Widespread shifts in Arctic tundra vegetation
evidence, projections, climate implications

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Acknowledgements

Scott Goetz

Isla Myers-Smith

Michael Loranty

Glenn Juday

Richard Pearson

Climate change

Increasing shrub abundance in the Arctic

Nature, 2001, Sturm, Racine & Tape

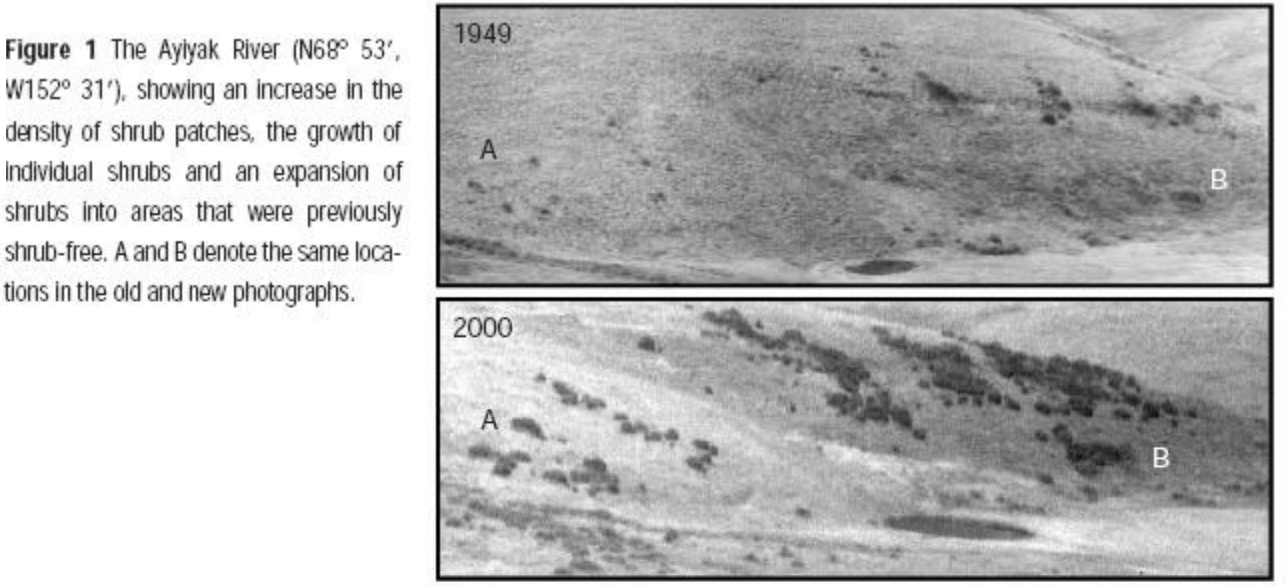
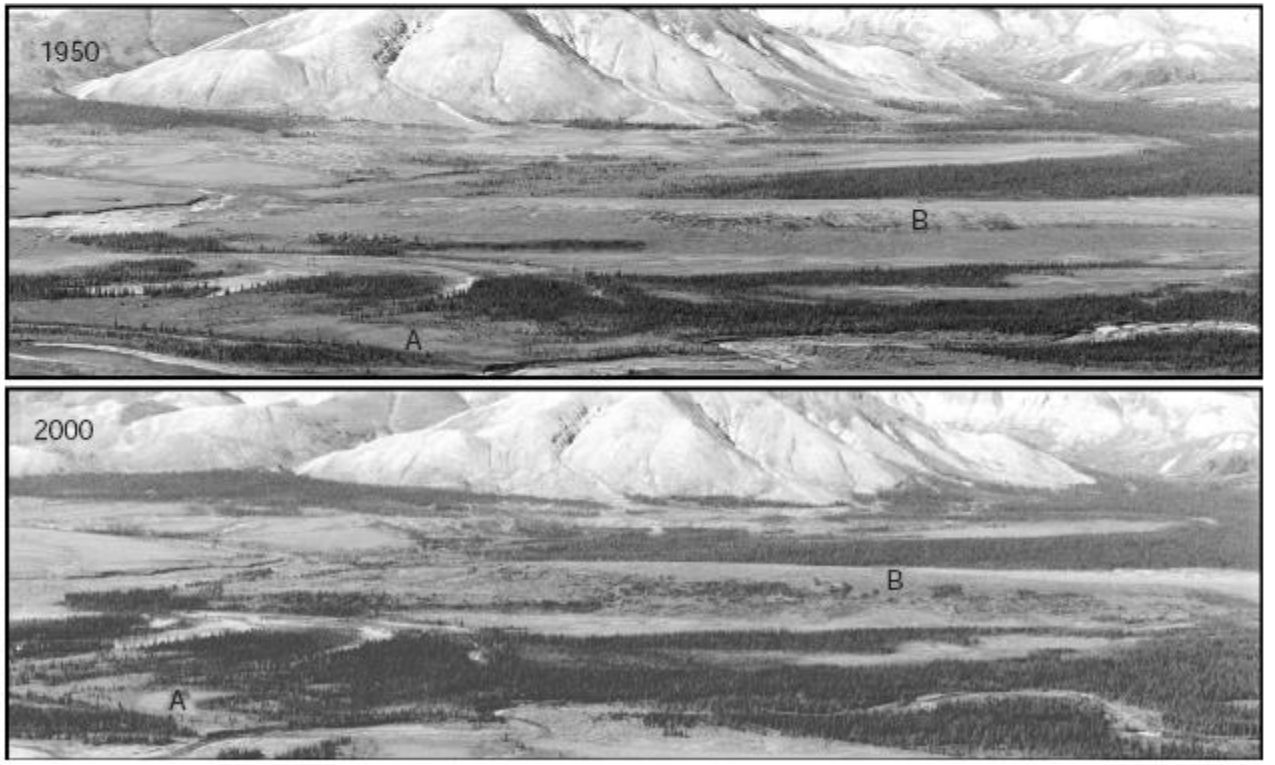
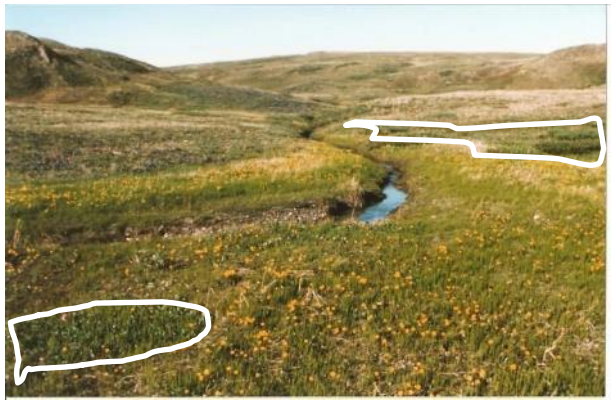


Figure 1 The Ayiyak River (N68° 53′, W152° 31′), showing an increase in the density of shrub patches, the growth of individual shrubs and an expansion of shrubs into areas that were previously shrub-free. A and B denote the same locations in the old and new photographs.



Repeat photography - evidence of rapid shrubification



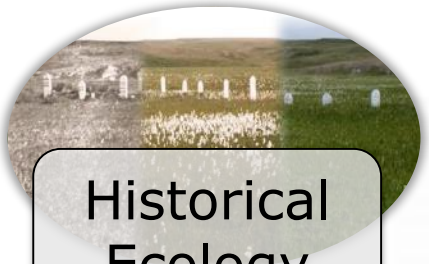
1987

2009

2013

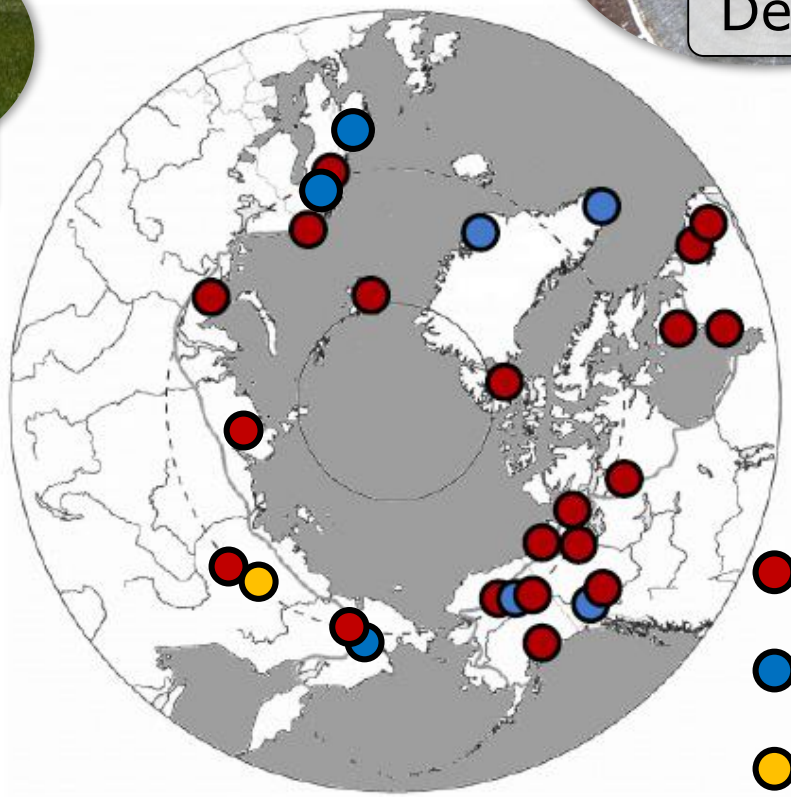
Herschel Island – Qikiqtaryuk. Courtesy of Isla Myers-Smith

Multiple lines of evidence for increased arctic shrub abundance



Historical Ecology

Dendroecology



Experiments

Ecological Monitoring

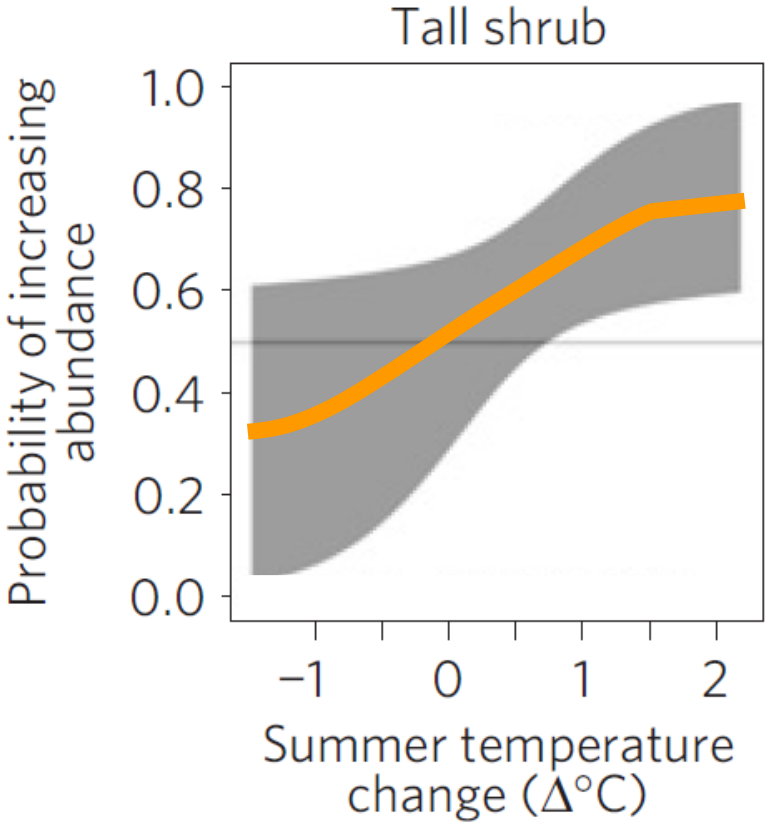
- Increasing shrubs
- Stable populations
- Decreasing populations

Myers-Smith *et al.* **ERL** 2011

Ecological monitoring – shrubs increase with warming

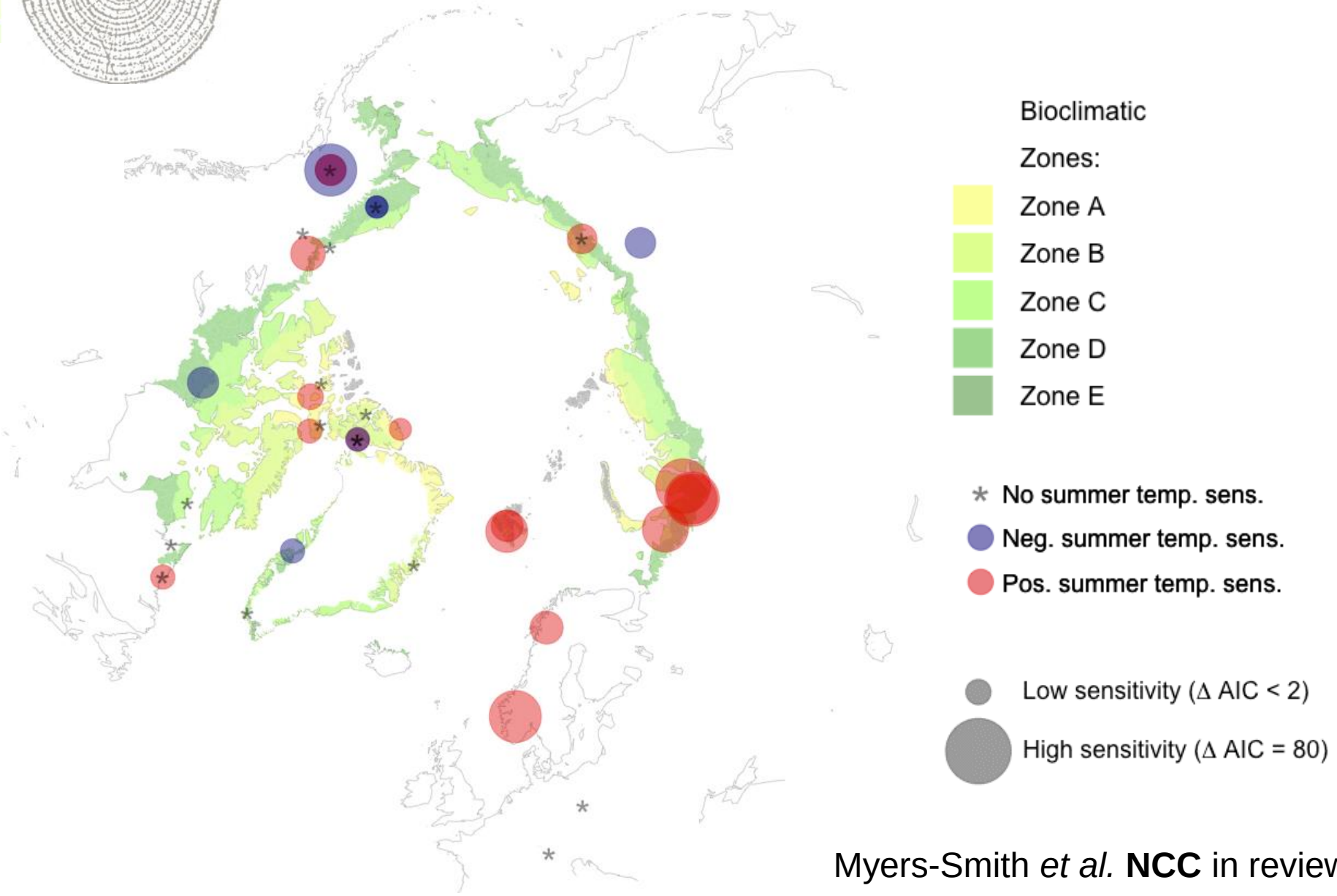
1999

2013



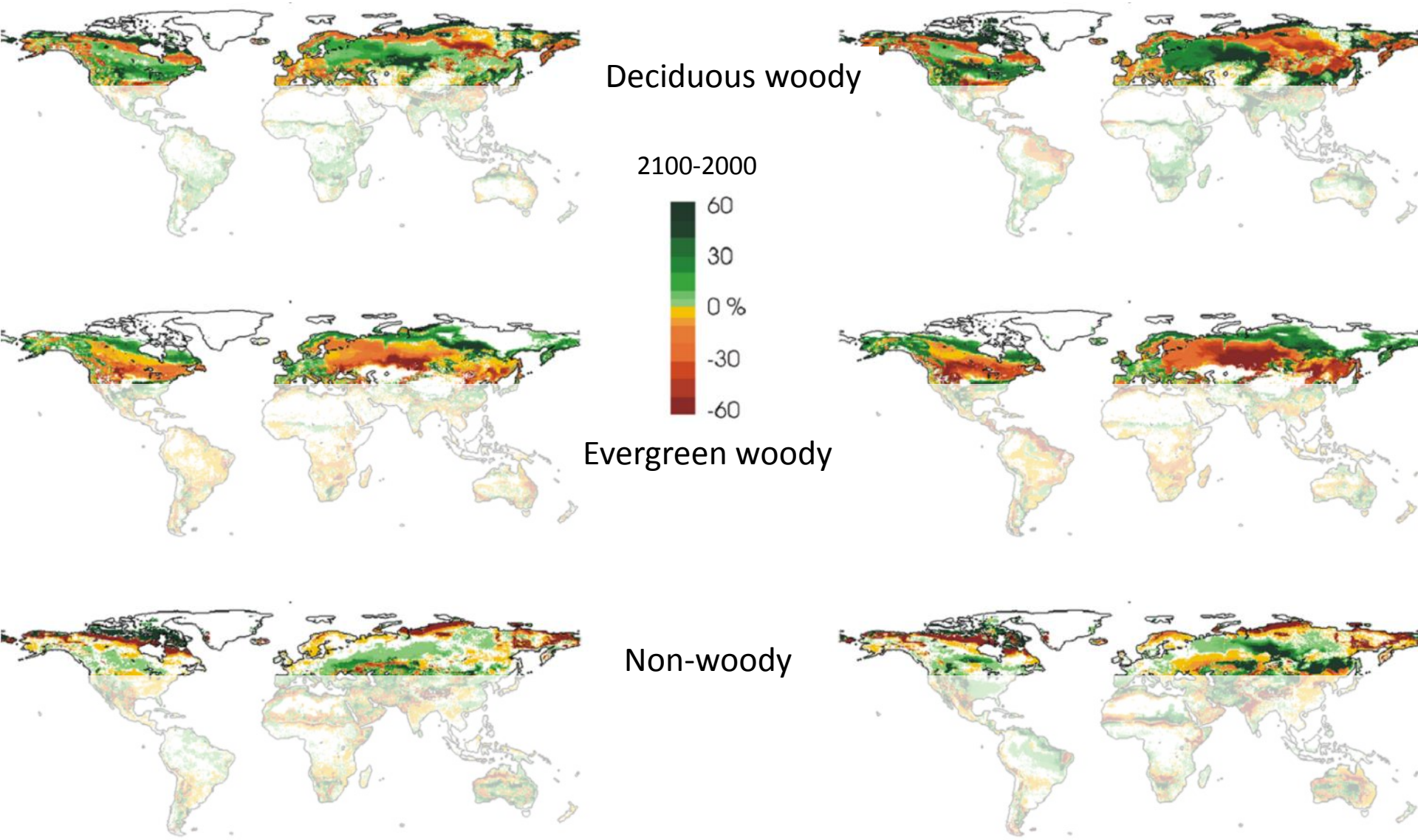
Elmendorf *et al.* **NCC** 2012

Is temperature driving shrub growth?

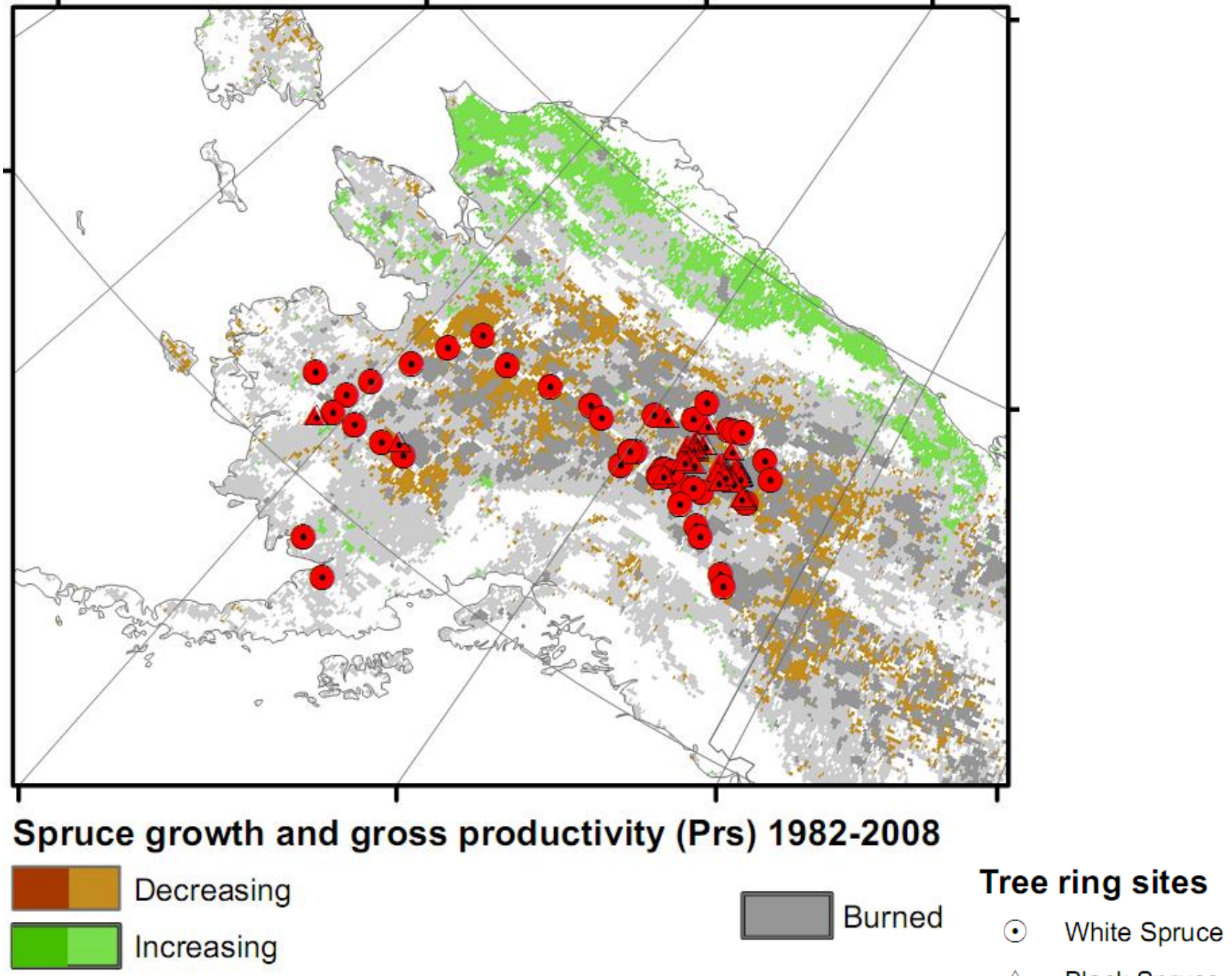


Myers-Smith *et al.* **NCC** in review

Global vegetation models predict 21st century 'biome shift'



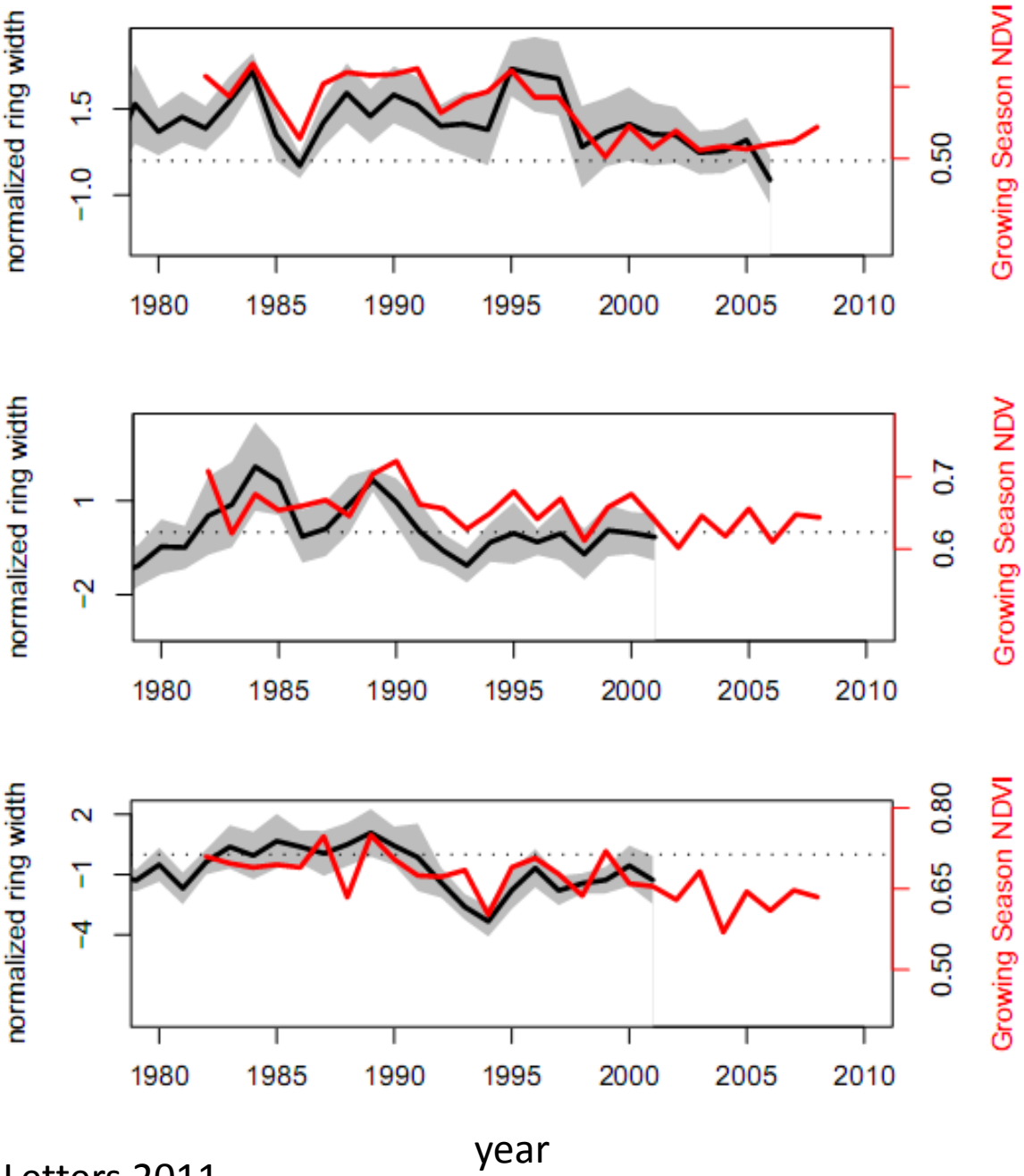
Lucht *et al.* Carbon Bal. Mgnmnt 2006



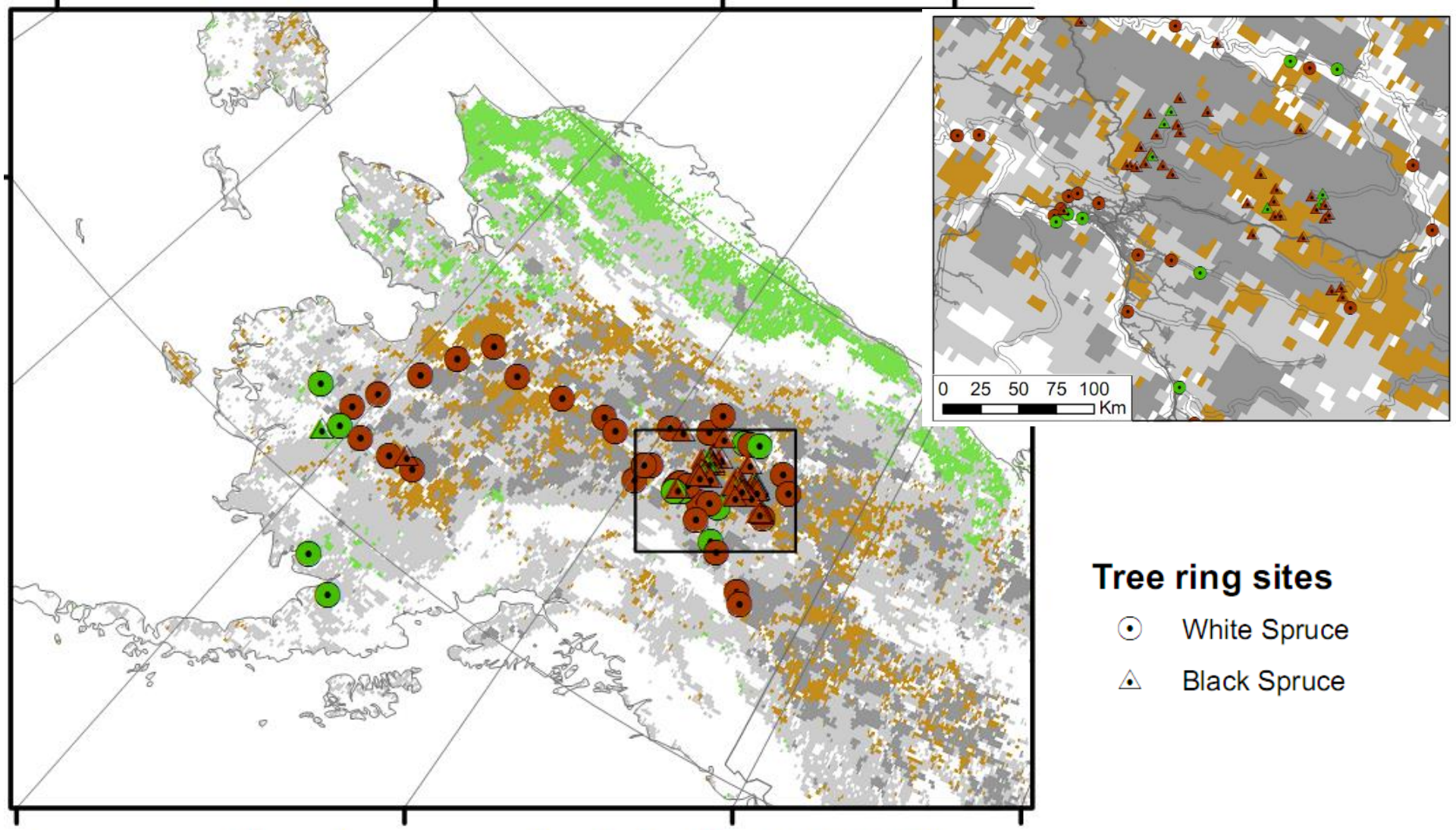
Beck *et al.* Ecology Letters 2011

GROSS-PRODUCTIVITY

& TREE RING time series

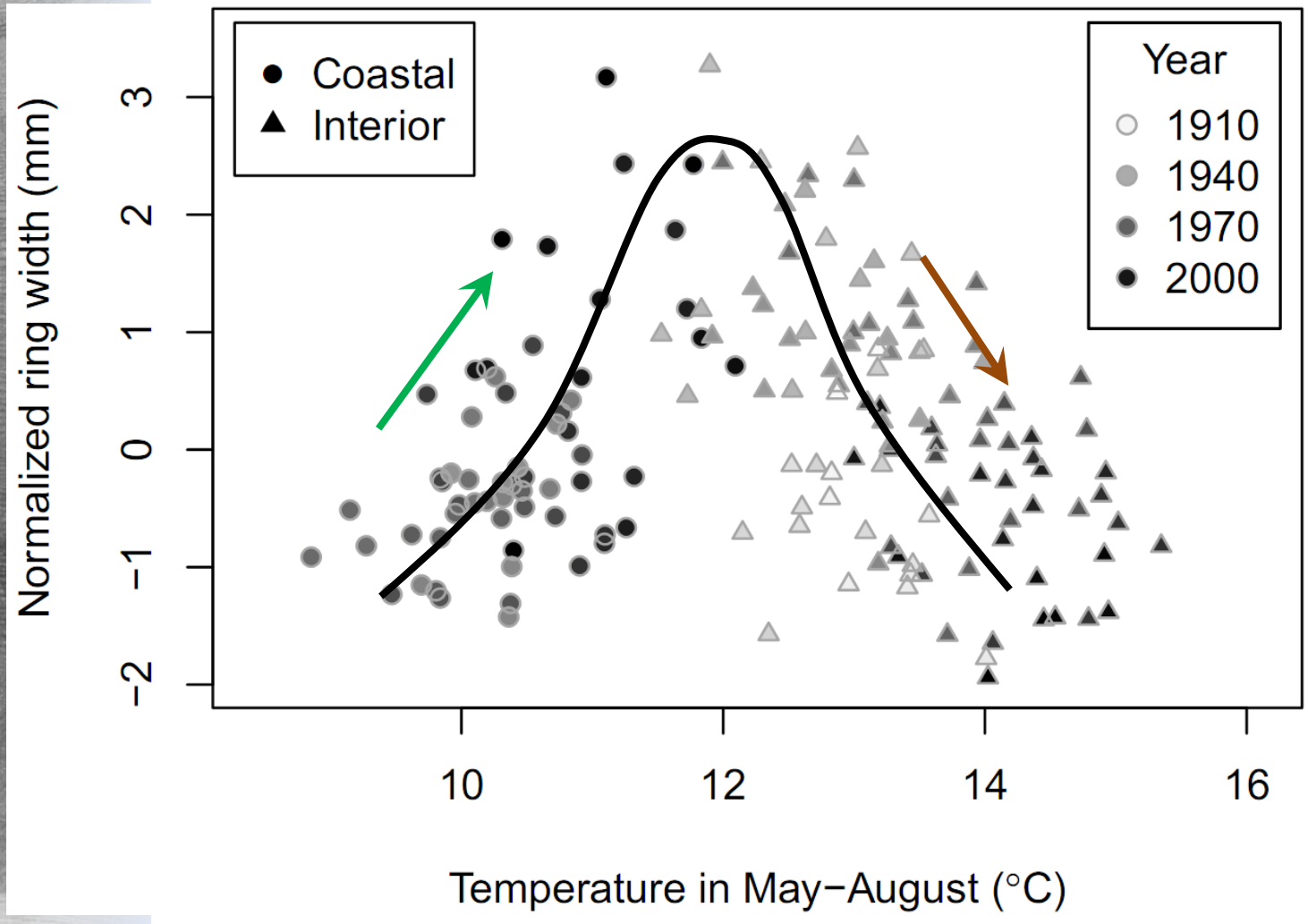


Beck *et al.* Ecology Letters 2011



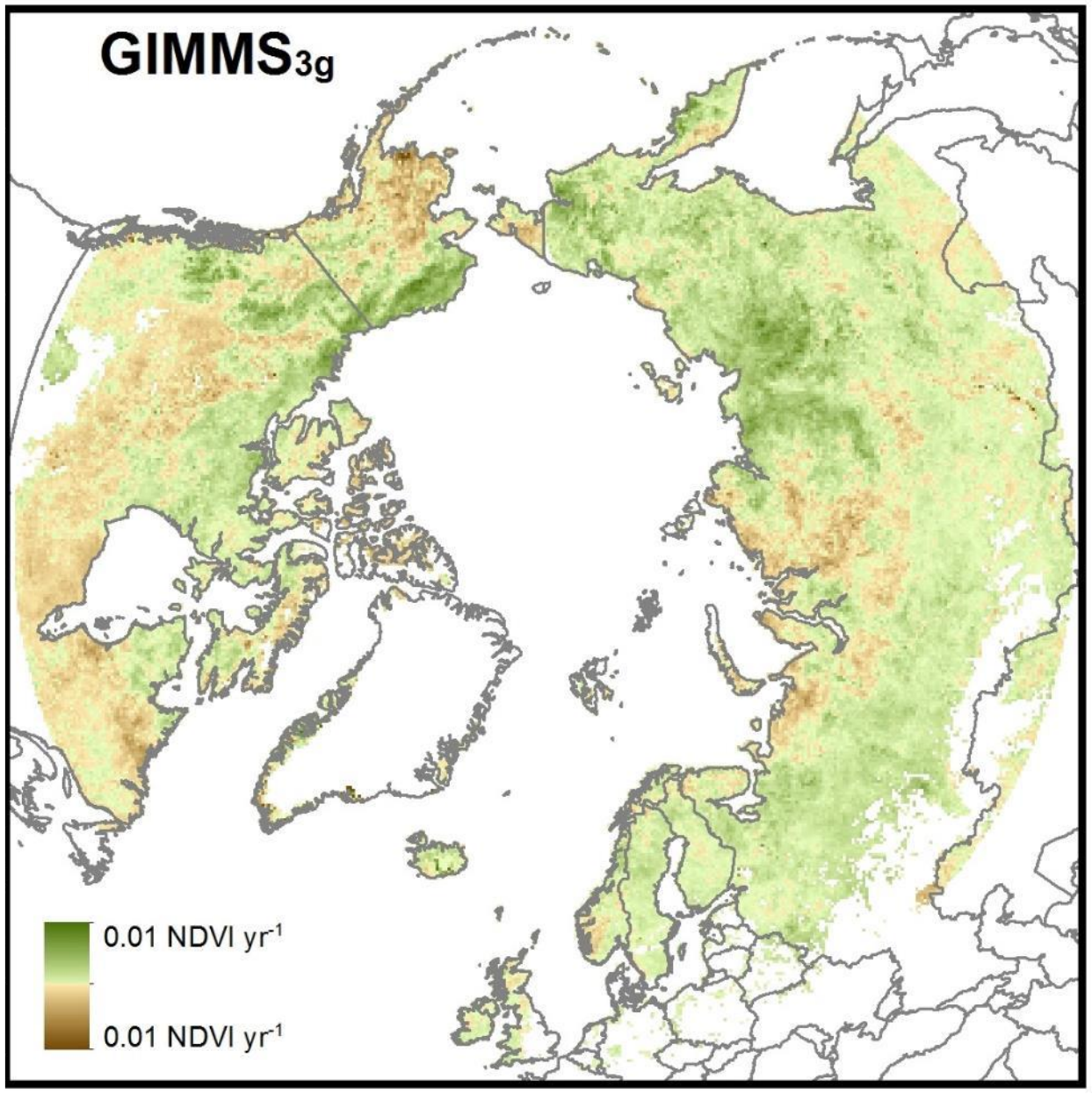
Beck *et al.* Ecology Letters 2011

Spruce growth patterns in Alaska indicate biome shift



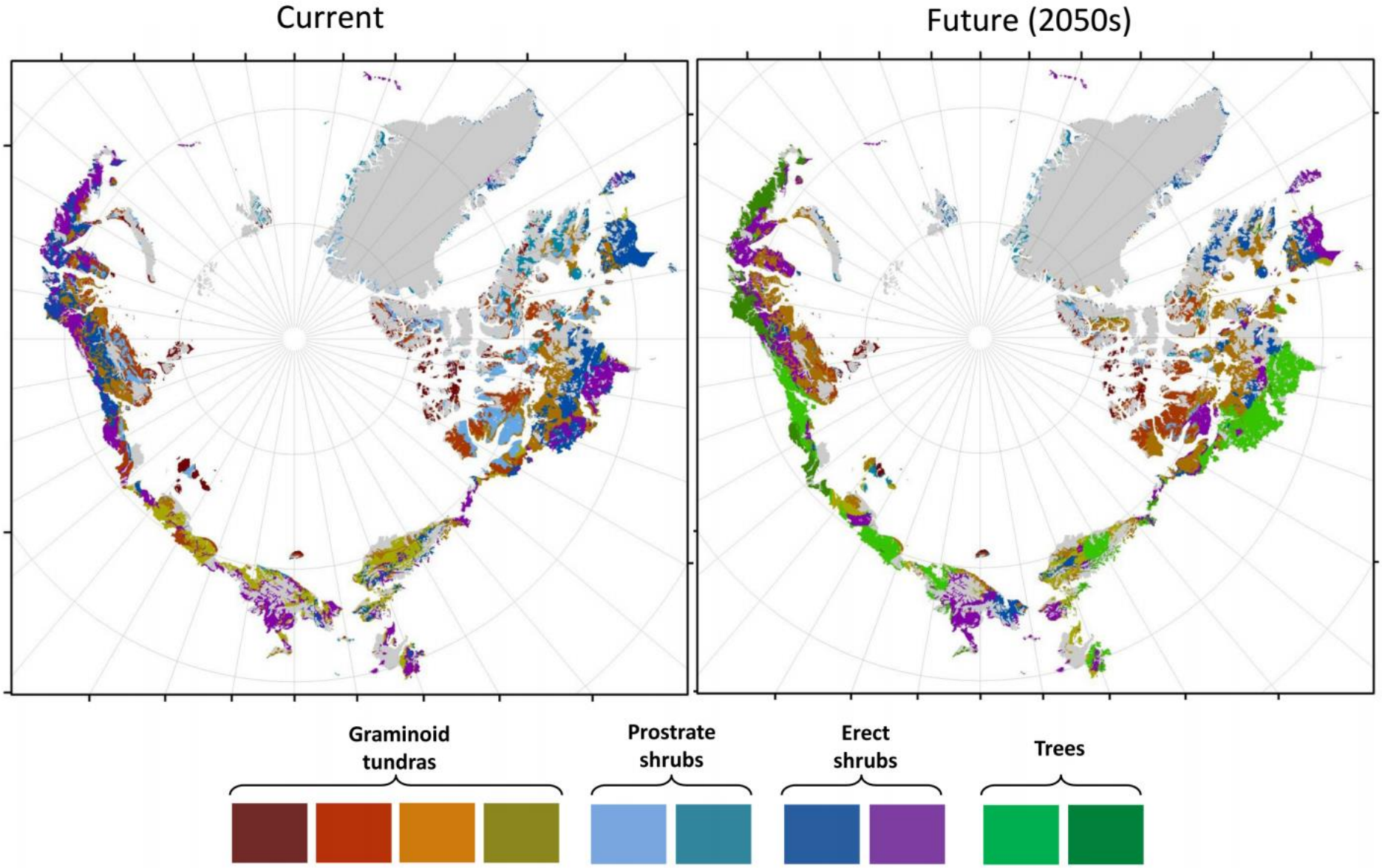
Beck *et al.* Ecology Letters 2011

Vegetation productivity 1982-2011



Guay *et al.* Global Change Biology 2014

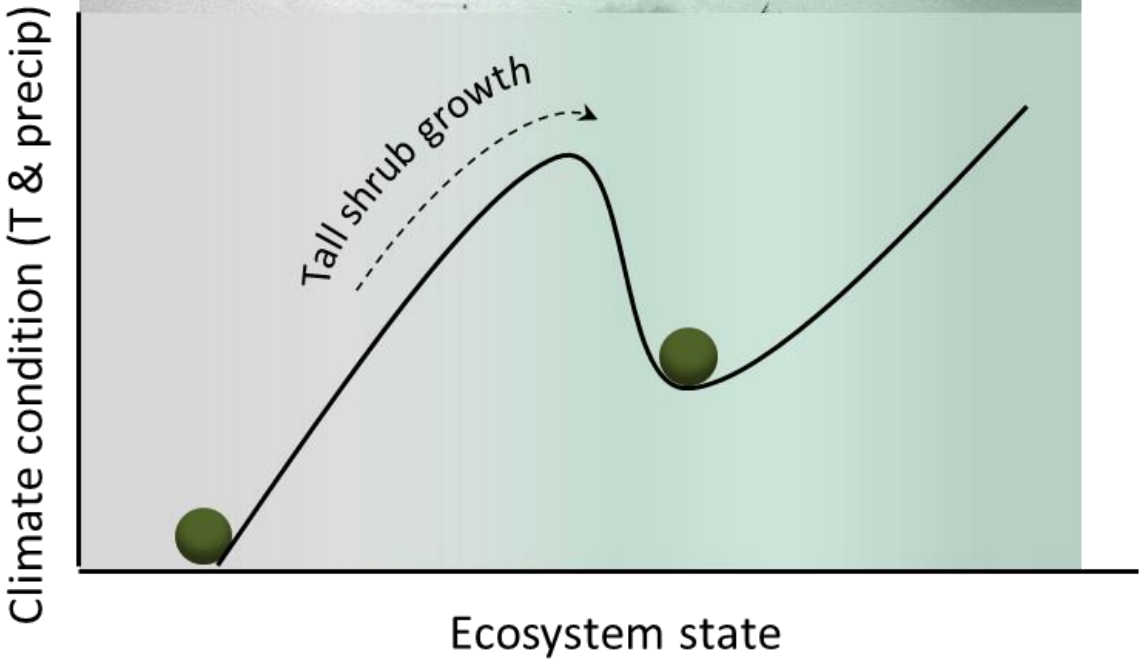
Climate change will drive drastic redistribution of Arctic vegetation



Pearson *et al.* 2013 Nature Climate Change

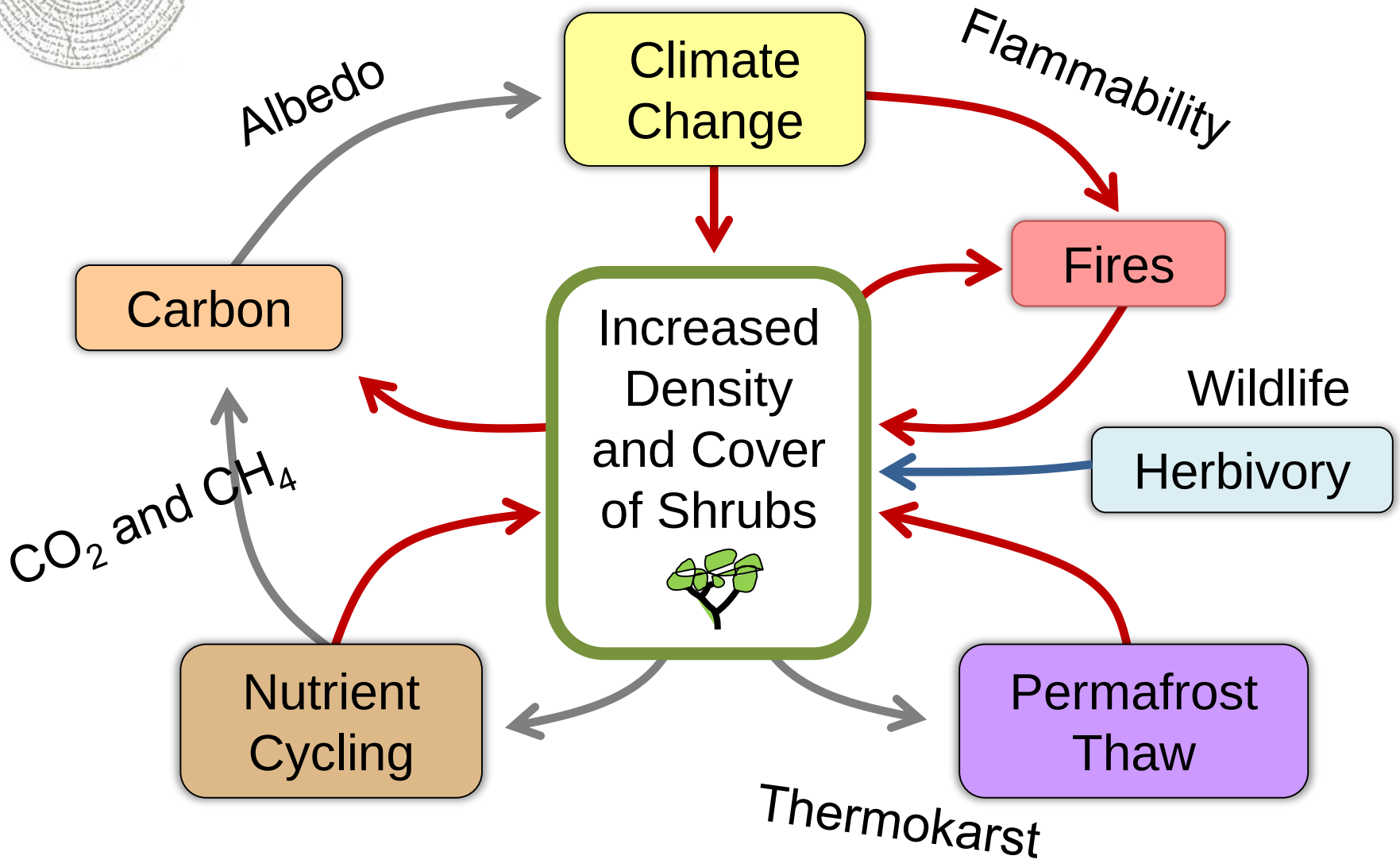
Shallow snow
Shallow active layer
Low N mineralization

Deep snow
Deeper active layer
High N mineralization



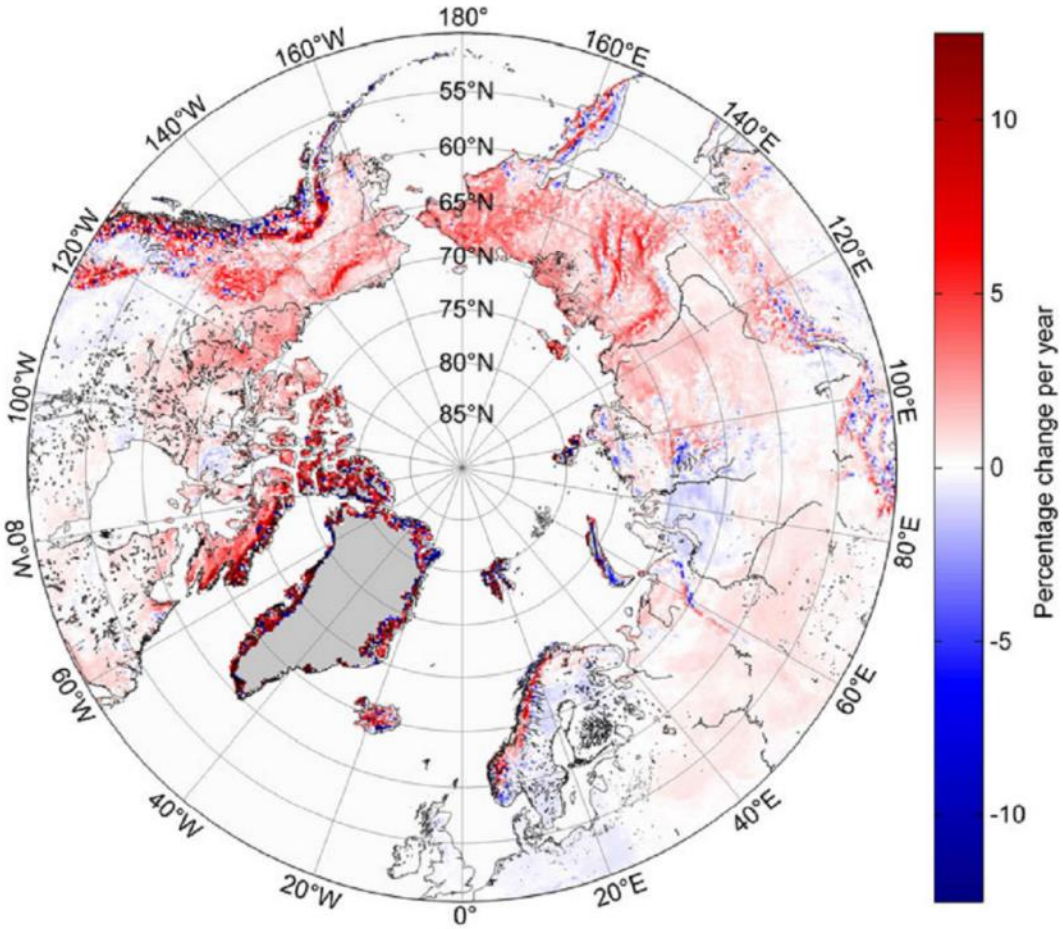
Sturm *et al.* 2005 BioScience

Ecosystem feedback loops



Myers-Smith *et al.* **ERL** 2011

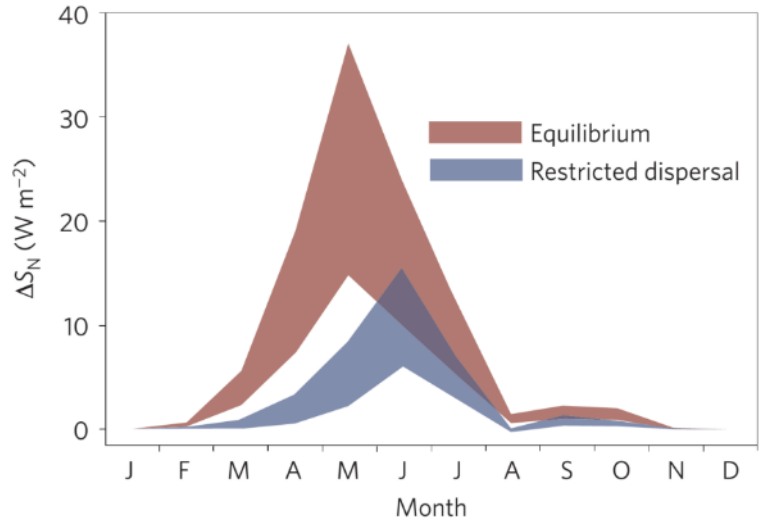
Solar radiation reaching land 1979-2010



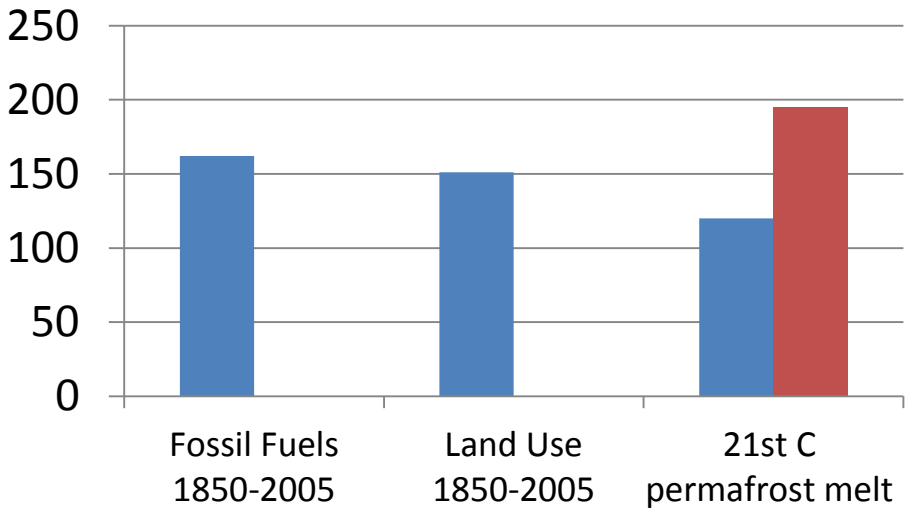
Clark *et al.* 2013. Global Change Biology

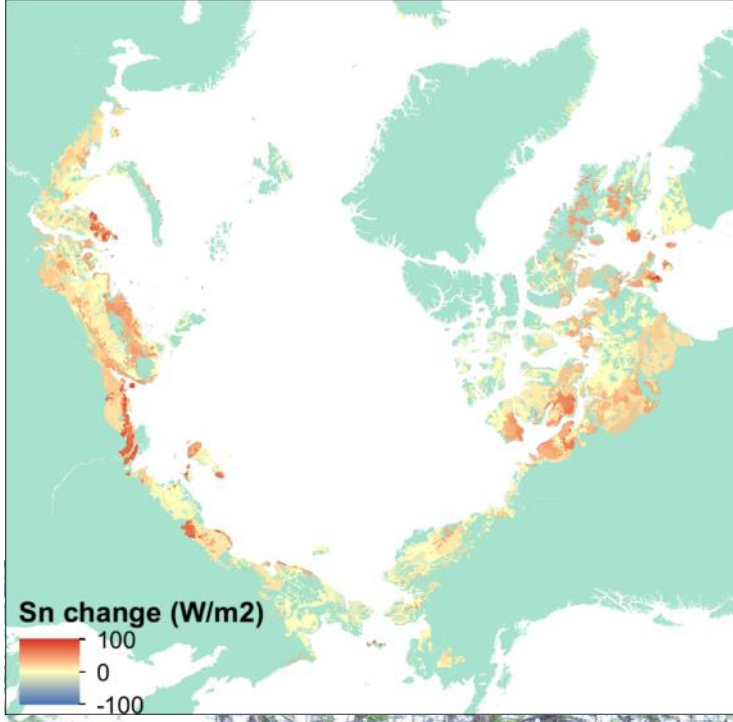
Arctic biome shift: climate feedbacks

Arctic surface energy change 2000-2050



Carbon emissions (Pg)





Schuur *et al.* , Pearson *et al.* Nat. Clim. Ch. 2013

In sum…

- **Shrubs are proliferating** in the Arctic due to climate warming and positive ecological feedbacks
- Post ca. 1950 vegetation productivity patterns in the northern latitudes are consistent with the **northward biome shift** predicted by global vegetation models
- Will **disturbance** increasingly shape arctic vegetation?
- Redistribution of Arctic vegetation during continued climate change will generate **strong positive feedbacks to warming** via **permafrost thaw**, and **decreased surface brightness**, which will outweigh any reductions in radiative forcing from carbon uptake by future Arctic vegetation.