INVESTIGATING PERMAFROST-SHRUB INTERACTIONS IN TORNGAT MOUNTAINS NATIONAL PARK, NORTHEAST CANADA

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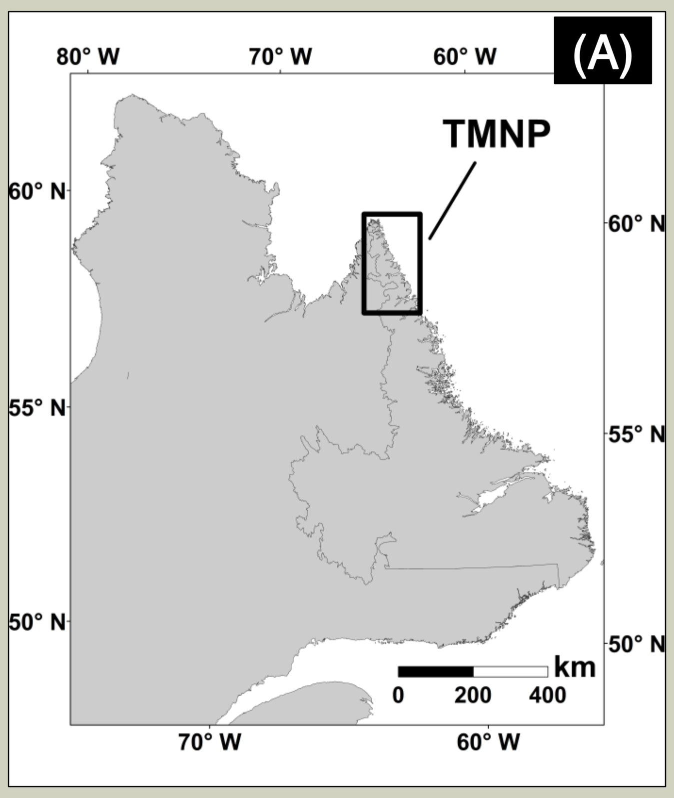
TORNGAT PERMAFROST PROJECT: OBJECTIVES

(1) Establish a permafrost monitoring network. ⟷ **(2)** Investigate potential impacts of shrub growth on permafrost. ⟷ **(3)** Understand impact of permafrost thaw on ecosystems and wildlife. ⟷ **(4)** Support and enhance existing ecological integrity initiatives. ⟷ **(5)** Generate permafrost distribution maps. ⟷ **(6)** Characterize permafrost's future susceptibility to a warming climate.

STUDY AREA

Torngat Mountains National Park (TMNP) is in the Canadian low-Arctic coastal region of northern Nunatsiavut, Labrador (Fig. 1). We established climate and ground temperature monitoring apparatus across the region at six field sites. Areas monitored range from polar desert to high Arctic tundra to low hypoarctic tundra ecozones.



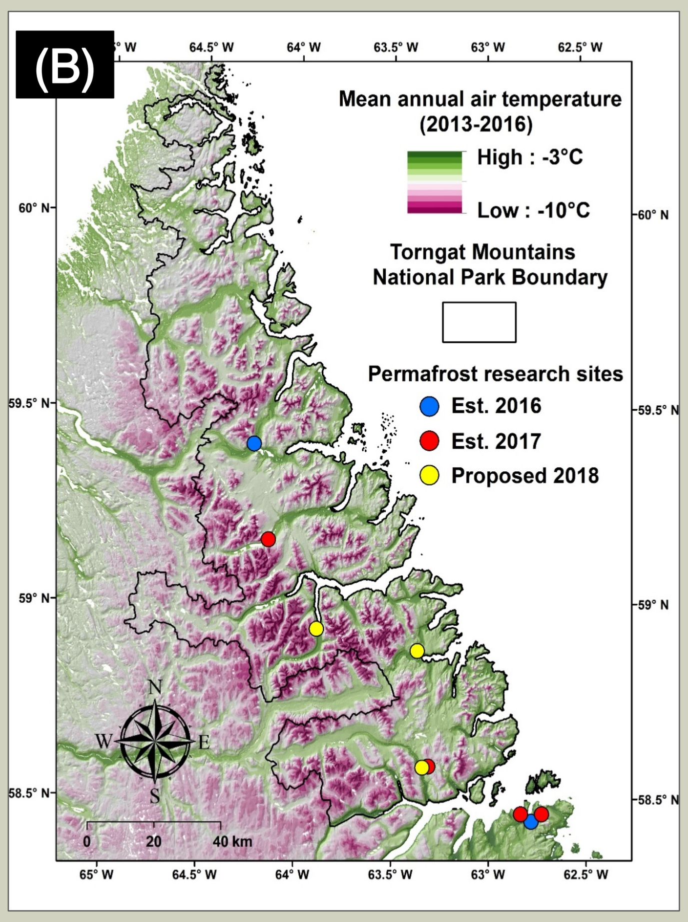


Fig. 1: (A) Location of TMNP in northern Labrador; **(B)** Field sites visited for permafrost and ecological research in 2016 and 2017 as part of this project. Sites proposed to be visited in 2018 are also illustrated. Research sites are superimposed on a map showing the spatial distribution of mean annual air temperatures in northern Labrador (2013-2016).

METHODS

We conducted 17 geophysical surveys using DC electrical resistivity tomography (ERT) along tundra-shrub transition transects (e.g., Fig. 2A). Additional data collected along the ERT transects included: (1) summer thaw depths from frost probing; (2) instantaneous ground temperatures profiles (e.g., Fig. 2B); (3) UAV photography to characterize geomorphology and shrub distribution; and (4) determinations of vegetative cover and height and density of prostrate and tall shrubs (e.g., Fig. 2B). Ground surface temperature (GST) loggers were installed at 2-3 cm depths at selected locations along ERT transects.

High elevation inland climate stations (n=3; e.g., Fig. 2C) were established to measure air, ground surface and ground temperatures (~80 cm depth), relative humidity and snow depth. Low elevation coastal environmental monitoring stations (n=2) were also installed for inter-comparison. Additional data was provided by Parks Canada from their ecological monitoring network in TMNP.

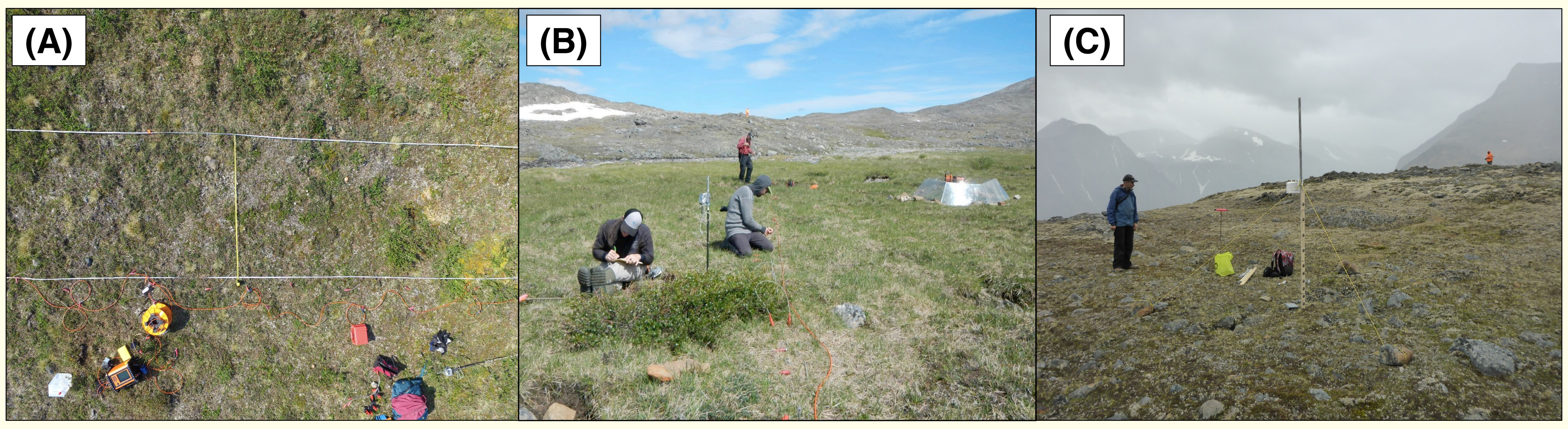


Fig. 2: (A) UAV image of ERT system, ERT survey line and vegetation surveying area (between white lines) at Komaktorvik1 field location; **(B)** Shrub and ground temperature profile data collection at Nakvak Brook field location; **(C)** Remote climate station (520 m a.s.l.) located in the high Arctic tundra ecozone adjacent to Komaktorvik River.

RESULTS: PERMAFROST-SHRUB INTERACTIONS

Combining ERT and vegetation surveys was an efficient technique for permafrost detection. Inferences from ERT (e.g. Fig. 3) and instantaneous ground temperatures suggested that tall shrubs were associated with warmer ground temperatures and thinner permafrost. In contrast, prostrate shrubs were correlated with higher near-surface resistivities and detectable permafrost. Shrub-permafrost linkages appear to be mediated by microclimate, surficial materials and topographic positions.

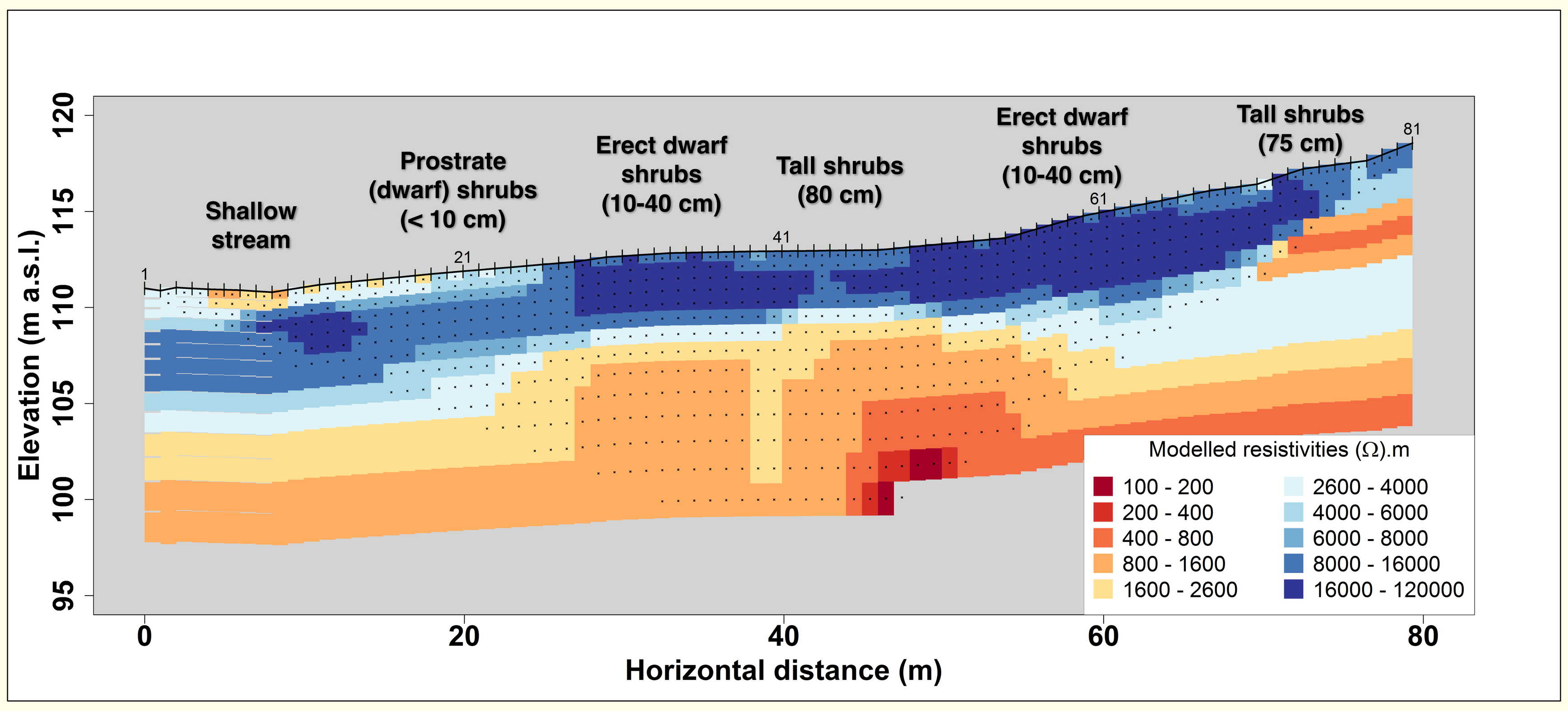


Fig. 3: Modelled resistivities along ERT profile at Komaktorvik River, where higher resisitivies (i.e. >4000 Ω.m) are inferred to indicate the presence of permafrost. Details: Error = 4.5%; Model iteration 4; Electrode spacing = 1.0 m; Hatching shows approximate depth of investigation per RES2DINV.

RESULTS: GROUND SURFACE TEMPERATURES

GST logger data (n=79) analyzed had a median temperature of -2.3°C with minimum and maximum values of -3.5°C and 1.9°C (e.g., Fig. 4A), respectively. Quality-controlled data for existing air temperature logger sites operational in TMNP were generated by infilling and gap-filling with atmospheric reanalysis data enabling complete daily temperature data coverage for TMNP from 2010-2017. Comparison between air and ground temperatures showed a median surface offset of 2.0°C and permitted analysis following Way and Lewkowicz (2018). Modelling with the temperature at the top of permafrost model (Way & Lewkowicz, 2016; rk: 0.7-1.0) indicated that permafrost may be present at 70–80% of logger sites suggesting that the regional distribution of permafrost in TMNP is more likely widespread (> 50% of land area; Fig. 4B) rather than continuous (> 90%) as depicted on permafrost maps.

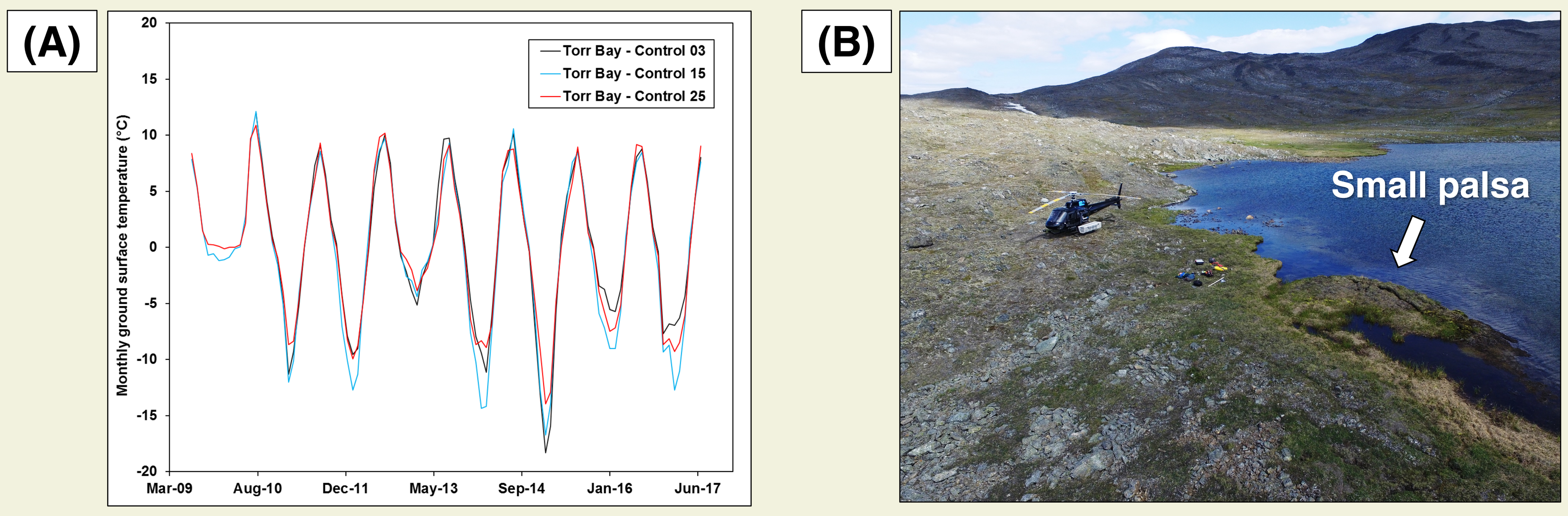


Fig. 4: (A) Example of monthly GST data (°C) measured from three loggers between 2009 and 2017 at Torr Bay; **(B)** Small palsa located at Nakvak Brook (427 m a.s.l.). This palsa, a feature typically found in discontinuous permafrost environments, is degrading as evidenced by large cracks in its surface peat cover.

FUTURE WORK IN TORNGAT MOUNTAINS

Future work includes: (1) visiting three new study areas to assess permafrost and shrub changes; (2) retrieval and analysis of GST loggers; (3) comparison of environmental and permafrost conditions between inland and coastal sites; (4) determination of permafrost-shrub interactions' influence on soil temperatures over the past decade; and (5) ground temperature monitoring across large areas.

REFERENCES

Way RG, Lewkowicz AG. 2016. *Canadian Journal of Earth Sciences*, 53(10): 1010-1028.

Way RG, Lewkowicz AG. 2018. *Permafrost and Periglacial Processes*, 29(2): 73-85.

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