NATURAL RESOURCES CANADA - INVENTIVE BY NATURE

Government of Canada

Boreal Research and Management Needs and Activities

Catherine Ste-Marie, Canadian Forest Service

Joint POLAR/ABoVE /NWT Workshop

Yellowknife, May 10-12 2016

NATURAL RESOURCES CANADA - INVENTIVE BY NATURE

Some Government of Canada (mainly CFS) Boreal Research and Management Needs and Activities

Catherine Ste-Marie, Canadian Forest Service

Joint POLAR/ABoVE /NWT Workshop

Yellowknife, May 10-12 2016

Overview

- Key synthesis and programs
  - Boreal synthesis
  - Carbon Blueprint
  - Forest Change
- Science activities (a sample!)
  - Inventories - Monitoring networks
  - Mapping - Integration of RS and ground observations
  - Modeling and research
- Information needs - knowledge gaps

CFS "Boreal Synthesis"

- Comprehensive review of the state of knowledge about the boreal
- 11 articles published in *Environmental Reviews* 2013-15.
- Identification of knowledge gaps

TOPICS

- Intro
- Carbon
- Climate change impacts
- Mitigation
- Adaptation
- Aquatic biodiversity
- Terrestrial biodiversity
- Soil and plant nutrition
- Water and wetlands
- Non-native species
- Protected areas.

Workshop – Follow-up to the "Boreal synthesis"

- Organized by the CFS March 2016
- 57 representatives of provincial forestry ministries, other resource sectors, non-governmental organizations, academia and resource industries
- Validation of knowledge gaps
- Development of a research agenda for enhancing boreal resource management to ensure the long-term sustainability of boreal ecosystems.

The Carbon Blueprint

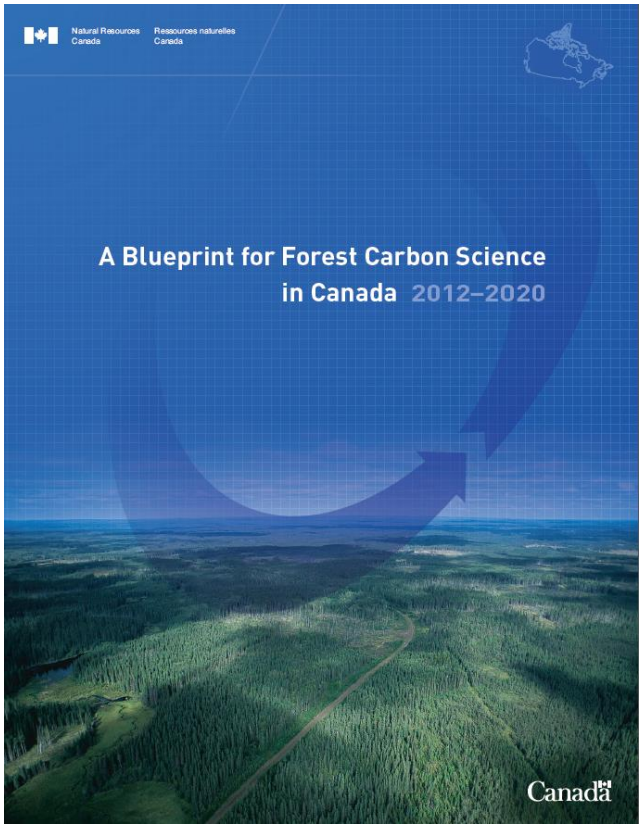


TABLE 2. Contribution of research activities and infrastructure to science questions.

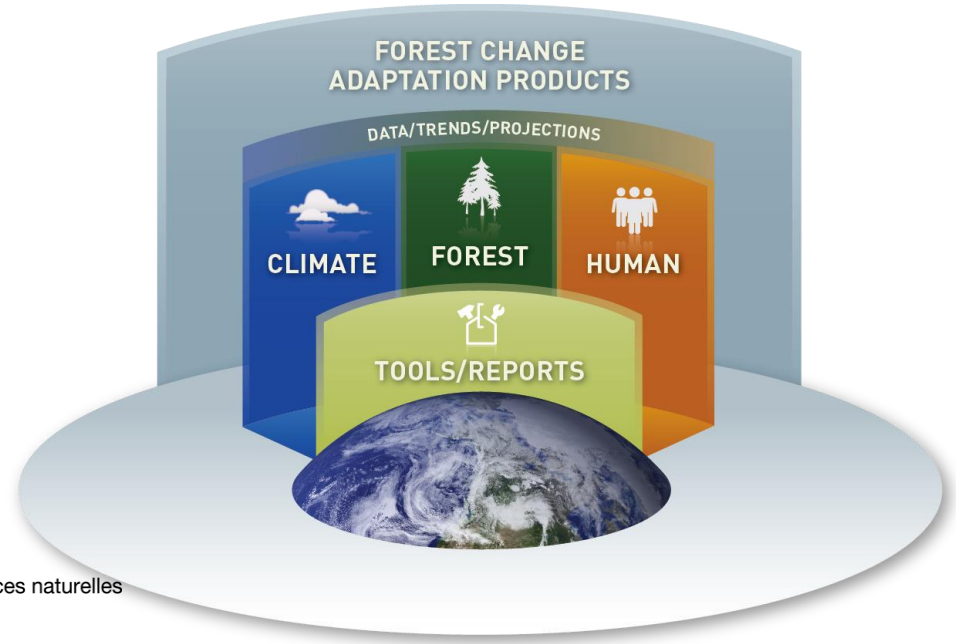
SCIENCE QUESTIONS	DATA ACQUISITION: MONITORING, OBSERVATIONS, AND EXPERIMENTS					DATA STORAGE AND DISTRIBUTION	DATA ANALYSIS, INTEGRATION, AND SYNTHESIS		
	Forest inventories	Remote sensing	Field studies	Flux towers	Measurements of atmospheric CO_2	Databases and information systems	Bottom-up ecosystem modeling	Top-down atmospheric modeling	Economic modeling
1.1 What are the impacts of natural disturbances, forest management, and land-use change on current forest C dynamics from stand to national scales and from subannual to multidecadal time scales?	+	+	+	+		+	+		
1.2 What are the impacts of climate variability, including drought, on current forest C dynamics from stand to national scales and from subannual to multidecadal time scales?	+	+	+	+		+	+		
1.3 How do local processes determining current forest C dynamics scale up to regional and national scales?	+	+		+	+	+	+	+	
2.1 To what extent will global changes alter C sources and sinks in Canada's forests?			+	+		+	+		
2.2 How will the impact of climate change on forest natural disturbances affect Canada's future forest C budget?			+				+		
3.1 How does the influence of forest C fluxes on climate compare to the influence of other processes and properties related to forest cover?	+	+							
3.2 What will be the contribution of Canada's forests to the future global GHG budget?	+		+	+			+		
4.1 What activities in forest ecosystems can best contribute to mitigation objectives?	+						+		+
4.2 What actions involving harvested wood products can best contribute to mitigation objectives?						+	+		+
4.3 What actions involving bioenergy from forest biomass can best contribute to mitigation objectives while ensuring the sustainability of biomass harvesting?	+		+			+			+

7

Forest Change – CFS adaptation program

Building on existing capacity, knowledge and expertise…

1. **A Tracking System** that reports on indicators of climate change impacts to identify forest sector vulnerabilities
2. **An Adaptation Toolkit** of actionable science for sustainable forest management under a changing climate
3. **Integrated Assessment** of climate change implications for the forest sector to guide policies and investment



National Forest Inventory

Project Manager: Graham Stinson (Pacific Forestry Centre, Victoria)

- Standardized measurements for consistent reporting and estimates of forest change
- Collaborative project involving federal, provincial & territorial agencies
- Multi-scale observations including air photo plots & remote sensing
- Includes ~1000 ground plots representing Canada's major forest types
- Plot network established 2002-2010 with plot re-measurements since then

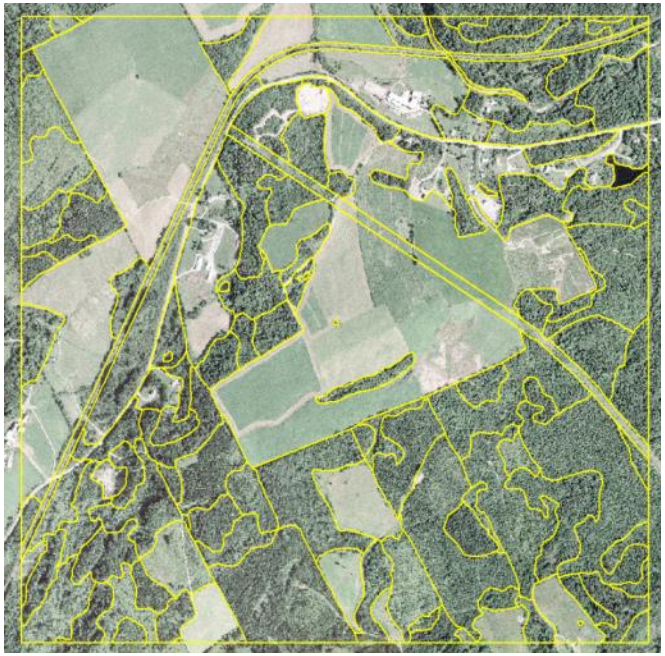
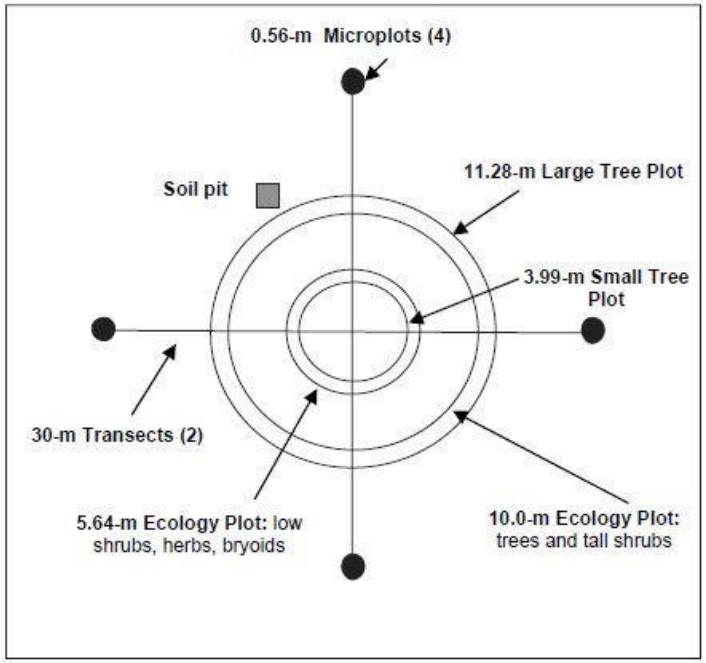
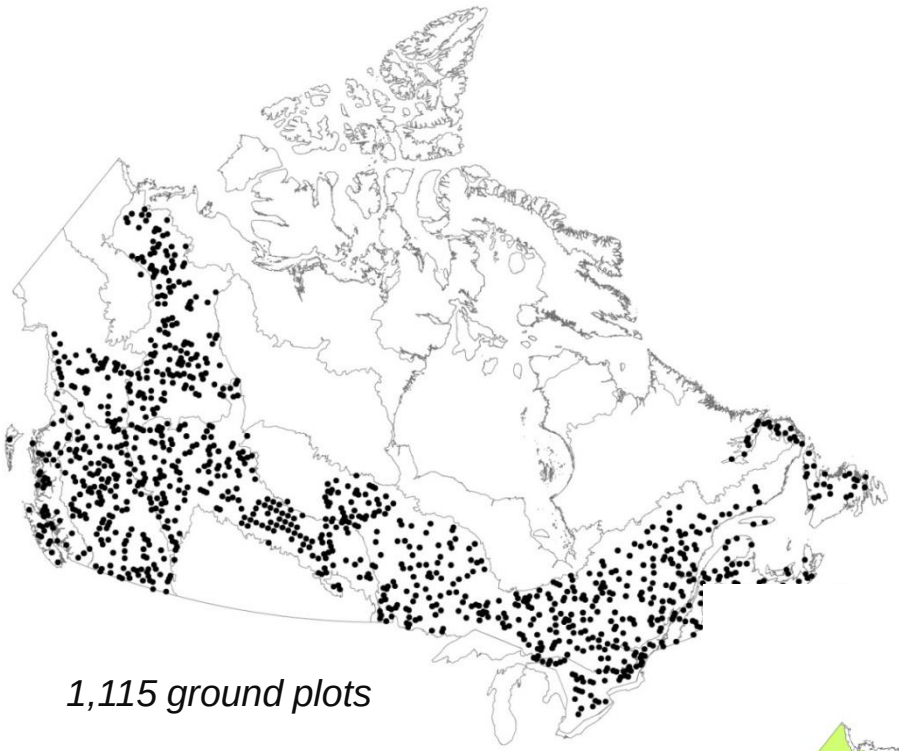


Photo-interpreted survey plot (forest cover layer)



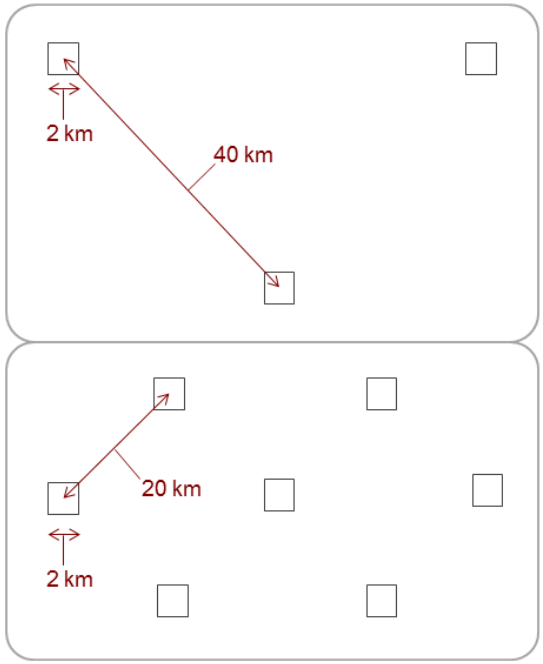
NFI ground plot layout

NFI - Remote sensing and ground plots



1,115 ground plots

Very high spatial resolution satellite survey covering 0.25% of light green zone



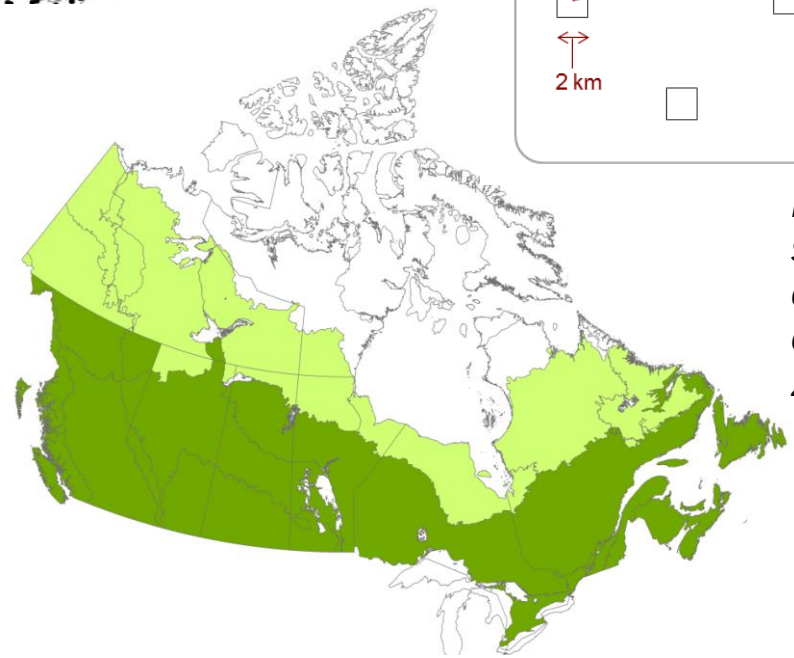
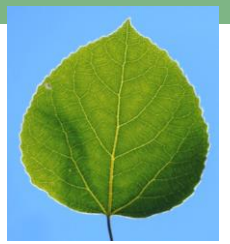


Photo-plot survey covering 1% of dark green zone

CIPHA study

Climate Impacts on Productivity & Health of Aspen

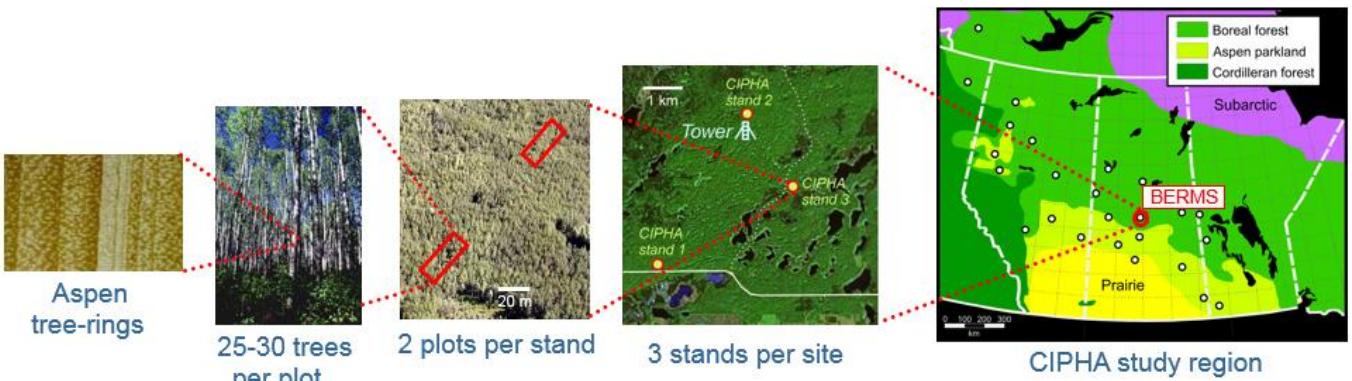


Aim: Provide knowledge of how severe drought & its interactions with forest insects & diseases affect aspen stand dynamics across multiple scales

- Methods include tree-ring analysis, annual plot-based measurements & remote sensing
- Initiated in 2000 by Canadian Forest Service & Environment Canada (Ted Hogg, NoFC)
- Proposed re-measurement in 2016 through partnership with 2 provinces (Alberta & Sask.)

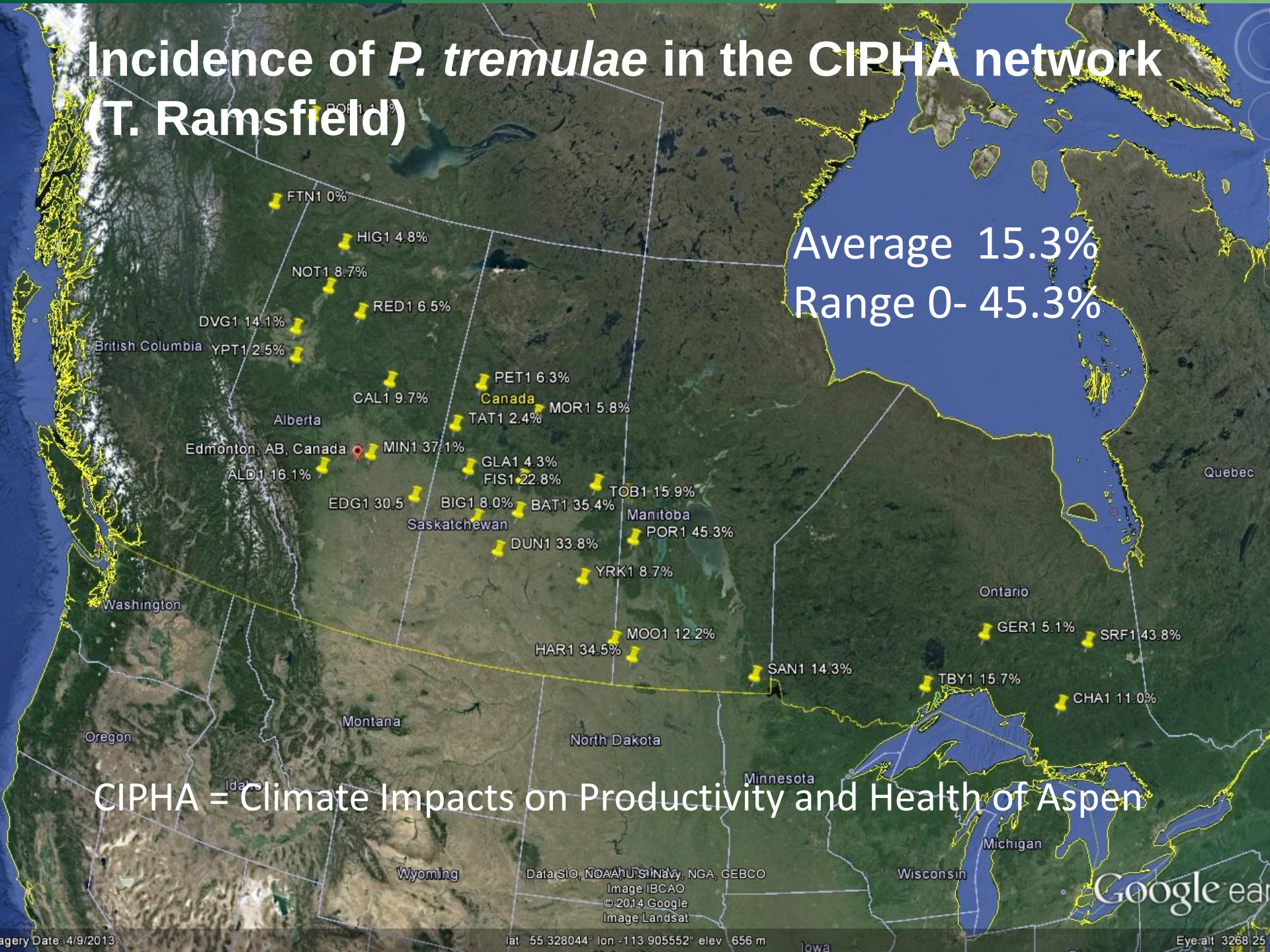
Key publications

Hogg et al. 2002, 2005, 2008 (CJFR); Michaelian et al. 2011 (GCB); Hogg & Michaelian 2015 (GCB)



Massive aspen mortality following the 2002 drought

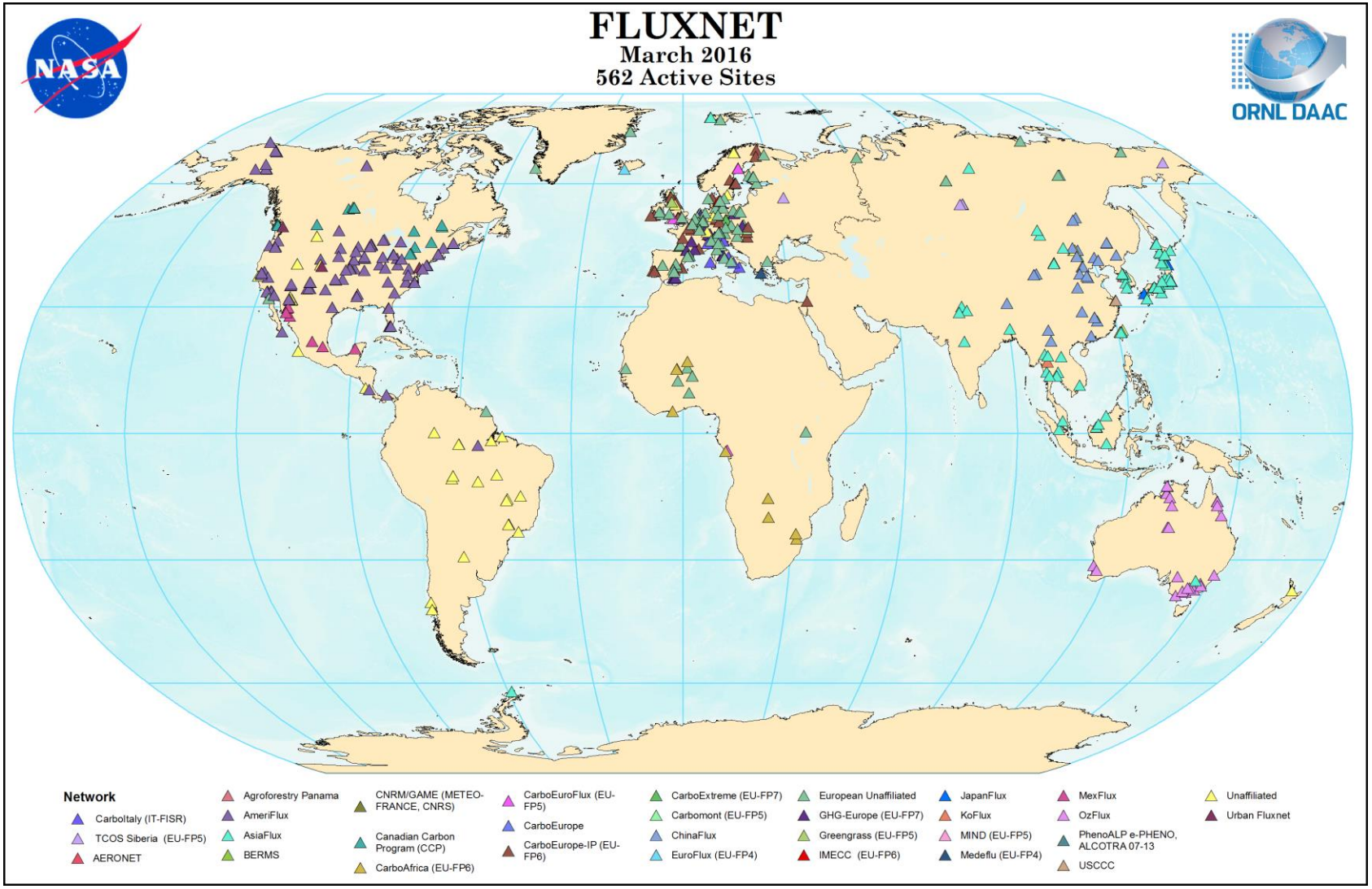
Incidence of *P. tremulae* in the CIPHA network (T. Ramsfield)



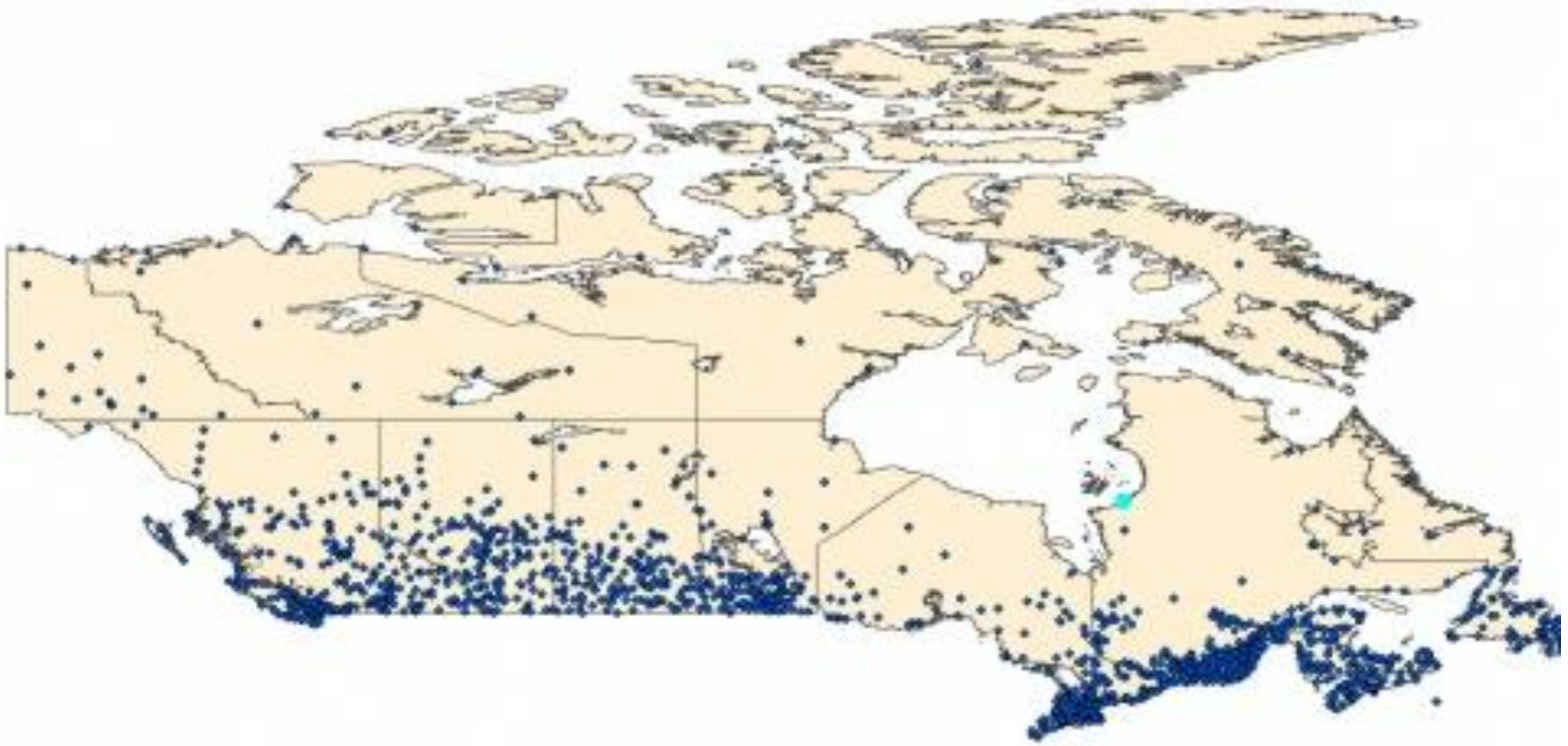
Average 15.3%

Range 0- 45.3%

CIPHA = Climate Impacts on Productivity and Health of Aspen


FLUXNET
March 2016
562 Active Sites
ORNL DAAC
Network
Carboltaly (IT-FISR)
TCOS Siberia (EU-FP5)
AERONET
Agroforestry Panama
AmeriFlux
AsiaFlux
BERMS
CNRM/GAME (METEO-FRANCE, CNRS)
Canadian Carbon Program (CCP)
CarboAfrica (EU-FP6)
CarboEuroFlux (EU-FP5)
CarboEurope
CarboEurope-IP (EU-FP6)
CarboExtreme (EU-FP7)
Carbomont (EU-FP5)
ChinaFlux
EuroFlux (EU-FP4)
European Unaffiliated
GHG-Europe (EU-FP7)
Greengrass (EU-FP5)
IMECC (EU-FP6)
JapanFlux
KoFlux
MIND (EU-FP5)
Medeflu (EU-FP4)
MexFlux
OzFlux
PhenoALP e-PHENO, ALCOTRA 07-13
USCCC
Unaffiliated
Urban Fluxnet

Environment Canada Weather Stations



Table

CanadianWeatherStations

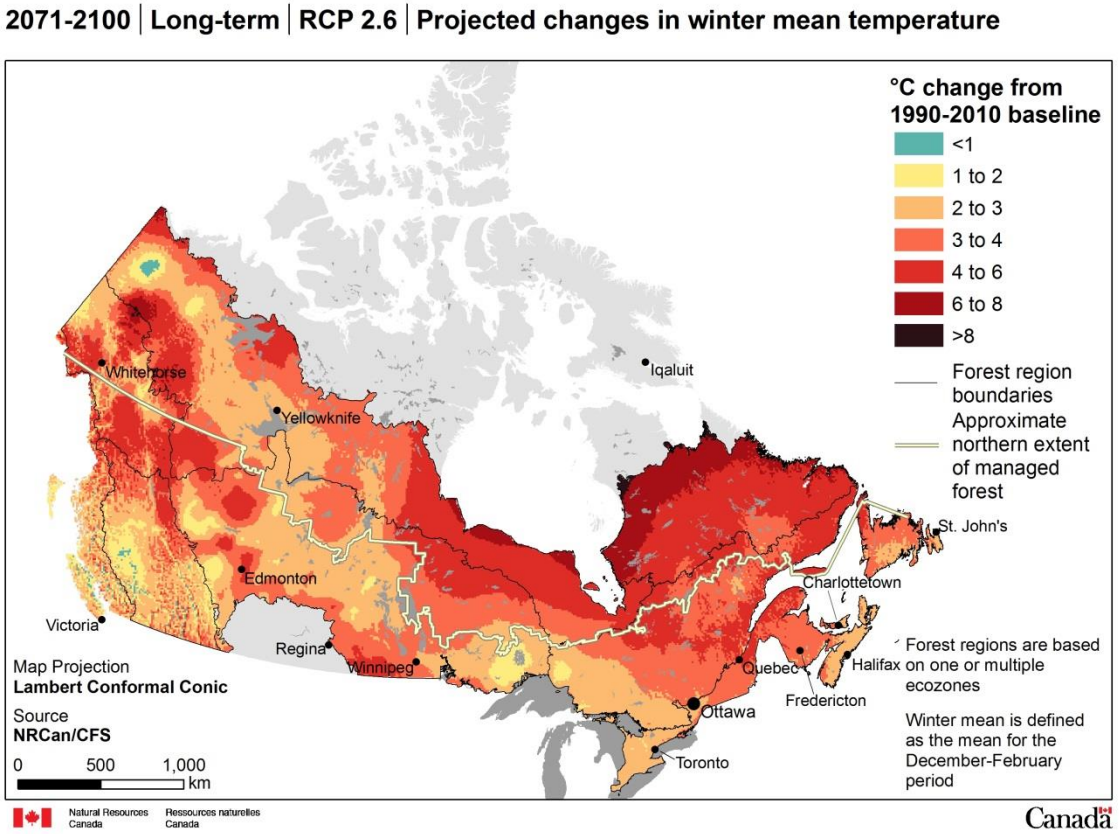
Station_Na	Province	Latitude	Longitude	Elevation	Latitude_	Longitude_	UTM_Grid_Z	Climate_ID	WMO_Compli	WI
KUUJJUARAPIK A	Quebec	55°17'00.000" N	77°45'00.000" W	10.4	55.283333	-77.75	18	7103536	Yes	
KUUJJUAQ A	Quebec	58°06'00.000" N	68°25'00.000" W	39.3	58.1	-68.416667	19	7113534	Yes	
SCHEFFERVILLE A	Quebec	54°48'00.000" N	66°49'00.000" W	521.8	54.8	-66.816667	19	7117825		
ACADIA FOREST EXP ST	New Brunswick	45°59'25.000" N	66°21'45.000" W	54	45.990278	-66.362333	19	8100100	Yes	
ALMA	New Brunswick	45°36'00.000" N	64°57'00.000" W	42.7	45.6	-64.95	20	8100200	Yes	
ARBOSTOOK	New Brunswick	46°42'44.000" N	67°42'56.000" W	60	46.712222	-67.715556	19	8100300	Yes	

1287 (1 out of 1480 Selected)

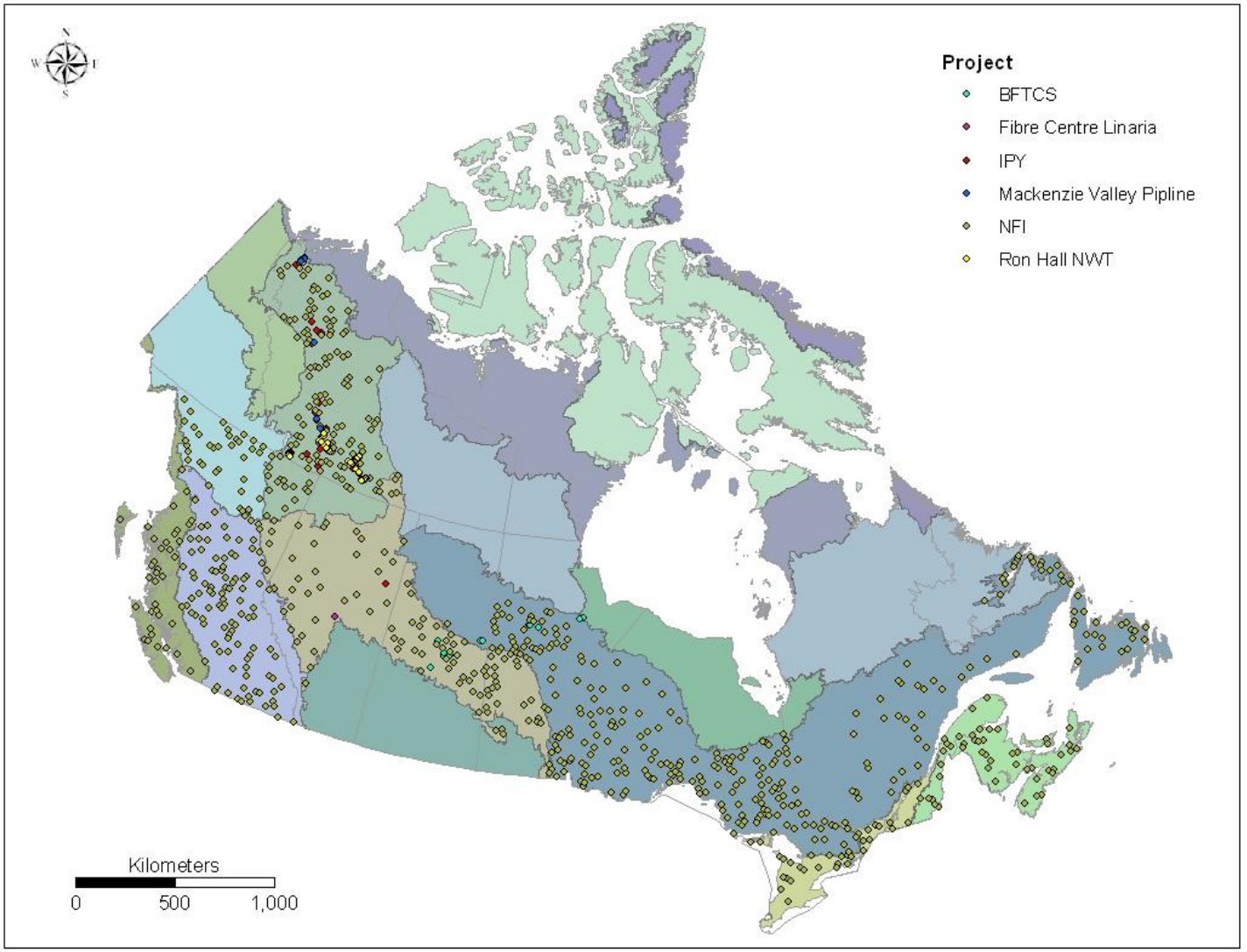
CanadianWeatherStations

Climate change projections (D. Price & D. McKenney)

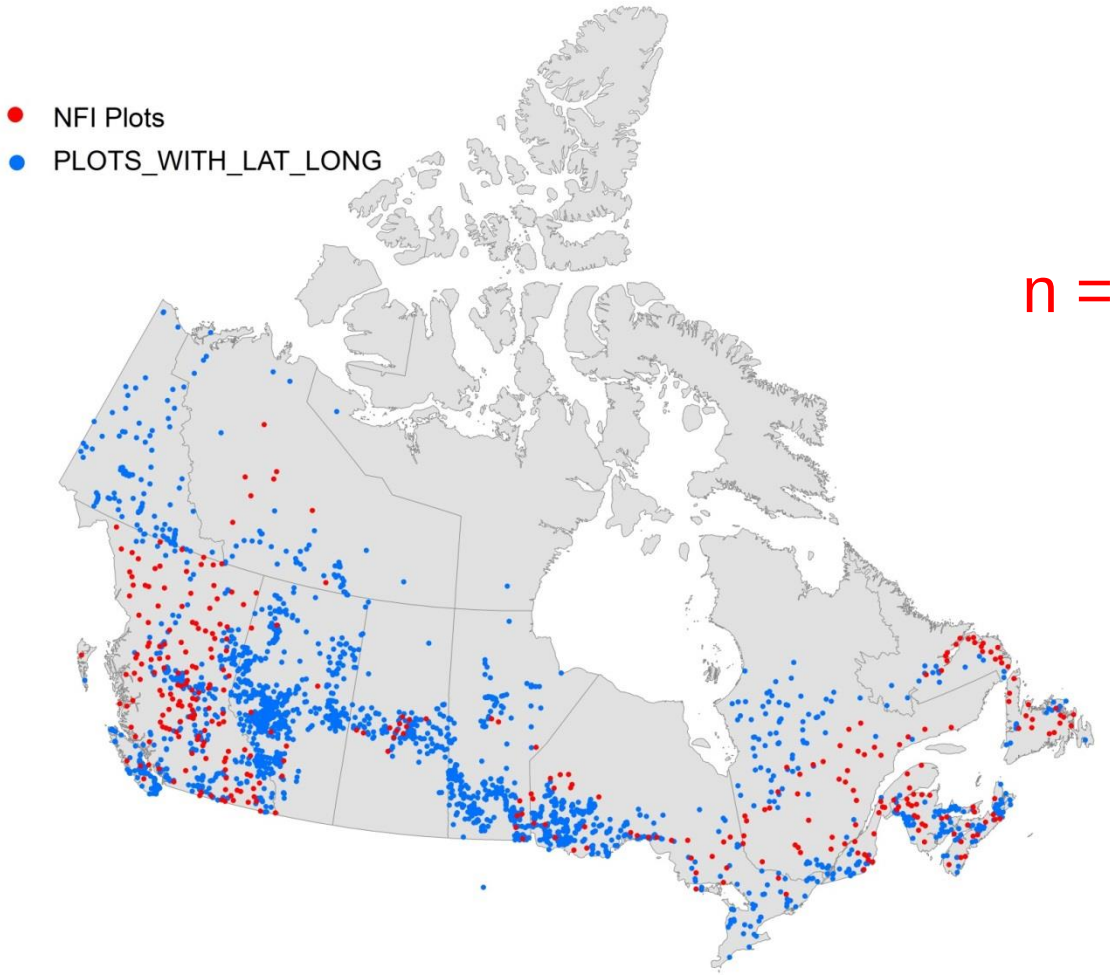
- Downscaling of IPCC AR5
  - ANUSPLIN
  - BIOSIM
- 3 time periods
  - short-term (2010-2040)
  - medium-term (2040-2070)
  - long-term (2070-2100)
- 3 GHG emissions scenarios
  - RCP 2.5 (low scenario),
  - RCP 4.5 (medium scenario)
  - RCP 8.5 (high scenario)
- Six variables: Tmin/max, Precip., Solar Rad., Wind, Vapour
- 10 km gridded data
- Canadian CGM



Tree ring networks - work in progress (Girardin, Metsaranta, Hogg, Bhatti and others)



Canadian Upland Forest Soil Carbon Database (Cindy Shaw)



n = 3480

Wildland Fire

Forests

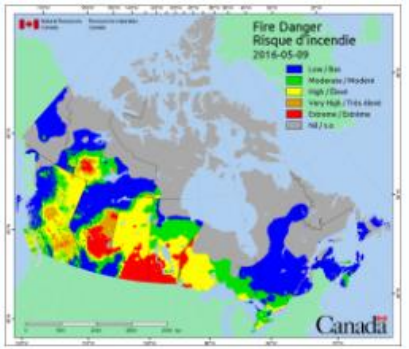
CWFIS

- Background Information
- Maps and Reports
  - Interactive map
  - Current Conditions
  - Fire Danger
  - Weather
  - Fire Weather
  - Fire Behavior
  - Fire M3 Hotspots
  - Monthly and Seasonal Forecasts
- National Wildland Fire Situation Report
- Historical Analysis

Canadian Wildland Fire Information System

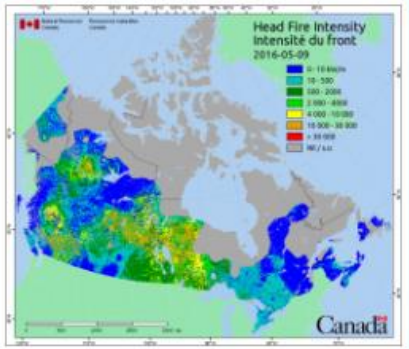
The **Canadian Wildland Fire Information System (CWFIS)** creates daily fire weather and fire behavior maps year-round and hot spot maps throughout the forest fire season, generally between May and September.

Fire Weather



View the most recent Fire Danger map

Fire Behavior



View the most recent Head Fire Intensity

Fire M3 Hotspots

View the most recent Daily Hotspot map

The **Canadian Wildland Fire Information System** is a computer-based fire management information system that monitors fire danger conditions across Canada. Daily weather conditions are collected from across Canada and used to produce fire weather and fire behavior maps. In addition, satellites are used to detect fires.

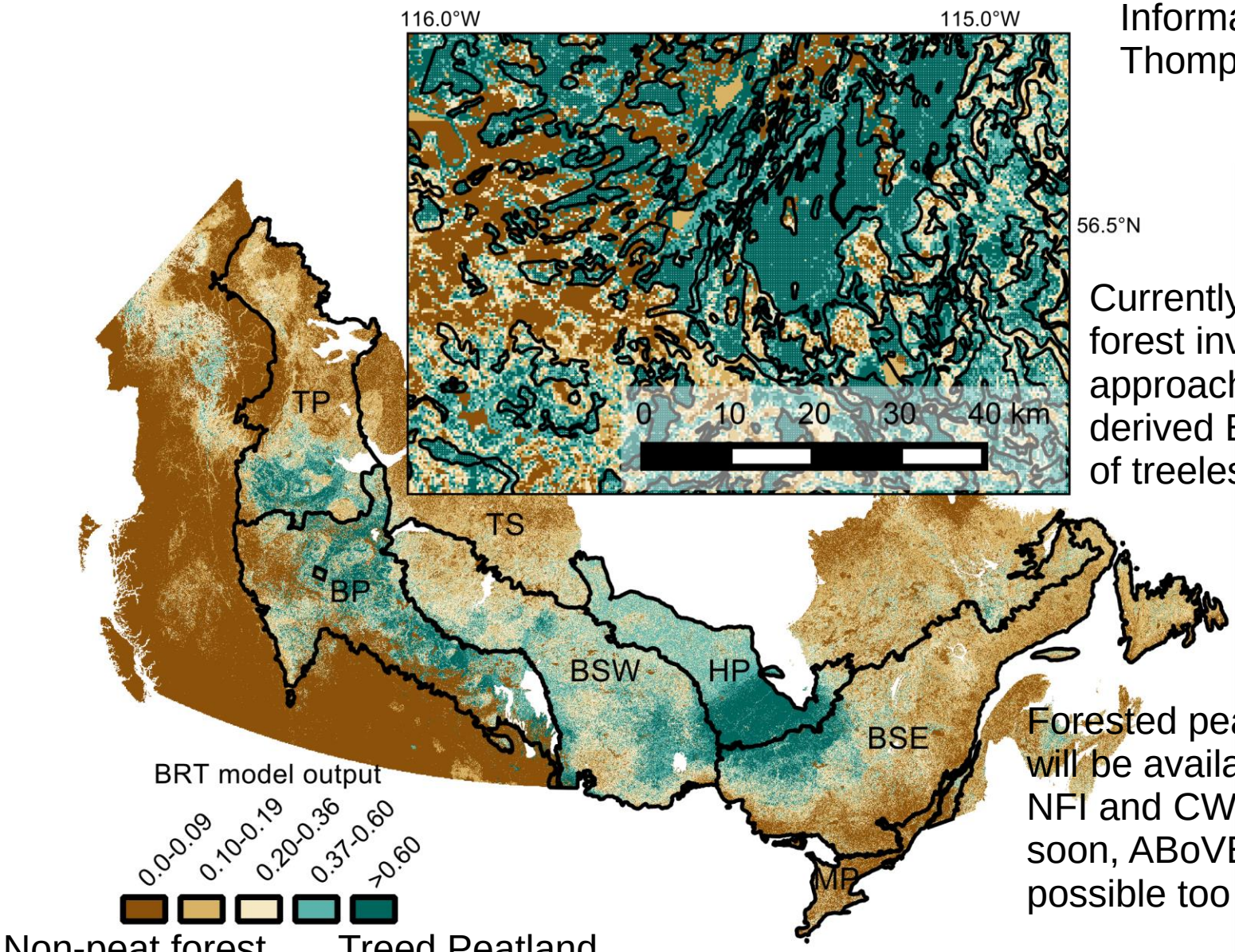
This site is divided into three main sections:

1. The Background Information section contains links that provide details about the CWFIS and outline the processes used to derive the data.
2. The Current Conditions section presents the current fire danger in Canada

Integrating RS and ground observations

- Several NRCan teams (and others around the world) are producing land cover and land-cover change products – 30 and 250 m resolution
  - e.g. location of disturbances, distribution of forest cover types, above-ground biomass, etc.

Mapping forested peatlands using forest inventory data



Information from Dan Thompson

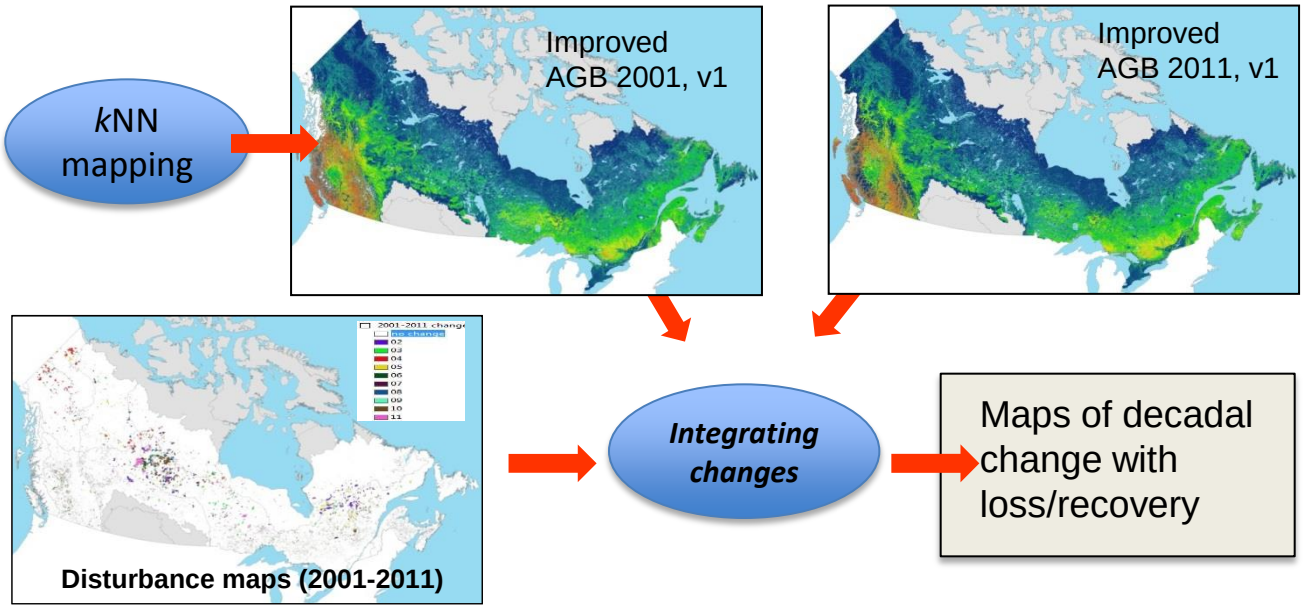
Currently combining this forest inventory-derived approach with LANDSAT-derived EOSD mapping of treeless peatlands

Forested peatland map will be available through NFI and CWFIS datamarts soon, ABoVE science cloud possible too

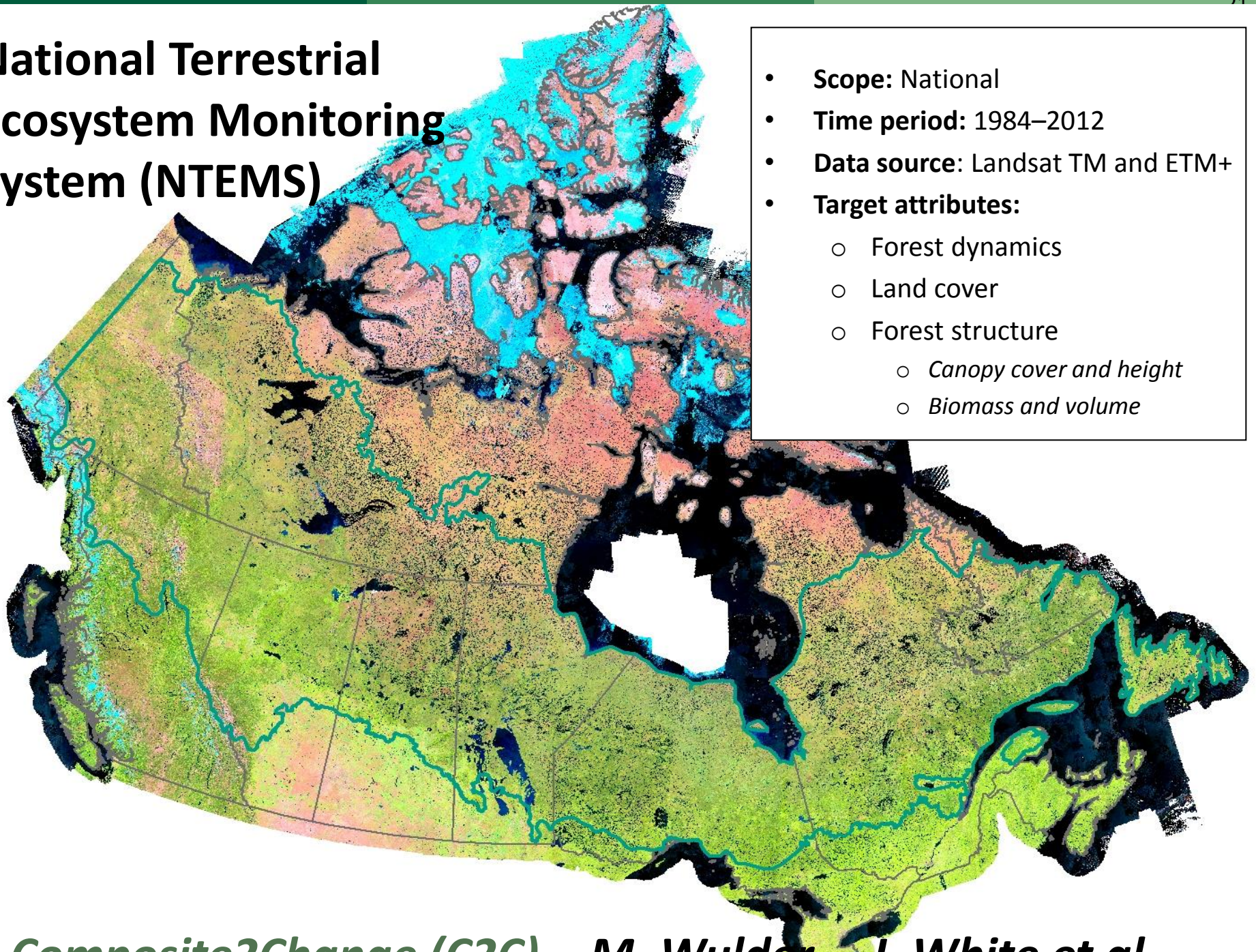
Thompson et al. *Forest Ecol. Man* (In Press)

1. Improved/updated mapping and monitoring of NFI attributes at 250 m based on MODIS

- **Geospatial data:**
  - 250 m MODIS time-series, 2001-2011 (CCRS)
  - LC, topo & climate features
- **Train/val:**
  - NFI photo-plots network/ k-fold cross-val
- **MODIS-based methods:**
  - Improved temporal *k*NN predictions of NFI attributes (2001-2011)
  - Decadal differentiation of *k*NN predictions integrated with yearly disturbance maps (fires, harvest) *(Guindon et al., 2014, CJFR)* : NFI attributes change with loss/recovery

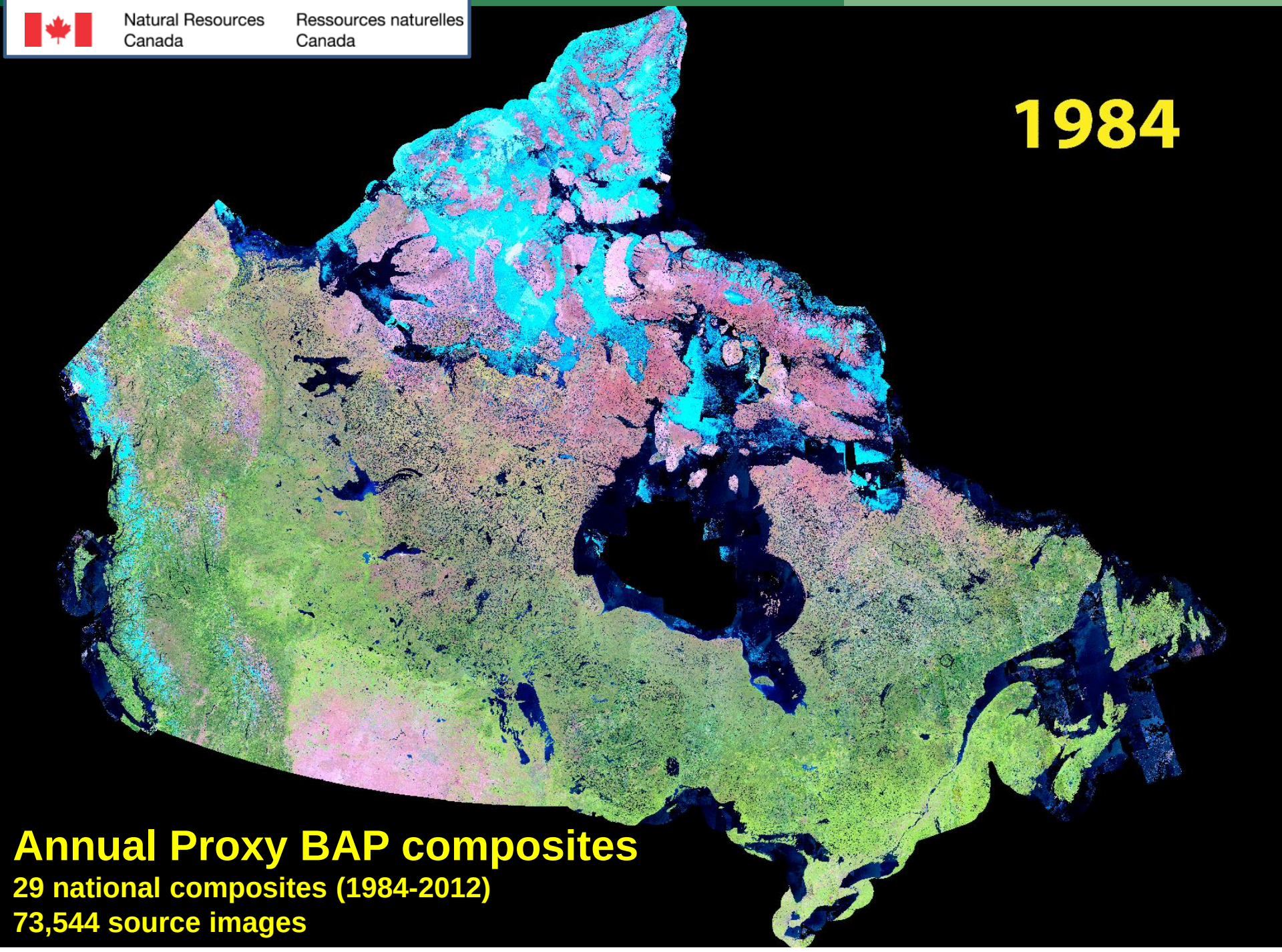


National Terrestrial Ecosystem Monitoring System (NTEMS)

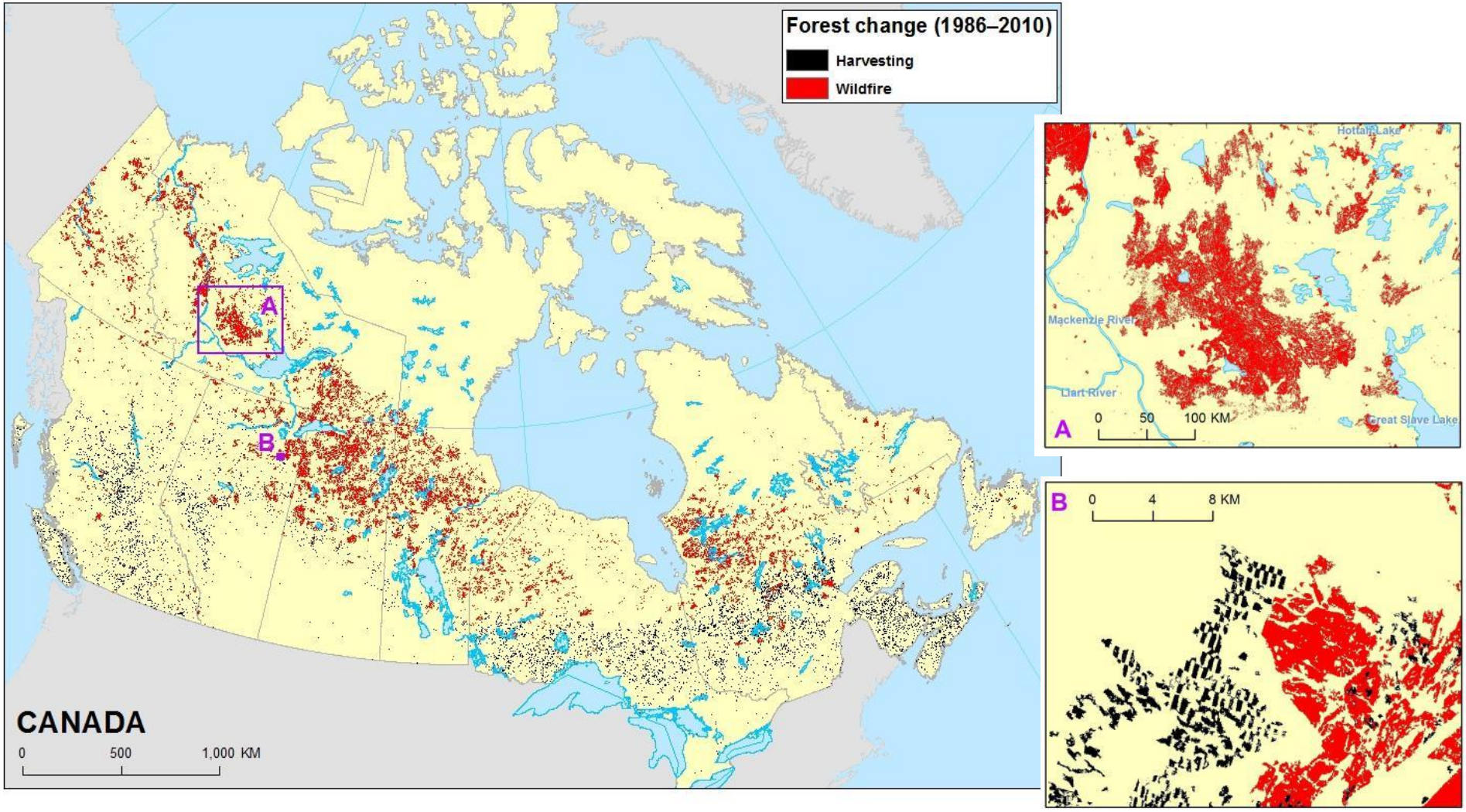


- **Scope:** National
- **Time period:** 1984–2012
- **Data source**: Landsat TM and ETM+
- **Target attributes:**
  - Forest dynamics
  - Land cover
  - Forest structure
    - *Canopy cover and height*
    - *Biomass and volume*

Composite2Change (C2C) - M. Wulder, J. White et al.


Natural Resources Canada
Ressources naturelles Canada
1984
Annual Proxy BAP composites
29 national composites (1984-2012)
73,544 source images

C2C: Attributed change



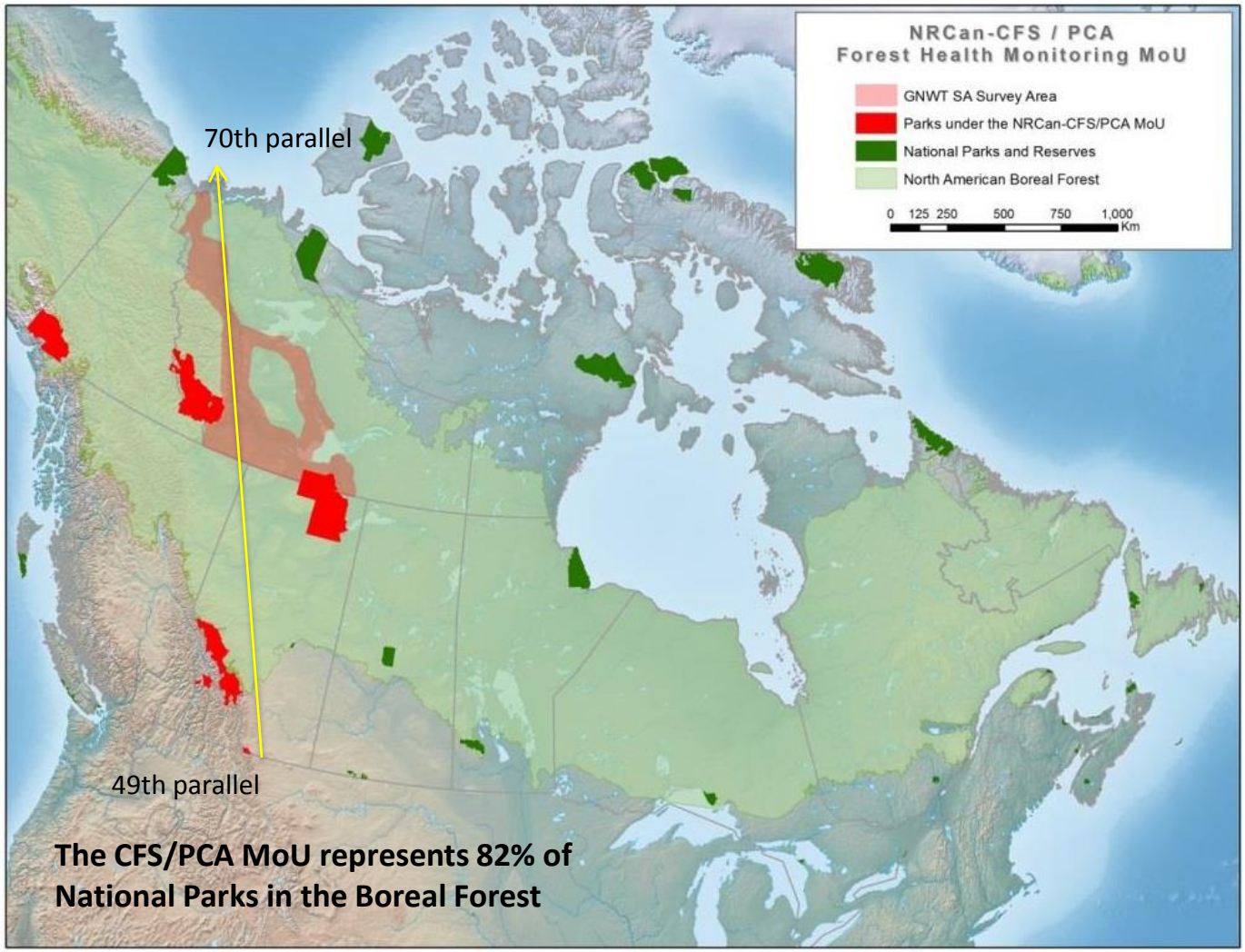
Northern and high-elevation Forest Health monitoring projects

NWT & Parks Canada Forest Health Monitoring

What we do: Annual surveys (aerial and some ground) to assess current forest health conditions, observe trends over time, and discover emerging issues.

What we see: Climate-related Forest Health observations have been increasing in scope, especially over the last decade. Direct and indirect damage due to drought and the ongoing warming trend.

How can we help: We have pest survey data dating back to 1954. Observations can direct attention to areas of concern or help confirm remotely-sensed issues.



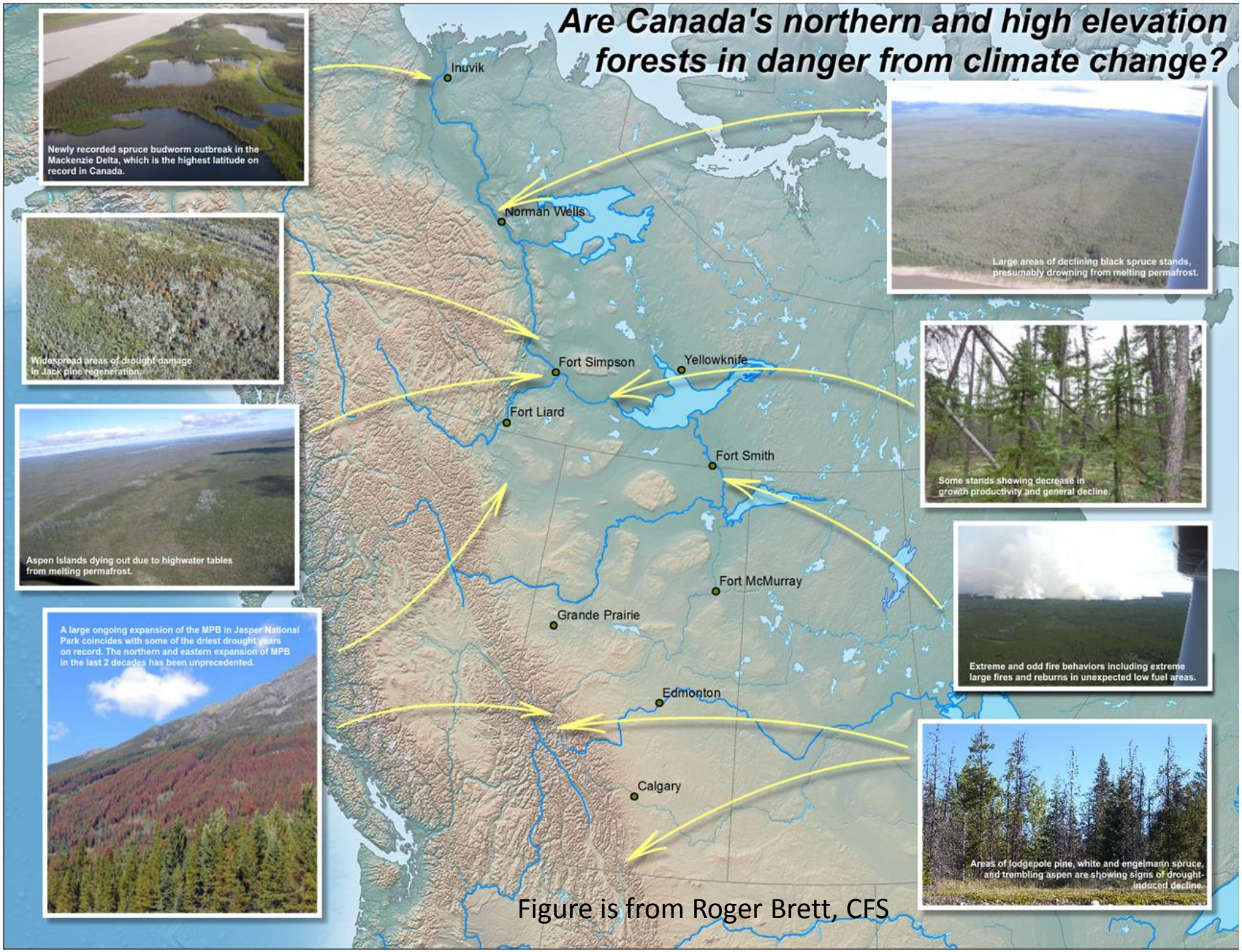


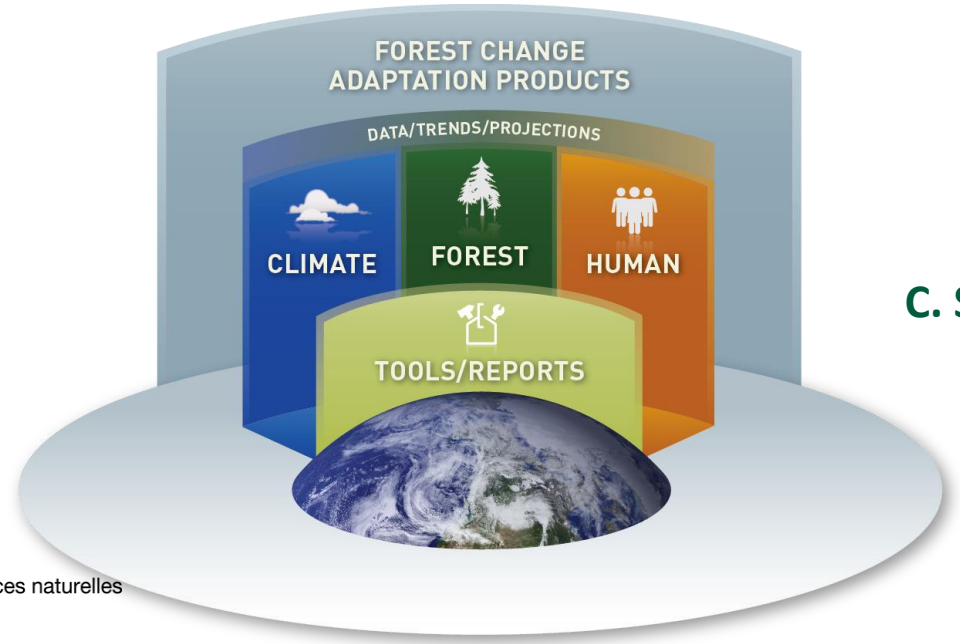
Figure is from Roger Brett, CFS

26

Forest Change

Building on existing capacity, knowledge and expertise…

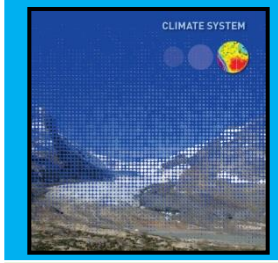
1. **A Tracking System** that reports on indicators of climate change impacts to identify forest sector vulnerabilities
2. **An Adaptation Toolkit** of actionable science for sustainable forest management under a changing climate
3. **Integrated Assessment** of climate change implications for the forest sector to guide policies and investment



C. Ste-Marie et al., CFS

27

Tracking system - The Indicators

System	Dimension	Indicator
Climate 	Drought	• **Climate Moisture Index (CMI)** • **Palmer Drought Severity Index (PDSI)** • **Soil Moisture Index (SMI)**
	Fire weather	• **Start+ End + Length of Fire Season**
	Growth conditions	• **Length of Growing Season**
Forest 	Tree species distribution	• **Distribution of Tree Species**
	Fire regime	• **Annual Area Burned** • **Number of Large Fires**
	Tree mortality	• **Percent annual loss of living tree biomass**
	Pest Incidence	• **Pest Species Distribution**
	Forest Growth	• **Radial Growth Trends**
	Phenology	• **Timing of Budburst**
Human 	Cost of Fire Protection	• **Wildfire suppression Resource Expenditures**
	Wildfire evacuations	• **Number of evacuations & evacuees** • **Evacuations location** • **Number of home losses**
	Wildland Urban Interface	• **Population at risk of forest fire**
	Transportation	• **Freeze-thaw of winter roads**

Reported data for each indicator

- Past trends
- Baseline
- Future projections:
  - 3 GHG emissions scenarios
    - RCP 2.6 (rapid emissions reductions)
    - RCP 4.5 (moderate emissions reductions)
    - RCP 8.5 (continued emissions increases)
  - 3 time periods
    - short-term (2011-2040)
    - medium-term (2041-2070)
    - long-term (2071-2100)

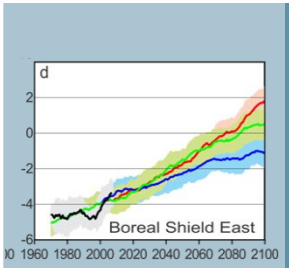
Vulnerability of Tree Species to Climate Change

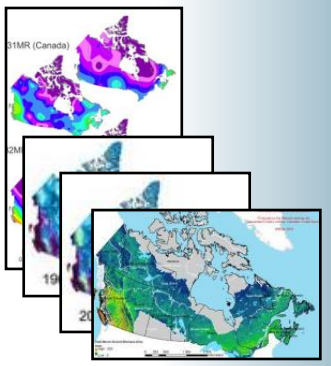
CLIMATE SCENARIOS
D. McKenney & team

CLIMATE MOISTURE INDEX
T. Hogg & team

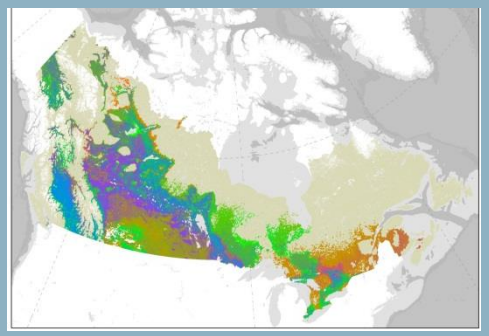
STAND COMPOSITION
A. Beaudoin & team

SPECIES TRAITS
I. Aubin & team





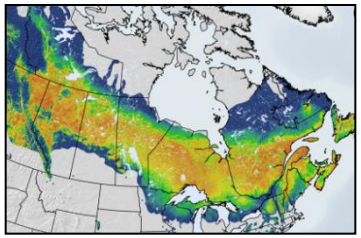
INTEGRATED INFORMATION PRODUCTS
I. Aubin & collab.

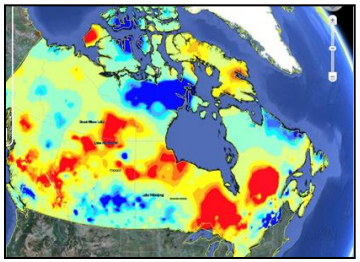


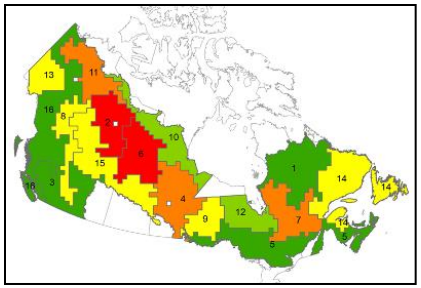
Sensitivity to drought of at-risk wood volume
2071-2100

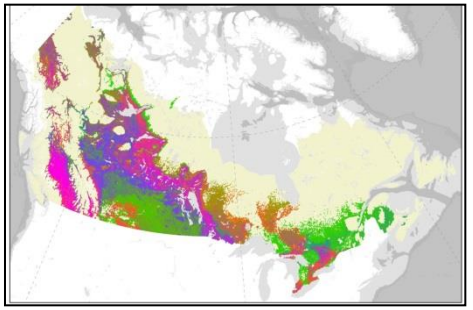
Potential Uses
- Multifaceted vulnerability assessment
- Integrating ecological knowledge with biophysical projections
- Creating value-added products from existing datasets

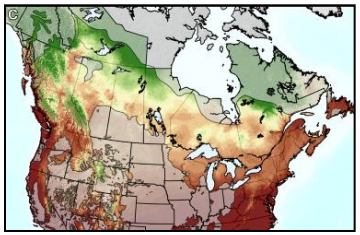
Integration of impacts

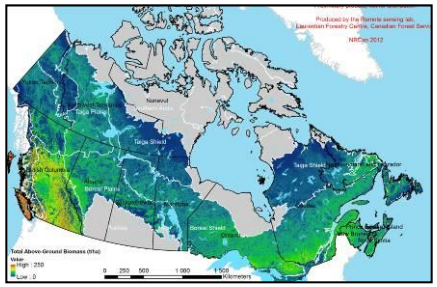


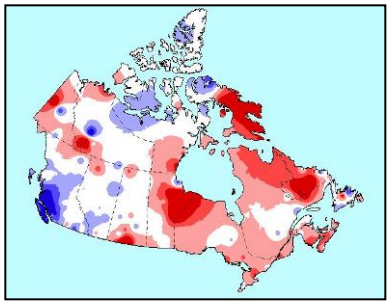


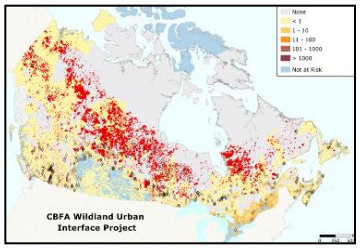


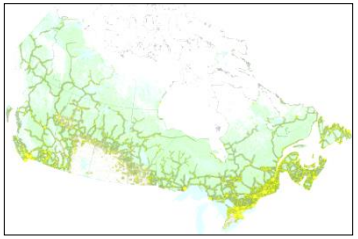


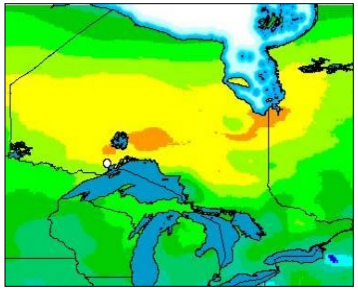


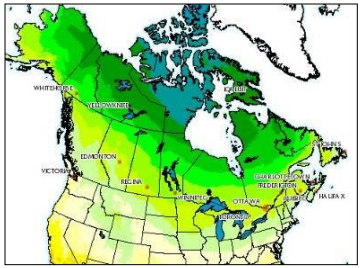


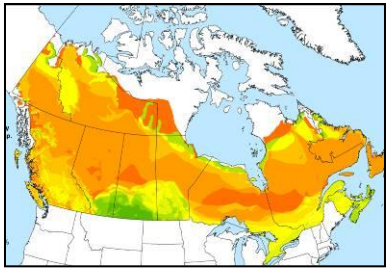


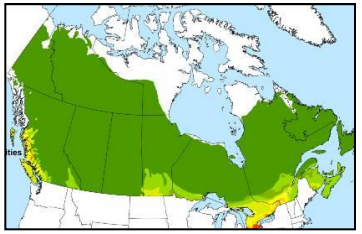






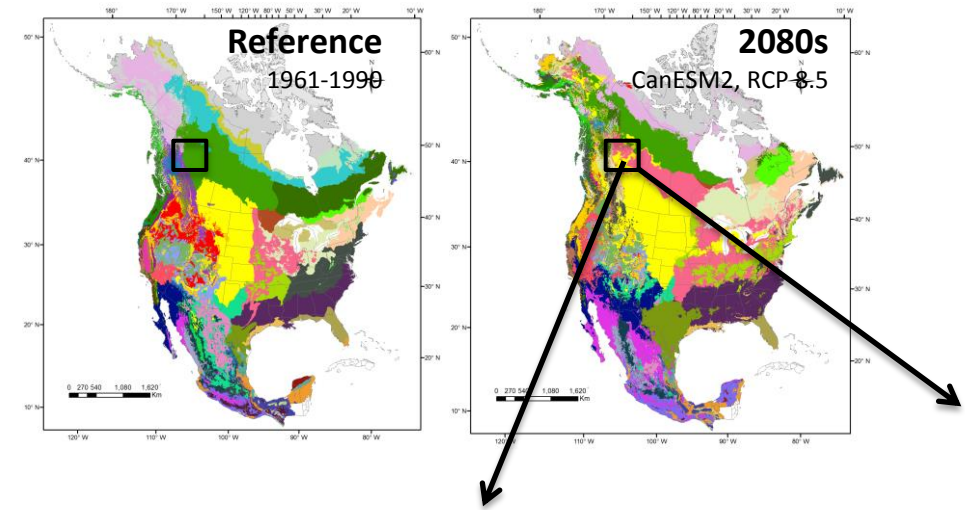


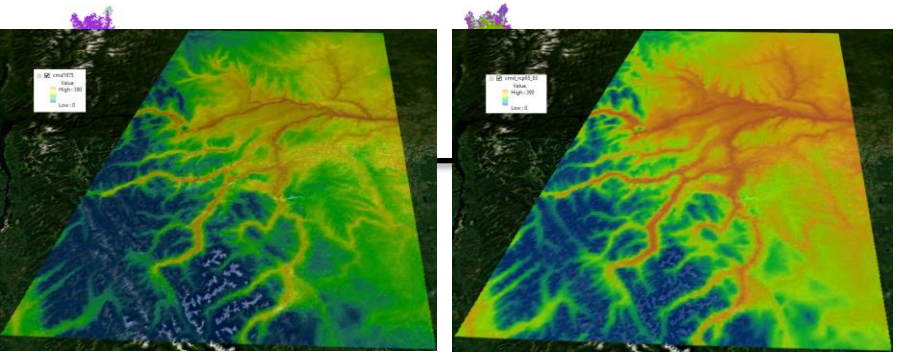


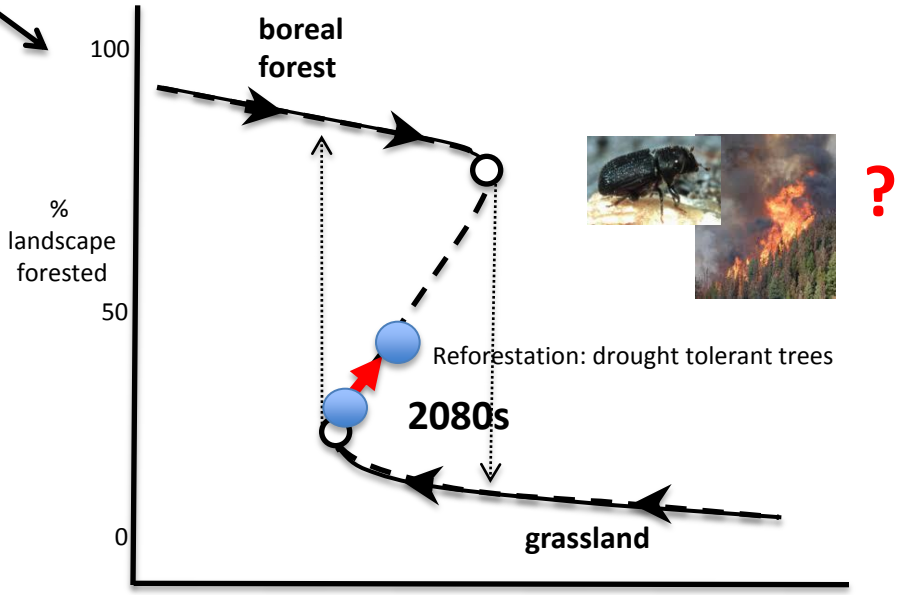


Forecasting changes in ecosystem structure/function (E. Campbell)

Climate niche models (ecoplot data/maps)



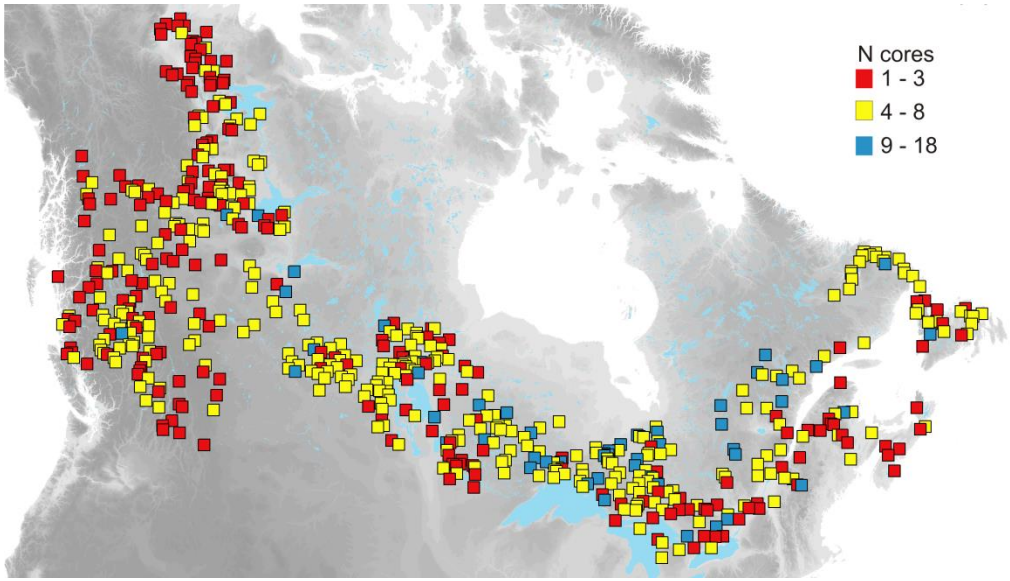




National tree-ring database to inform projections of Canada's present and future forest growth (Girardin, Metsaranta, Hogg, Bhatti, Kurz et al)

Sampling of 749 NFI plots

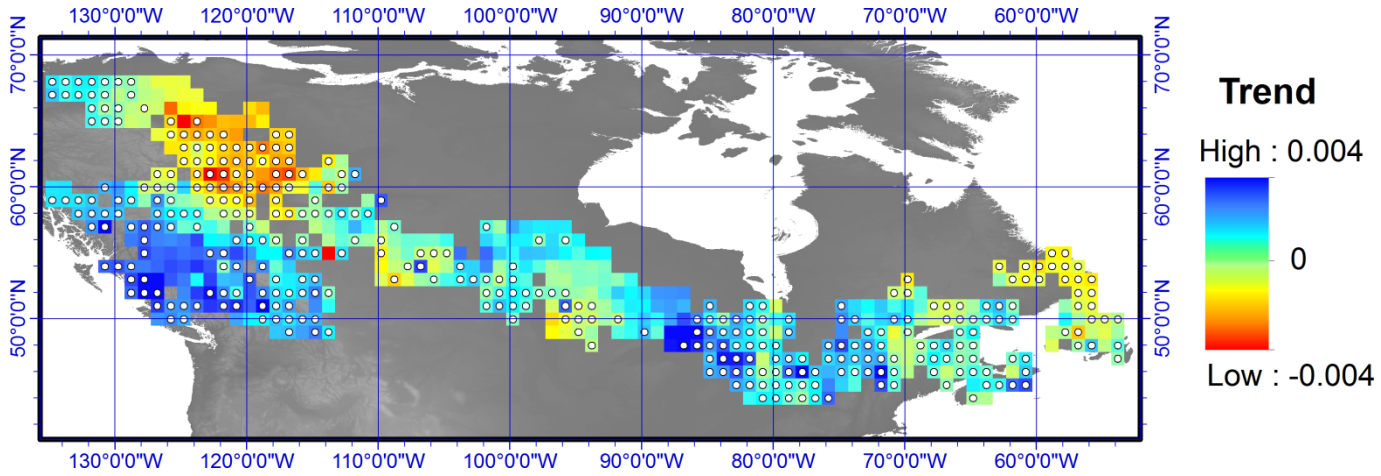
- 4,395 core samples collected from 58 tree species
  - Black spruce (31%)
  - White spruce (8%)
  - Trembing aspen (8%)
  - Jack pine (6%)
  - Balsam fir (6%)



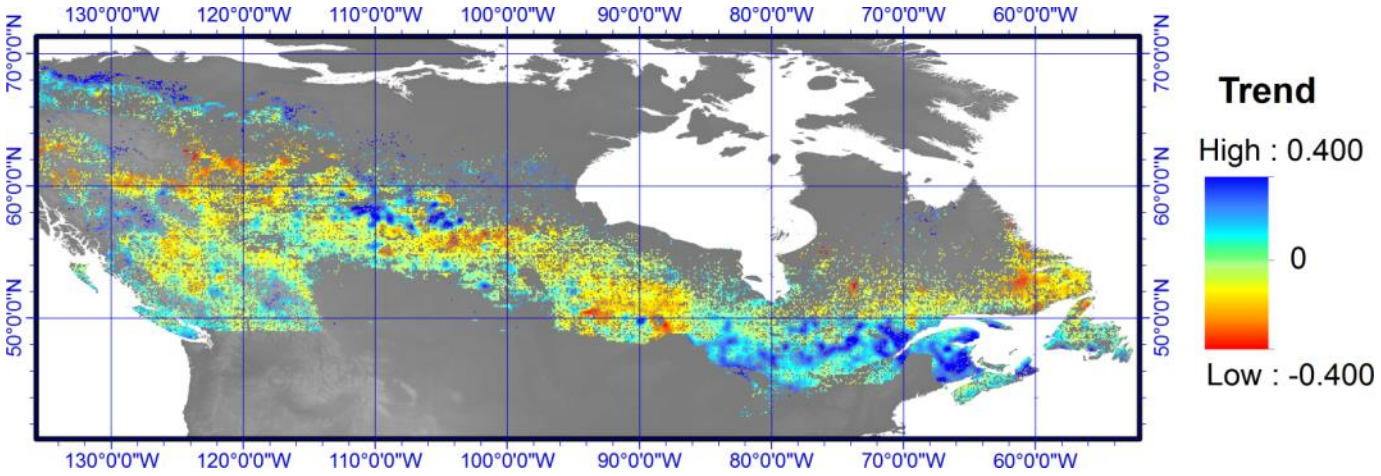
- >2,800 samples accurately crossdated

Linear growth and NDVI trends 1982-2002

NFI Tree Rings 1982 to 2002



NDVI 1982 to 2002



White-dots on top map indicate agreement in direction of trends

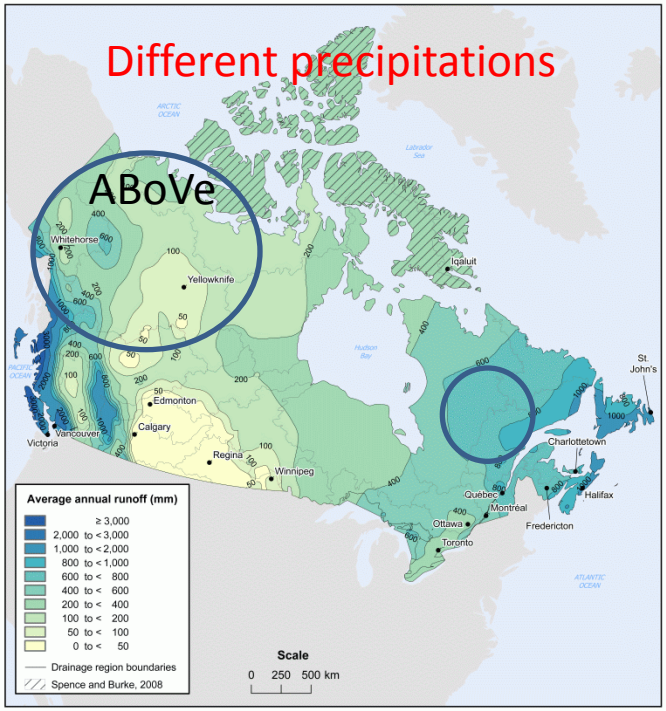
David Paré, CFS- Quebec City, david.pare@canada.ca

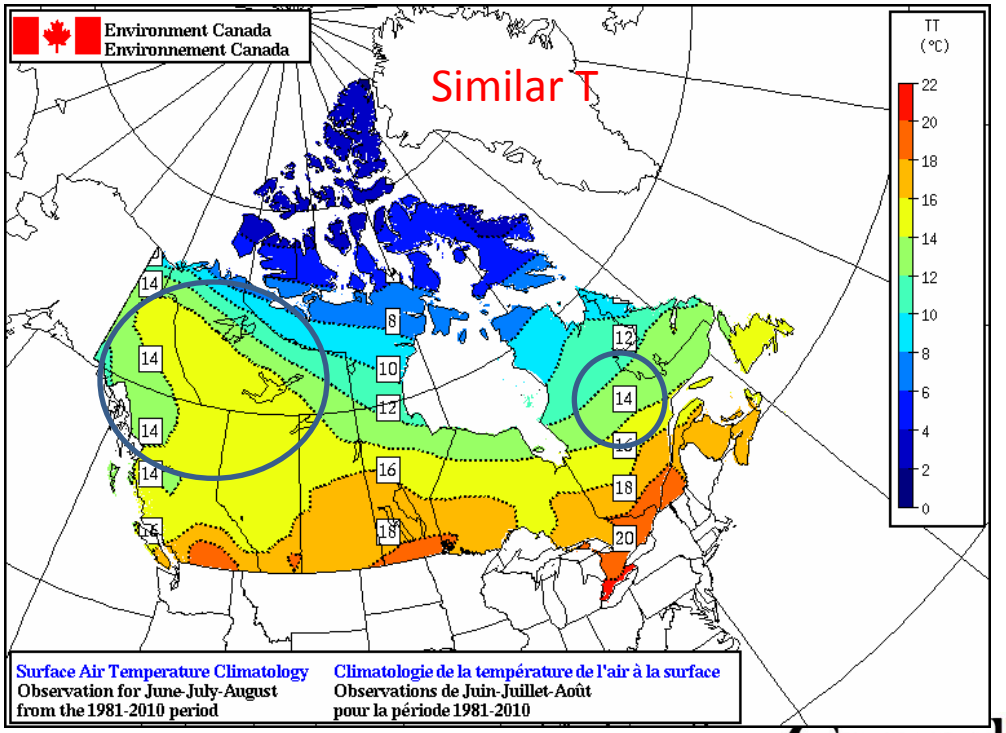
Ongoing projects: Soil carbon stocks, dynamics and properties as influence by climate, fire frequency and forest composition at the closed-open canopy forest transition in Eastern Canada;

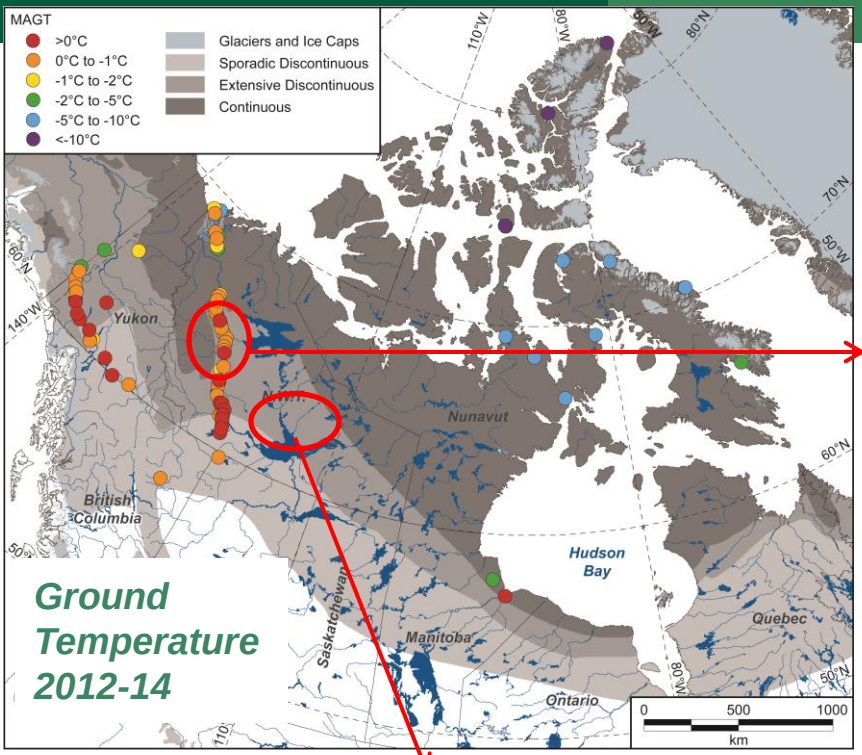
Potential linkages with ABoVe: Stretching the gradient of environmental conditions in the study of impacts of climate and fire regime on soil C

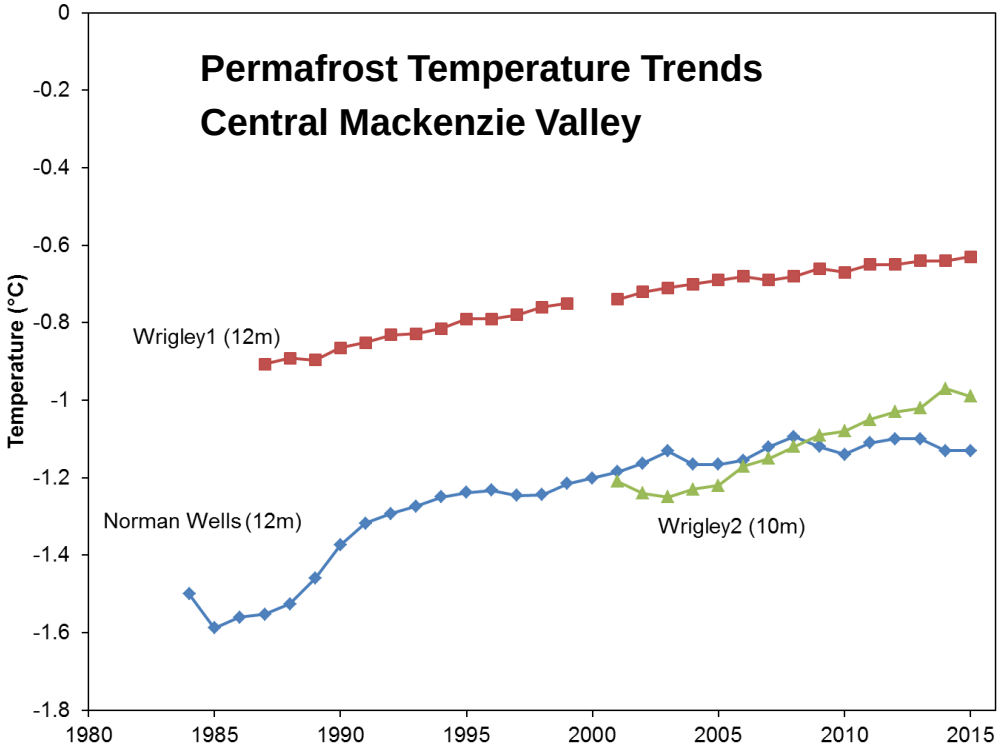
Contrasting Precipitation: (runoff ABoVE) 100-200mm vs (East) 400-1000; snow

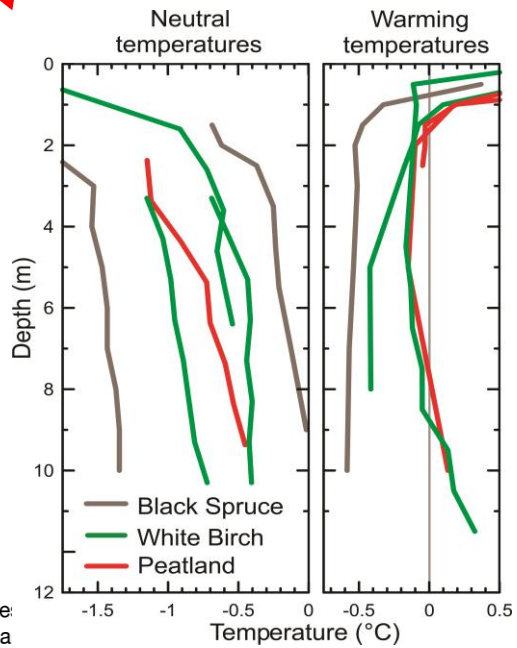
Similar: temperature regime; plant composition











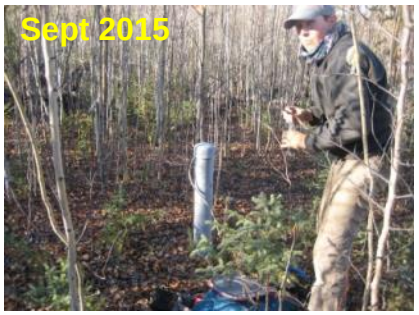
Characterization of ground thermal conditions to:

- Improve assessment of response of permafrost terrain to:
  - *changing climate*
  - *environmental disturbance*
- Support adaptation planning

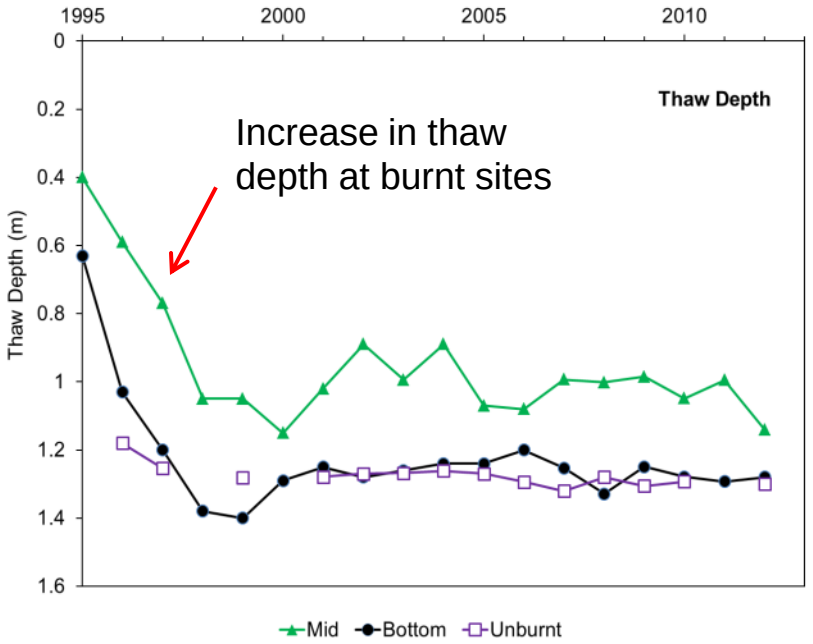
Sharon Smith, GSC, NRCan

Canada

Long-term effect of fire and vegetation recovery on permafrost environments

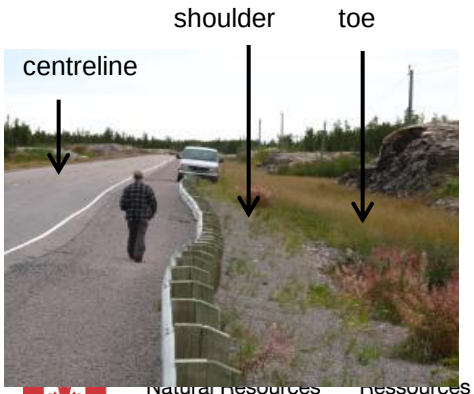


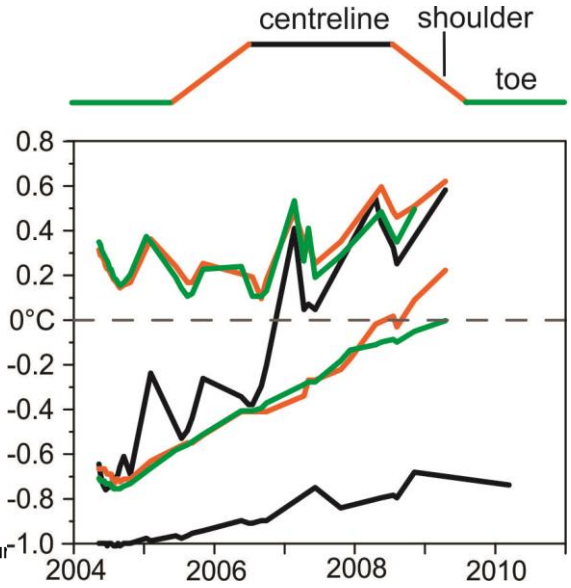
Warm permafrost slope – Central Mackenzie



Impact of highway construction on ground temperature

Ground temperature beneath Hwy 3 near Yellowknife

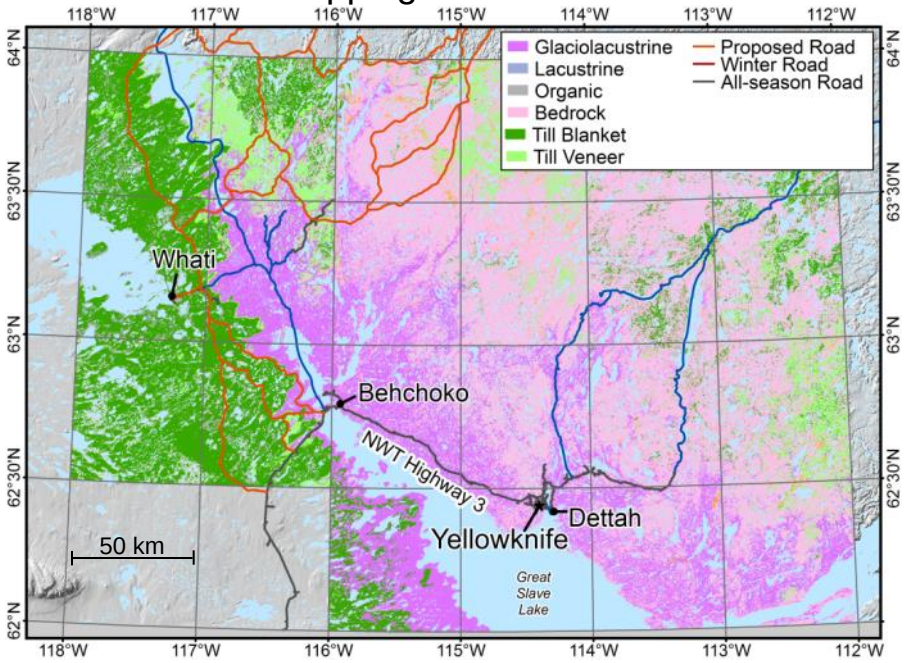




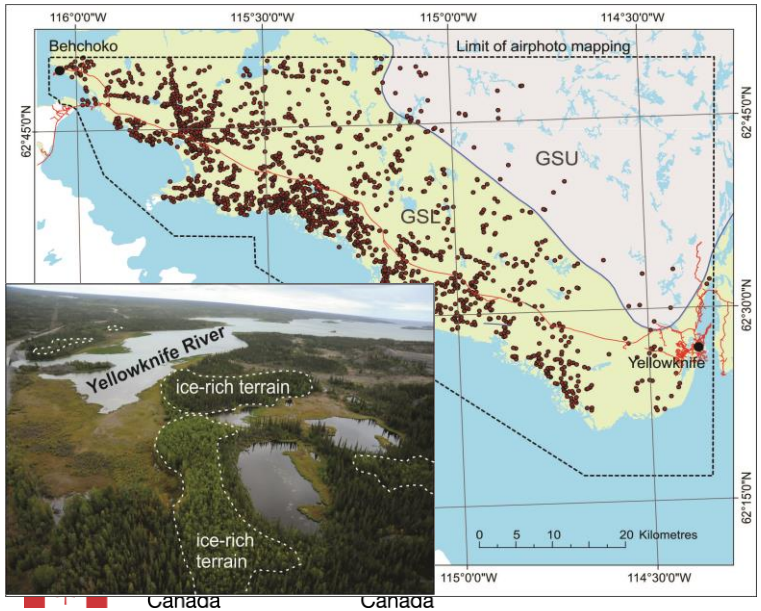
Investigations to assess response of permafrost to environmental disturbance such as vegetation clearing, forest fires and infrastructure development

Sharon Smith, GSC, NRCan

Surficial mapping – subarctic NWT



Ice-rich terrain in the Great Slave Lowland and Upland

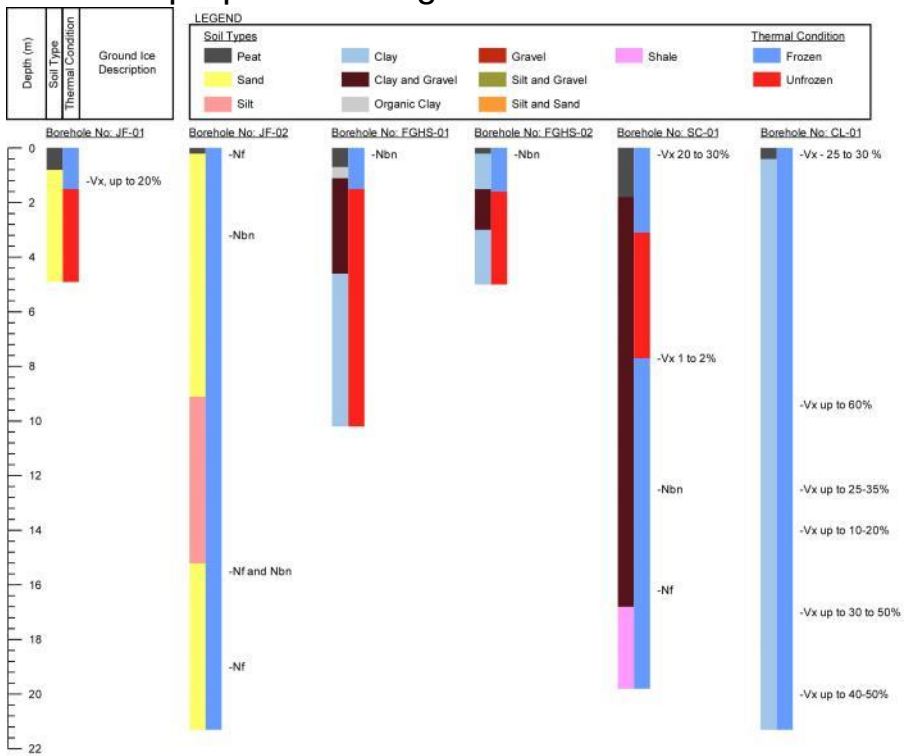


Characterization of surficial materials in major corridors

- Surficial geology mapping
- Identification of ice-rich terrain
- Geotechnical information
- Supports terrain sensitivity assessments

Sharon Smith, GSC, NRCan

Borehole logs northern Sahtu (Mackenzie Valley)
Material properties and ground ice content



Needs

Data! The boreal is vast, complex, and, in great parts, remote from populated areas.

There are several information gaps, especially in the unmanaged forest:

Weather information, Soil properties,
Ground temperatures, Sp. Distribution…

Opportunity to improve efficiency via complementarity of efforts and improved coordination between data collection activities

Needs

Tracking and understanding

- Direct impacts of climate change on
  Regeneration, Phenology - synchrony with pests, Sp. Distribution, Productivity & Mortality…
- Disturbances: Interaction between disturbance, environmental drivers of disturbance, changes in disturbance regimes…

Integrating biophysical and socio-economics

- …