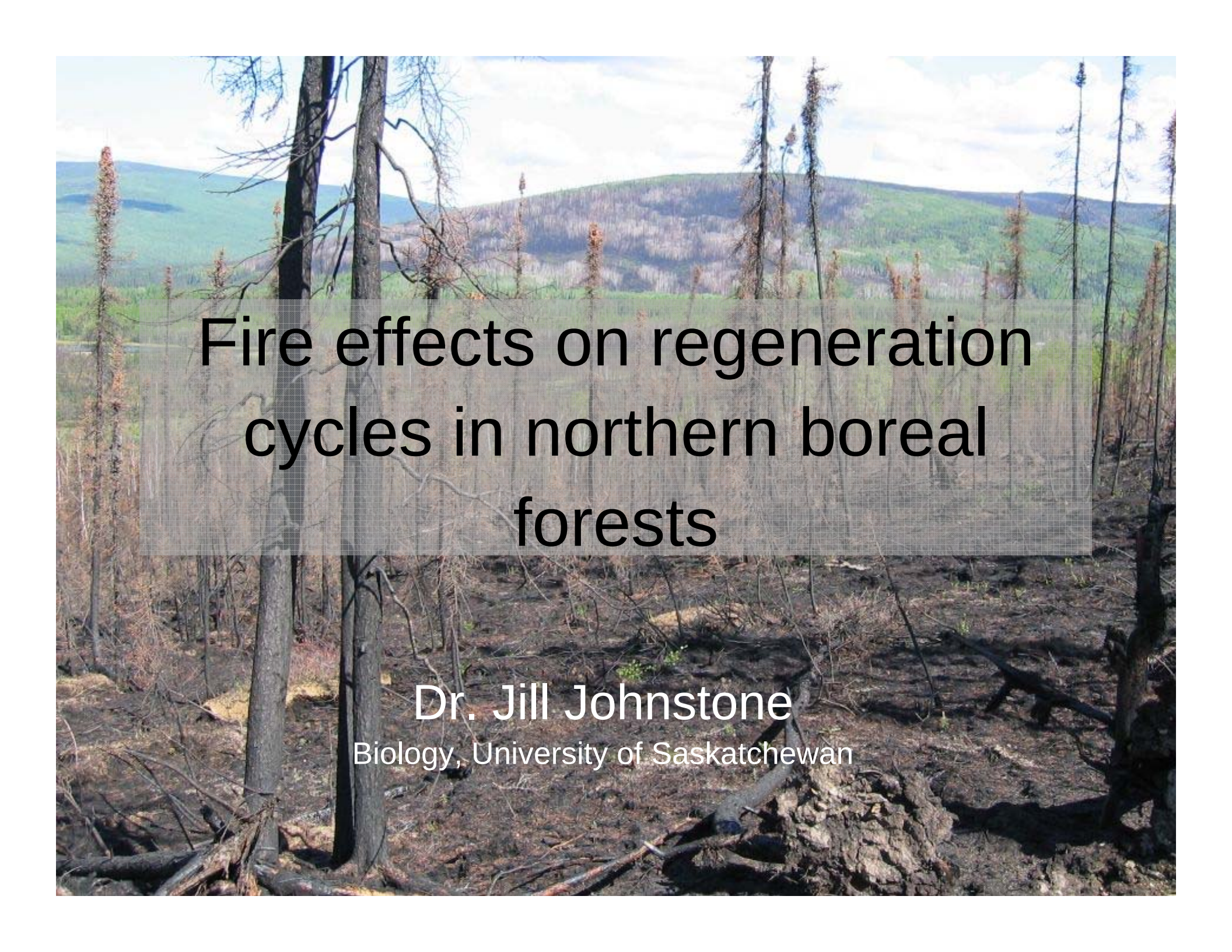




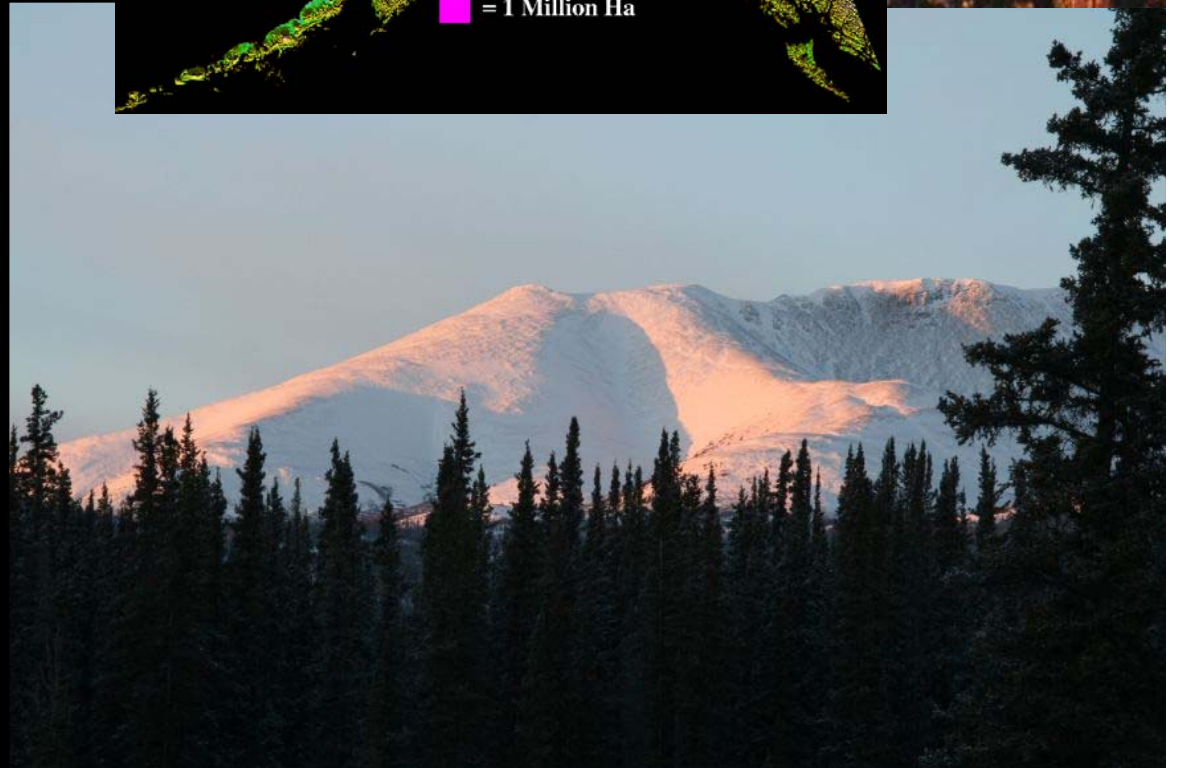
Fire effects on regeneration cycles in northern boreal forests

Dr. Jill Johnstone

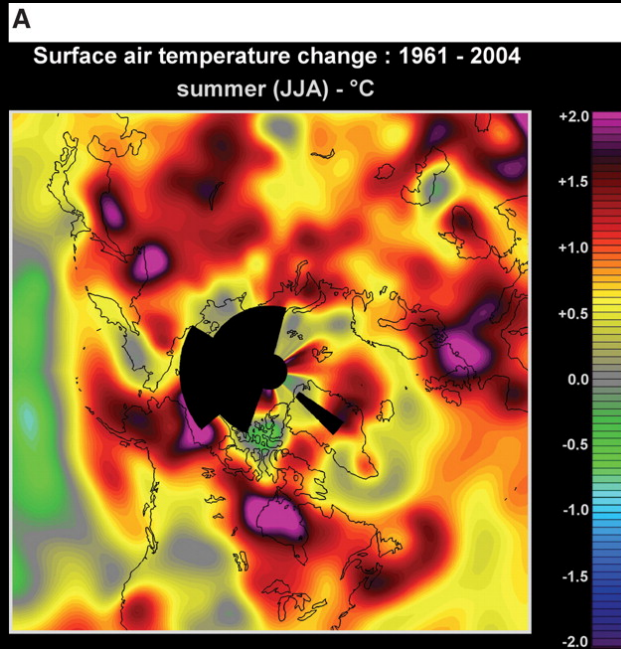
Biology, University of Saskatchewan

Northern boreal forest

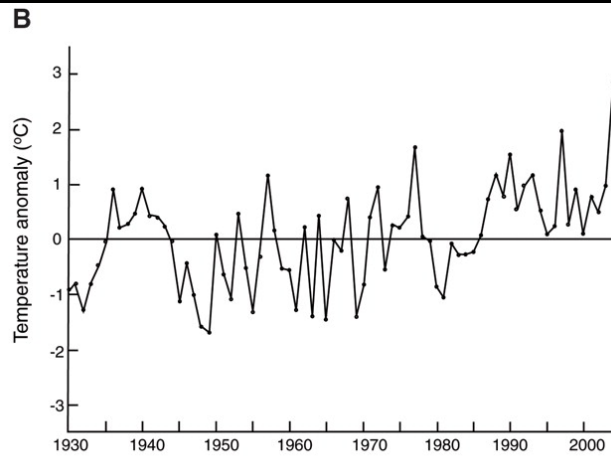
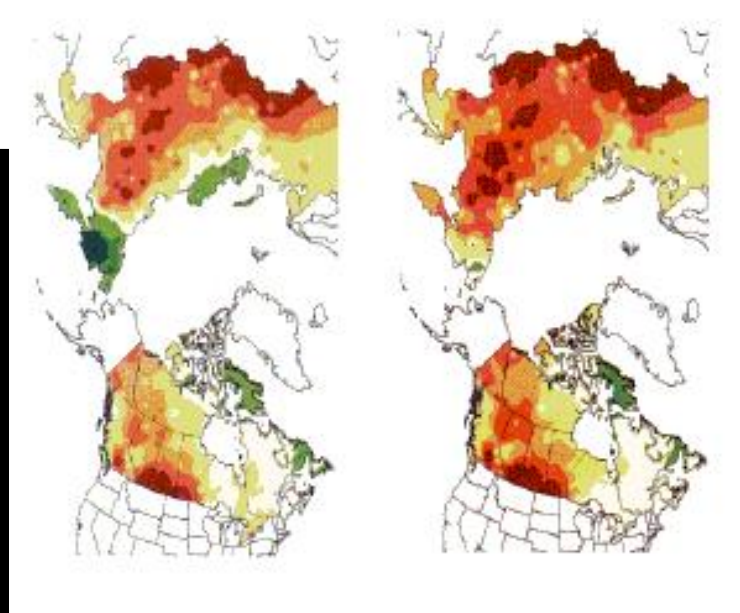
- Conifer dominated
- Cool soils, slow growth & decomposition
- Widespread fire disturbance



Fire and Global Change



Chapin *et al.* 2005

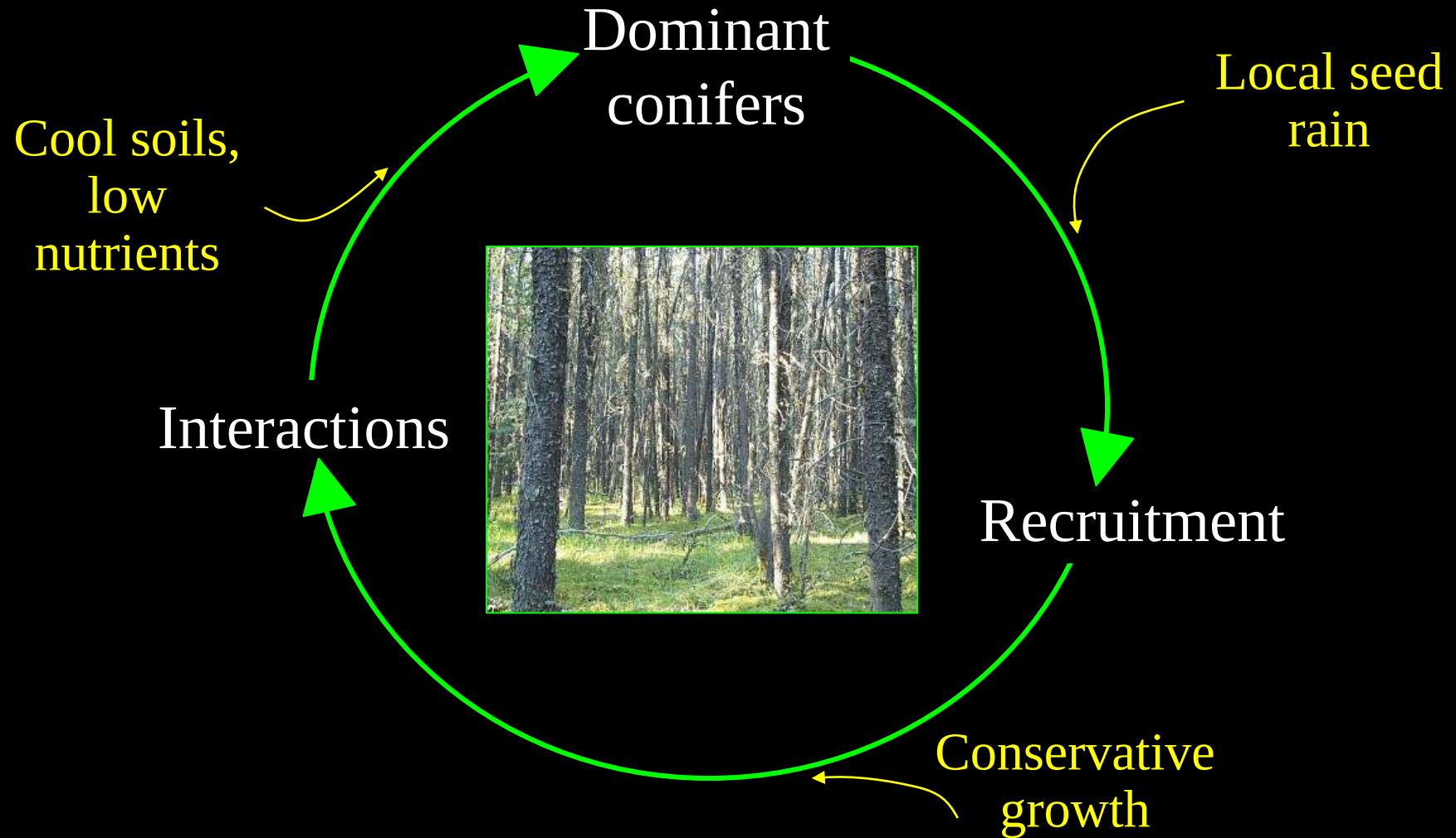


Stocks *et al.* 1998

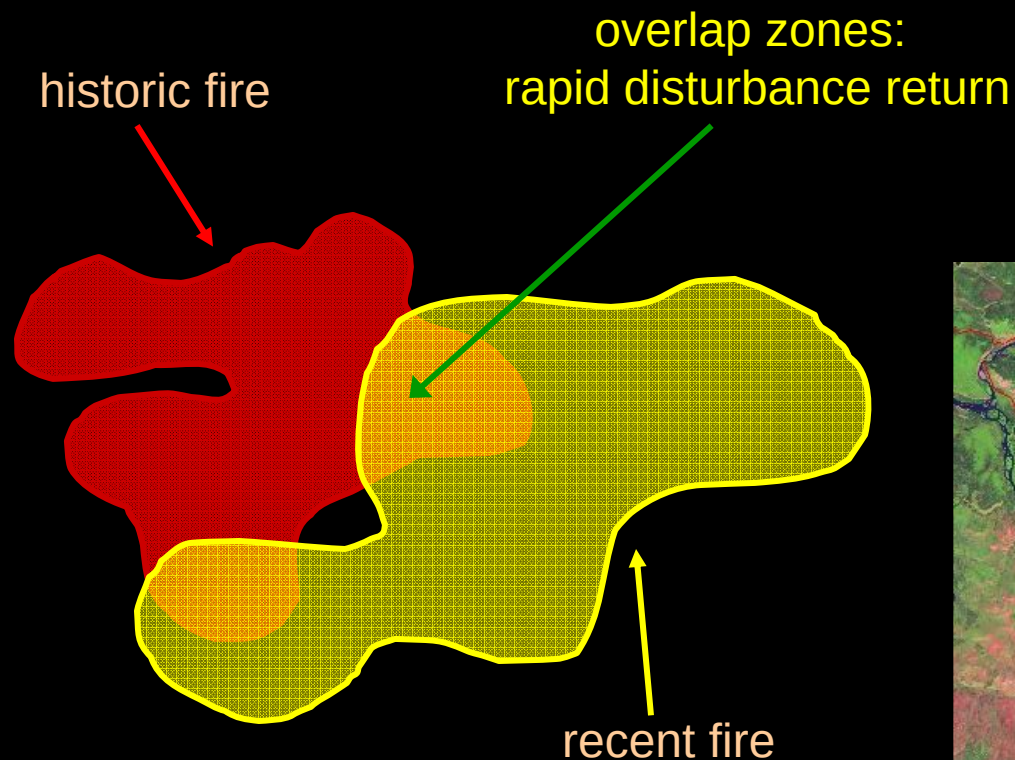
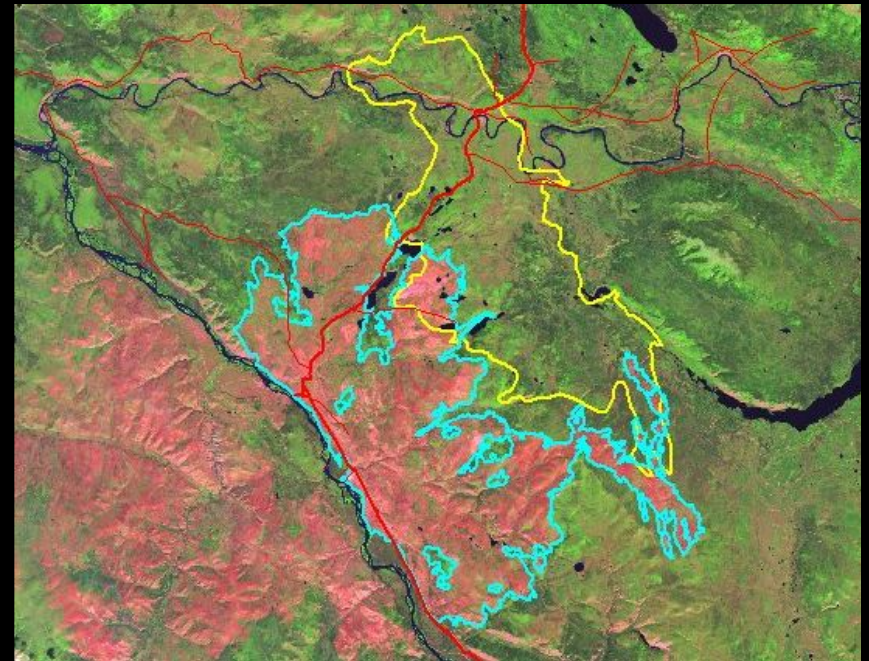
How are changing fire regimes likely to alter forest dynamics?



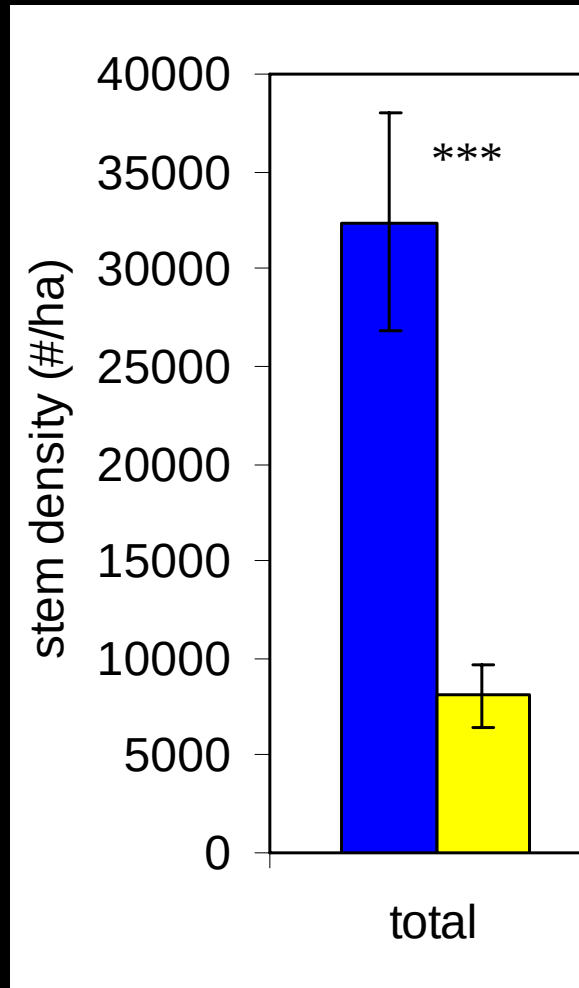
Regeneration Feedbacks



Studies of fire frequency using overlapping fires



Repeat fires alter tree regeneration



Johnstone & Chapin (2006) *Ecosystems* 9: 268-277.

Effects of fire frequency

- Short fire intervals can short-circuit conifer regeneration pathways
- Plant types that regenerate by resprouting are strongly favored
- Net effect is to shift trajectories to increased deciduous dominance



A photograph showing the aftermath of a forest fire. The ground is covered in dark, charred soil and ash. Several young, bright green coniferous seedlings are growing in the foreground. In the background, there are taller, reddish-brown plants, possibly shrubs or small trees, some of which are marked with yellow flags. A semi-transparent black box with white text is overlaid in the center of the image.

Fire severity and forest regeneration

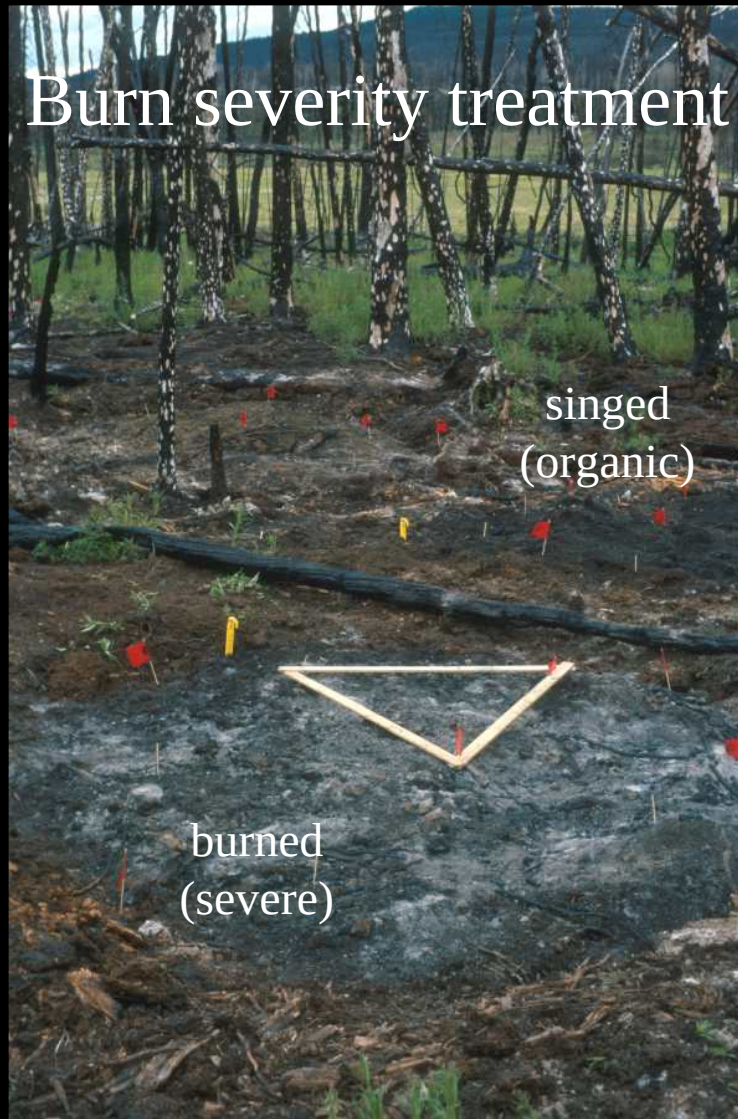
Fire severity affects seedbed quality



Burning of organic soils influences patterns of post-fire recruitment

Patch-scale Experiments

Burn severity treatment

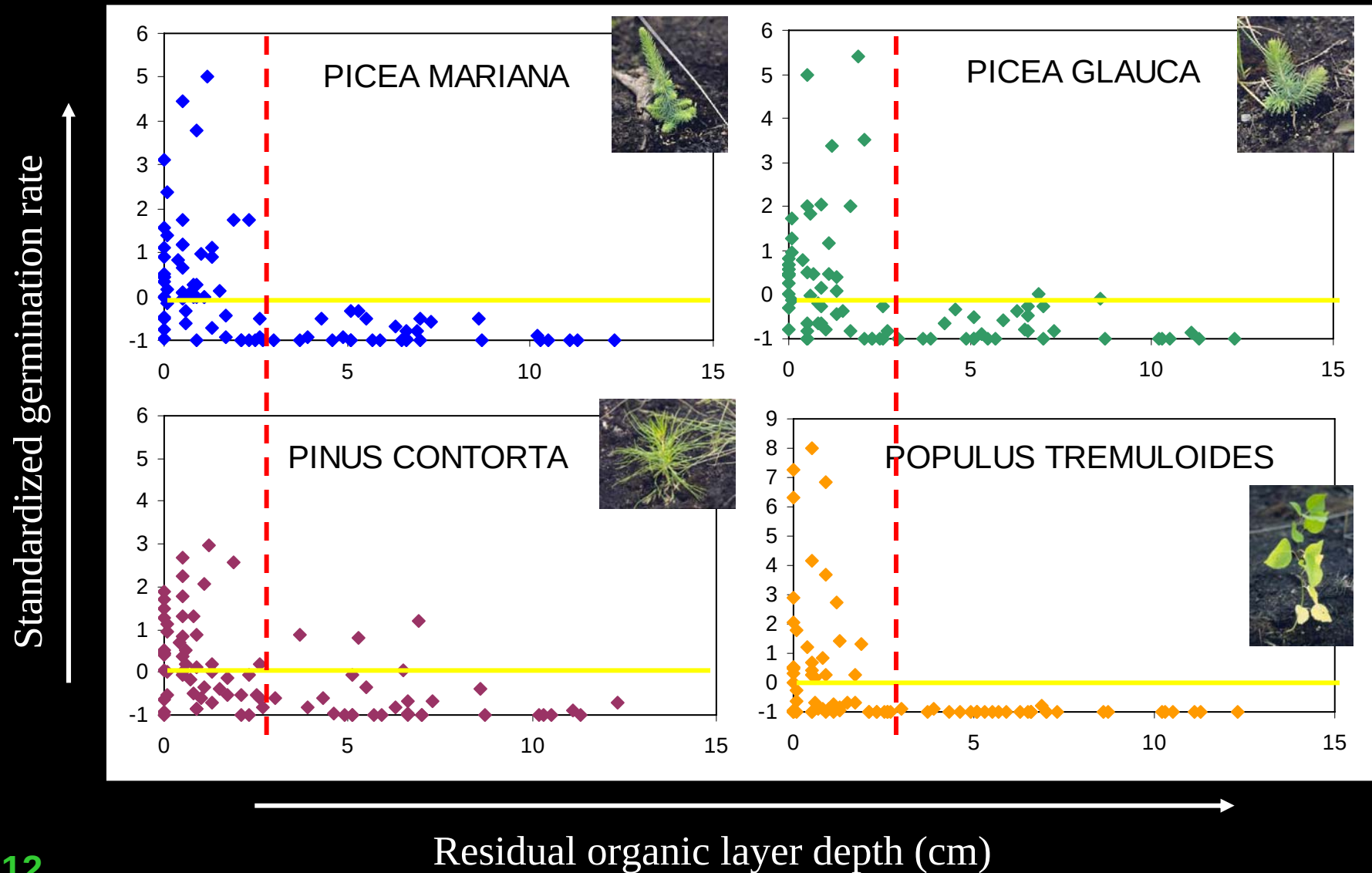


Seeds & Seedlings of:

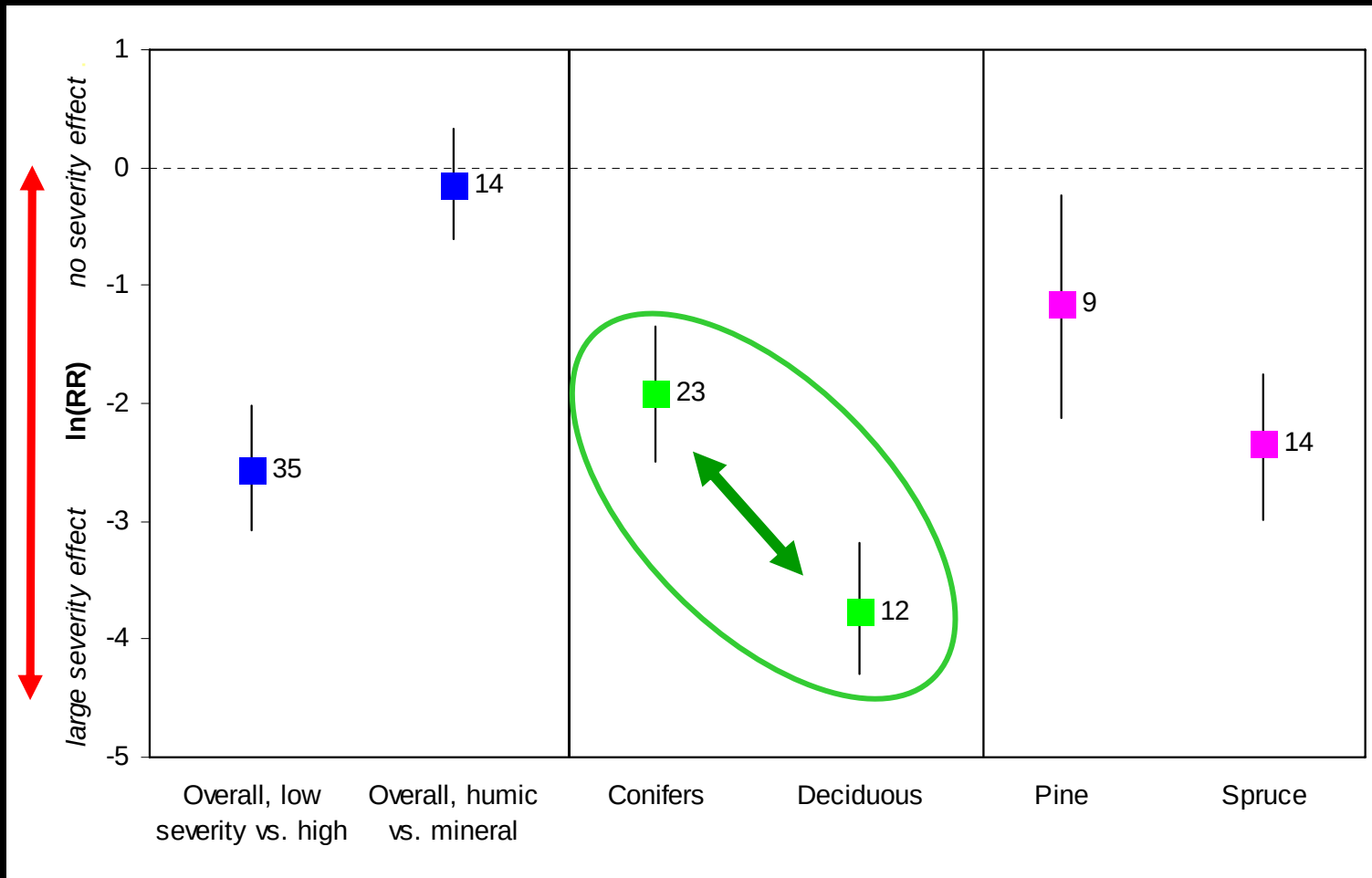
- *Pinus contorta* (lodgepole pine)
- *Picea glauca* (white spruce)
- *Picea mariana* (black spruce)
- *Populus tremuloides* (aspen)



Recruitment declines with increased organic depth



Meta-analysis shows species differ in sensitivity to severity



Patch effects of fire severity

Low severity (organic)

- Poor seedbeds
- Recruitment requires high seed inputs
- Strongly favors conifers



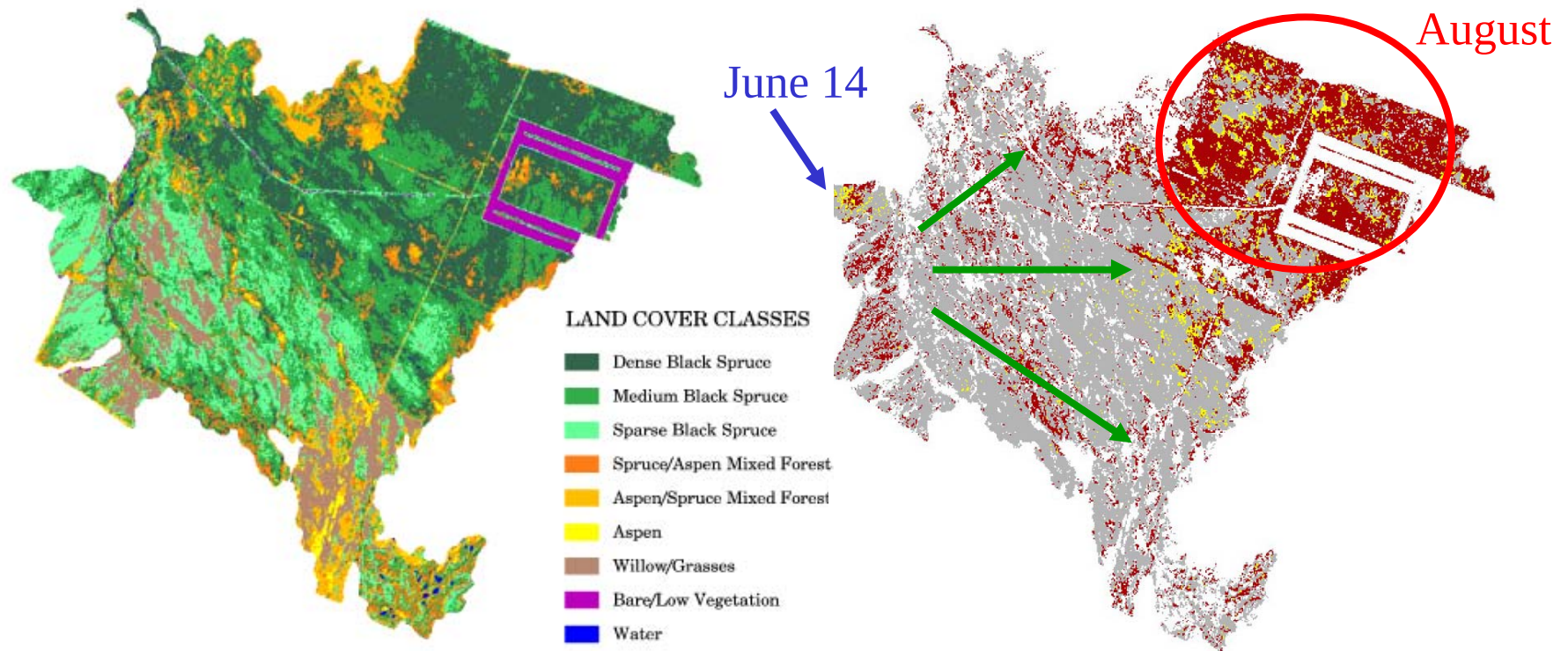
High severity (mineral)

- Higher quality seedbeds
- Creates opportunity of deciduous establishment

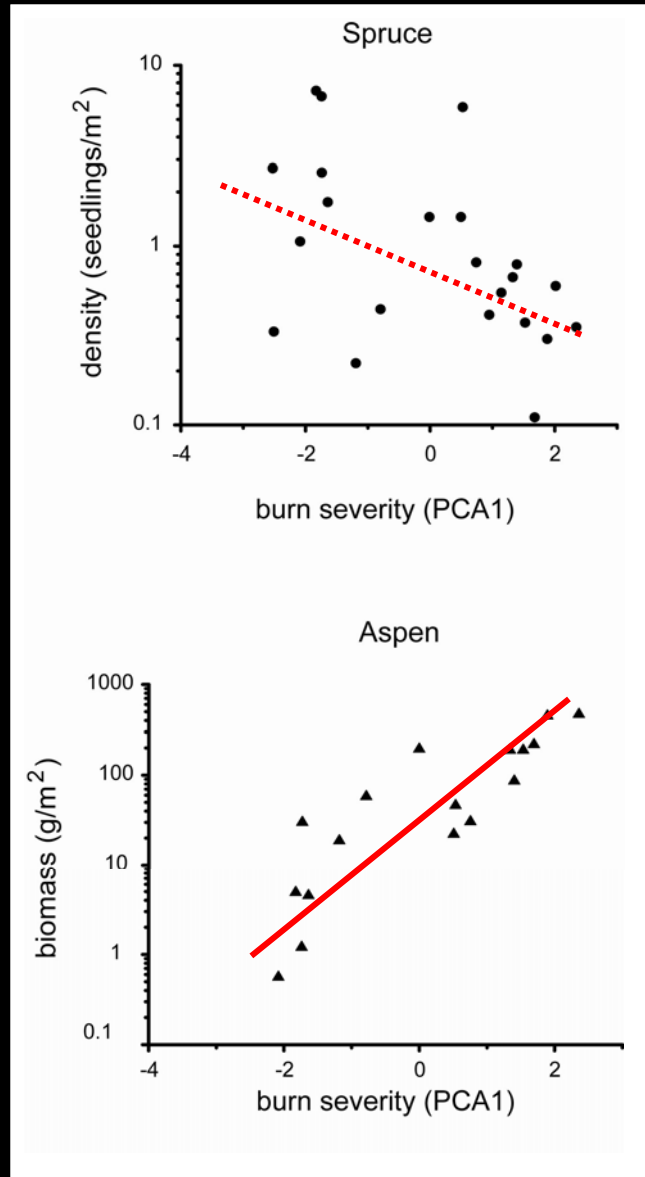


Scaling up: From small
plots to a single wildfire

Natural variations in fire severity: 10,000 ha burn in interior Alaska



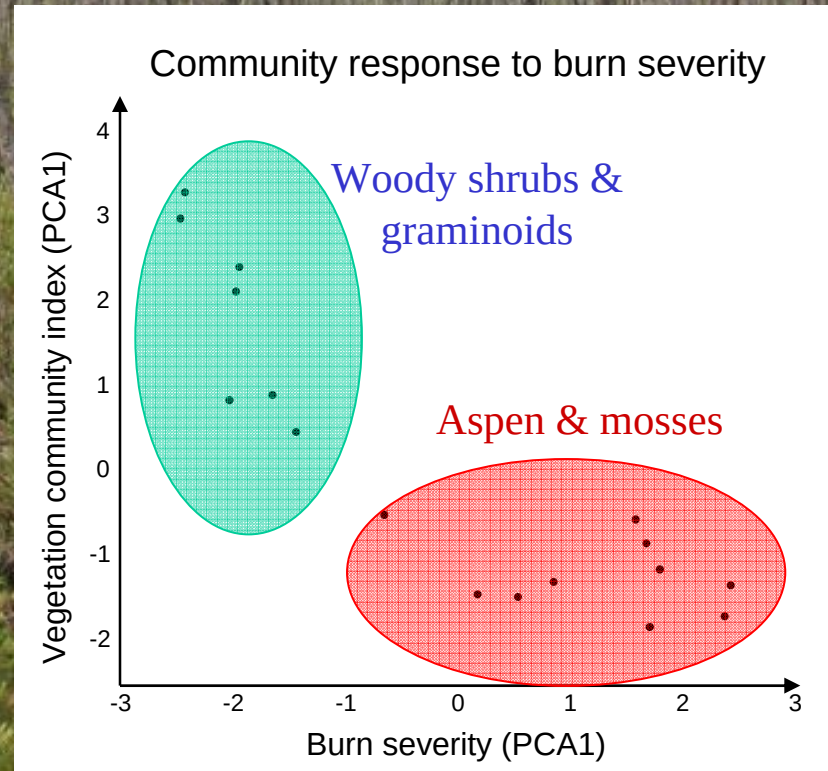
Johnstone & Kasischke (2005) *Can. J. For. Res.* 35: 2151-2163.



Tree seedling responses

- Spruce
 - Weak negative response
- Aspen
 - Contrary to experiments
 - Strong positive response
 - Consistent with experiments

Community responses

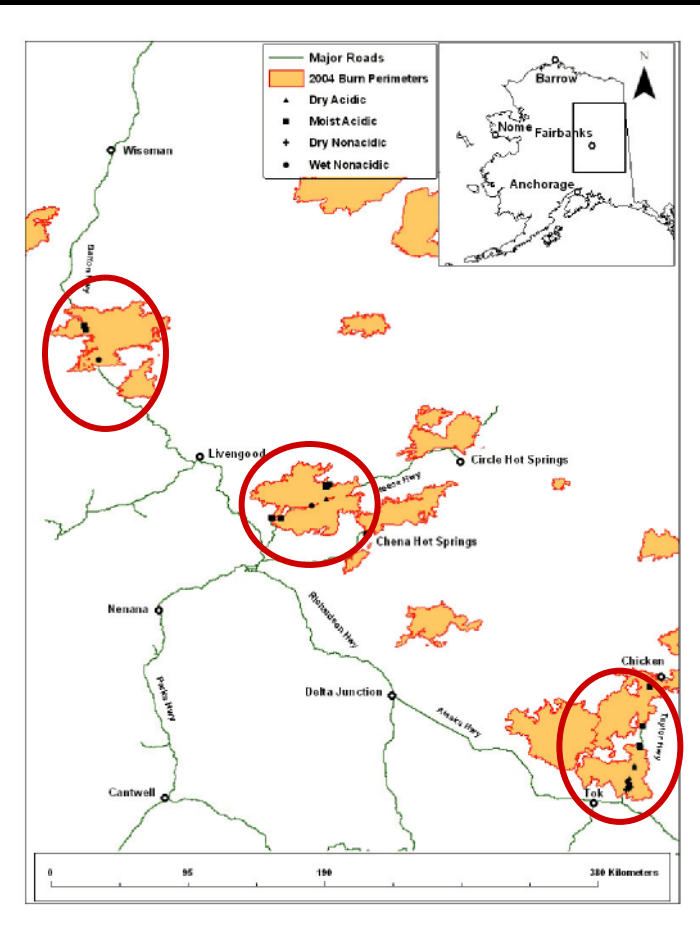


Scaling fire severity effects to large landscapes



Interior Alaska

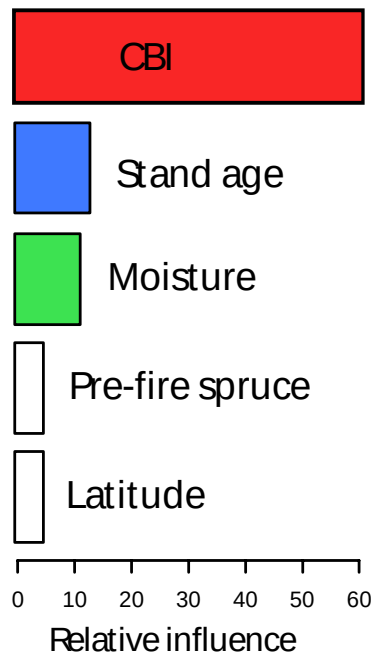
- Widespread 2004 fires
- 3 fire complexes
- 90 black spruce sites





- **Environmental conditions**
 - Site moisture
 - Elevation
 - Potential insolation
- **Pre-fire stand structure**
 - Stem density
 - Stem basal area
 - % Standing after fire
- **Fire severity**
 - Canopy consumption
 - Composite Burn Index (CBI)
 - Post-fire organic layer depth
- **Post-fire recruitment**
 - Tree seedling density
 - 4 years post-fire

Spruce dominance of seedling regeneration



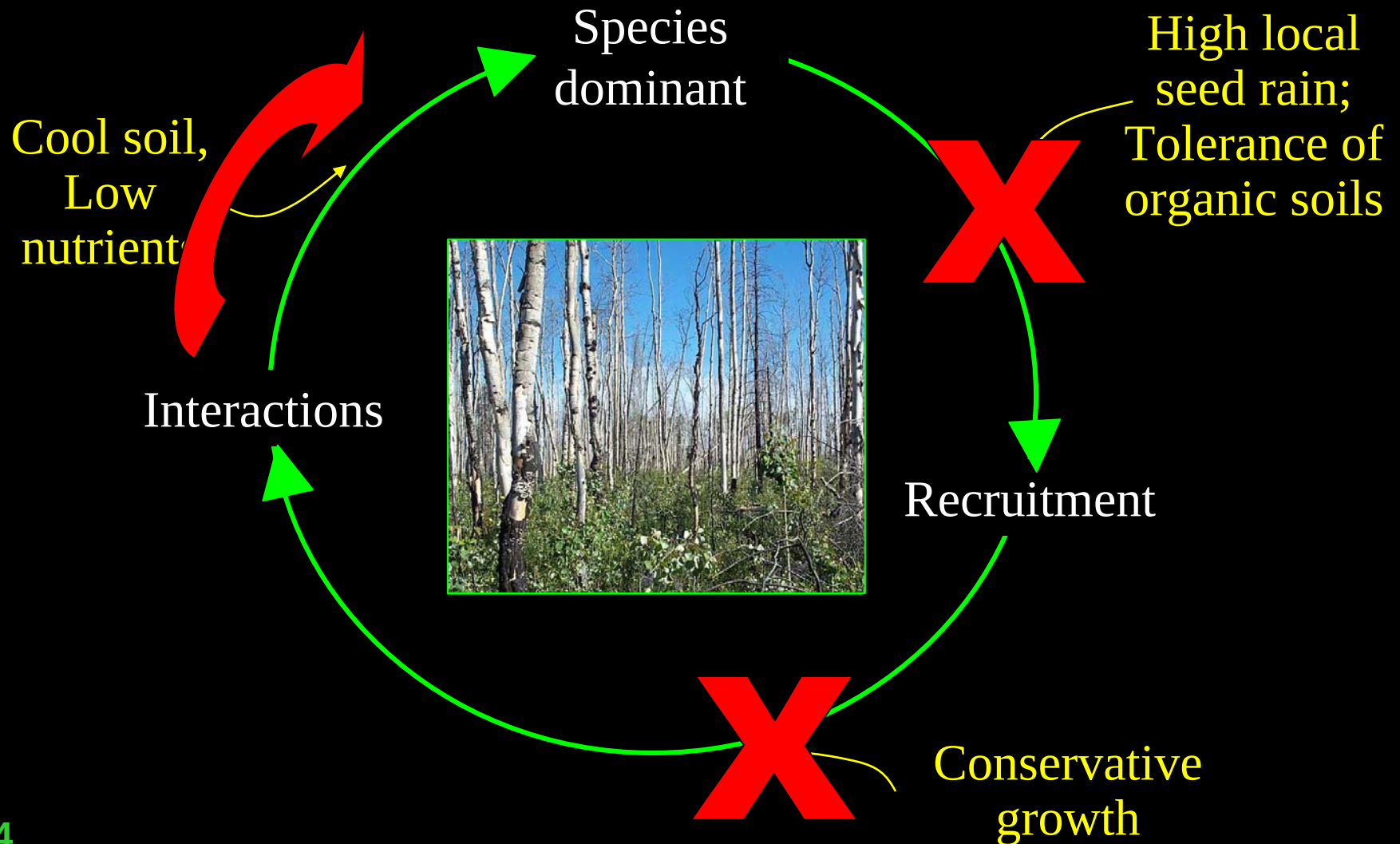
Boosted regression tree model (n=90, prediction error=0.42)

Spruce resilience reduced when:

- Fires consume the organic layer
 - Reduces BS reproductive advantage
- Fires burn after a short interval
 - Insufficient seed availability
- Sites are well drained
 - Severe fires more likely
 - Warm, dry soils favor aspen growth
 - Permafrost thaw -> drainage changes
- Loss of resilience can tip regeneration balance away from black spruce



Regeneration Feedbacks & Changing Fire Regime



Potential feedbacks to fire behavior: ALFRESCO simulation model

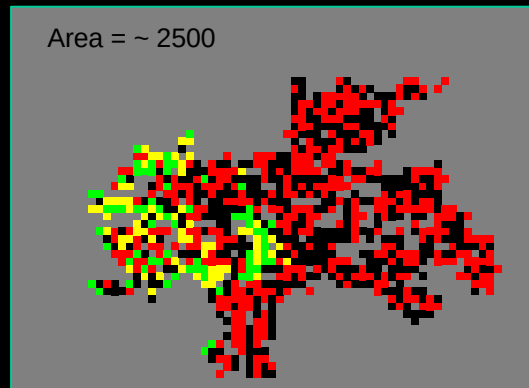
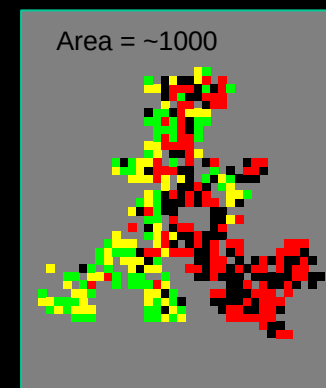
- Succession modeled as a function of fire severity
- Fire severity increases with fire size
- 3 Severity Scenarios:
 - Low (LSS): All fires burn with low severity (spruce replacement)
 - High (HSS): Maximum plausible extent of high severity (mixedwoods)
 - Mix: Intermediate proportion of high and low severity

KEY:

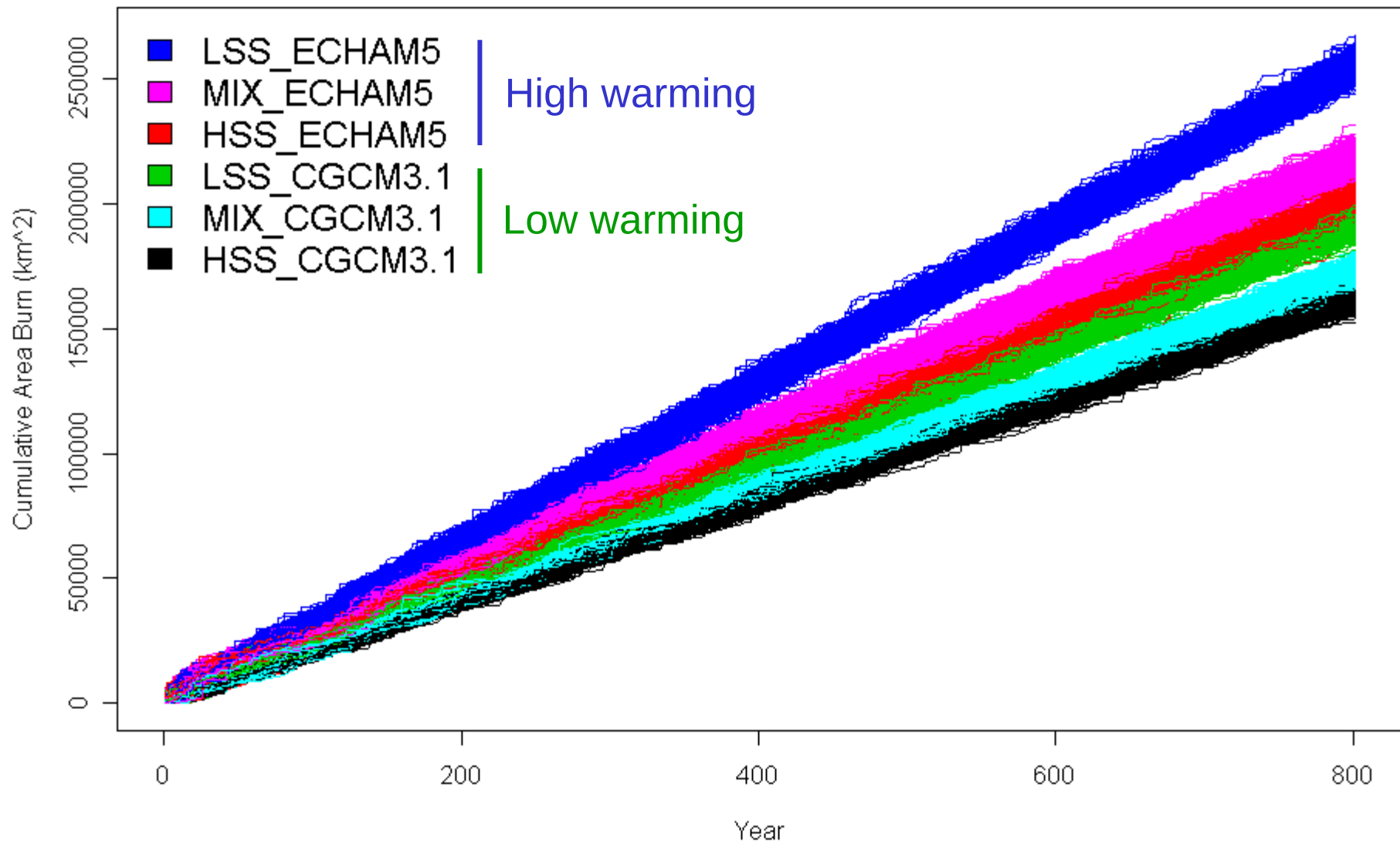
Green & Yellow = Low Sev.

Red = High Sev. in HSS

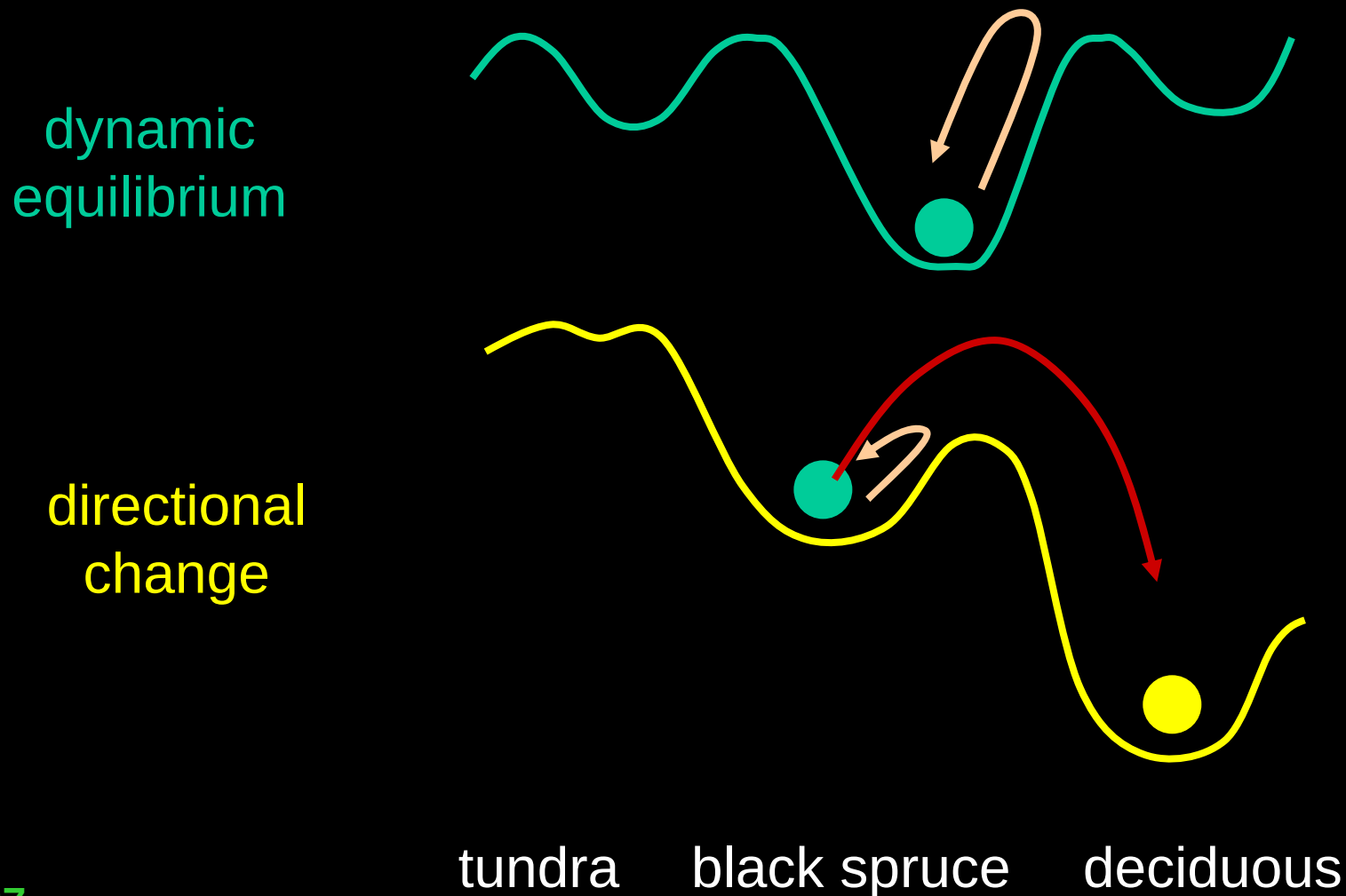
Black = High Sev. in Mix + HSS



Cumulative area burned under different climate and severity scenarios



Disturbance & climate interact to alter black spruce resilience



Conclusions

- Fire is both catalyst and driver of change
 - Critical & sensitive post-fire window
 - Both frequency and severity have critical effects
- Landscape context => vulnerability to change
 - Understanding the drivers of resilience is key to predicting future change



Thank You!

Collaborators:

Terry Chapin

Teresa Hollingsworth

Scott Rupp

Eric Kasischke

Michelle Mack



Bonanza
Creek

