



# Evaluating thaw resilience and ecosystem change of peatland permafrost in coastal Labrador with repeat uncrewed aerial vehicle surveys

Meagan C. Moroney<sup>1</sup>, Robert G. Way<sup>1</sup>, Yifeng Wang<sup>2,3</sup>, and Jordan M. Beer<sup>1,4</sup>

<sup>1</sup> Northern Environmental Geoscience Laboratory, Department of Geography and Planning, Queen's University, Kingston, Ontario, Canada

<sup>2</sup> Natural Resources Canada, Geological Survey of Canada, Ottawa, Ontario, Canada

<sup>3</sup> Department of Geography and Planning, Queen's University, Kingston, Ontario, Canada

<sup>4</sup> Waters Division, Crown-Indigenous Relations and Northern Affairs Canada, Iqaluit, Nunavut, Canada

# Introduction

## Peatlands

Wetlands characterized by the accumulation of partially decomposed organic matter (peat)

## Peatland Permafrost

Peat and underlying materials, that remain at or below 0 °C for at least two consecutive years



# Introduction

## Palsa

Dome shaped mounds

~1 – 10 m high



## Peat Plateau

Flat topped continuous features

1 – 3 m high and 10 - 100s m wide



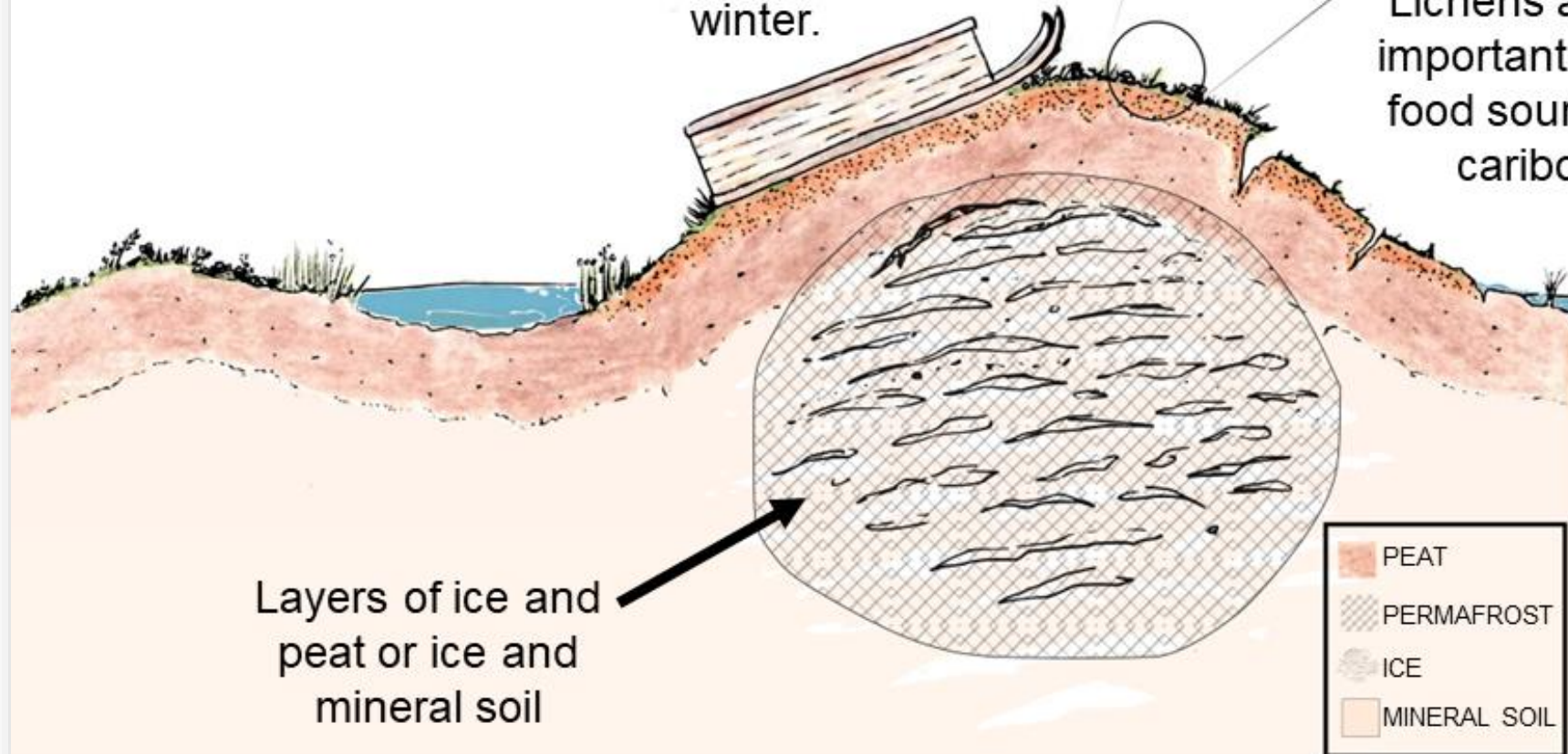
Palsas are ecologically and culturally important features.

Bakeapples (cloudberries) often grow on or near palsas.



Palsas tend to be blown clear of snow in winter.

Lichens are an important winter food source for caribou.



Layers of ice and peat or ice and mineral soil



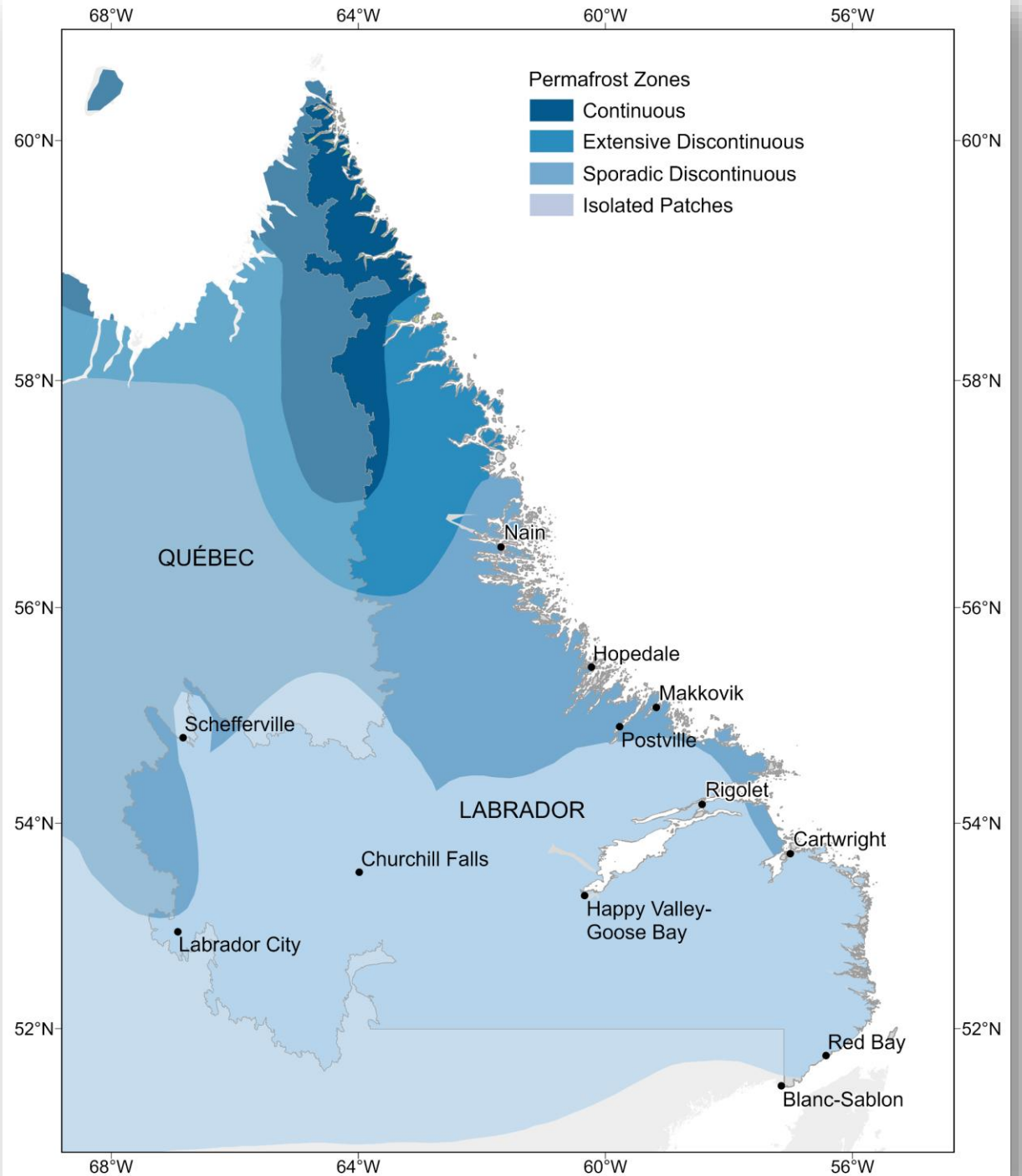
# Regional Context

## Labrador

Long cold winters, short cool summers

## Coastal Labrador

High precipitation and coastal barrens

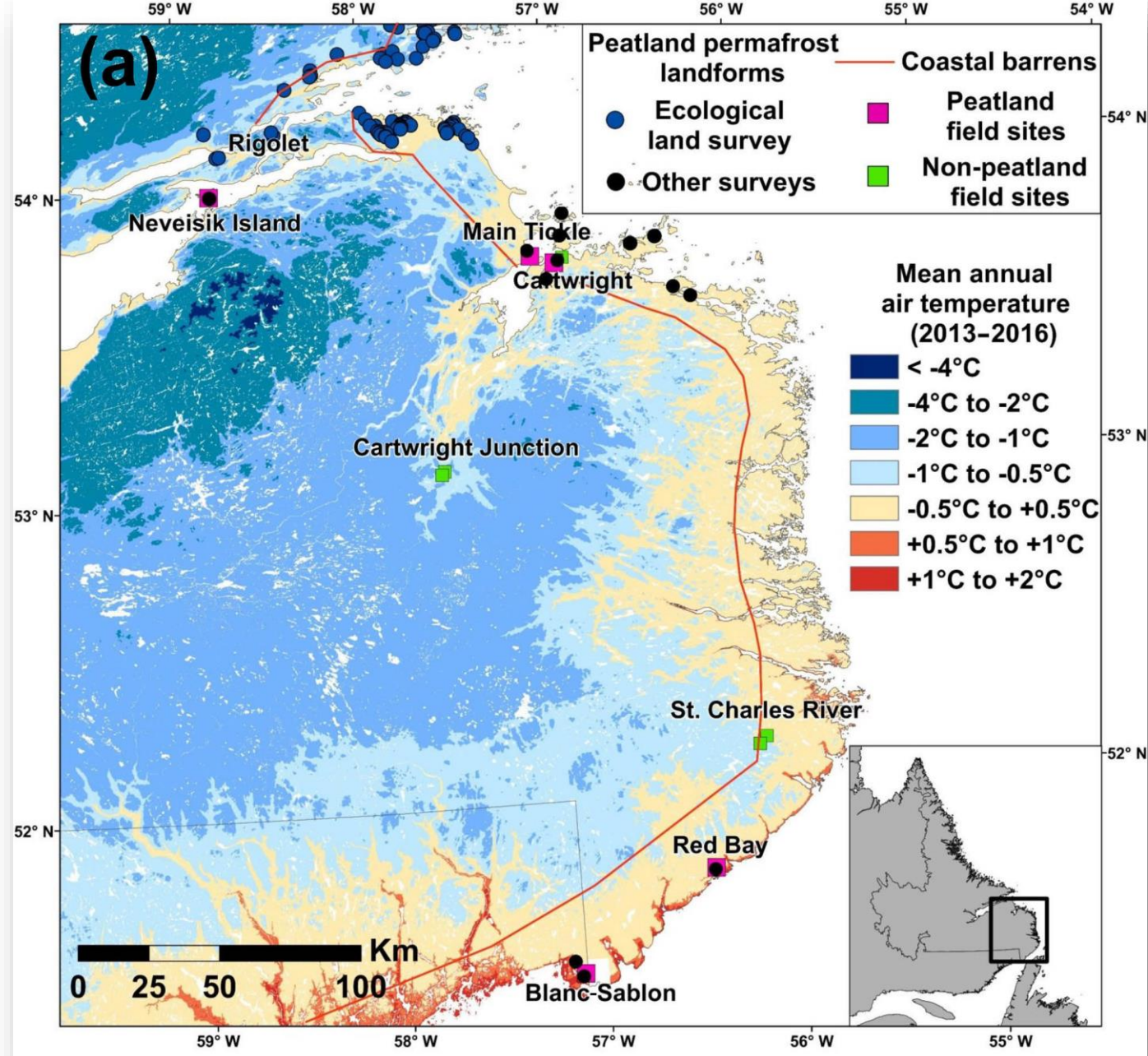


# Background

In 2018, the first contemporary papers to draw attention to the unrecognized abundance of peatland permafrost ecosystems in coastal Labrador were published.

The need for an evaluation of peatland permafrost distribution was highlighted

Way et al. (2018) and Anderson et al. (2018)

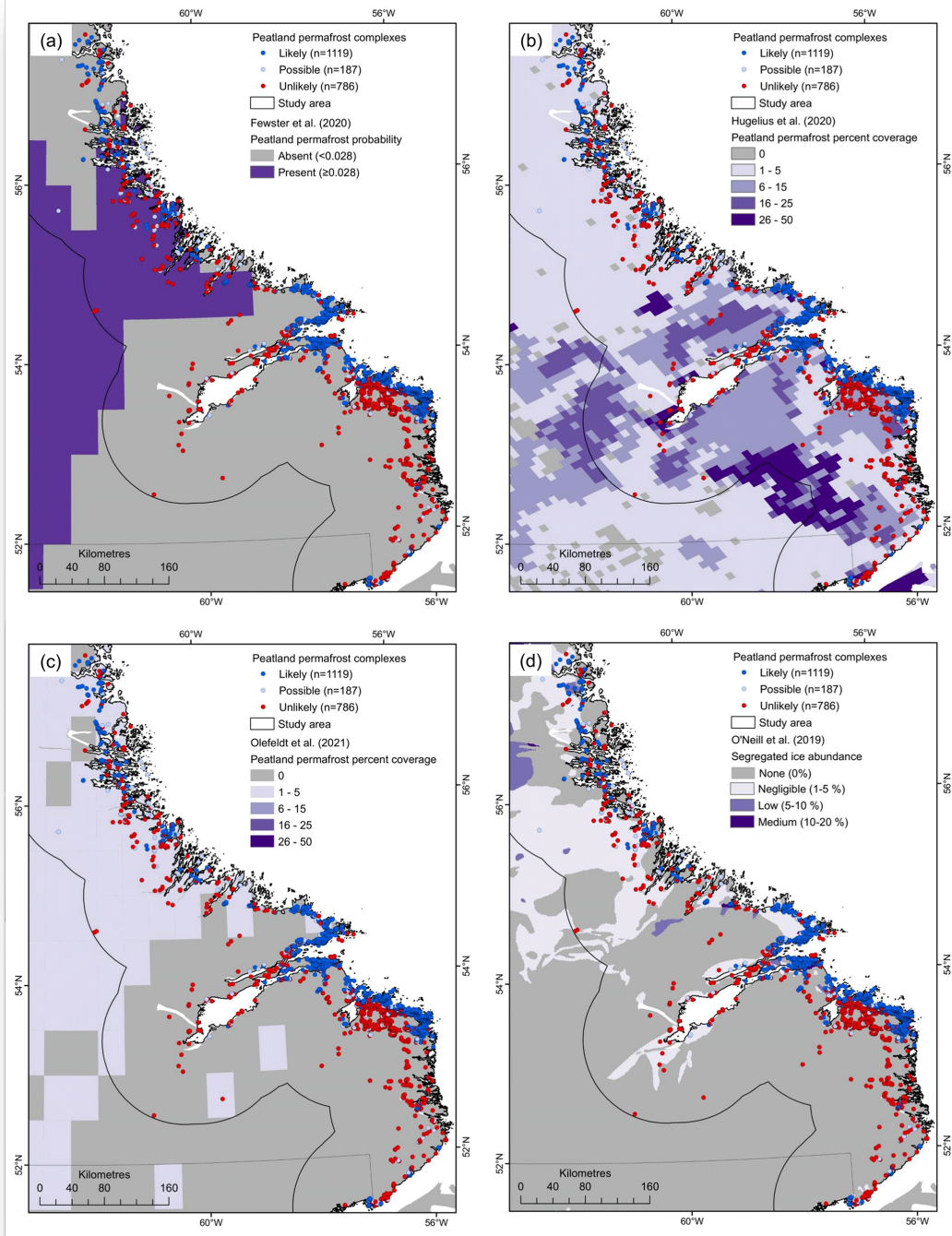


Way et al. (2018)

# Background

In 2023,  
the distribution these environments  
along coastal Labrador was first  
addressed when the presence of  
peatland permafrost was inventoried  
at a subset of peatlands.

Wang et al. (2023)



Wang et al. (2023)

# Background

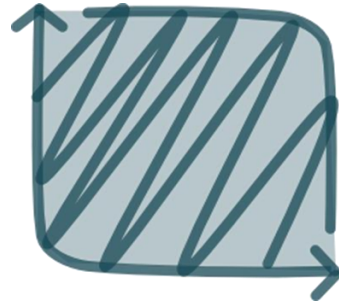
In 2024-25,  
research used geomorphology  
and ground temperatures to  
characterize current conditions  
and vulnerability to change.

Beer et al. (2024), Wang et al. (2024)  
and Wang and Way (2025)

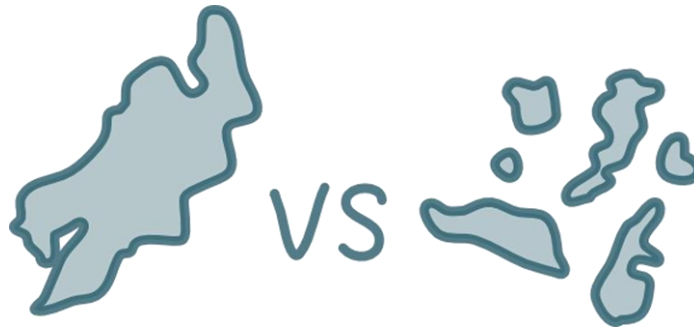


# Vulnerability Indicators

Beer et al. (2024) hypothesized that the following three factors were important for local vulnerability:



Total **area** of palsa or peat plateau



**Fragmentation** of palsa or peat plateau



Total estimated **volume** of ice present within palsa or peat plateau

# Research Question

What are the local-regional controls on thaw resilience and how do ecosystems change due to thawing peatland permafrost in coastal Labrador?

# Research Objectives

**1**

Quantify short-term and recent permafrost thaw.

**2**

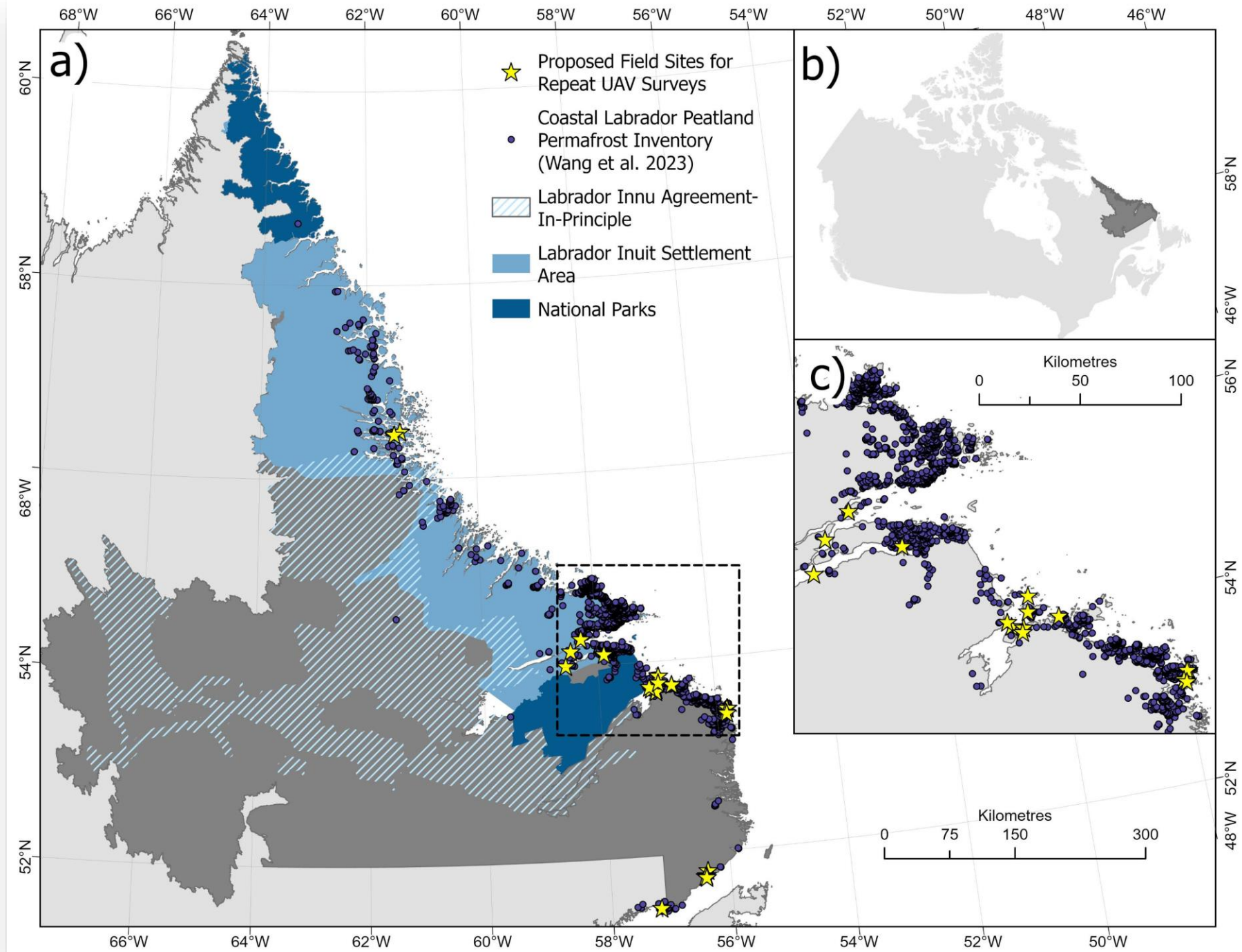
Determine regional-to-local controls on thaw rates and thaw vulnerability.

**3**

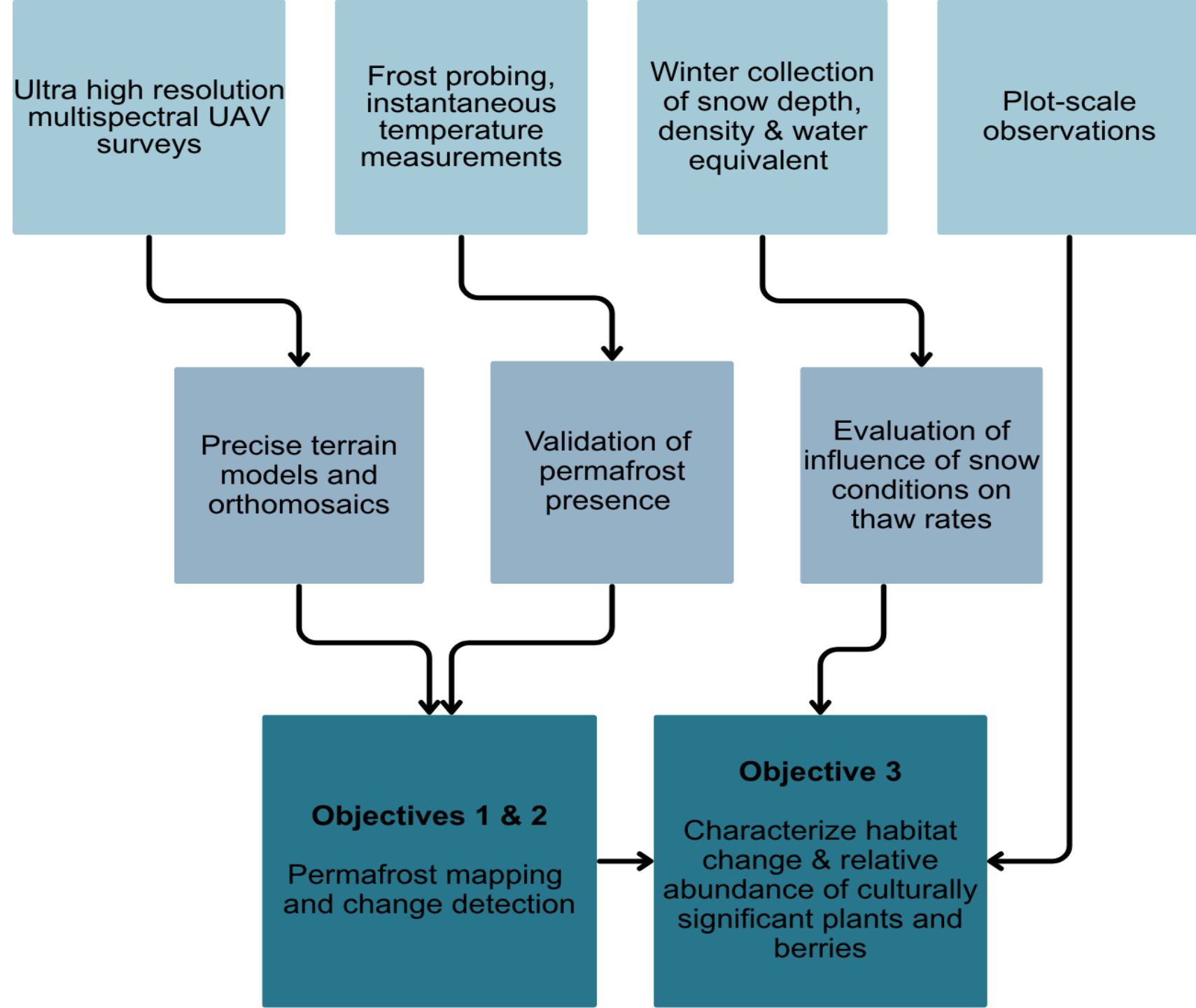
Characterize ecosystem change due to thaw, focusing on Cultural Keystone Species as identified by Labrador Inuit and Innu.

# Study Sites

22 study sites across coastal Labrador (51.4°N to 56.5°N)

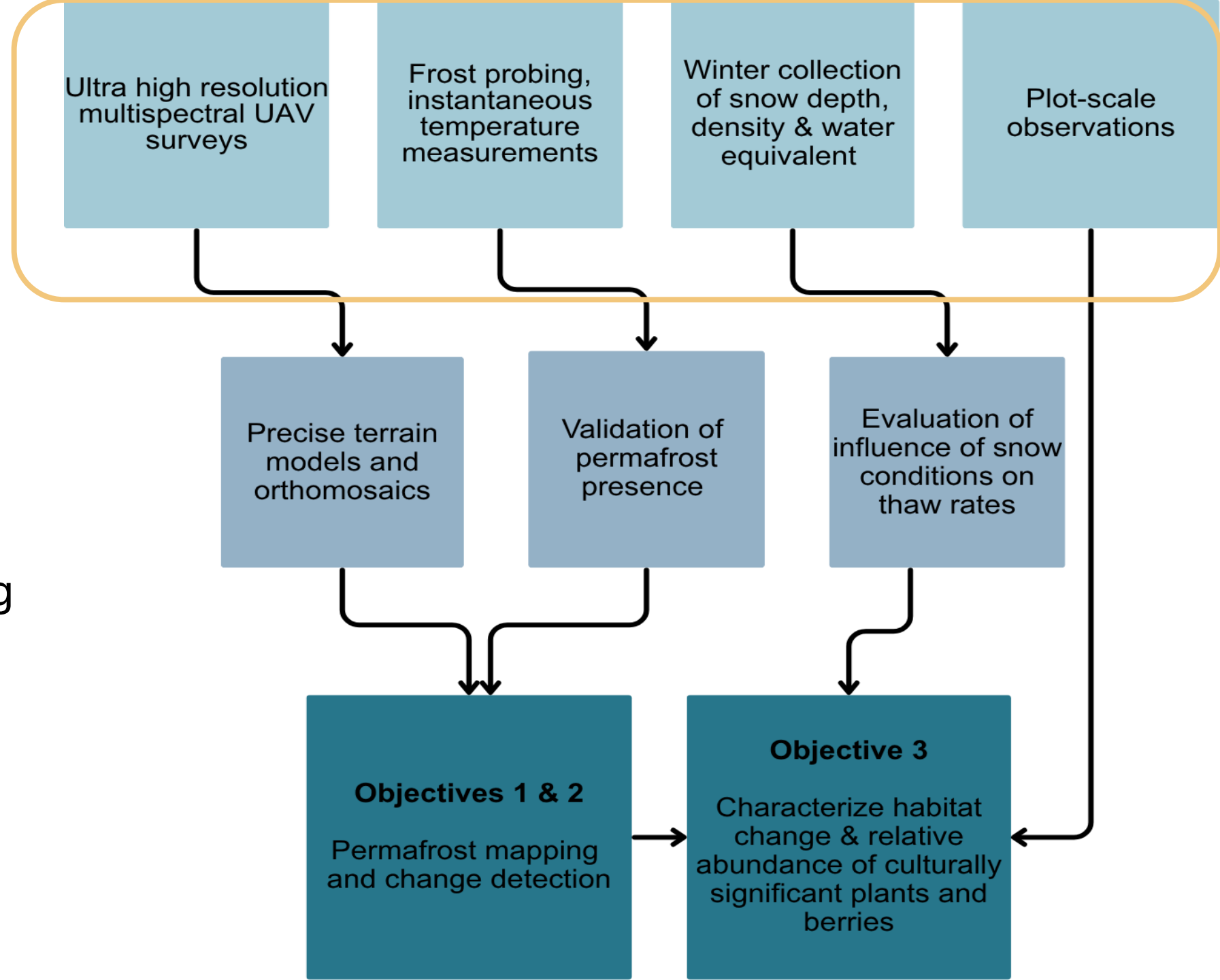


# Methodology



# Methodology

Collection of data using field-based techniques





## Field Based Techniques

### Uncrewed aerial vehicles (UAV)

At each site, ultra high-resolution multispectral UAV surveys will be completed.





## Field Based Techniques

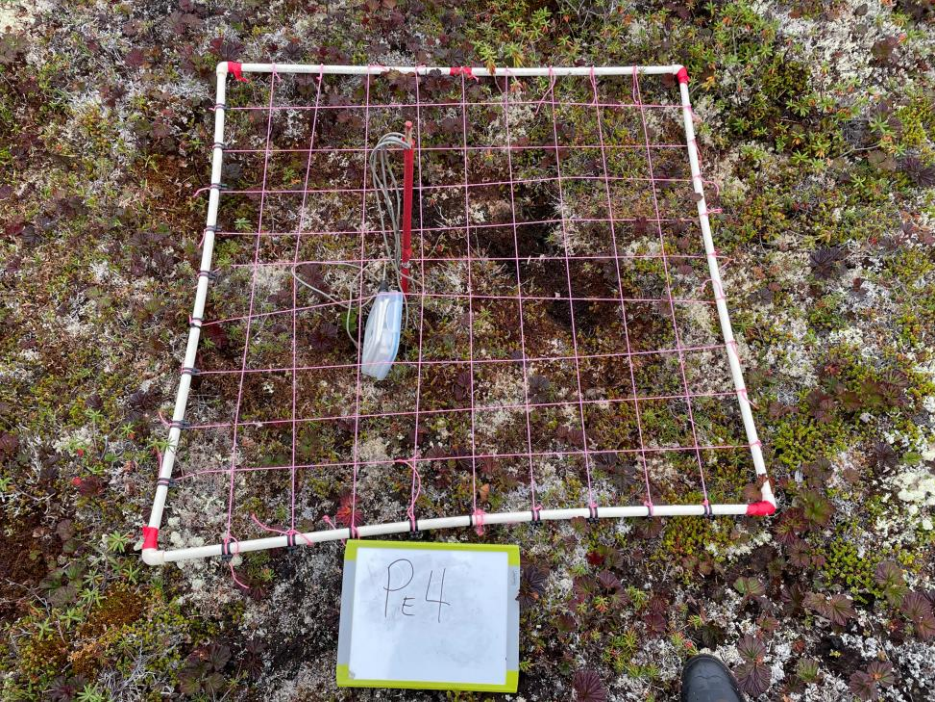
### Frost Probing

Measuring the active layer thickness (ALT)



### Instantaneous Temperature Measurements

Confirm presence or absence of permafrost



## Field Based Techniques

### Vegetation Plots

Characterize vegetation and habitat change, particularly in the abundance of culturally significant plants and berries

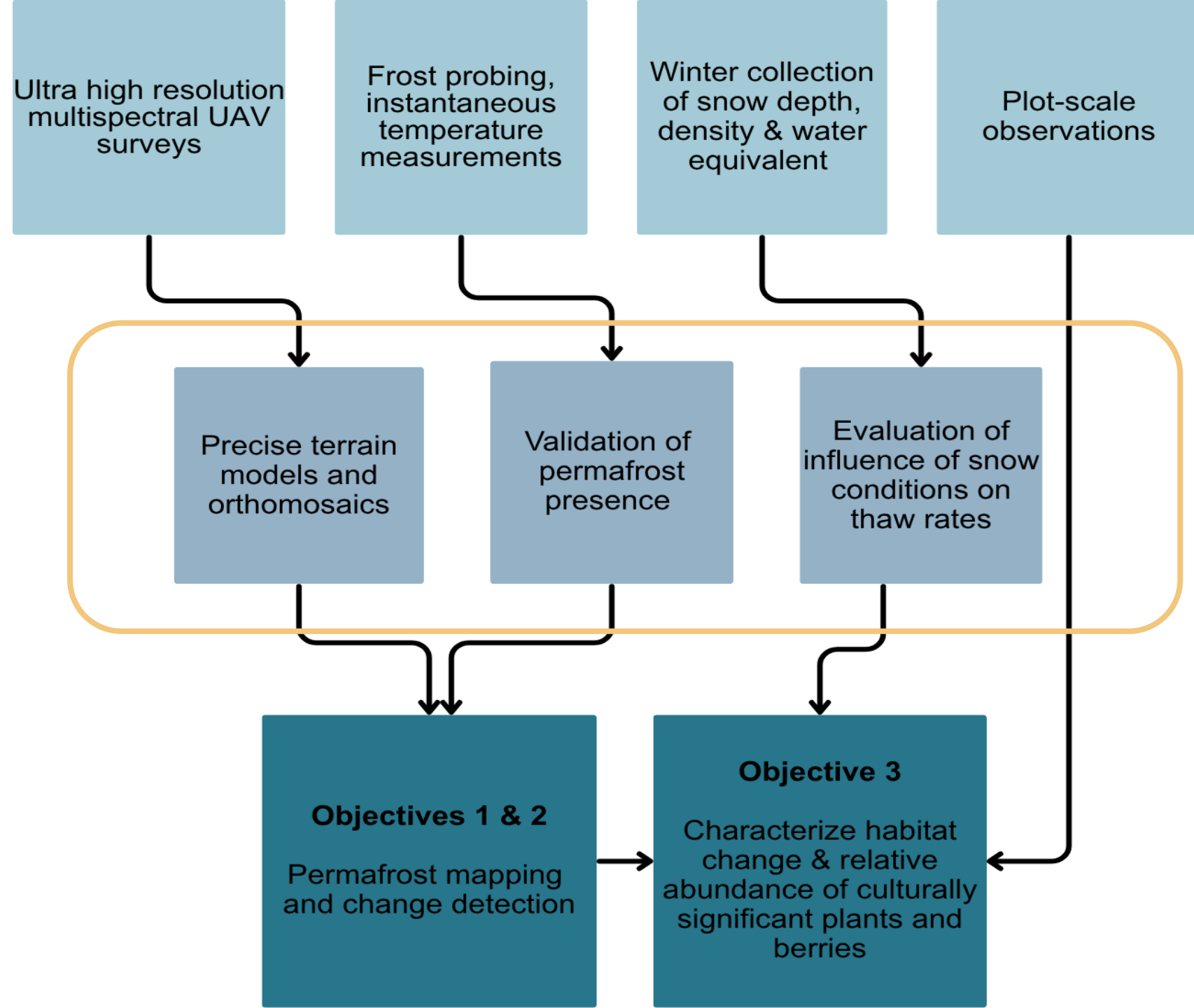


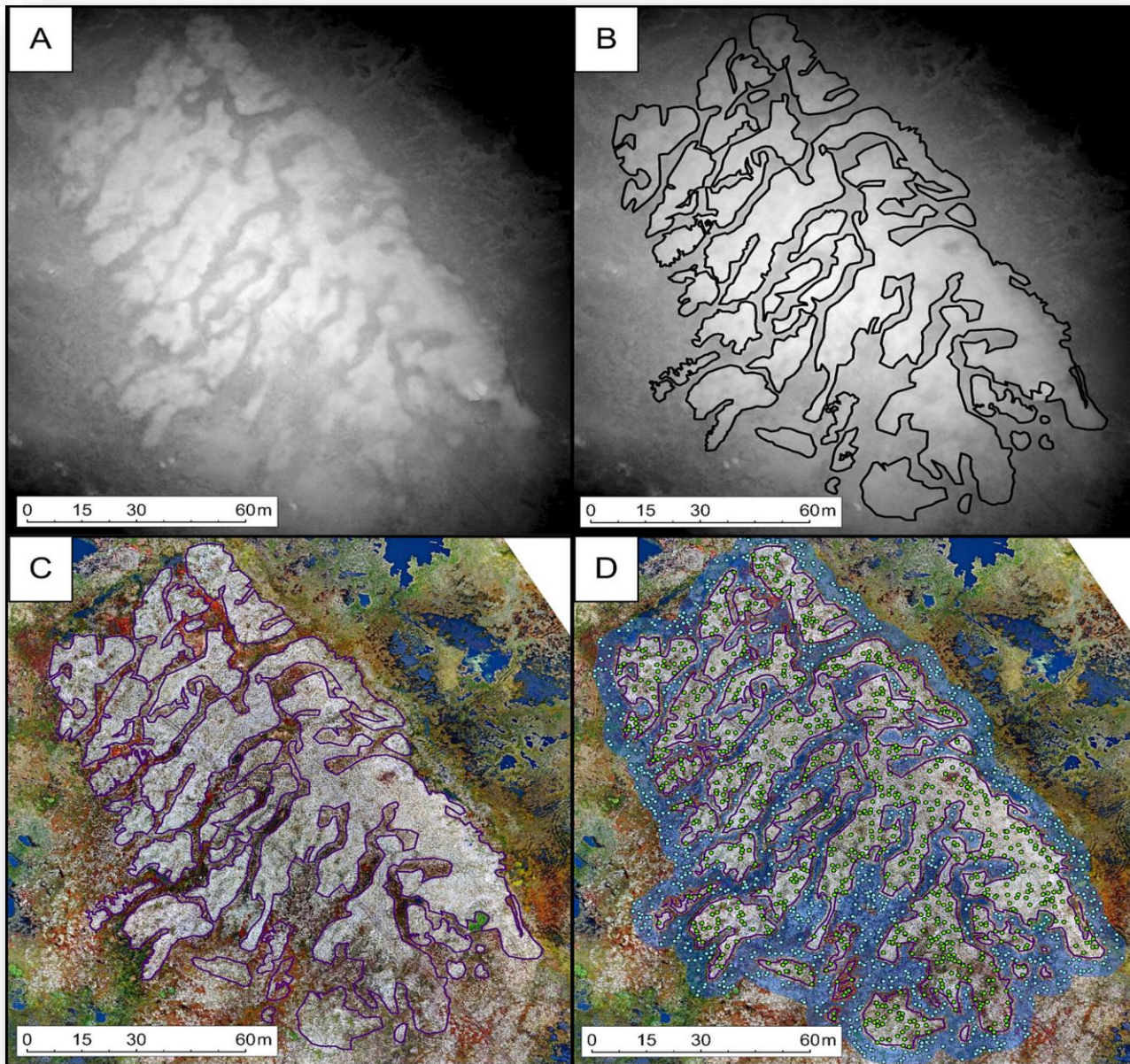
### Snow Density Measurements

Assess snow condition variability within and across the study sites

# Methodology

## Validation and Analysis





# Validation and Analysis

## Analysis

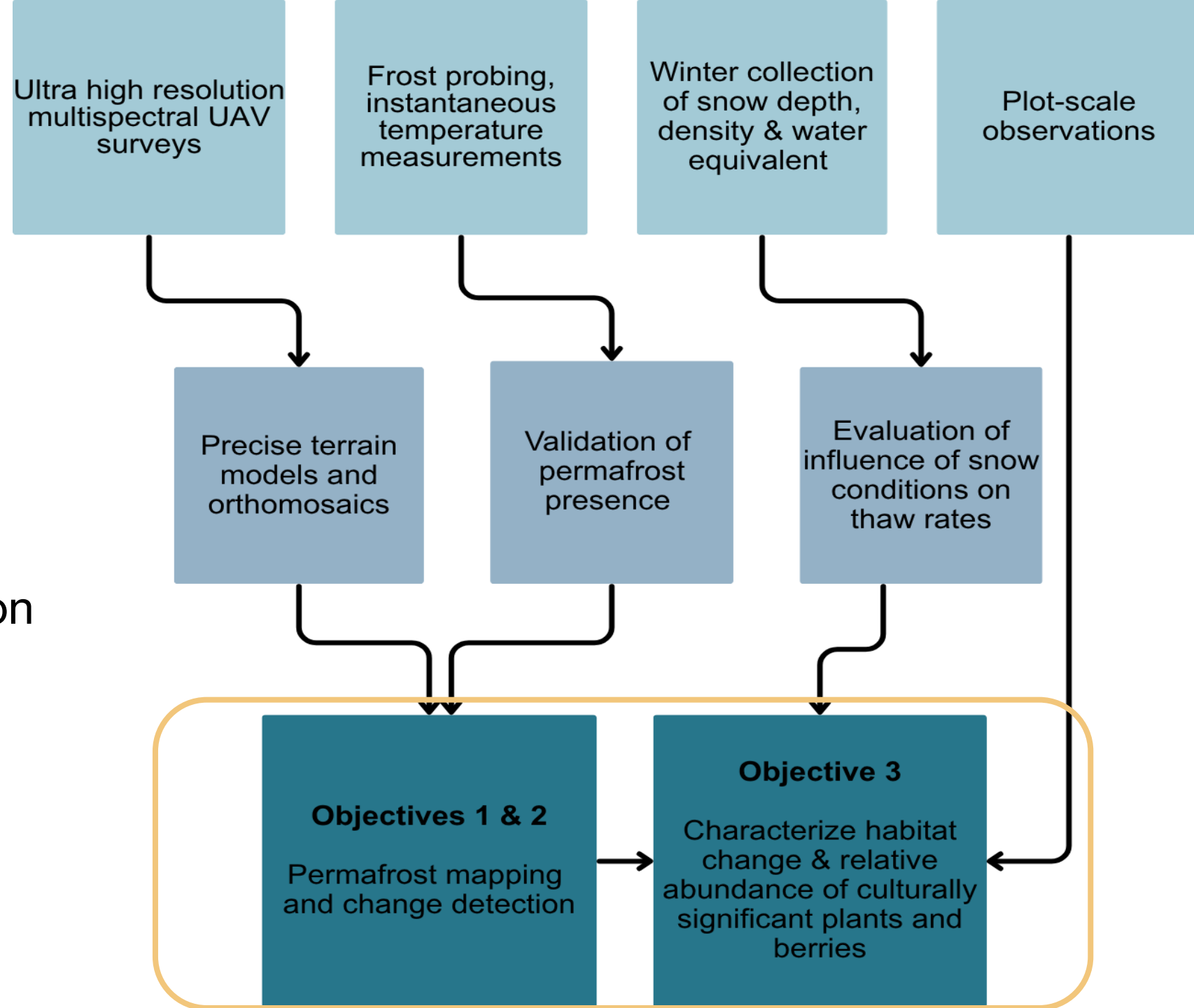
UAV imagery will be used to generate precise terrain models and orthomosaics.

## Validation

Presence, elevation, extent of permafrost will be validated using observations from frost probing and instantaneous temperature measurements.

# Methodology

Mapping, change detection  
and habitat change  
characterization



# Mapping, change detection and habitat change characterization

- Map extent of permafrost
- Difference 2021-22 and 2026 features

**Objective 1**  
Quantify short-term and recent permafrost thaw.

- Compare rates of thaw
- Characterise local-regional controls on thaw

**Objective 2**  
Determine regional-to-local controls on thaw rates and thaw vulnerability

- Chronosequence ecosystem characteristics
- Evaluate change of culturally Keystone species

**Objective 3**  
Characterize ecosystem change due to thaw

# Research Significance



## **Scientific community**

Help disentangle factors influencing the persistence and/or disappearance of permafrost in warming Subarctic peatlands.

## **Globally**

Contributing to improved permafrost mapping initiatives, representations of thermokarst environments and carbon stores modeling.

# Research Significance



## Regionally

Providing information to governments and organizations in Labrador about ongoing and future ecosystem change.

Allowing for more informed decisions and evaluation of potential protection and/or adaptation approaches in northern coastal and at-risk ecological areas.

# Research Significance



## Local communities

Providing information to anticipate and plan for changes to ecological integrity for Cultural Keystone Species.

This will support better planning and resource allocation for all rightsholders and stakeholders.



# Acknowledgements

We thank all the organizations and community partners who have supported this research, without whom this work would not be possible. A special thanks to Victoria Colyn for the creation of infographics used in this presentation.

We thank the Nunatsiavut Government (NG) and Nunatsiavut Research Centre for their longstanding support and permitting of peatland permafrost research in Nunatsiavut. We also thank Innu Nation, Parks Canada and Nunatukavut Community Council for supporting permitting process in Akami-Uapishk<sup>u</sup>-KakKasuak-Mealy Mountains National Park Reserve.

We would like to acknowledge funding from the Natural Sciences and Engineering Research Council of Canada, the Northern Scientific Training Program, National Research Council Canada, the Canada Research Chairs Program, the Canadian Foundation of Innovation and Queens University



# References

Way, Robert G., Antoni G. Lewkowicz, and Yu Zhang. “Characteristics and Fate of Isolated Permafrost Patches in Coastal Labrador, Canada.” *The Cryosphere* 12, no. 8 (2018): 2667–88. <https://doi.org/10.5194/tc-12-2667-2018>.

Anderson, Darya, James D. Ford, and Robert G. Way. “The Impacts of Climate and Social Changes on Cloudberry (Bakeapple) Picking: A Case Study from Southeastern Labrador.” *Human Ecology* 46, no. 6 (2018): 849–63. <https://doi.org/10.1007/s10745-018-0038-3>.

Wang, Yifeng, Robert G. Way, Jordan Beer, Anika Forget, Rosamond Tutton, and Meredith C. Purcell. “Significant Underestimation of Peatland Permafrost along the Labrador Sea Coastline in Northern Canada.” *The Cryosphere* 17, no. 1 (2023): 63–78. <https://doi.org/10.5194/tc-17-63-2023>.

Wang, Yifeng, Robert G. Way, and Jordan Beer. “Multi-Decadal Degradation and Fragmentation of Palsas and Peat Plateaus in Coastal Labrador, Northeastern Canada.” *Environmental Research Letters* 19, no. 1 (2024): 014009. <https://doi.org/10.1088/1748-9326/ad0138>.

Beer, Jordan, Yifeng Wang, Robert Way, Anika Forget, and Victoria Colyn. “Uncrewed Aerial Vehicle–Based Assessments of Peatland Permafrost Vulnerability Along the Labrador Sea Coastline, Northern Canada.” *Permafrost and Periglacial Processes* 35, no. 4 (2024): 461–77. <https://doi.org/10.1002/ppp.2242>.

Wang, Yifeng, and Robert G. Way. “Future Trajectories of Peatland Permafrost Under Climate and Ecosystem Change in Northeastern Canada.” *Journal of Geophysical Research: Earth Surface* 130, no. 2 (2025): e2024JF007930. <https://doi.org/10.1029/2024JF007930>.