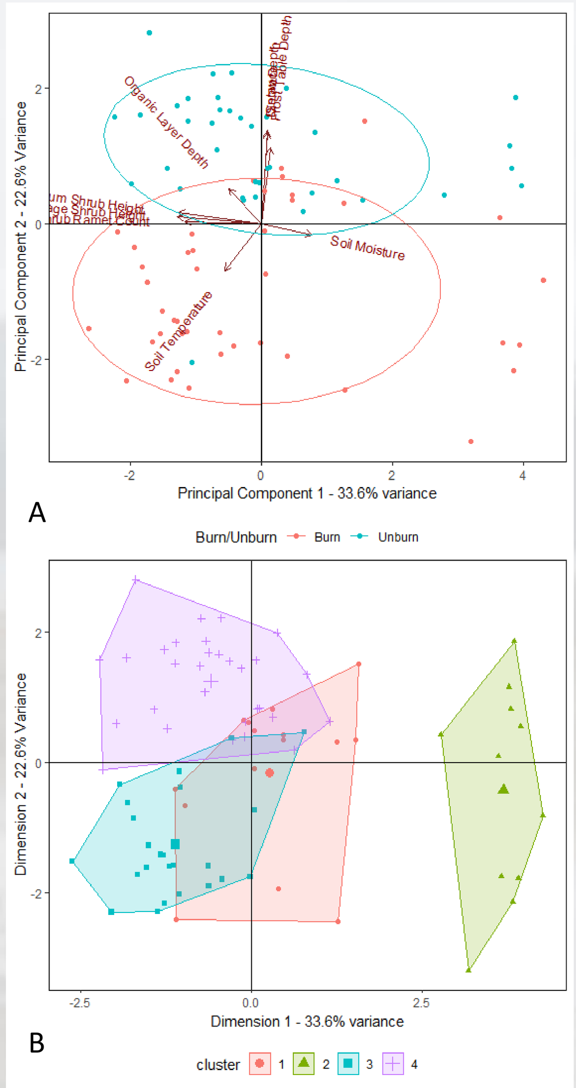

Figure 5. A) Principal components and B) cluster analysis of observations taken along 2 80-m-long ERT transects across burned to unburned transitions at the WB site.

At the Tikkoatokak Bay site:

- Low resistivities in the burned area are associated with thinner organic layers, warmer ground temperatures, and taller and denser shrubs.
- A thin body of frozen ground is present in the unburned forest.
- High resistivities typically correspond to frozen ground or bedrock. Progressive permafrost degradation may be occurring from the burned to unburned area.

CONCLUSION

Preliminary findings are consistent with predicted impacts of fire disturbance and shrub growth on permafrost. These field observations will inform and validate thermal modelling of ecosystem-protected permafrost in Nunatsiavut, Labrador. Thermal modelling will be used to predict long-term changes to thermal ground characteristics, with forest fires and shrub growth serving as the primary factors of surface change.

ACKNOWLEDGEMENTS

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