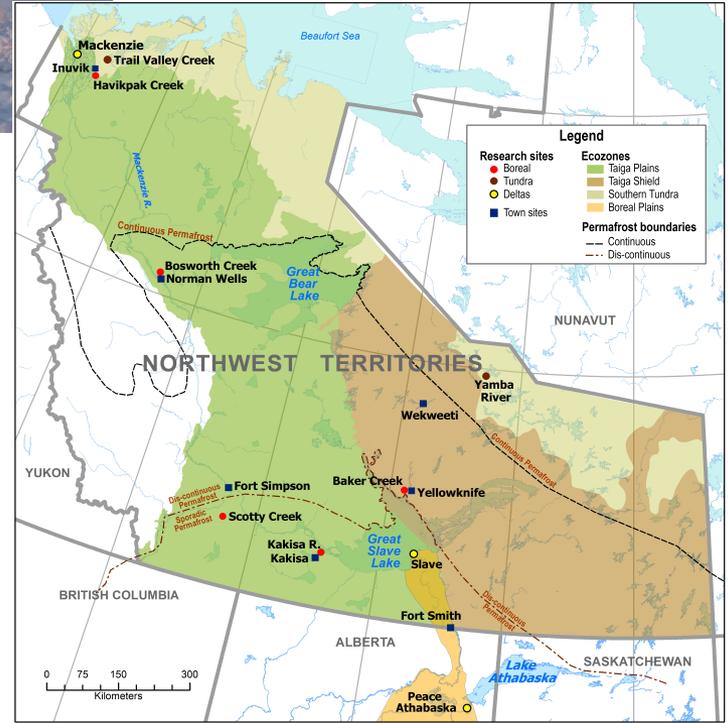


# Tundra-Taiga-Boreal Academic Research: Researching and Networking Needs



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Wilfrid Laurier University  
Cold Regions Research Centre  
Waterloo, ON Canada



# Research & Networking Needs

- Focus on the NWT, but many of these issues extend across the arctic
- Certainly not comprehensive or exhaustive
- But will discuss programs that are organized by Wilfrid Laurier University with our Partner the Government of the NWT, as examples of what is needed to build our research capacity to address key issues
- And consider how appropriate links with ABoVE can help further advance science issues of interest to ourselves and ABoVE. What do we gain by solidifying the link between ABoVE and the programs I will talk about here.

# General Thoughts

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1. Climate change: is the major environmental challenge facing society over the coming decades, and presents an ongoing challenge to scientists to provide sound advice to society and governments.
2. Arctic/Sub-Arctic: challenges are exacerbated due to the complex interactions between the cryosphere (snow, lake/river ice, and permafrost) – vegetation – water. Fundamental advances in process understanding, and integrative studies, are needed
3. Ongoing Research: there are numerous ongoing, research projects in northern Canada that are addressing these issues, and are making significant progress in understanding the responses of the arctic system responses

# General Thoughts

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4. Networking: there are significant opportunities for improved networking and interaction between ongoing Canadian and International studies that would help achieve the dramatic advances required
5. Infrastructure: advances are being made to enhance research infrastructure in northern Canada, but additional investment is needed. CHARs is one example of new investment. Ongoing investments at other sites are urgently needed in order to meet the challenges we face. Canadian Network of Northern Research Operators (CNNRO – such as the Western Arctic Research Station, etc) is making progress to help enhance links between these stations.

# Key Science Challenges

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## Why Boreal-Taiga-Tundra?

- Covers a huge area of the NWT and the Canadian Arctic. Home to the majority of the NWT population, and is undergoing significant development (highways, fiber optic links, satellite download stations etc etc) and is undergoing dramatic environmental change.

Understanding these changes, and predicting future changes, is extremely challenging due to:

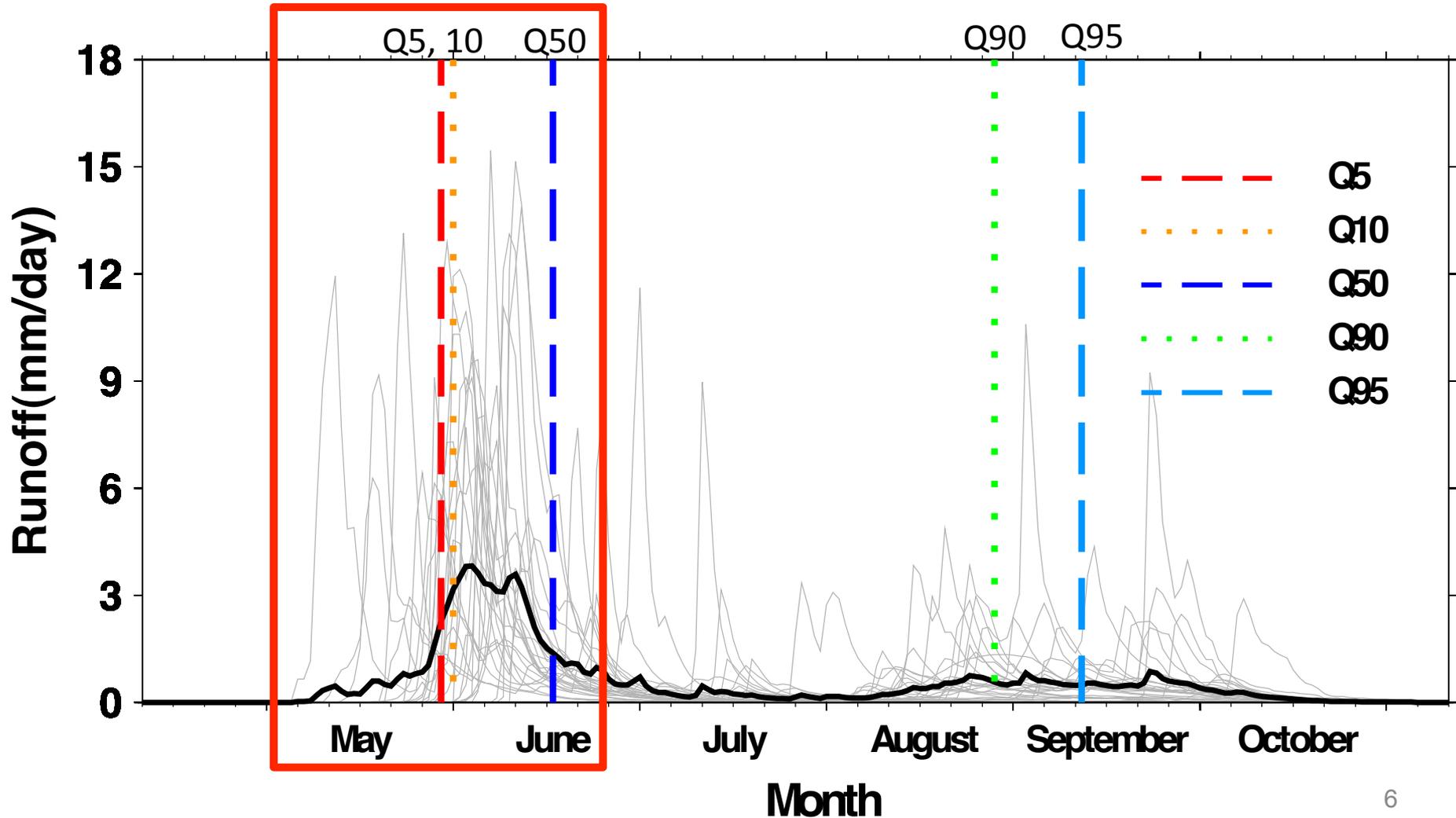
- Thawing and slumping of ice-rich permafrost
- Ongoing uncertainties in our knowledge of snowfall and snow on the ground, and the controls of winter processes on summer conditions
- The key role of fire in both forested and tundra systems
- Browning of the boreal forest and greening of tundra
- Uncertainties in soil moisture due to its extreme spatial variability
- Carbon fluxes from permafrost systems
- Controls on water quantity (lakes levels and stream flows) and quality

We have good knowledge of many of these individually, but it is the the non-linear, and often unexpected, responses that we need to be prepared for. Advances can only be made through an integrated program of field observations, experiments, remote sensing and modelling.

How do we put together all the pieces to make sure this happens?

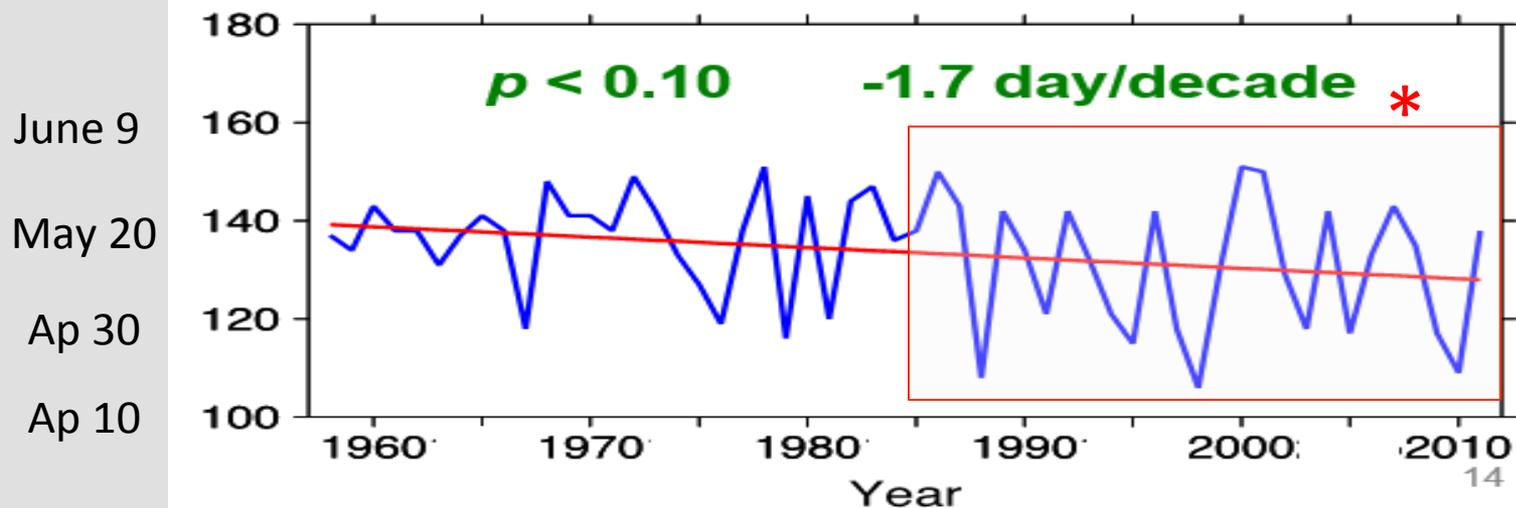
# One example of an unexpected, non-linear, change

Trail Valley Creek – north of Inuvik. 1985 to 2011

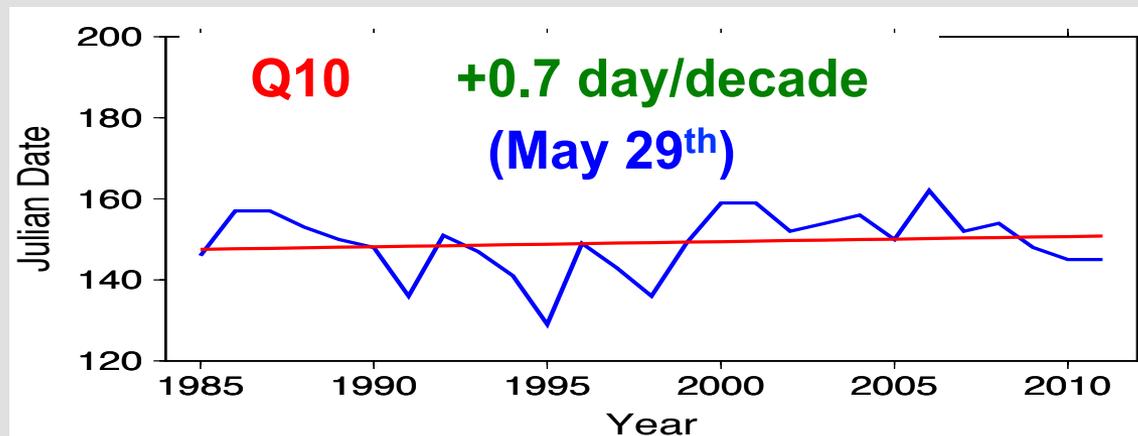


# One example of such unexpected, non-linear, changes

## 1) Date of start of melt is occurring earlier in the spring



## 2) But – Q10 (the date when 10% of flow occur)



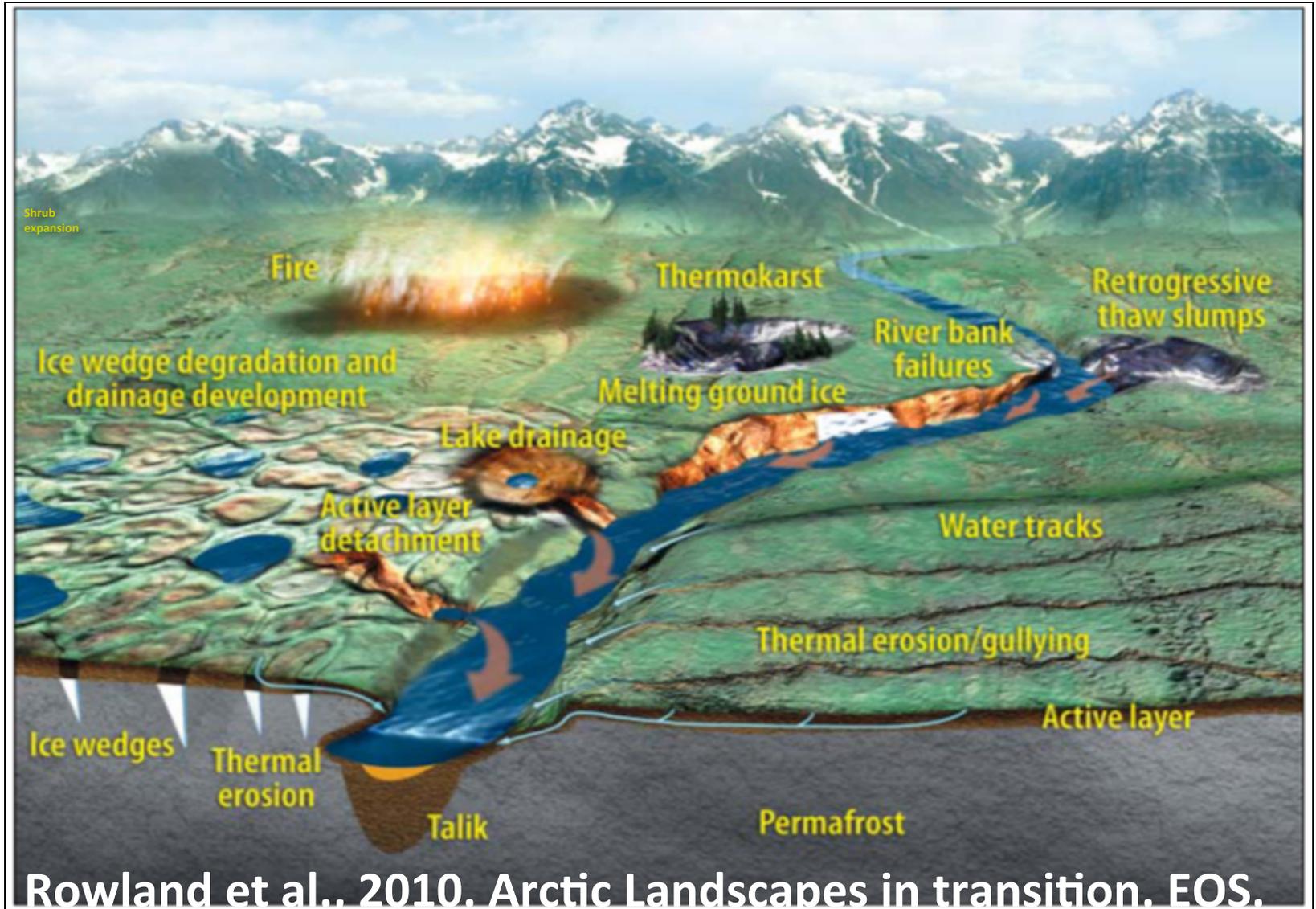
# Key Science Needs required to make significant advances

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## Needs:

- Field studies at a network of sites in order to validate/check/falsify remote sensing and modelling
- Carry out carefully controlled field experiments at these field sites in order to test key aspects of interactions
- With the increased use of complex field instrumentation, there is an ever increasing need for improved infrastructure at remote field camps (robust AC power systems for camps and instrumentation, high speed internet access, and winter access)
- Increased use of remote sensing to expand from field site scale to regional scale to the pan-arctic
- Use of high resolution, physics based, modelling for both carrying out numerical experiments, diagnosing past changes, and for considering the future
- In Canada, there is an urgent need for greatly increased funding for data archiving

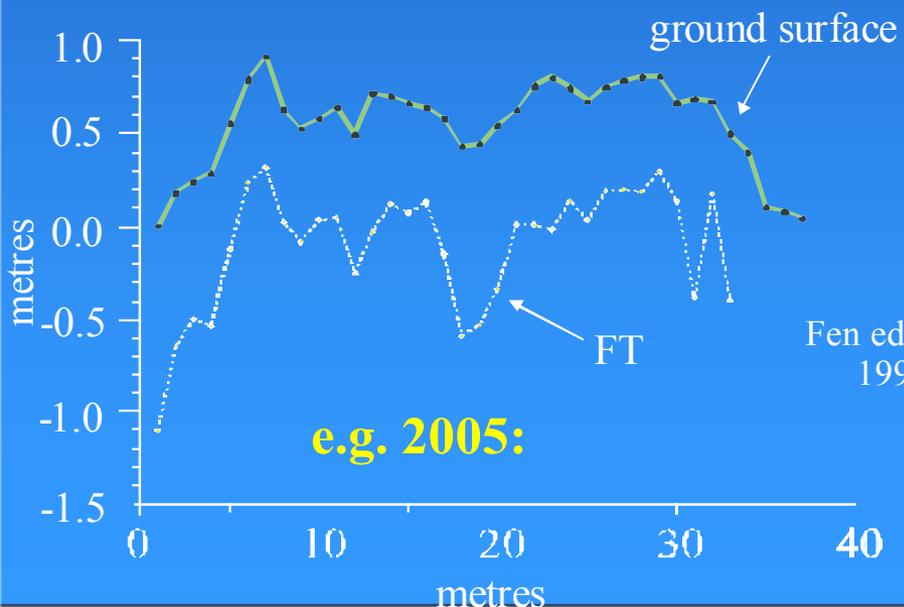
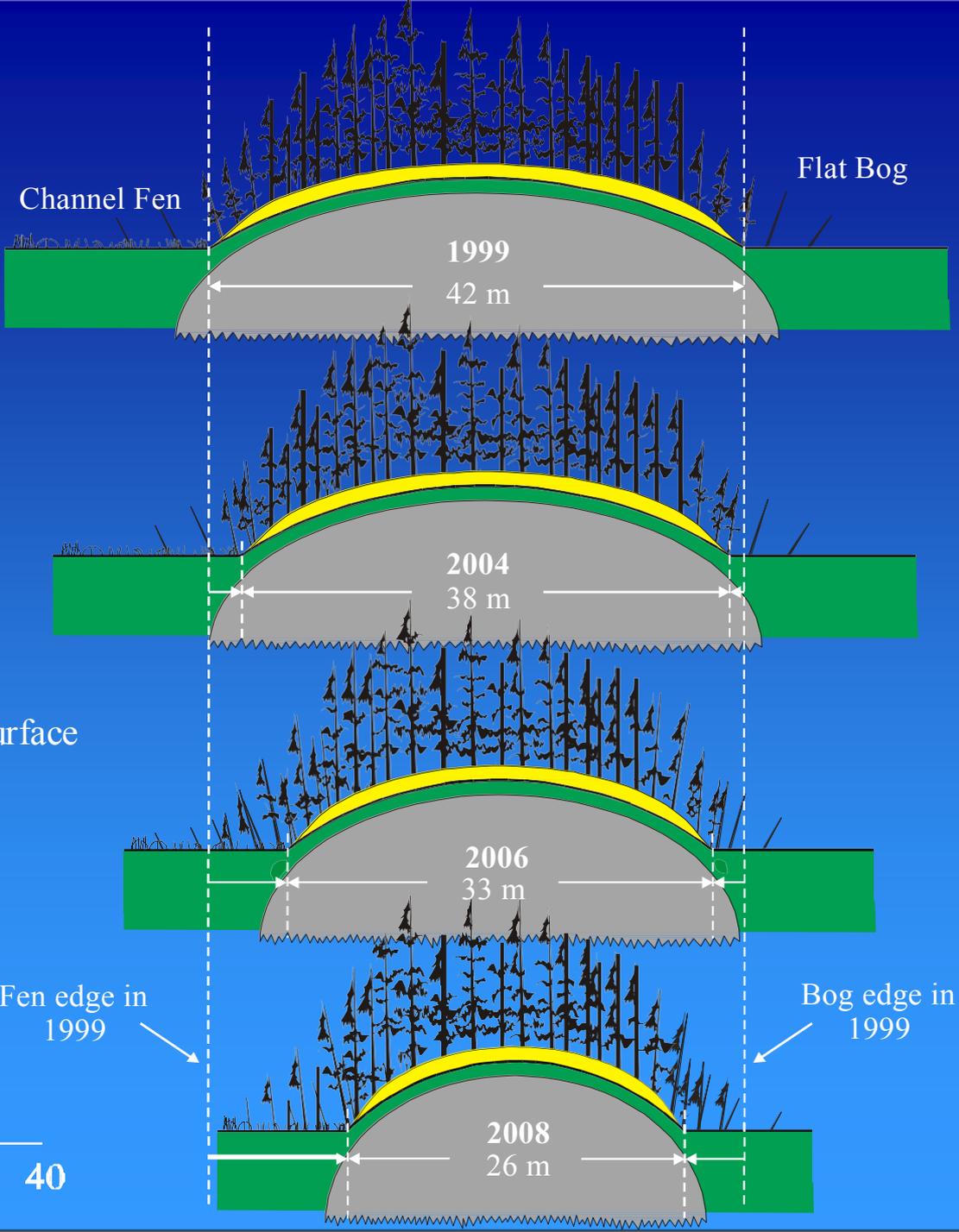
# Permafrost



Rowland et al., 2010. Arctic Landscapes in transition. EOS.

# Scotty Creek, NWT

## W. Quinton



Fen edge in 1999

Bog edge in 1999

# Snow

Snow plays a key role in many aspects of the arctic, including many summer conditions

- Often more than 50% of the annual precipitation and runoff
- Controls soil moisture for at least the early portion of the summer

But

- Snowfall is extremely difficult to measure (WMO Solid Precipitation Intercomparison Experiment - SPICE)
- Standard snow on the ground measurements often over estimate snow by some 20 to 30%
- There is an urgent need for improved remote sensing (programs within the CSA AND NASA SnowEX are addressing these issues)

# Wilfrid Laurier University has developed a coordinated approach to building a research program to address these issues

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1. Government NWT - Wilfrid Laurier University Partnership (2010-2020)
  
2. Canada Foundation for Innovation infrastructure investments
  - Canadian Aquatic Laboratories for Interdisciplinary Boreal Ecosystem Research (CALIBER). CFI program. (2010 to present)
  - Changing Arctic Network (CANet) – CFI Funded Project (2016 - 2021)
    - Collaborative effort with scientists from Laurier, GNWT, 10 other universities, and several federal government departments
    - CFI approved this project in March 2015, all funding in place, final approval expected this summer

# GNWT – WLU Partnership

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1. 10 year partnership: 2010 to 2020
2. Goal: to expand the Territories' capacity to conduct environmental research and monitoring, and to train the new expertise needed to manage its natural resources for future generations
3. The purpose is to provide new infrastructure and expertise to the GNWT for environmental research and education in order to expand the Territories' capacity to conduct environmental research and monitoring, and to train the new expertise needed to manage its natural resources for future generations in face of emerging challenges from climate change and the impacts of growth and development.

<https://nwtwlu.com/>

# Canadian Aquatic Laboratories for Interdisciplinary Boreal Ecosystem Research (CALIBER).

The GNWT and Wilfrid Laurier University share the \$6.3 million grant from the Canadian Foundation for Innovation (CFI), which served as the first stage in an infrastructure platform for the Partnership. Encouraged collaboration between GNWT and Laurier personnel on numerous research and training initiatives.

B. Quinton is the PI

Scotty Creek Research Watershed



Centre for Cold Regions and Water Science at WLU



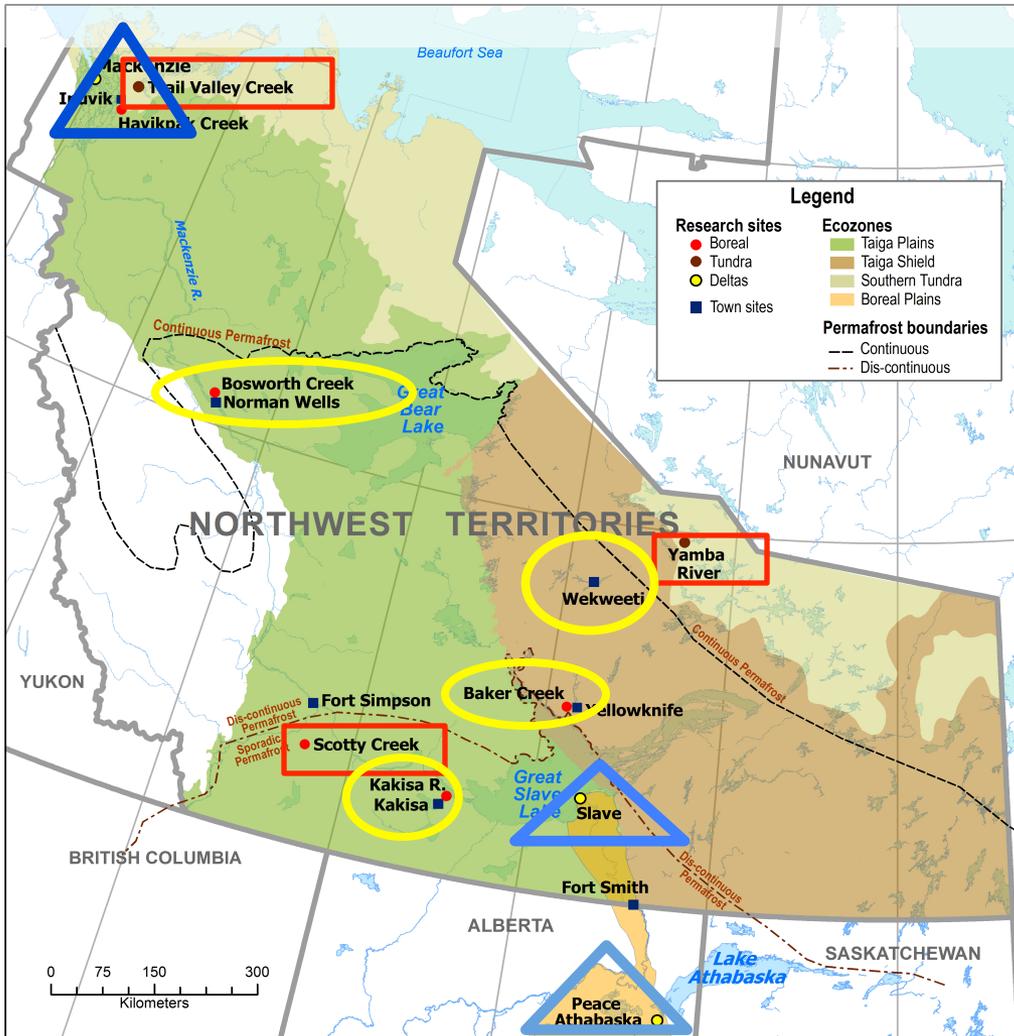
# Changing Arctic Network (CANet)

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1. CANet builds upon the GNWT-Laurier Partnership and CALIBER
2. Funded by CFI-GNWT-Laurier
3. CANet's main objective is to *enhance the understanding and prediction of ecosystem processes across the mainland NWT.*
4. CANnet will:
  - carry out interdisciplinary, integrated environmental research that brings together ecologists, biochemists, climatologists, hydrologists, and social scientists to tackle difficult interdisciplinary problems relating to climate change and resource development;
  - conduct sophisticated field studies in remote northern watersheds stretching across much of mainland NWT with a view to enhanced understanding of key processes and feedbacks in arctic and subarctic ecosystems; and
  - use state-of-the art predictive tools for understanding past and future changes to the fragile northern environment.
5. Will invest a total of \$8 million in field and laboratory instrumentation and camp infrastructure

# Changing Arctic Network (CANet)

## Integrated Environmental Observatories



### Remote Field Camps (red boxes)

- Trail Valley Creek (Tundra)
- Scotty Creek (Taiga)
- Tundra Ecosystem Research Station (Tundra)

### Other Sites (yellow ovals)

- Norman Wells (Boswell Ck)
- Kakisa (Kakisa R)
- Wekweeti
- Yellowknife (Baker Ck)

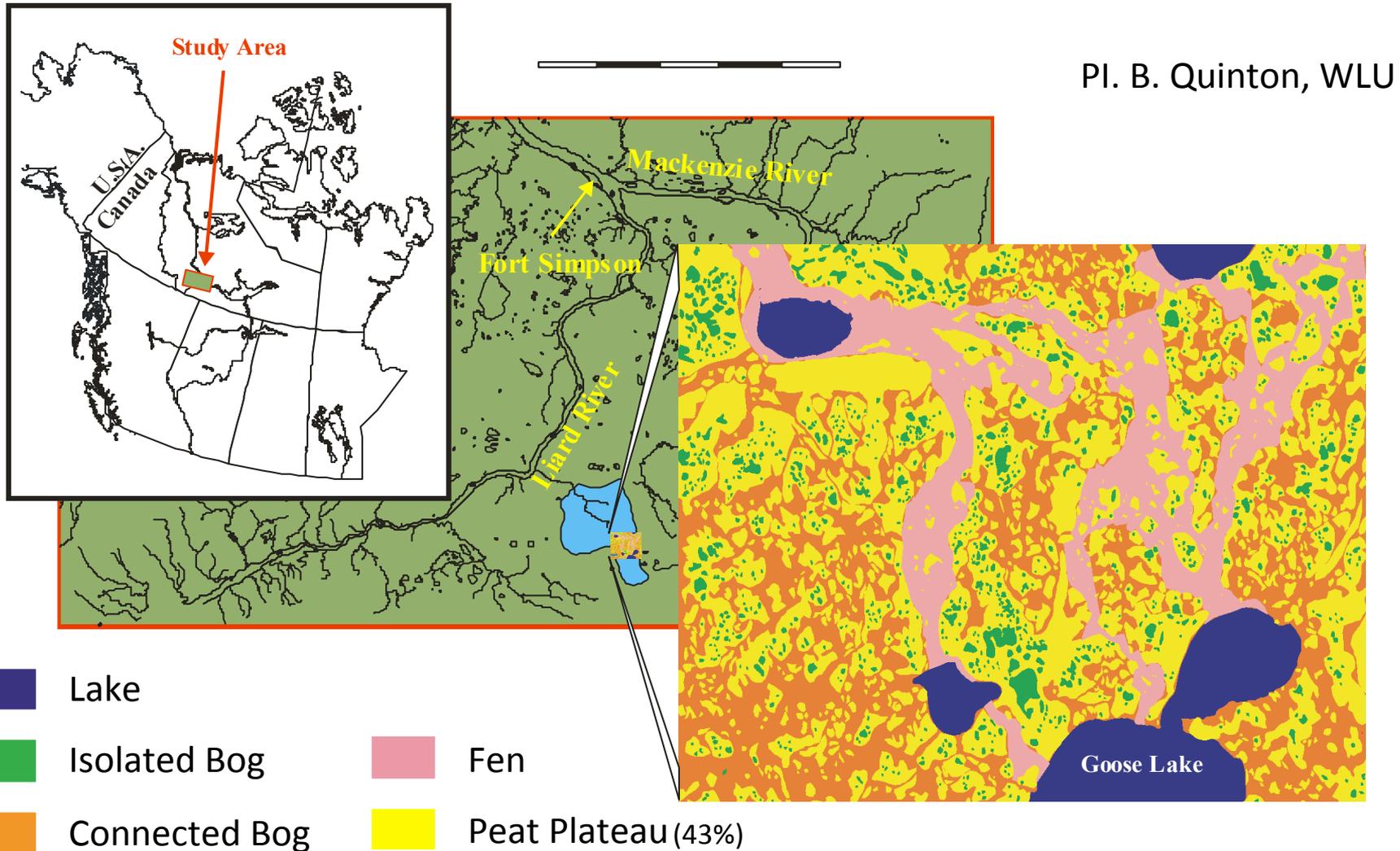
### Deltas (blue triangles)

- Peace-Athabasca
- Slave
- Mackenzie

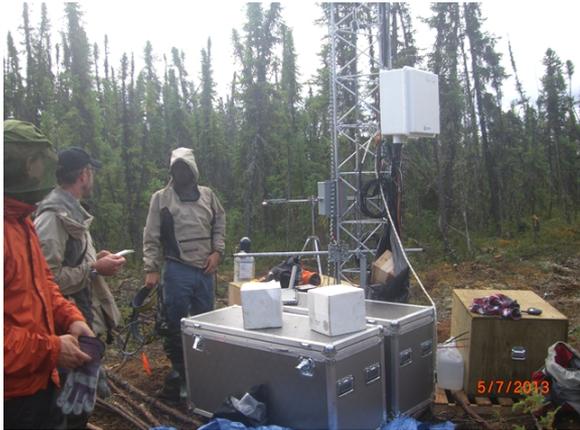
### GNWT – ENR Labs

- Yellowknife
- Ft. Simpson
- Inuvik

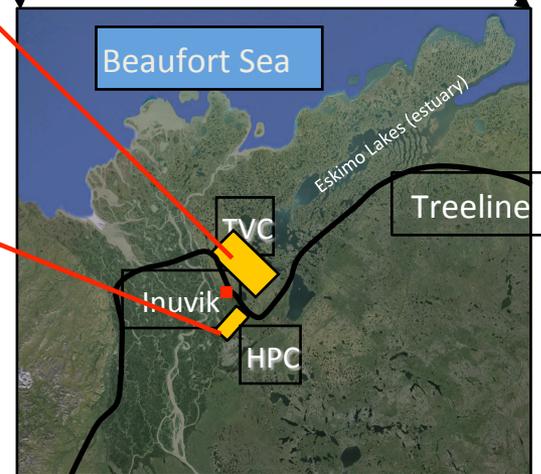
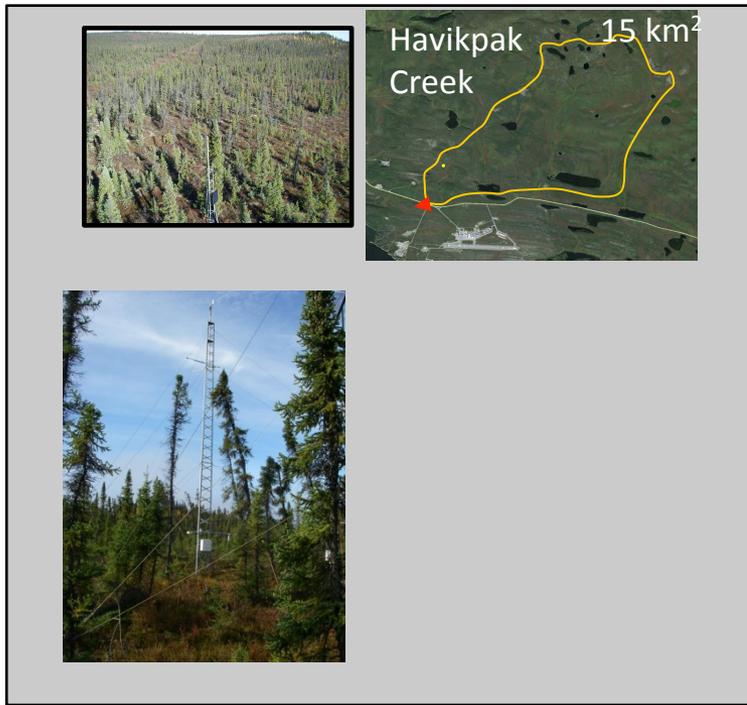
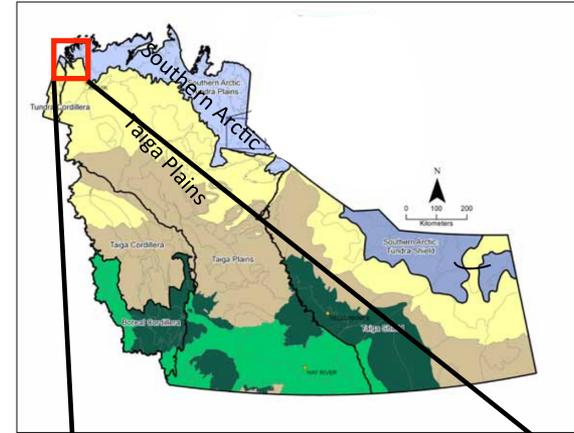
# Scotty Creek Integrated Environmental Observatory



# Scotty Creek Integrated Environmental Observatory



# Trail Valley and Havikpak Creeks Integrated Environmental Observatories



PI is P. Marsh, WLU

# Trail Valley Creek study area

## TVC vegetation cover

Tundra (<0.5 m):	83.4%
Low Shrub (<1.25 m):	10.8%
High Shrub (<3.0 m):	5.4%
Trees (>3.0 m):	0.4%

### Drift site



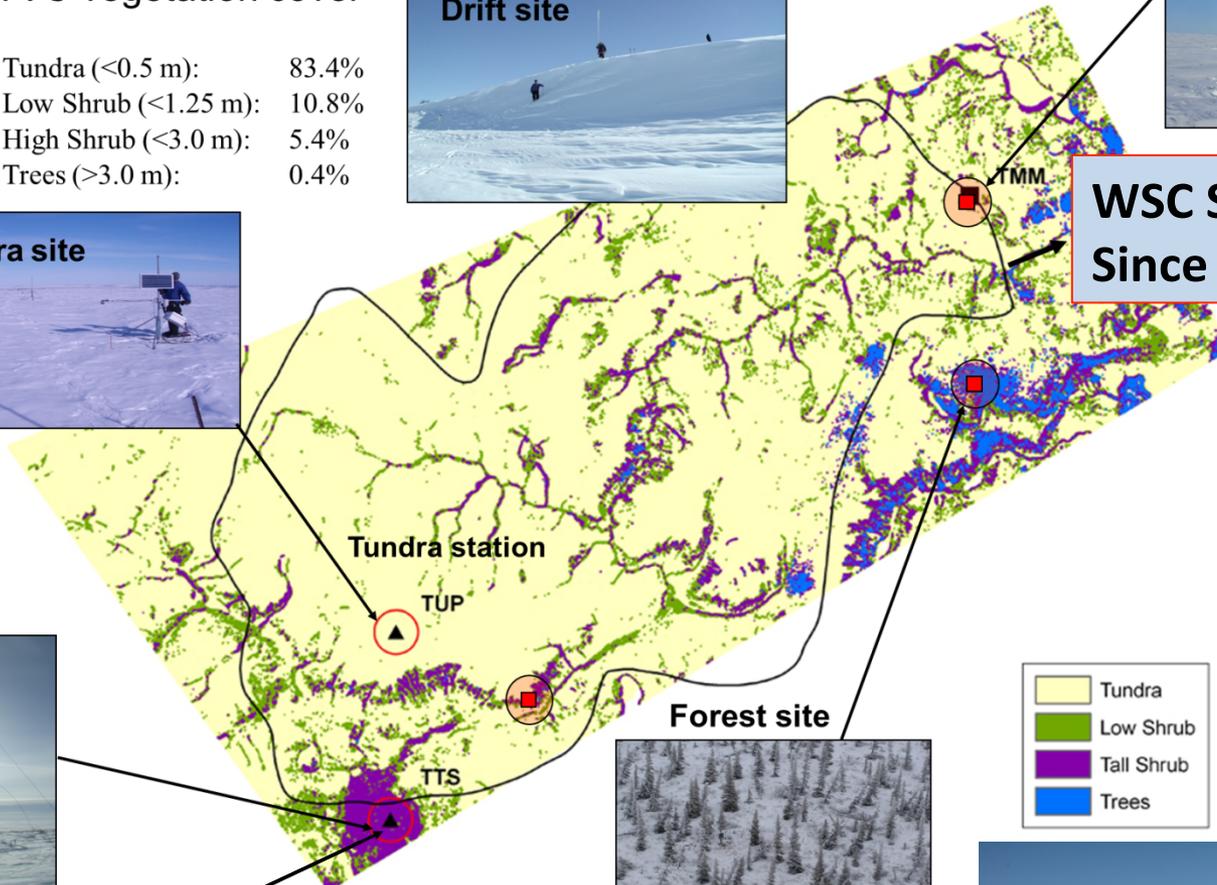
### Tundra site



## WSC Stream Discharge Since 1985



### Tundra site

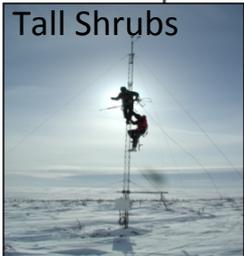
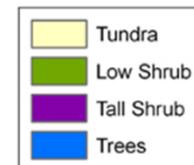


### Tundra station

TUP

### Forest site

TTS



### Tall Shrubs

### Shrub tundra site



### Tall Shrubs

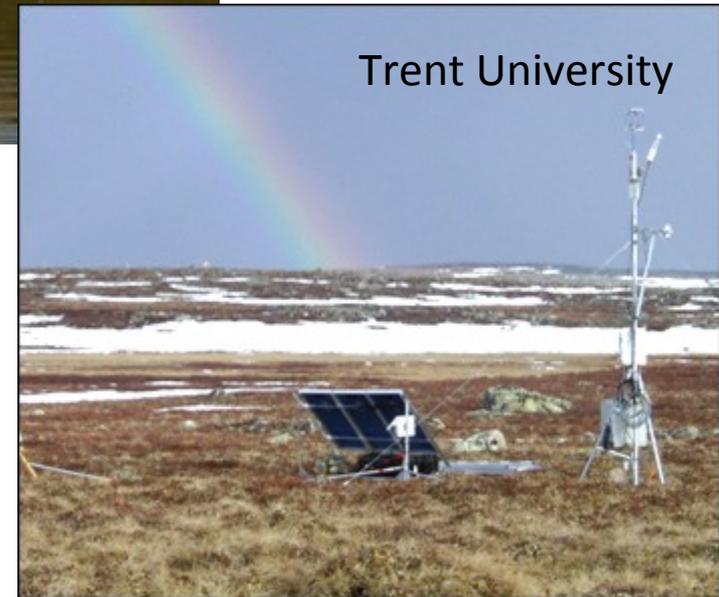


Basin is approx. 60 km<sup>2</sup>



# Tundra Ecosystem Research Station Integrated Environmental Observatories

Operated by GNWT-ENR. K. Clark



<http://www.enr.gov.nt.ca/programs/tundra-ecosystem-research-station/information-researchers>

# Changing Arctic Network (CANet)

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Primary Objectives include:

- O1. Develop an understanding of the long-term stability and resilience of arctic ecosystems to past perturbations;
- O2. Develop fundamental and integrative knowledge of present arctic ecosystems;
- O3. Develop and apply integrative models to reliably project potential future ecosystem responses to climate warming and anthropogenic disturbance; and
- O4. Engage northern communities to build adaptive capacity and resilience in the face of climate and landscape change.

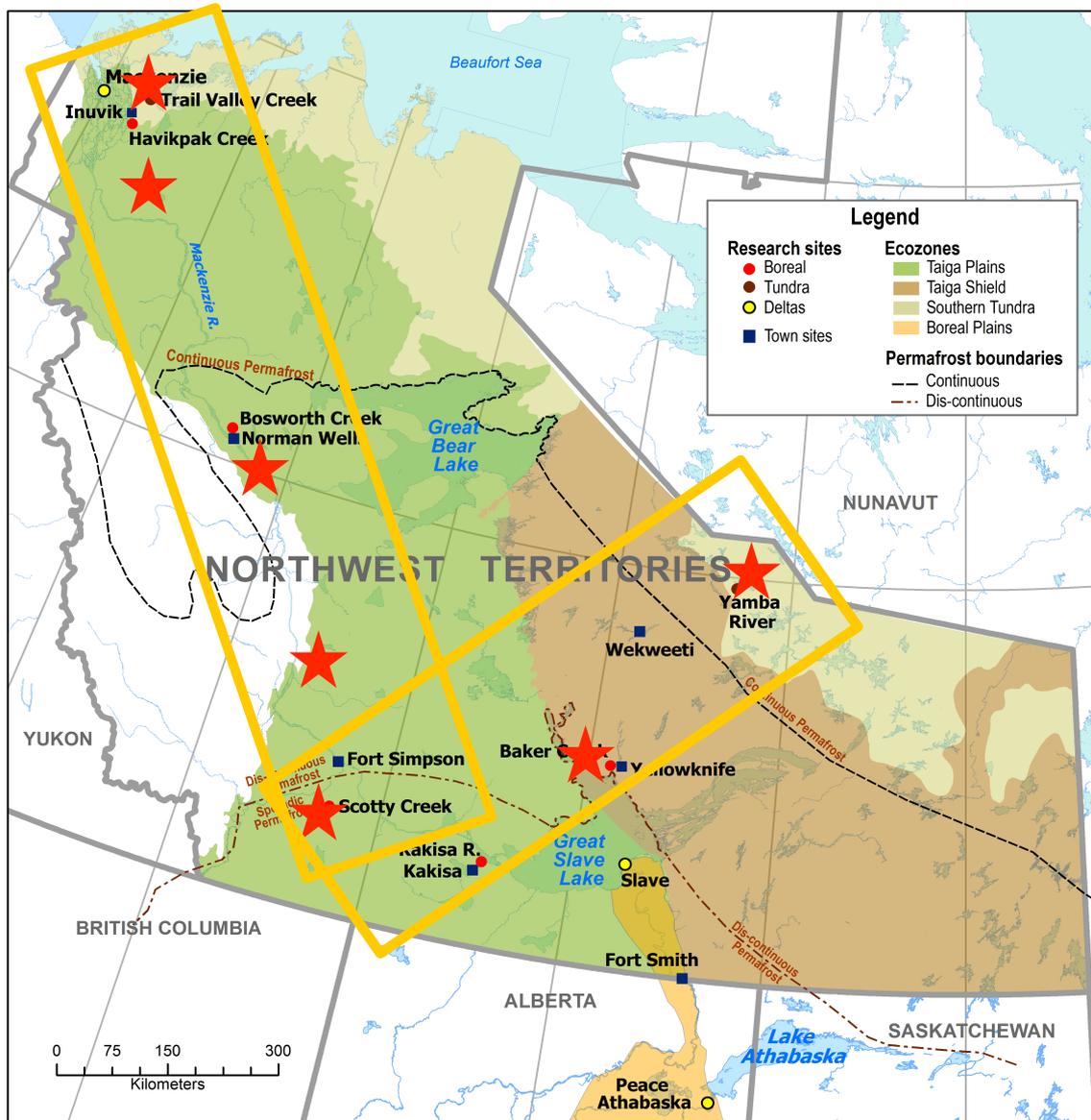
# Changing Arctic Network (CANet)

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## Primary Infrastructure Categories:

- Unit 1: Resilience Unit
- Unit 2: Forest Response Unit
- Unit 3: Permafrost Unit
- Unit 4: Phenology Unit
- Unit 5: Carbon Unit
- Unit 6: Water Quantity Unit
- Unit 7: Water Quality Unit
- Unit 8: Biomonitoring Unit
- Unit 9: Northern Community Unit
- Unit 10: Laboratory Unit
- Unit 11: Support Unit
- Unit 12: Camp Infrastructure Unit
- Unit 13: NWT Laboratory Unit

# CANet – Tower based carbon flux program



- Eddy Covariance Towers
- Chambers

O. Sonnentag  
M. Turetsky  
J. Baltzer  
P. Lafleur  
E. Humphreys  
P. Marsh  
B. Quinton

# Numerous Funded (or in some cases under funded) Research programs contributing to the Laurier – GNWT Partnership Programs

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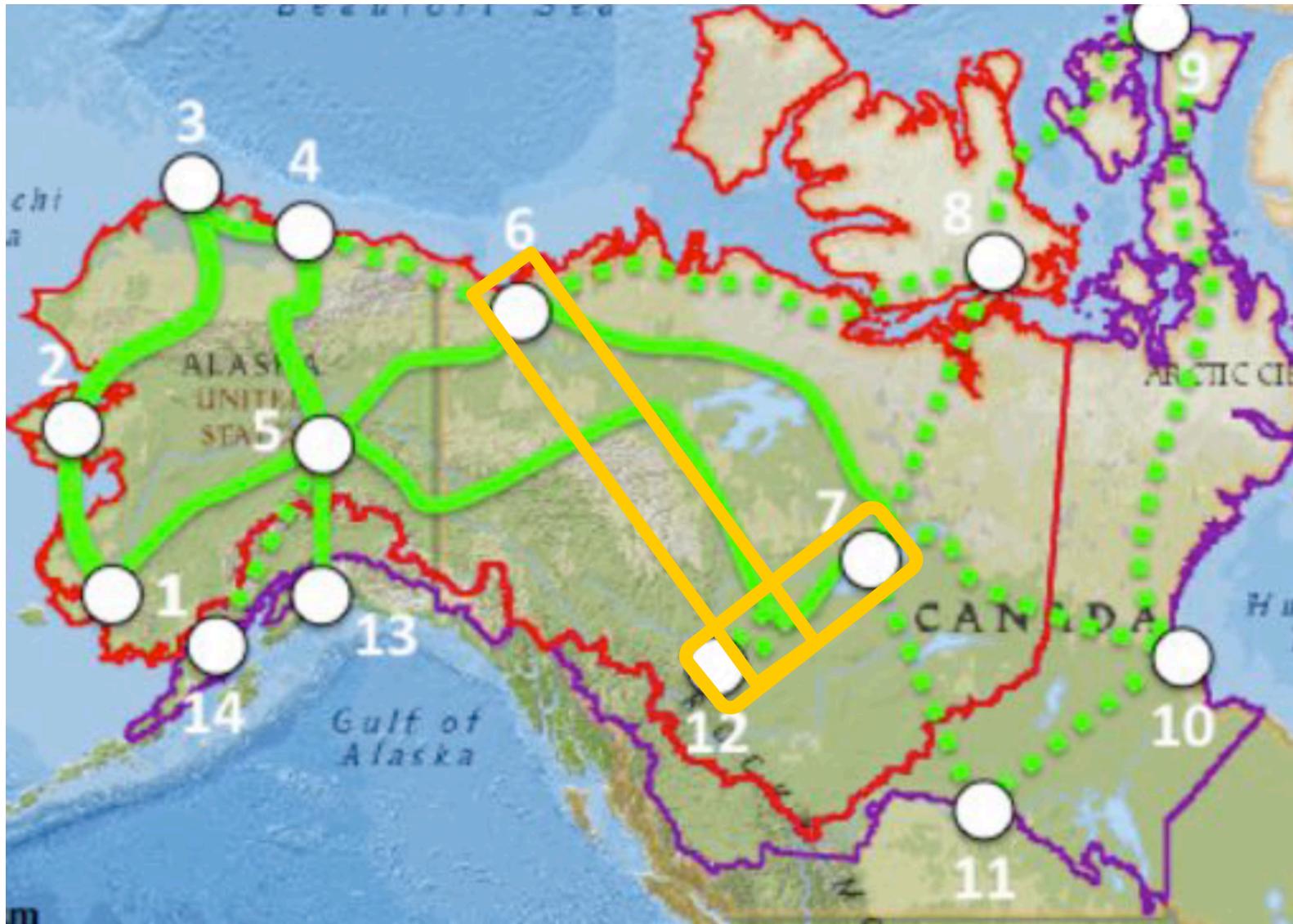
1. Fire Project (2015 - ). Baltzer et al.
2. Carbon Flux Program (2013 - ). Sonnentag et al.
3. Changing Cold Regions Network (CCRN) (2012-18) Quinton et al.
4. Two POLAR Knowledge Canada Funded projects:
  1. Fire and aquatic systems. Tank-Quinton et al.
  2. Cyrosphere, vegetation, water. Marsh et al
5. ArcticNet project on Snow and Vegetation (Marsh et al.)
6. A number of NWT-CIMP funded programs
7. NSERC Discovery Grants and Northern Supplements

# Next Steps and needs to build on our Partnership/CALIBRE/CANet programs

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- Continue field observations at key sites across the NWT
- Further develop the use of experimentation at these sites
- Incorporate high resolution, physics based modelling (example – NGEE-Arctic. Painter et al. High resolution, 3D subsurface model with deforming topography)
- Greatly improve data archiving and access
- Improved integration between studies and projects
- Remote sensing – improved links to ABoVE clearly presents a massive opportunity we have to build upon
  - **The outstanding question is how do we move this forward, with significant challenges for funding, data, critical mass of researchers/HQP**
  - **What options are available for making progress quickly in the next year?**

ABOVE's Foundational Airborne Measurements (green solid lines), with Partnership/CANet "transects" (in orange)



# Questions?

