Implications of Peat Burn Severity on C Emissions and Post-Fire Successional Trajectories in Boreal Northwest Territories Canada

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Project Objectives

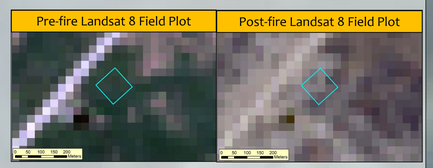
Integrate remote sensing, spatial analysis, and field data to understand the vulnerability and resiliency of peatlands and uplands to wildfire across the southern Northwest Territories study area where peatlands are abundant

- Map peatland and upland ecotypes
- Develop Landsat algorithms to map organic soil (peat) burn severity
- Study the effects of wildfire on peatlands and uplands
- Use field data to quantify revegetation patterns in peatlands/uplands
- Evaluate satellite radar retrievals of peat moisture pre- and post-fire to understand moisture effects on burning and regrowth

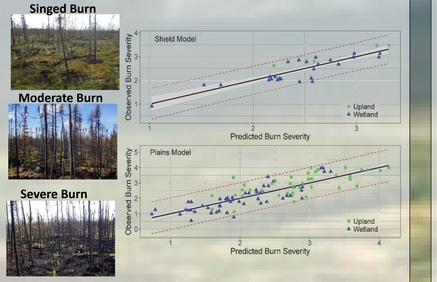
Field and Remote Sensing Methods

Study Area Northwest Territories
- Area surrounding Great Slave Lake

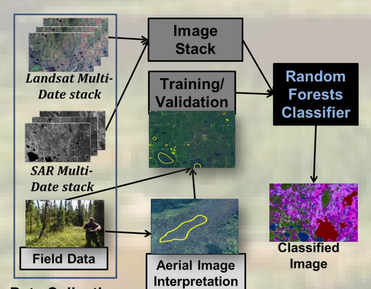
- **Field sampling**
  - 62 bog, 62, fen, 17 lowland (<40 m peat) and 11 upland sites
  - Each 1 ha site is characterized using six 10 m^2 plots
  - Burn severity of percent area quantified into a 5 class index
  - Burn depth using adventitious root method
  - Pre-burn tree density, biomass
  - Soil moisture coincident with SAR satellite acquisitions
  - Post-fire tree recruitment and vegetation regrowth



- **Burn severity algorithm**
  - Paired field measurement of surface (peat) burn severity with pre and post-fire Landsat 8 data
  - Machine learning variable selection to create multiple linear regression models with K-folds cross validation
  - Separate models for shield and plain ecoregions applied to phenologically matching pre- and post-fire Landsat 8 mosaics within fire perimeters to create data layers of burn severity



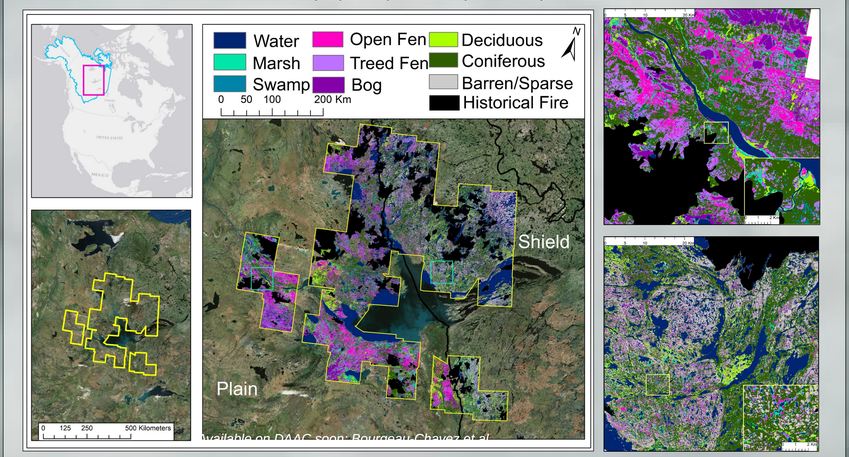
- **Peatland & Upland Ecotype Mapping**
  - Raster stacks of multi-season Optical-SAR fusion
    - 129 PALSAR, 143 Landsat scenes used
  - Over 12,000 training data polygons created using Worldview imagery and field validation data.
  - Ensemble classifier, Random Forests, used for ecosystem classification (80/20 Training/Testing)

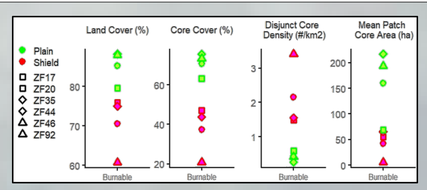


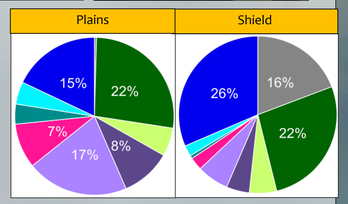
Bourgeau-Chavez et al. 2017 Can J. For. Res.

Results – Peatland-Upland Ecotype Maps Completed

13,677,119 km^2 area mapped, 2,440,599 km^2 masked by historical fire, 11,226,520 km^2 classified
All classes > 82% user accuracy, (except swamp = 73%)







- **Plains characterized by** less frequent larger lakes, more peatlands, and larger tracts of continuously vegetated land
- **Shield characterized by** frequent smaller lakes, fewer peatlands, and a patchwork of vegetated land and barren or sparsely vegetated ecosystems

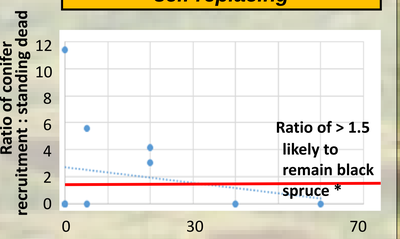
Prediction of Early Post-Fire Succession

Mixed model effects analysis used to assess how different levels of severity and peat consumption varied by ecotype, season of burn and the relationship to tree recruitment. *Kane et al. in prep*

Results show:

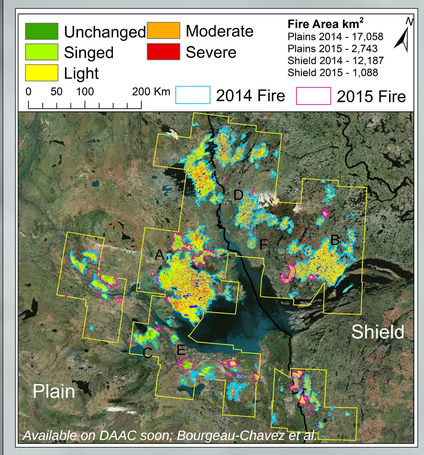
- No significant difference in consumption by ecotype
- Significant difference in consumption by season
  - 4.0 cm for June
  - 5.7 to 7.8 for July-August burns
- deciduous succession had a significant correlation to canopy burn severity.
- coniferous regeneration had a significant positive correlation with peat burn severity (p = 0.003), but not with shrub or canopy severity

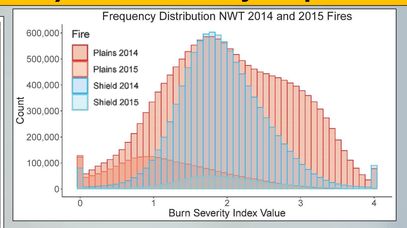
Some conifer not self replacing



Thus, burn severity to the organic surface is an important metric to map from satellite remote sensing. Coupled with land cover mapping, it can be used to predict broadleaf vs.conifer succession geospatially.

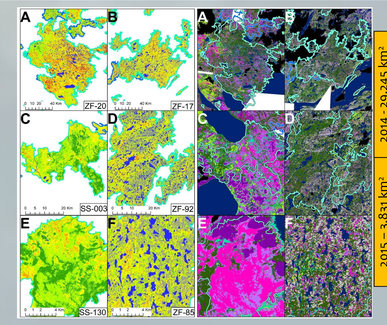
Results – Organic Surface (Peat) Burn Severity Maps

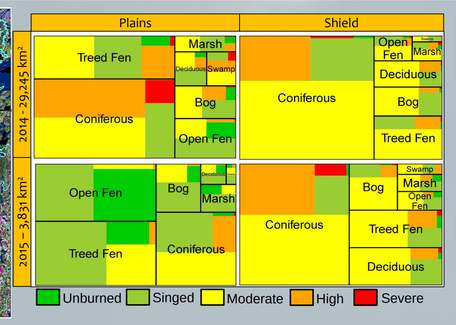




- Plains R^2 = 0.67, Shield R^2 = 0.73
- Near and shortwave IR were most significant model variables
- Severity values in the shield are normally distributed, plains vary year to year
- *French et al. in prep.*

Results – What Ecotypes are Burning and How Severely?

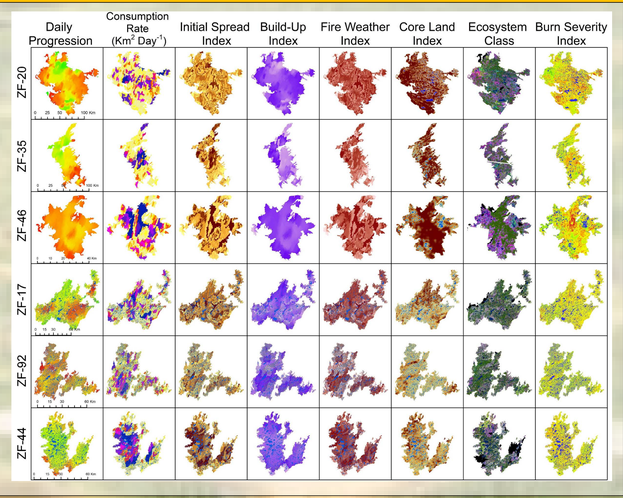




Work is underway to analyze this large dataset relative to ecotype proportions on the landscape,
- shield vs. plains
- 2014 vs 2015 fire years

Bourgeau-Chavez et al. In prep

Treemap figure: area of each box represents the proportion of that respective class and class/severity combination resulting from the intersection of the ecosystem and burn severity layers for shield vs. plains in 2014 vs 2015

What Factors Influence Fire Effects?

- Incorporating additional data
  - Fire weather
  - Topography
  - Landscape statistics
  - Seasonality
- Exploring different modelling approaches
  - Structural equation modelling
  - Random forest regression