WG leads / Michelle Mack and Laura Bourgeau-Chavez

Fire Disturbance

Legacy Carbon Combustion and Consequences

Michelle Mack (Northern Arizona U.)

Jill Johnstone (U. of Saskatchewan)

Ted Schuur (NAU)

Scott Goetz (Woods Hole Research Center)

Xanthe Walker (NAU)

Brendan Rogers (Woods Hole Research Center)

Merritt Turetsky (U. of Guelph)

Jennifer Baltzer (Wilfred Laurier U.)

Tundra Fires

Tatania Loboda (U. of Maryland)

Liza Jenkins (Michigan Tech. Research Institute)

Michael Billmire (MTRI)

2014 NWT Wildfires

Laura Bourgeau-Chavez (Michigan Tech. Research Institute)

Nancy French (MTRI)

Evan Kane (Michigan Technological University)

Sarah Enders (MTRI)

Michael Battaglia (MTRI)

Scaling wildfire feedbacks to climate

Brendan Rogers (Woods Hole Research Center)

Scott Goetz (WHRC)

Sander Veraverbeke (U. of California-Irvine)

Merritt Turetsky (U. of Guelph)

Institutional Collaborations

- Federal or state Management agencies
  - US: National Park Service (Denali), USDA Forest Service, NOAA, USFWS, Alaska Wildland Fire Coordinating Group
  - Canada: Government of the Northwest Territories, Canadian Fire Service, Natural Resources Canada
- Canada First Nations:
  - Kakisa community in the Dehcho District and Wekweeti and Gameti communities in the Tlicho District
- Other groups:
  - Alaska Fire Science Consortia, Bonanza Creek and Arctic LTERs

Science Questions

How vulnerable or resilient are ecosystems and society to environmental change in the Arctic and boreal region of western North America?

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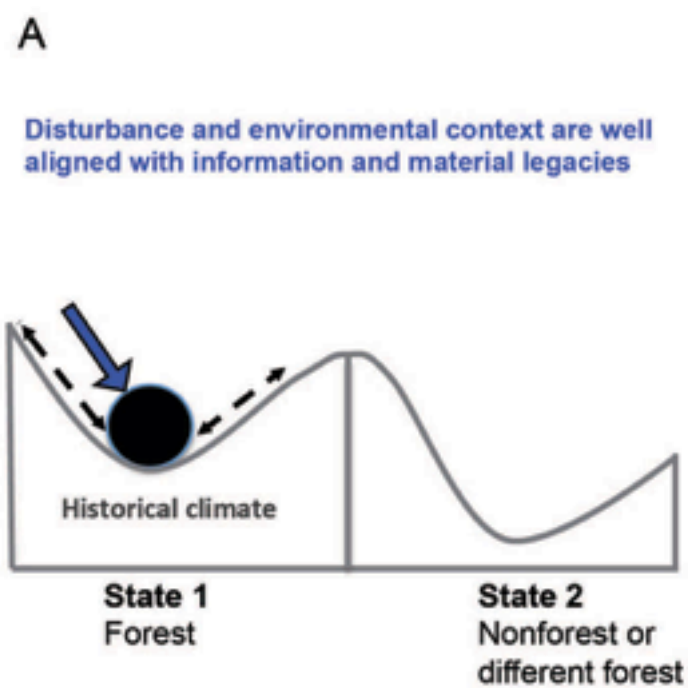
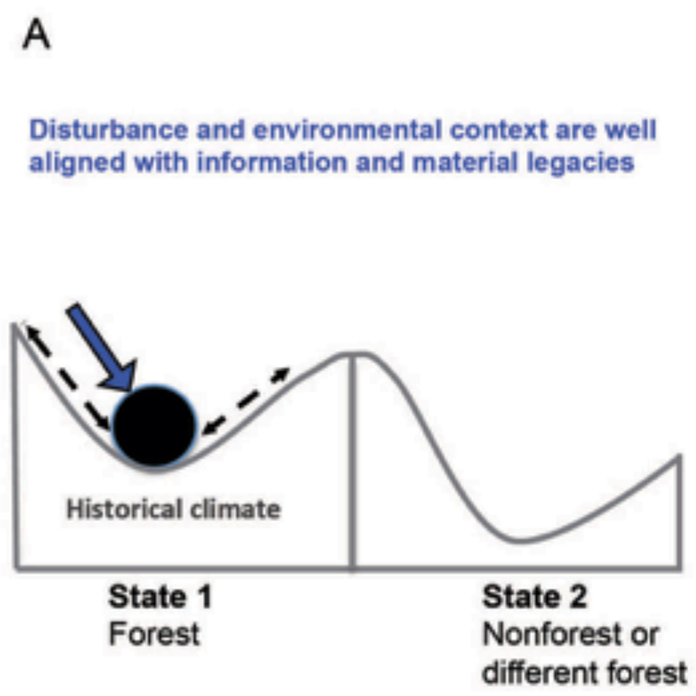
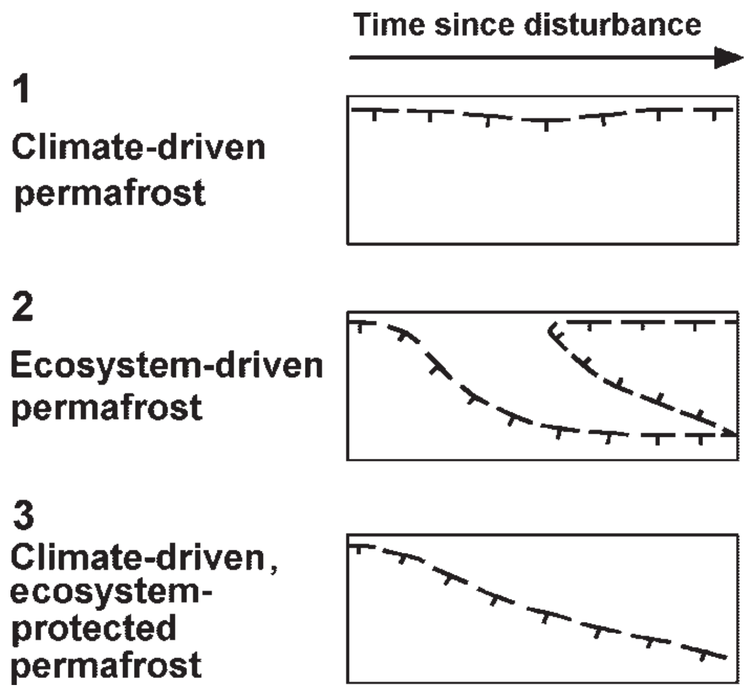


Science Questions

How vulnerable or resilient are ecosystems and society to environmental change in the Arctic and boreal region of western North America?





Shur and Jorgenson 2007

Science Questions

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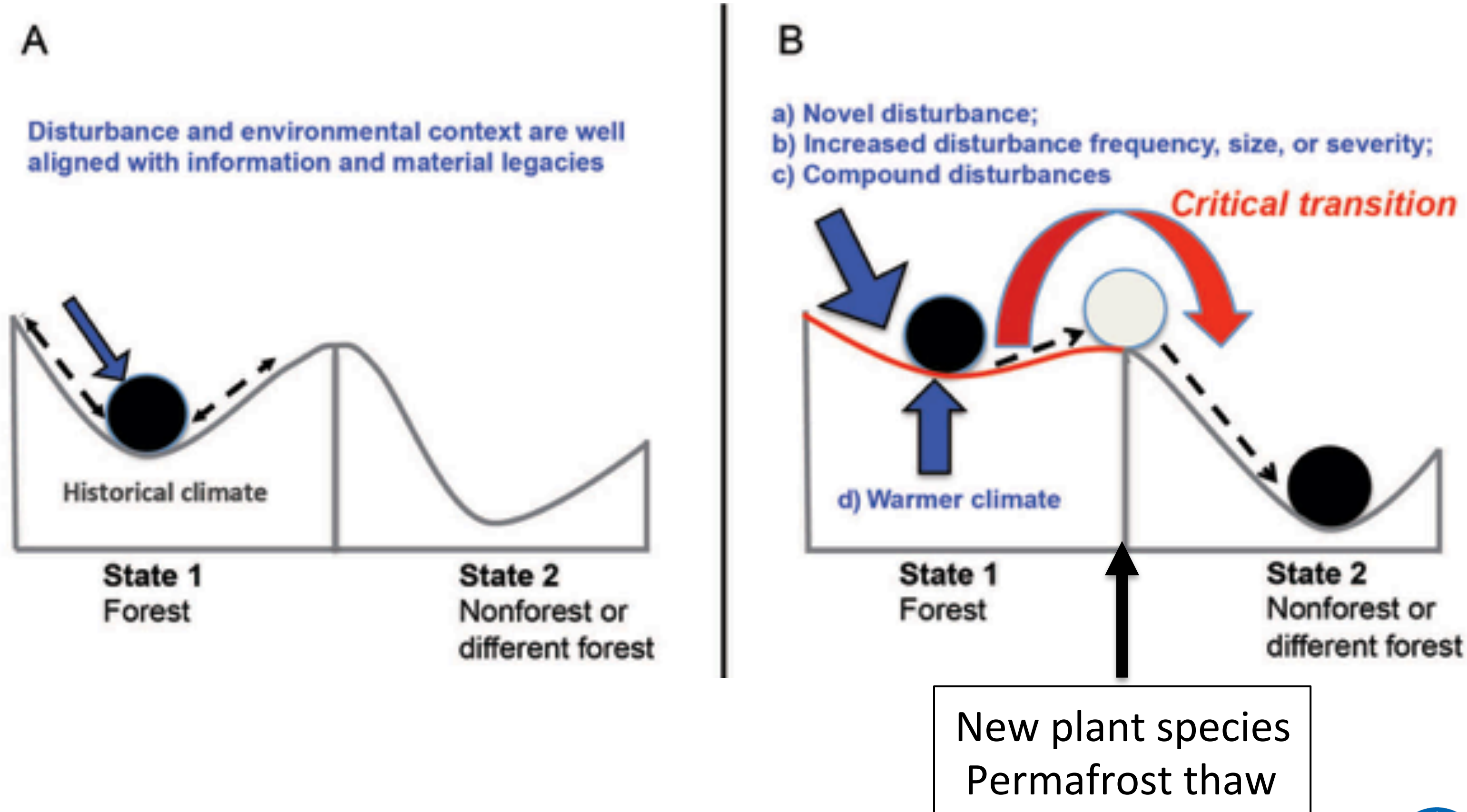


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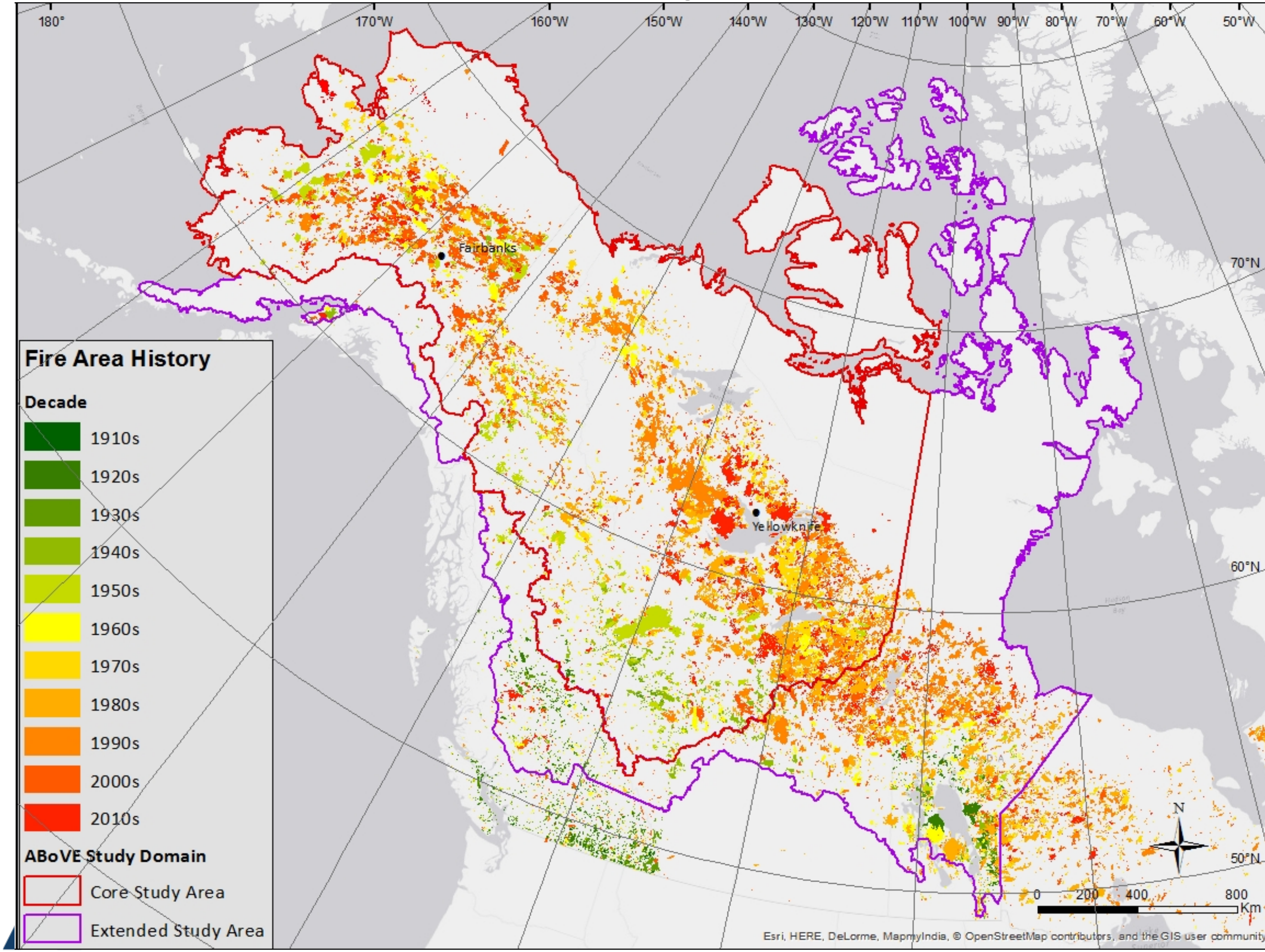
Science Questions

- What controls the spatial and temporal variability of fire severity?
- Are there pre-season indicators of severe fire years?
- How do fire effects differ across vegetation types and permafrost conditions?
- How does within-site severity compare to past fire events? Where on the landscape is "old carbon" combusted?
- What are the sources of ecosystem resilience or drivers of vulnerability to change after severe fires?
- How do fire feedbacks to climate vary across ABoVE regions?

Science objectives

1. Identify environmental and fire controls and their interactive effects on spatial and temporal variations in burn characteristics (e.g., size, severity, age of C combusted, spatial heterogeneity).
2. Characterize fire effects on C biogeochemistry, permafrost, hydrology, flora, fauna, and ecosystem services and determine how they vary across ABoVE regions.
3. Characterize fire impacts on ecosystem services, including those that impact both local and global stakeholders.
4. Identify regional shifts in fire regimes and, based on objectives 1 and 2, refine models to project impacts on C-biogeochemistry, permafrost, hydrology, flora, fauna, and ecosystem services.
5. Work with regional land and fire managers to create “use-inspired science”: knowledge and products that address emergent fire and management issues in a warming climate.

Historic fire perimeters



ARCTIC BOREAL
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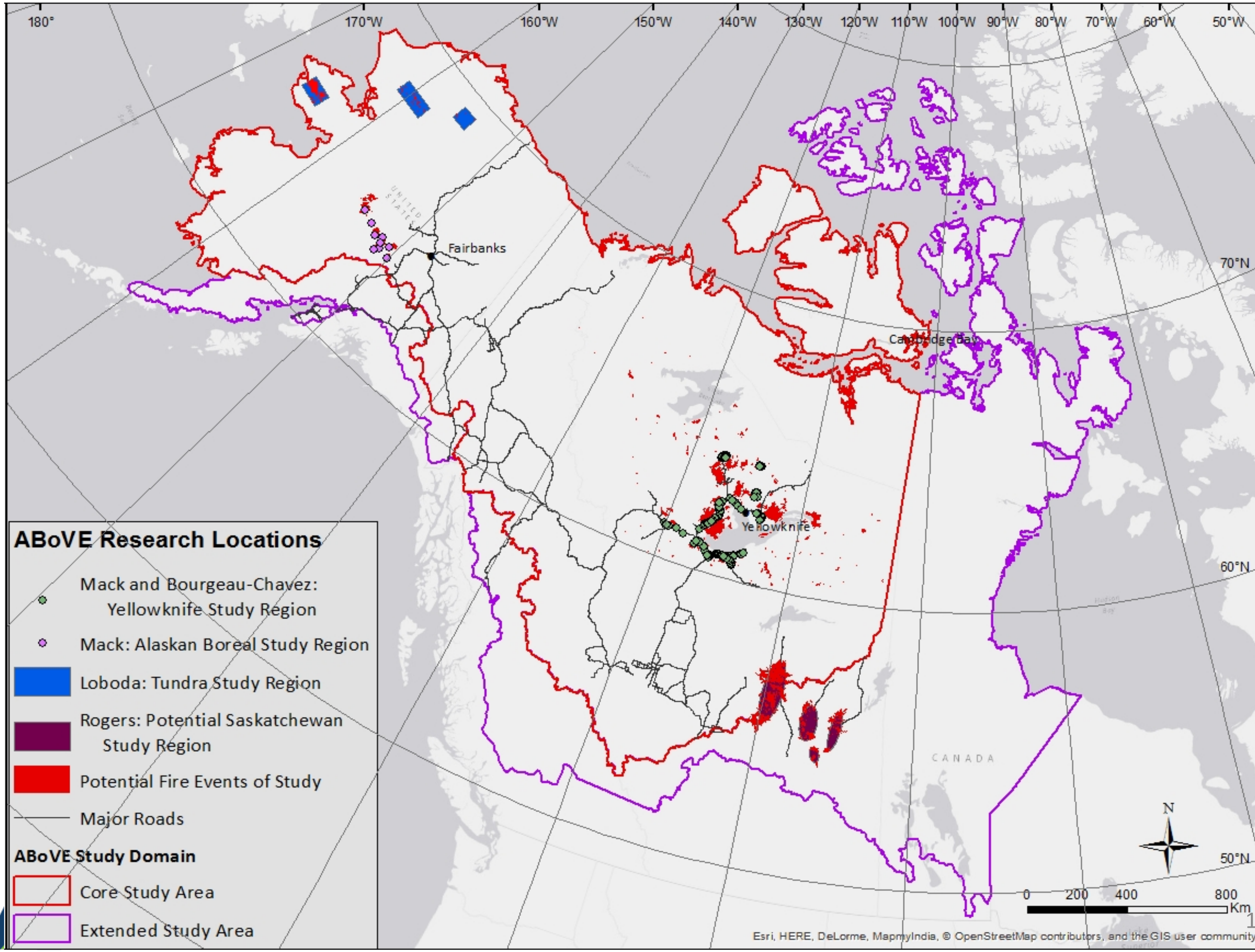
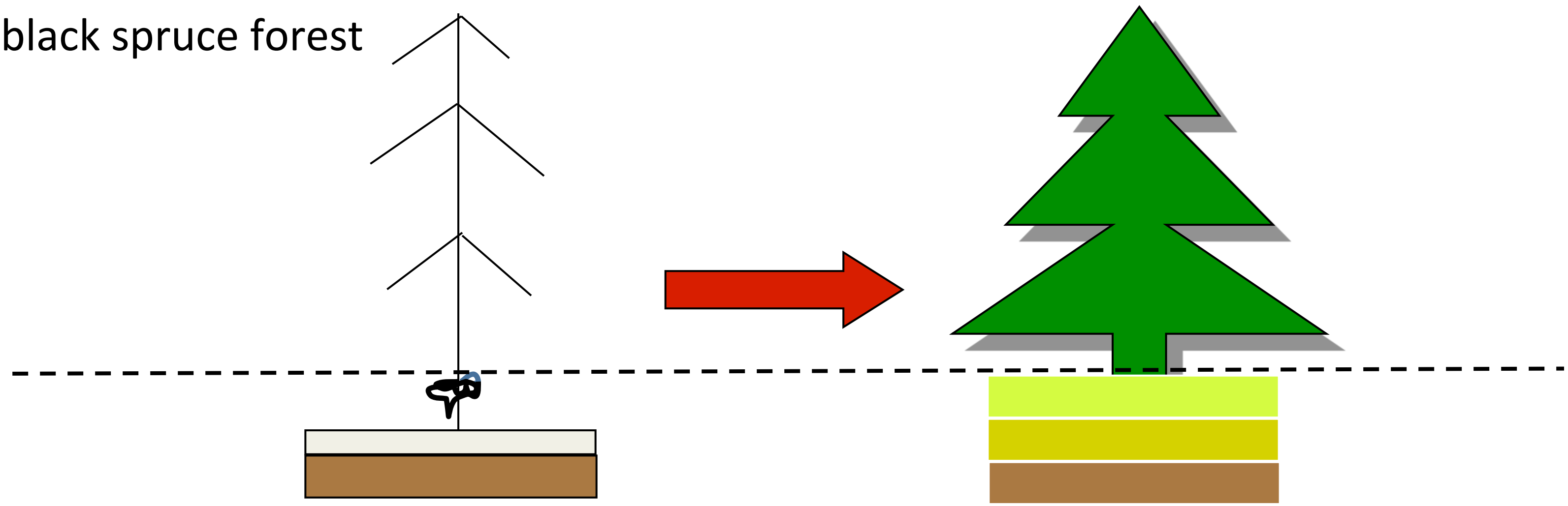
EXPERIMENT

ABoVE Intensive field sites

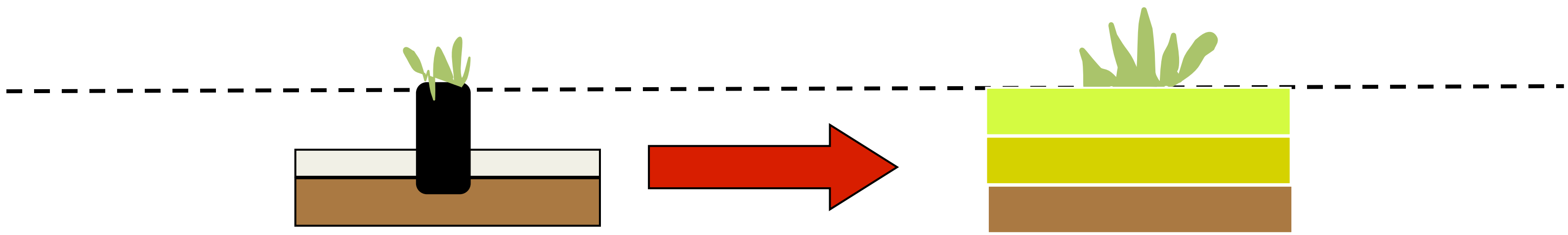


Field studies—ground measurements

Boreal black spruce forest



Moist acidic tussock tundra



Field studies—Ground measurements

What were pre-fire characteristics?

- Slope, aspect; Soil texture; Drainage class; Vegetation type; Tree density, size and state; Moss and lichen identity; Pre-fire organic layer depth; Fire history; Stand age or soil organic layer age
- Calibrate regional relationships between morpho-metric and soil organic layer depth, bulk density and element concentration with depth

Field studies—Ground measurements

How severe was the fire?

- CBI or other ocular estimate of change; Canopy combustion estimates (inventory); Depth of SOL burning metrics (roots, stems, tussocks); % mineral soil exposed (seedbeds!); Estimates of carbon and nitrogen emissions; Age of burned surface, estimate of old carbon combustion

What remains?

- Residual soil organic layer (depth, bulk density, C/N); Residual carbon and nutrient stocks; Coarse woody debris; Soil moisture; Depth to water table; Depth to frost (end of season); Micro-topography; Surviving or resprouting vegetation

Field studies—Ground measurements

Did fire trigger state change in vegetation or permafrost?

- Resprouting vegetation; Seed rain; Seeding vegetation; Distance to unburned seed source;
- Change in active layer depth; Change in micro- or macro topography; Change in water table depth; Evidence of subsidence and/or thermal erosion

Spaceborne Remote Sensing

- **What were pre-fire characteristics?** Landsat, MODIS, Radar products
- **When did the fire burn and what were the weather conditions at the time of the fire?** MODIS products
- **What is the spatial patterning of fire on the landscape?** Landsat, MODIS, various differencing products (e.g., dNBR)
- **How much carbon was emitted?** Landsat, MODIS, high resolution imagery (Digitalglobe)
- **How does surface energy balance change with time after fire?** NASA/GEWEX, NIMBUS-7 SMMR and DMSP SSM/)-SSMIS
- **Where does fire trigger indicators of ecosystem state change?** Landsat, MODIS, Radar products

Airborne Remote Sensing

- **Did fire trigger indicators of ecosystem state change?** Lidar, high-res L-band InSAR, Digitalglobe "in-track" stereo collection

Modeling Efforts

- Statistical modeling frameworks: boosted regression, random forests, structural equation modeling
- Conceptual advances to enable prognostic modeling of fire regimes in a changing climate
- Lots of parameter values
- Validation datasets
- Models? Alaska Integrated Ecosystem Model (Dave McGuire, Scott Rupp), Charlie Koven

Geospatial Data Products

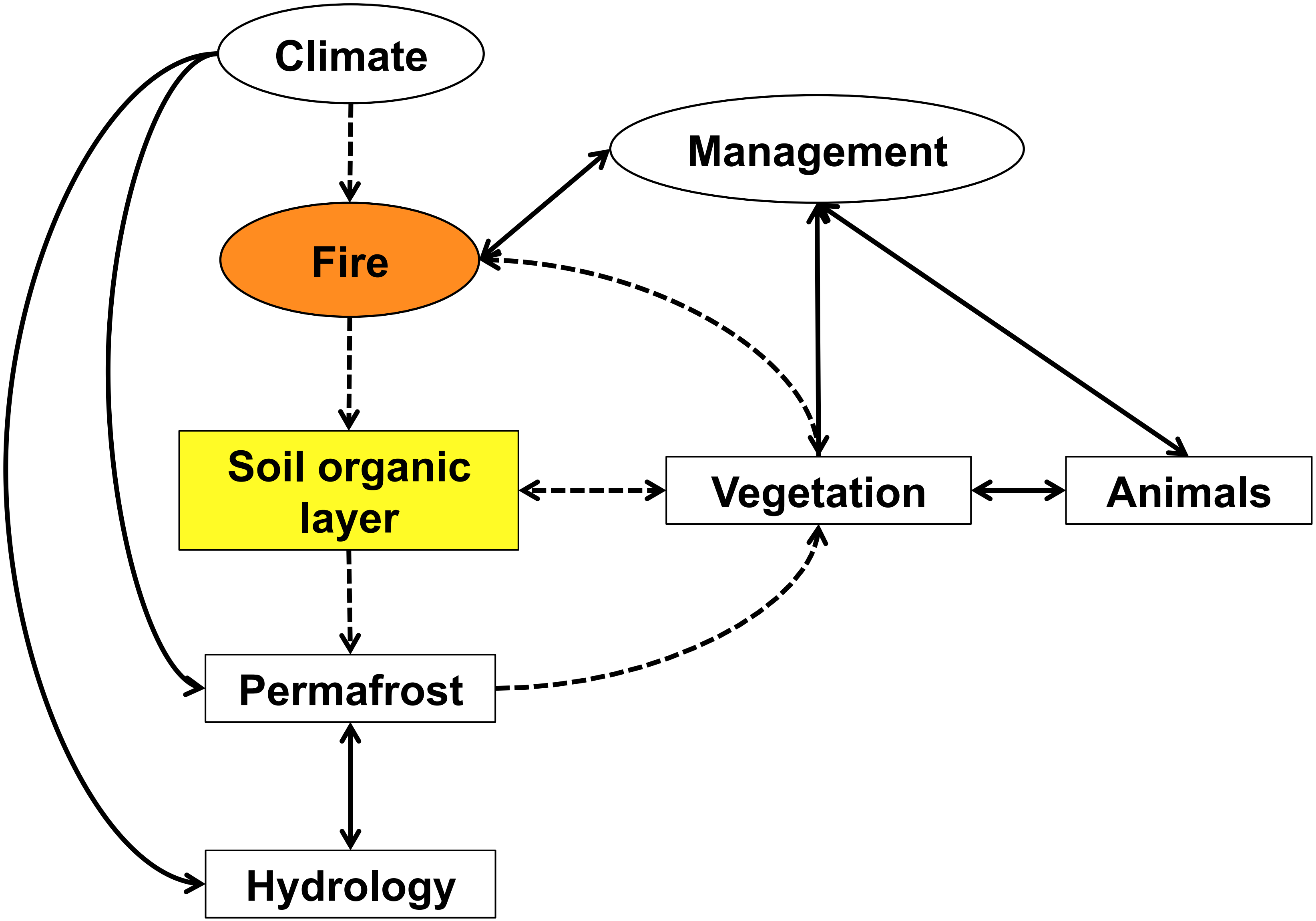
Bourgeau-Chavez-02, -03	Pre-fire maps of Peatland types for Fires of NWT in 2014 Burn Severity maps of Peatlands from Landsat for NWT 2014 fire events
Bourgeau-Chavez-03	Database of field data on: Fuel loading, post-fire regeneration, and permafrost depths
Bourgeau-Chavez-03	Risk map for high severity burning based on times series of soil moisture
Loboda-01	Cloud Climatology for ABoVE domain (view)
Loboda-01	Active fire detection record compilation (view)
Loboda-01	Coarse resolution tundra burned area maps (view)
Loboda-01	Moderate resolution burned area maps from optical data (view)
Loboda-01	Tundra fire progression maps (view)
Loboda-03	Site vegetation maps; year since fire; burn severity; slope, aspect, elevation; drainage for tundra fire sites
Loboda-03	Field data measurements including depth of active layer, soil moisture, soil temperature, vegetation characteristics (fractional representation, tussock metrics, shrub stem count and dimensions), SOL thickness
Loboda-03	Satellite data metrics including, for Landsat: soil exposure (spring TCB), surface thermal brightness (seasonal if possible), surface albedo, vegetation greenness (NDVI); for InSar: soil moisture, surface roughness; and for MODIS/VIIRS: fire spread rate, fire radiative power.

Geospatial Data Products

Mack	Static variables for NWT site locations: topography (slope, slope position, aspect, insolation), surficial geology, ecoregion classification, proximity to water feature (from Carroll project), drainage class (primary, secondary, etc.)
Mack	Fire variables at burned sites including date of burning; fire weather at time of burn; rate of burning (MODIS hot spot); smoldering evidence; overlap with past burn--% area, time; distance to burn edge
Mack	Legacy carbon vulnerability maps for Denali Tundra and NWT conifer forests
Mack	Carbon cycle resilience and vulnerability maps for Denali Tundra and NWT conifer forests
Rogers	Burned area products: Burned area (500 m, 2001-2015) and combustion in kgC m^{-2} (500m, 30 m, 250 m; 2001-2015) (for fire events in regions studied)
Rogers	Radiative Forcing products: GHG RF (500 m, 2001-2015); Aerosol RF (500 m, 2001-2015); Net RF (500 m, 2001-2011); RF projections during season and during event (500m, current) (for fire events in regions studied)
Rogers	Spring Albedo products: Increase in spring albedo (500 m, 2001-2011); Spring albedo RF (500 m, 2001-2011) (for fire events in regions studied)

Thoughts and hopes

- How can we change our language or "tweak" objectives and outcomes to better address AWFCG and Canadian research needs?
- How can we expand current objectives or sites to link better with active management needs?
- As we move towards phase II, what are the most important ecosystem services on which we should focus?
- Moving beyond fire: fuel management and fuelwood, thermokarst formation and thermal erosion, pests and pathogens, human-caused disturbance


Climate
Management
Fire
Soil organic layer
Vegetation
Animals
Permafrost
Hydrology

Thoughts and hopes

- How can we change our language or "tweak" objectives and outcomes to better address the AWFCG and Canadian research needs?
- How can we expand current objectives or sites to link better with active management needs?
- We are using gradients to infer impacts of a changing fire regime, but not measuring change. How can we move forward with this?
- What are the most important ecosystem services that we should be focusing on?
- We are missing links to fauna and hydrology…

Needs

- Randi: smoke modeling
- Fire behavior in different veg types
- Fuel management and biofuel harvest effects on permafrost integrity and successional trajectories
- Fire, lichen, caribou; fire-moose
- Tune up landfire
- Randi: how much purchase does fire management have on fire regime? How does this differ in tundra versus forest?

Science Objectives

- **Determine impacts of changing wildfire characteristics on ecosystem dynamics, including:**
  - Permafrost integrity and distribution
  - Plants, animals and microbes: key traits, diversity, distribution
  - Vegetation-hydrology interactions (and feedbacks on fire dynamics)
  - Carbon biogeochemistry and regional ecosystem carbon balance
  - Fish and wildlife habitat*
- **Determine impacts of changing wildfire characteristics on ecosystem services, including:**
  - ***Climate regulation at regional to global scales: energy and carbon balance***
  - Transportation: smoke impacts on aircraft; downed trees, thermokarst
  - Human health outcomes: smoke impacts on humans
  - Subsistence: changing moose vs caribou habitat distribution
  - Local communities, land management policies and practices: Fire management zone, fuels management treatments
  - Human decisions that feedback to fire and ecosystem services: fire management policy

- The ABoVE Campaign is (loosely) structured around resilience theory, so all projects in this working group focus on (or at least allude to) the task of identifying key sources of resilience in arctic-boreal systems: interactions and feedbacks that reinforce system-level recovery to historic state in the face of changing fire disturbance impacts.
- Similarly, projects seek to identify factors that are likely to push ecosystems beyond historic boundaries and drive state changes that have lasting impacts on local, regional, and even the global land-atmosphere system.

Science Questions

- **What processes are contributing to changes in fire disturbance regimes and what are the impacts of these changes?**
- **How are flora** and fauna **responding to changes in *fire impacts*, and what are the impacts on ecosystem structure and function?**
- **How are the magnitudes,** fates, **and land-atmosphere exchanges of carbon pools responding to *fire impacts*, and what are the biogeochemical mechanisms driving these changes?**
- **How does wildfire activity impact the distribution and properties of permafrost and what are the impacts of these changes?**
- **What are the causes and consequences of changes in the hydrologic system, specifically the amount, temporal distribution, and discharge of surface and subsurface water?**
- **How are *changes in fire characteristics* affecting critical ecosystem services, and how are human societies responding?**

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