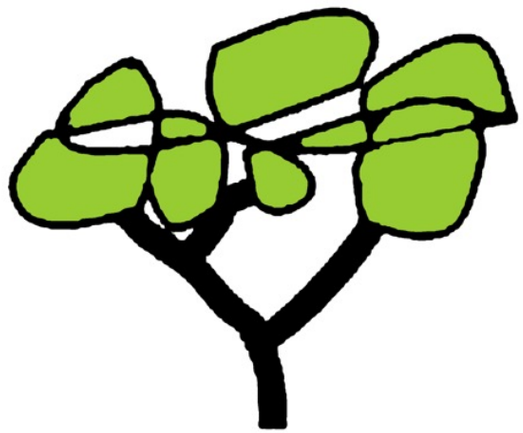
Vegetation Dynamics and the Greening of the Arctic



Isla Myers-Smith, University of Edinburgh
Logan Berner, Northern Arizona University
Jeffrey Kerby, Dartmouth College

Scale

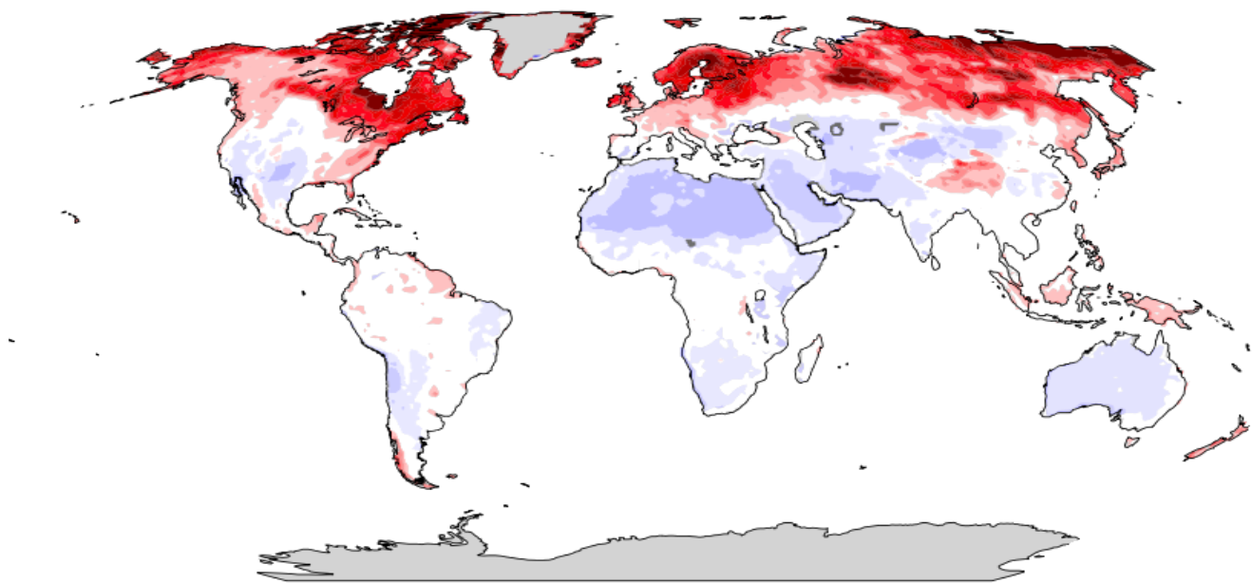
"The problem of relating phenomena across scales is the central problem in biology."

Levin Ecology 1992

NASA

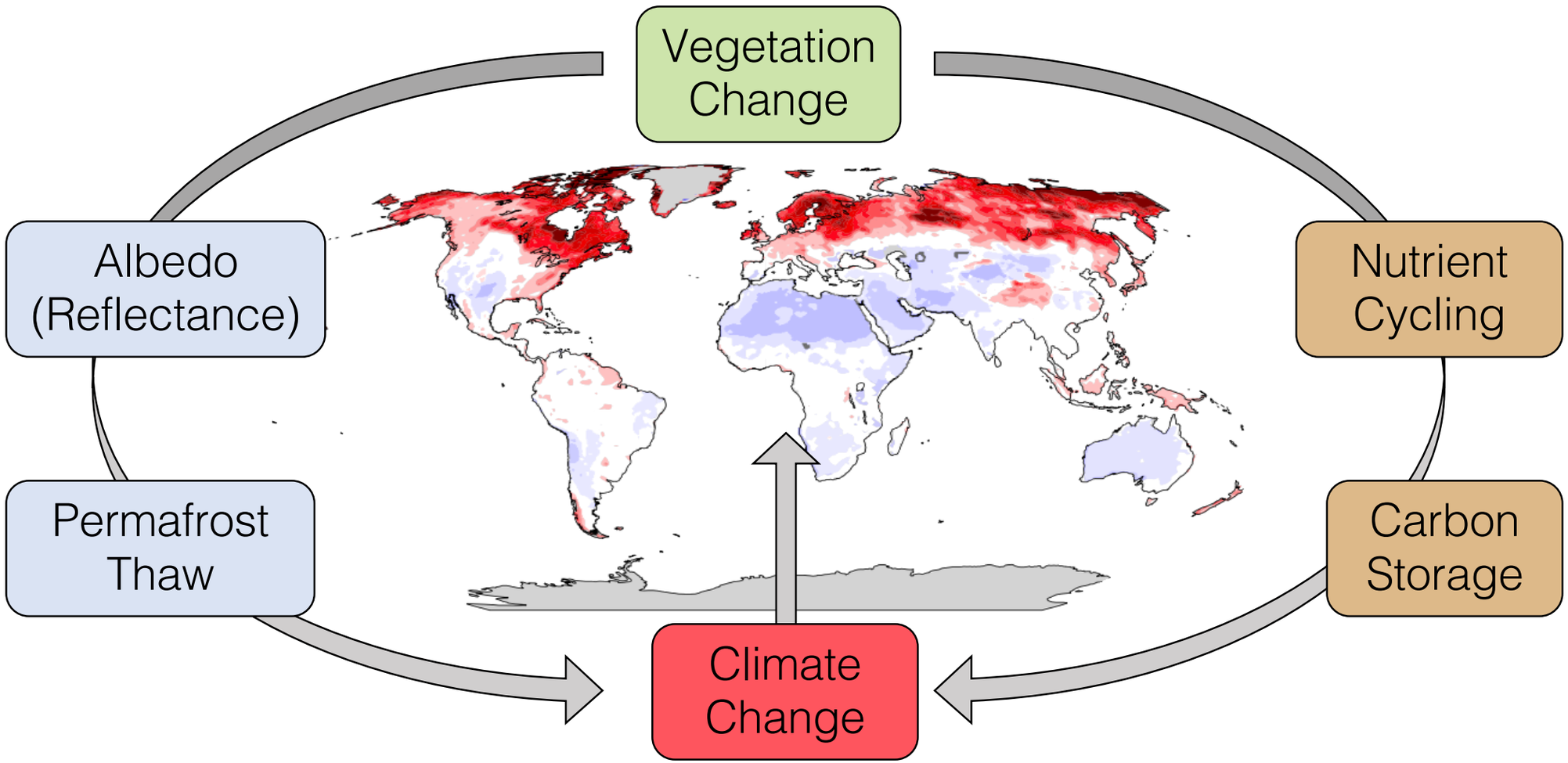
Arctic Greening
Sandra Angers-Blondin

Why does tundra change matter globally?



Crowther *et al.* Nature 2016
Gestel *et al.* Nature 2018

Why does tundra change matter globally?



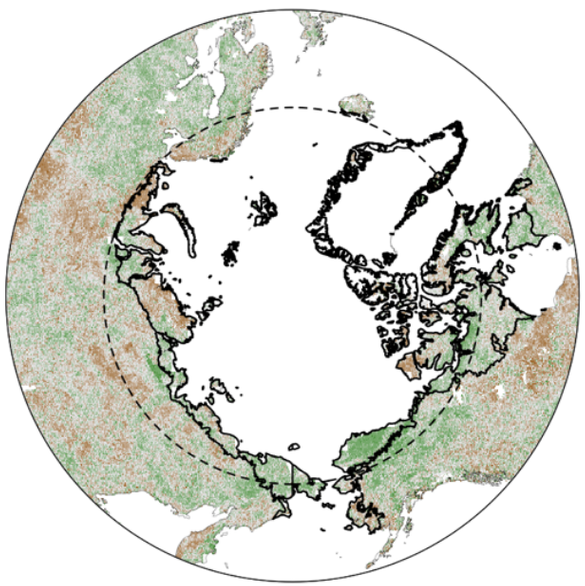
Pearson *et al.* NCC 2013

A warming Arctic…
Anne Bjorkman

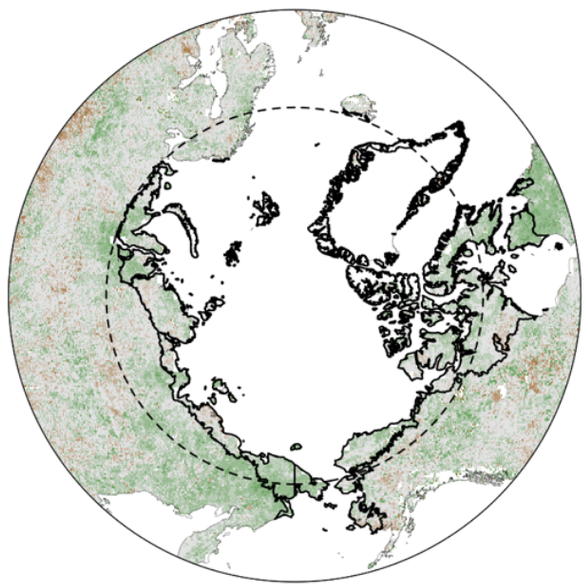
A warming
Arctic…
Jeff Kerby

Satellite observations indicate tundra greening

GIMMS trends
(2000 – 2015)



MODIS trends
(2000 – 2015)



Landsat trends
(2000 – 2016)

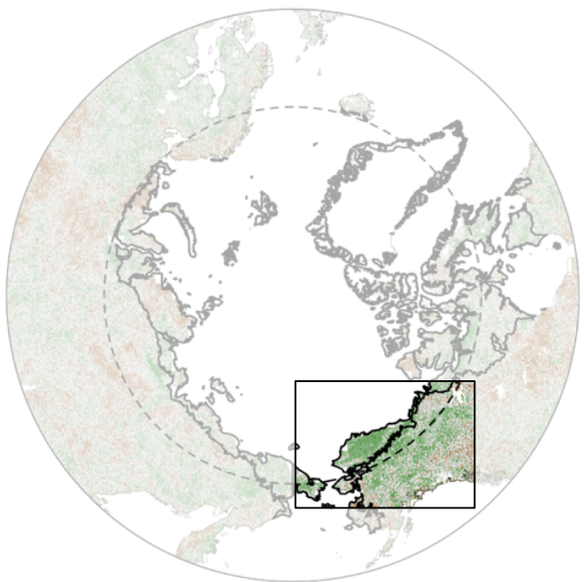
Analyses not yet public

Increasing NDVI
Decreasing NDVI

Berner *et al.* submitted (Goetz-01 Project)
Myers-Smith, Kerby *et al.* NCC in review

Satellite observations indicate tundra greening

GIMMS trends
(2000 – 2015)



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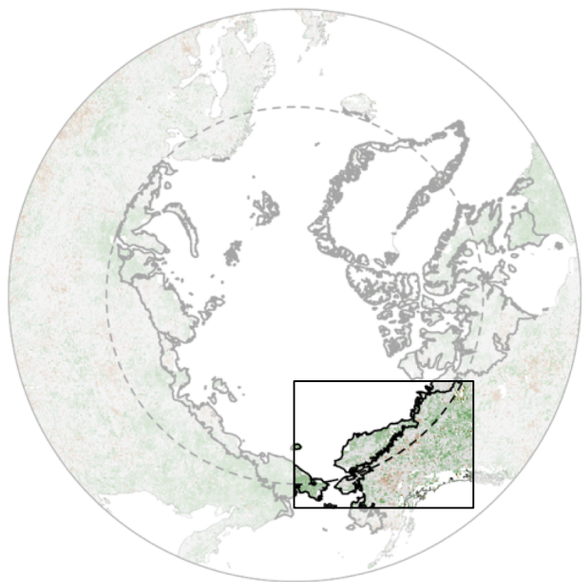

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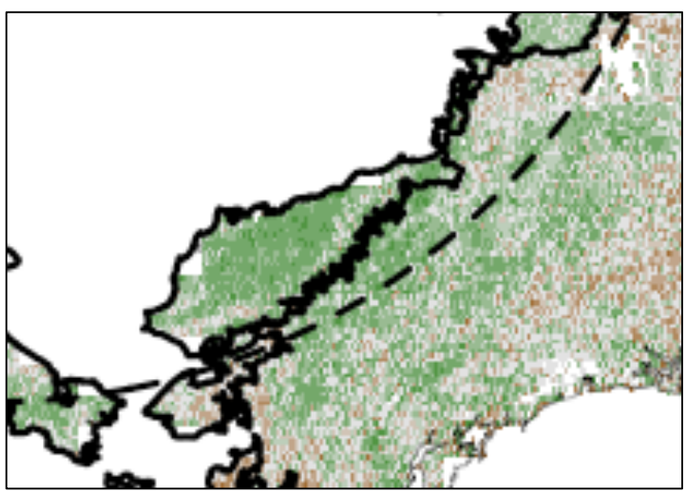
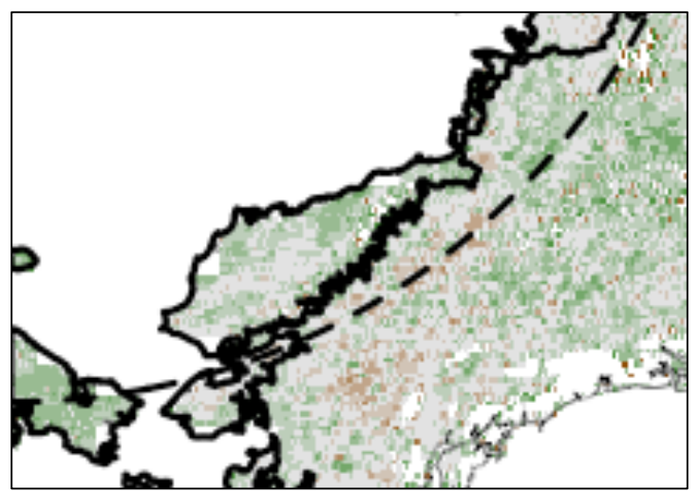


MODIS trends
(2000 – 2015)

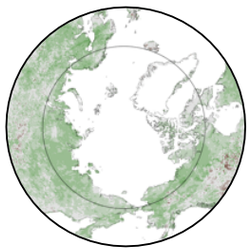


Landsat trends
(2000 – 2016)

Analyses not yet public

Berner *et al.* submitted (Goetz-01 Project)
Myers-Smith, Kerby *et al.* NCC in review

Conclusions



1. Arctic ecosystems are greening, but satellite datasets do not entirely agree

How are greening and browning defined?

Greening refers to a systematic increase or positive trend in a vegetation measurement associated with growth, NDVI or productivity observed over a period of time set by the researcher.

Browning is a systematic decrease in vegetation growth or the death of vegetation that results in a negative trend in growth, NDVI or productivity.

Greening – increased productivity

Browning – loss of plant biomass (event)

Browning – decreased productivity

Increased heterogeneity in productivity

No change in productivity

NAS 2019

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

Vegetation change

Anne Bjorkman

Wetland change
Jeff Kerby

Snow melt
dynamics
Team Shrub

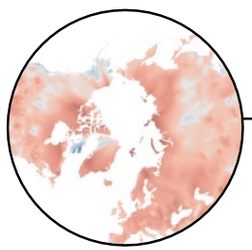
Herbivory
Jeff Kerby

Fire
Jeff Kerby

Permafrost thaw
Jeff Kerby

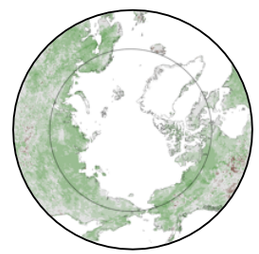
Arctic greening – the simple story

Climate warming



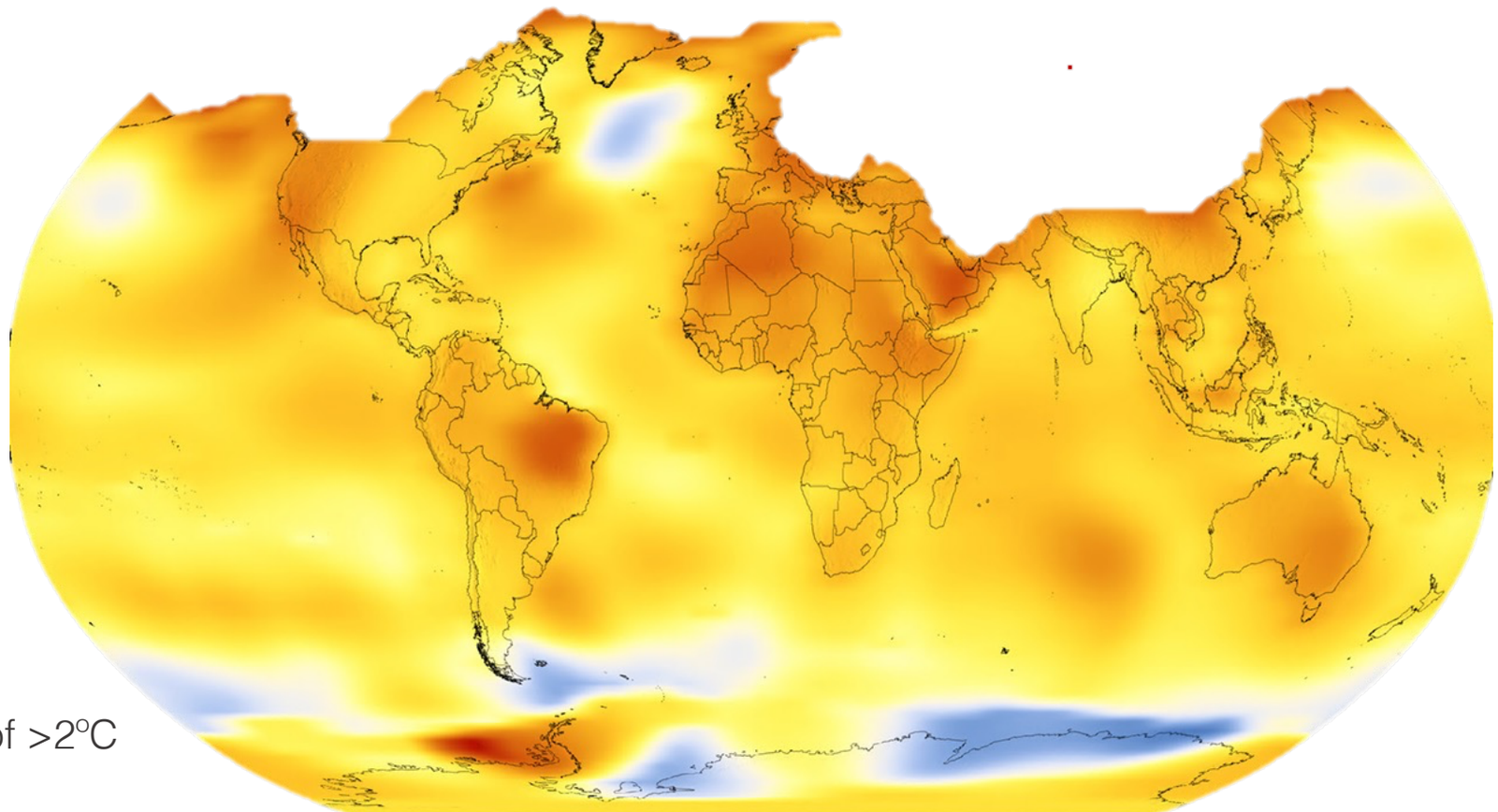
Vegetation change

Arctic greening



Is warming causing the greening?

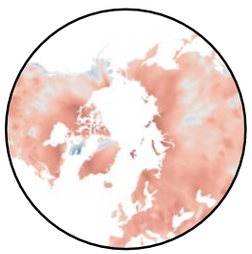
Temperature anomalies for 2013 to 2017 compared with 1951 - 1980



Warming of >2°C

NASA

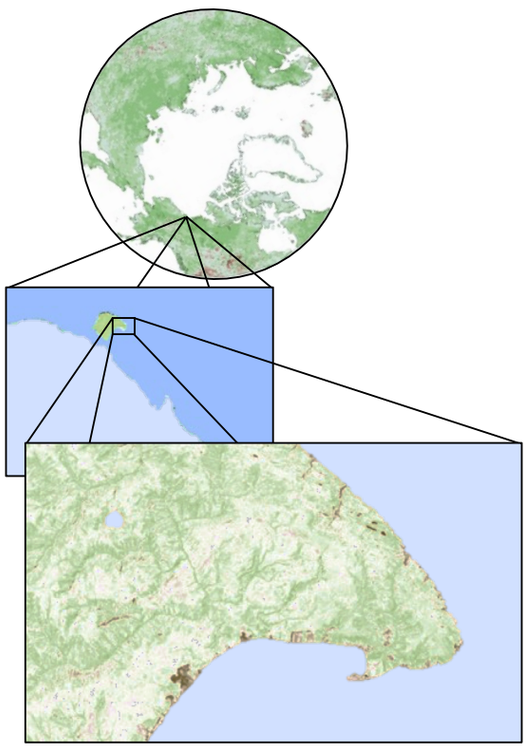
Conclusions



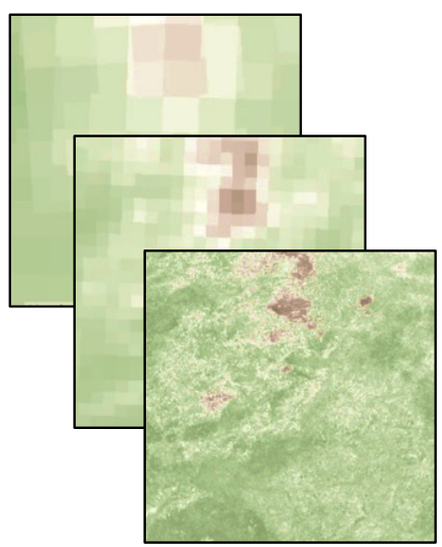
2. Warming is linked with greening, but greening has not occurred at all sites that have warmed

Scale can inform mechanism

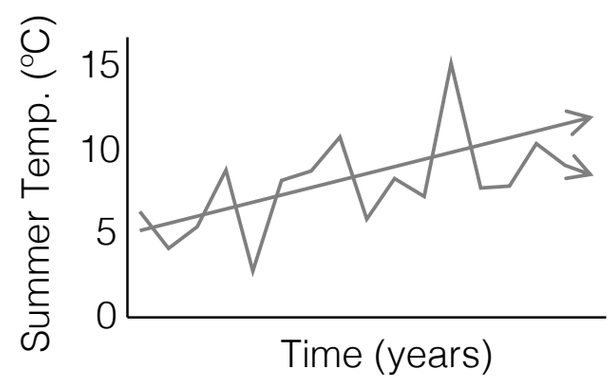
Extent



Spatial resolution

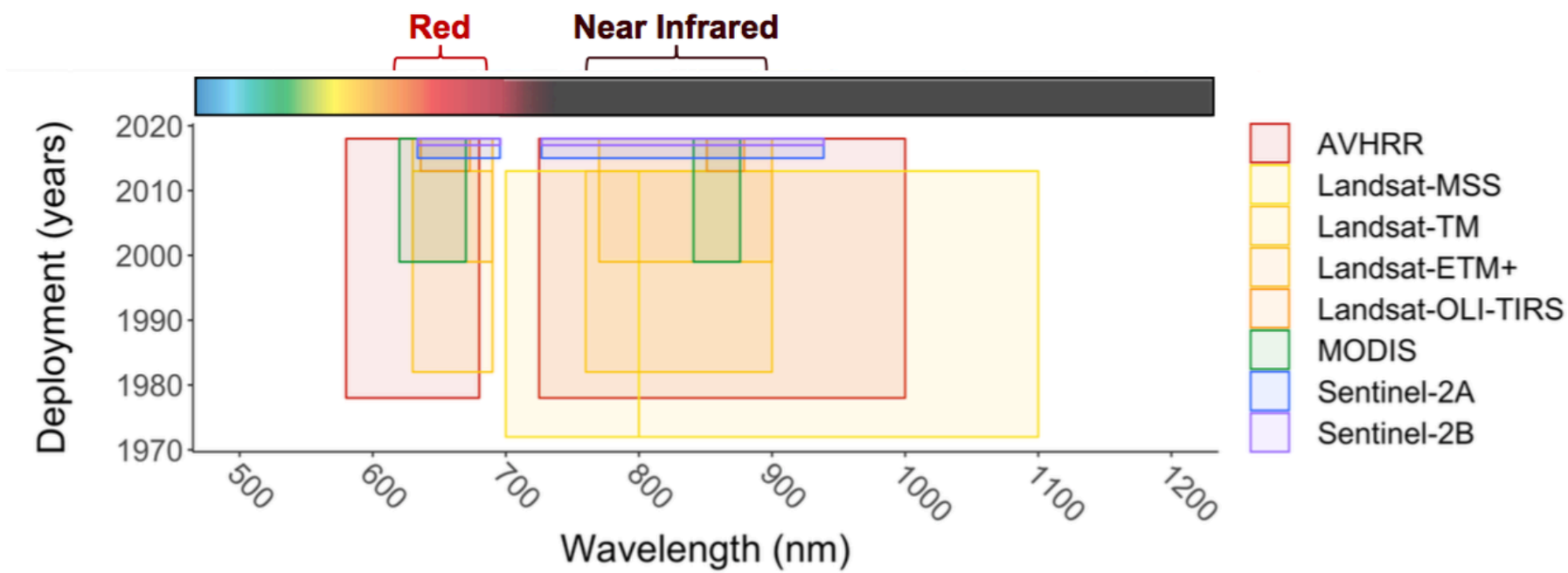


Temporal resolution



Scale can inform mechanism

Spectral resolution



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

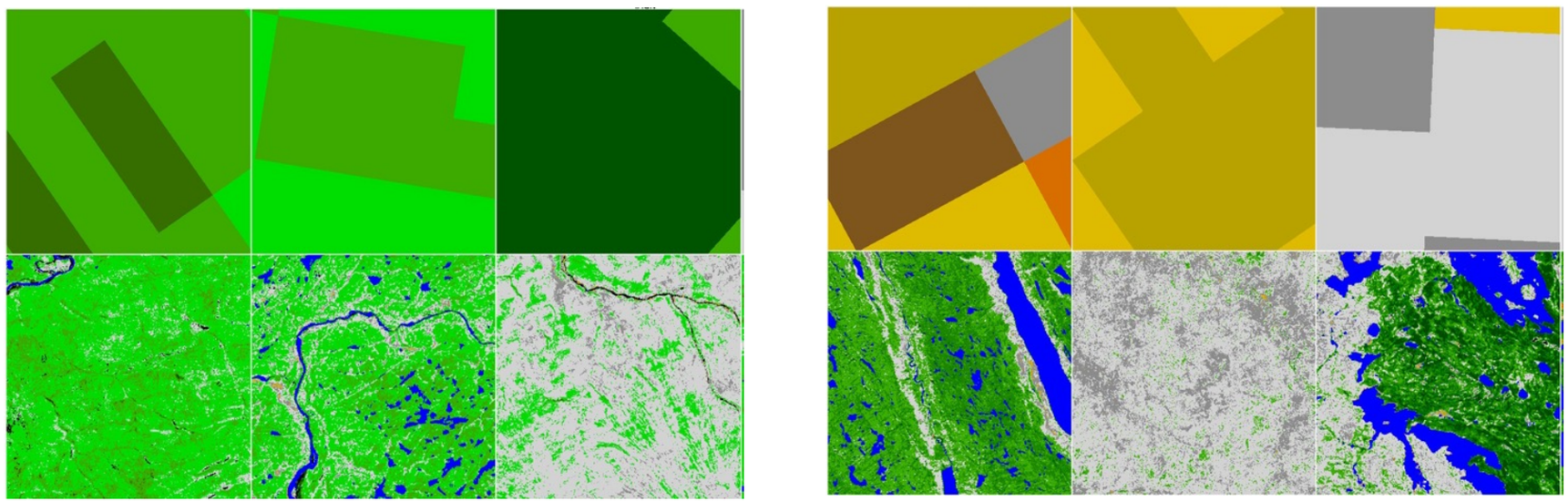
Greening and browning across scales

Greening

Browning

AVHRR

Landsat



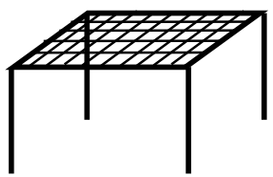
Ju and Masek RSE 2016
NAS 2019

The challenge of incorporating scale

Individual

Individual

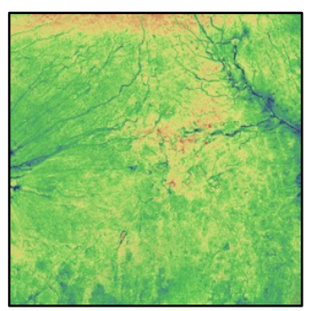
Plot



Community

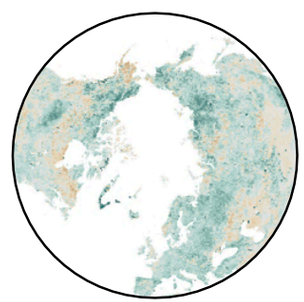
Drone and Airborne Data

Landscape

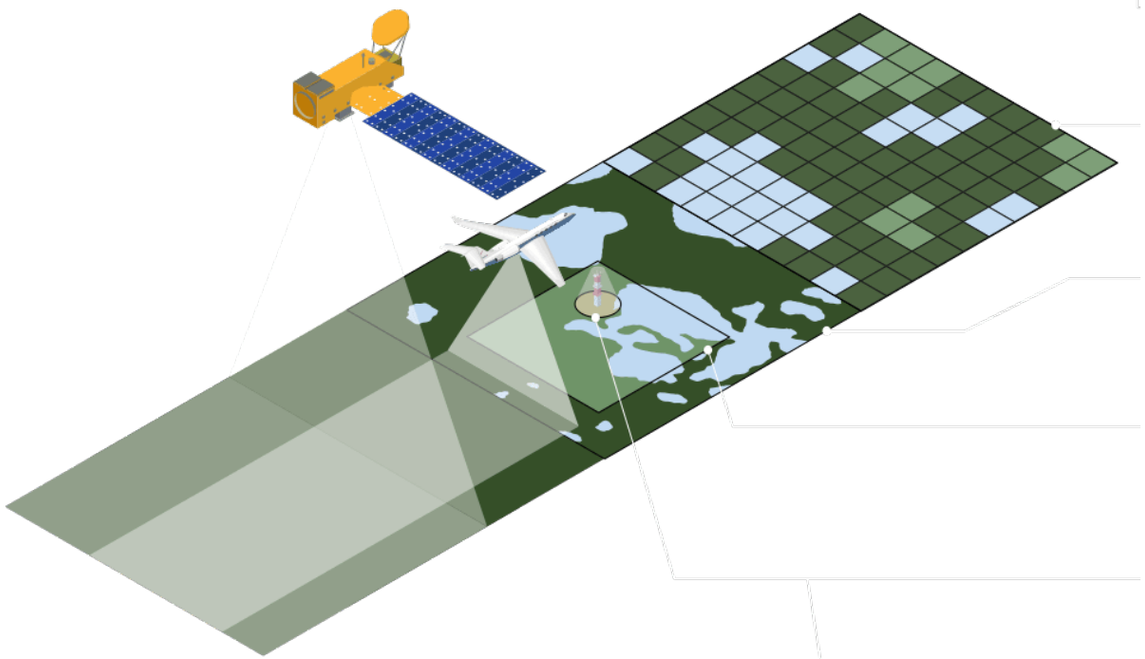


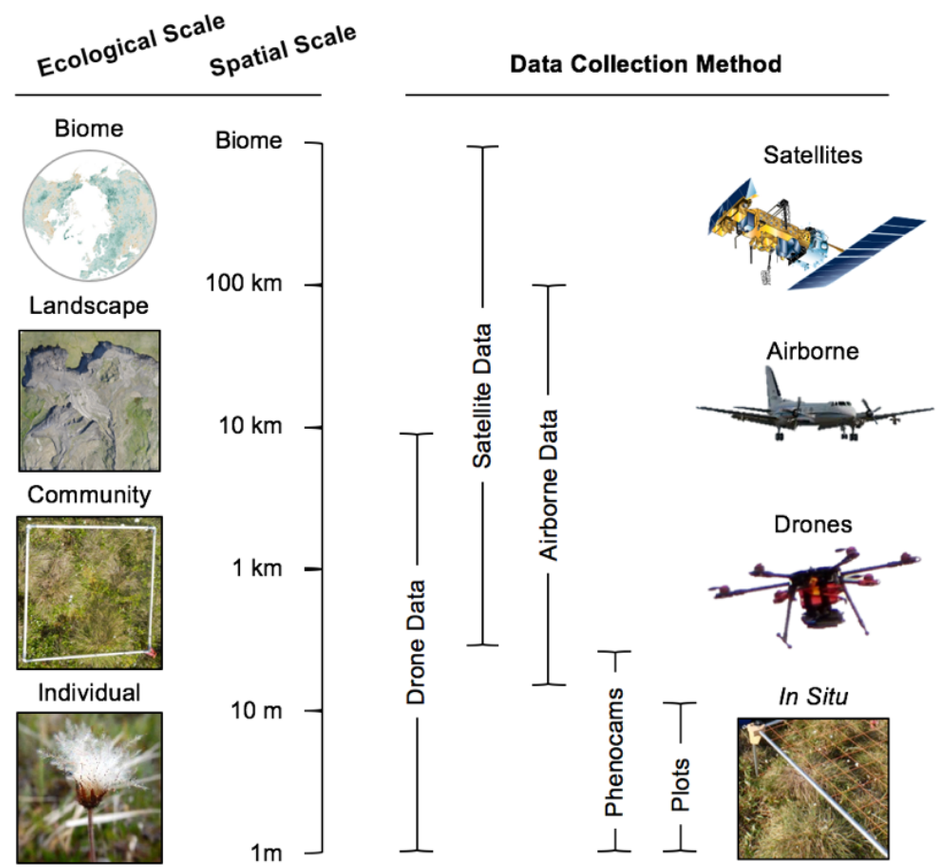
Satellite

Biome



Data collection across scales





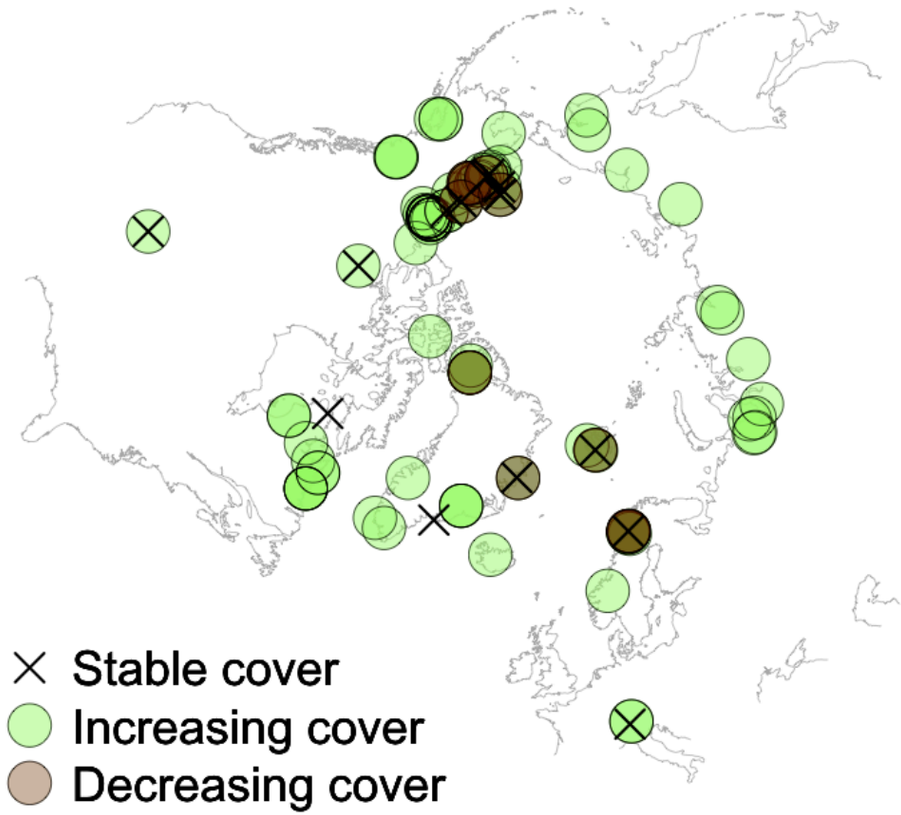
NAS 2019

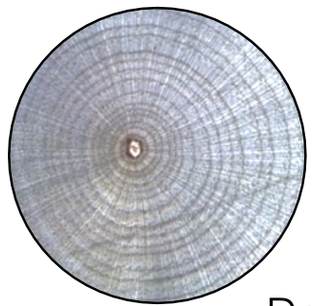
What is causing tundra greening?

Shrubification is wide spread in the tundra

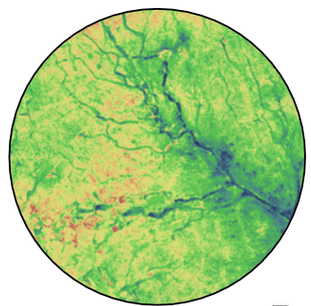
Historical
Ecology

Ecological
Monitoring





Dendroecology



Remote
Sensing

Myers-Smith *et al.* ERL 2011
Elmendorf *et al.* NCC 2012
García Criado, Myers-Smith *et al.* in prep.

Sandra Angers-Blondin

Shrubification

1987

2009

Myers-Smith *et al.* Ambio 2011
Myers-Smith *et al.* Ecol. Mono. 2019

Shrubification

1987

2013

Myers-Smith *et al.* Ambio 2011
Myers-Smith *et al.* Ecol. Mono. 2019

Shrubification

1987

2014

Myers-Smith *et al.* Ambio 2011
Myers-Smith *et al.* Ecol. Mono. 2019

Shrubification

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Myers-Smith *et al.* Ecol. Mono. 2019

Shrubification

1987

2016

Myers-Smith *et al.* Ambio 2011
Myers-Smith *et al.* Ecol. Mono. 2019

Shrubification

1987

2017

Myers-Smith *et al.* Ambio 2011
Myers-Smith *et al.* Ecol. Mono. 2019

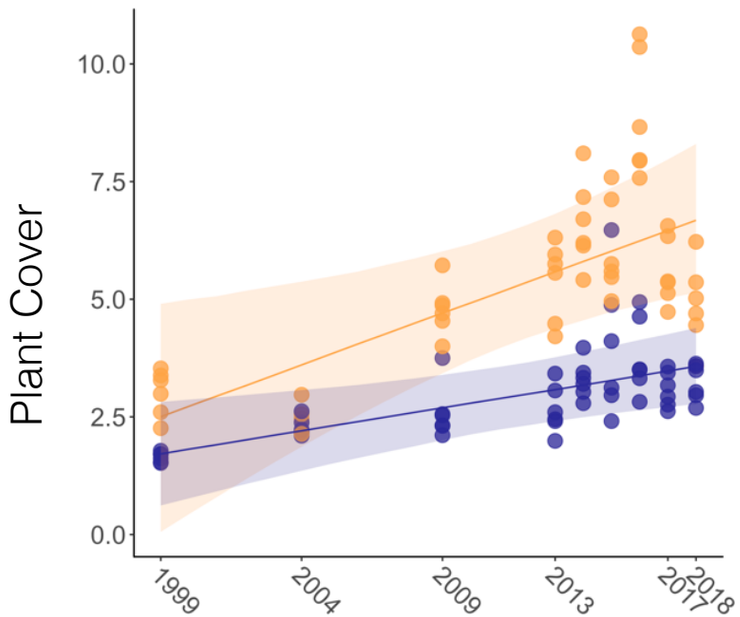
Shrubification

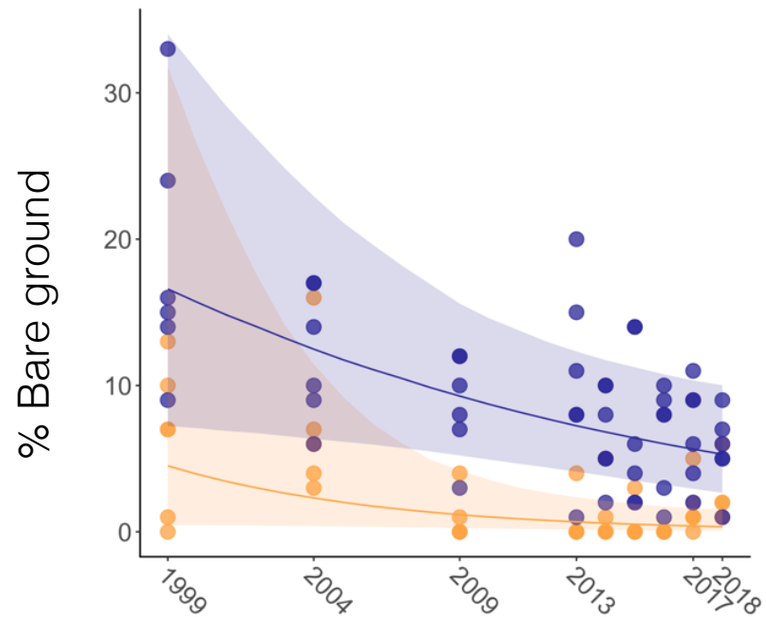
1987

2018

Myers-Smith *et al.* Ambio 2011
Myers-Smith *et al.* Ecol. Mono. 2019

Plant cover is increasing over time

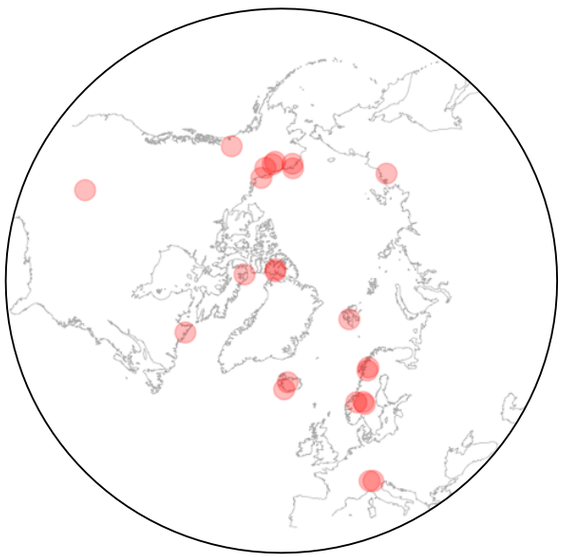


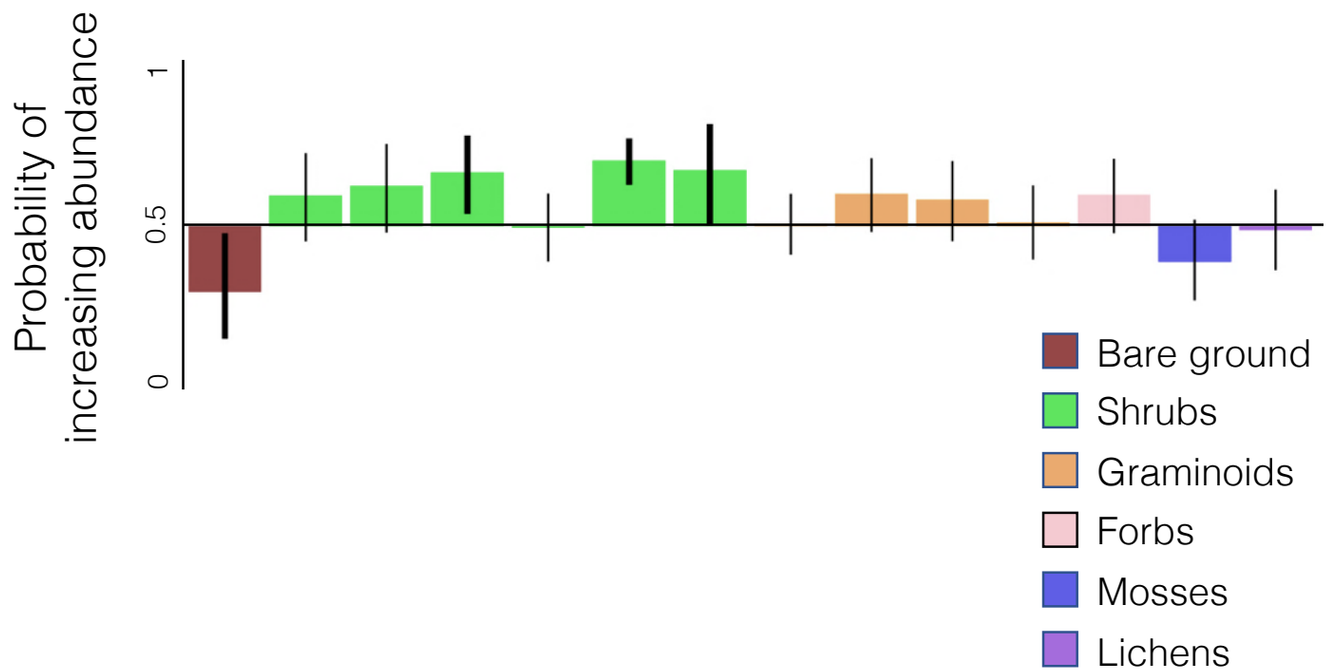


Myers-Smith *et al.* Ecol. Mono. 2019

Plant cover is increasing over time

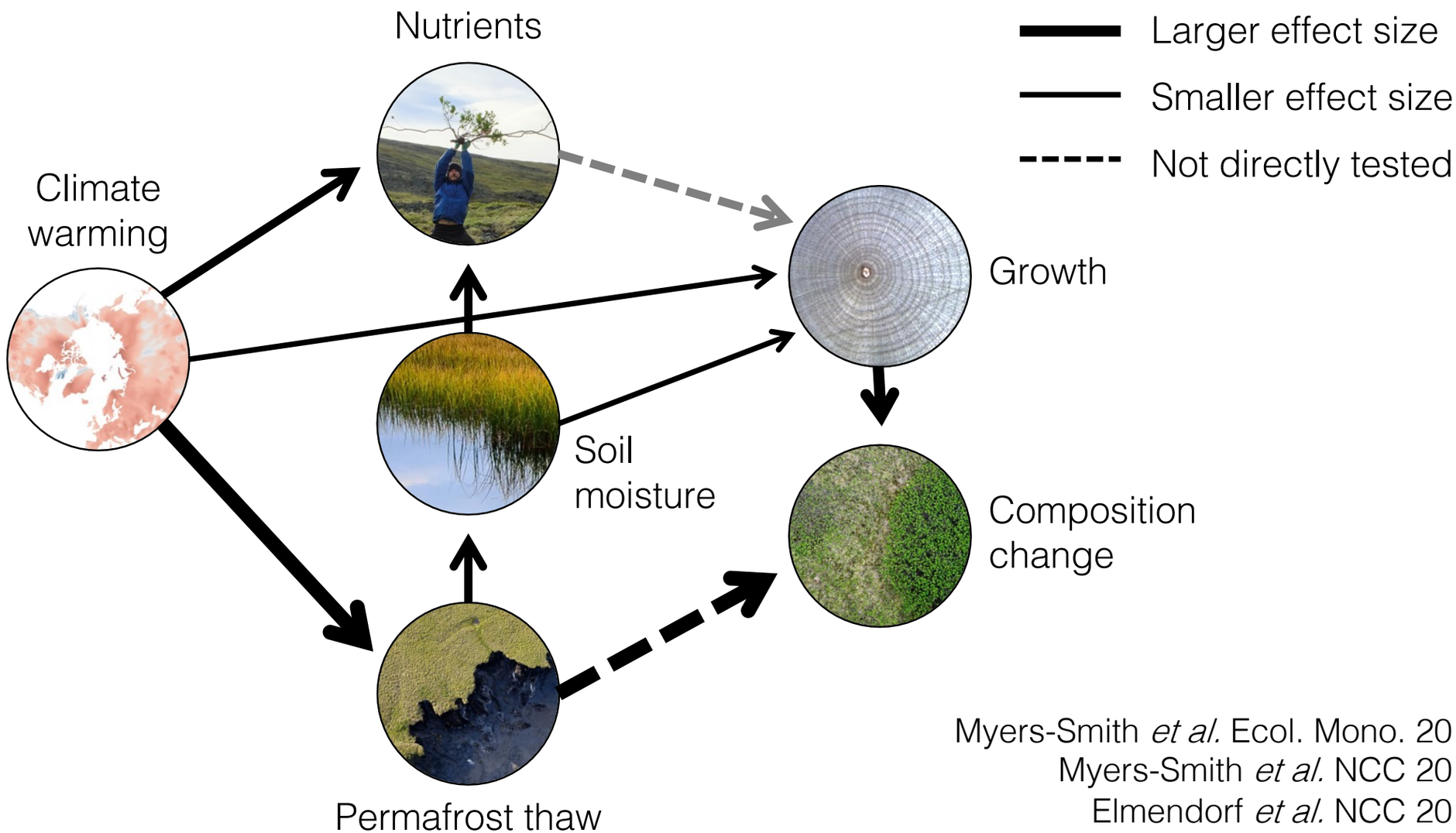
ITEX plant cover sites





Elmendorf *et al.* NCC 2012

Is warming the driver of vegetation change?



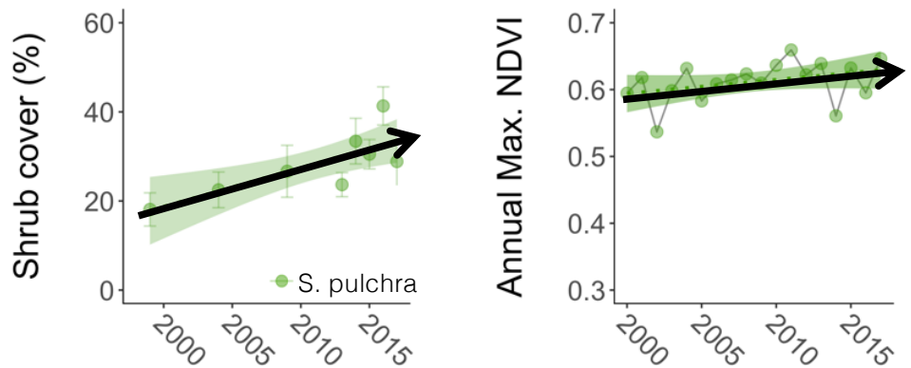
Myers-Smith *et al.* Ecol. Mono. 2019
Myers-Smith *et al.* NCC 2015
Elmendorf *et al.* NCC 2012

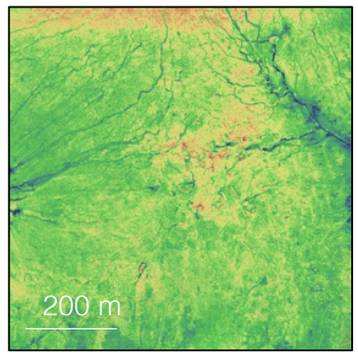
Do shrub growth and satellite records correspond?

Sandra Angers-Blondin

Greening trends and shrub cover trends do not correspond

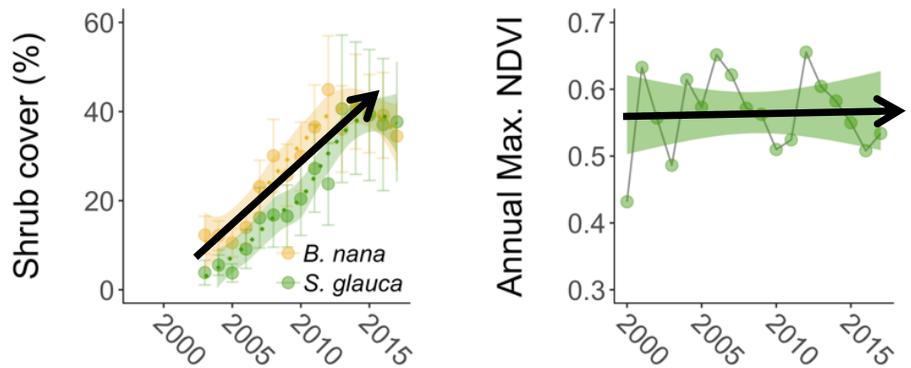
Qikiqtaruk, Canada

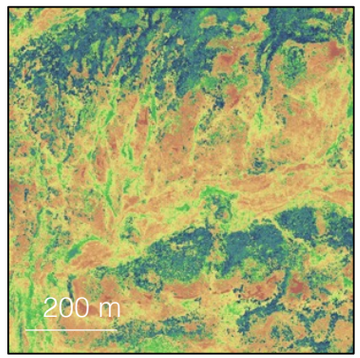




Drone-derived NDVI

Kangerlussuaq, Greenland





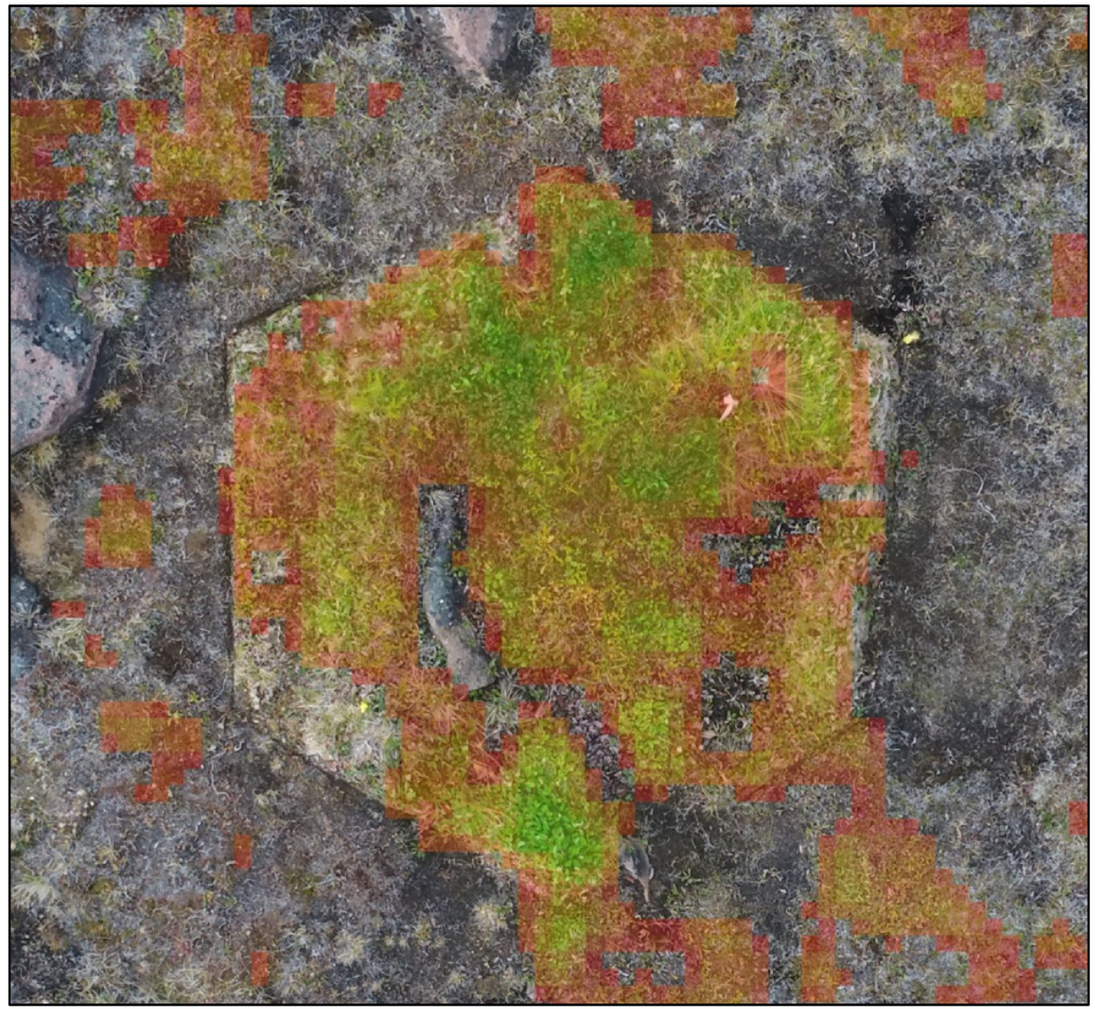
Drone-derived NDVI

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

Conclusions

3. Tundra vegetation is increasing, but not always where satellites indicate greening or vice versa

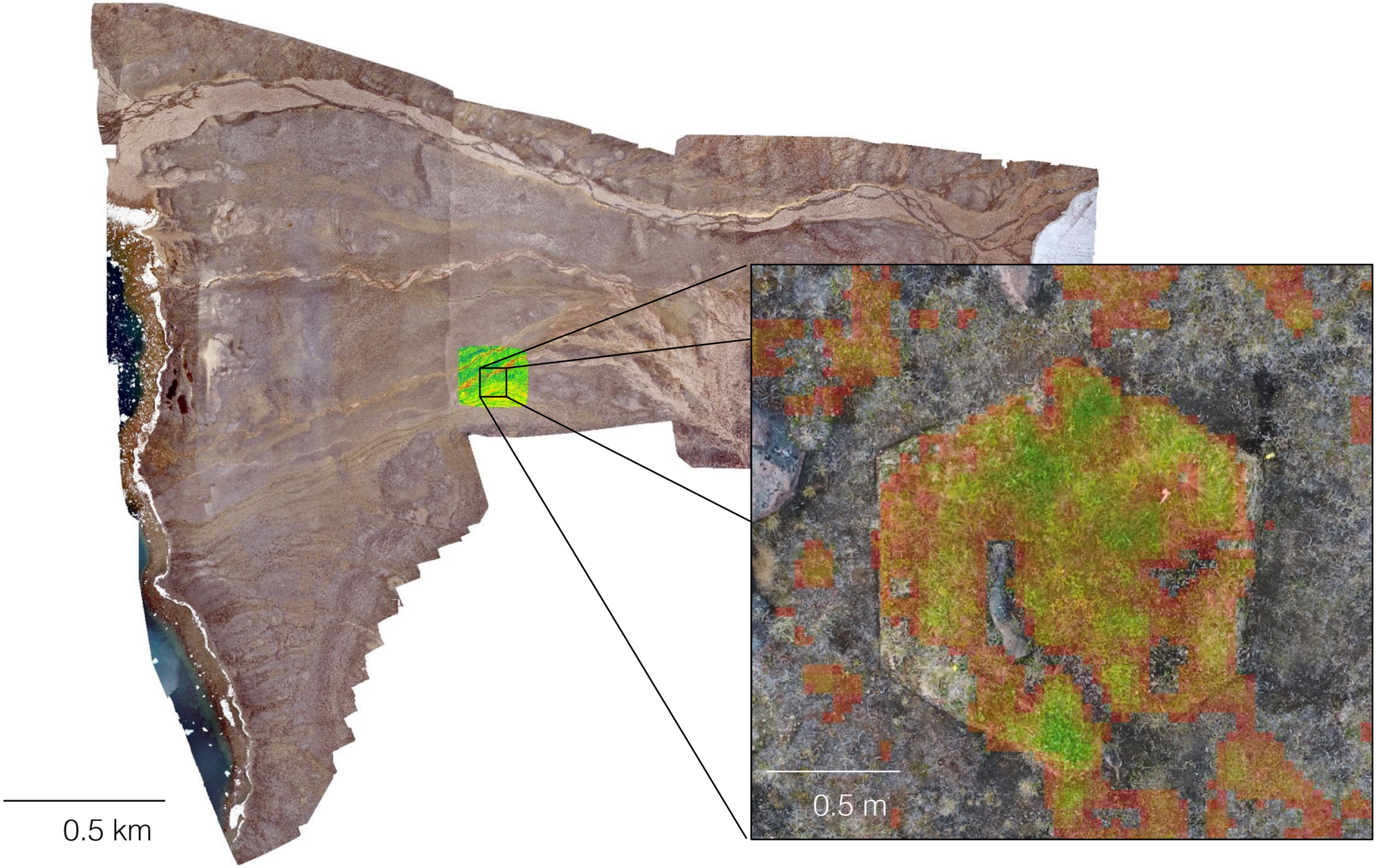
What is happening beyond the plots?



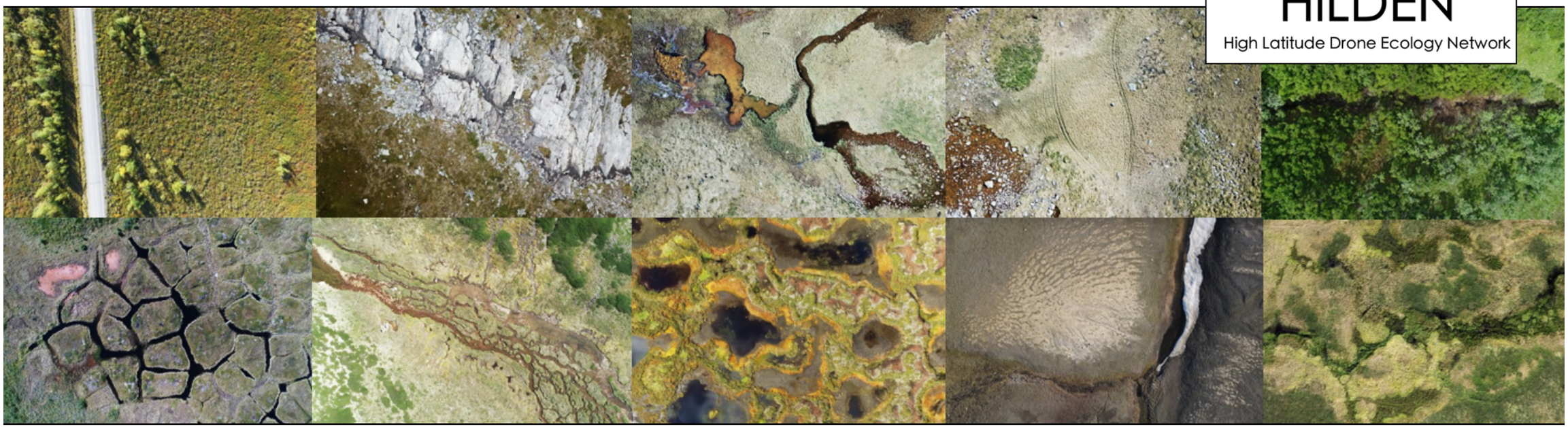
High NDVI

Low NDVI

Kerby *et al.* in prep.


0.5 km
0.5 m

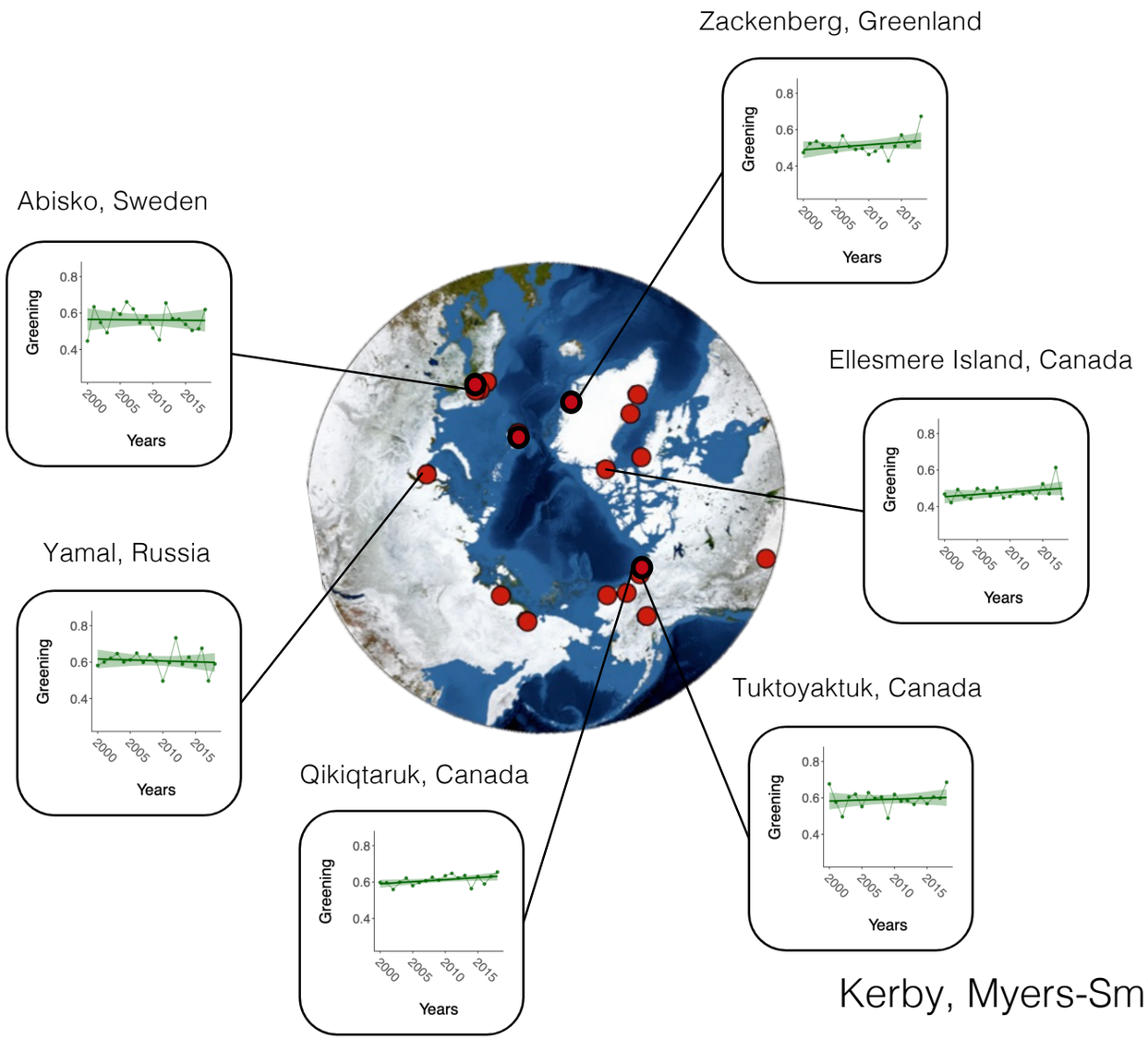
High Latitude Drone Ecology Network

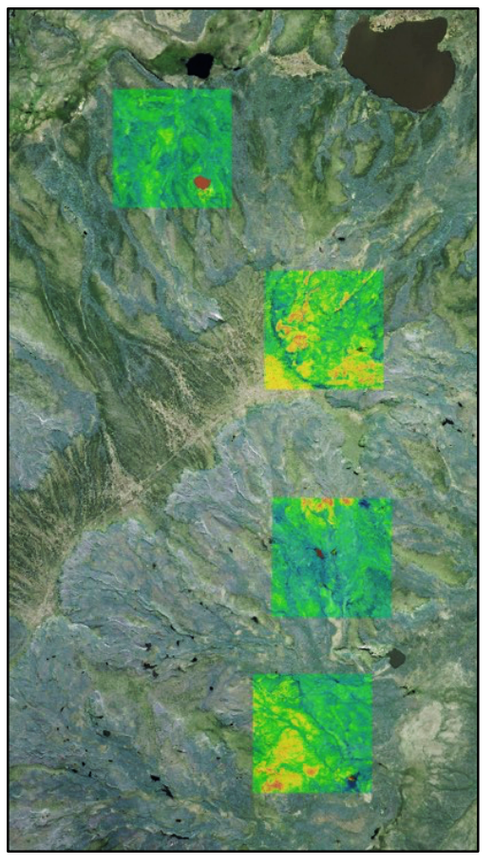


Over 40 scientists at 42 Arctic locations

https://arcticdrones.org/, NAS 2019

Drone data collection at 42 sites across the Arctic





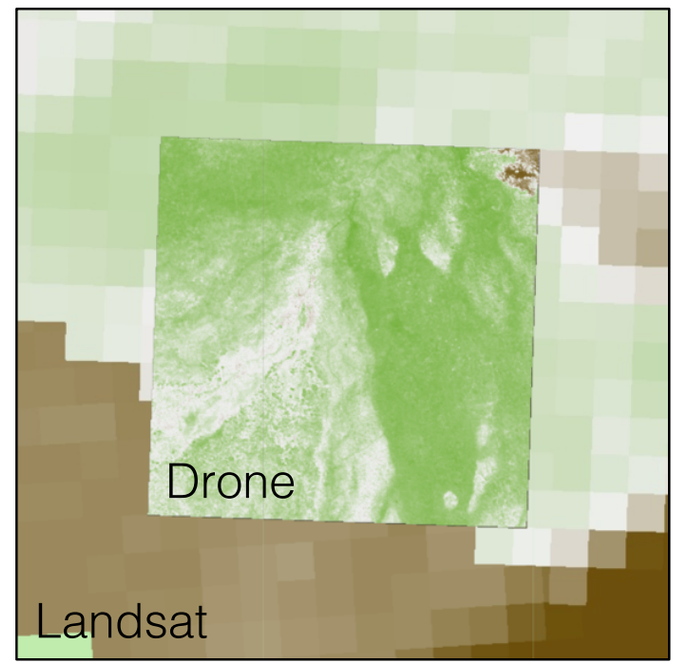
Kerby, Myers-Smith, Assmann, Berner *et al.* in prep.

Drone data collection in the ABoVE domain

Atqasuk, Alaska

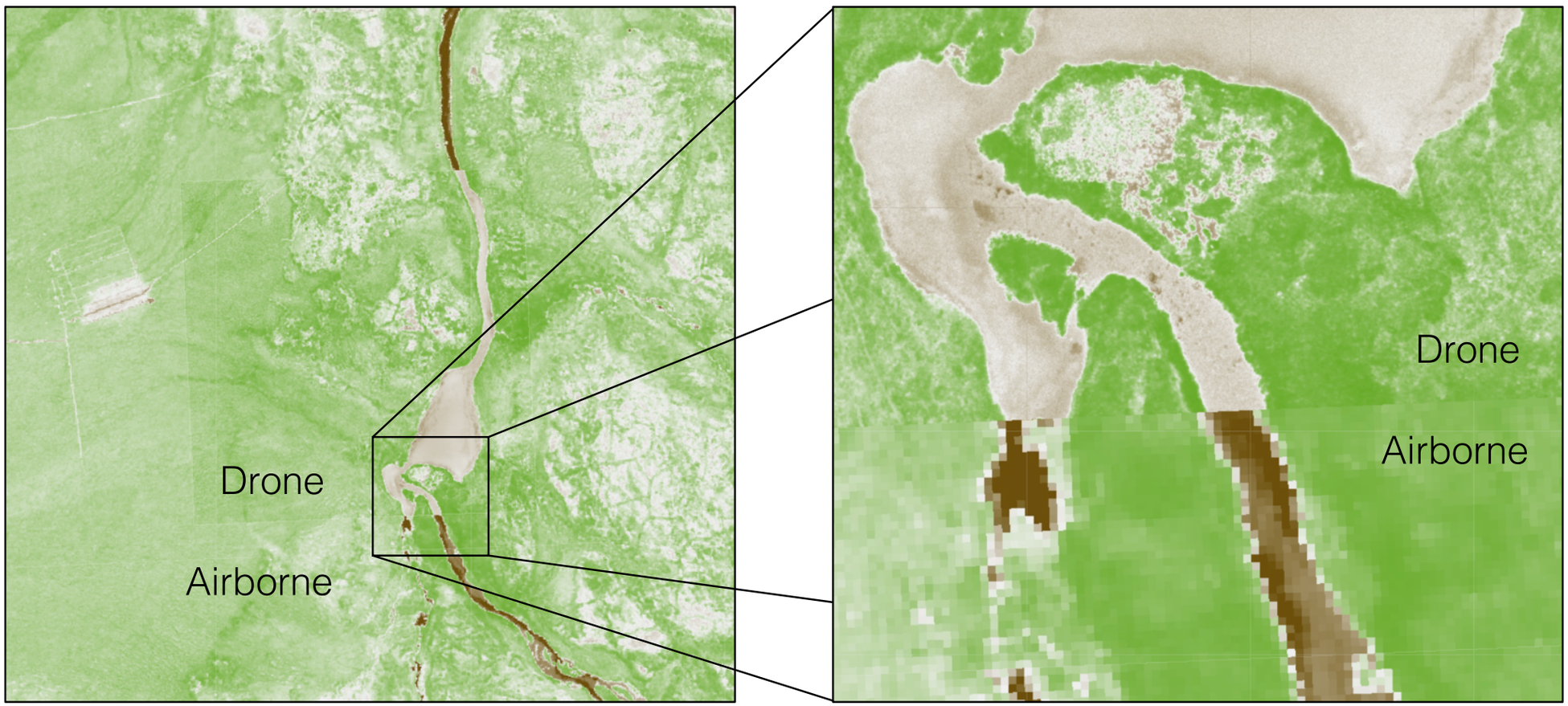
Toolik Lake, Alaska

Qikiqtaruk - Herschel, Yukon



Kerby, Myers-Smith, Assmann, Berner *et al.* in prep.

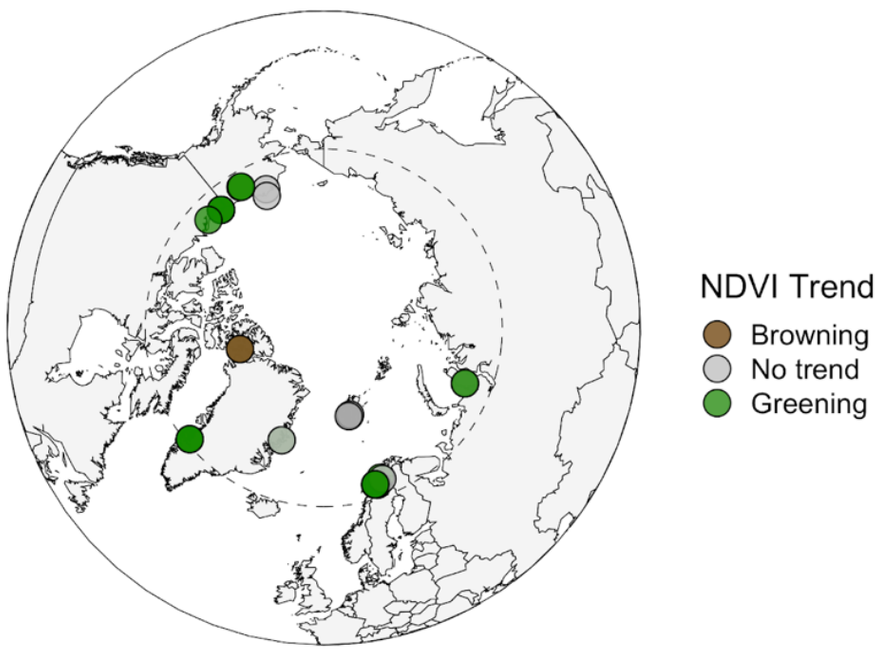
Incorporation of airborne data



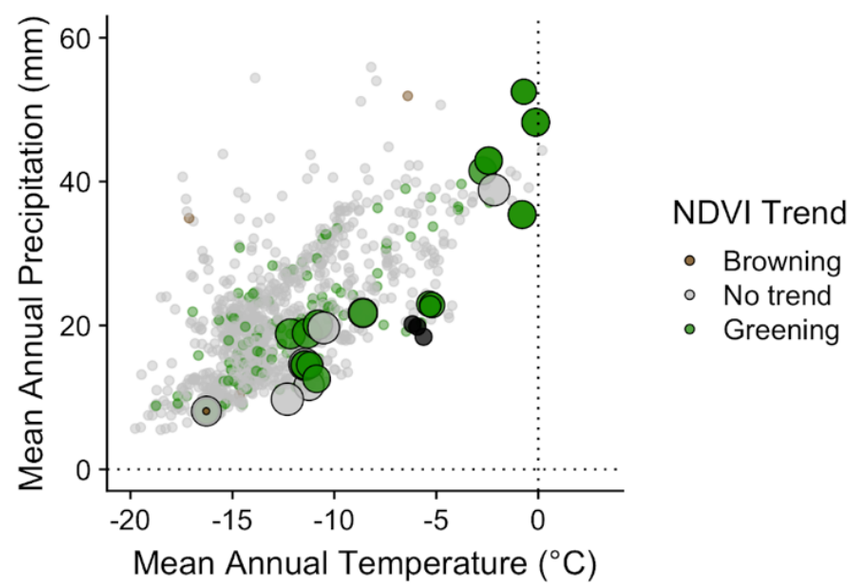
NEON and HiLDEN data from 2018

Greening trends across the HiLDEN network

MODIS greening trends (2000 – 2018)

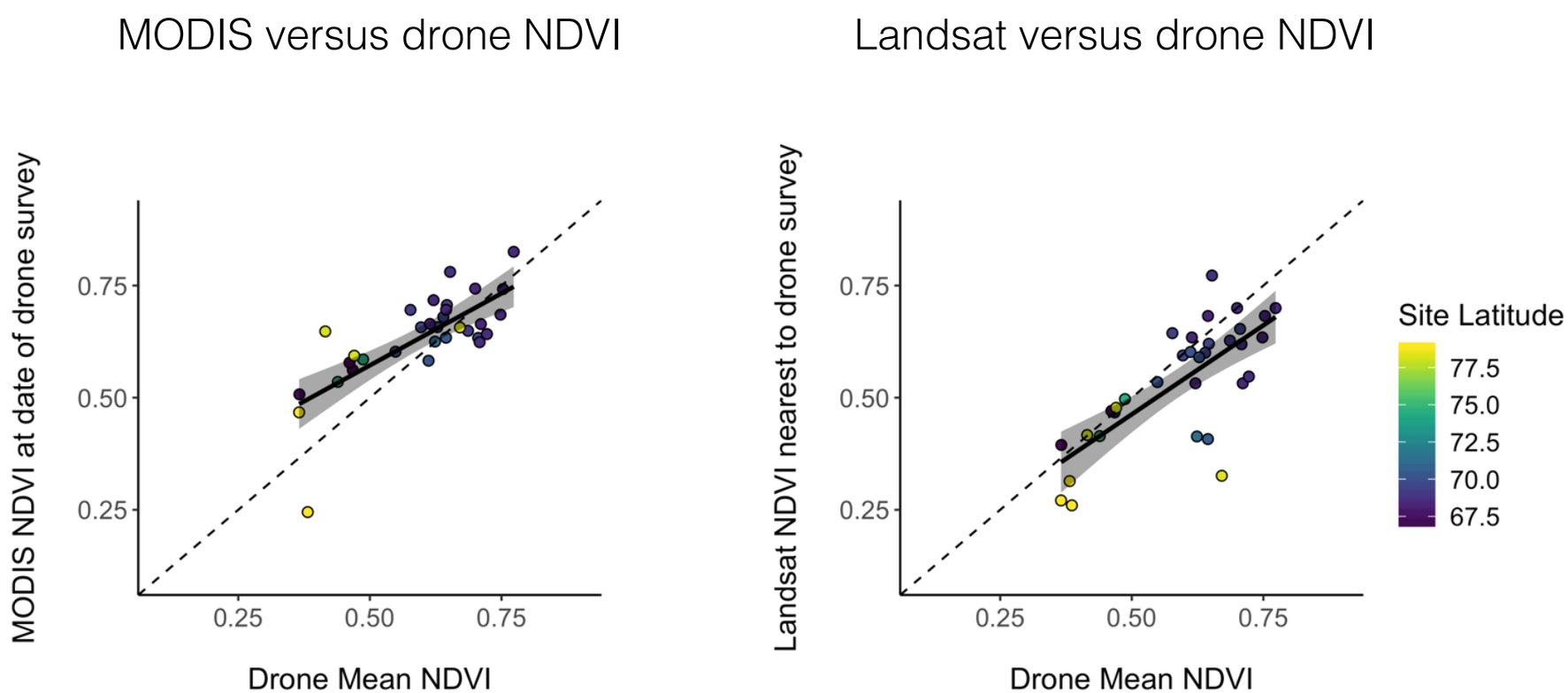


MODIS greening trends across climate space



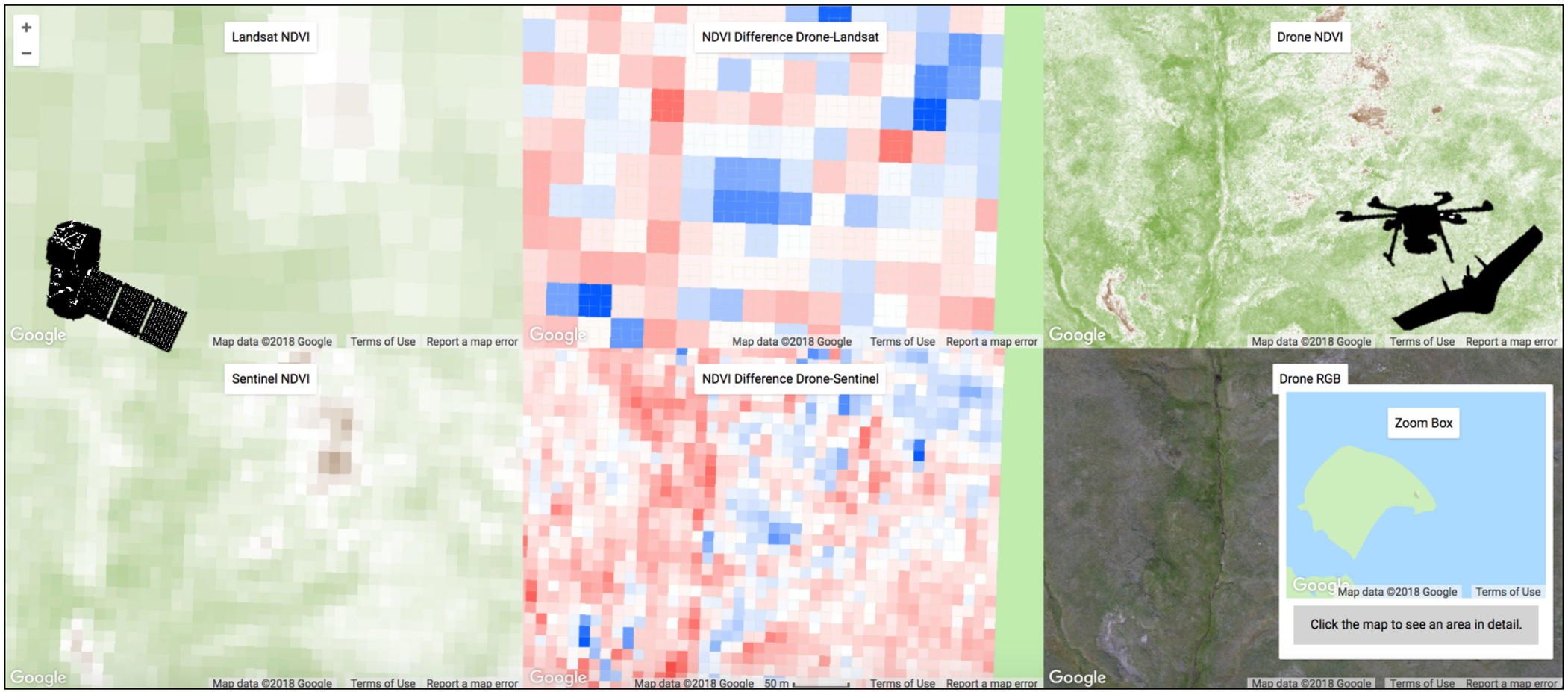
Kerby, Myers-Smith, Assmann, Berner *et al.* in prep.

Correspondence among drones and satellites



Kerby, Myers-Smith, Assmann, Berner *et al.* in prep.

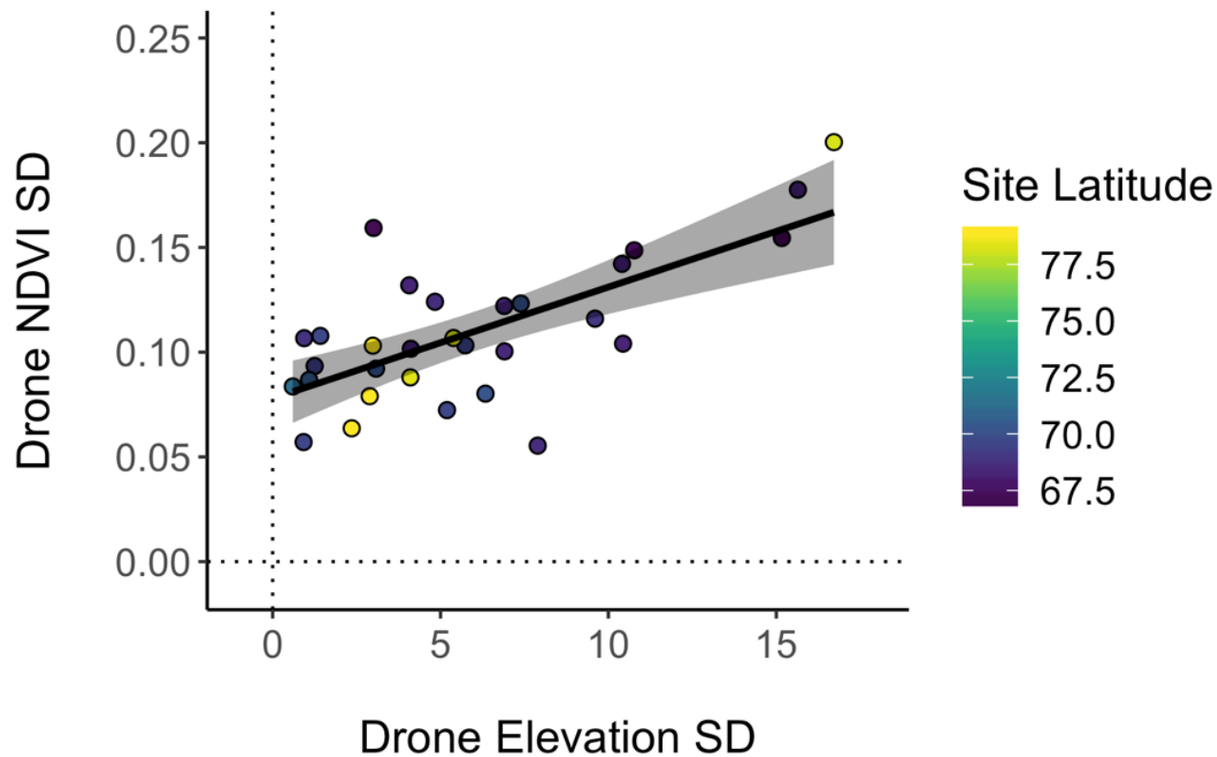
What explains where drones and satellites do not correspond?



Kerby, Myers-Smith, Assmann, Berner *et al.* in prep.

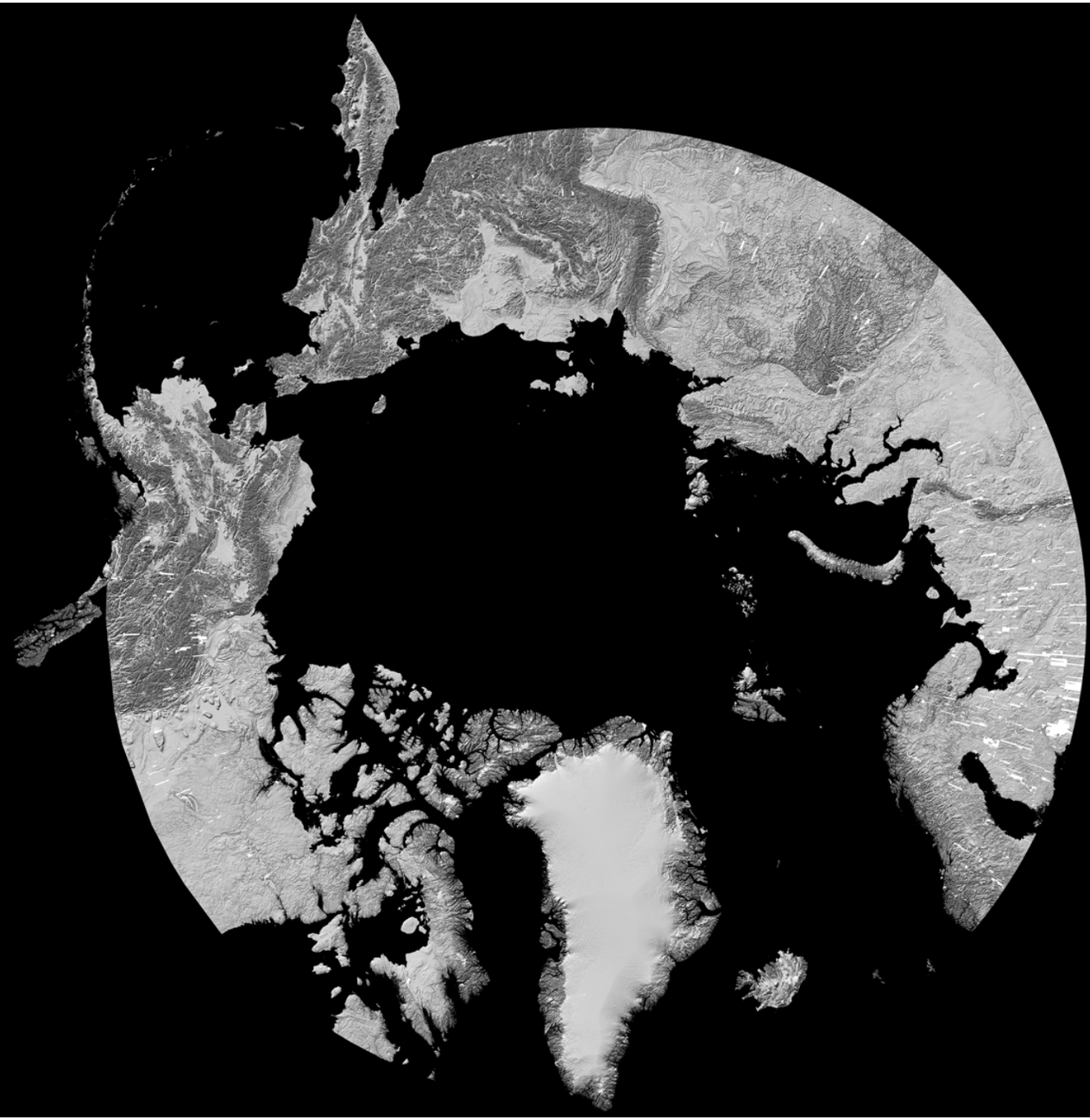
What explains where drones and satellites do not correspond?

Variation in elevation explains
variation in NDVI across drone plots



Kerby, Myers-Smith, Assmann, Berner *et al.* in prep.

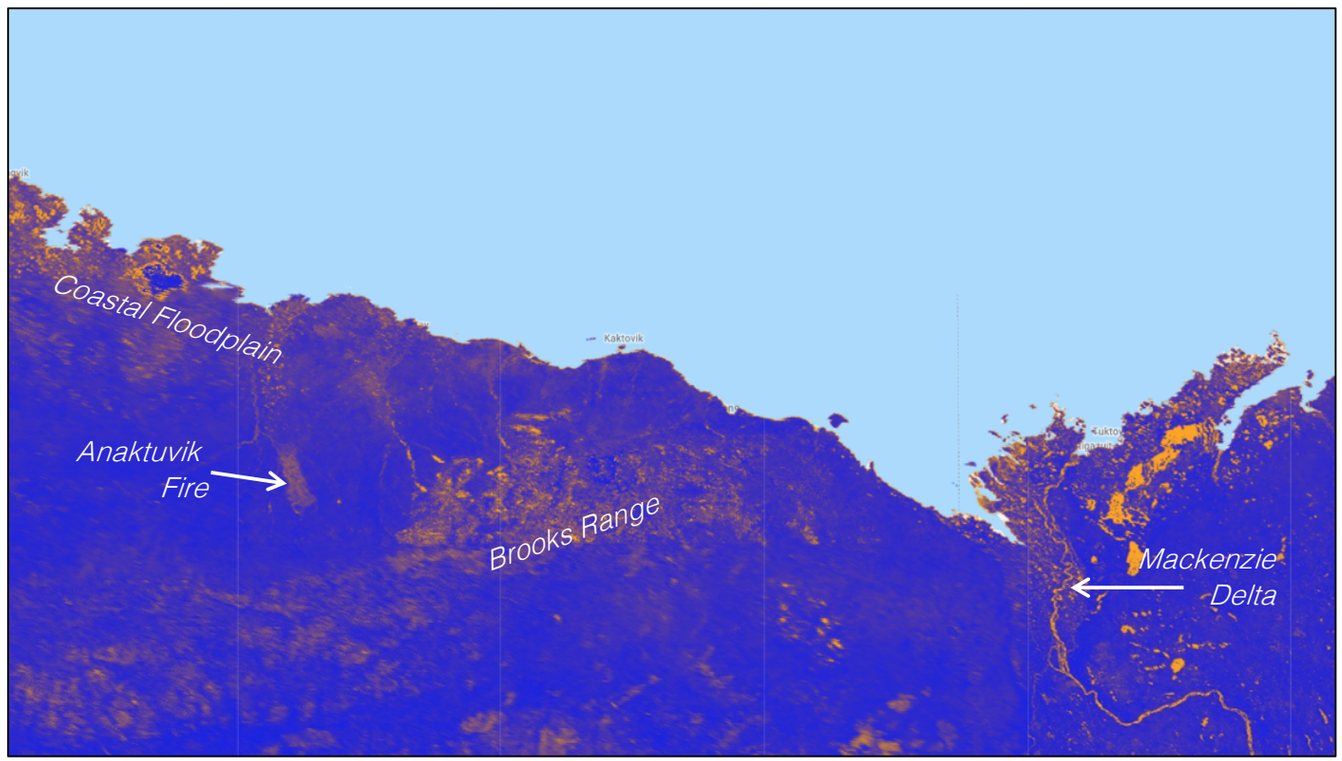
Arctic DEM



Polar Geospatial Center

What explains where drones and satellites do not correspond?

Greening variance (MODIS) among years

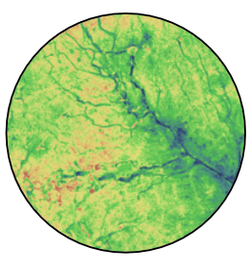


Low variance in NDVI

High variance in NDVI

Kerby, Myers-Smith, Assmann, Berner *et al.* in prep.

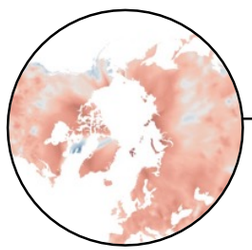
Conclusions



4. Landscape-level data collection across scales can help us understand the drivers of tundra greening

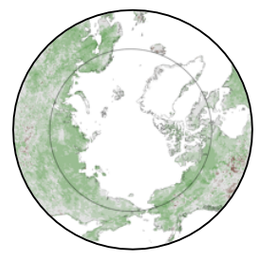
Arctic greening – the simple story

Climate warming

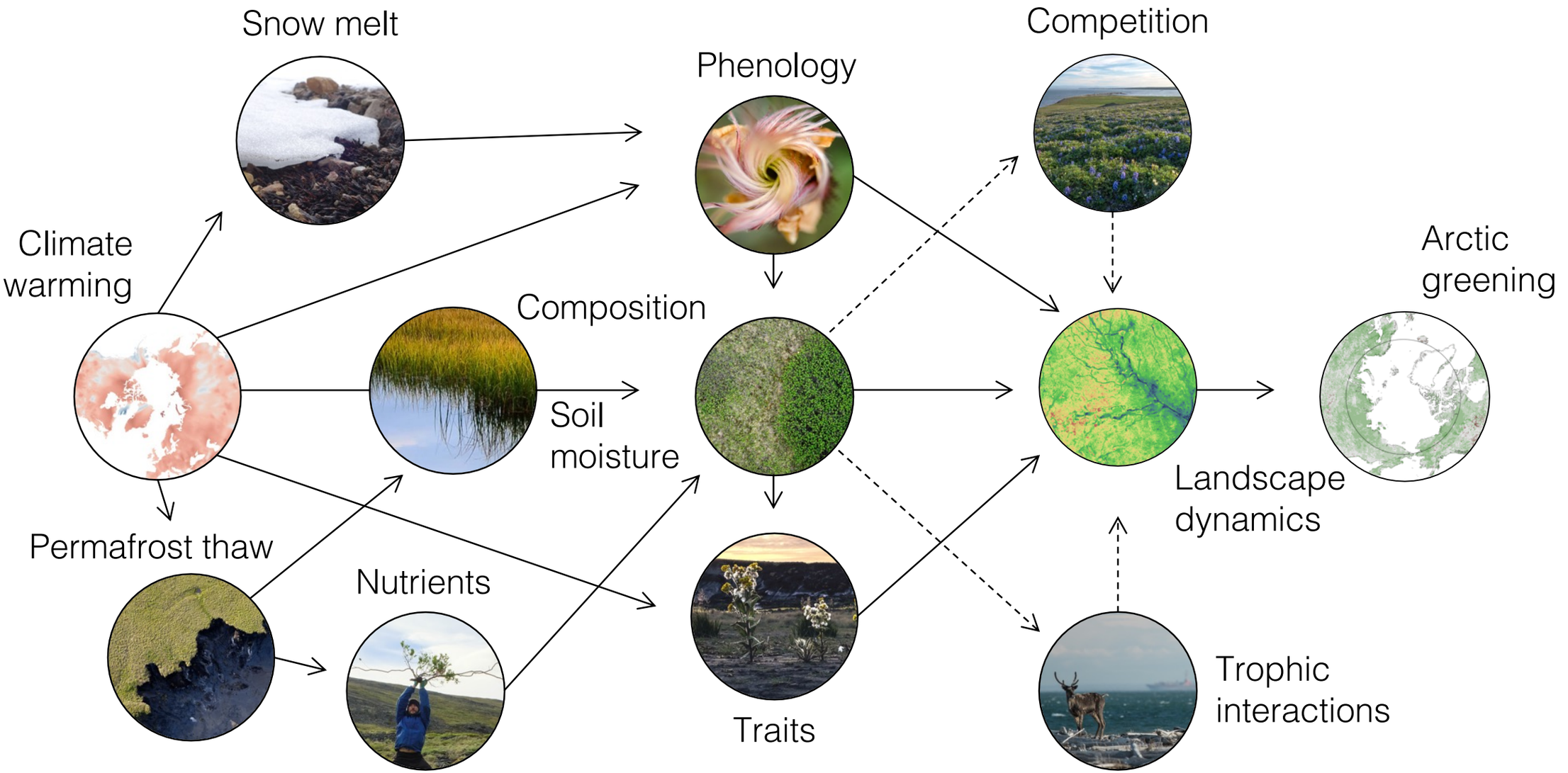


Vegetation change

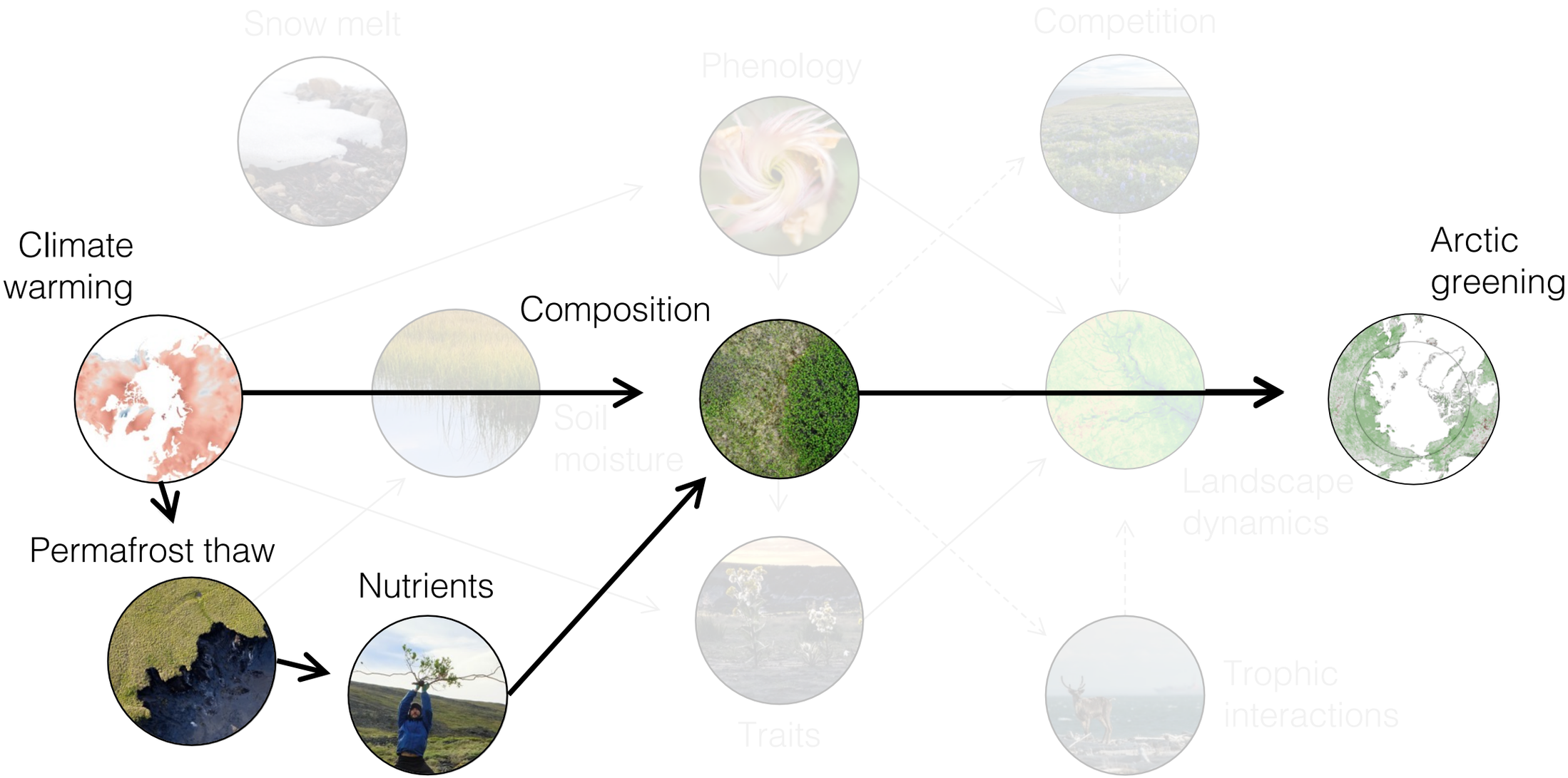
Arctic greening



Arctic greening – complexity



Arctic greening – scale changes our predictions



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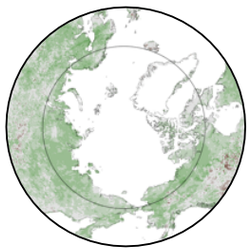

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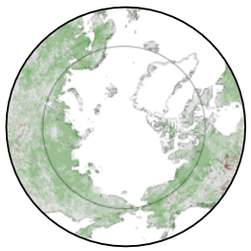

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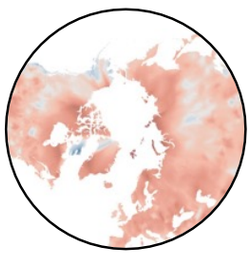

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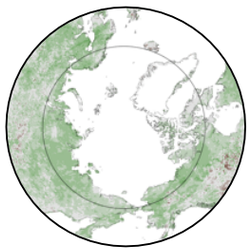

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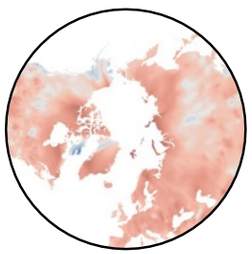

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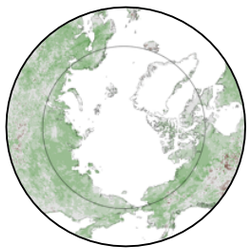

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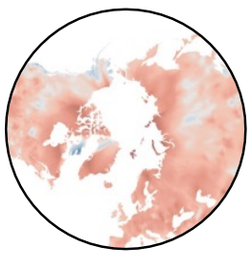

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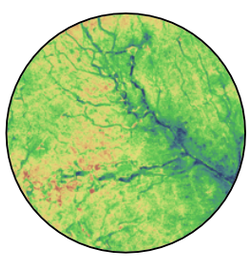

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What lies ahead for future data collection?

Sandra Angers-Blondin

Future research – where can ABoVE lead?

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3. New ways of sensing change in plant communities with hyperspectral, structural and other data?

The Arctic is ‘greening’, but there is still a lot of uncertainty around that signal across scales.
Jeff Kerby

Thank you!

@TeamShrub #TeamShrub teamshrub.com

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