Mapping Degrading Dendritic Peat Plateaus in the Central Mackenzie Valley, Northwest Territories, Canada

UNIVERSITY OF ALBERTA

Alexandre Chiasson[1], Brielle Andersen[1], Alejandro Alvarez[1], Steve Kokelj[3], Jurjen van der Sluijs[4], Ashley Rudy[3], Duane Froese[1]

Government of Northwest Territories / Gouvernement des Territoires du Nord-Ouest

1. Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Canada; 3. NWT Geological Survey, Government of Northwest Territories, Yellowknife, Canada; 4. NWT Centre for Geomatics, Government of Northwest Territories, Yellowknife, Canada

BACKGROUND & INTRODUCTION

In the discontinuous permafrost zone, thermokarst lakes and thermal erosion are widespread and common permafrost thaw-related phenomena. Thermokarst features are indicative of thaw sensitive permafrost terrain and can lead to reduced ground stability and changes in landscape and drainage configuration.

Peatland permafrost features, including peat plateaus and palsas, are particularly vulnerable to thaw in response to global warming because frozen organic materials consolidate when thawed and typically overly ice-rich mineral deposits. Peat plateaus dissected by dendritic fluvial and fen networks are common landforms in the central Mackenzie Valley, Northwest Territories. These networks tend to be associated with gradually sloping terrain (up to ~3m per km) and develop primarily on moraines and glaciolacustrine sediments, hosting segregated ground ice. To our knowledge, no studies have been conducted on the origin of dendritic peat plateau networks.

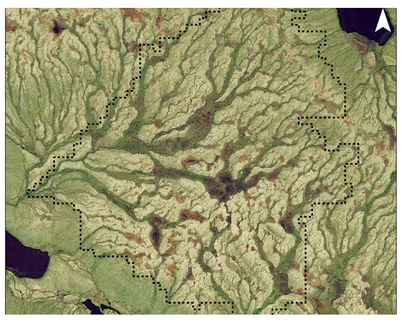

Fig. 1: Area of interest. Degrading dendritic peat plateau near Mackenzie Mountains.

The central Mackenzie Valley is characterized by discontinuous permafrost with low to medium ice content. Borehole records, and semi-remote sensing approch were carried out to describe morphology and permafrost conditions associated with dendritic peat plateau networks.

Objectives: Provide a model of dendritic peat plateau evolution from their initial configuration, and to better understand the origin of this particular landform.

METHODOLOGY

Fieldwork

1

- In 2021, fieldwork investigations involving drilling with recovery of undisturbed permafrost cores, electrical resistivity tomography surveys (ERT) and installation of three climate stations (<3m).

Landform mapping and spatio-temporal analysis (remote-sensing)

2

- High-resolution 2018 SPOT 6/7 1.5 m resolution imagery and aerial photographs from 1949 and 1970.
- Assessment of the degree of thermokarst expansion within peat plateau (65°13.478'N, 128°16.984'W).
- Fine-scale peat plateaus mapping (1:1000) to asses the rate of thermokarst expansion.
- Grid cell mapping method (50x50m) to determine the proportion of the area affected by thermokarst.

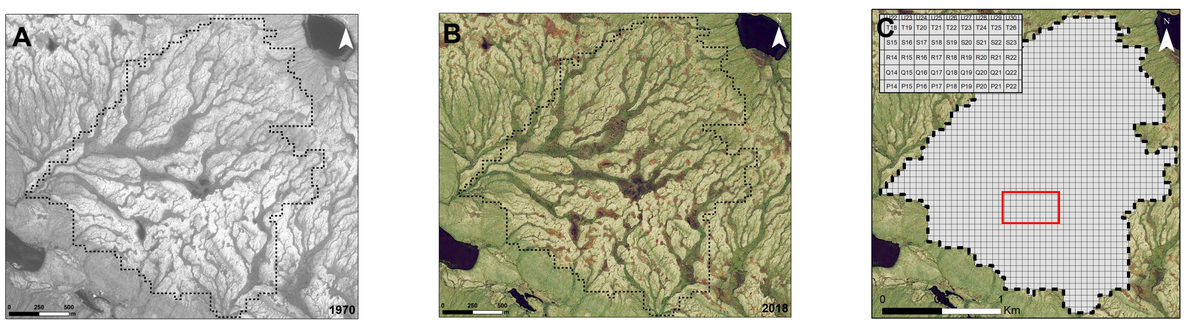

Fig. 2: A) aerial photograph (1970) acquired at the National Air Photo Library. B) High-resolution SPOT 6/7 1.5 m true color and false-color composite. C) Grid cell (50x50m) covering the area of interest.

LANDSCAPE EVOLUTION (1949-2018)

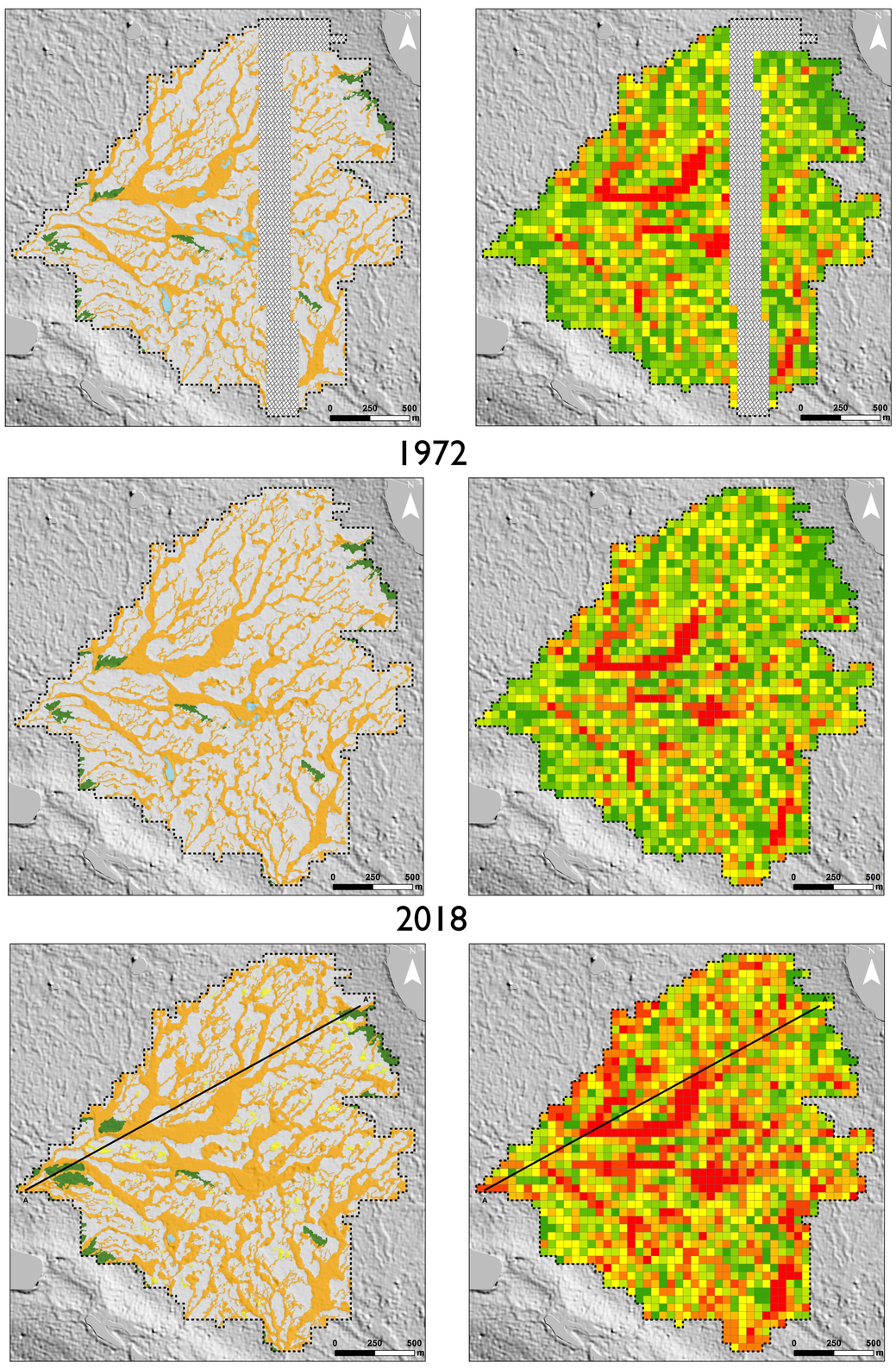

Fig. 3: Left: Landform mappimg of the dendritic peat plateau (1949, 1970, 2018). Right: Percentage of degradation (1949, 1970, 2018).

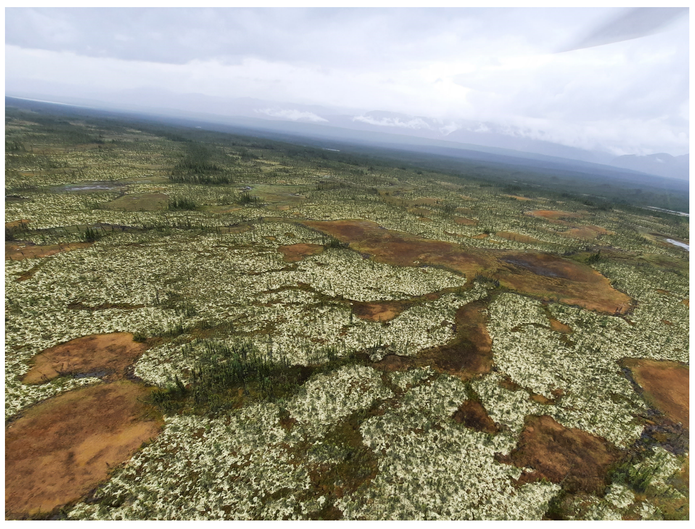

Fig. 4: Degrading peat plateau. Fens and bogs are present within the dendritic peat plateau.

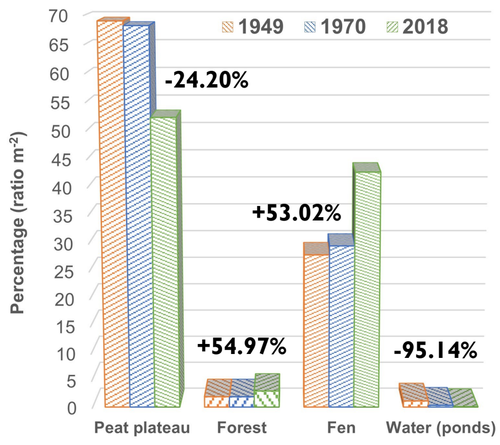

Fig. 5: Percentage of changes from spatio-temporal mapping of degrading dendritic peat plateau (1949-2018).

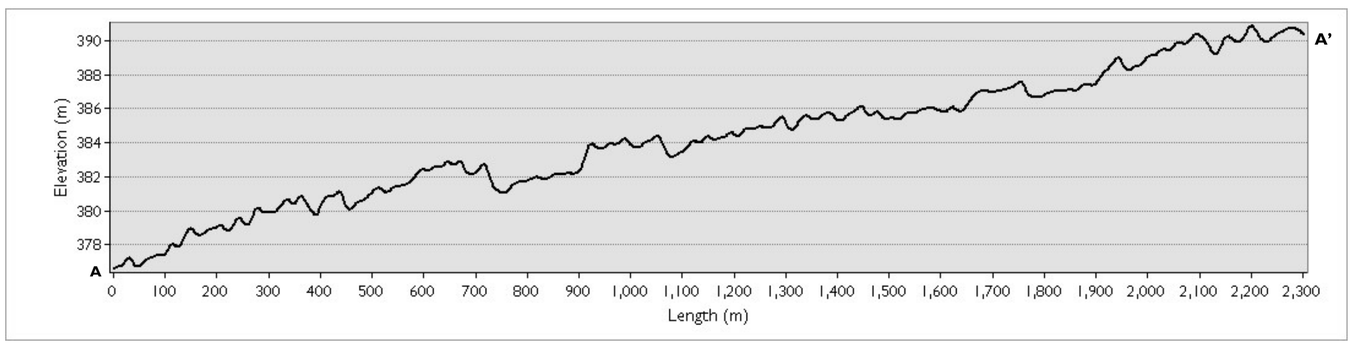

Fig. 6: Cross-sectional view along the degrading dendritic peat plateau. The gradient is up to ~3m per km. The slope is 0.65%.

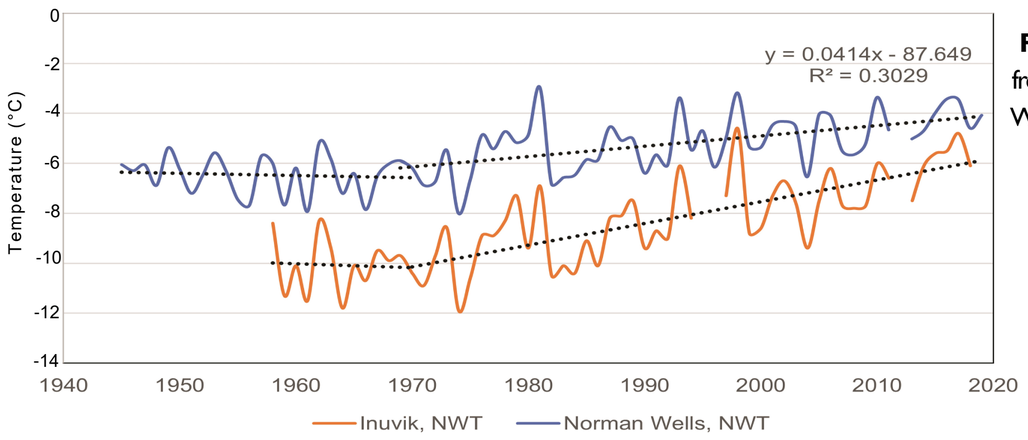

Fig. 7: Mean annual air temperature from Environment Canada's Norman Wells (65°16'57.0"N 126°48'01.0"W) and Inuvik (68°18'15.0"N 133° 28'58.0"W) climate stations.

SCAN ME

LEGEND

Mapping outline

Mapping symbology

- Peat plateau
- Fen
- Water (Ponds)
- No data
- Permafrost-free bog
- Forest (Trees)

Grid cell peat plateau Percentage - degradation (50x50m)

- 0.00 - 7.34
- 7.35 - 17.23
- 17.24 - 27.31
- 27.32 - 38.10
- 38.11 - 51.27
- 51.28 - 66.52
- 66.53 - 84.69
- 84.70 - 100

DISCUSSION & SUMMARY

- Fine-scale mapping (1:1,000) allows us to determinate that the fens has increased by ~55% over the last ~70 years (**Fig. 3-5**).
- Permafrost is typically thin in these areas (5-12m), and through-going taliks forming the channel network are common, and increase in frequency downslope (**Fig. 6**). Field investigation of peat plateaus in 2021 showed that peat thicknesses were ~2m with structureless pore ice, that was overlaying several metres of ice-rich diamict or glaciolacustrine sediments.
- Peat plateaus degradation is driven by thermal erosion of the plateau edges from the ice-rich diamict deposit underlying the peat deposit, but also by the formation of ponds and drainage in the peat plateaus.
- Results indicated that the degradation of the dendritic peat plateau did not start before 1970. Between 1949 and 1970, there was no significant degradation of the peat plateau as the mean annual air temperature decreased (**Fig. 7**).
- We hypothesize that these are slowly expanding thaw networks, likely driven by basal permafrost thaw near taliks, and expansion of fens along margins.

References

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Contact information

Alexandre Chiasson, Ph.D. Student. Department of Earth & Atmospheric Sciences, University of Alberta
Email: Chiasso1@ualberta.ca

Duane Froese, Professor & Canada Research Chair. Department of Earth & Atmospheric Sciences, University of Alberta
Email: duane.froese@ualberta.ca

Collaborators

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