Wetlands and roads in Alberta's Boreal

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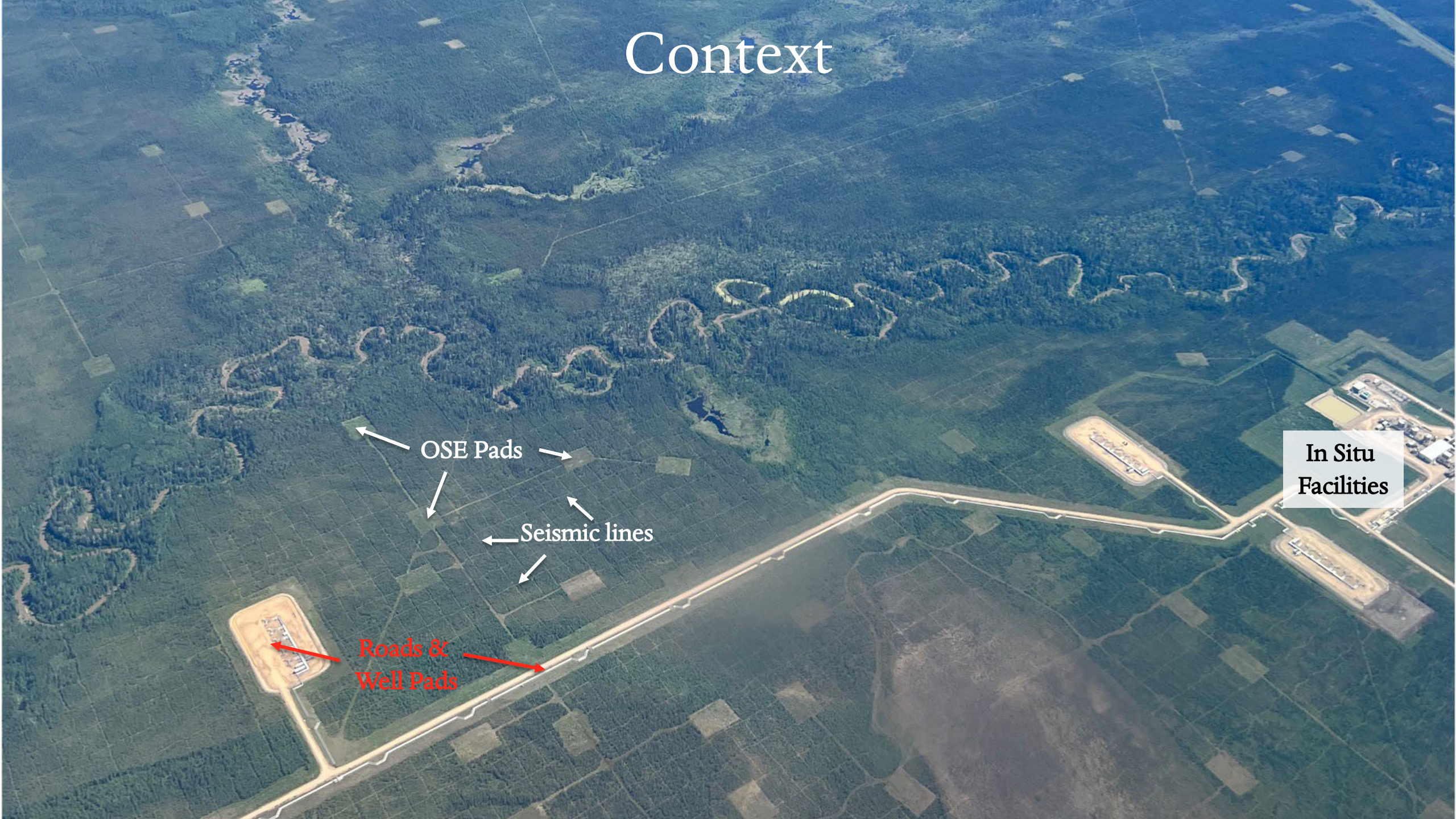
Athabasca University respectfully acknowledges that we are on and work on the traditional lands of the Indigenous Peoples (Inuit, First Nations, Métis) of Canada. We honour the ancestry, heritage, and gifts of the Indigenous Peoples and give thanks to them.

Context

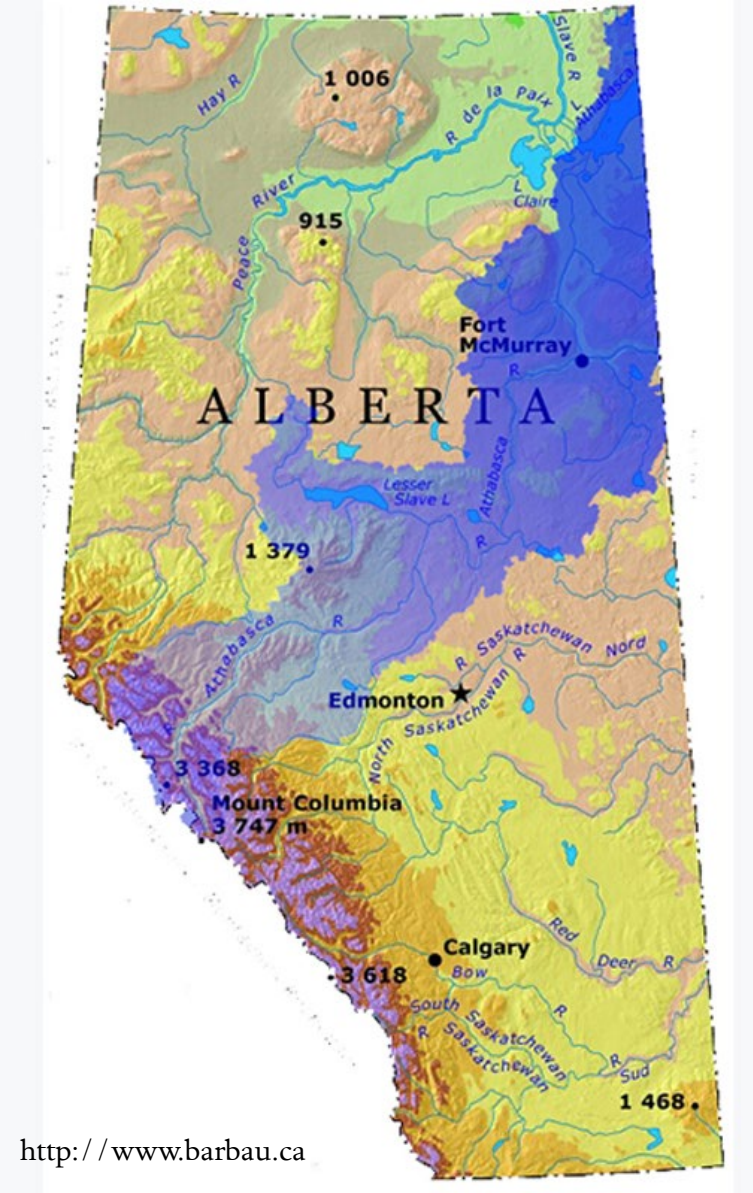


Context

- Wetlands (mostly peatlands) cover up to 50% of the landscape in the Western Boreal Plain
  - Play an important ecological and hydrological role
- Regional sub-humid (dry) climate
- Resource exploration and development infrastructure
- Combined landscape with water-limited setting and abundant resource footprint

Overall Research Goal: Understand the influence of resource exploration and development infrastructure on the local (and regional) ecohydrological conditions and water availability

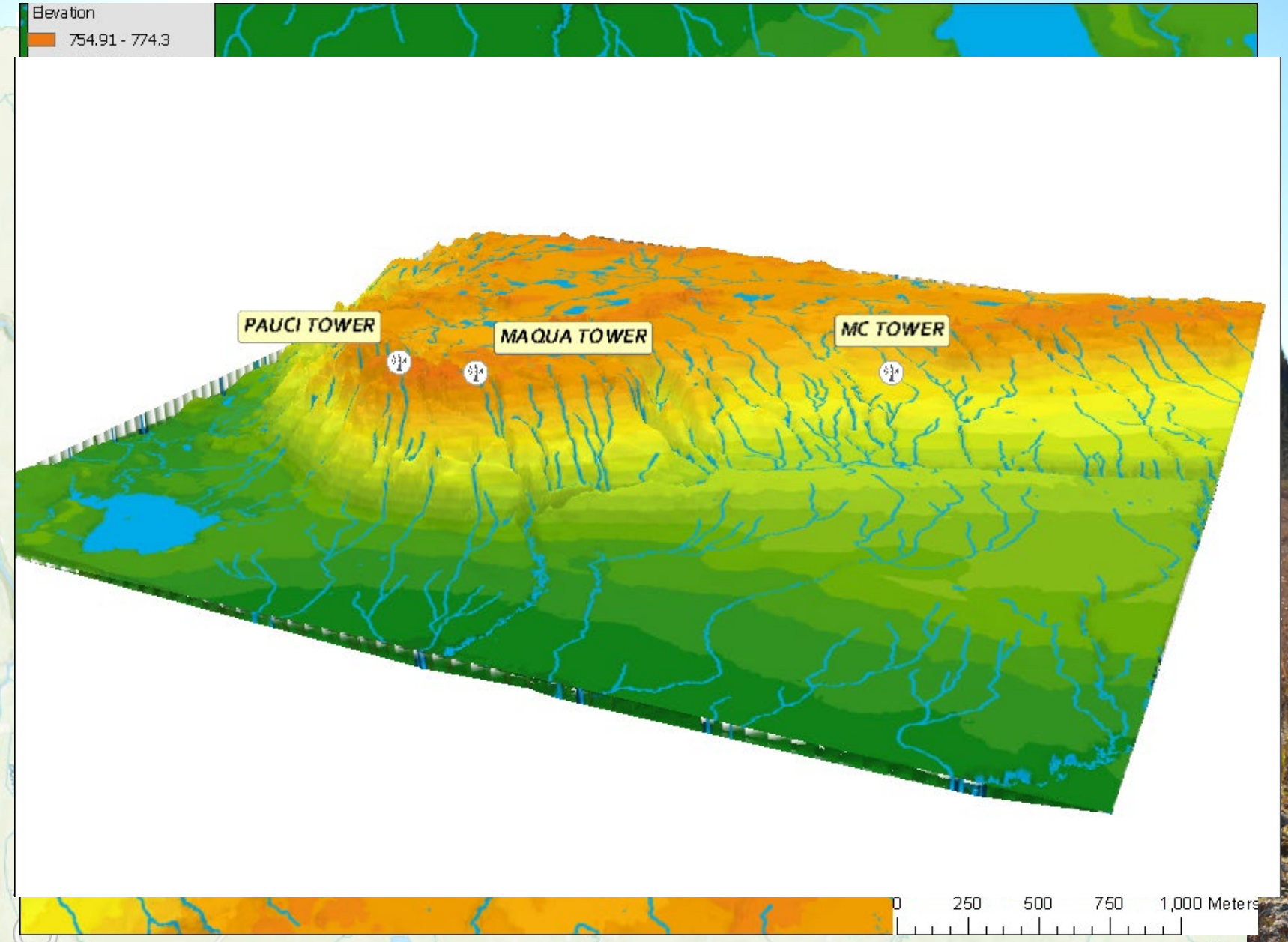
The Athabasca River Basin



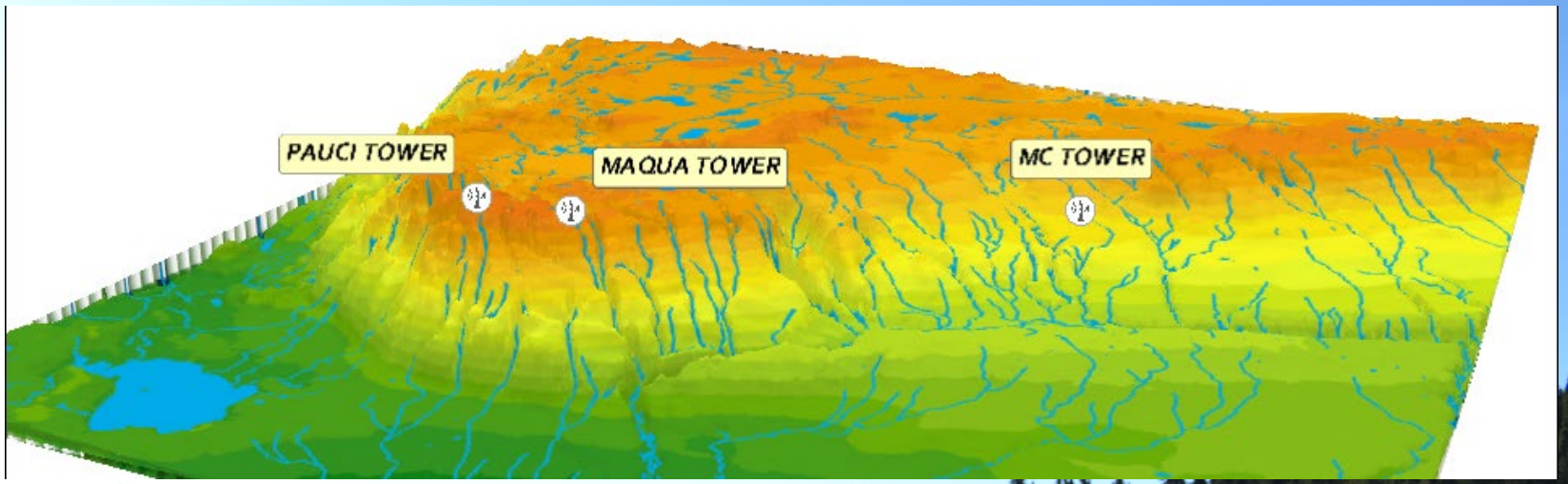
http://www.barbau.ca

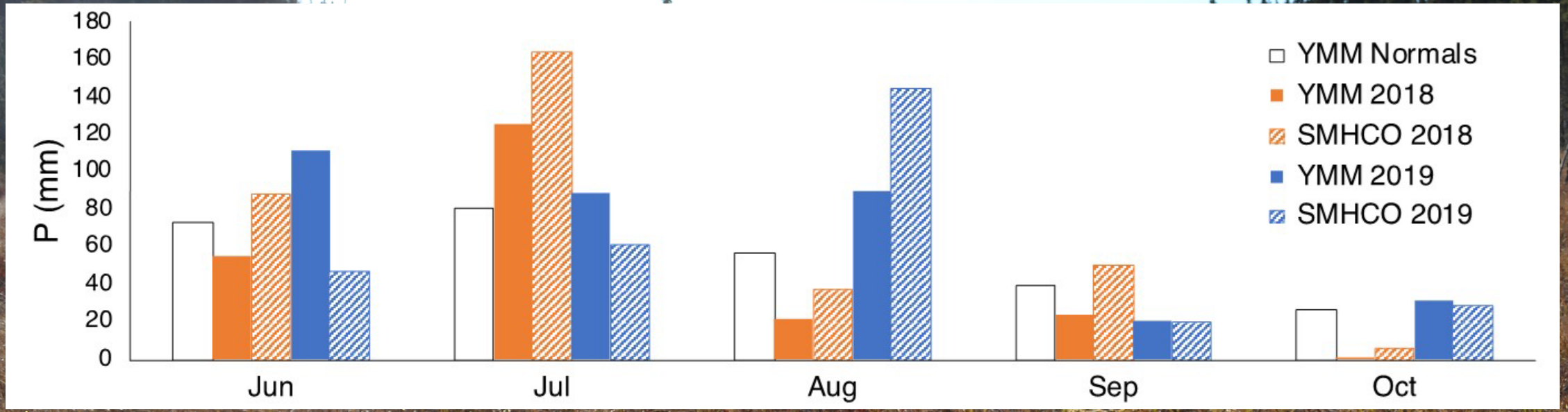
- Drains vast areas of Canada's Boreal Plain
  - Catchment area ~159,000 km^2
- Volumetric flow increases, yet less productive (per-area basis) in the mid-to-low reaches
- Understanding processes controlling water movement that ultimately contributes to streamflow is very important

Northern Alberta's "Mountains" and Water Availability



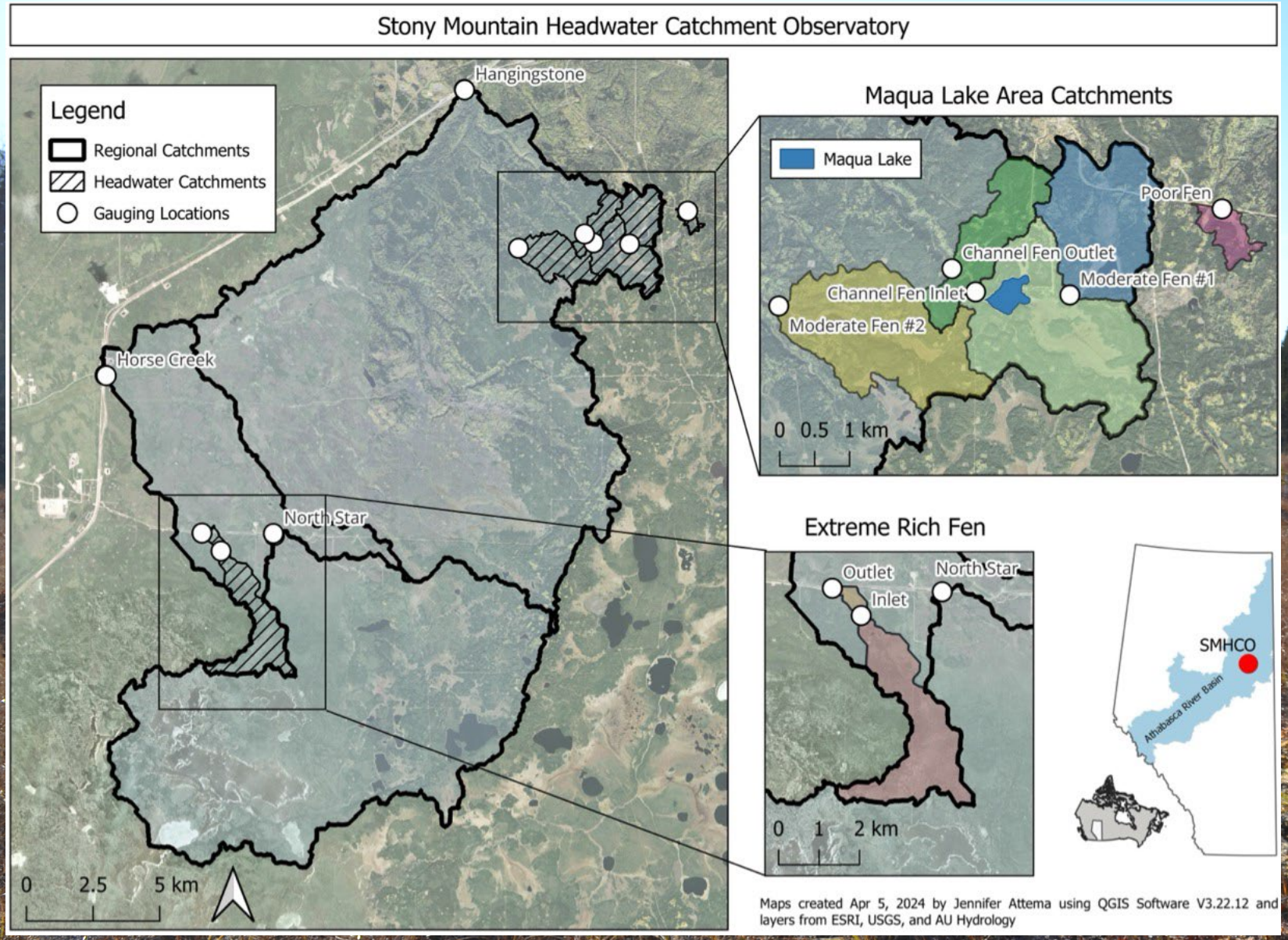
More Precipitation

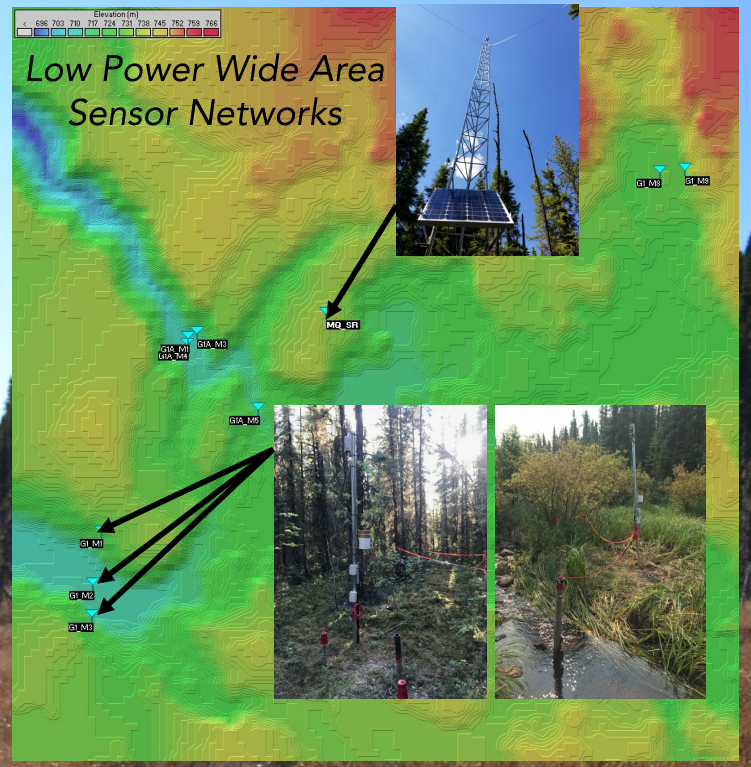




- Average 2019 rainfall was similar; 2018 was 30% (~60 mm) higher on SMHCO than YMM station over the same period
  - Dependent on nature of rainfall

The Stony Mountain Headwater Catchment Observatory





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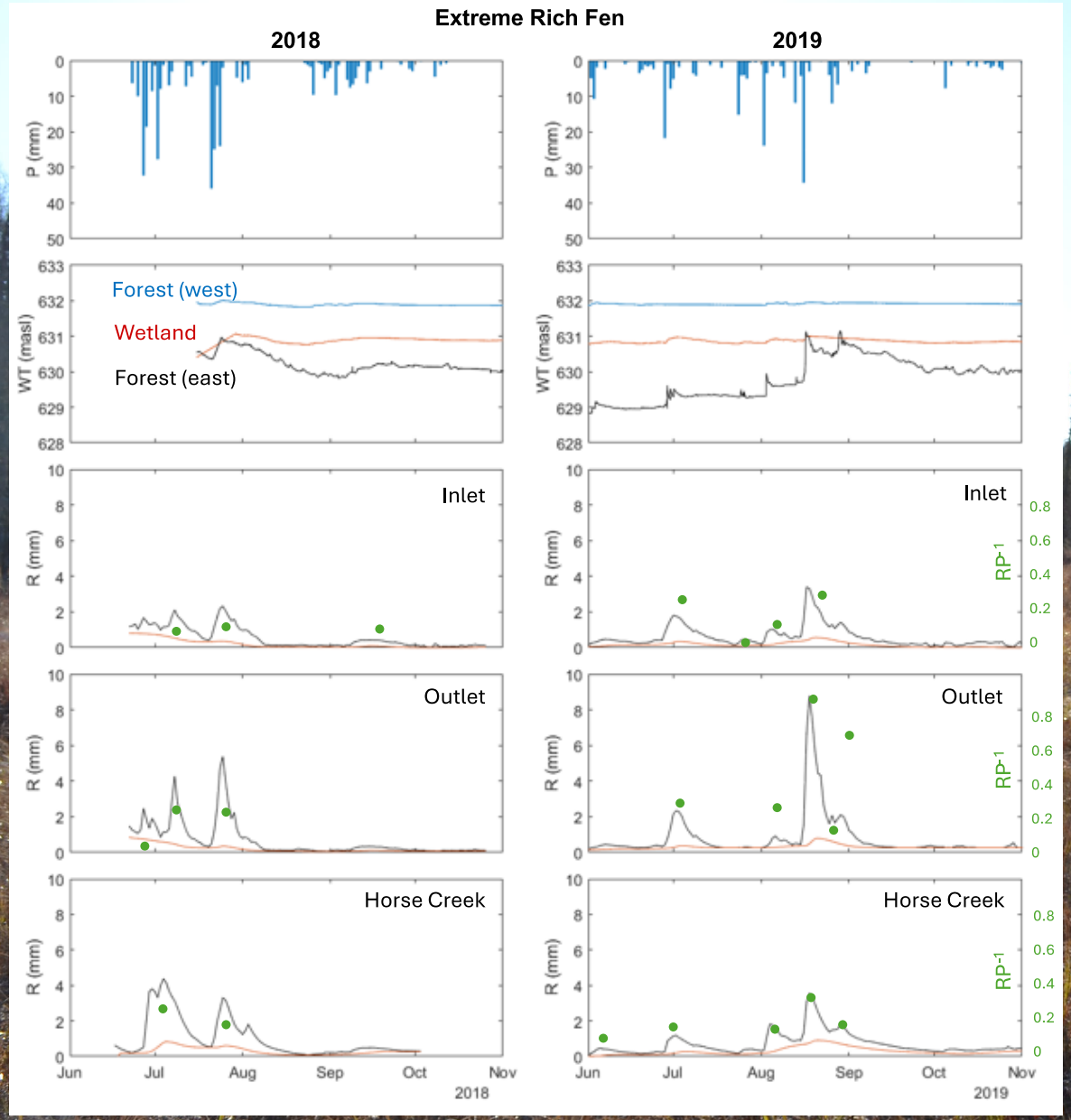
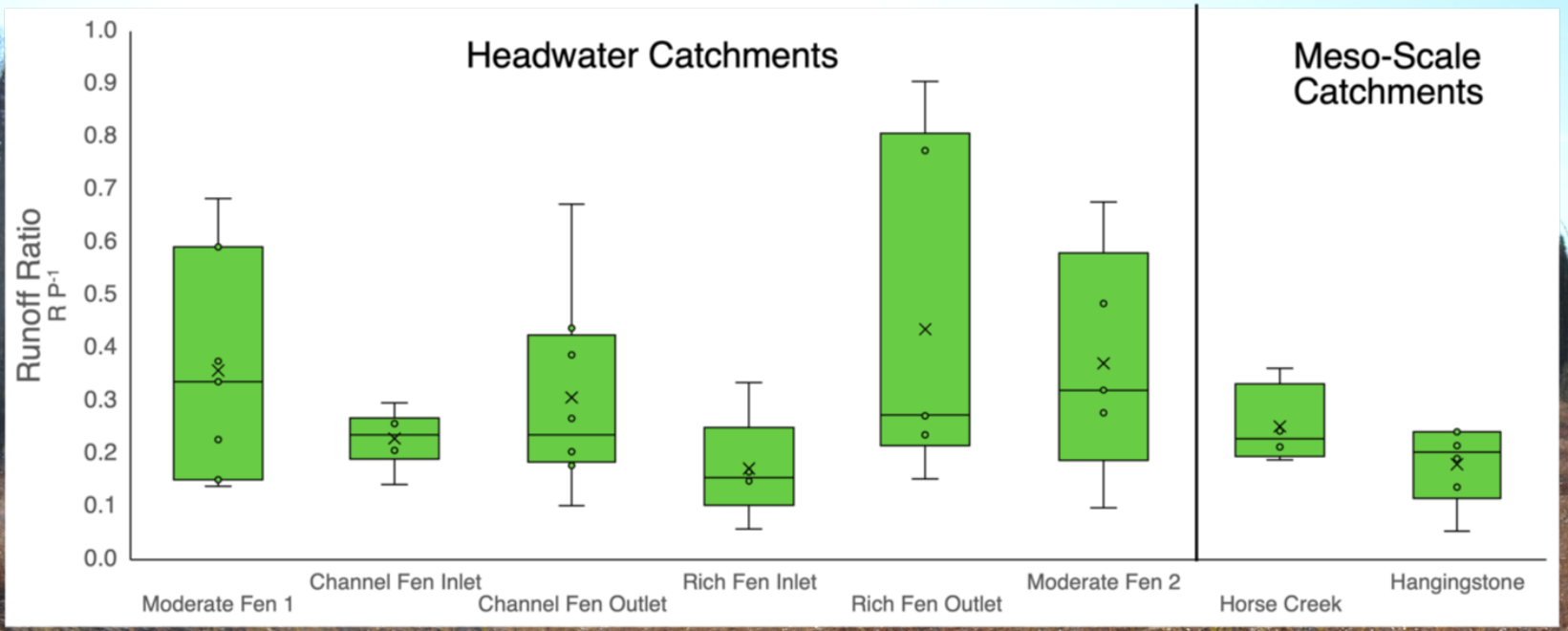
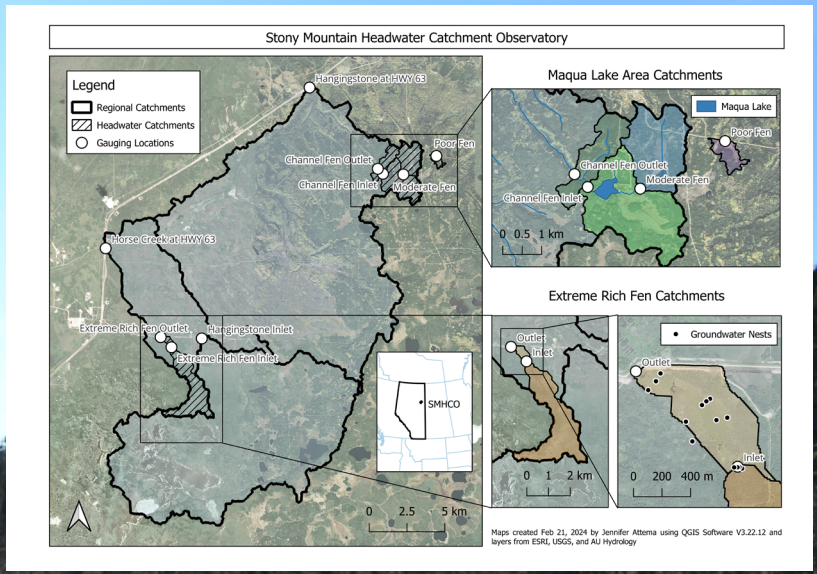
The Stony Mountain Headwater Catchment Observatory



- Catchment runoff response related to forestland-wetland connections
  - Strong runoff responses observed when forests and wetlands connect
- Variability highlights importance of antecedent conditions

The Stony Mountain Headwater Catchment Observatory

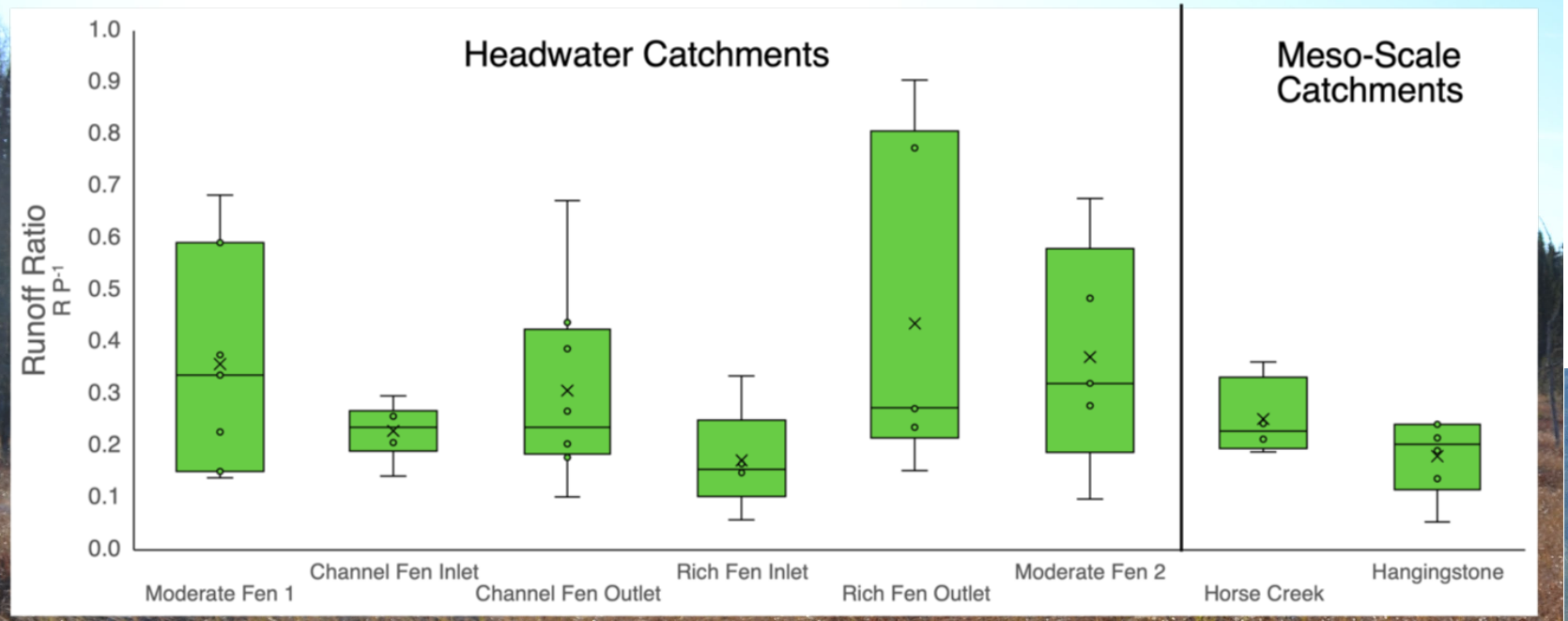


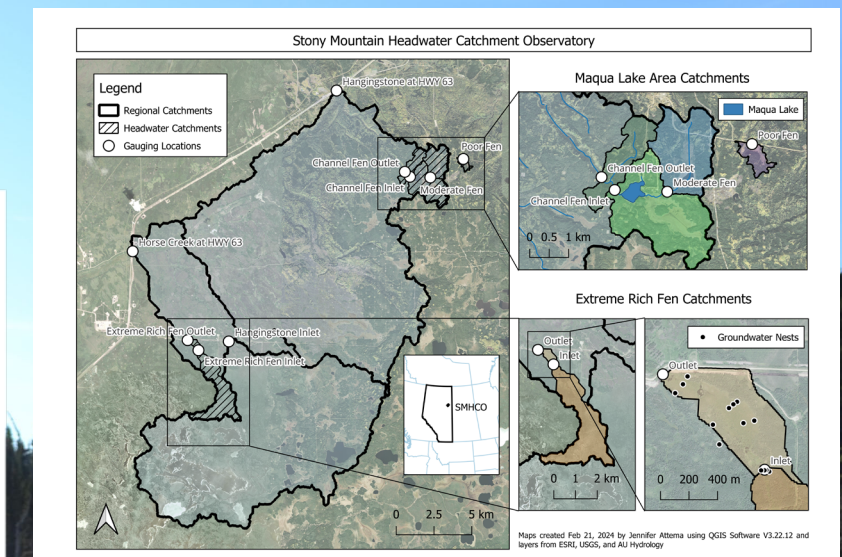


- 65 rainfall – runoff events analysed using HydRun (Matlab)

- Runoff generation highly variable, both among catchments and with time
  - Headwater runoff ratio: 0.9 to 0.1; Average: 0.32
  - Meso-Scale runoff ratio: 0.36 to 0.1; Average: 0.2

The Stony Mountain Headwater Catchment Observatory





KEY MESSAGE: Headwater catchments have higher runoff efficiencies & are important regions for water supply

Context: In situ extraction & roads

Quantifying the effect of in situ oil sands development on wetland function:

Managing to mitigate impact and optimize reclamation outcomes

Scott Ketcheson, Maria Strack, Greg McDermid, Bin Xu, Lelia Tuffner, Joseph Tuffner, Niklas Heiss, Julia Huber

Aspen Research Project

University of Calgary

University of Waterloo

NAIT

NSERC CRSNG

Conserving Canada's Wetlands

Athabasca University

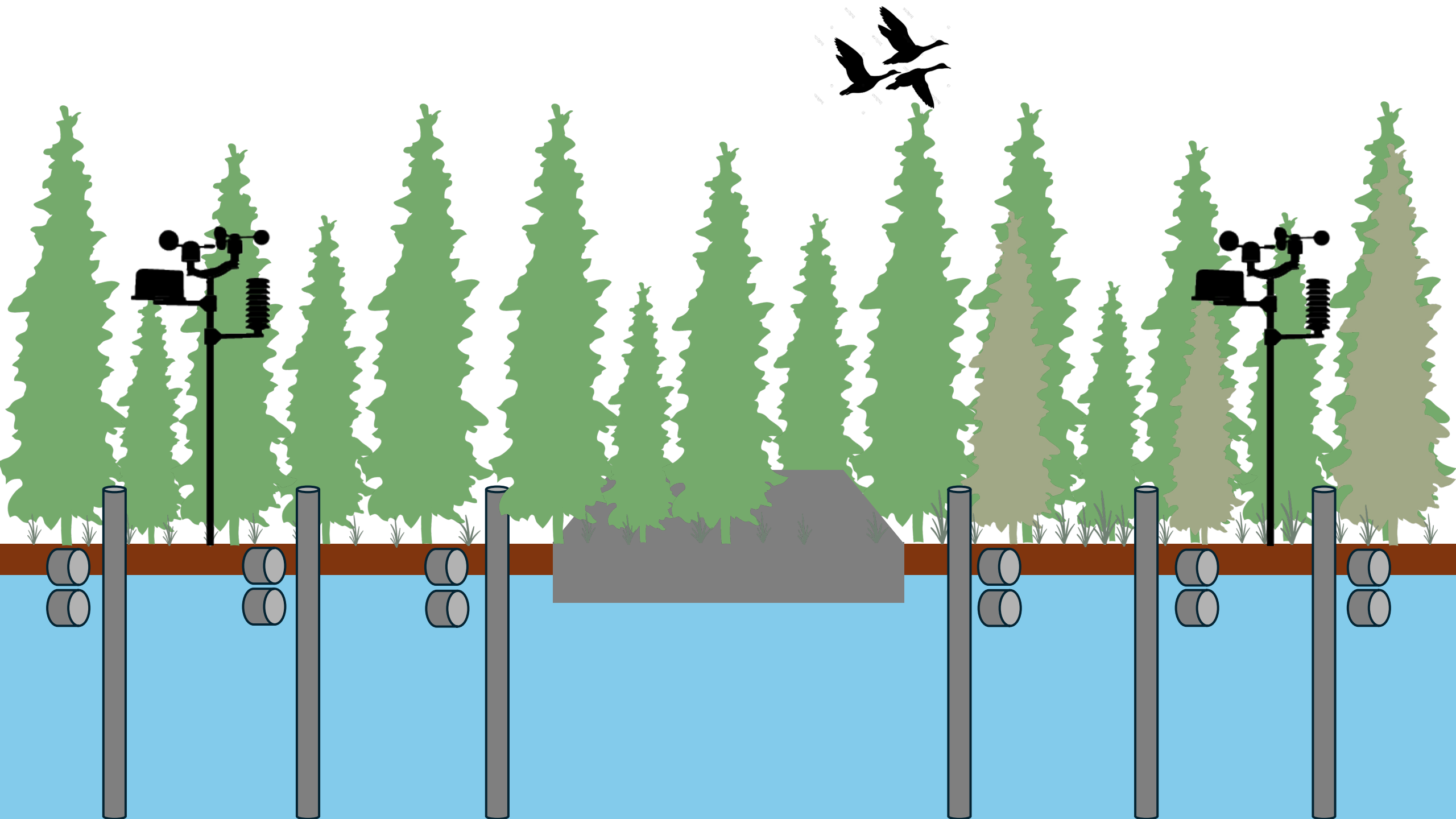
Alberta Innovates

Imperial

The Aspen Project

CONTEXT

- 30% of Canada's boreal region is covered by peatland
- In situ oil sands developments affect large wetland areas directly and indirectly
  - Changes to local hydrology
  - Implications for plant community composition and carbon dynamics
  - Remote sensing presents a powerful tool for quantifying ecosystem response
- Mitigation of wetland alteration during in situ oil sands operations can lead to more efficient reclamation at closure



The Aspen Project

RESEARCH GOAL

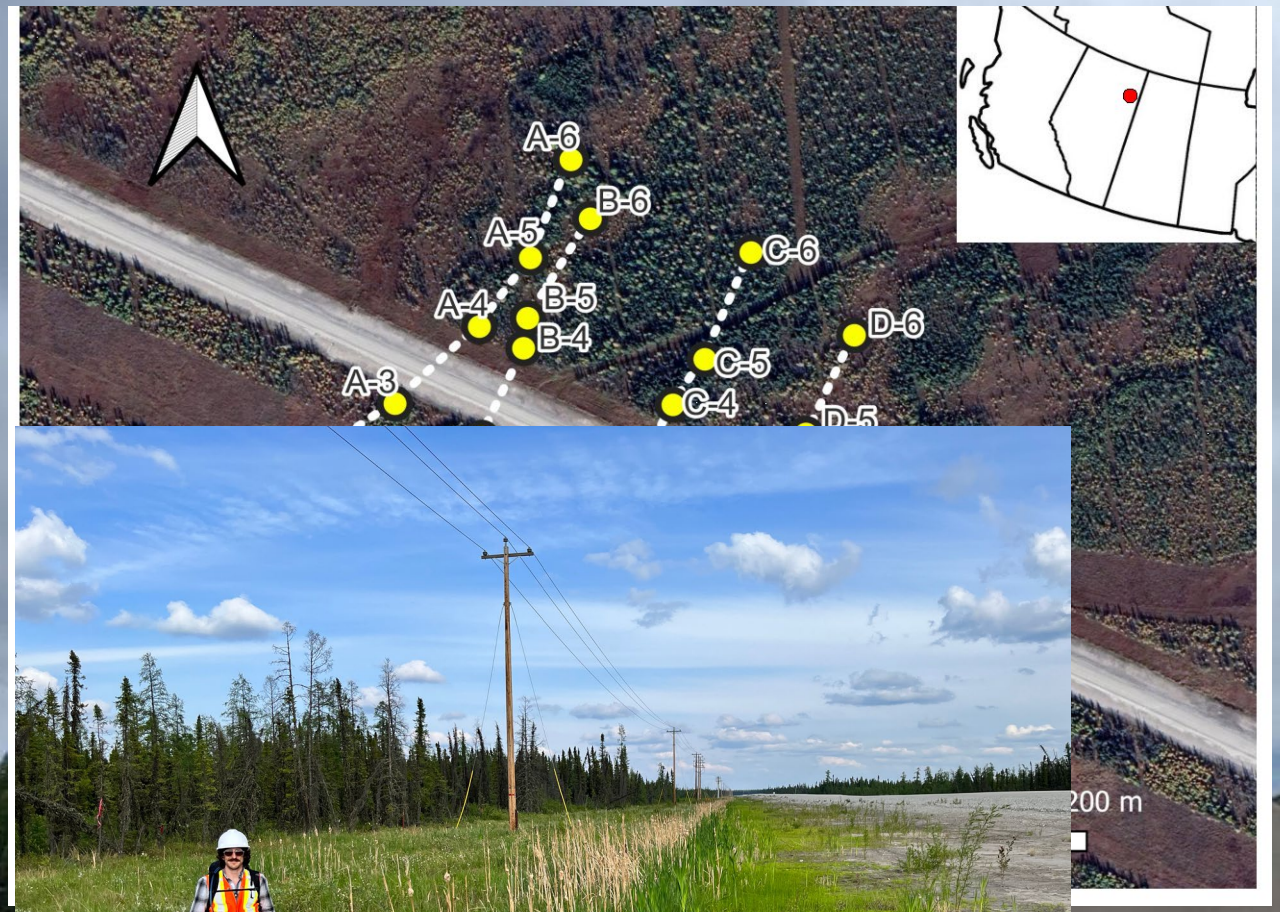
- Quantify the effect of in situ oil sands development on wetland hydrology, plant communities and carbon exchange

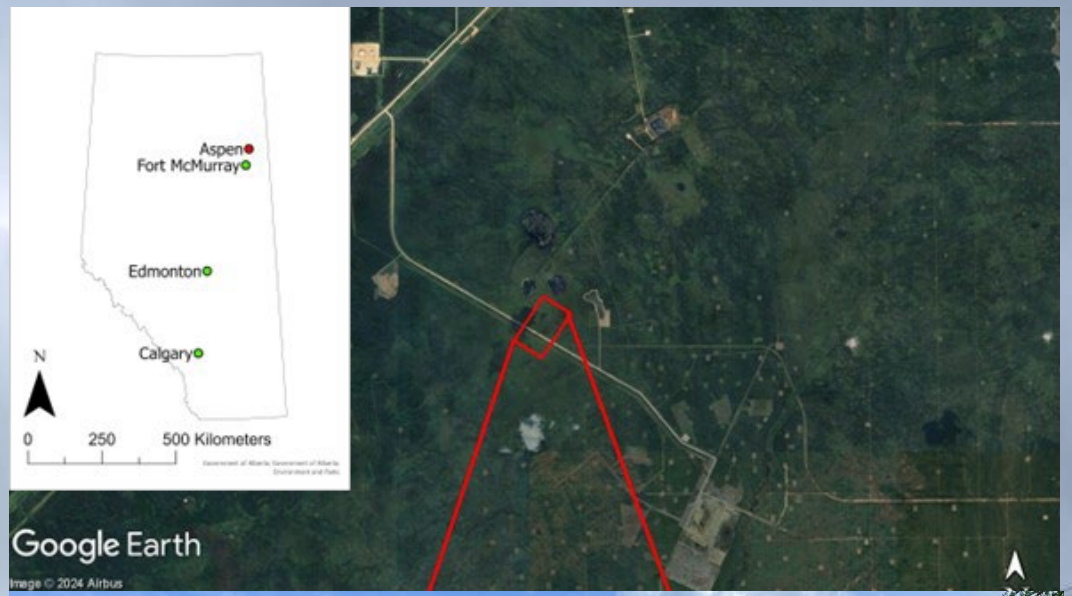
Hydrology | Carbon Dynamics | Remote Sensing | Stockpiled peat

SPECIFIC OBJECTIVES

1) Determine the effect of in situ infrastructure, including roads, culverts and well pads, on wetland hydrology and how this varies among wetland types and the impacts to small local water bodies;
2) Relate hydrological changes to wetland carbon dynamics and plant community composition, productivity, and peat accumulation rates;
3) Evaluate the timing of the ecohydrological response to infrastructure construction;
4) Determine best management practices for stockpiled peat and the effect of varying stockpiling practices on greenhouse gas emissions.

RESEARCH APPROACH





RESEARCH APPROACH

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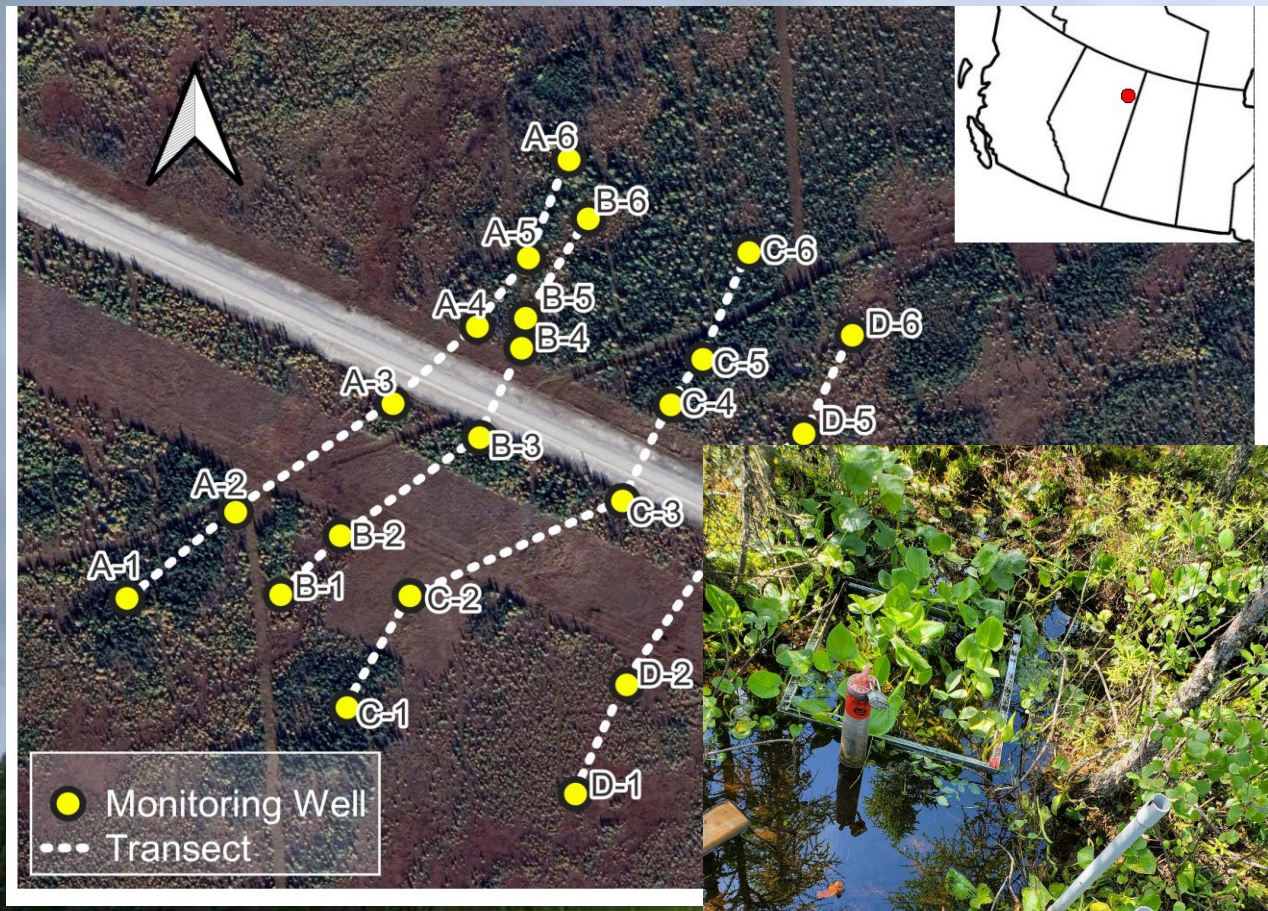

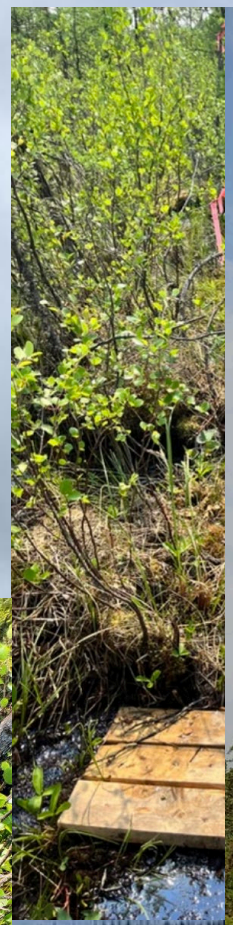

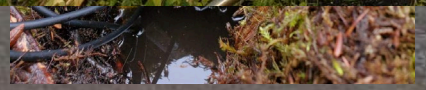

RESULTS – WATER TABLE

Quantifying the impact of access roads on peatland water table depth and lateral hydrological connectivity in the Alberta oil sands region

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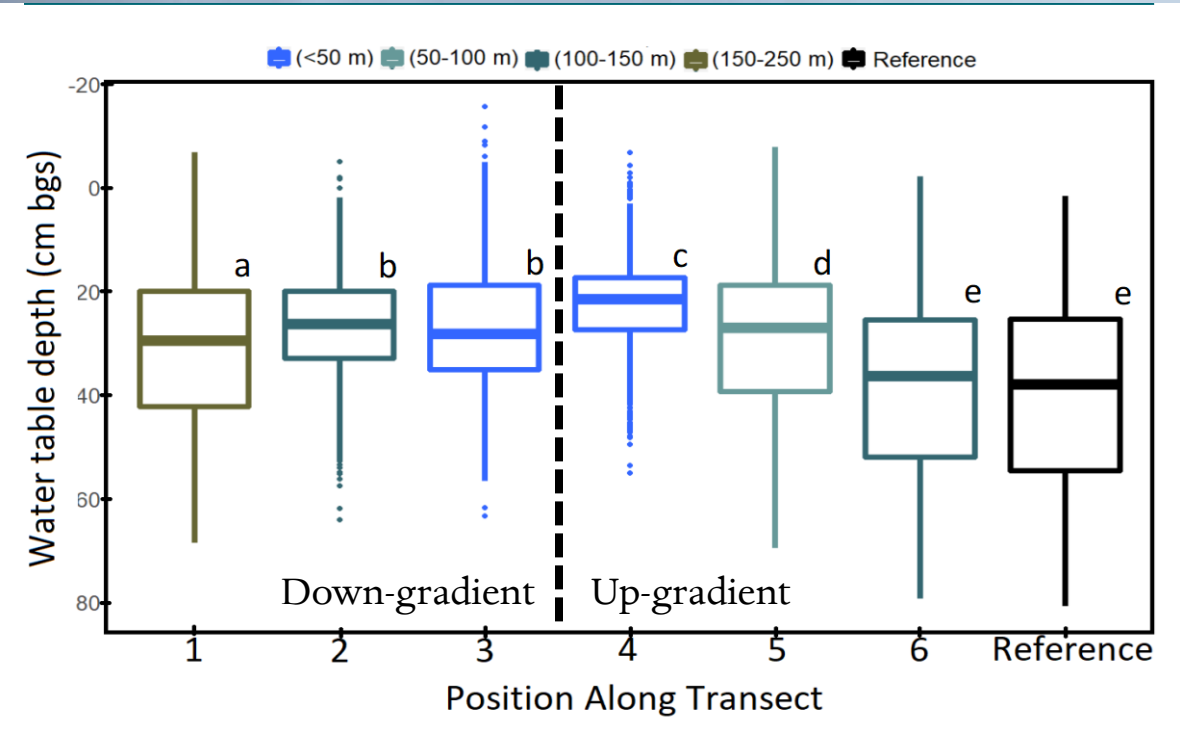
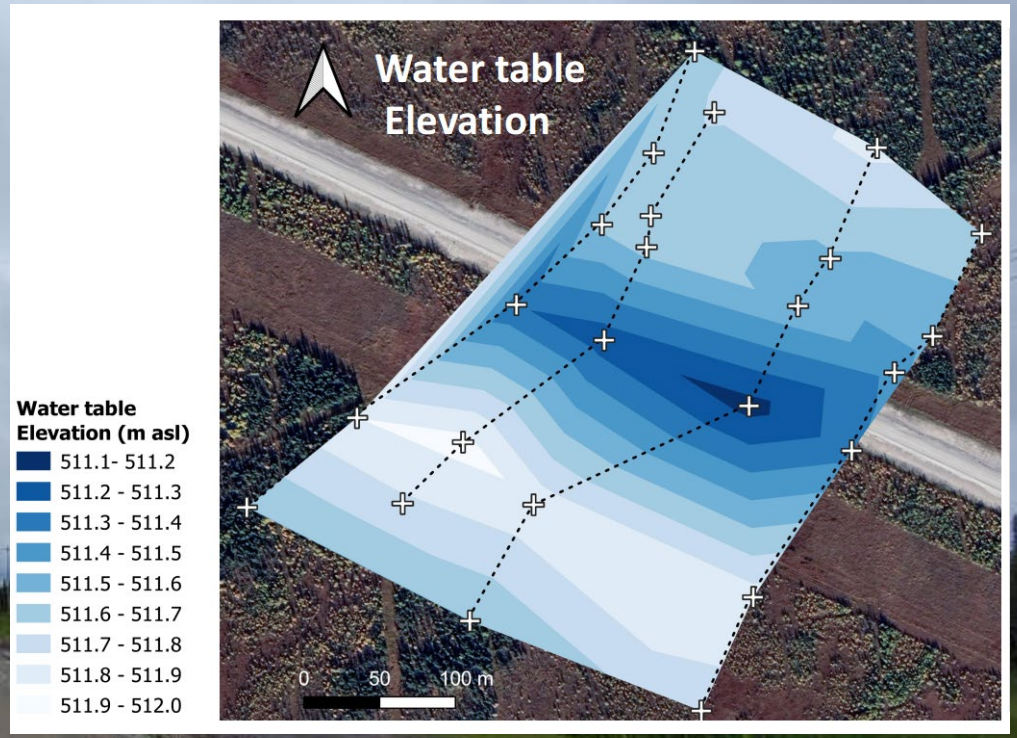
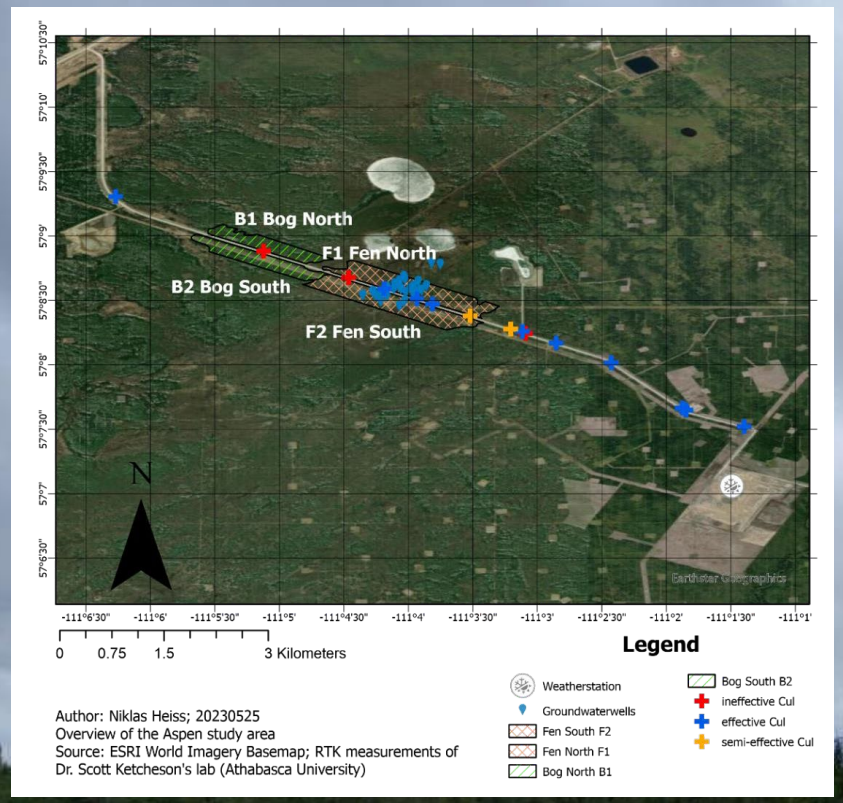




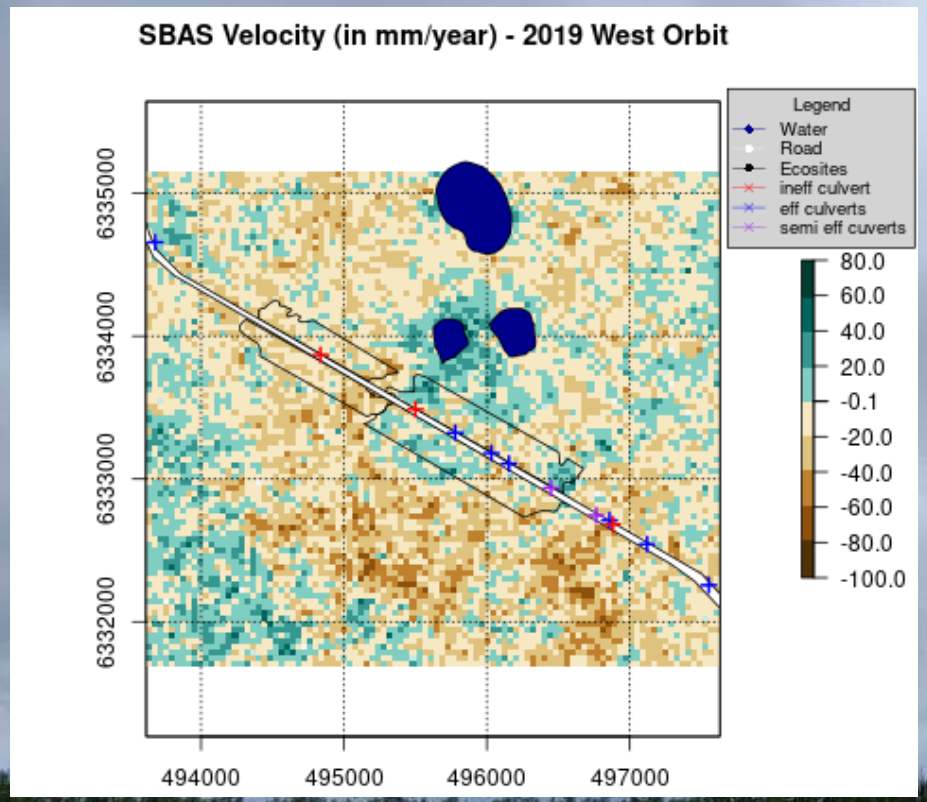
- Water table closest to surface (wettest conditions) just up-gradient of road
- Extent of impoundment limited to <~150 m
- Changes to the water table causes additional changes (volume, peat properties)

RESULTS – PEAT VOLUME CHANGE

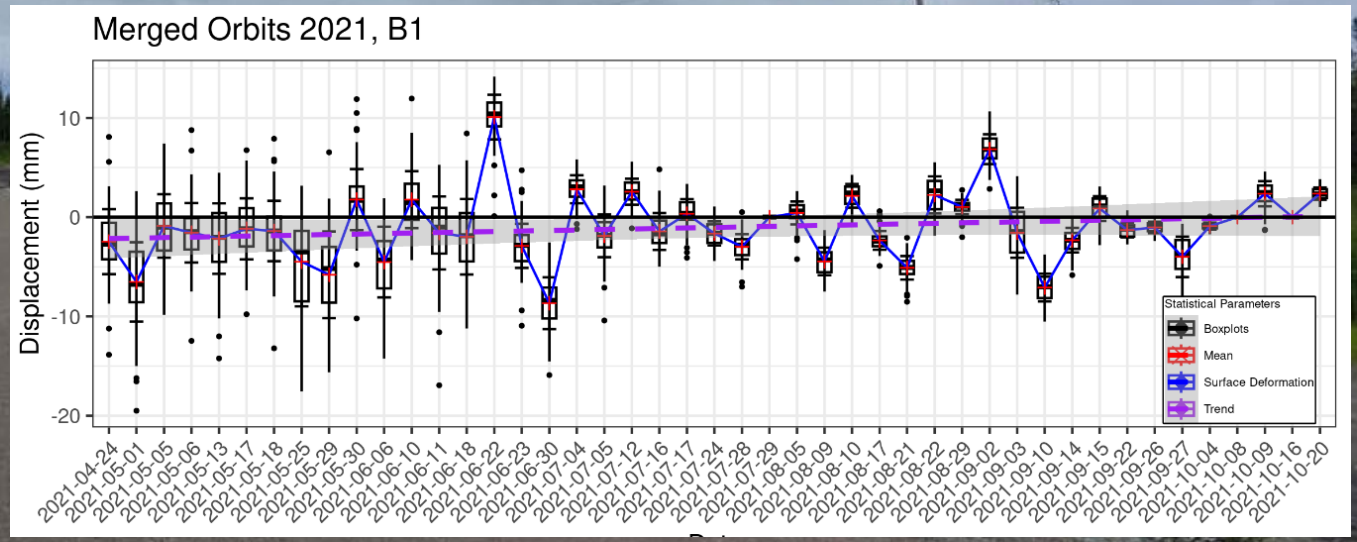


- Two Interferometric Synthetic Aperture Radar (InSAR) techniques applied to determine and characterize peatland surface deformation
  - Persistent Scatterer Interferometry (PSI) and Small Baseline Subset (SBAS)

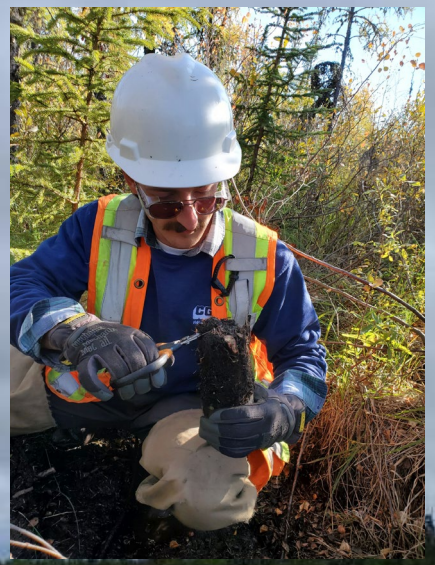
RESULTS – SURFACE DEFORMATION



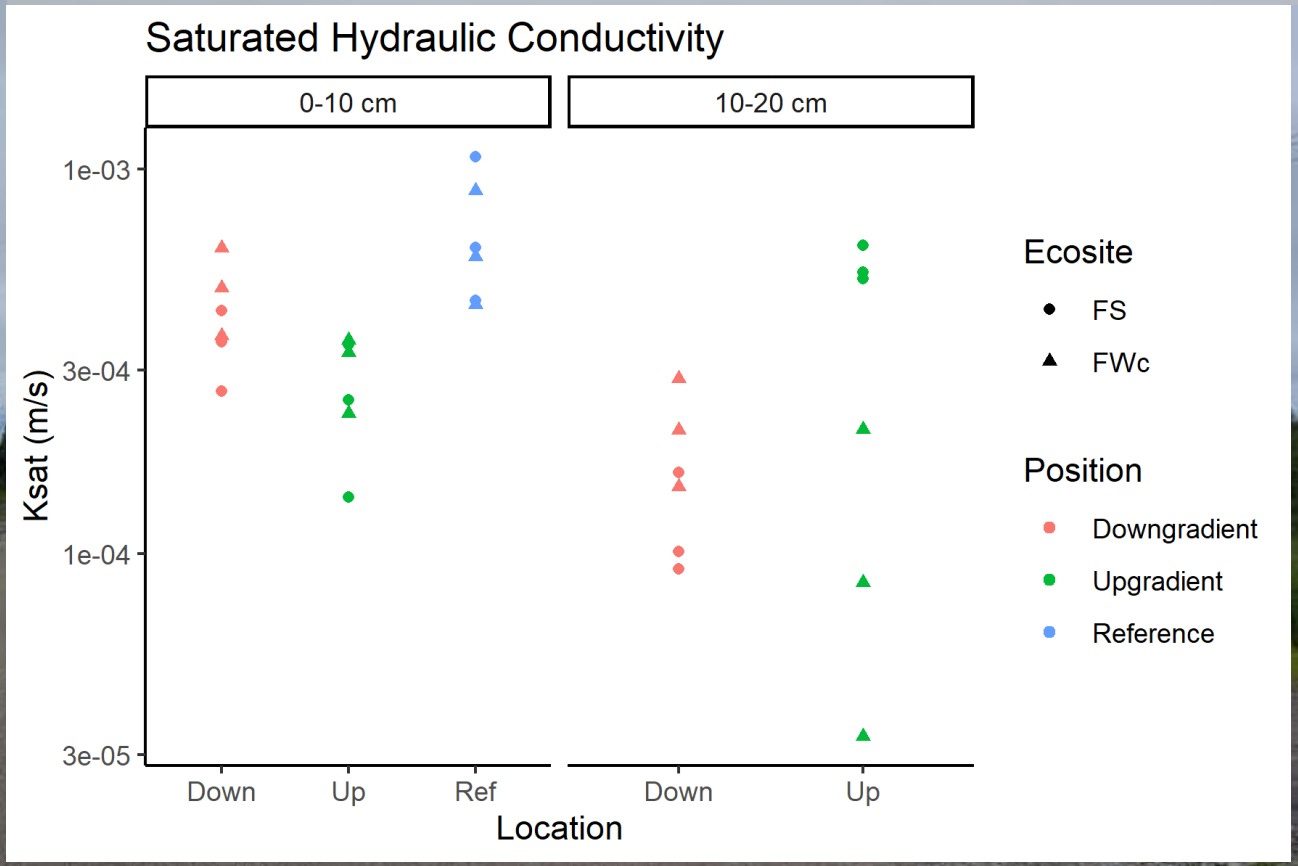
- Neither the trends nor the timeseries were sufficient for a detailed and specific interpretation
- Differences of the two approaches outweigh distinctions between up/downstream sides of the road
- Factors such as inadequate spacing and data resolution contribute to this limitation



RESULTS – SOIL PROPERTIES

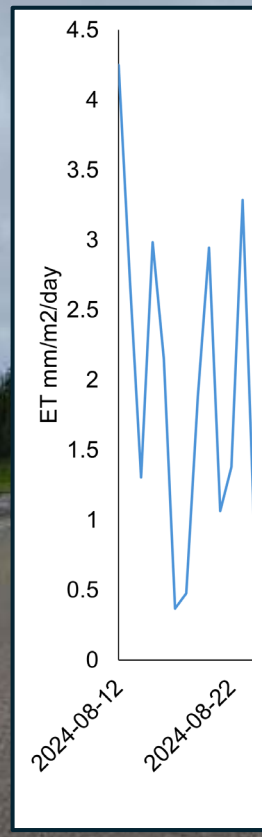


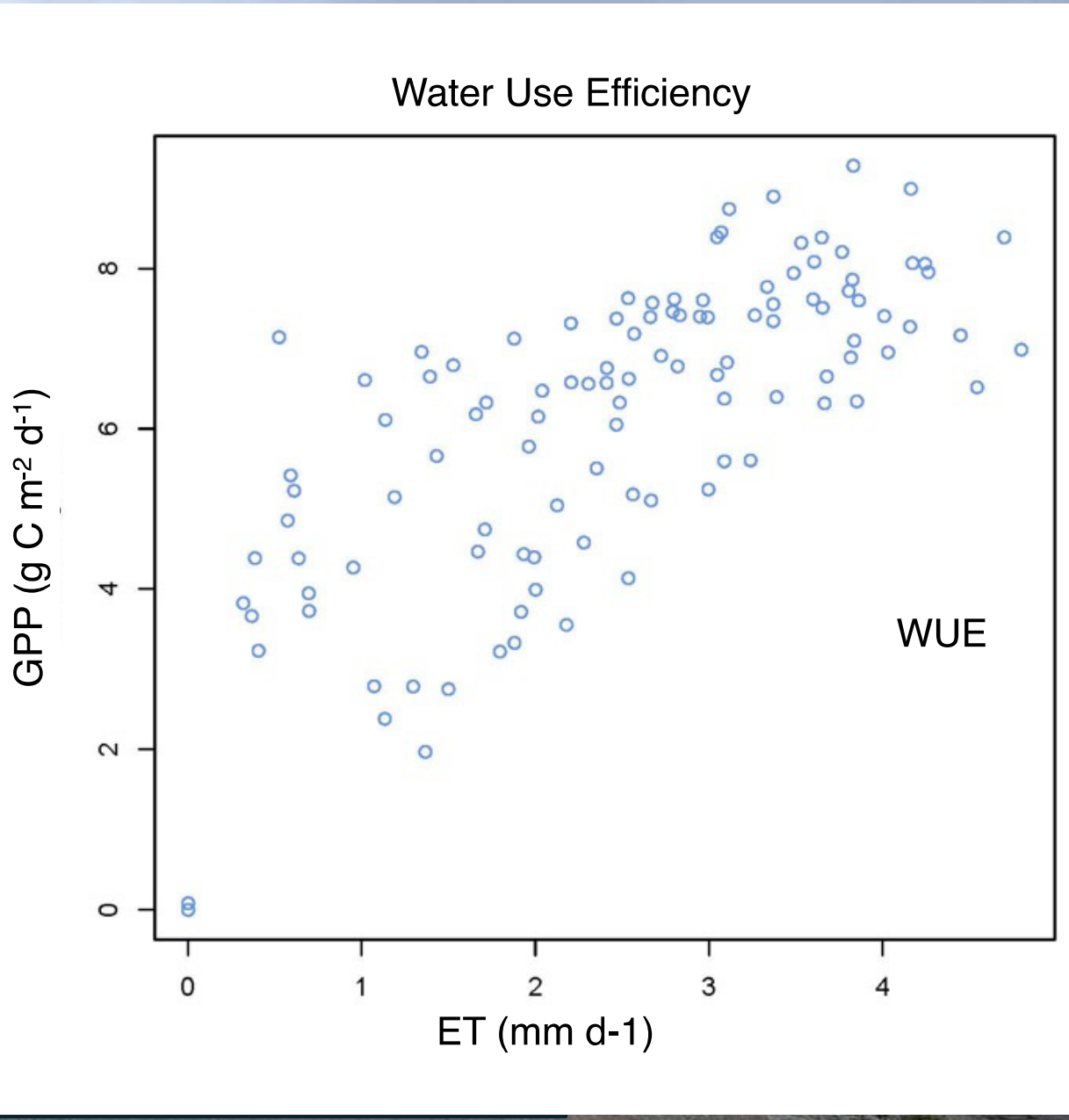
- Highest Ksat at reference wetlands
- Greater variability deeper in profile

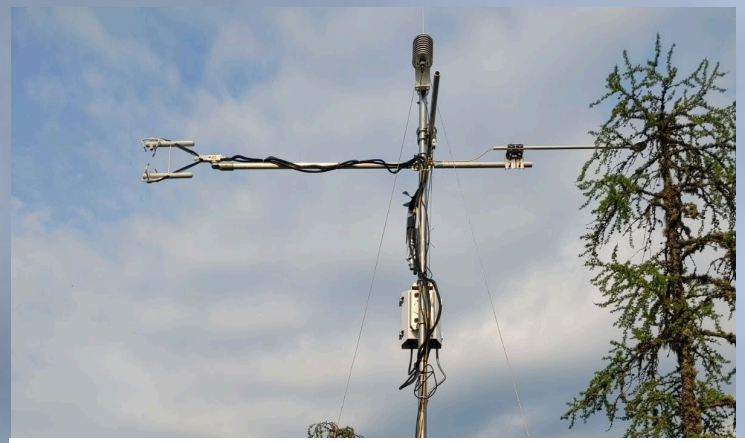


RESULTS – EDDY COVARIANCE

- Provides ecosystem-scale fluxes of water and carbon
- Combined to assess metrics of ecosystem health and response to disturbance

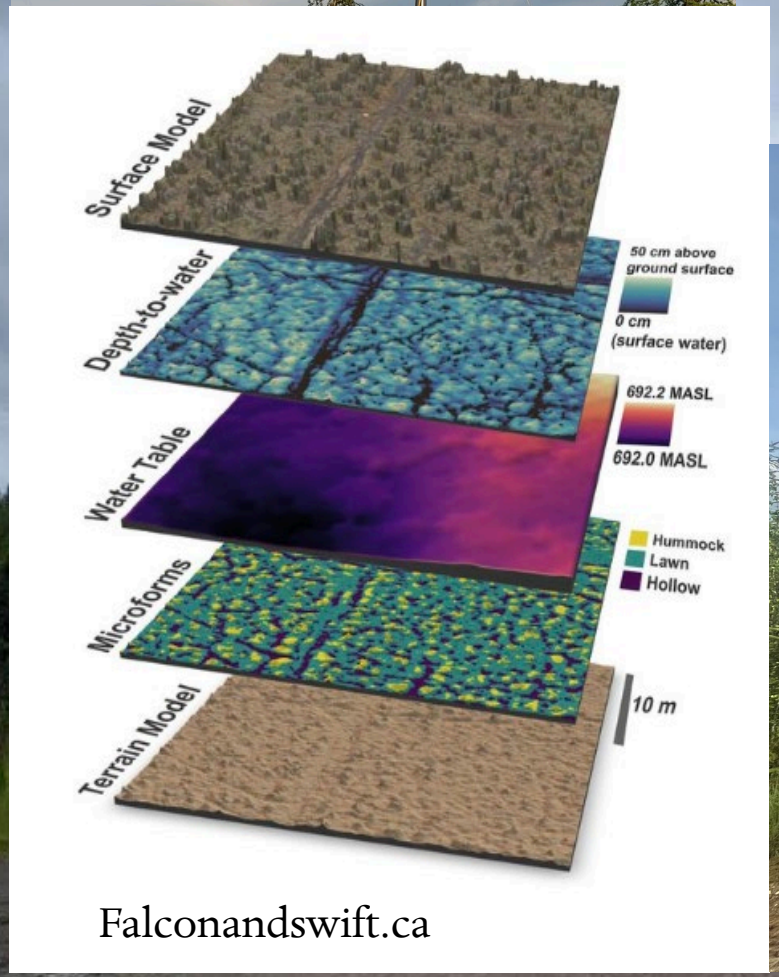






RESULTS – EDDY COVARIANCE

- Manual measurements allow us to compare the ecosystem-scale tower datasets to small-scale features (hummocks/lawns/hollows)
- Determine microtopographic controls on carbon and water
- Quantify ecosystem responses with remote sensing



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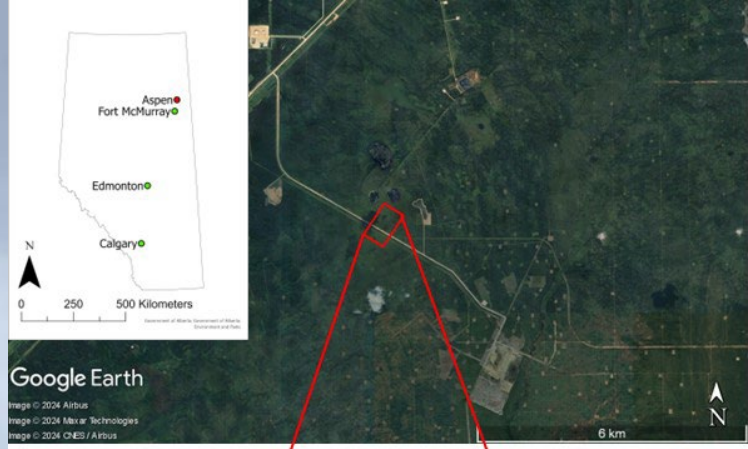
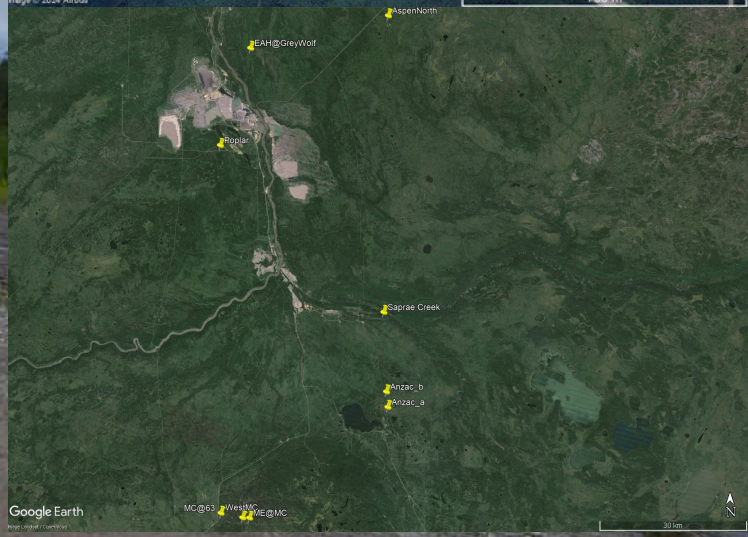
SYNOPTIC SITES

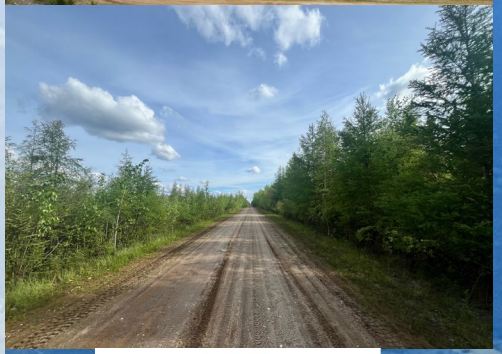
- Complement to the intensive measurements from the Aspen site
- Additional wetland types to capture the range in variation of ecohydrological response
- Expands the geographical area beyond the Aspen lease to encompass a broader range of ecosites, hydrogeological settings and responses





Summary

- Headwater catchments have higher runoff efficiencies & are important regions for water supply
  - Role of wetlands variable but depends on antecedent conditions
- Mineral roads cause local impoundment of water in wetlands
  - Extent limited to ~150 m
  - Results in additional changes to peat soils, carbon and vegetation
- Approach: minimize impact through mitigation
  - Avoid most sensitive wetland types, leading to more efficient reclamation at closure



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