Vegetation Dynamics Working Group updates, boreal version

Brendan Rogers (presenter)

Contributors: Melissa Boyd, Laura Bourgeau-Chavez, Laura Chasmer, Jan Eitel, Nikki Fiore / Mike Goulden, Adrianna Foster, Richard Massey, Christopher Potter, Jon Wang / Curtis Woodcock

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26 projects primary
16 projects secondary
81 members

ABOVE
ARCTIC-BOREAL VULNERABILITY EXPERIMENT

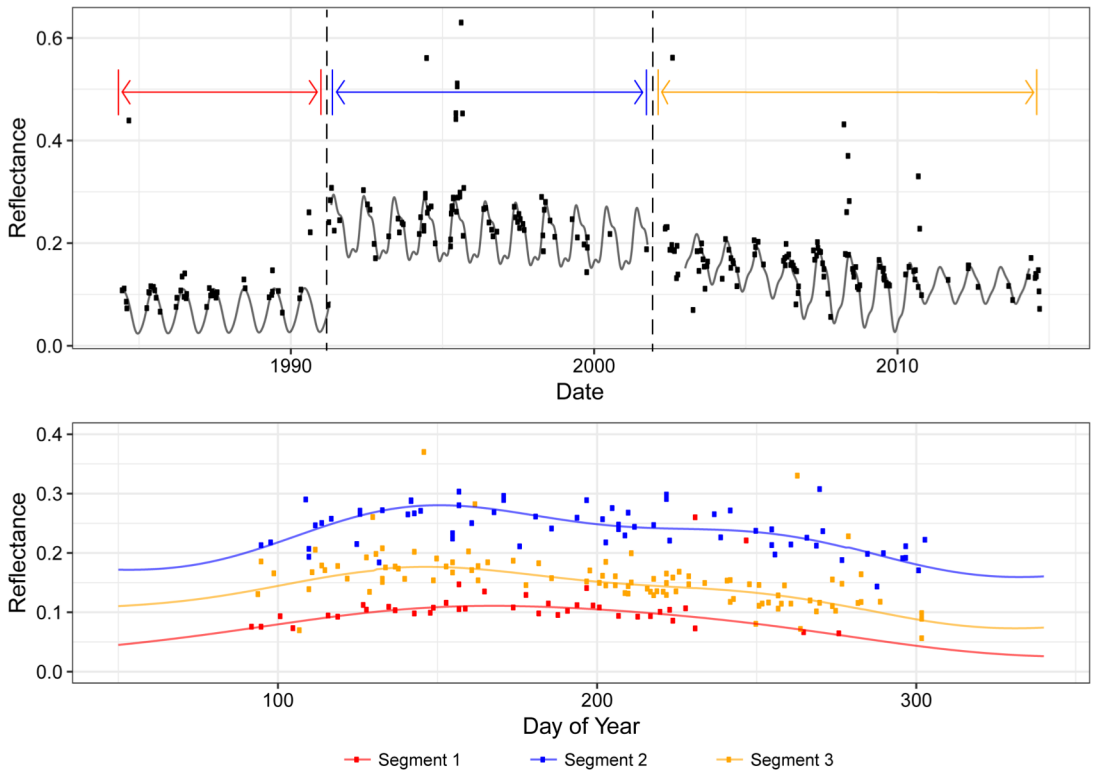
Emergent themes

- ~30m mapping of disturbance, greenness and its trends, biomass, and land cover
- Post-disturbance recovery
- How greening / browning trends are related to wildfires, pests, climate, and forest demographics
- Interactions between changing vegetation, permafrost, and hydrology
- Linking forest structure to function
- Ecosystem modeling to project dynamics

ABOVE
ARCTIC-BOREAL VULNERABILITY EXPERIMENT

Landscape-Scale Histories and Active Monitoring of Disturbance, Seasonality and Greenness Trends for ABoVE from Landsat

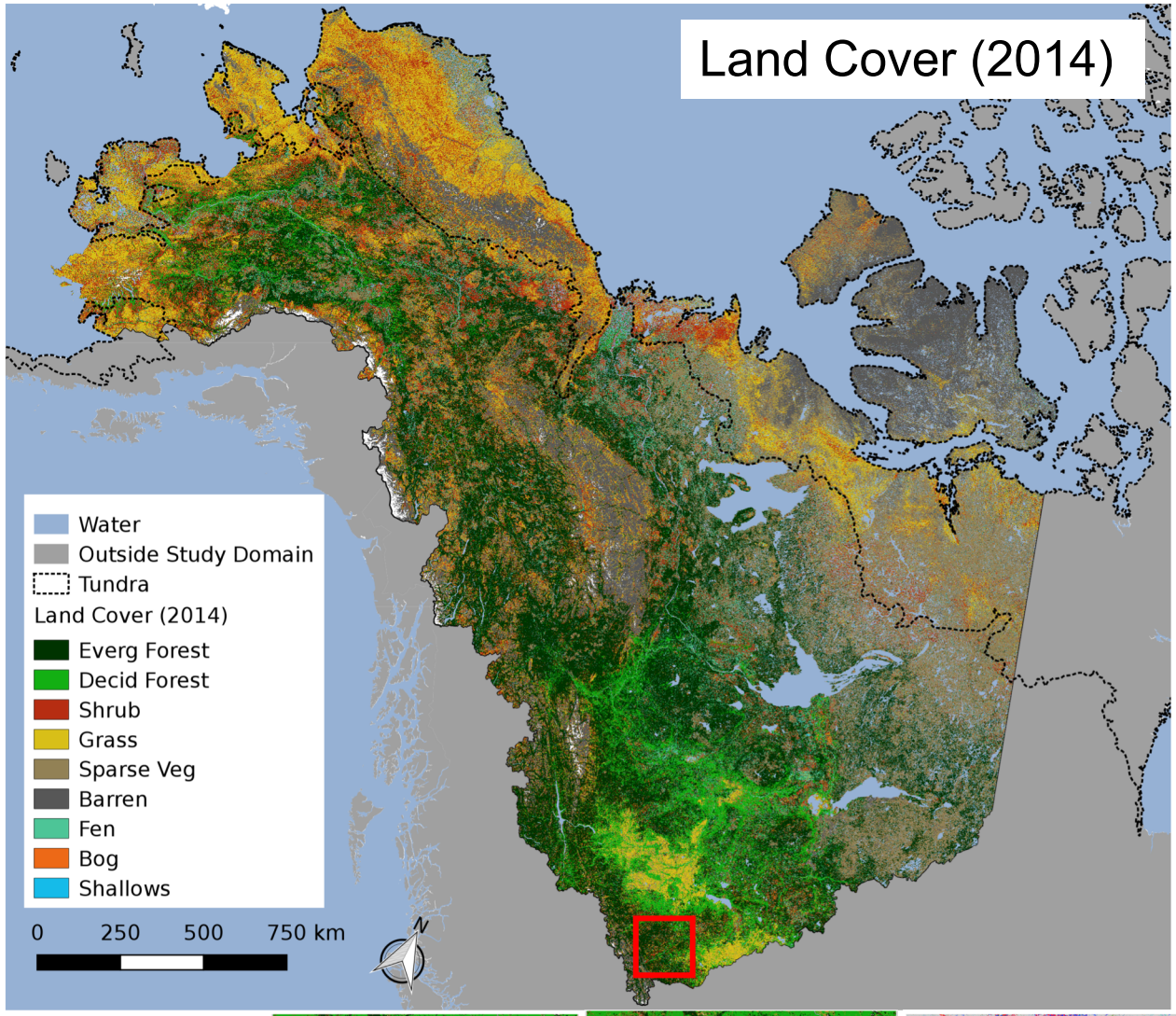
Curtis Woodcock, Mark Friedl, Damien Sulla-Menashe, Jonathan Wang, Oliver Sonnentag, Eli Melaas, Yingtong Zhang, Yetianjian Wang, Shijuan Chen
Boston University, Dept. of Earth and Environment and Université de Montréal, Dept. de Géographie

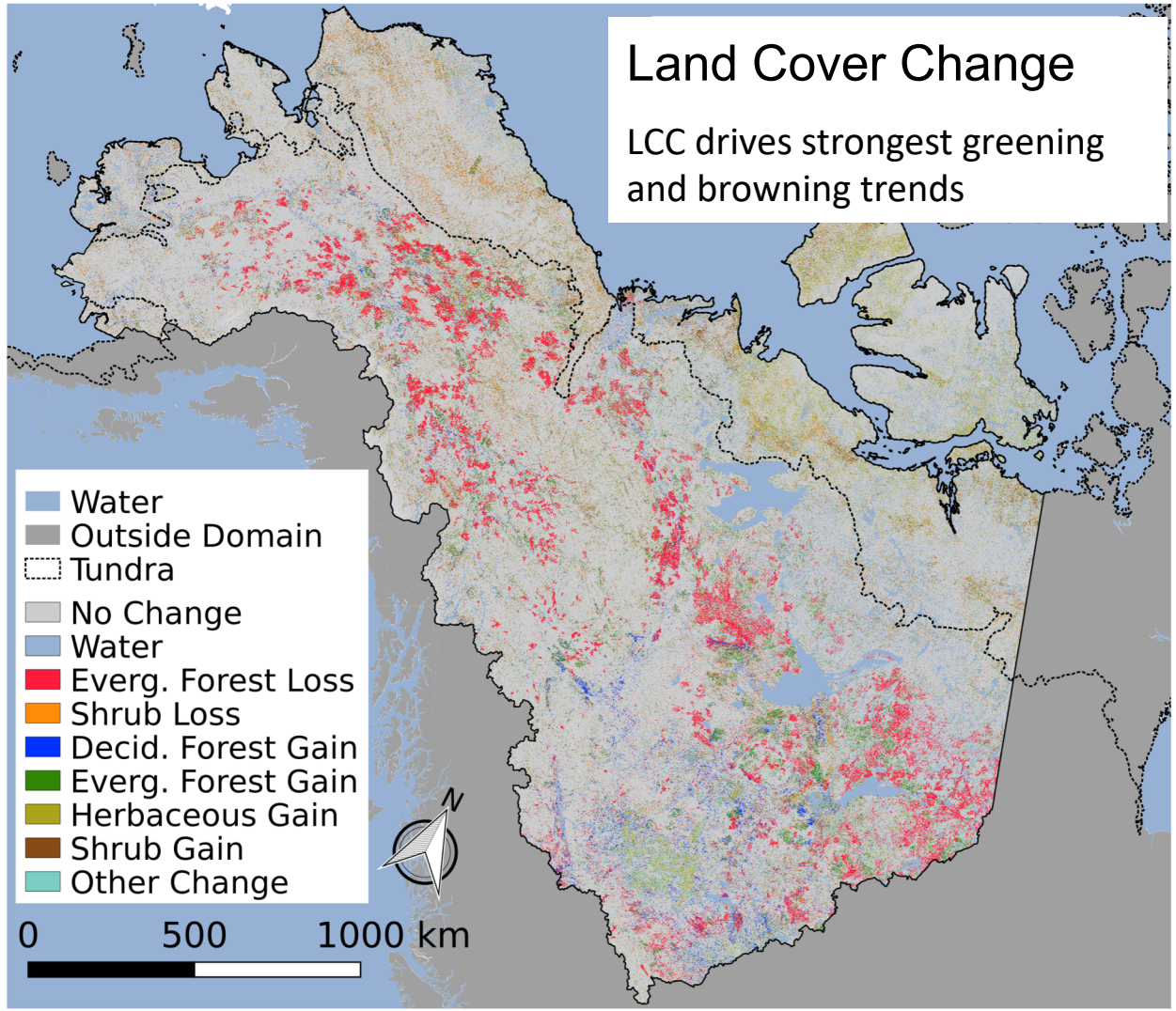


Time series analysis performed at every Landsat pixel in ABoVE Core Domain using the Continuous Change Detection and Classification (CCDC) algorithm

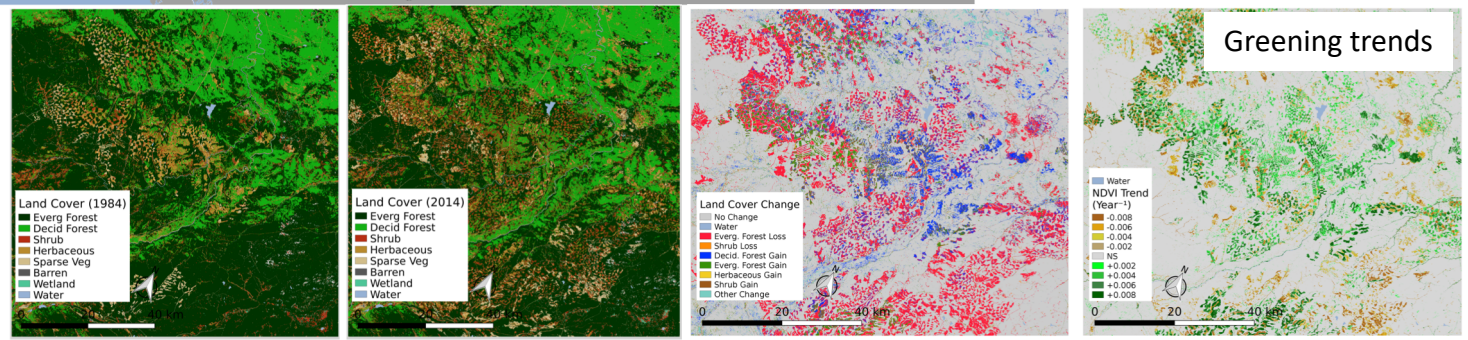
All products depend on disturbance detection from CCDC

- All products are annual (1984-2014), 30 m resolution
- Disturbance Type
  - Timing and location of fires, insects, logging, other
  - Validation ongoing
- Phenology and Peak Greenness
  - Mean and interannual greenup and senescence dates
  - Summer growing season NDVI and NBR
  - Finished; Uploaded to the ORNL DAAC
- Land Cover
  - Arctic-boreal PFT areas and changes quantified
  - Land cover change drive largest greening/browning trends
  - Finished; Uploaded to the ORNL DAAC
- Above Ground Biomass
  - Quantify boreal forest changes from disturbance and regrowth
  - Ongoing, preliminary results

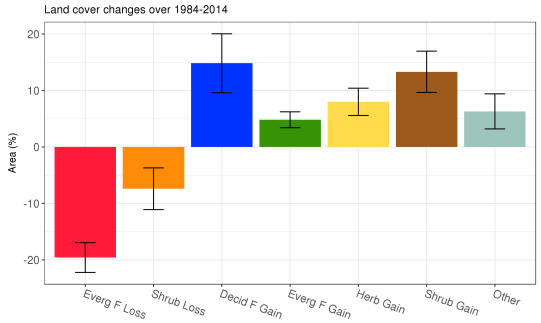




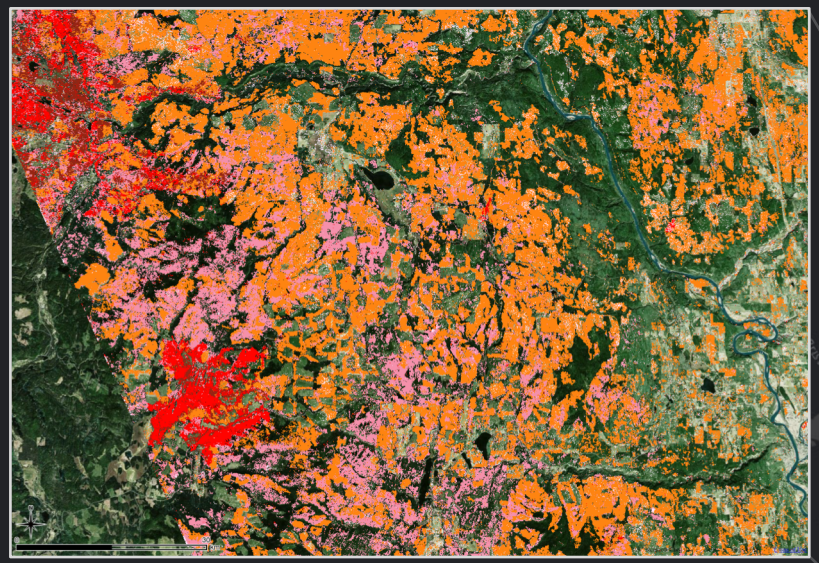
Harvest LC, LCC and greening trends example:

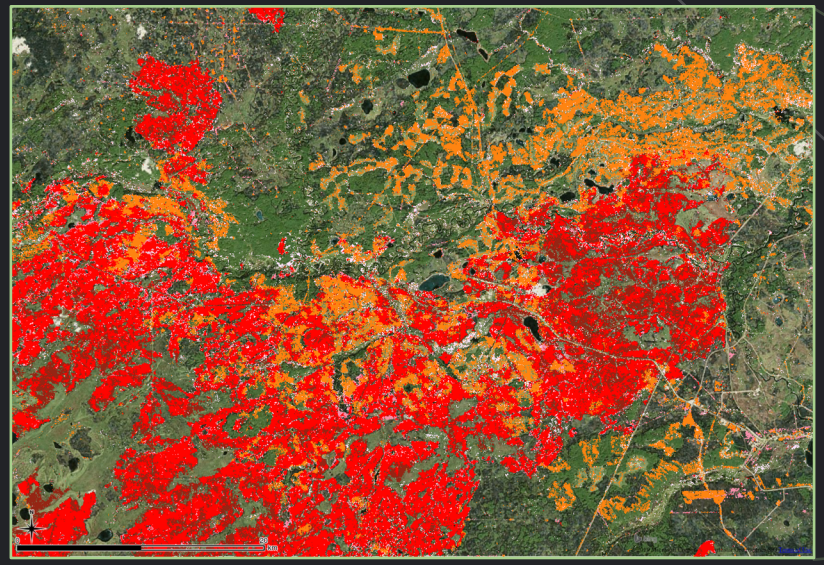


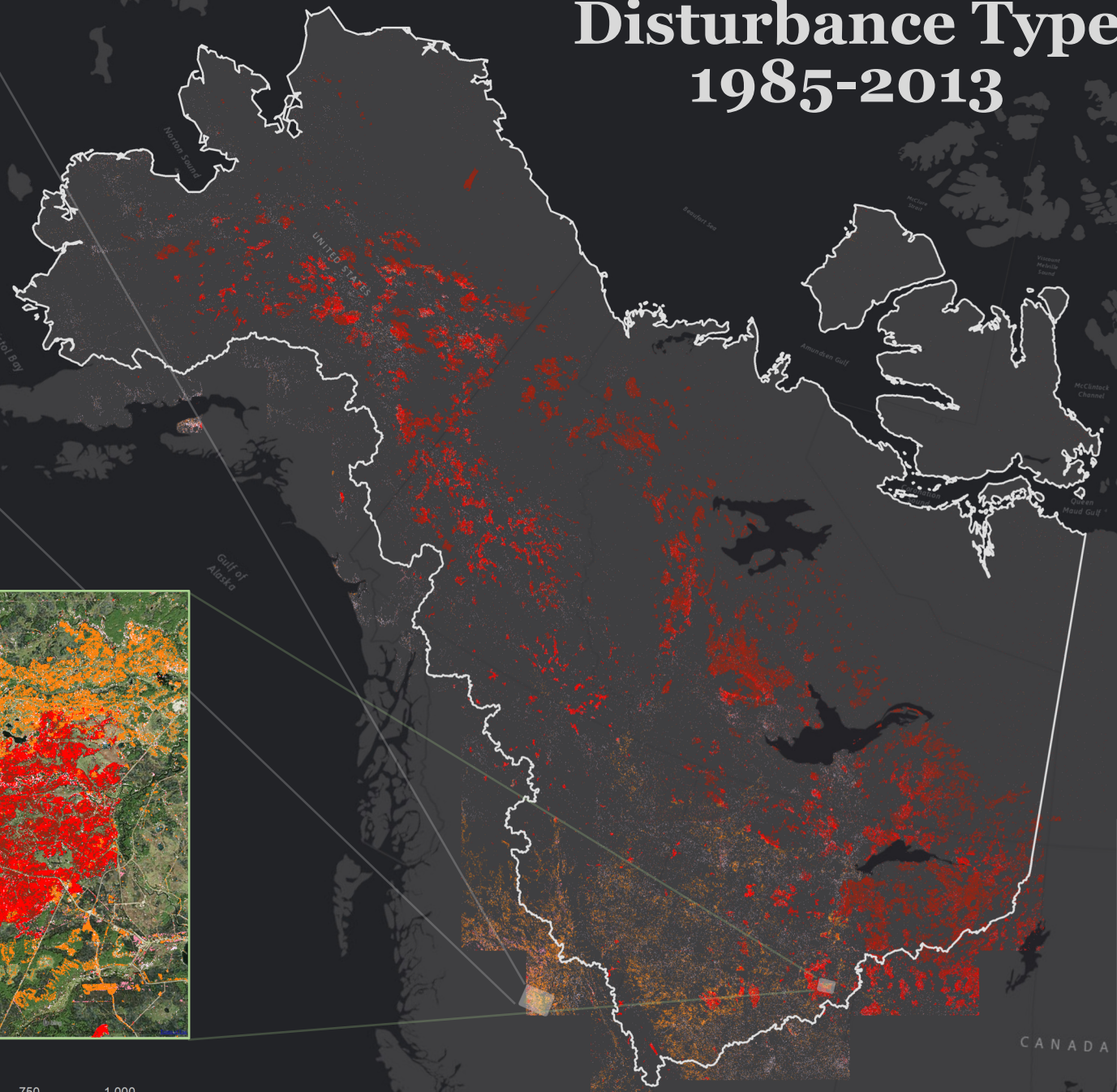
Domain-wide area of land cover change:



Disturbance Type 1985-2013







FN: Forest to Non-forest annual change

NN: Non-forest to Non-forest annual change

Legend

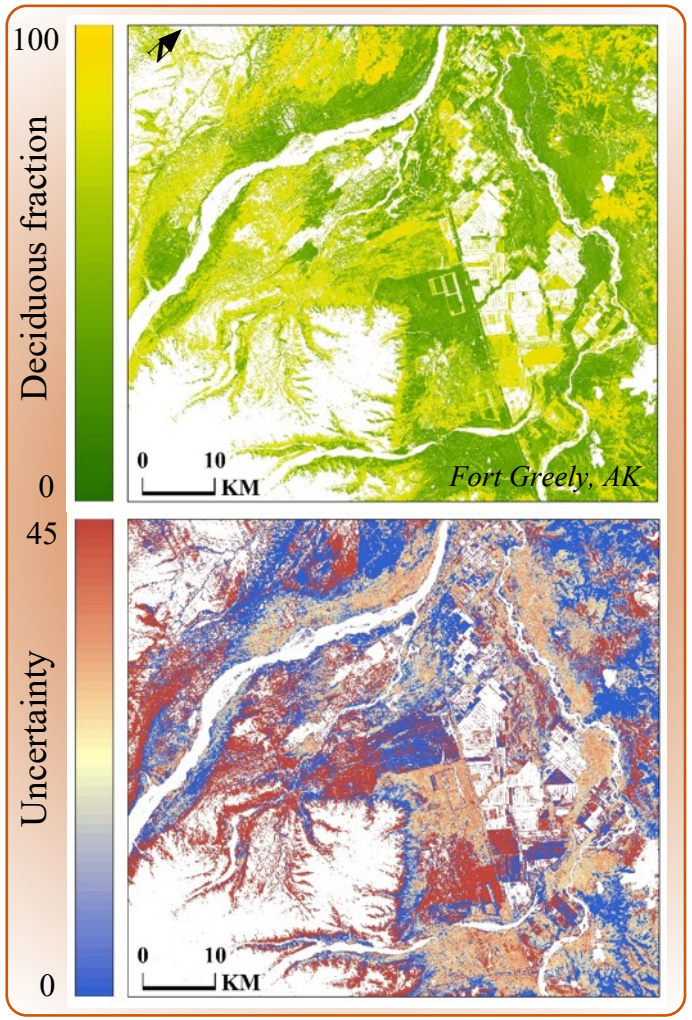
- ABoVE Core Domain
- FN fire
- FN insect
- FN logging
- FN other
- NN fire

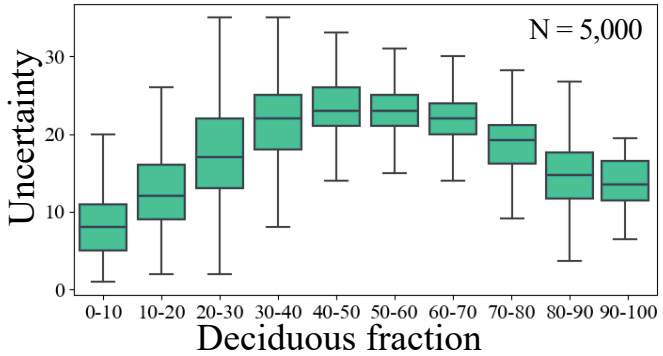
0 125 250 500 750 1,000 KM

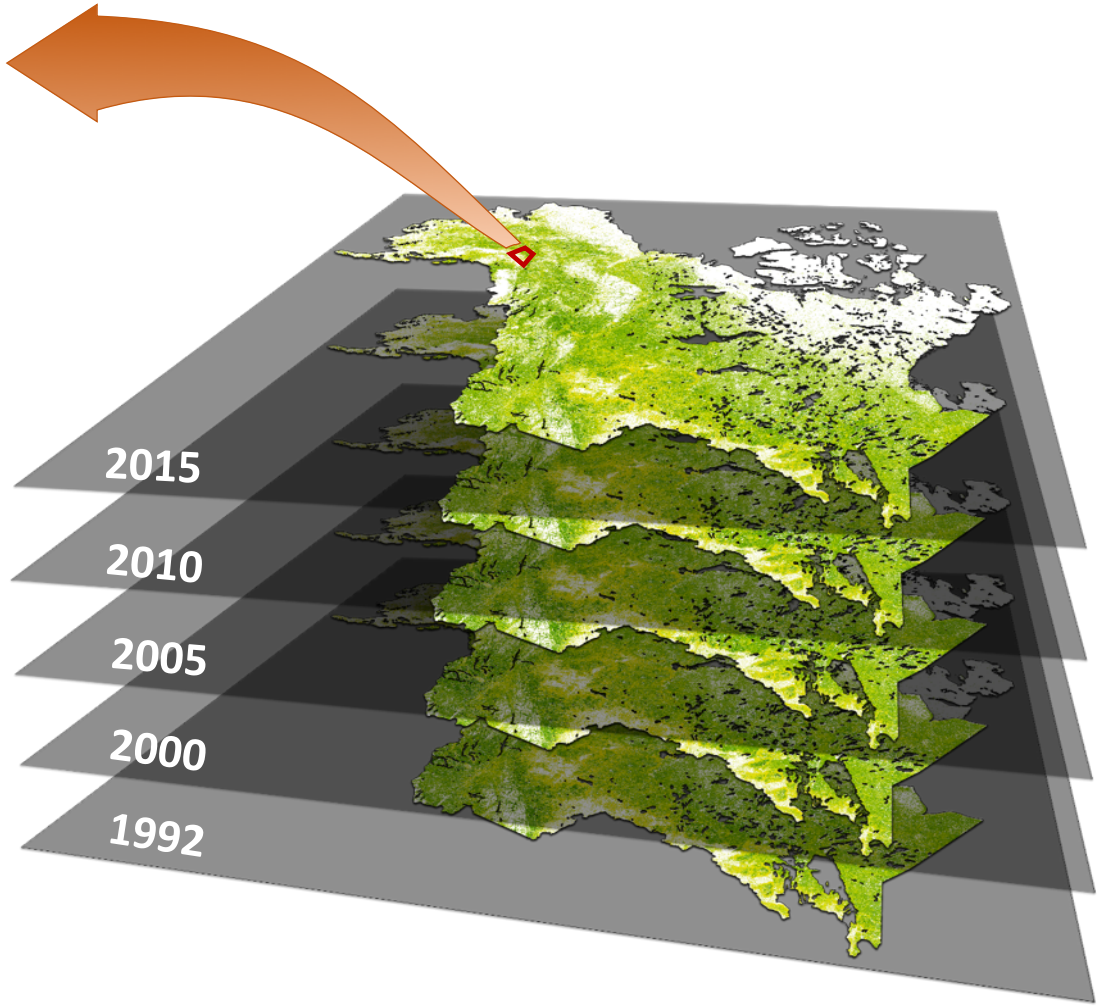
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

Deciduous Fraction Maps

Nominal 1992 - 2015







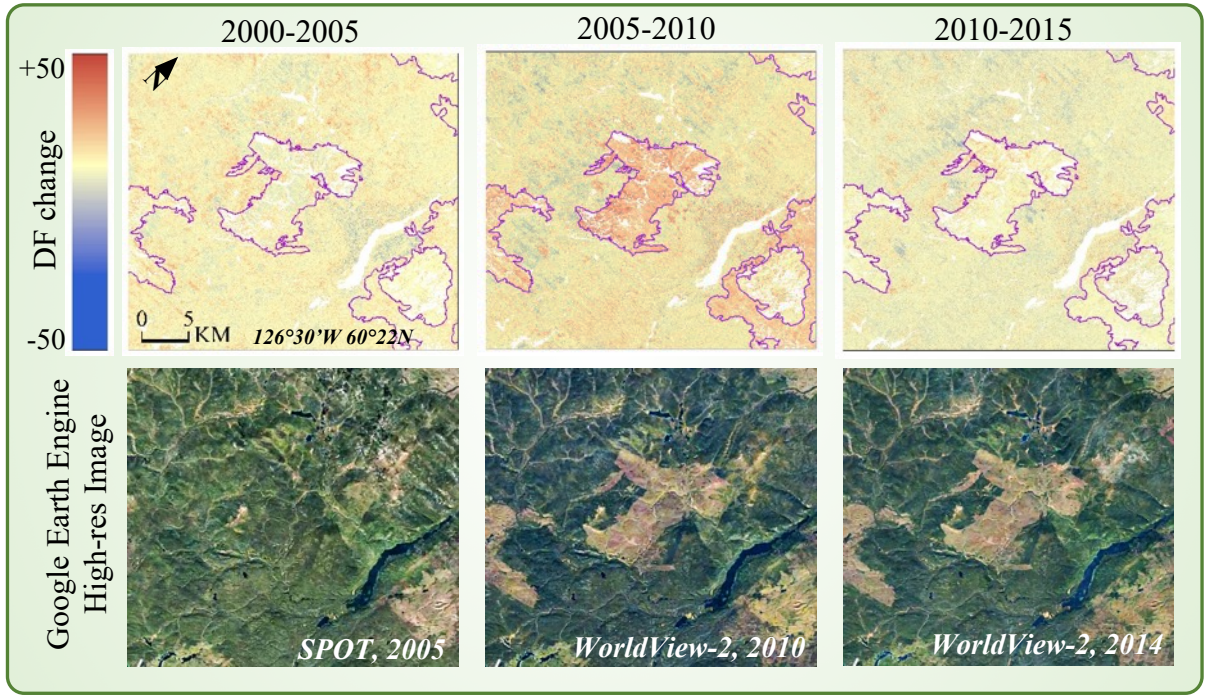
Massey et al (Forthcoming)
Goetz-01 and Rogers-02 projects

Change Maps

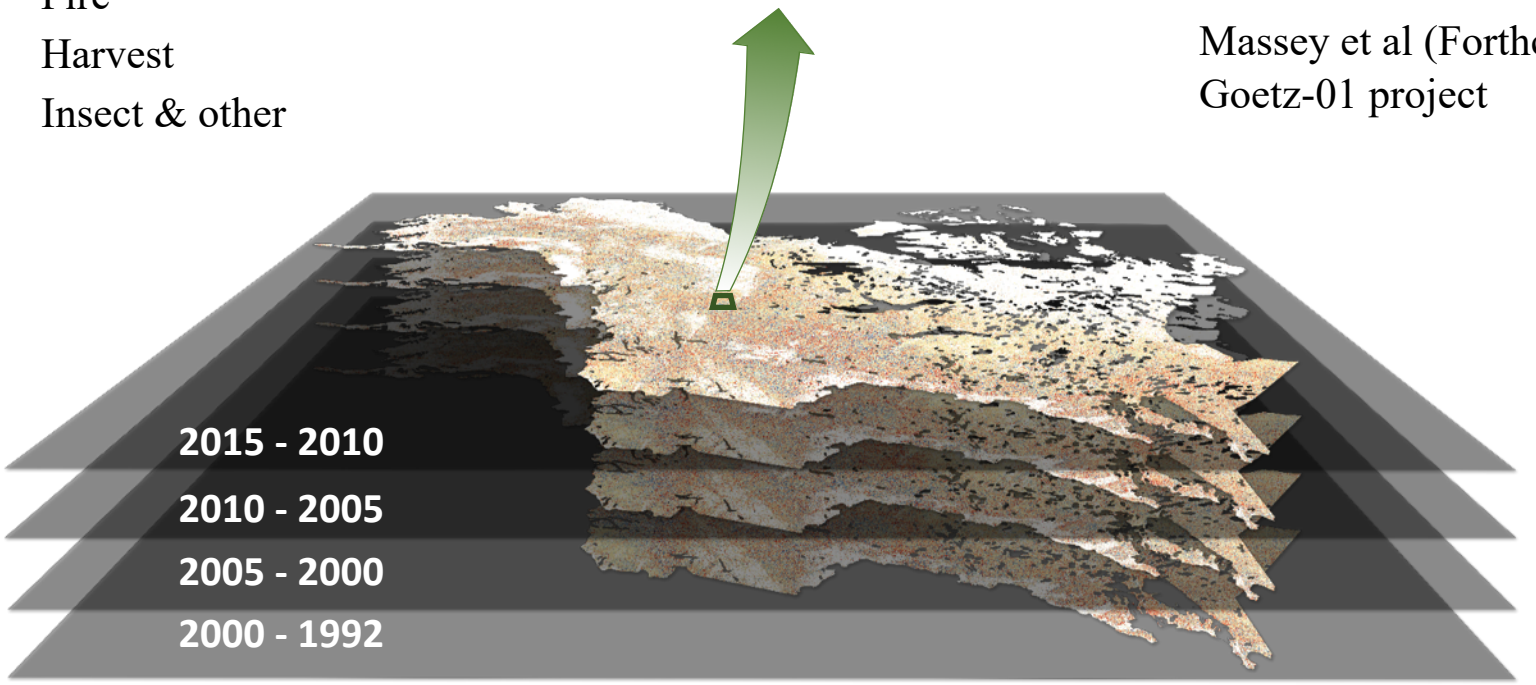
Deciduous fraction

- Change in per-pixel deciduous fraction due to forest disturbance

- Disturbance types:
  - Fire
  - Harvest
  - Insect & other



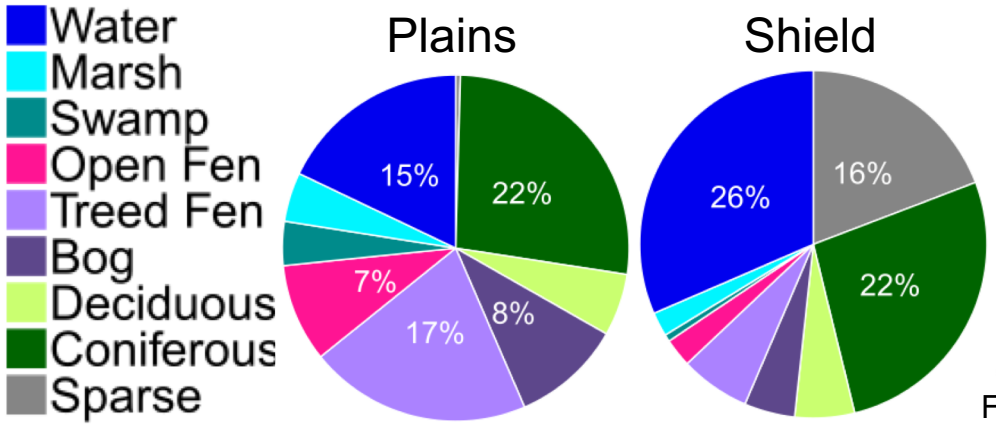
Massey et al (Forthcoming)
Goetz-01 project

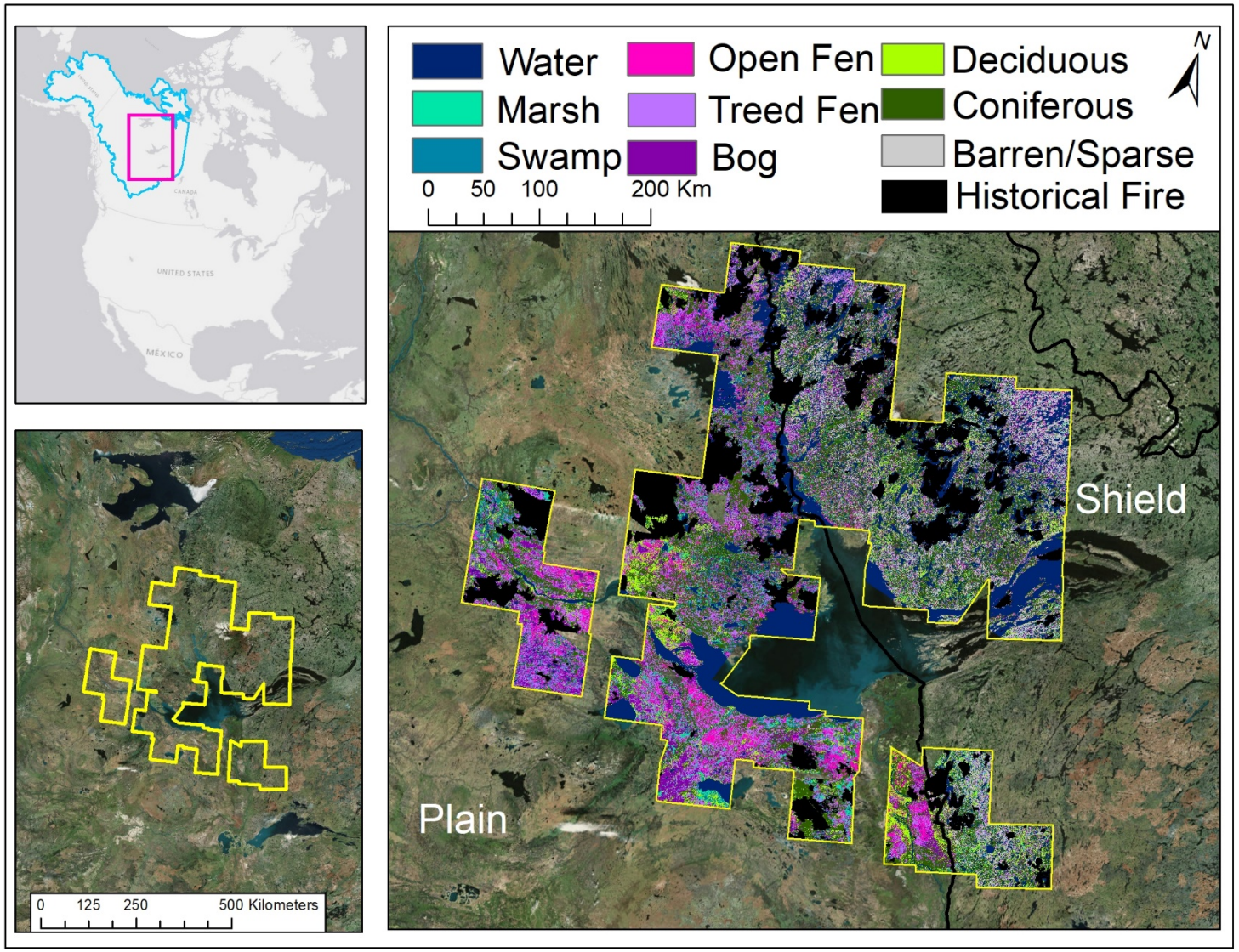


Northwest Territories Ecosystem Mapping

Bourgeau-Chavez TE-2014

- **Circa 2007 Peatland/Wetland/Upland Map**
  - 13,677,119 km^2 mapped
  - Region of 2014-15 wildfire affected areas around Great Slave Lake
- **Based on: Field data and Multi-season SAR and Landsat**
  - 9,943 training /2,149 validation polygons
  - 0.2 ha minimum mapping unit
  - All classes > 82% user accuracy, except swamp (73%)
  - Available on DAAC soon & Map extension under new project (*French TE-2018)*





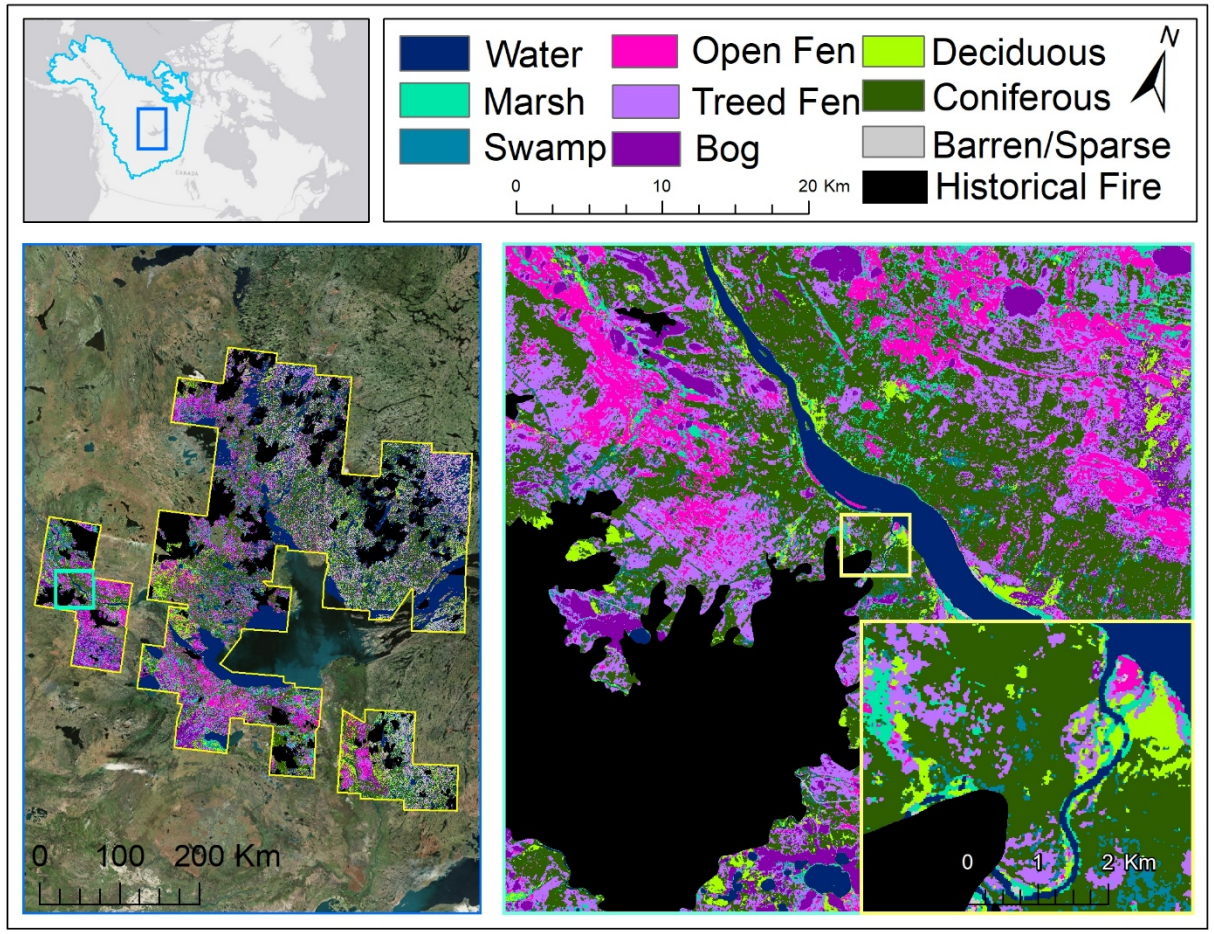
Fires pre-imagery are masked out (black), regenerating ecosystems need to be trained for classification

Northwest Territories Ecosystem Mapping

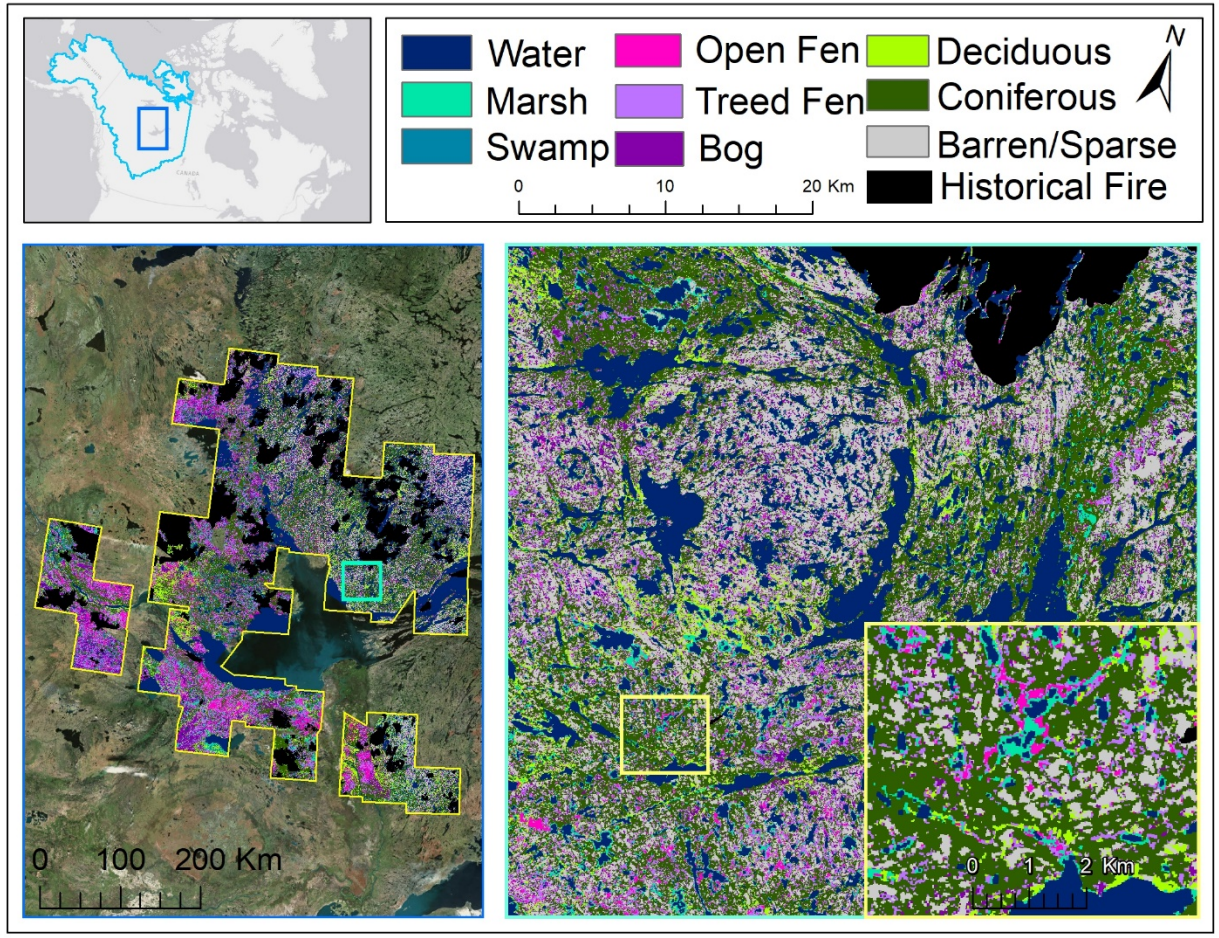
Bourgeau-Chavez TE-2014

Map Detail Examples

Plains

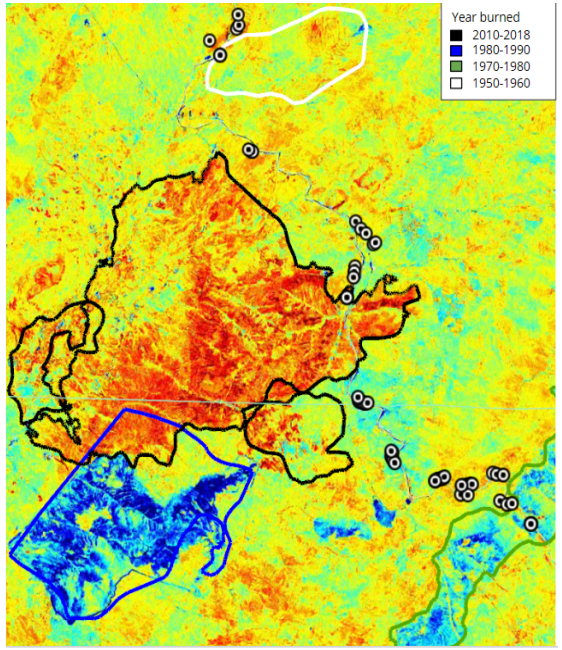


Shield



Poster 2-43: Composition and structure of browning and greening forests in interior Alaska

(Fiore, N.M., Goulden, M.L., Czimczik, et al)



Methods:

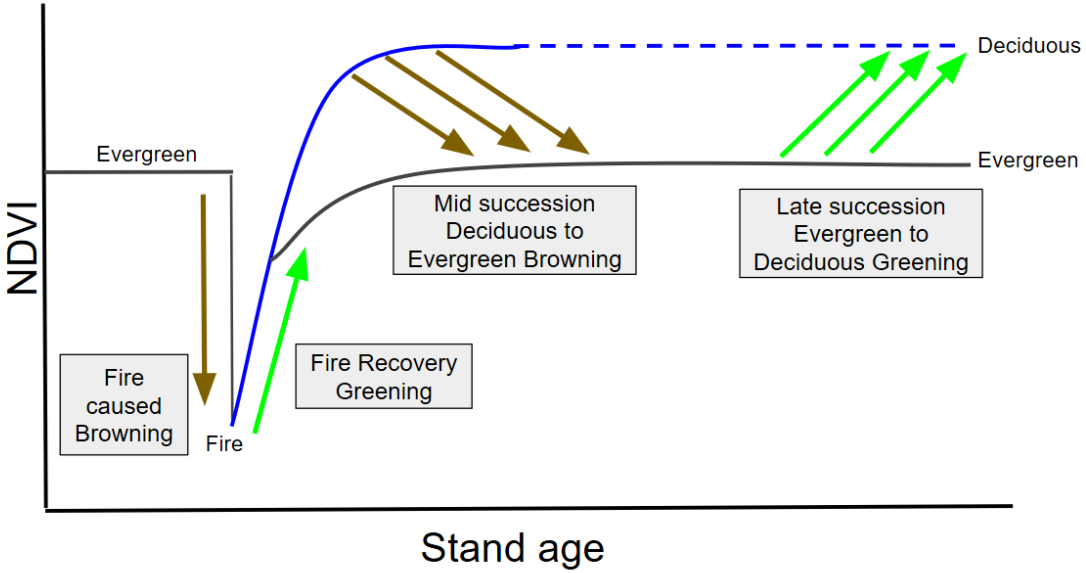
- Landsat NDVI time series (browning/greening) paired with forest surveys in interior Alaska
- Sites sample both burned & unburned areas showing either browning or greening

Results:

- Recent burns a large driver of NDVI trends (left image)
  - Burns after 2010= strong browning (black polygon)
  - Burns before 1990= strong greening (blue)
- Unburned areas show weaker NDVI trends (bottom)
  - Mid succession Deciduous to Evergreen= Browning
  - Late succession Evergreen to Deciduous= Greening

Conclusions:

- Browning and greening occur naturally with fire, recovery, and succession
- It does not necessarily reflect a large scale change in boreal ecology



Biospheric Science

Ames Research Center

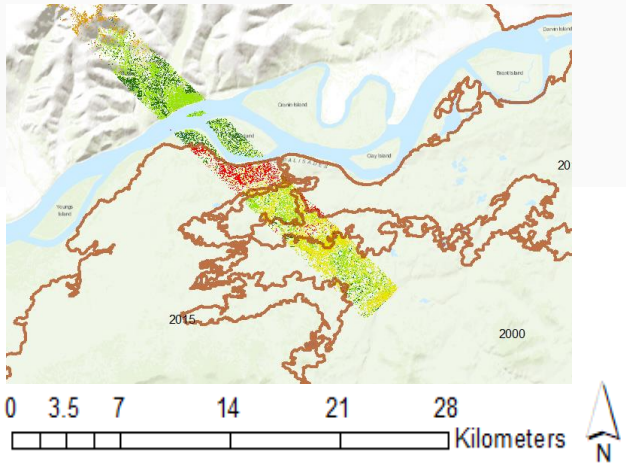
Recovery of Vegetation Cover in Burned Ecosystems of Interior Alaska Derived from a Combination of ABoVE-AVIRIS and Landsat Imagery

Author and Contact: Christopher Potter, NASA Ames Research Center, chris.potter@nasa.gov

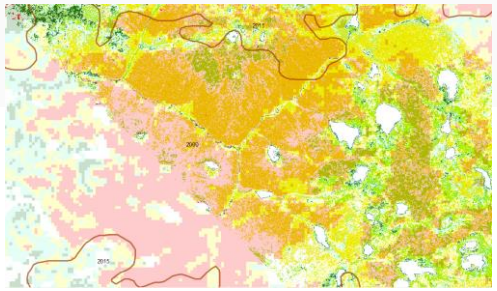
- **Background**: In the summer of 2015, hundreds of fires burned across the interior forests of Alaska, resulting in the second highest acreage burned for the state in a single year. To better understand how vegetation attributes and disturbances interact in the ABoVE study domain, surface reflectance measured by the AVIRIS-NG instrument (in flights between June and August of 2017 and 2018) were collected at approximately 5-meter resolution near the height of recent growing seasons. One AVIRIS flight line was collected over high burn severity (HBS) areas of the Blind River Fire of 2015 and the Bering Creek Fire of 2000 near the confluence of the Yukon River and Montana Creek, 60 km west of Tanana. The full hyperspectral reflectance image (425 bands at 5 nm intervals) was classified into seven cover classes using Spectral Angle Mapping (SAM) algorithms (Kruse et al., 1993). These classes were Evergreen forest, Deciduous Forests, Shrub, Herbaceous wetland, Barren, Open Water, and HBS. Endmember locations for the SAM classification were derived from Landsat land cover (NLCD, 2011) at 30-m resolution for these same (unburned) classes. Burn severity classes from the MTBS project (Eidenshink et al., 2007), derived from the relative difference normalized burn ratio (RdNBR) of Landsat NIR and SWIR bands, were overlaid to assess changes in vegetation cover from AVIRIS.

- **Results**: Within the HBS class areas of the Blind River Fire of 2015, the 2017 AVIRIS classification predicted a predominance of HBS and Barren cover, with sparse recovery of herbaceous vegetation in low burn severity (LBS) areas. Within the HBS class areas from 2000 burns, the 2017 AVIRIS classification predicted a predominance of herbaceous vegetation recovery and some deciduous tree cover, and sparse recovery of evergreen tree cover in LBS areas.

AVIRIS Vegetation Cover Classification and Burn Area Boundaries of the Blind River Fire of 2015 and the Bering Creek Fire of 2000



Details of HBS areas from the year 2000



References Cited:

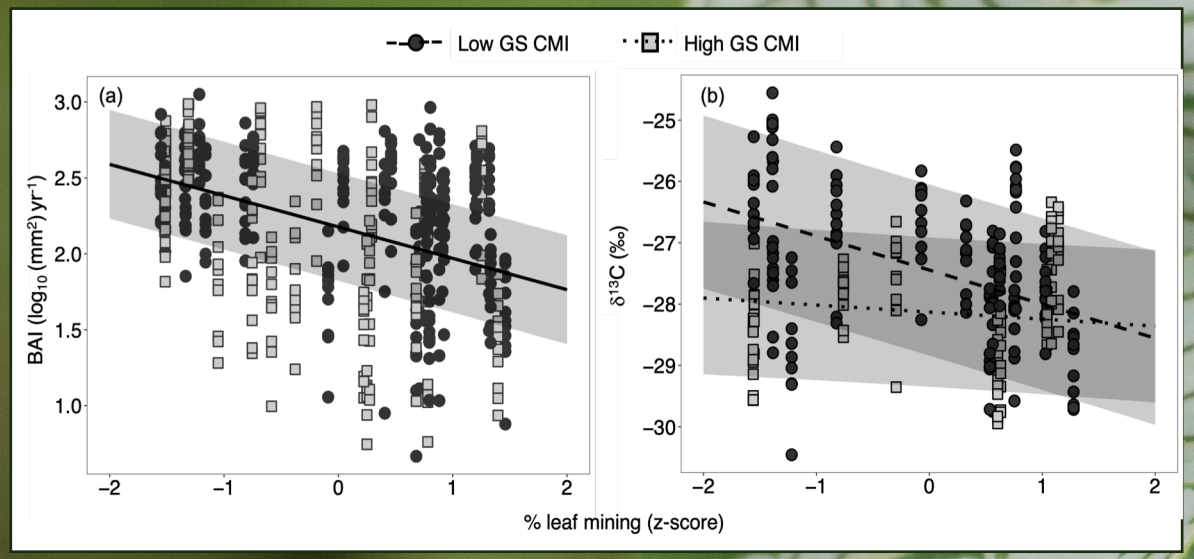
Eidenshink, J., et al., 2007, A project for monitoring trends in burn severity. *Fire Ecology Special Issue*, 3: 3-21.

Kruse, F., et al., 1993, Interactive visualization and analysis of imaging spectrometer Data. *Remote Sensing of Environment,* 44: 145-163.

Impacts of climate and insect herbivory on productivity and physiology of trembling aspen (*Populus tremuloides*) in Alaskan boreal forests

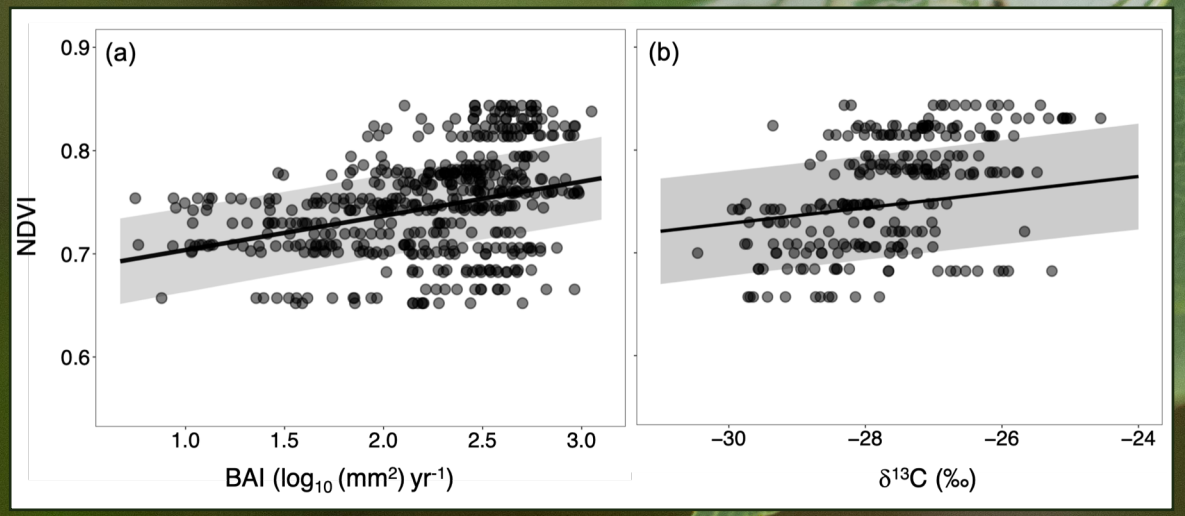
Boyd MA, Berner LT, Doak P, Goetz SJ, Rogers BM, Wagner D, Walker XJ, Mack MC

In press *Environmental Research Letters*



- Productivity (BAI) decreased with leaf mining
- Tree ring $\delta^{13}C$ decreased with leaf mining when moisture availability was low

<u>Conclusions</u>: leaf mining has larger impact on aspen productivity and physiology than climate



- Summer NDVI reflects productivity (BAI) and $\delta^{13}C$, capturing the effects of leaf mining on aspen BAI and physiology

<u>Conclusions</u>: It is essential to account for leaf mining when interpreting NDVI trends in interior Alaska

Drivers of trembling aspen (*Populus tremuloides*) productivity decline and mortality in boreal forests of interior Alaska

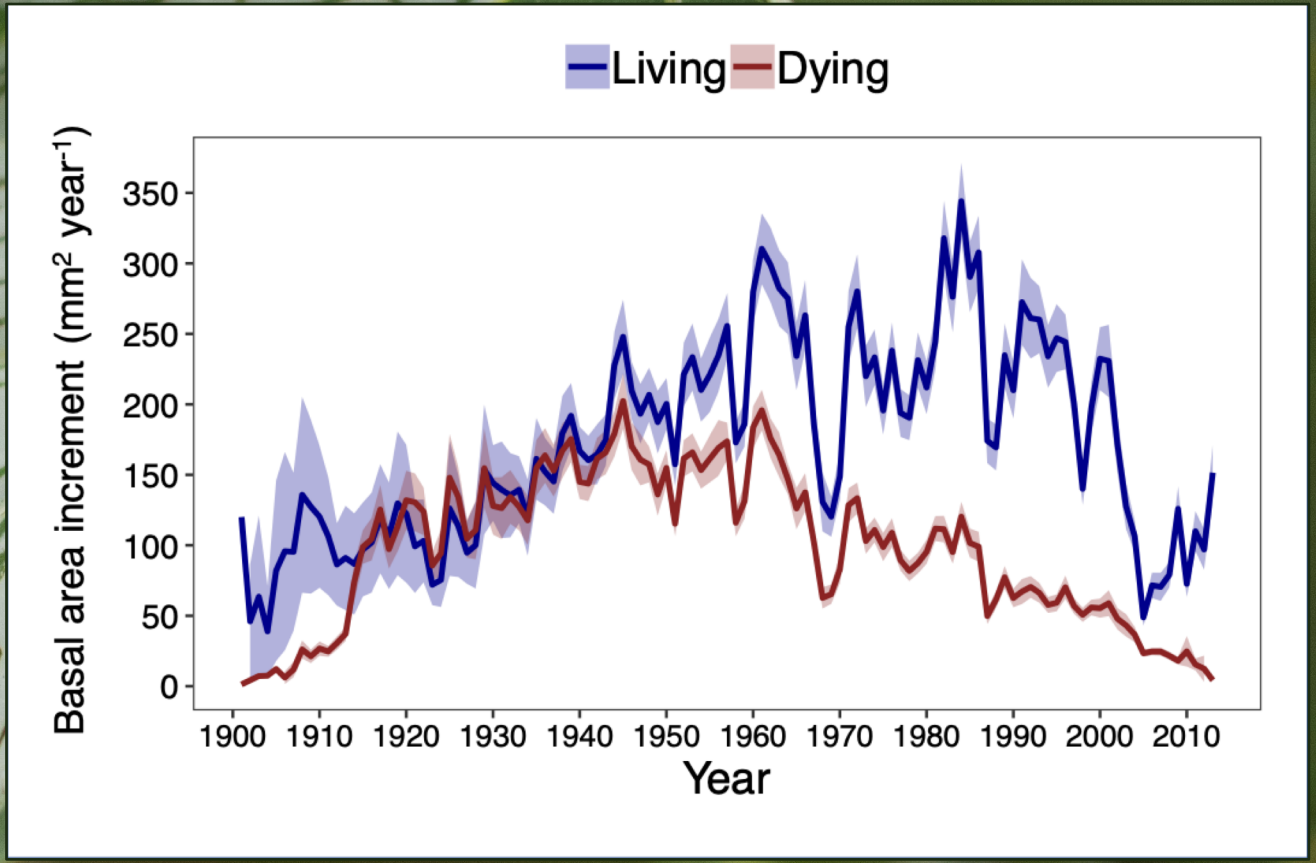
Boyd MA, Berner LT, Foster AC, Goetz SJ, Rogers BM, Walker XJ, and Mack MC

In prep. *Ecology*

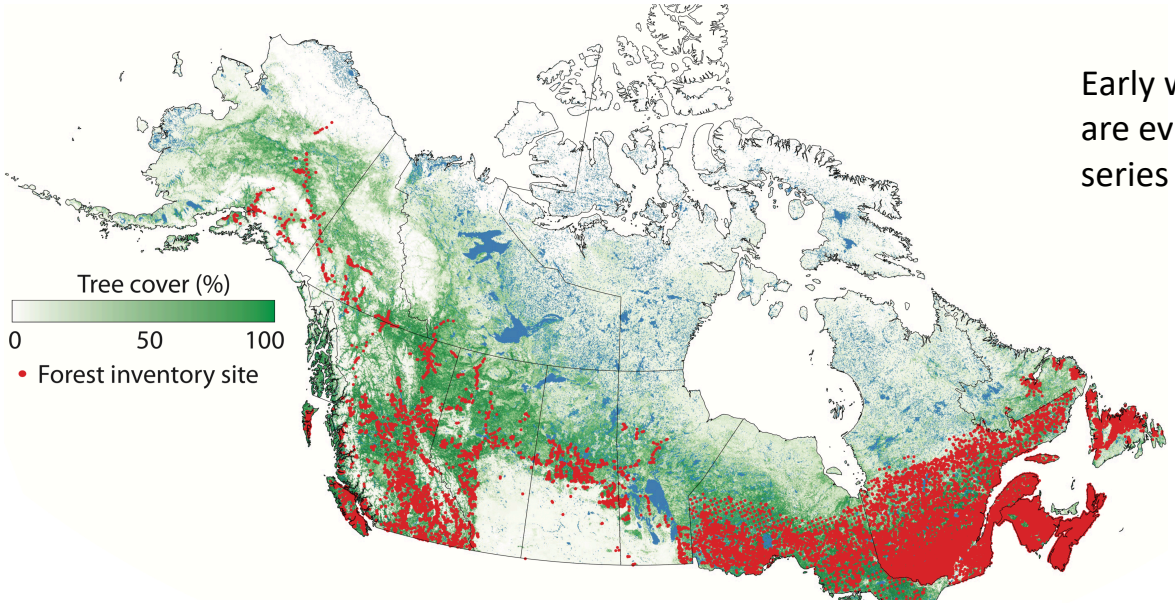
Primary Objectives:

1. Determine the impacts of moisture stress and infestation by aspen leaf miner on aspen mortality and productivity decline

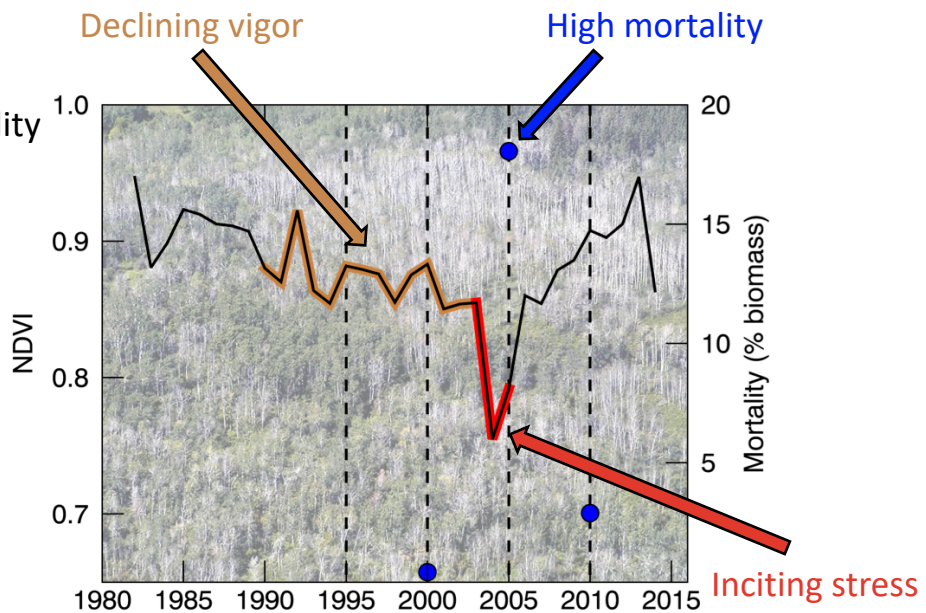
2. Determine how tree mortality events and trends and infestation by aspen leaf miner are linked to NDVI

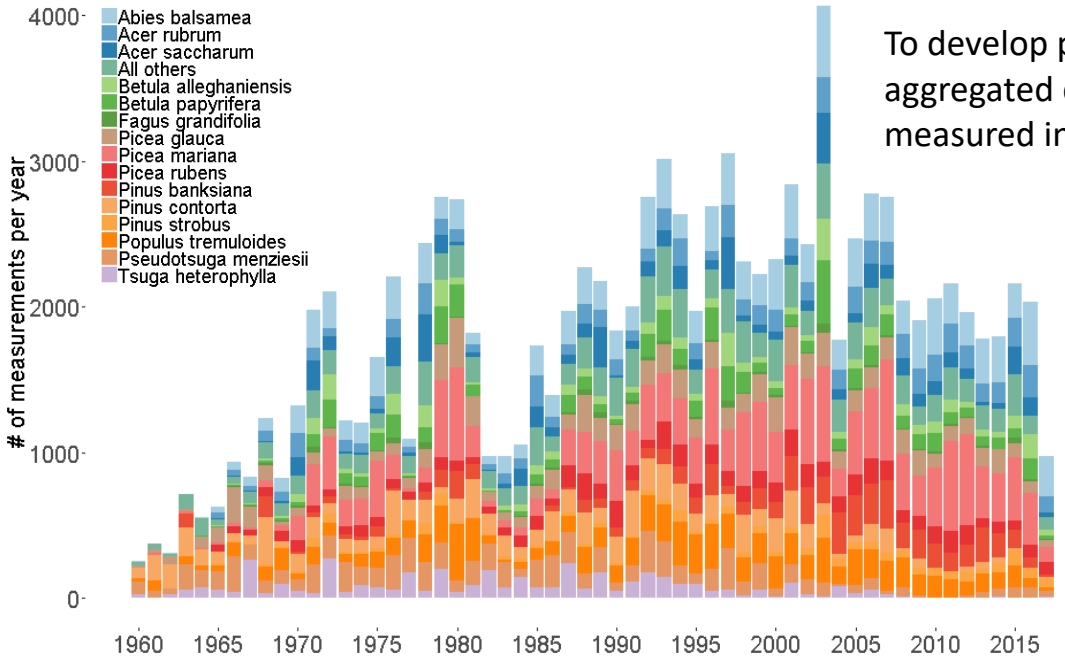


Using long-term NDVI and field observations to model forest demographics (Goetz TE 2014)



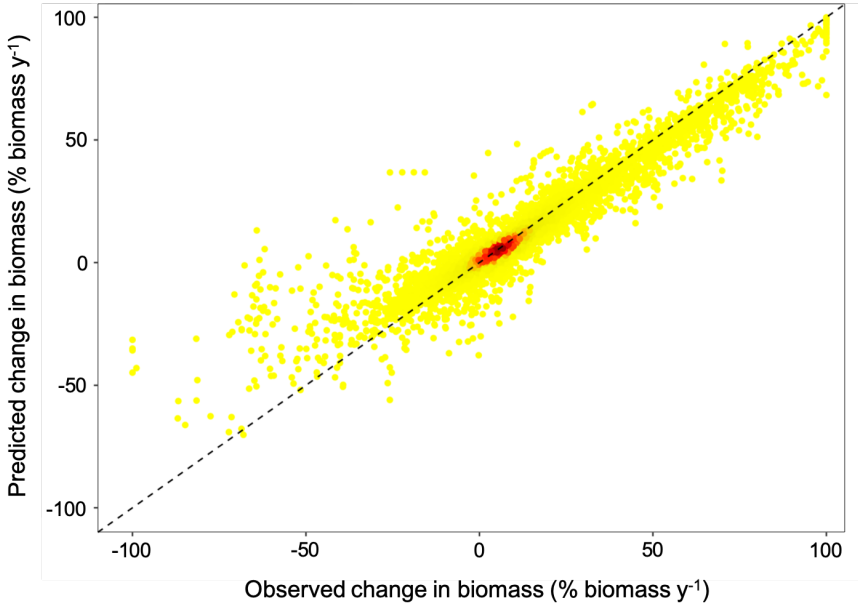
Early warning signals of tree mortality are evident in long-term NDVI time series (Rogers et al., 2018 *GCB*)





To develop predictive models, we aggregated data from 13 re-measured inventories (~20k plots).

Preliminary predictive models of changing forest biomass.



Permafrost Thaw and Wetland Vegetation Dynamics Scotty Creek, NWT: 1970's, 2008 – 2015

Laura Chasmer[1], Chris Hopkinson[1], William Quinton[2]

[1]University of Lethbridge, Lethbridge AB Canada

[2]Wilfrid Laurier University, Waterloo ON Canada

Laura.chasmer@uleth.ca; c.Hopkinson@uleth.ca; wquinton@wlu.ca

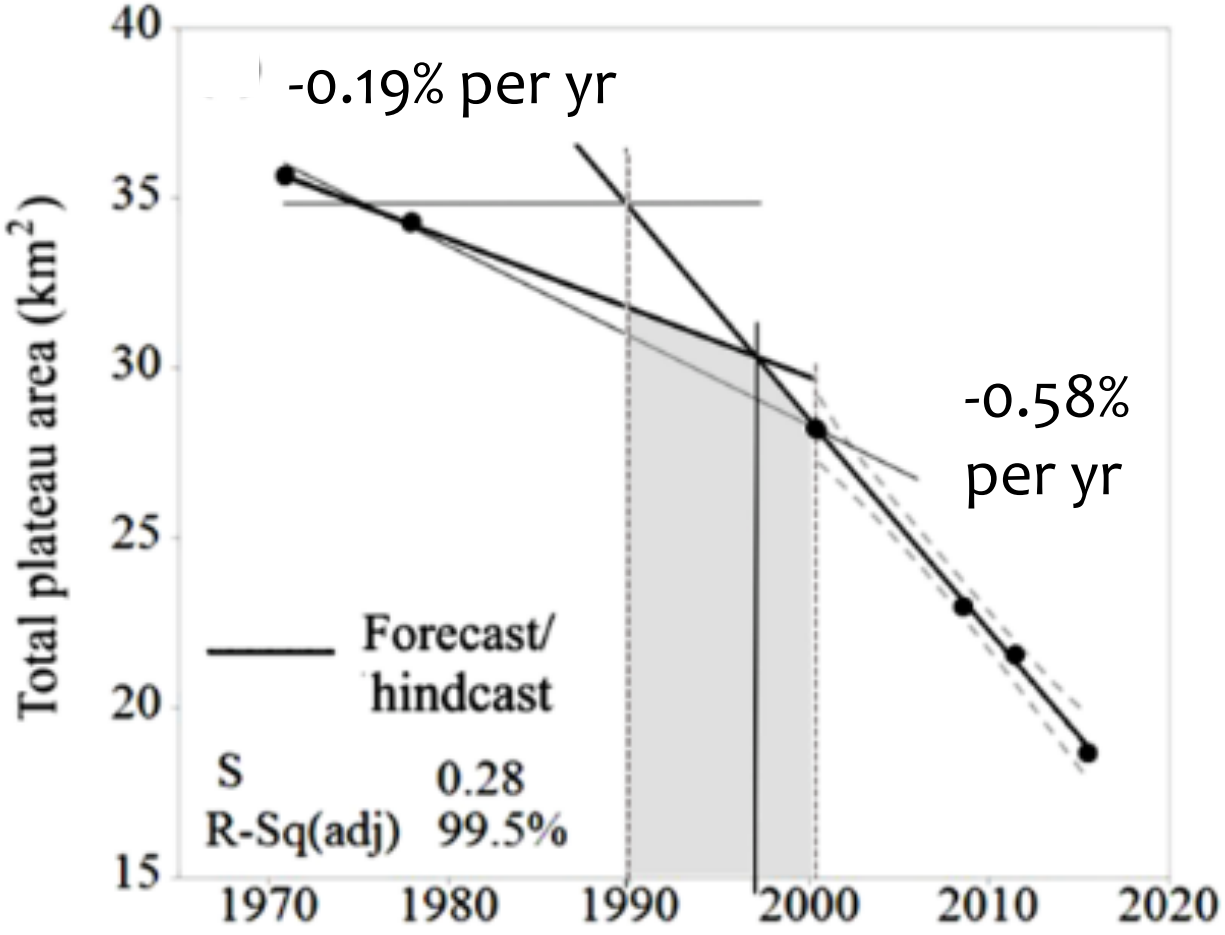
Increased Rate of Loss after ~1998 at Scotty Creek

Classification of plateau areas using air photos and time series lidar data to determine changes over time

Hydro-climate changes:
Reduced snow cover period:
~50 days shorter (from 1970s);
~30 days shorter (2000s +)

Earlier fall snowfall & spring thaw
Increased air temperature (~2°C)

Shift in response corresponds with ENSO



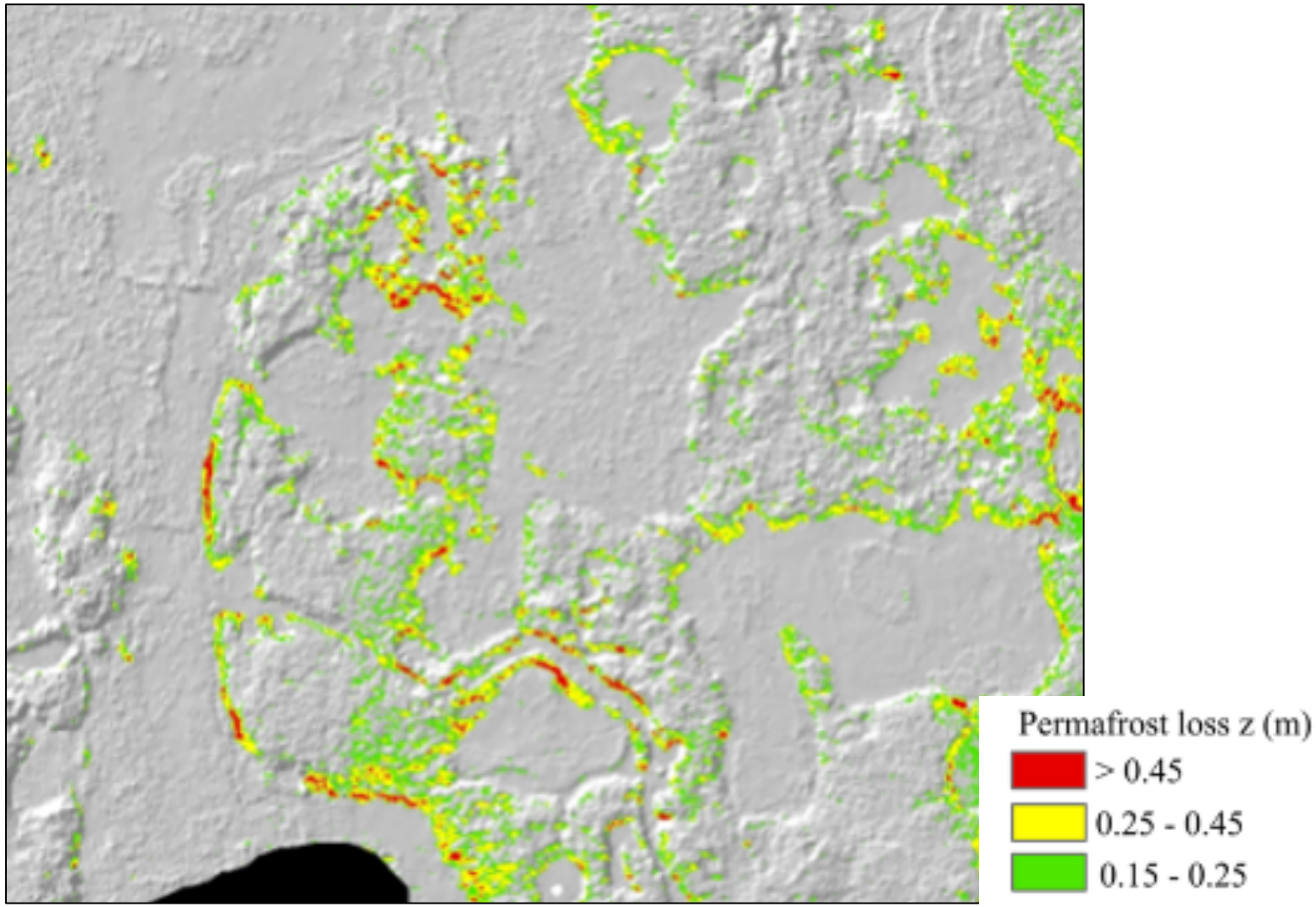
Map of Permafrost thaw 2008 minus 2015 (subset)

What can be done with lidar data

Permafrost plateaus with loss determined from time series lidar data

Vertical + horizontal loss of discontinuous permafrost along south-facing and west facing edges

Has implications for connectivity, hydrology



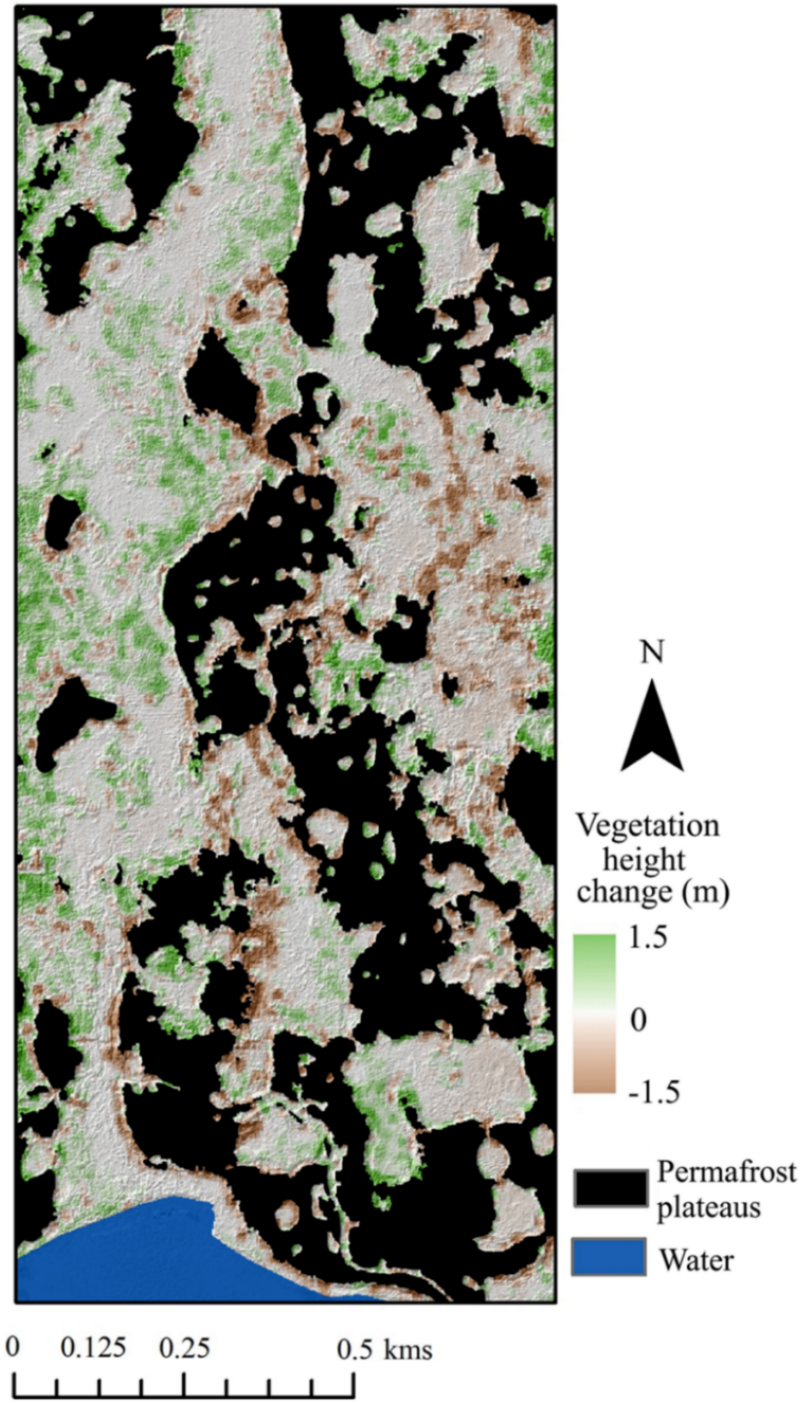
Results from Chasmer and Hopkinson 2016 GCB; Activities are ongoing

Map of Wetland Vegetation Change 2008 to 2015 (larger subset)

Vegetation height changes from time series lidar data for small sub-area

Plateaus in black

Increased shrubification of fen (increase in height) from 2008 to 2015; reduced height of shrubs/trees possibly associated with mortality within recently connected bogs



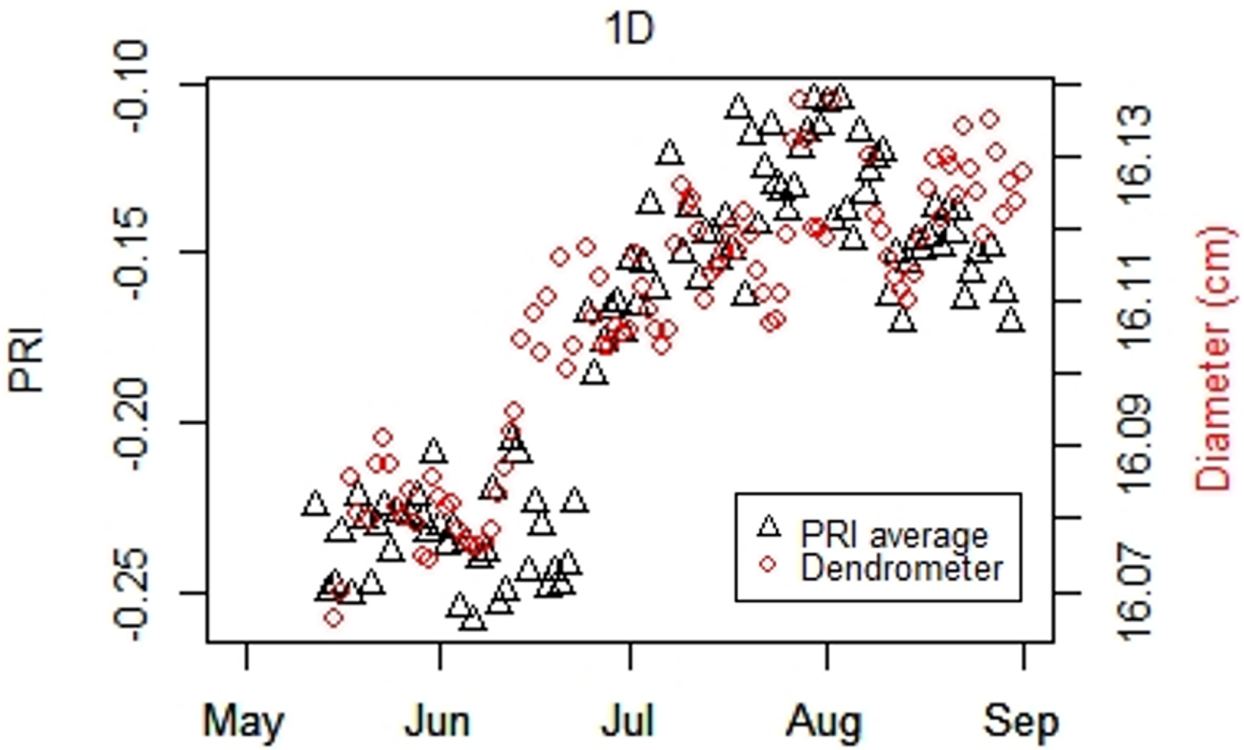
Objective - Characterize forest-tundra ecotone (FTE) structure:

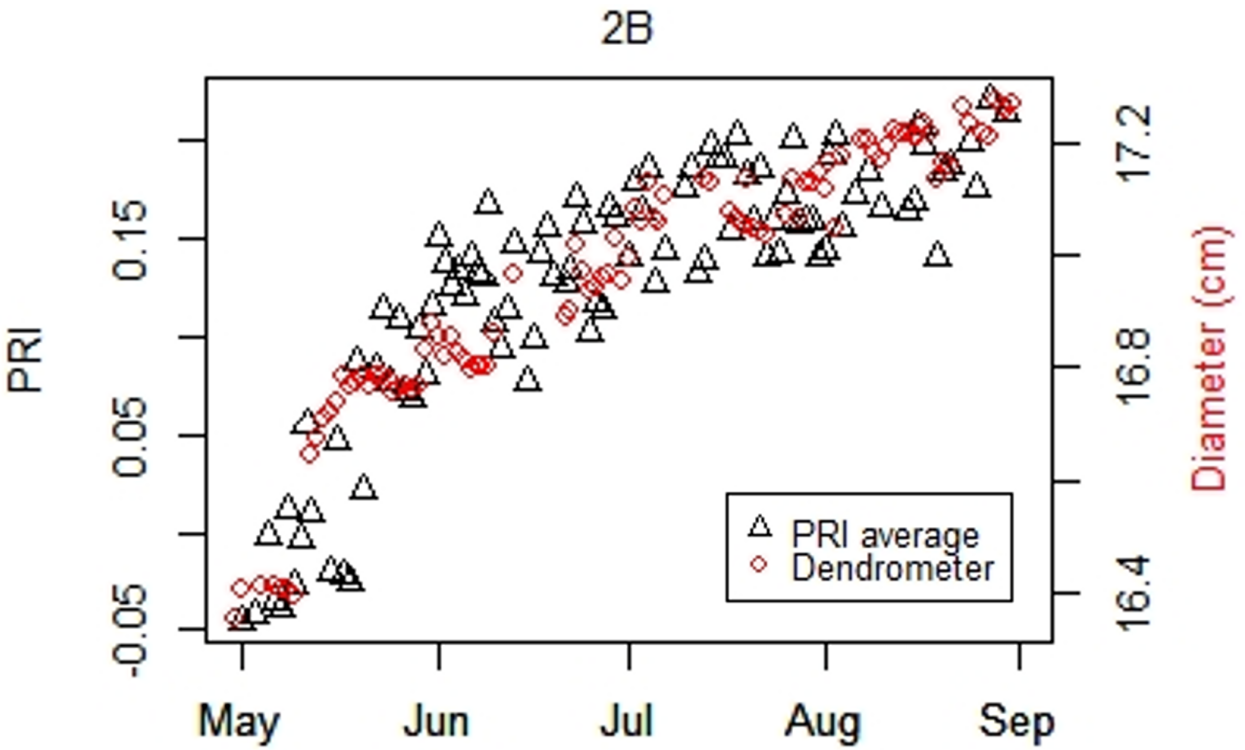
- Developed novel remote sensing approach for characterizing treeline structure (Meddens et al., 2018).

Objective - Linking FTE structure and function:

- Variability in microstructure modulates photosynthetic functioning of small-stature white spruce (Maguire et al., 2019).
- Lidar-derived tree height reveals treeline demography and associated C storage (Jensen et al., in prep).
- Simple light modeling approach improves interpretation of chlorophyll fluorescence (Maguire et al., in prep).
- Results revealed no significant ($p>0.05$) differences in photosynthetic characteristics between high and low canopy needles (Schmiege et al., in prep).

- **Objective - Assess FTE vulnerability and resilience:**
  - PRI time series of fall phenological transitions can help our understanding of the FTE response to climate change (Eitel et al., 2019).
  - PRI time series showed to track intra-seasonal radial growth dynamics of white spruce (Eitel, Griffin et al., soon to be submitted)(**see poster session for more details**):



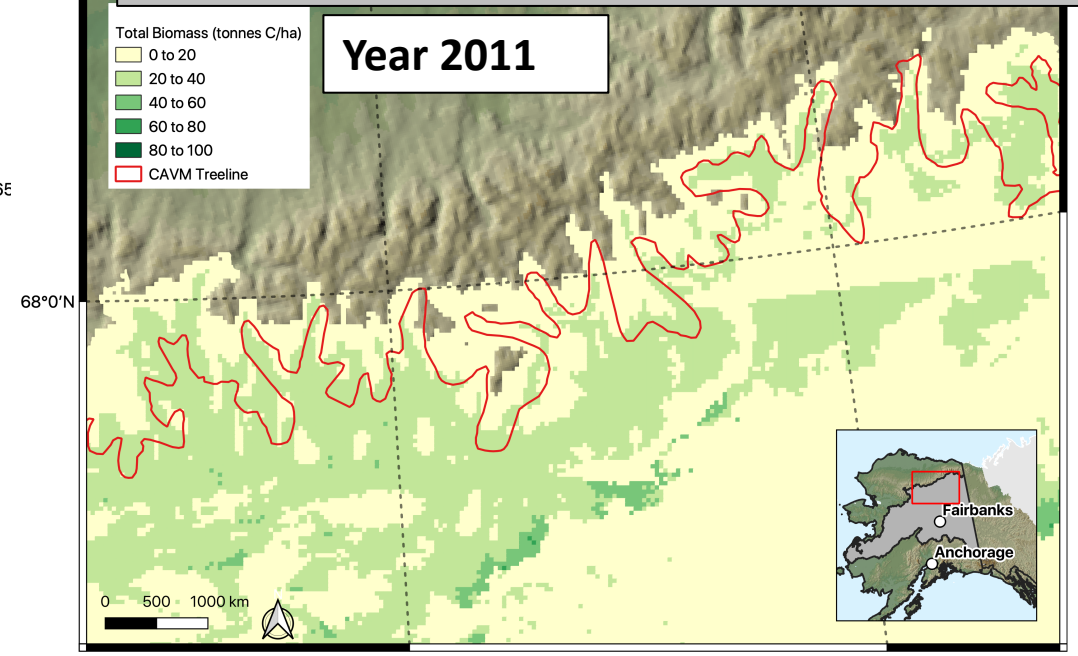


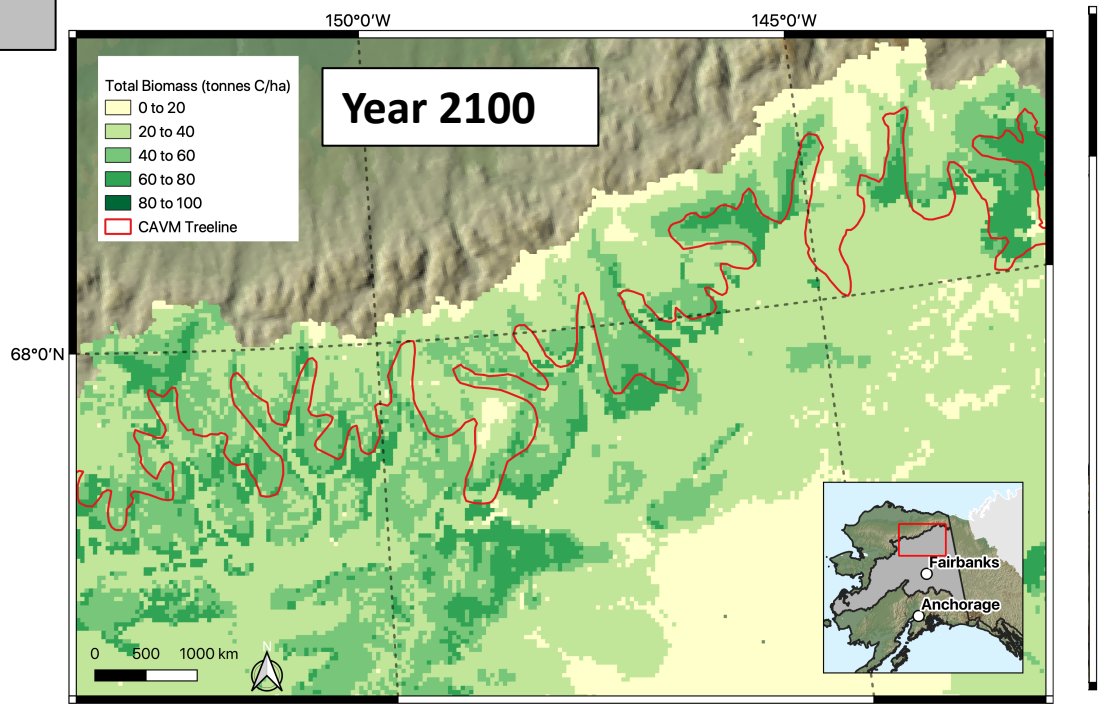
UVAFME – individual tree-based forest model

Simulates individual tree establishment, growth, and mortality based in response to the environment, climate, competition, light, and disturbances

Also simulates soil moisture, permafrost, decomposition, and wildfire dynamics in response to climate and vegetation drivers

Increasing biomass at northern range limits





Foster et al., in prep for *Global Change Biology*

Review

Synthesis activities

- Boreal browning & greening
- Disturbance and recovery

ABOVE
ARCTIC-BOREAL VULNERABILITY EXPERIMENT