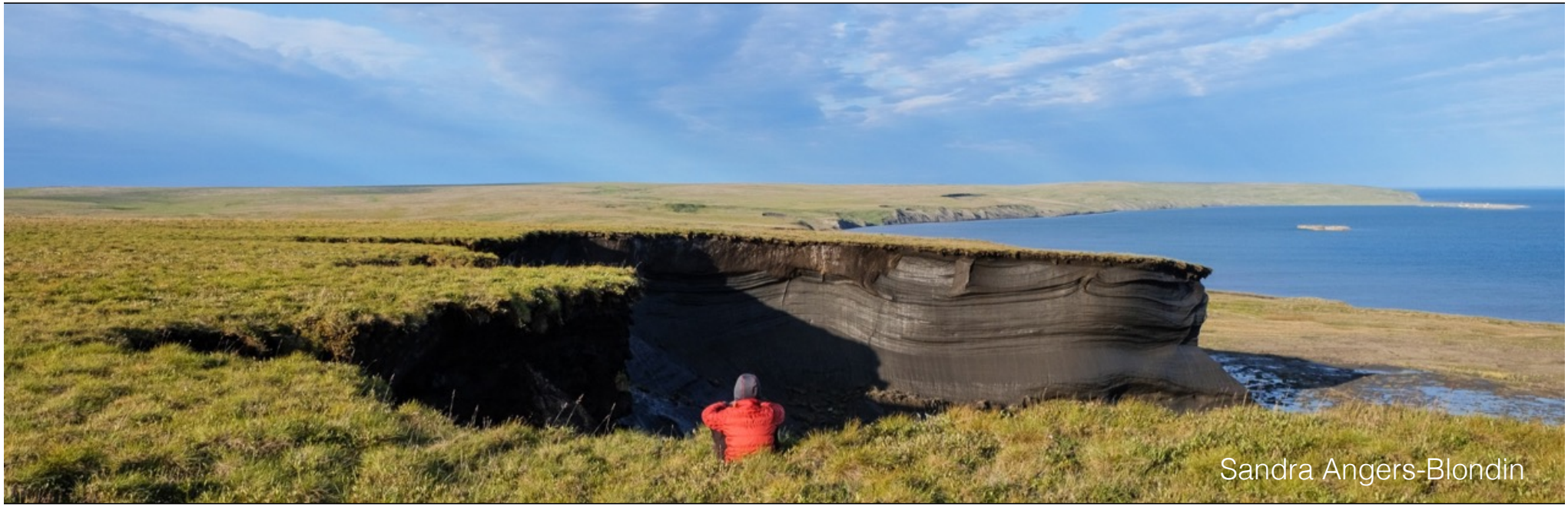
ITEX syntheses: Attribution of ecological change to warming across the tundra biome



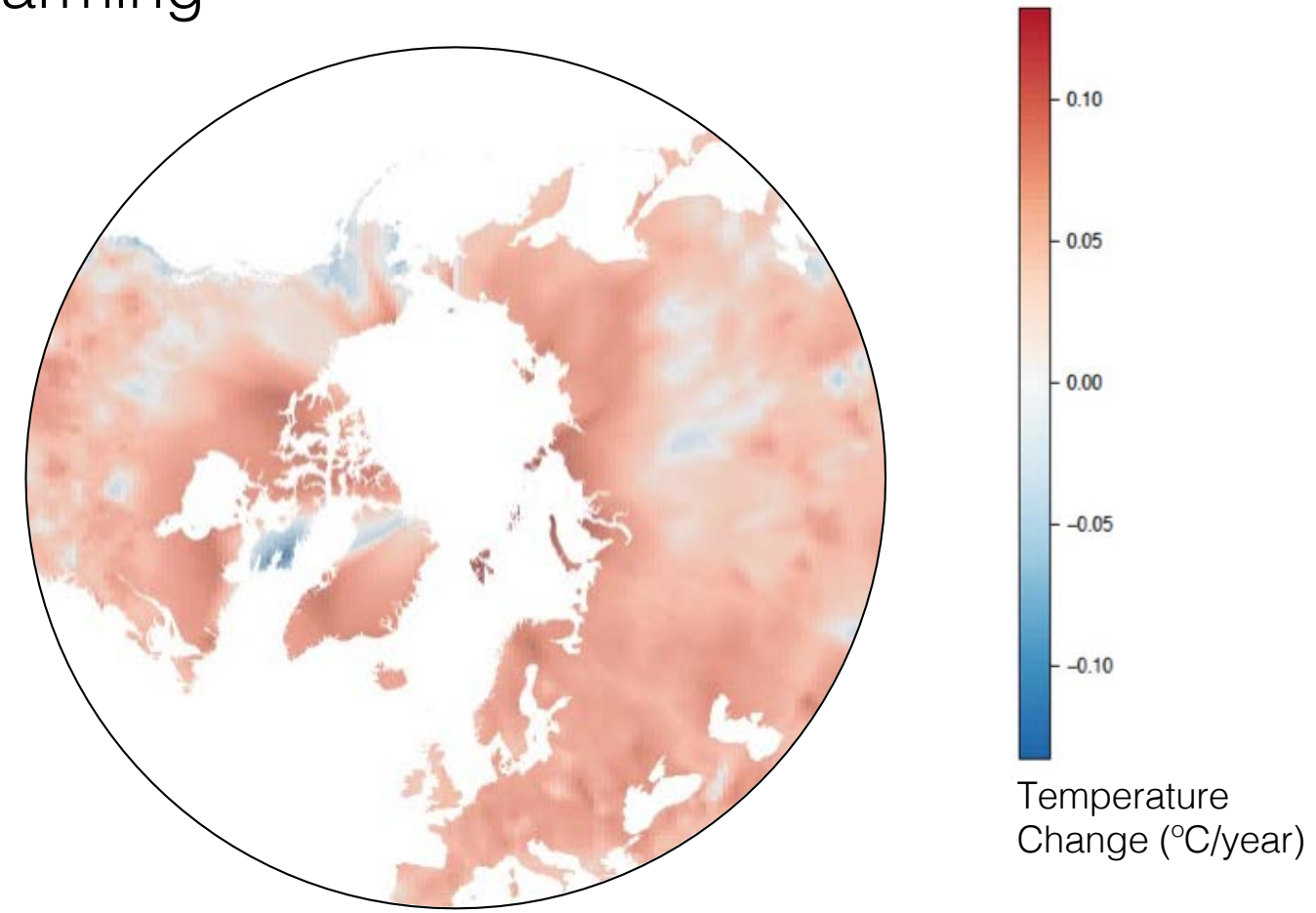
Isla H. Myers-Smith, Anne Bjorkman, Sarah Elmendorf, Team Shrub,
ITEX Network, ShrubHub Network and many more

University of Edinburgh


A warming Arctic…
Anne Bjorkman


A warming Arctic…
Gergana Daskalova

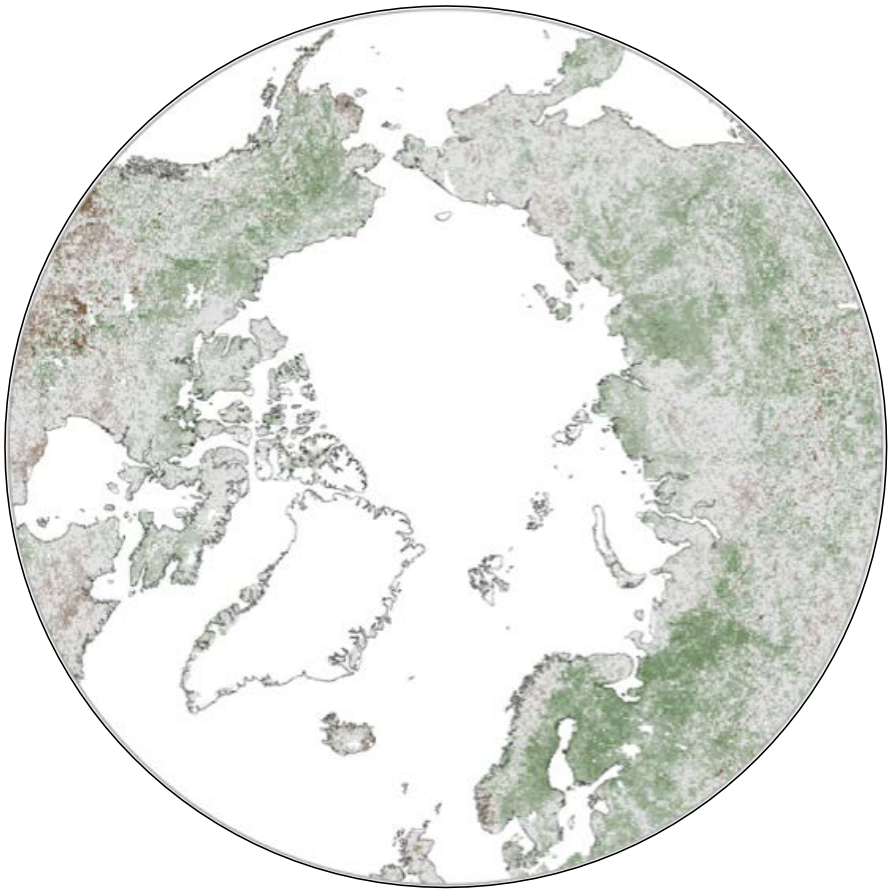
The Arctic is warming



Mean Annual Temperature Change 1978 to 2013


A Greening of the Arctic…
Jeff Kerby

The Arctic is greening

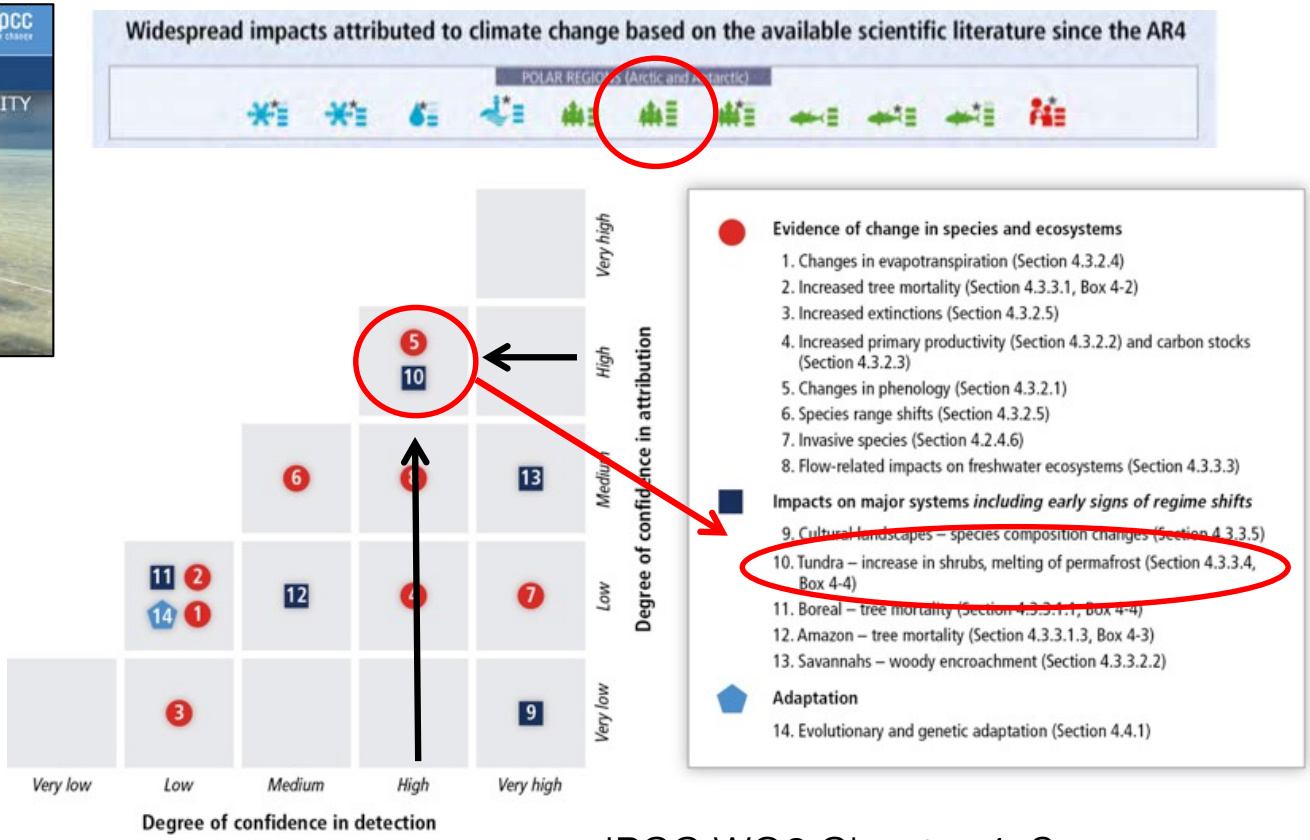


Increasing NDVI

Decreasing NDVI

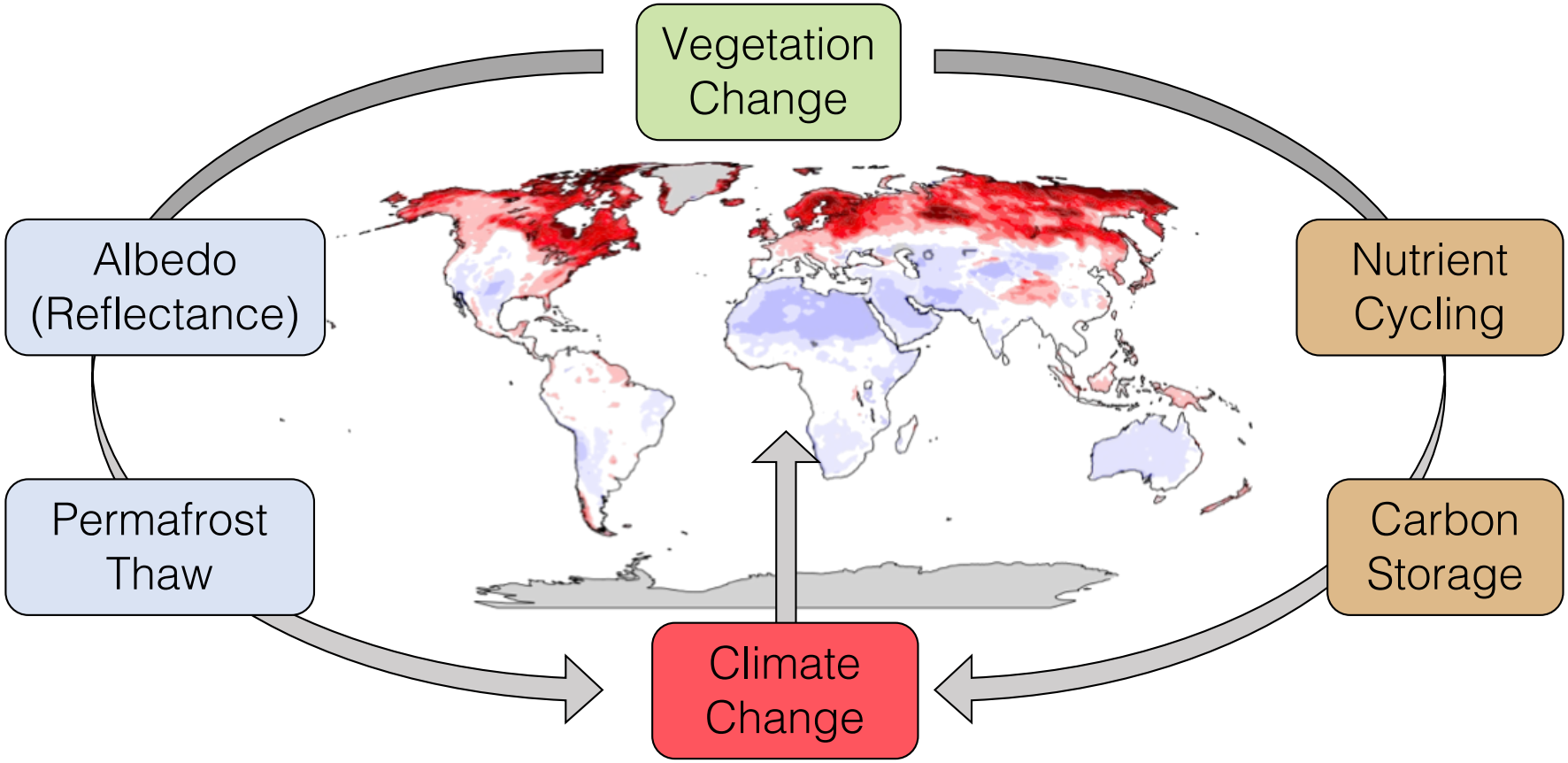
GIMMS 3g Satellite Data 1982 to 2015

IPCC Reports – detection and attribution



IPCC WG2 Chapter 4, Summary report 2014

Why tundra matters – feedbacks

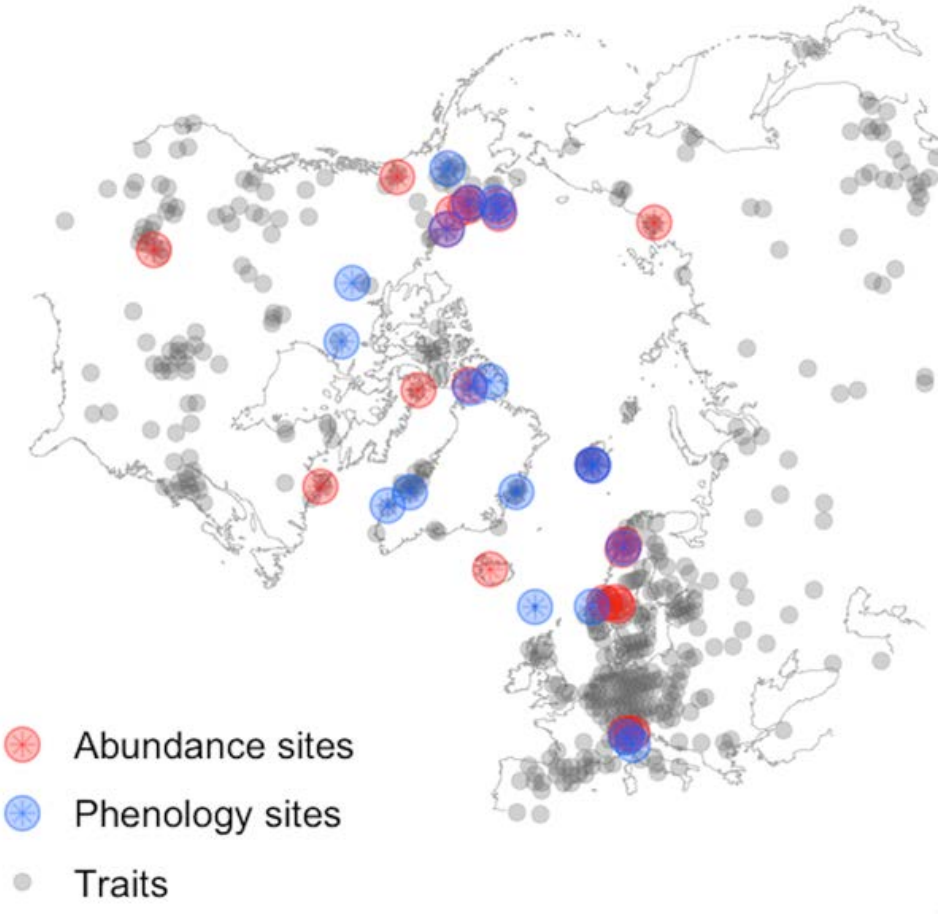


Myers-Smith *et al.* ERL 2011, Crowther *et al.* Nature 2016, Gestel *et al.* Nature 2018

The Network approach

International Tundra Experiment

Tundra Trait Team



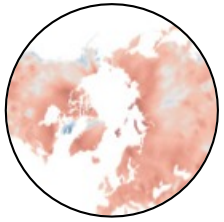
Shrub Hub

High Latitude Drone Ecology Network

Tundra Tea Bag Experiment

Our research questions…

1. How is tundra vegetation changing?



2. Is climate warming causing vegetation change?

Variables of interest:

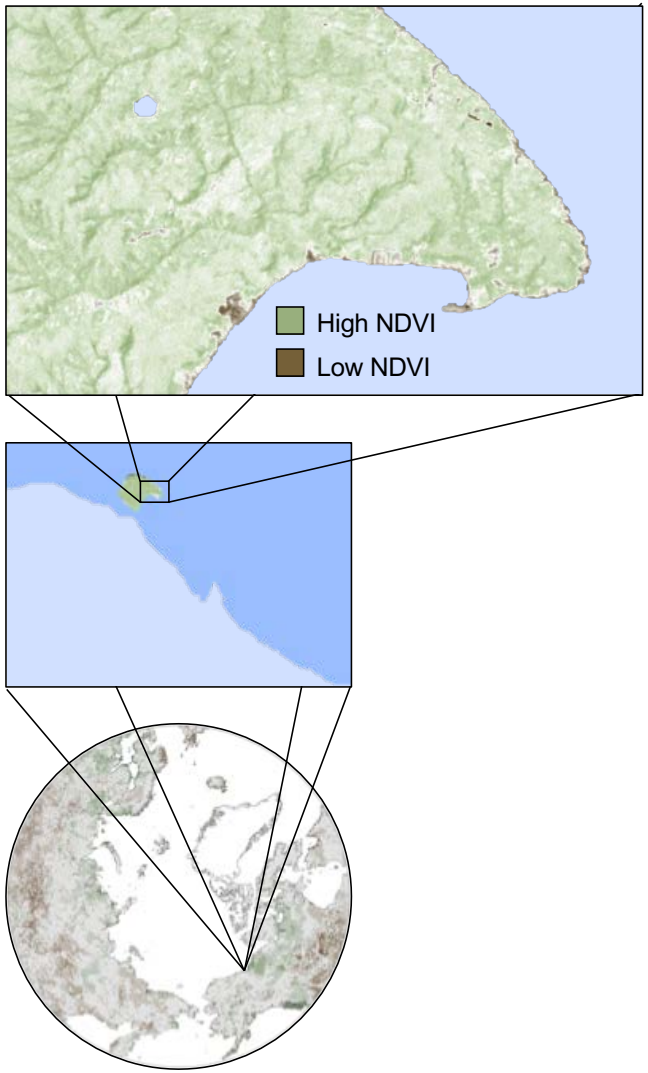
Phenology Change

Shrubification

Compositional Change

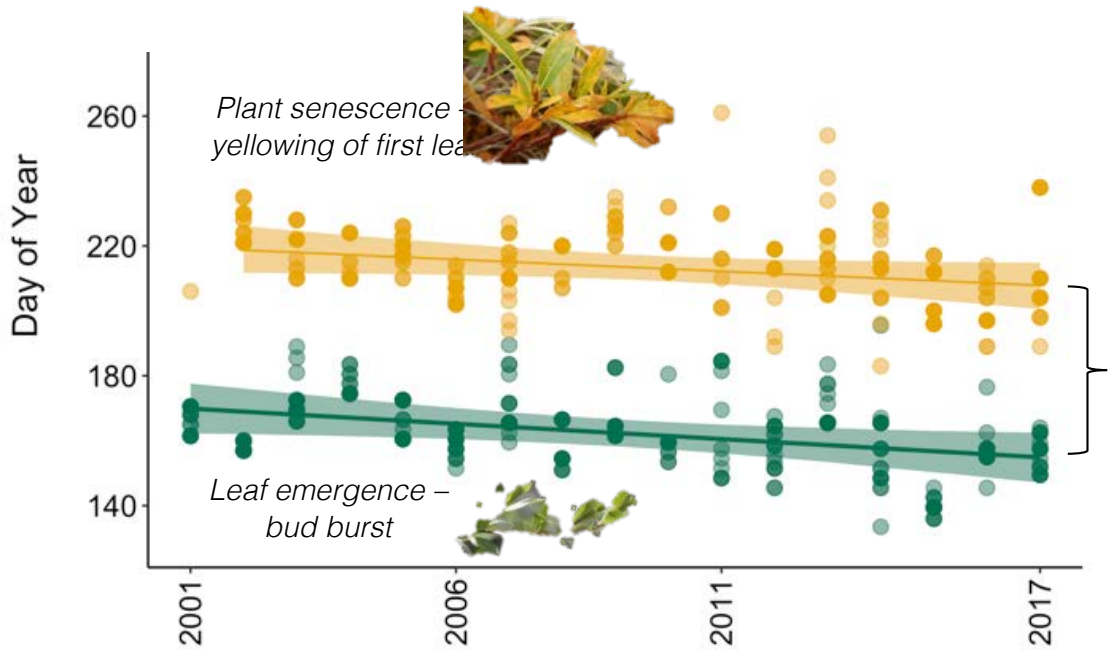
Trait Change

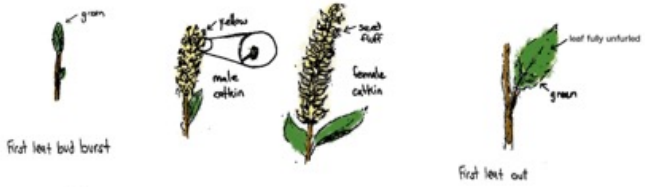
Phenology


High NDVI
Low NDVI


Qikiqtaruk –
Herschel Island

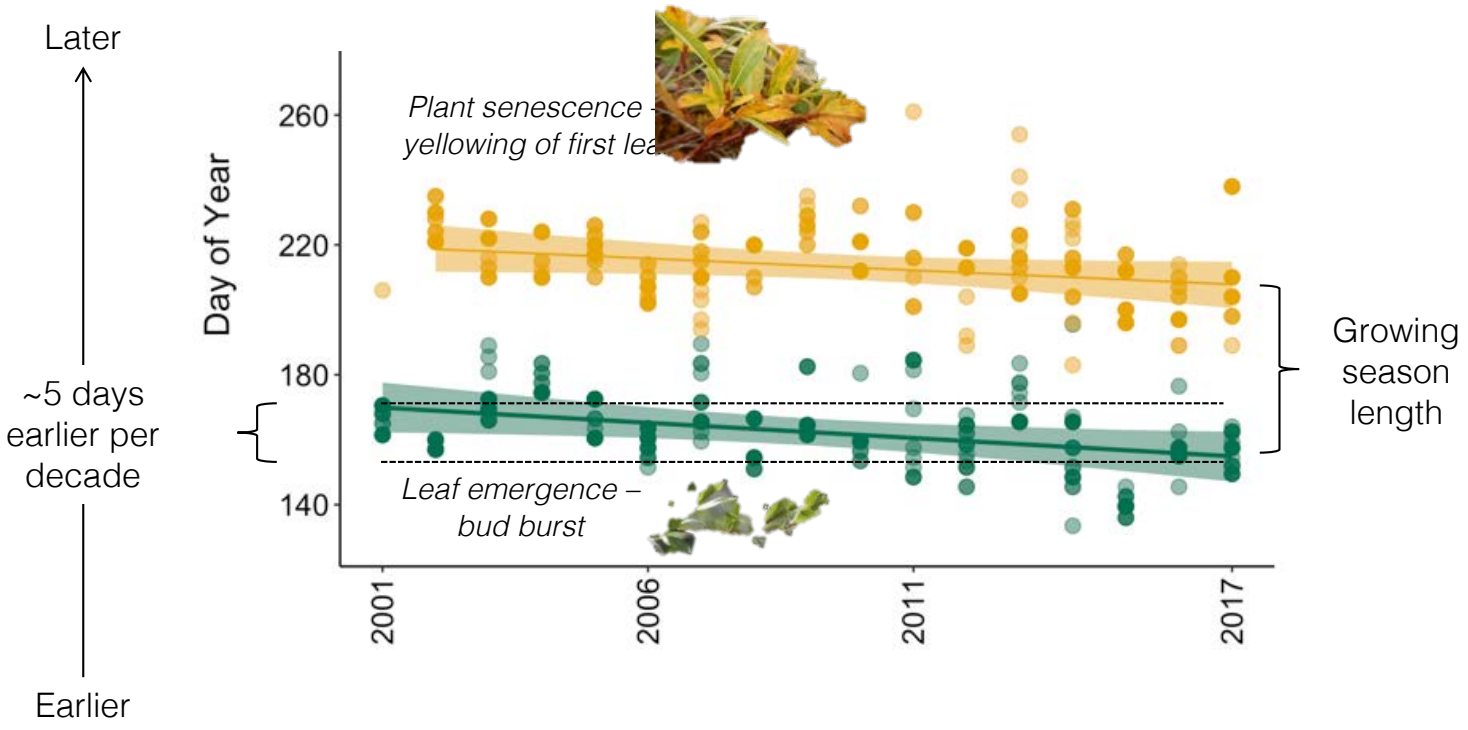
Plants are greening up earlier in the spring





Myers-Smith *et al.* in prep.

Plants are greening up earlier in the spring



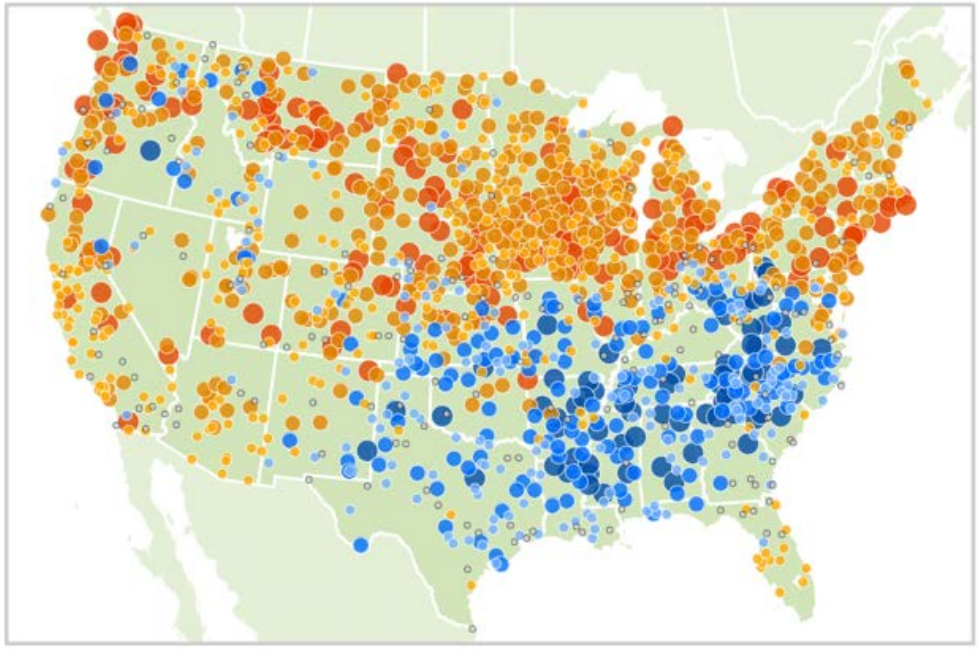
Myers-Smith *et al.* in prep.

Plants are greening up earlier in the spring

Tundra:

~5 days earlier per decade

Change in first leaf date – 1950s to 2010s

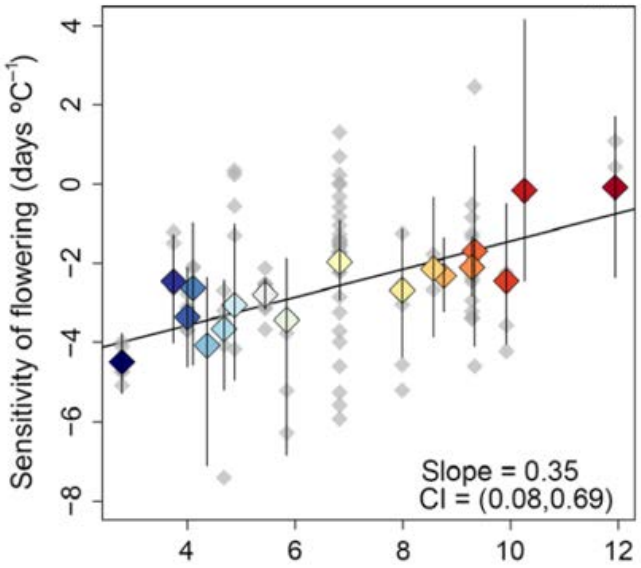


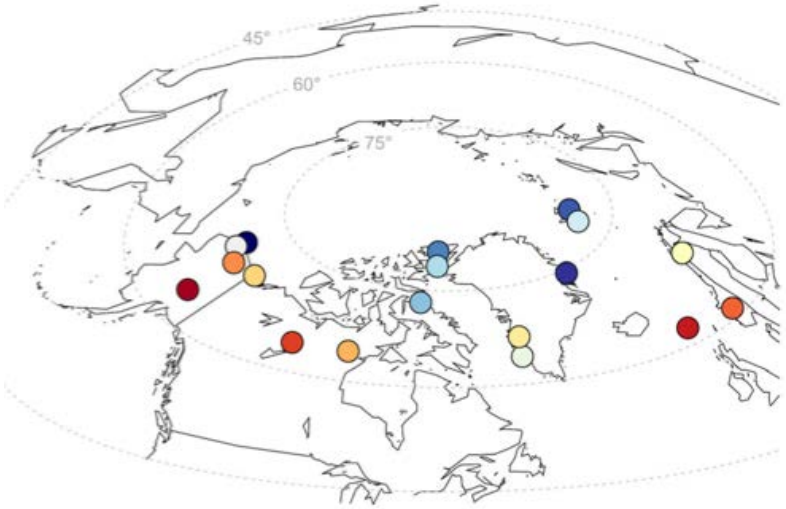
Lilac

Honeysuckle

Schwartz *et al.* 2016

Phenology ~ temperature



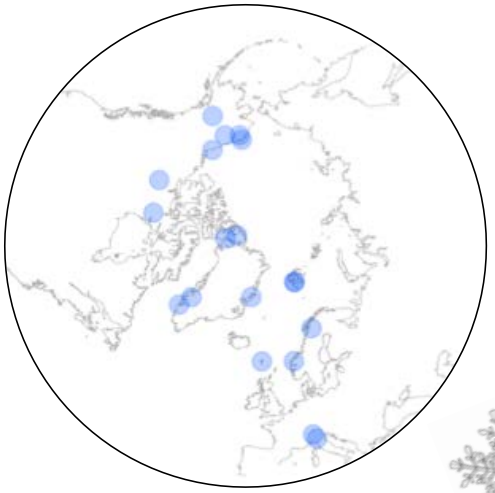


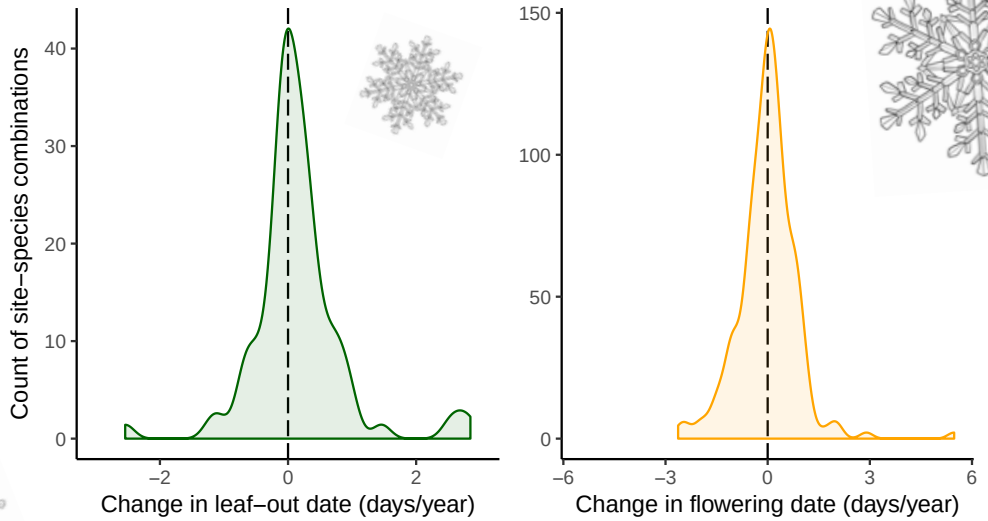
High Arctic ⟵ ⟶ **Low Arctic**

Prévey *et al.* GCB 2017

Phenology over time

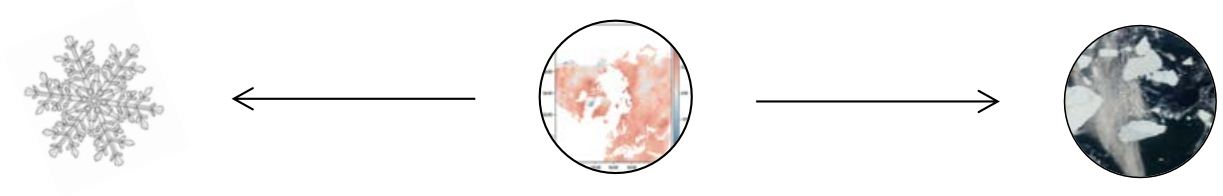
ITEX phenology sites:





Bjorkman *et al.* in prep.

Phenology ~ snow melt + temperature + sea ice



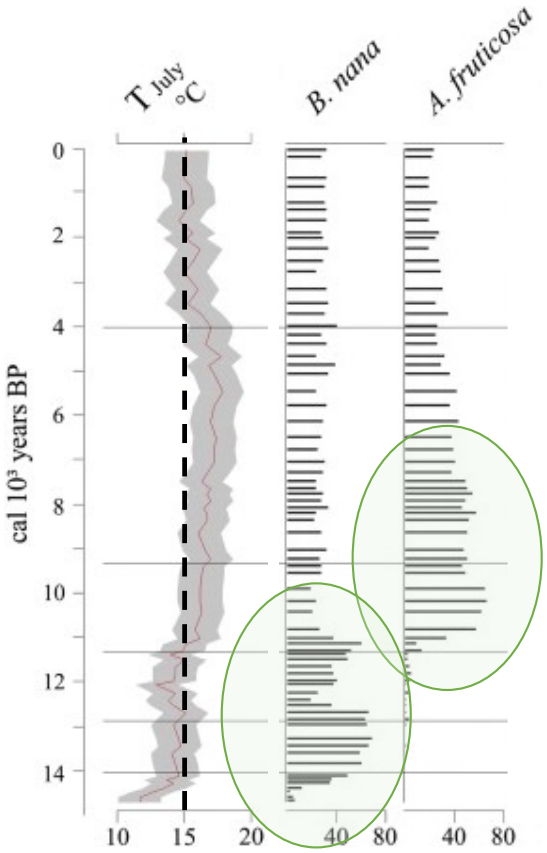
?

Assmann *et al.* in prep.

	Detection	Attribution 
	+ / −	✓
		
		
		

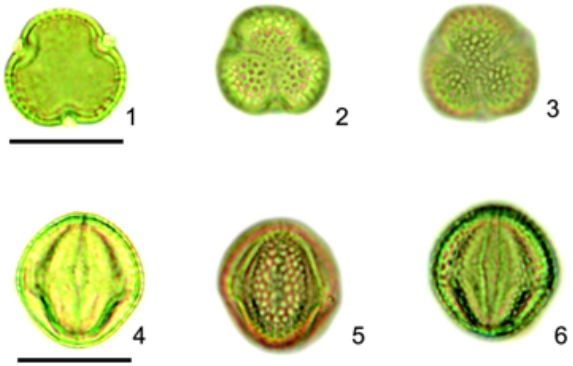
Shrubification

It was warmer and shrubbier in the past!



14 000 – 6000 years ago

Willow pollen:



Klemm et al. Paleo 2013

Shrubification

1987

2009

Qiqiktaruk – Herschel Island, Canadian Arctic

Shrubification

1987

2013

Qiqiktaruk – Herschel Island, Canadian Arctic

Shrubification

1987

2014

Qiqiktaruk – Herschel Island, Canadian Arctic

Shrubification

1987

2015

Qiqiktaruk – Herschel Island, Canadian Arctic

Shrubification

1987

2016

Qiqiktaruk – Herschel Island, Canadian Arctic

Shrubification

1987

2017

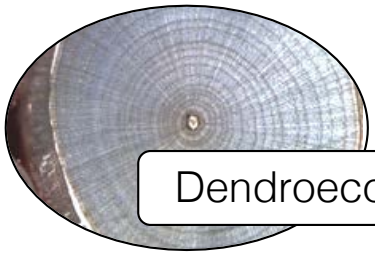
Qiqiktaruk – Herschel Island, Canadian Arctic

Shrubification

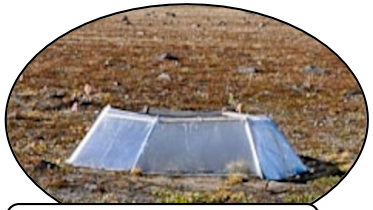
Historical Ecology

Ecological Monitoring

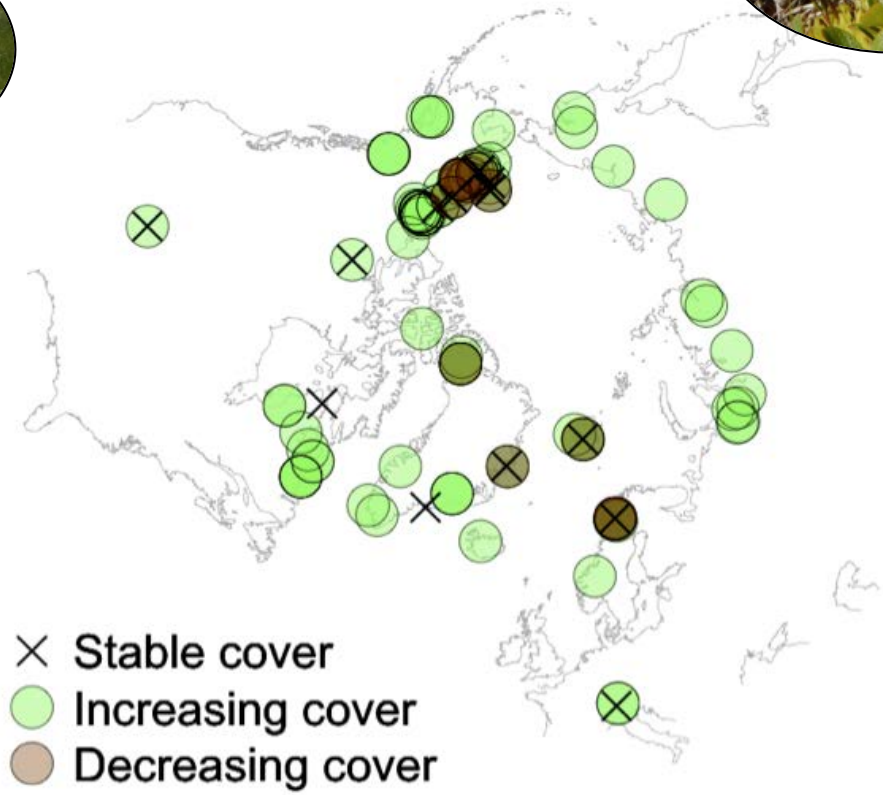
Phenology



Dendroecology

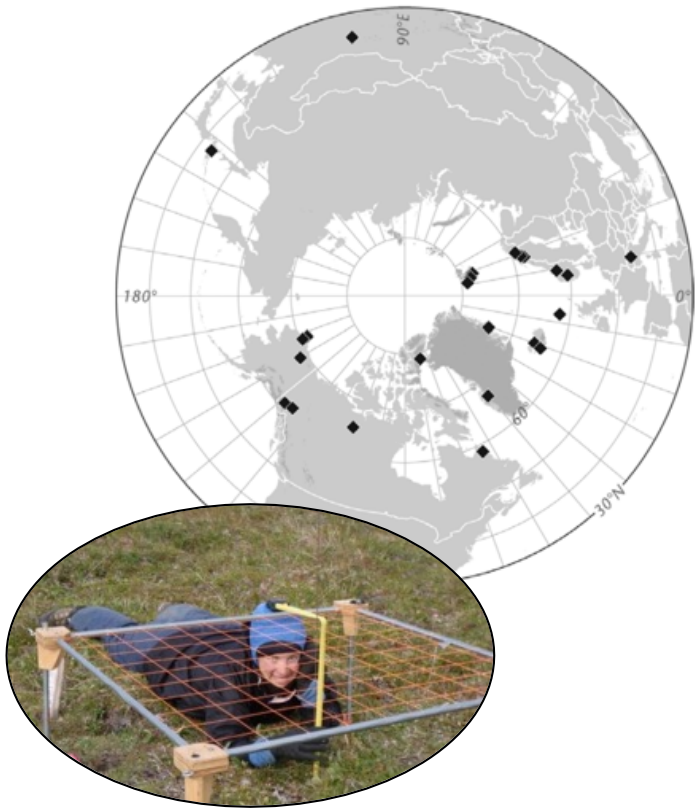


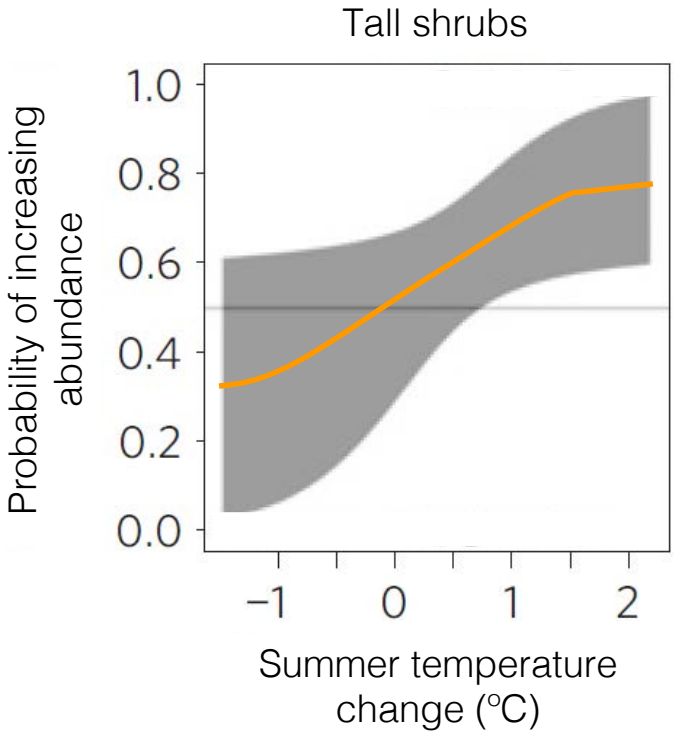
Experiments



Myers-Smith et al. ERL 2011, Myers-Smith et al. 2017

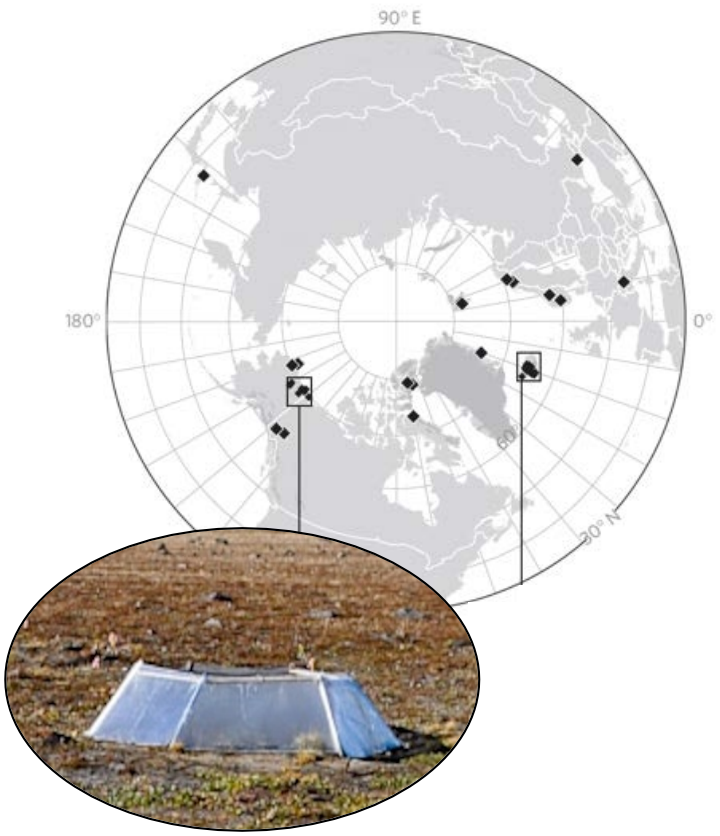
Shrubs increase ~ warming

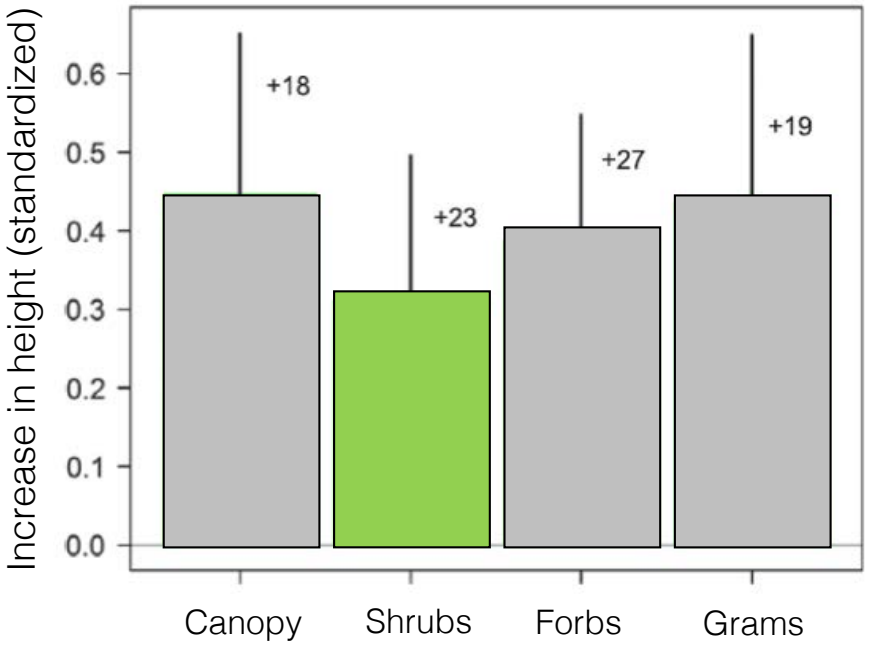




Elmendorf *et al.* NCC 2012, PNAS 2016

Shrub height ~ experimental warming

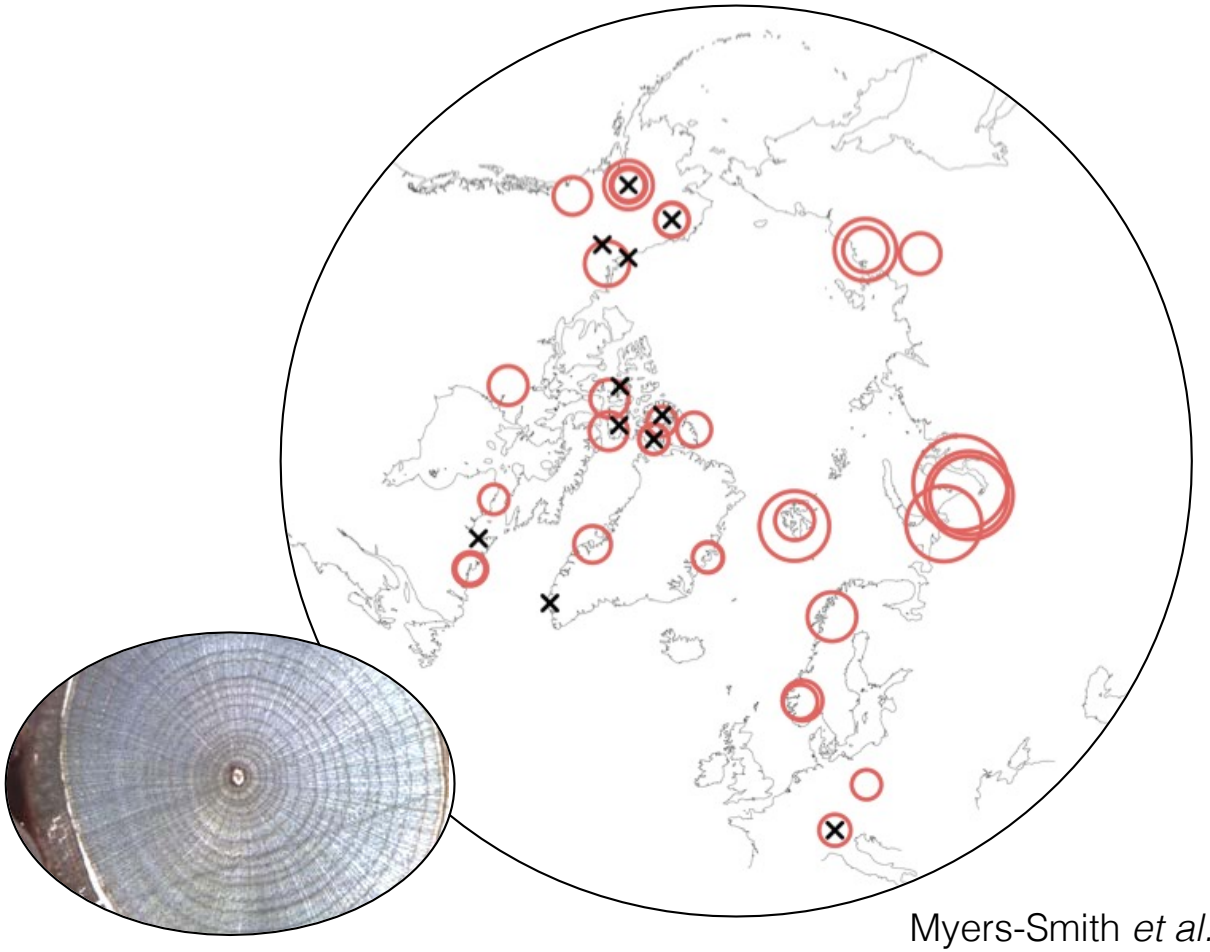




Effects of warming on vegetation height

Elmendorf *et al.* Ecol. Lett. 2012

Shrub growth ~ temperature



Low sensitivity (ΔAIC < 5)

High sensitivity ((ΔAIC = 40)

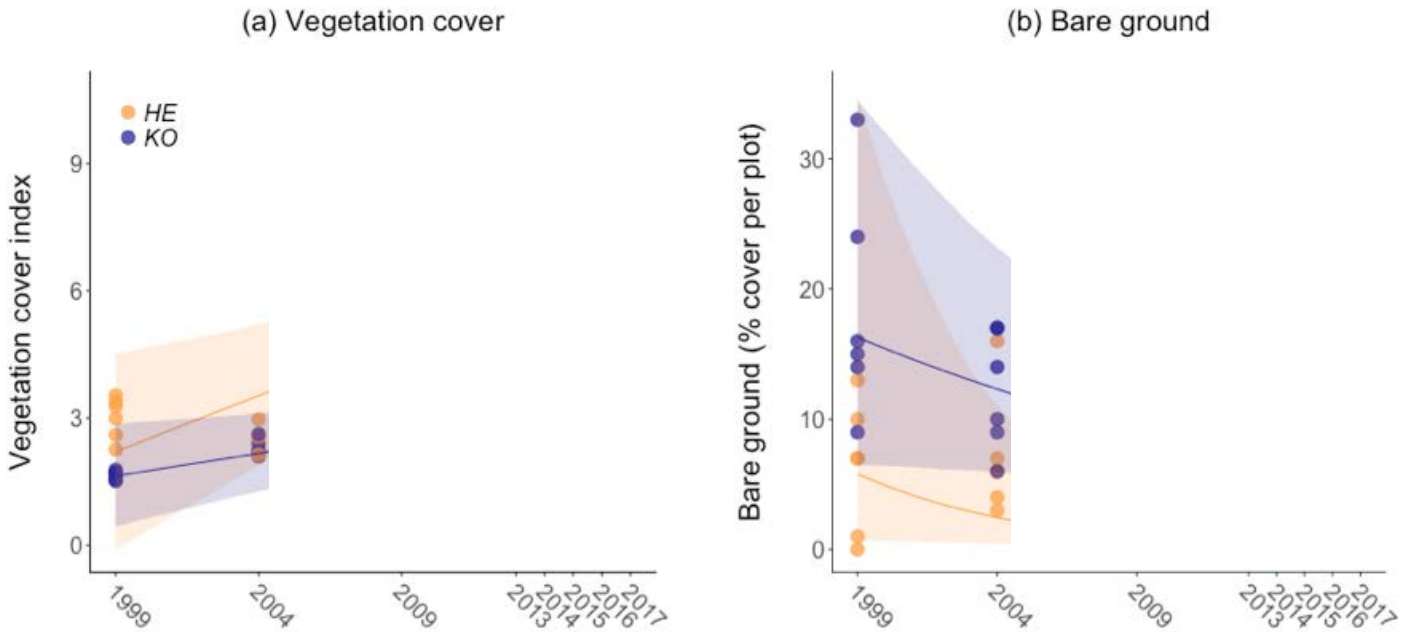
Not sensitive to climate

Myers-Smith *et al.* NCC 2015, Myers-Smith *et al.* J. Ecol. 2017

	Detection	Attribution 
	+ / −	✓
	+	✓
		
		

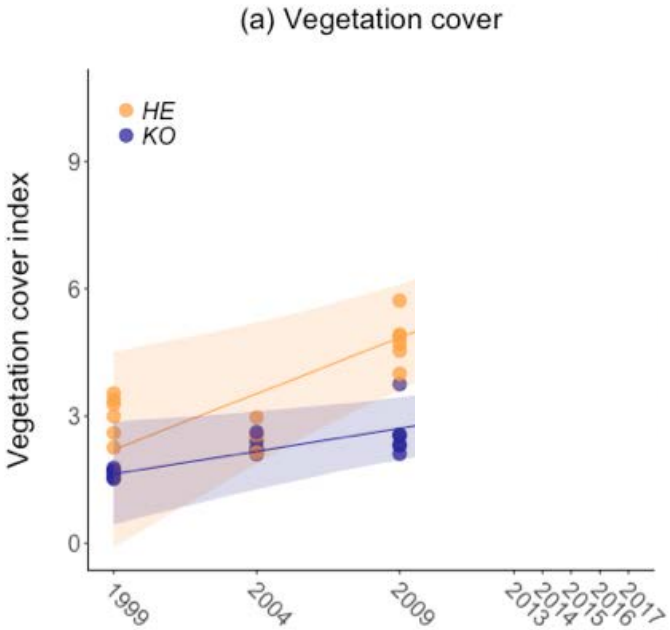

Plant composition

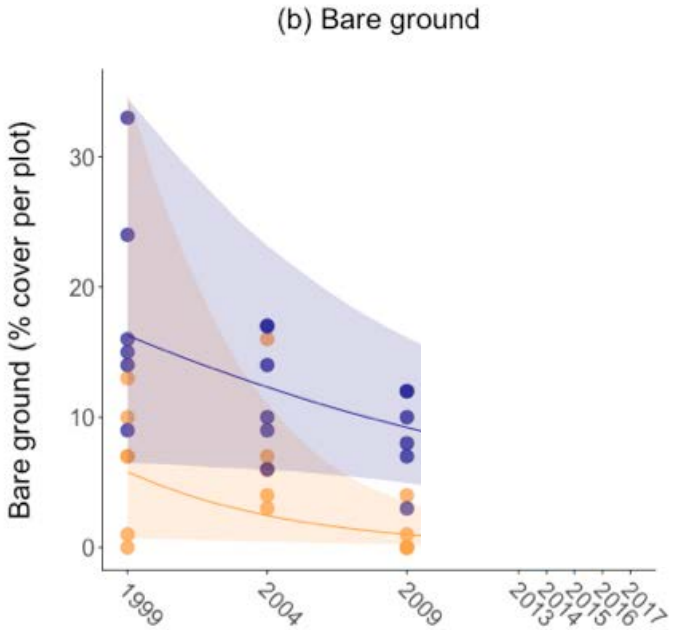
Plant cover ~ time

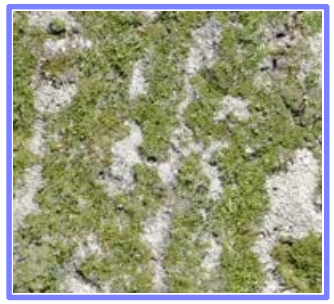


Myers-Smith *et al.* in review

Plant cover ~ time

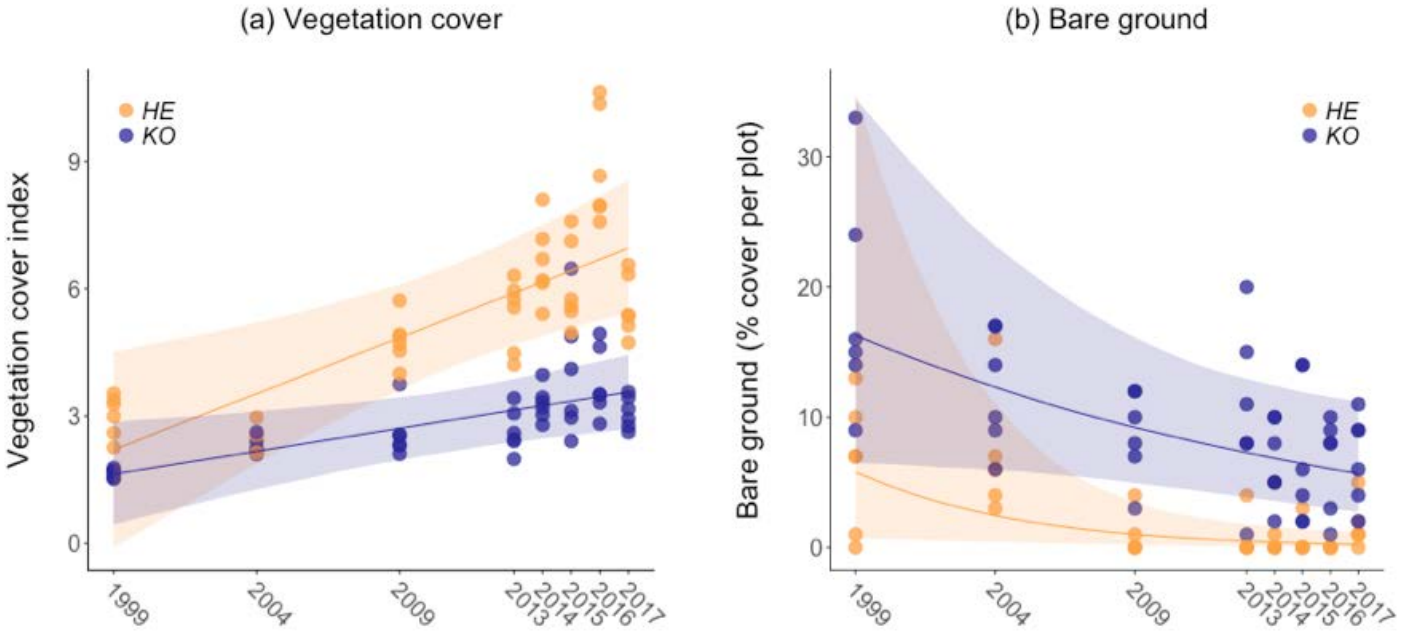






Myers-Smith *et al.* in review

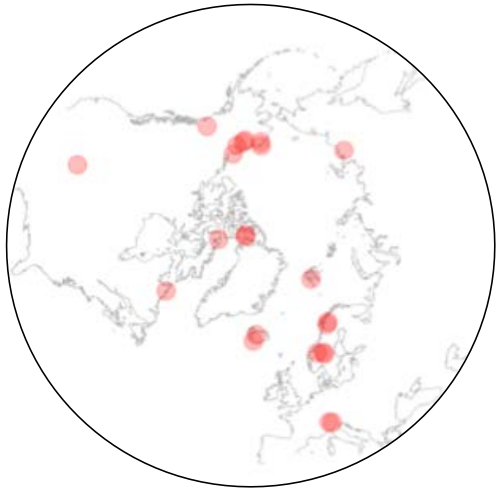
Plant cover ~ time

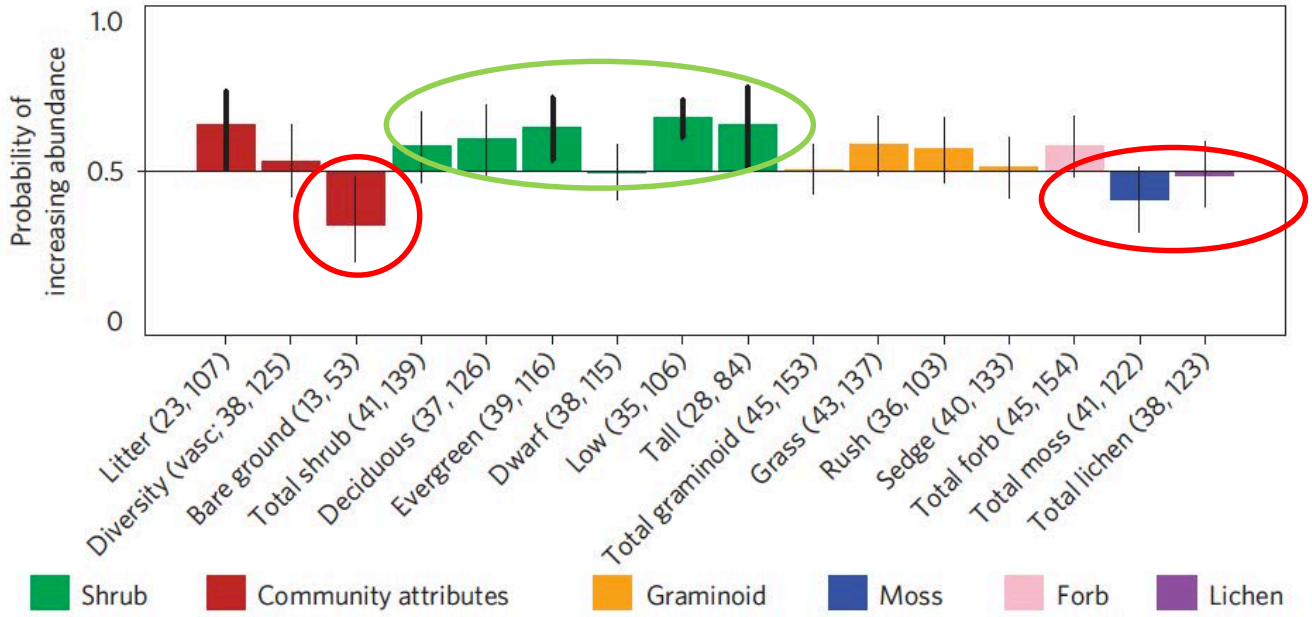


Myers-Smith *et al.* in review

Plant cover ~ time

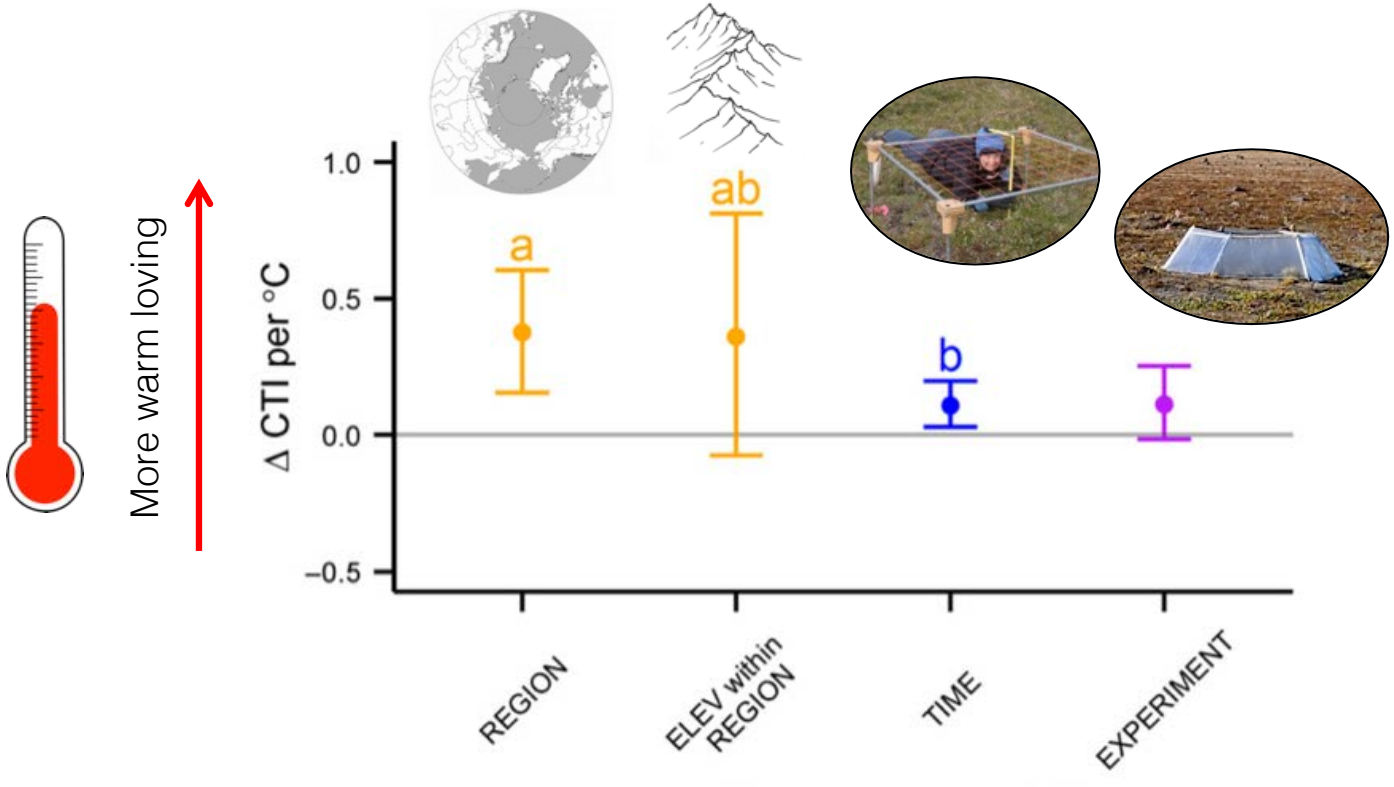
ITEX plant cover sites:





Elmendorf *et al.* NCC 2012, PNAS 2016

Plant community change favours warm-loving species



Elmendorf *et al.* NCC 2012, PNAS 2016

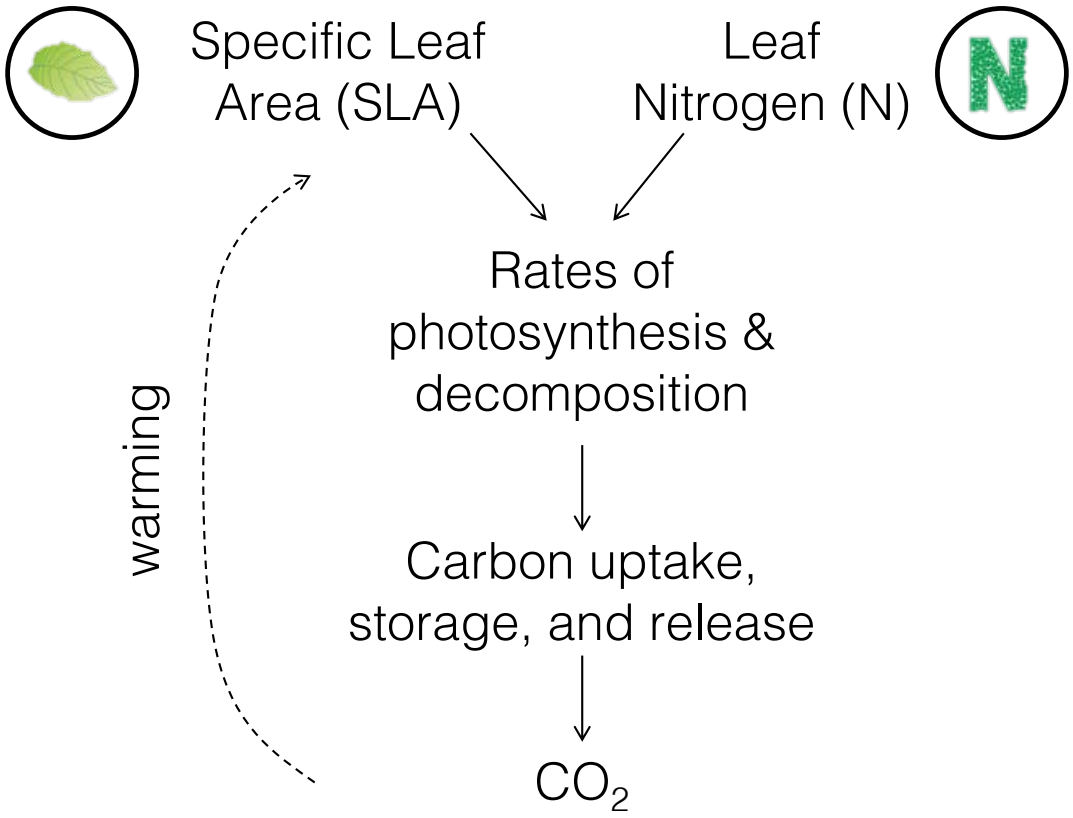
	Detection	Attribution 
	+ / −	✓
	+	✓
	+ / −	✓
		

Traits

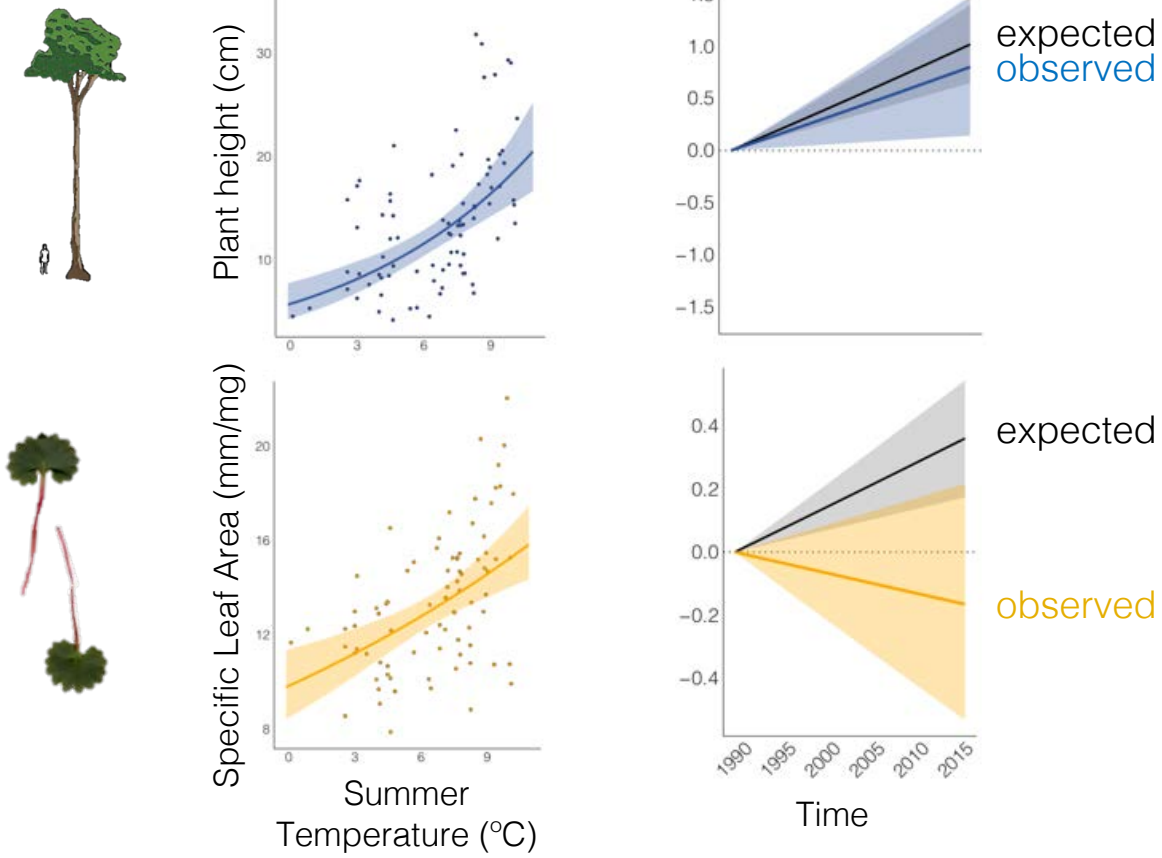
Trait change

The traits of species, not their identity, affect ecosystem function

Leaf traits link to decomposition and carbon cycling



Trait change ~ warming



Observed:

Plant height changes in line with predictions

But other traits like SLA lag

Bjorkman, et al. in revision

How will plants respond to future change?

Warming experiments

+

Tundra Trait Team

+

Common garden experiments

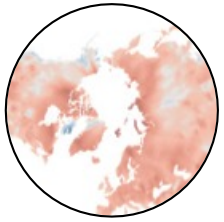
=

Estimates of traits in non-analog warmer climates

	Detection	Attribution 
	+ / −	✓
	+	✓
	+ / −	✓
	+ (height)	✓ (height) / ✗ (other)

Our research questions…

1. How is tundra vegetation changing?

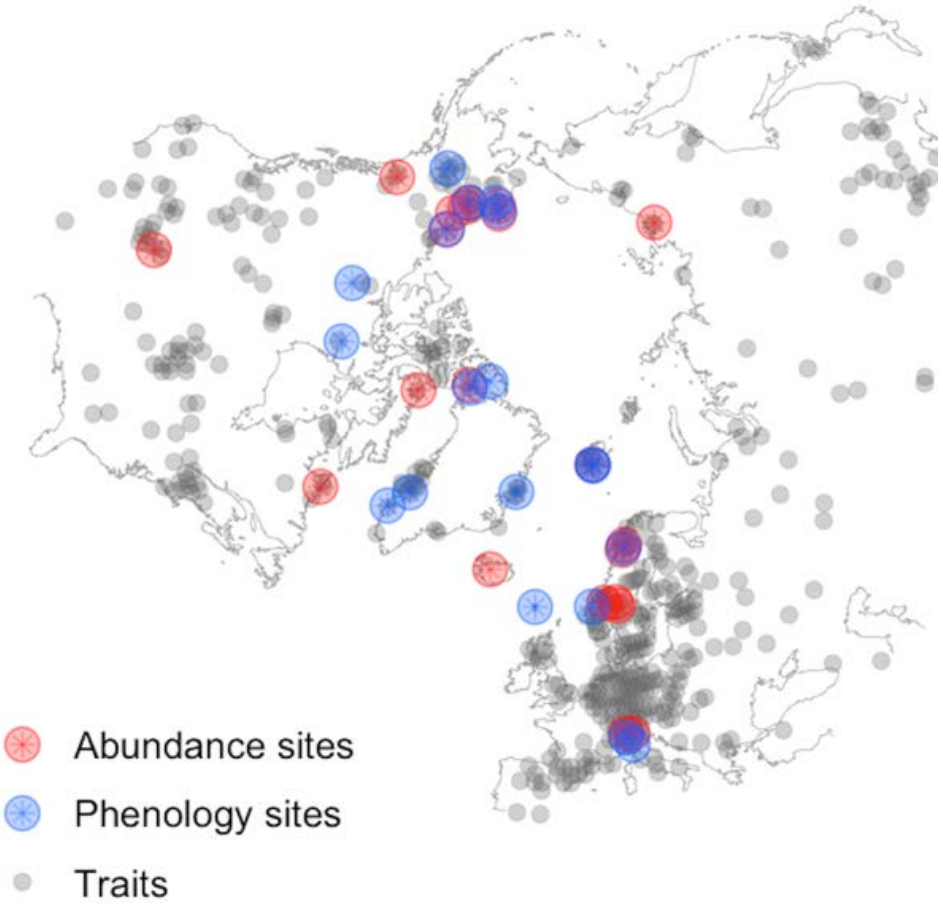


2. Is climate warming causing vegetation change?

Other drivers of change

Herbivory

Fire

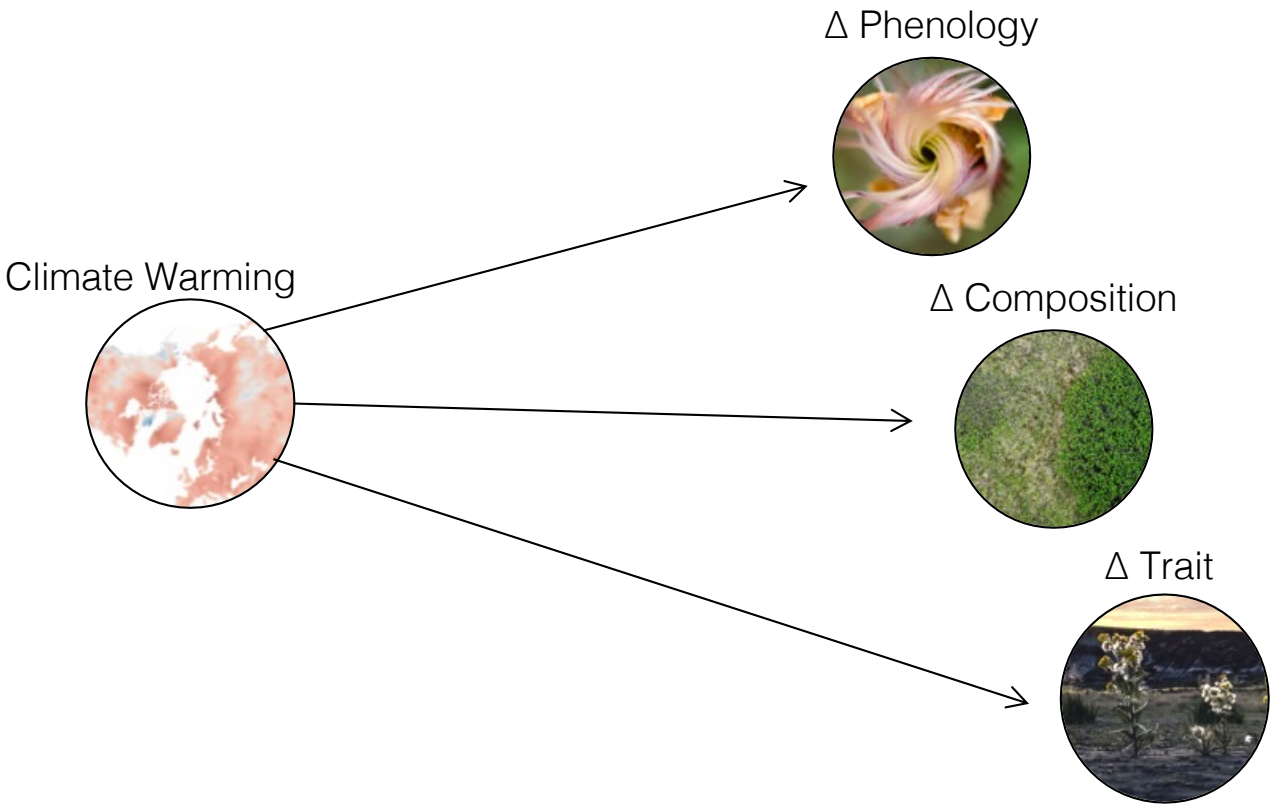


Nitrogen fertilization

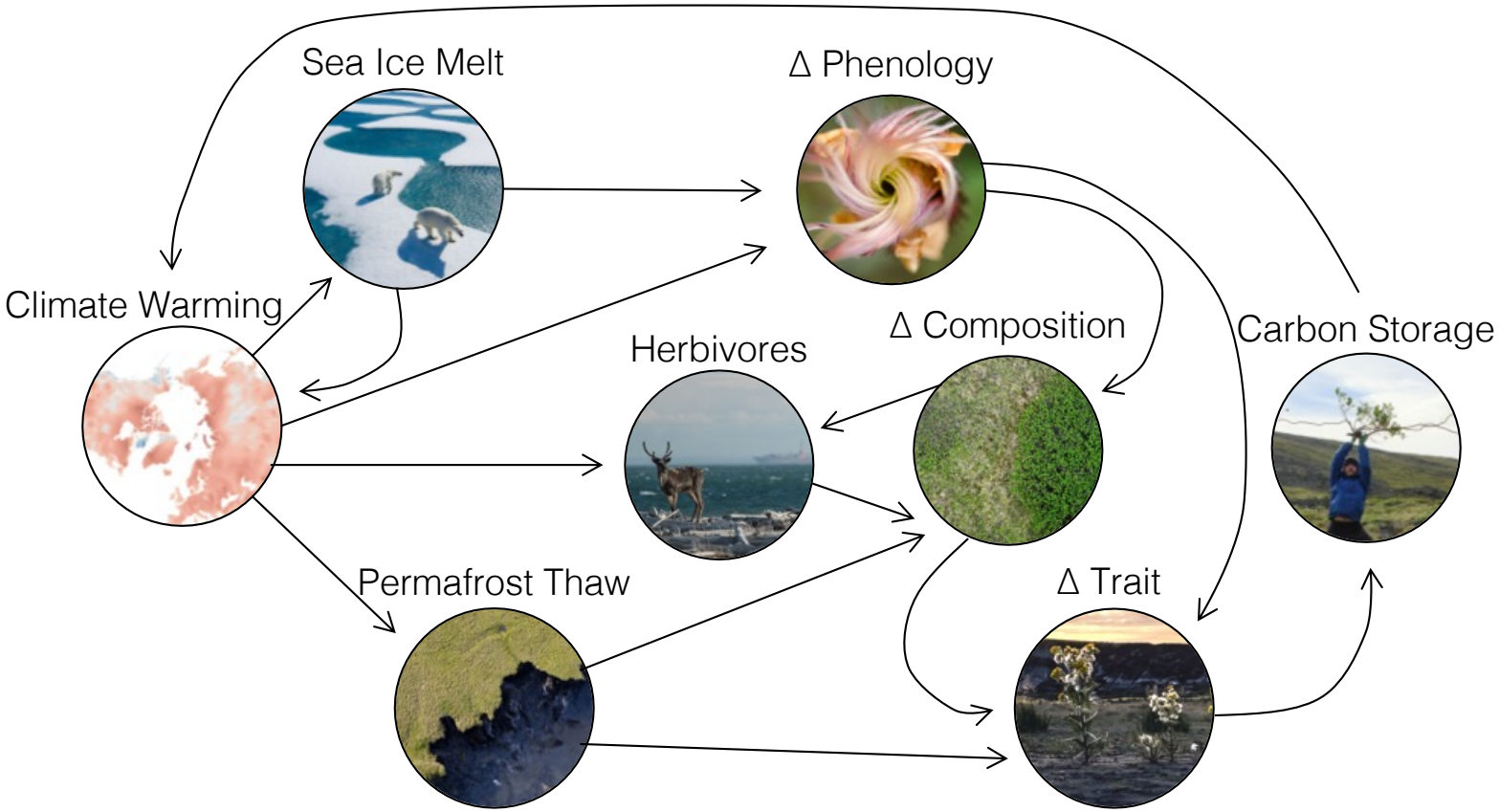
CO_2 Fertilization

Below-ground matters: up to 80% of tundra biomass

Simplicity: attribution of vegetation change to climate

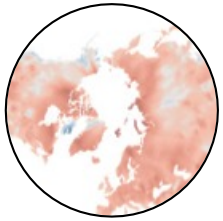


Complexity: direct versus indirect mechanisms



In summary…

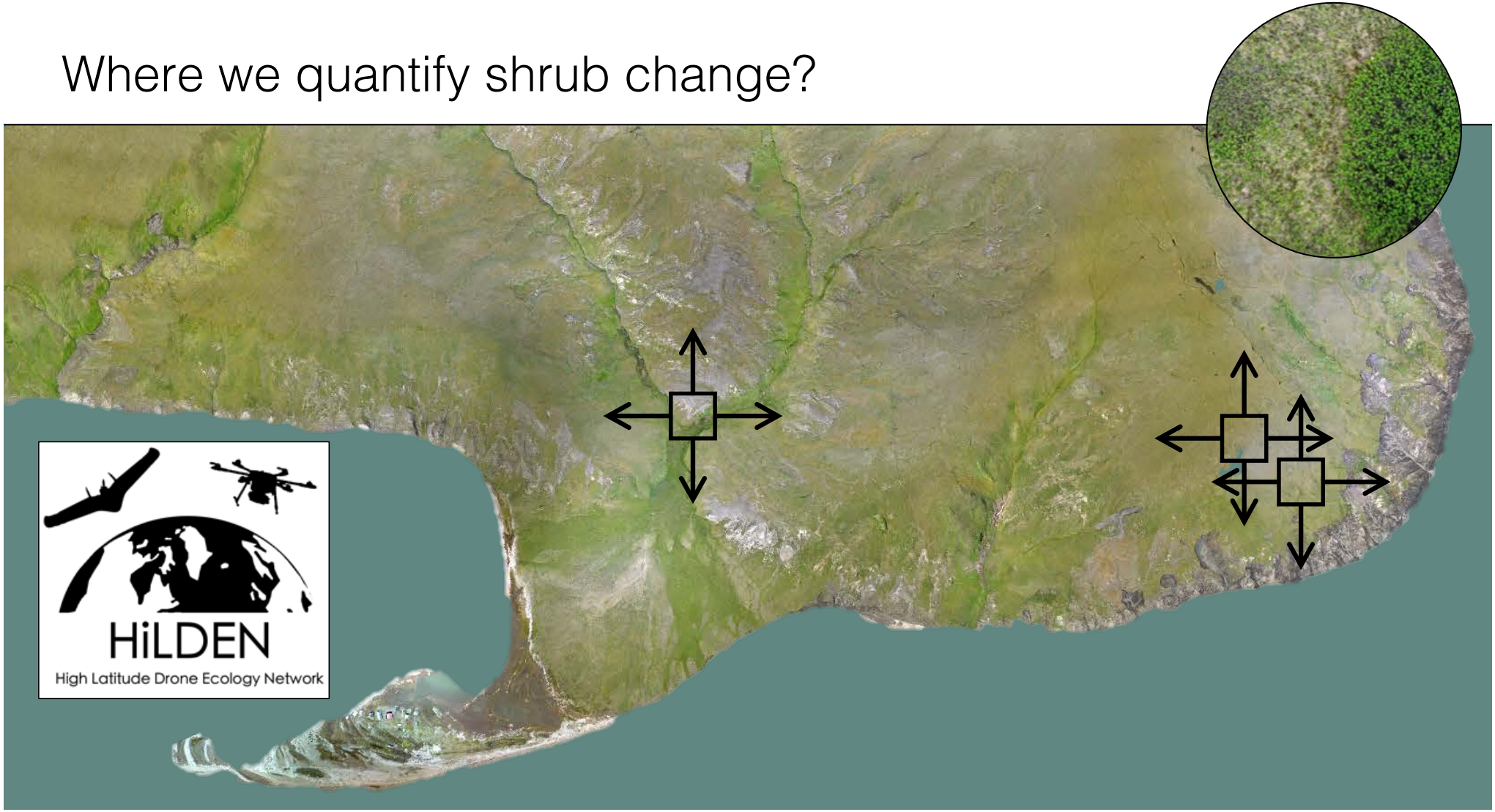
1. How are tundra ecosystems changing?
   - Changing phenology (some of the time)
   - Shrubification and increased plant cover and height



2. Is climate warming causing vegetation change?
   - Plant phenology and growth is climate sensitive
   - Plant communities are responding to warming


Sandra Angers-Blondin

Where we quantify shrub change?

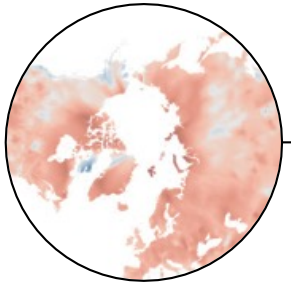


Global Change Drivers

Tundra Ecosystem Reponses

Ecosystem-level Impacts

Climate Warming



Sea Ice Melt

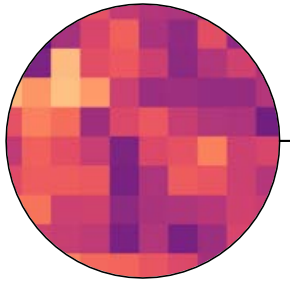
Permafrost Thaw

Compositional Change

Phenology Change

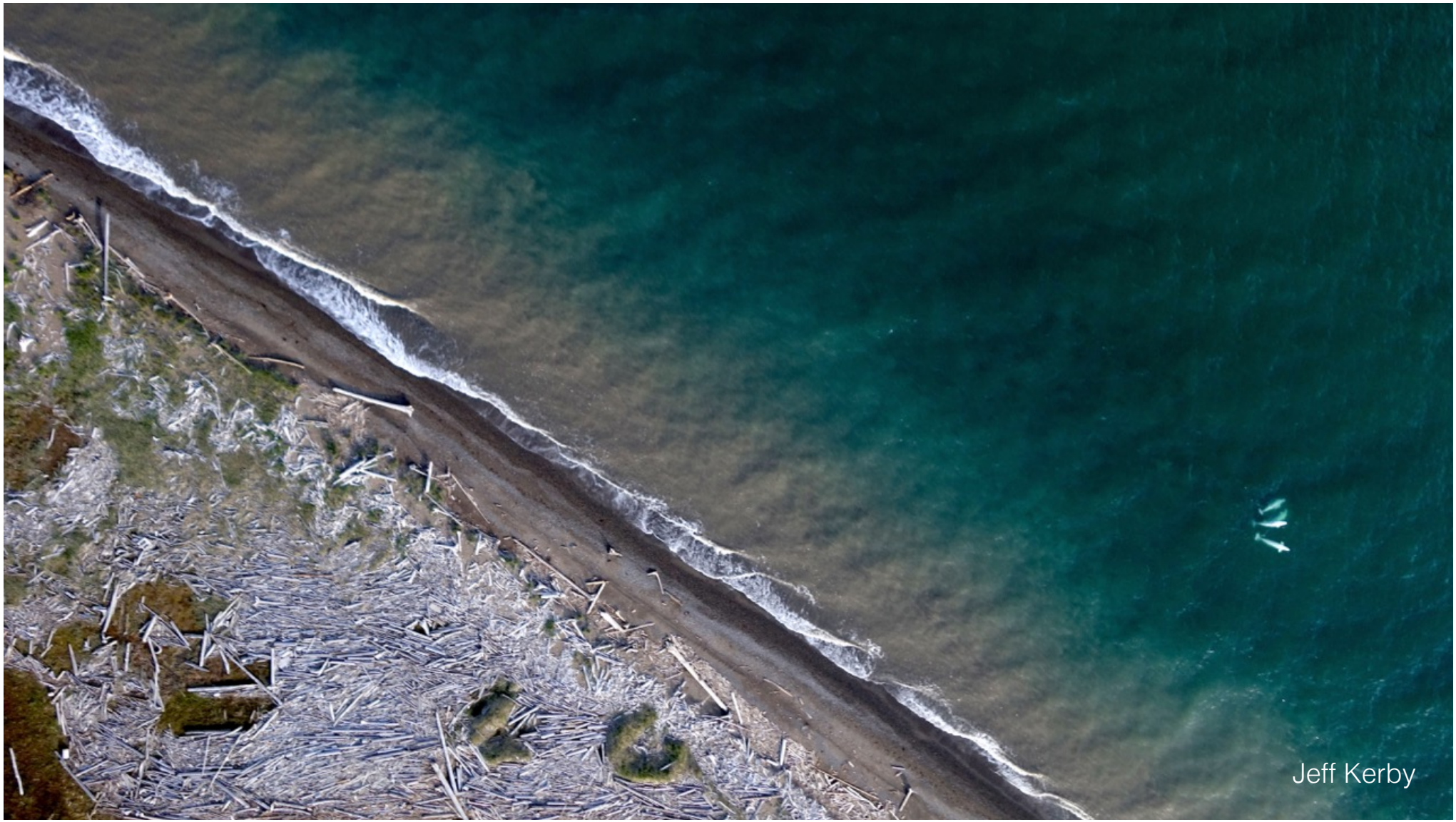
Trait Change

Surface Reflectance



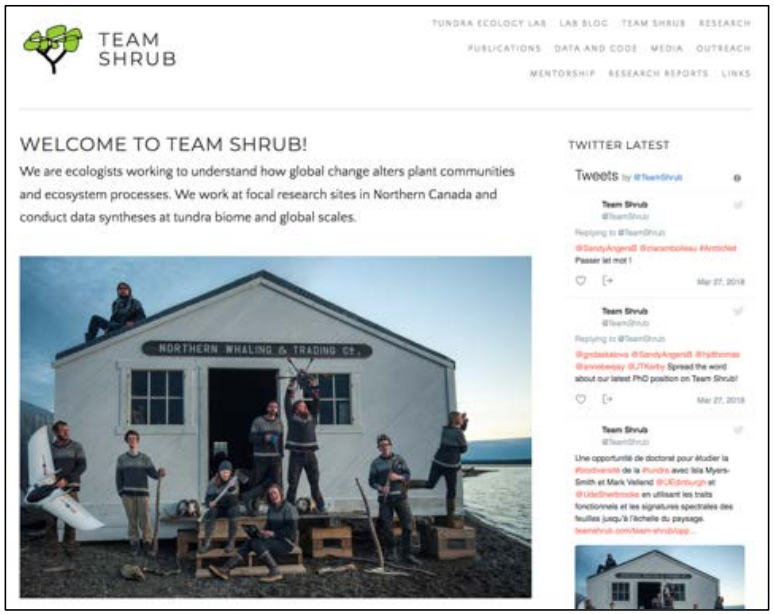
Trophic Impacts

Carbon Storage


Jeff Kerby

Thank you!

For more information… https://teamshrub.com/



isla.myers-smith@ed.ac.uk

@TeamShrub #TeamShrub

Less vegetation

Less carbon in biomass and more carbon in soils?

More vegetation

More carbon in biomass and less carbon in soils?