Early results from the Anaktuvuk River fire: How similar are the Arctic and boreal forest?

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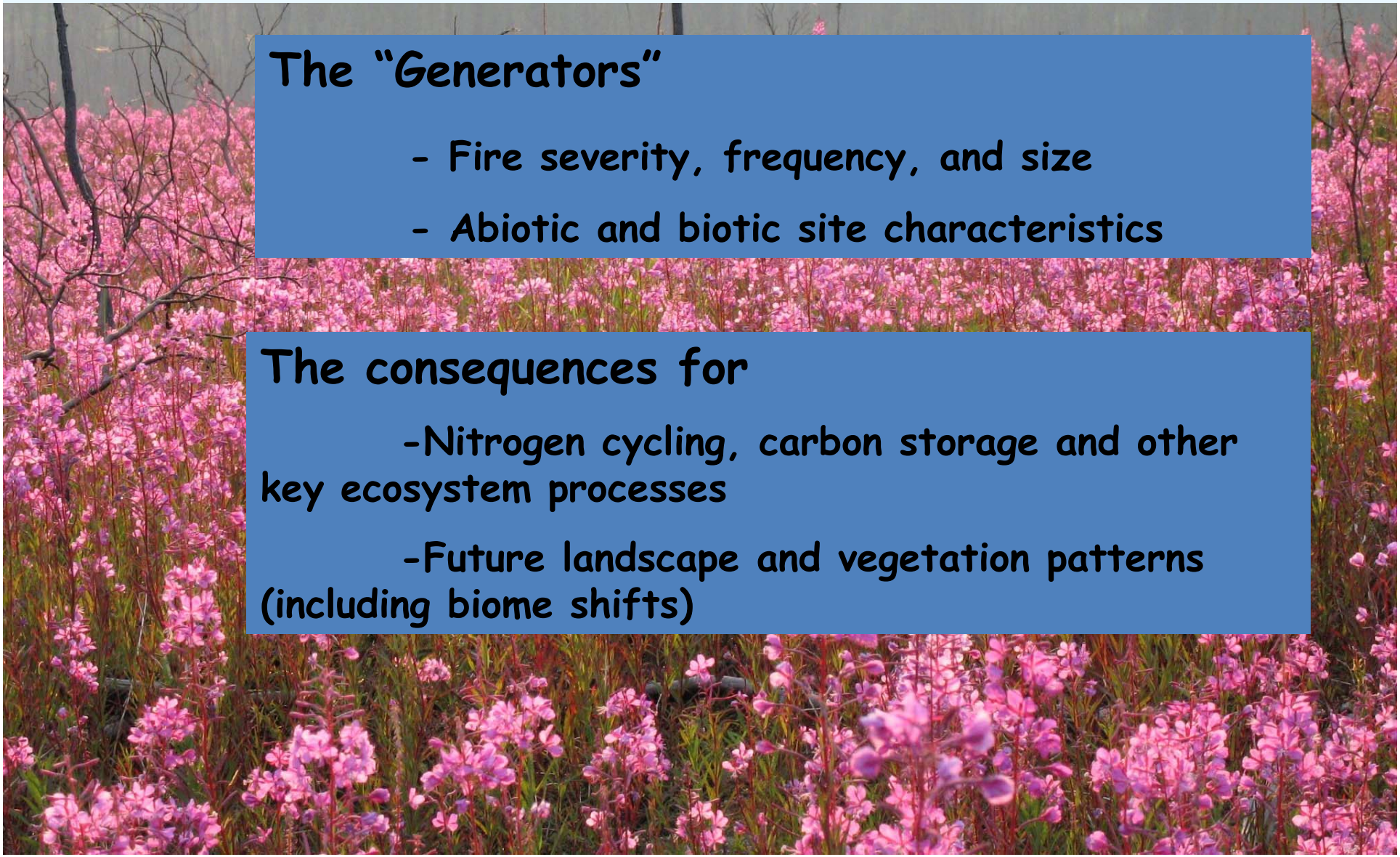
The patterns and consequences of post-fire successional trajectories in Alaska's boreal forest



The "Generators"

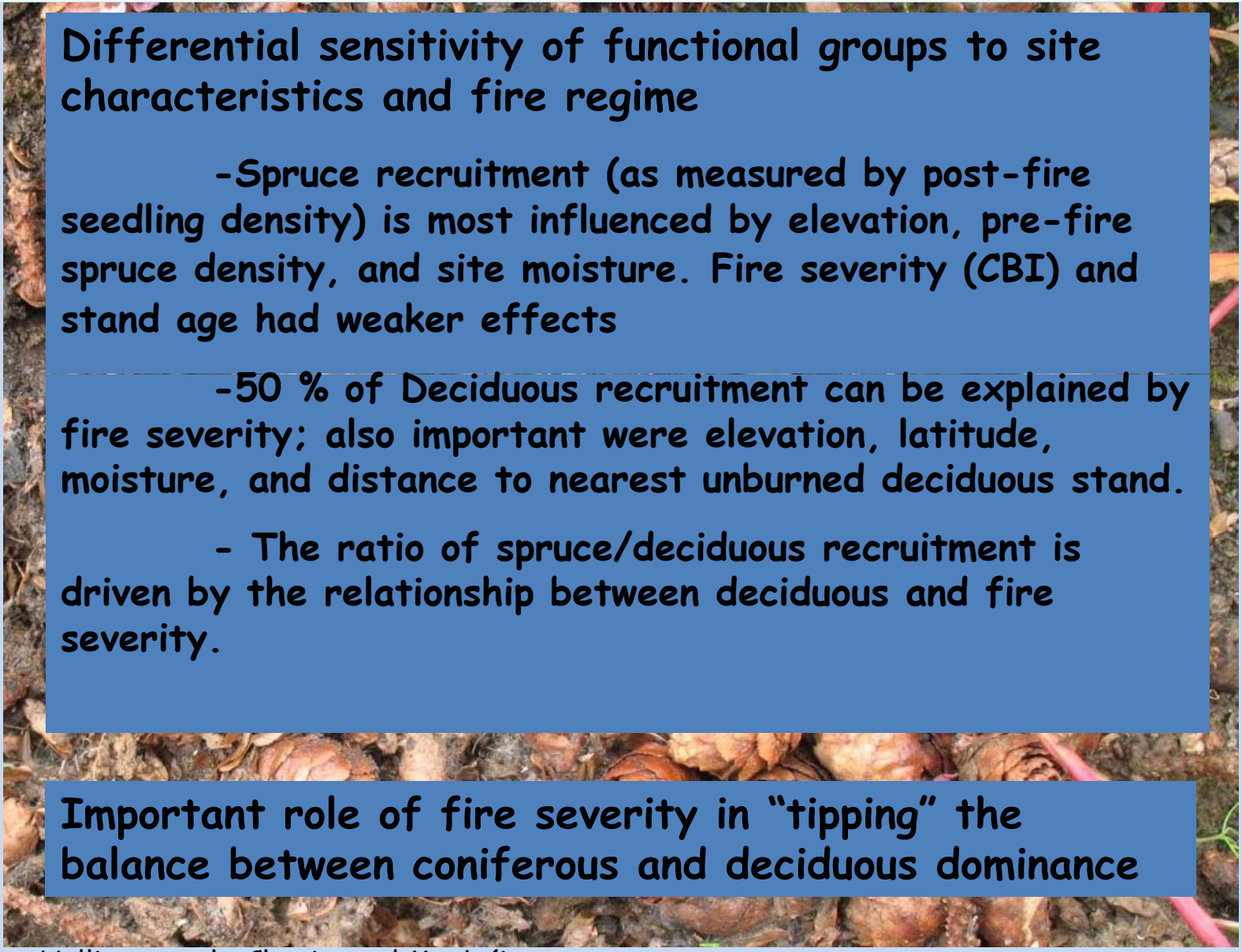
- Fire severity, frequency, and size
- Abiotic and biotic site characteristics

The consequences for

-Nitrogen cycling, carbon storage and other key ecosystem processes

-Future landscape and vegetation patterns (including biome shifts)

What drives natural post-fire seedling recruiment?



Differential sensitivity of functional groups to site characteristics and fire regime

-Spruce recruitment (as measured by post-fire seedling density) is most influenced by elevation, pre-fire spruce density, and site moisture. Fire severity (CBI) and stand age had weaker effects

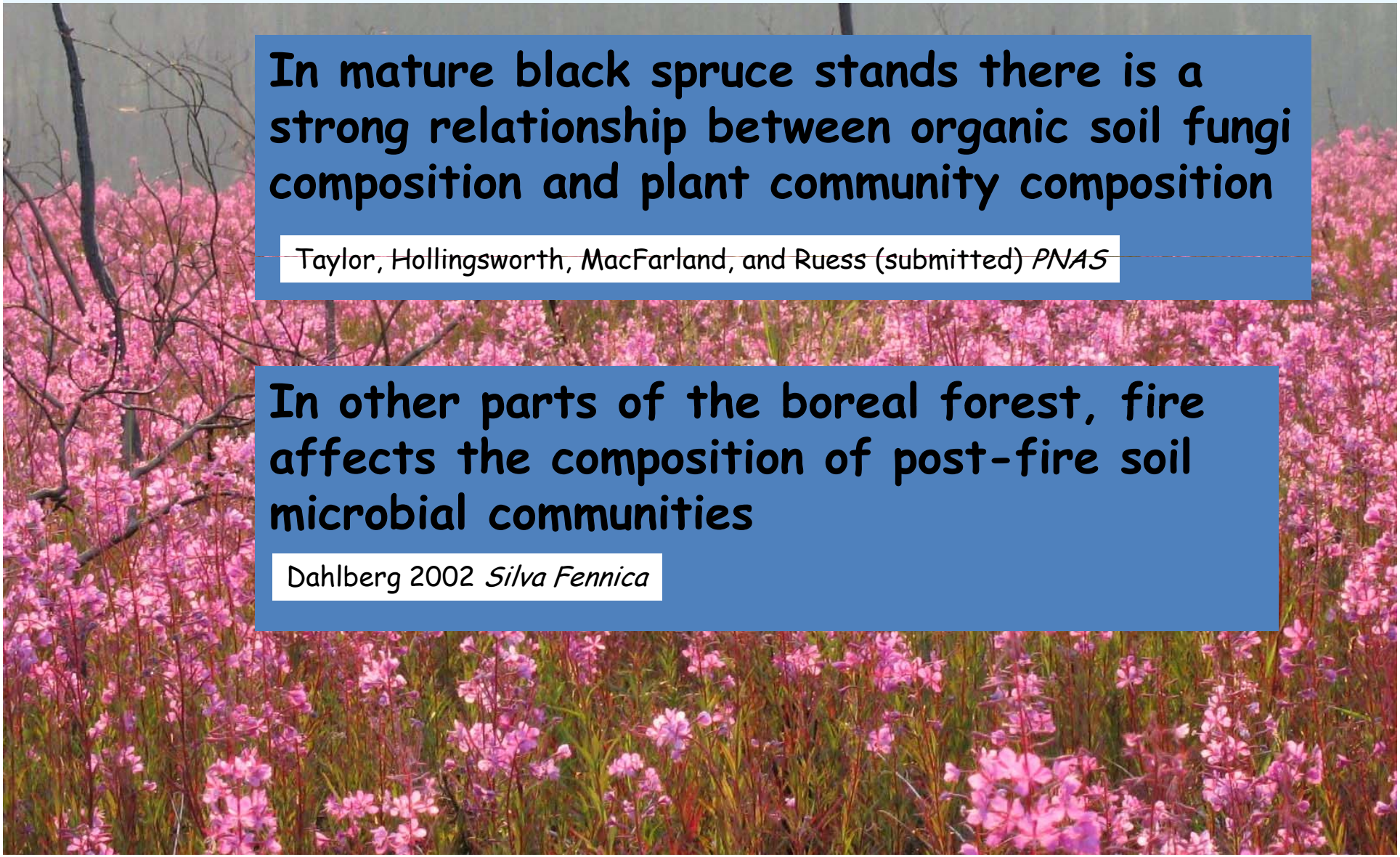
-50 % of Deciduous recruitment can be explained by fire severity; also important were elevation, latitude, moisture, and distance to nearest unburned deciduous stand.

- The ratio of spruce/deciduous recruitment is driven by the relationship between deciduous and fire severity.

Important role of fire severity in "tipping" the balance between coniferous and deciduous dominance

Johnstone, Hollingsworth, Chapin, and Mack (in revision) *Global Change Biology*

Linking soil microbial symbionts to above-ground community composition



In mature black spruce stands there is a strong relationship between organic soil fungi composition and plant community composition

Taylor, Hollingsworth, MacFarland, and Ruess (submitted) *PNAS*

In other parts of the boreal forest, fire affects the composition of post-fire soil microbial communities

Dahlberg 2002 *Silva Fennica*

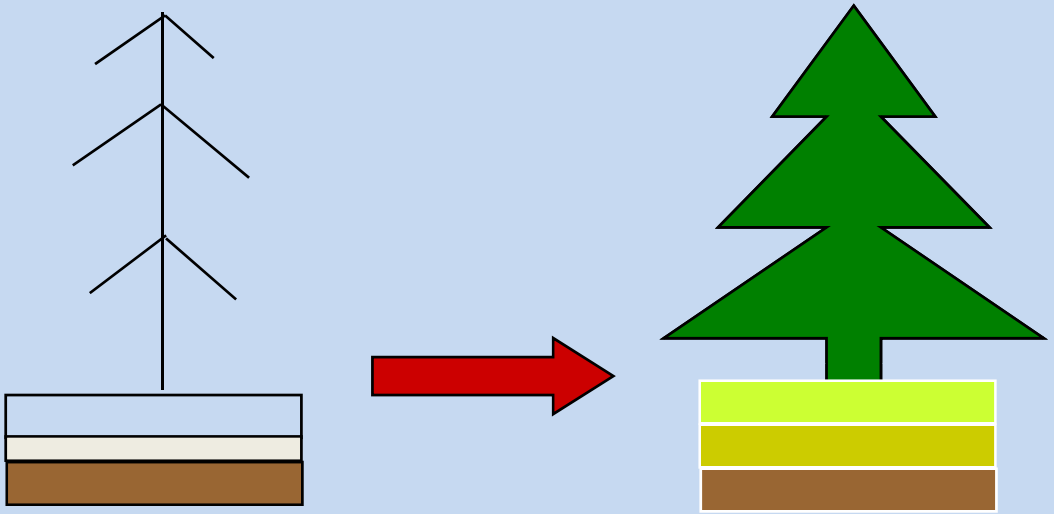
Calculating soil N loss

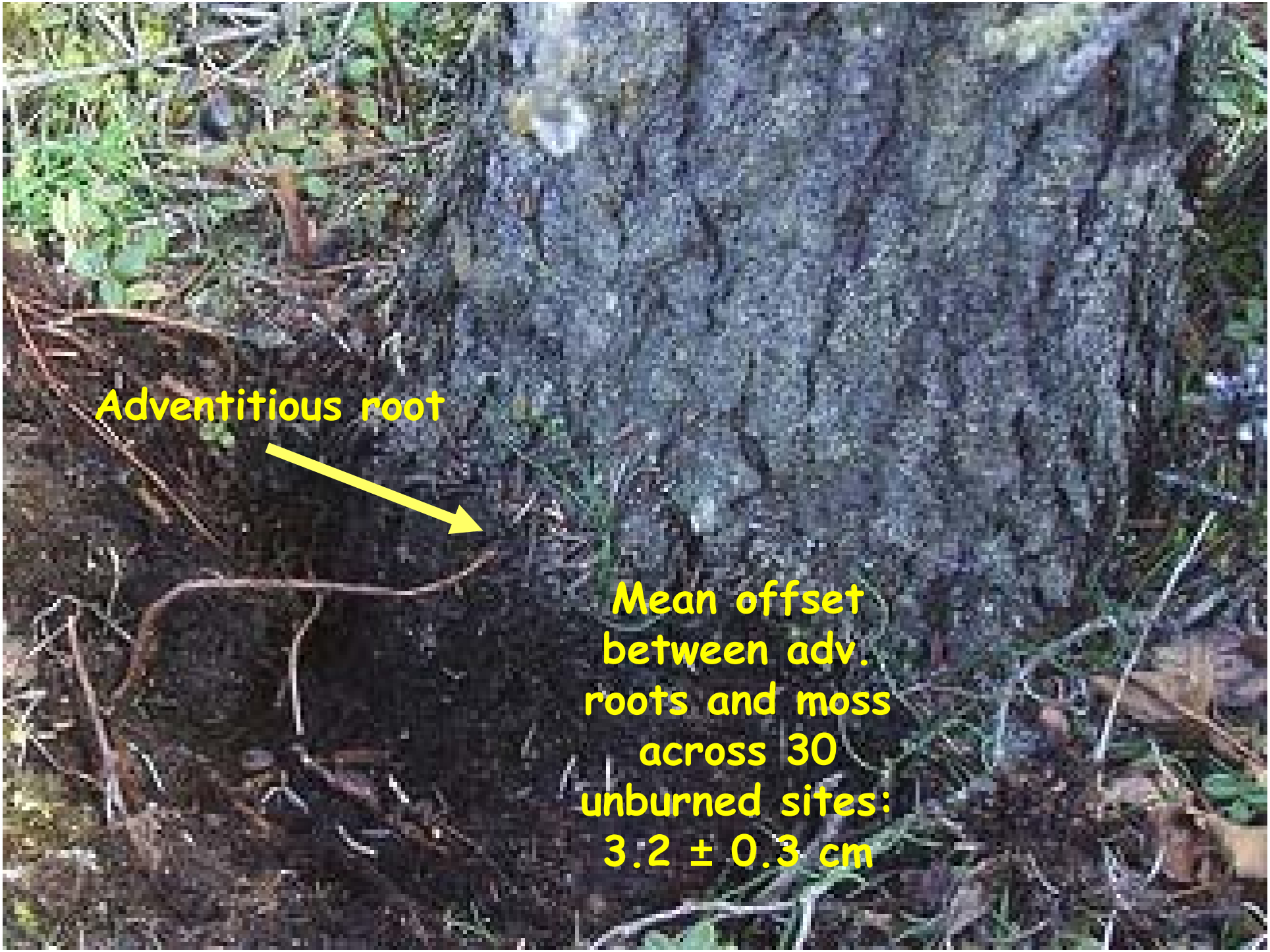
Net **loss of N from forest floor/organic soil =**

Pre-fire forest floor N pool - Remaining N pool

[+ Ash from plants and upper layers]

[- Leaching, erosion, gaseous loss]



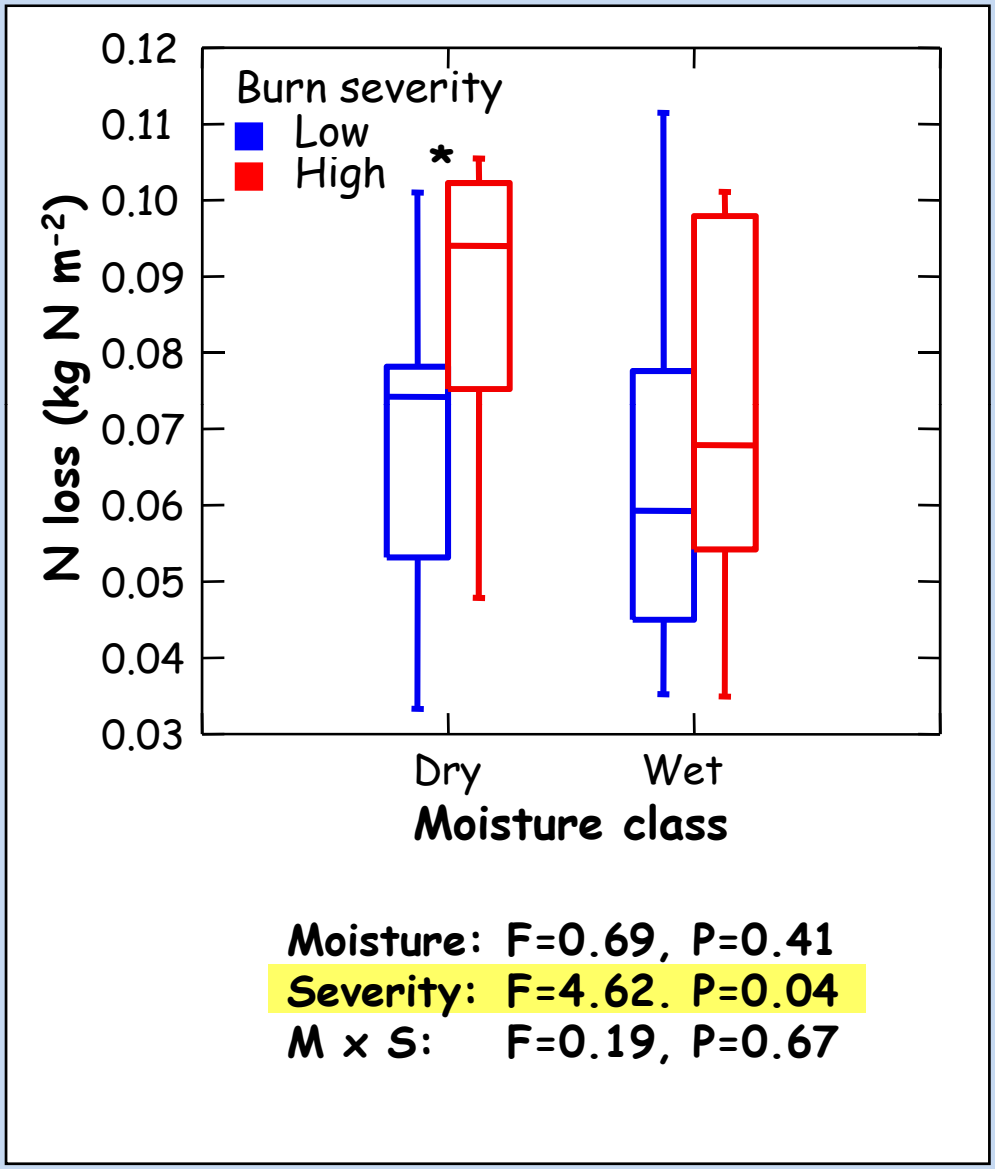

Adventitious root
Mean offset between adv. roots and moss across 30 unburned sites: 3.2 ± 0.3 cm

Residual organic soil depth, bulk density and [N]

N pool in missing layers = root collar depth x empirical relationships derived from unburned stands

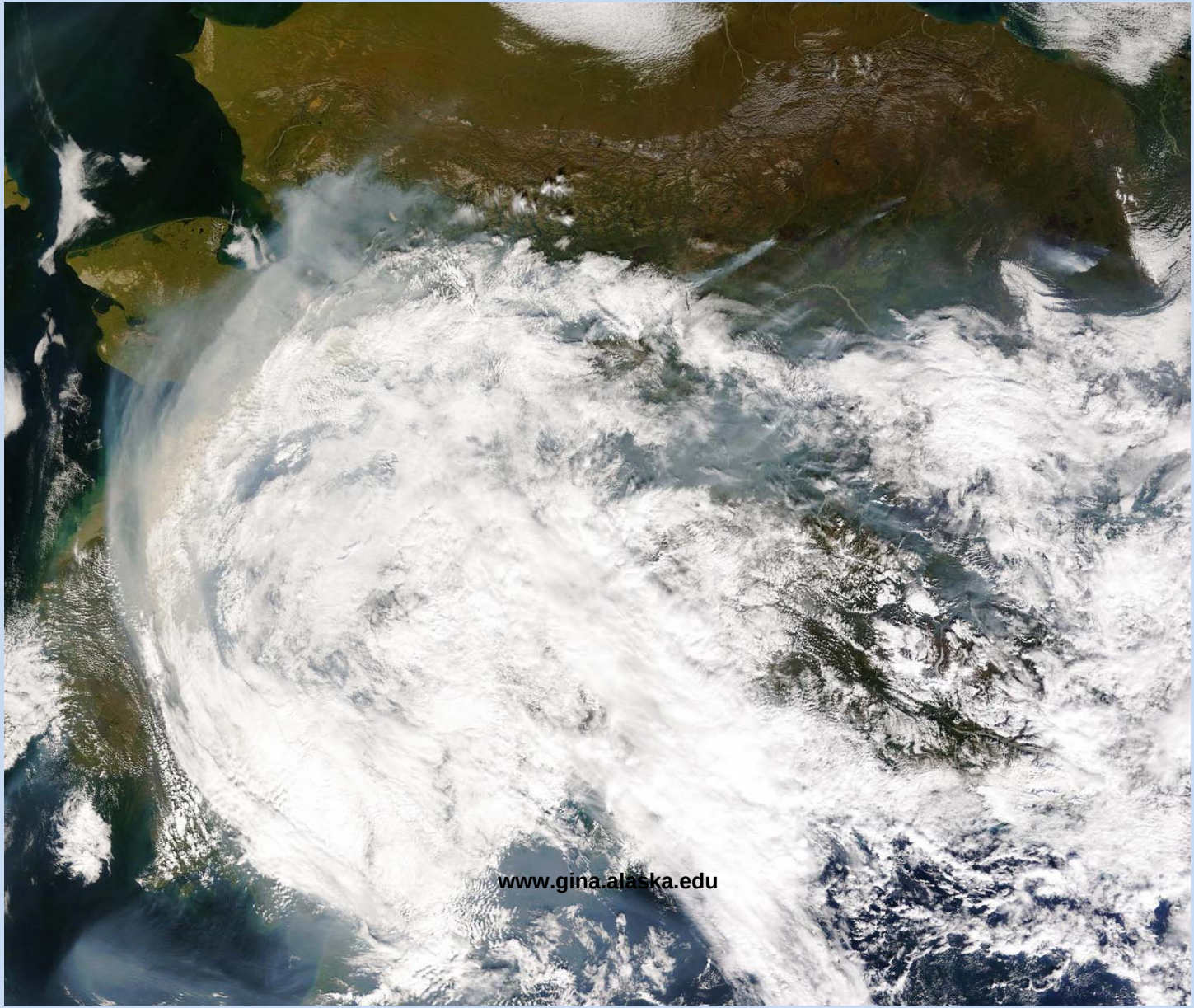
Adventitious root collar to burned soil = depth of organic matter combusted

Soil organic N loss across sites in the boreal forest



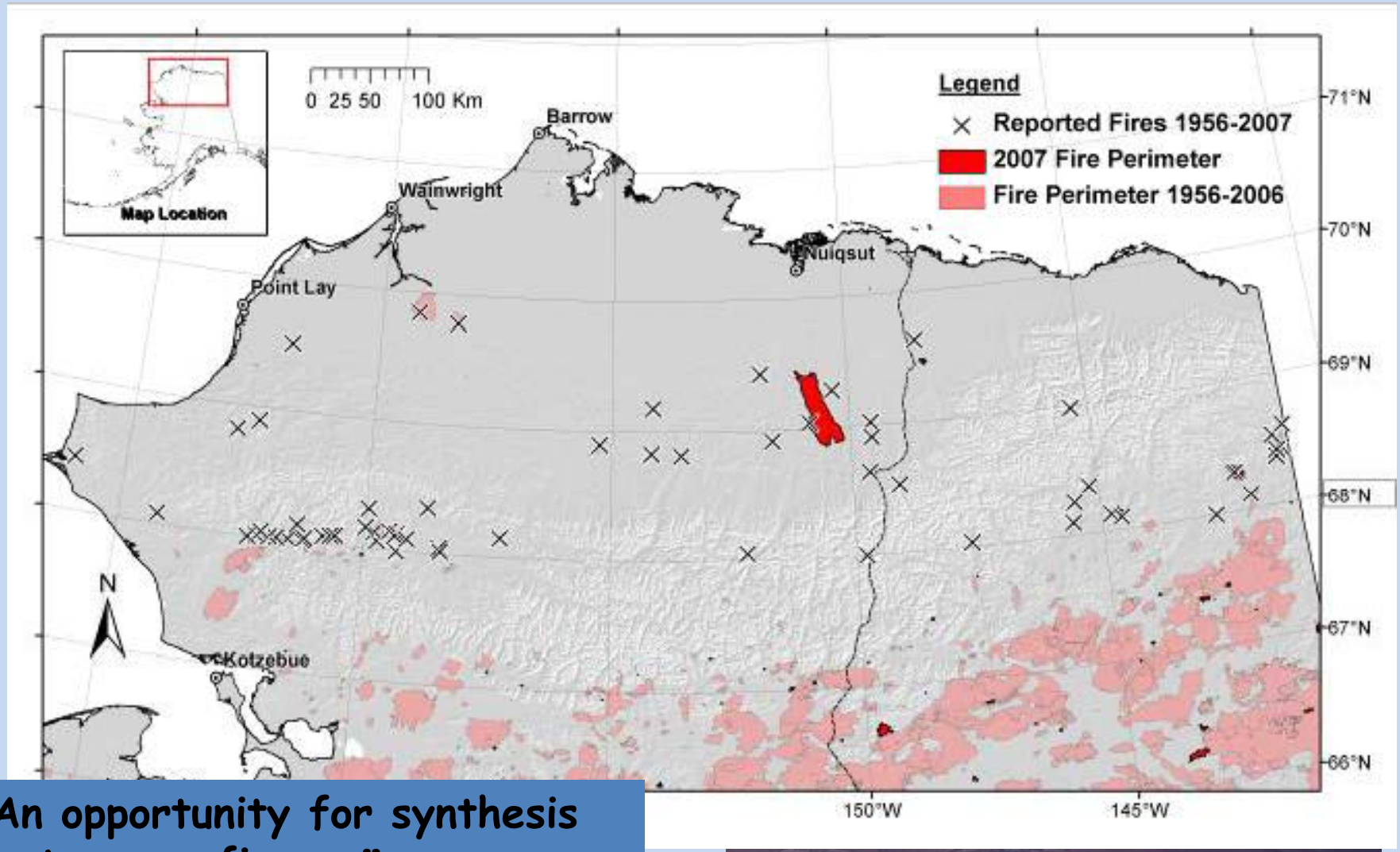
- **Mean =80 ± 4 g·N m^{-2}**
- 1-94 % of pre-fire organic layer N pool
- N inputs are low
  - Alder fixation max.
  - Lichen/moss norm. (<0.1 g·N m^{-2} yr^{-1})
- Mean stand age: 94 ± 5.4 yrs
- Mining N? Alder inputs? Occult N?

Comparing the boreal forest to the Arctic



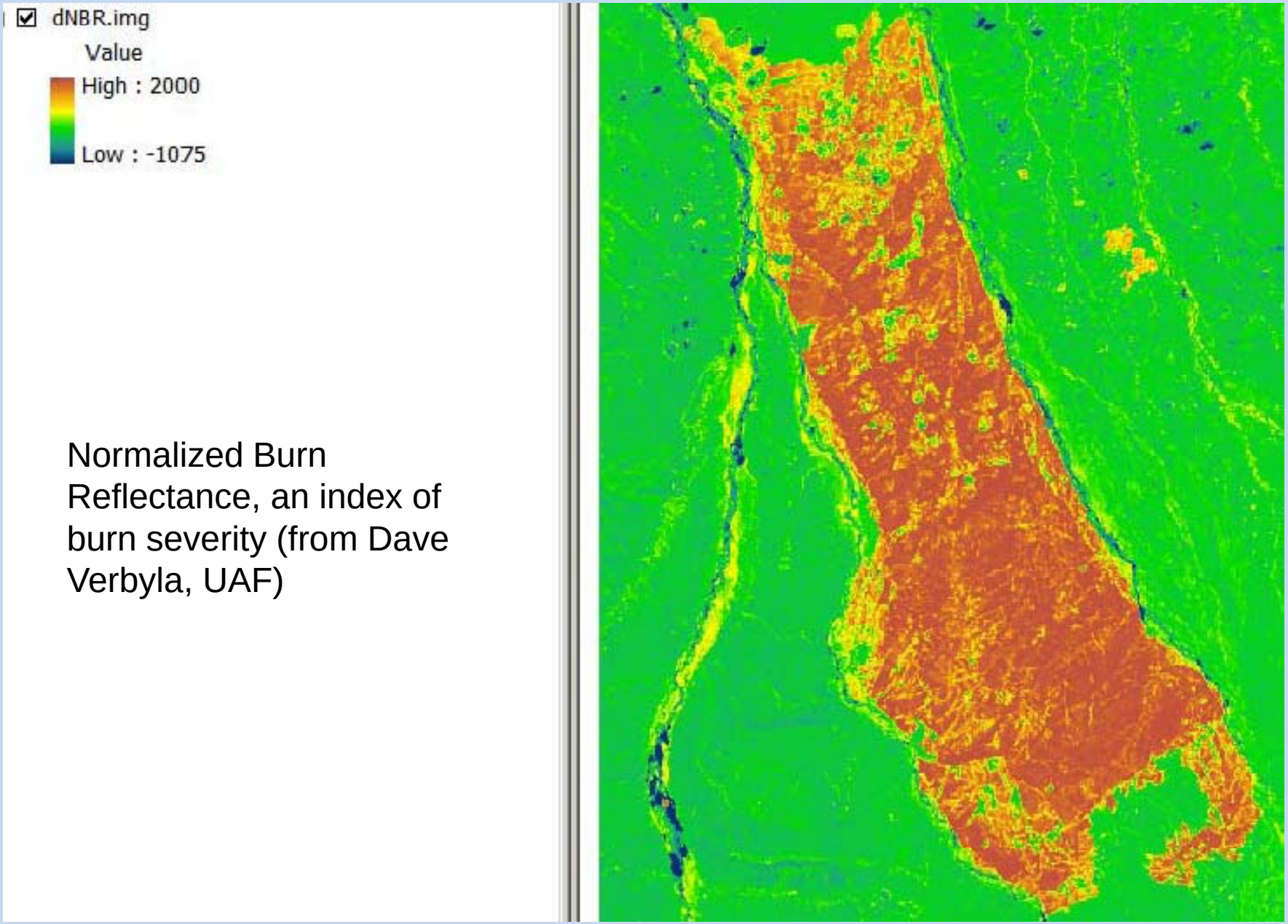

16 Jul 2007
SEPTEMBER 19, 2007
2:30 PM
5:30 PM
13 Sept 2007
30 Sept 2007
4 Oct 2007

Anaktuvuk River Fire 2007



An opportunity for synthesis between a fire-naïve versus a fire-experienced biome

How severe was the Anaktuvuk River fire?



Normalized Burn Reflectance, an index of burn severity (from Dave Verbyla, UAF)

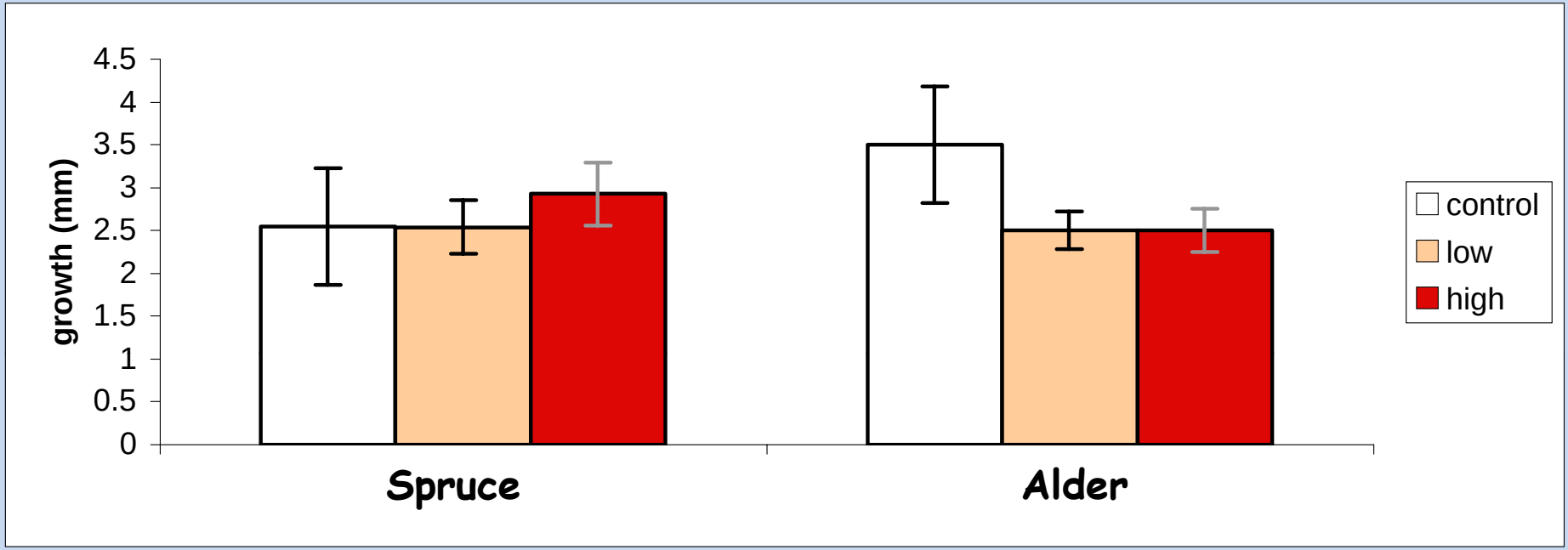
Research Questions

- Do our known relationships between seedling regeneration, vegetation composition, and site characteristics hold true for tundra fires?
- How much carbon and nitrogen was lost during the Anaktuvuk River Fire?

Seedling methods

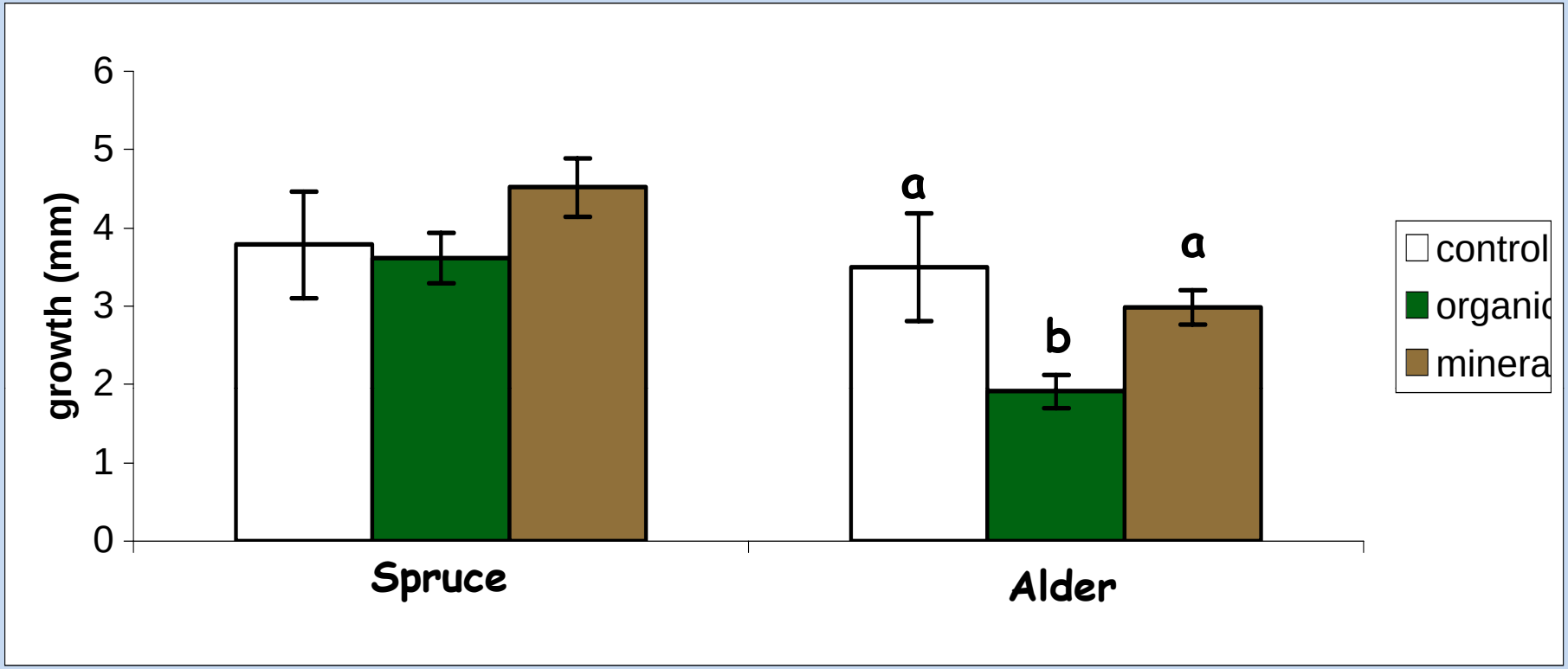
- 9 transects across the Anaktuvuk River fire sampled
- 10 points along each transect sampled and combined for a) mineral soil and b) organic soils
- Germinated alder and spruce seedlings
- Autoclaved Tanana River silt as growth substrate
- Innoculated with organic or mineral soil from 9 sites (18 treatments)
- Minimal fertilizer (want them to survive but not thrive)

Seedling growth results



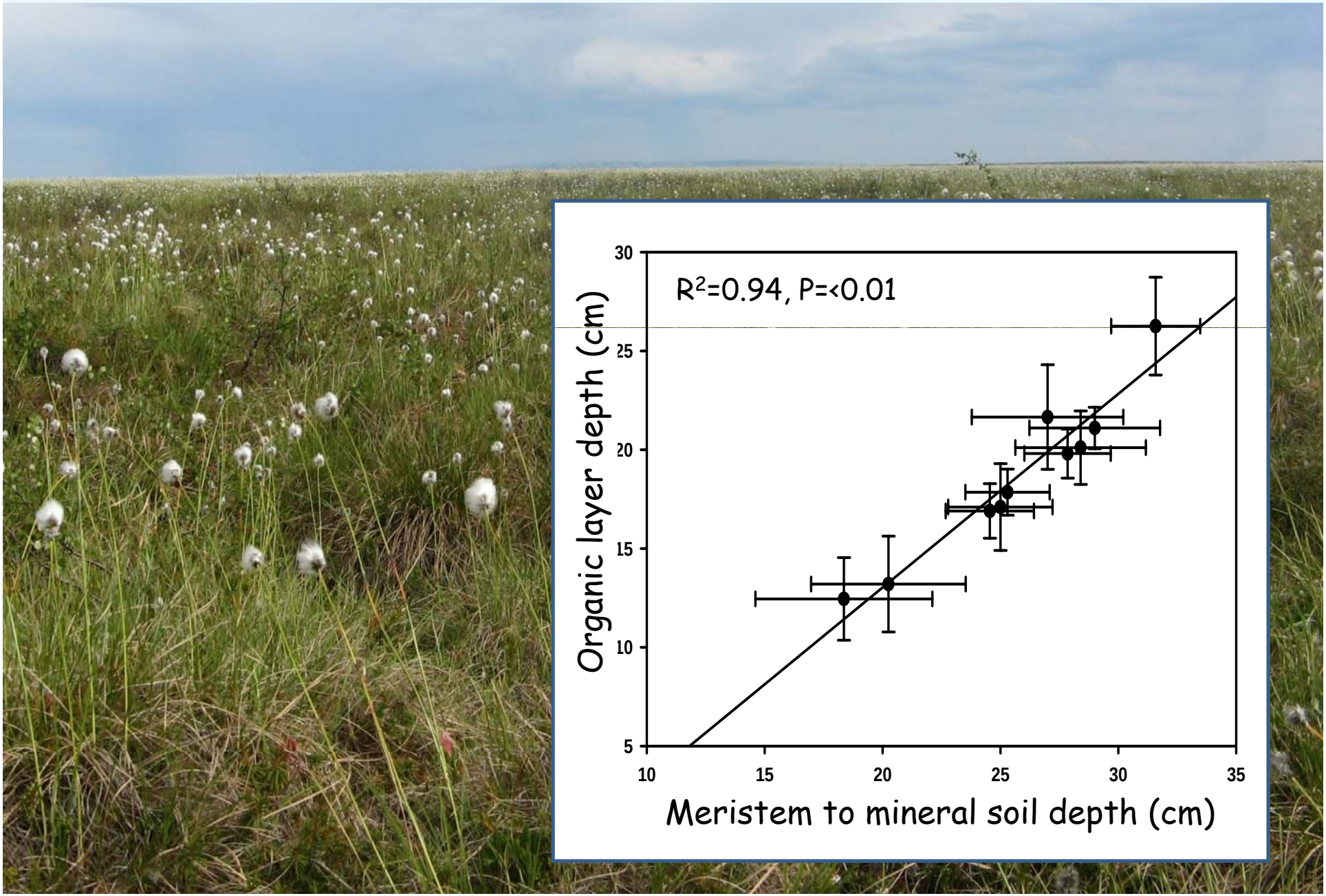
- There is a significant difference in seedling growth across the 18 treatments (spruce p=.001, alder p=.003).
- However when the soils are grouped into control, low, and high fire severity there is no significant difference in growth from August to February.

Seedling growth results



Alder grows more with mineral soil inoculum

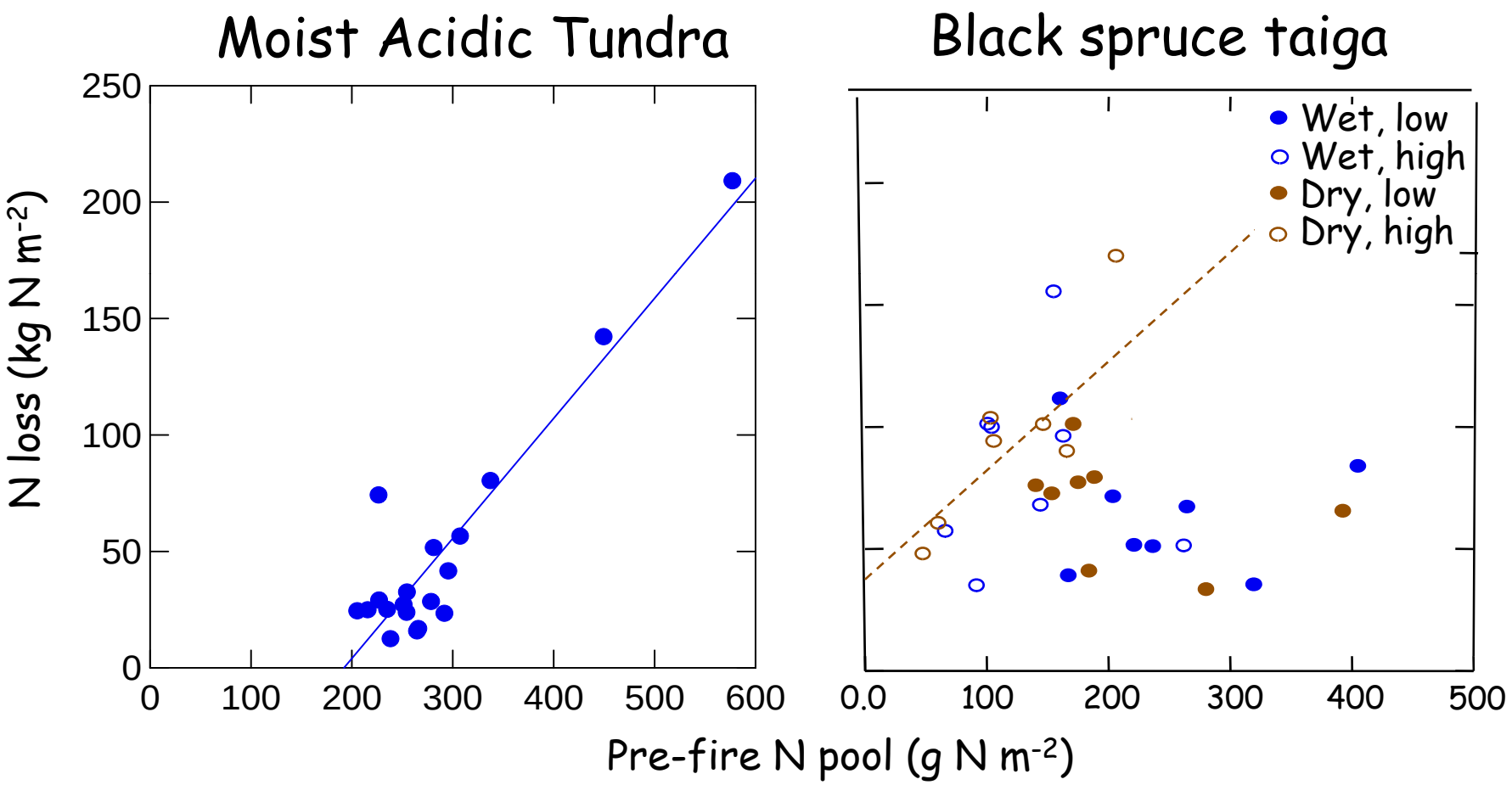
Estimating pre-fire soil organic matter pools



Pre-fire pools and fire-driven losses of nitrogen from tundra and the taiga

Pools		MAT	Black spruce
Pre-fire O layer ($g\ N\ m^{-2}$)	*Mean:*	280	200
	Range:	206 to 578	50 to 429
	N:	20	90
O layer N loss ($g\ N\ m^{-2}$)		33	103
		7to 209	30 to 180
% O layer N loss		10.4	50
		2 to 36	1 to 94

N loss versus pre-fire N pools



All sites R^2=0.86, P<0.001

High-Dry R^2=0.61, P<0.02
No relationship for other categories

How much C was lost in the Anaktuvuk River fire?

- Assume 10 cm peat loss over 800 km^2 (total area of burn is ~1000 km^2)
- There are 8 x 10^{12} cm^2 in 800 km^2, 8 x 10^{13} cm^3 in the upper 10 cm
- Peat is ~45% C with a bulk density of ~0.06 g/cm^3, or 0.027 g C/cm^3
- Total C loss is 0.027 * 8 x 10^{13} = 2.16 x 10^{12} g, or 2.16 Mt C lost in this one fire

Conclusions

- Based on our initial assessment of fire severity, there doesn't appear to be a relationship between alder and spruce height growth and fire severity.
  - If substrate quality or nutrient content alone was driving growth, we would expect there to be significant differences in growth across fire severity classes.

- However, there is a significant effect of substrate, suggesting that mycorrhizal fungi present might be inhibiting growth in organic substrates or promoting growth in mineral substrates.

Conclusions (cont.)

- In taiga, sites with more accumulated N lost a smaller % of total N, while sites with more N lost a larger %
  - Fire driven N loss reinforces landscape patterns of N accumulation
- In arctic tundra, sites with more accumulated N lost more N
  - Fire smoothes landscape heterogeneity in N accumulation
- There was ~ 2 MG C lost from the Anaktuvuk River Fire
- In arctic tundra, scale is extremely important when assessing burn severity remotely.

Acknowledgements

Jack Ahgook Jr., Leslie Boby, Randi Jandt, Janet Jorgenson, Eric Miller, and Dave Yokel (2007 Field Crew)

Arctic LTER, Bonanza Creek LTER, IAB greenhouse, Gus Shaver, Jack MacFarland, Roger Ruess, Dave Verbyla

A Key for Predicting Postfire Successional Trajectories in black spruce forests of interior Alaska

www.fs.fed.us/pnw/pubs/pnw_gtr767.pdf