Long-term vegetation change, resistance and lack of change in Arctic ecosystems

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T.V. Callaghan

Back to Basics – IPCC 1990

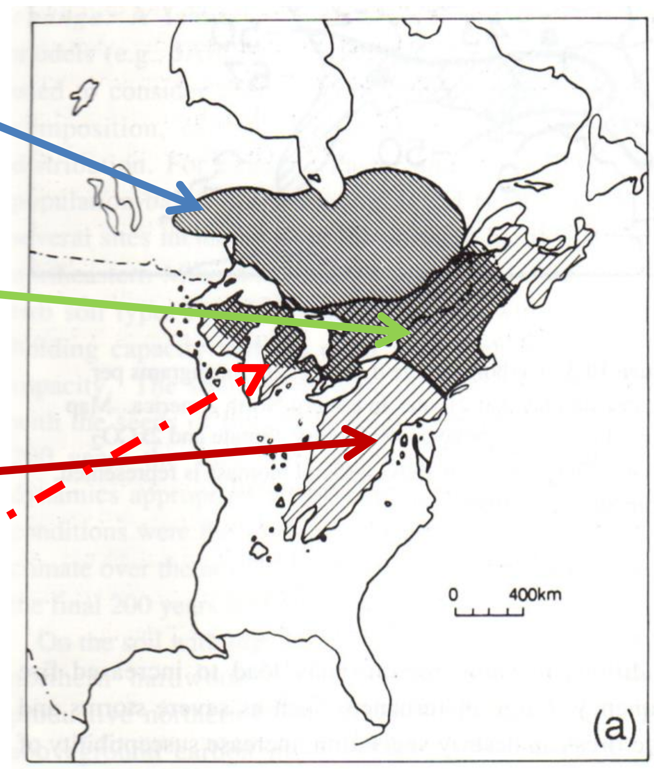
"Ecosystems ….may not be able to keep pace with climate change."
(Little mention of events)

Potential range for 2 x CO2

Realised range 100 years:
Greening?

Current range
Browning?

No change?



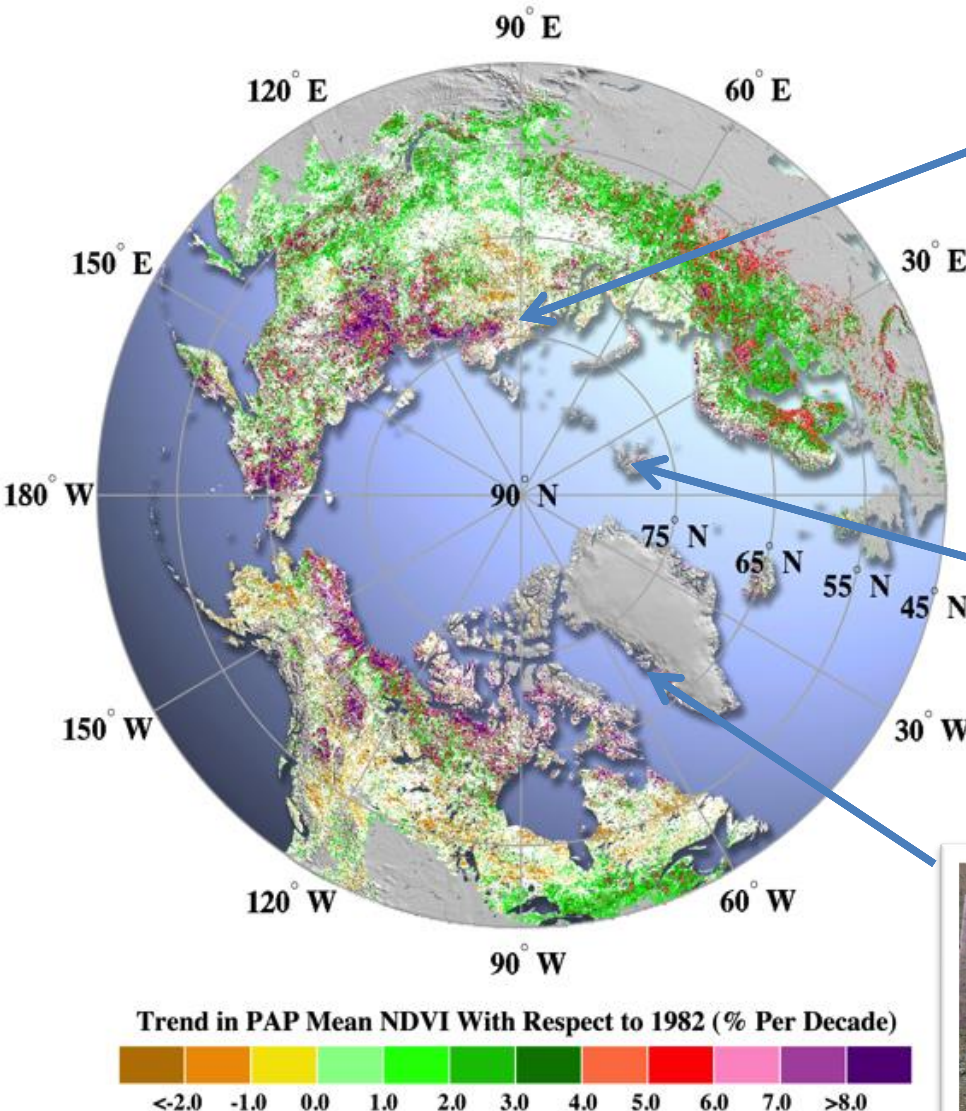
Literature search based on increases *versus* decreases (*Gatti et al., in prep*.):

Prelim. Of 356 Arctic papers,
89.7% greening
10.3% browning
?% No change

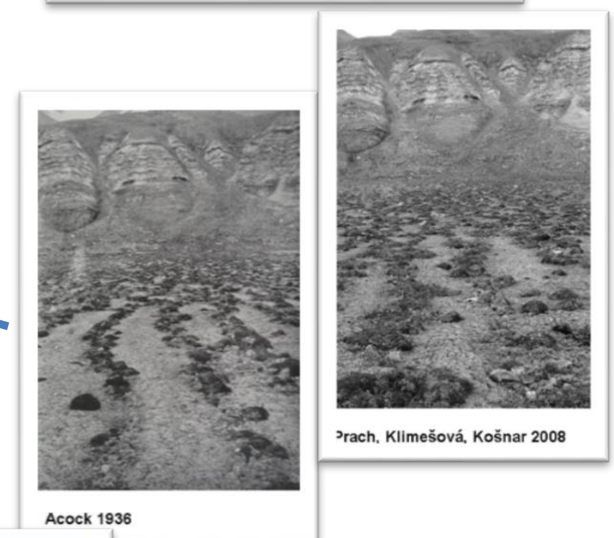
From satellite-based NDVI (1982-2012) (*Xu et al., 2013*):
32-39% greening
4% browning
61-68% no *significant* change

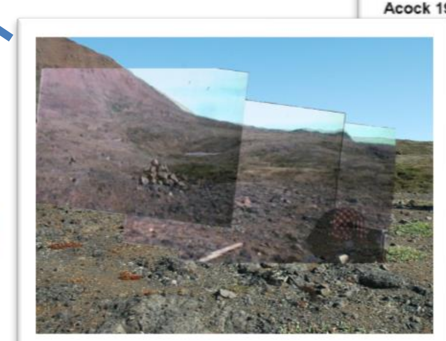
Present and future range of eastern hemlock (Hansen et al., 1983, Melillo et al., 1990 in IPCC)

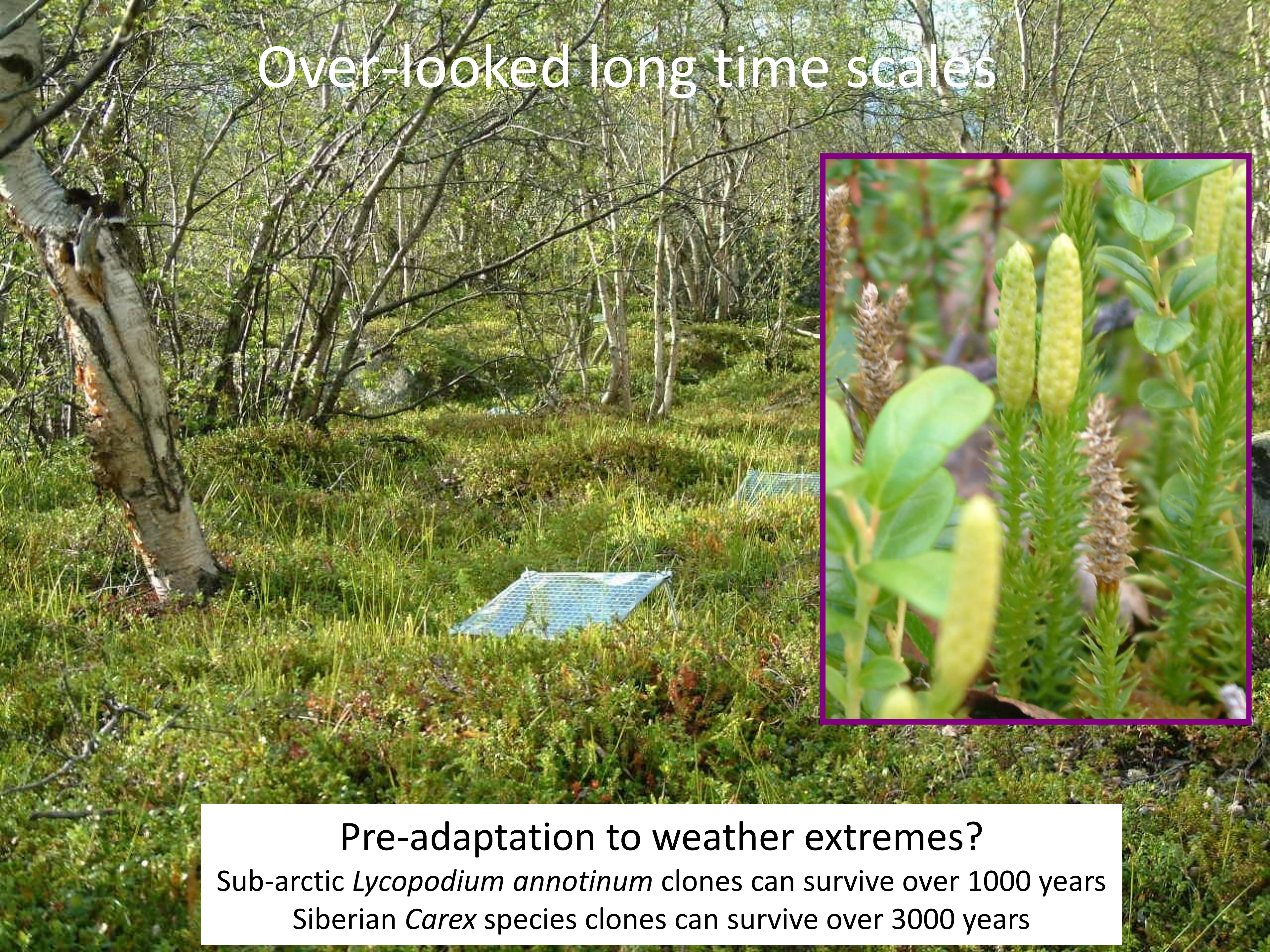
No change?



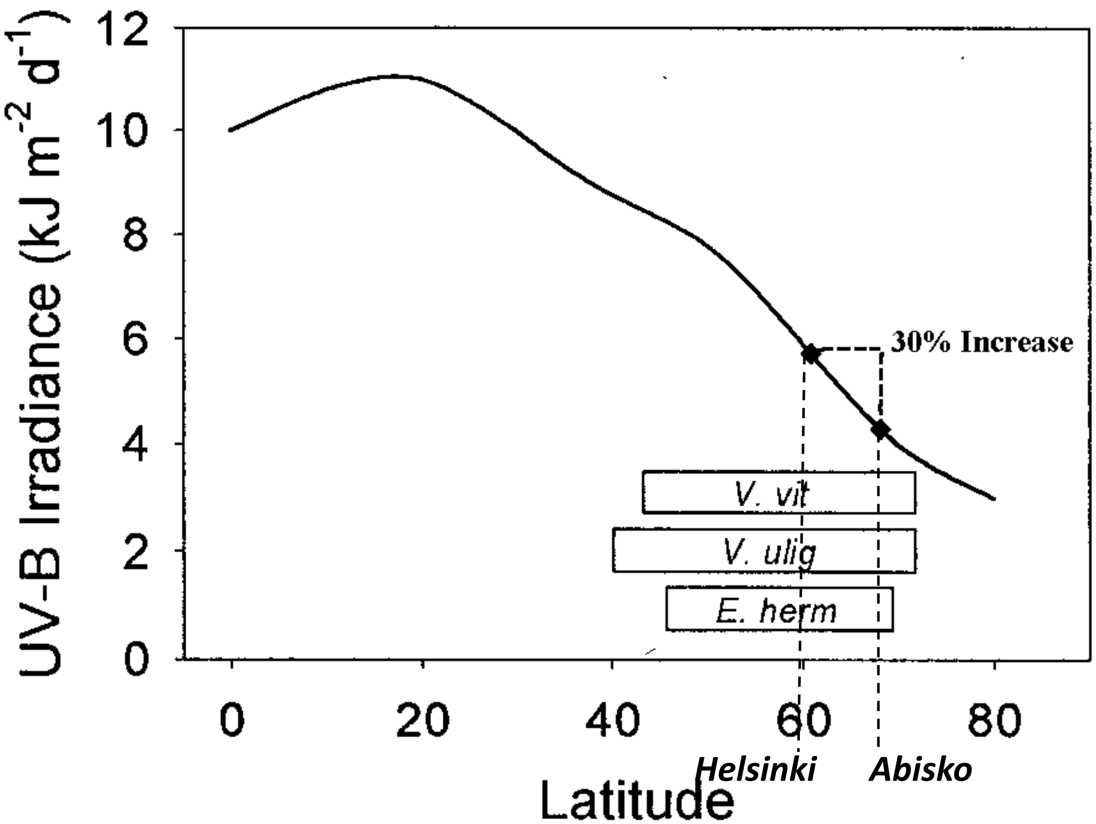
Xu et al., 2013





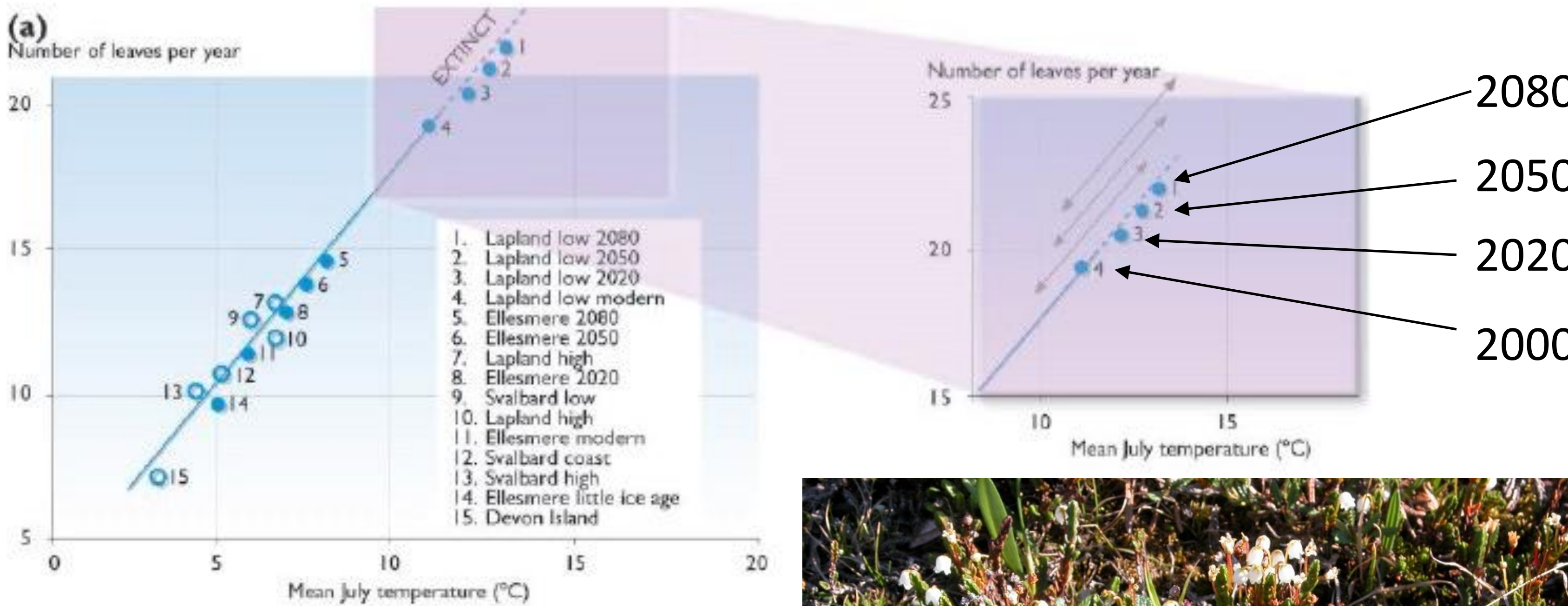

Over-looked long time scales
Pre-adaptation to weather extremes?
Sub-arctic *Lycopodium annotinum* clones can survive over 1000 years
Siberian *Carex* species clones can survive over 3000 years

UV-B effects on plants are few as they have experienced higher UV-B in the Holocene



(Phoenix et al.; Hultén)

Current species distributions can tell us about the future: = geographical analogues



Growth of plants in warmer parts of their present ranges is an analogue of growth under future warmer climates at their northern distributions: plants at the extreme southern limit may not be able to grow more and will be replaced

Cassiope tetragona

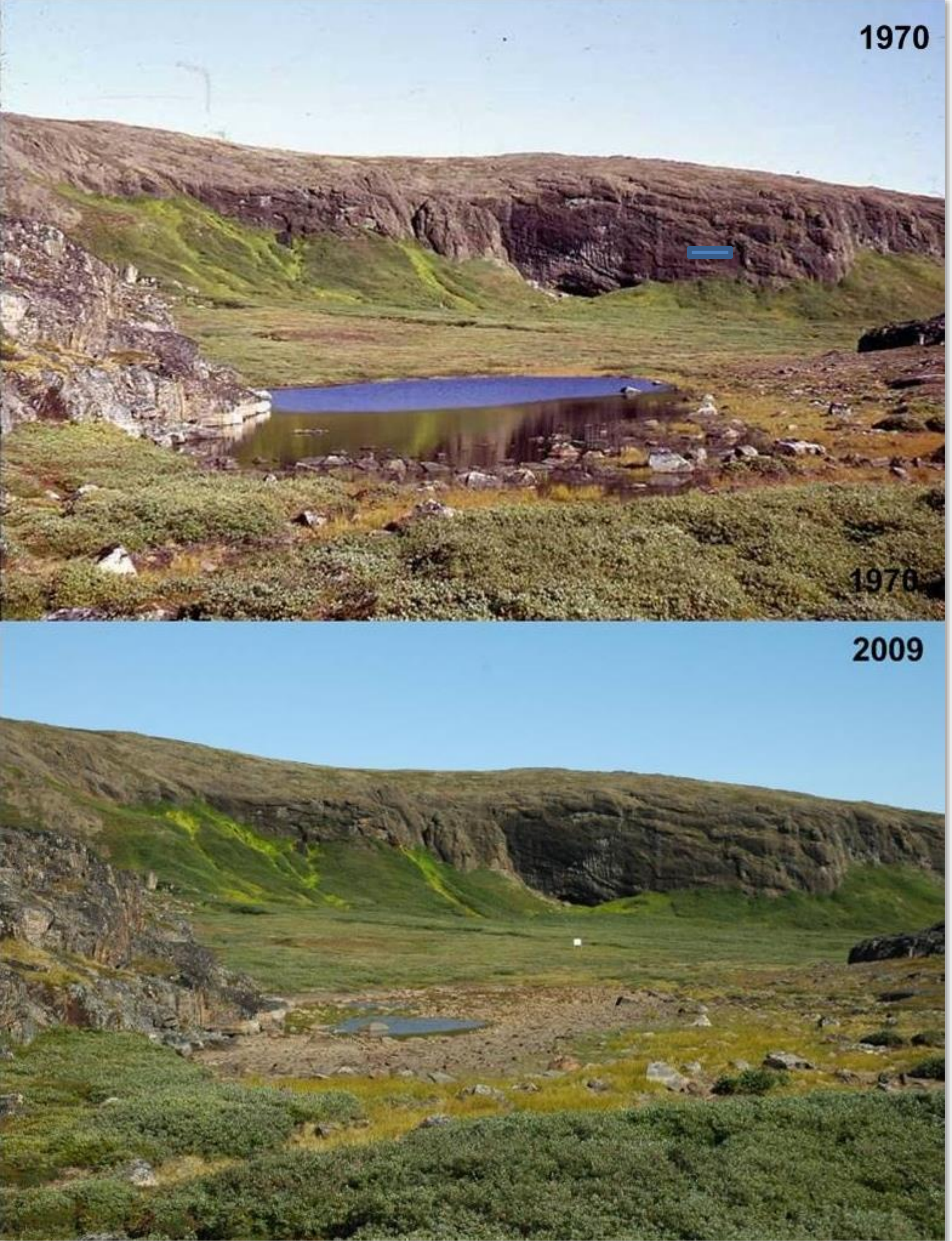
Over-looked wide geographical ranges

Eriophorum and thermokarst thaw slumps – Sub-arctic Sweden

Eriophorum and peat slumps –

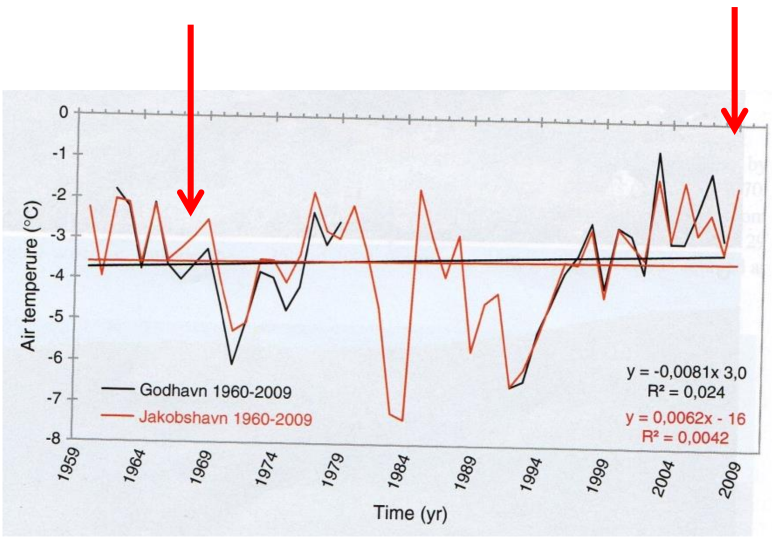
…………………………………

Manchester UK!!!!

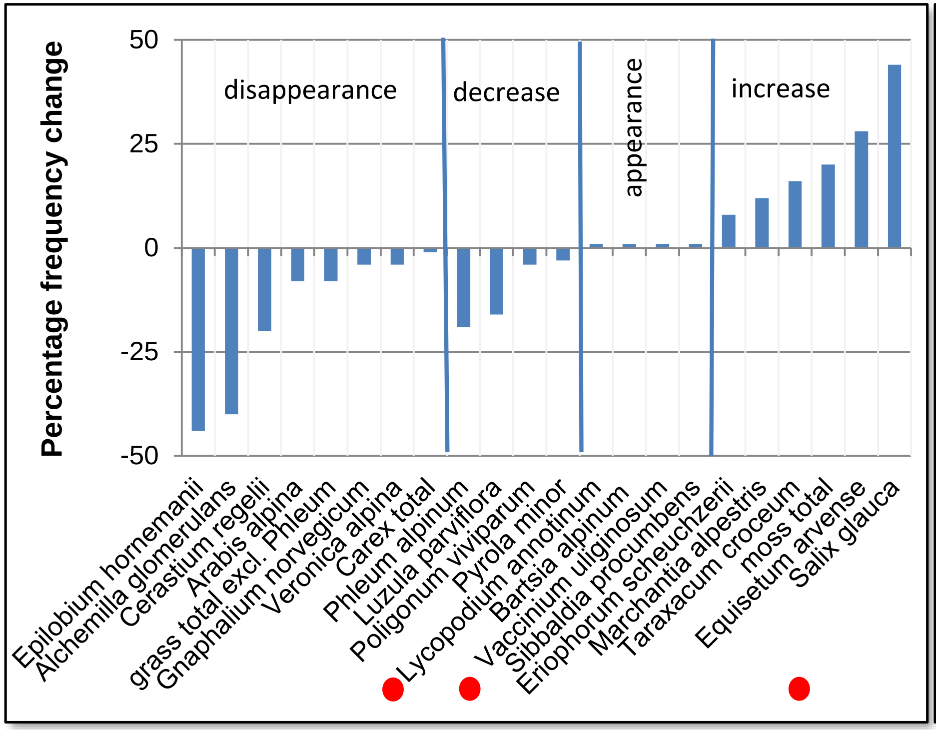


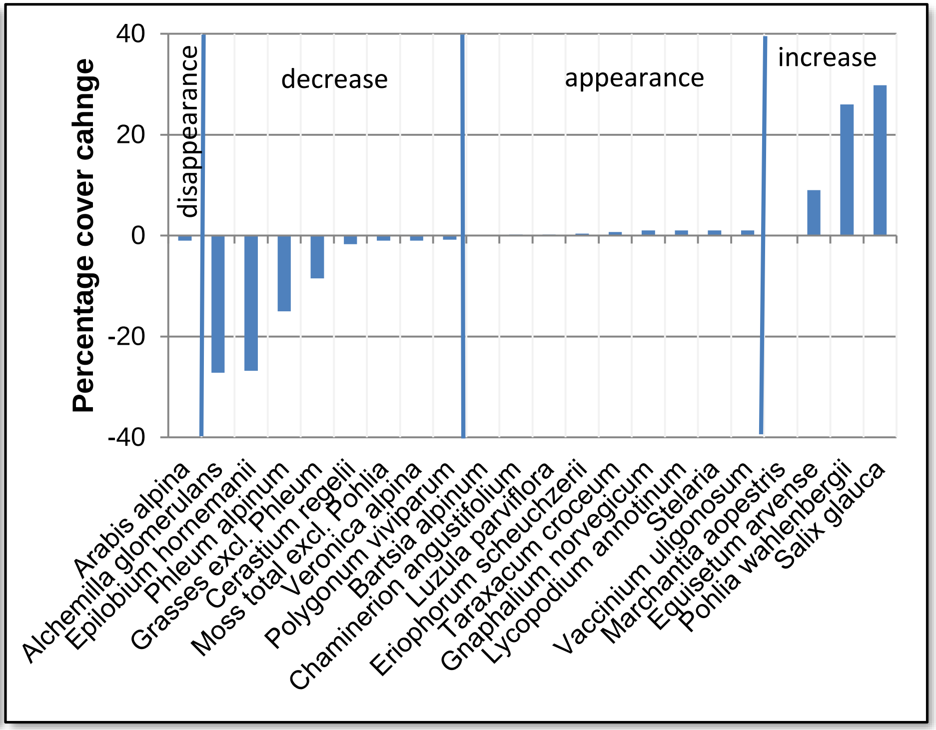
Disko Island,
mid-west Greenland

- Obvious landscape change,
- little vegetation change
- little species change
- little growth change.



Community structure





Percentage frequency change

Percentage cover change

Callaghan et al., 2011

Species response

Lack of ability to respond opportunistically – limit of structure

Phleum alpinum
biotic limit

Phleum alpinum
environmental limit

Phleum alpinum: Biometry

- Homeostasis

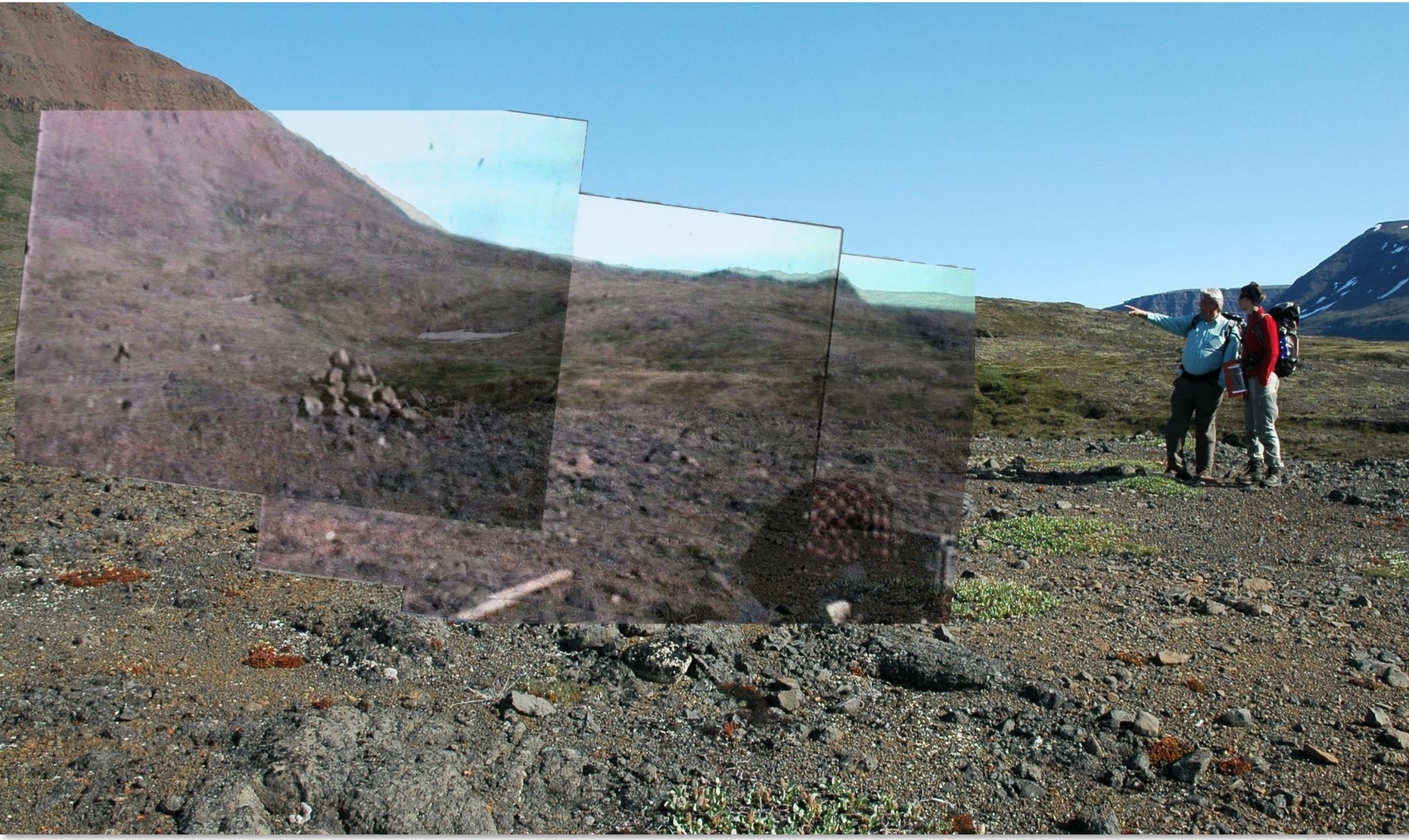
Variable	Value, 2009	Value, 1970
Number of flowers/m^2	21,3	19,8
Inflorescence width (mm)	11,9	12,4
Inflorescence length (mm)	30,9	30,7
Length of longest leaf on vegetated tiller (mm)	106,9	94,5
Length of youngest leaf on flowering tiller (mm)	35,9	33.3
Number of leaves per vegetative tiller	3,2	3,3

Callaghan et al., 2011

Lack of ability to respond opportunistically

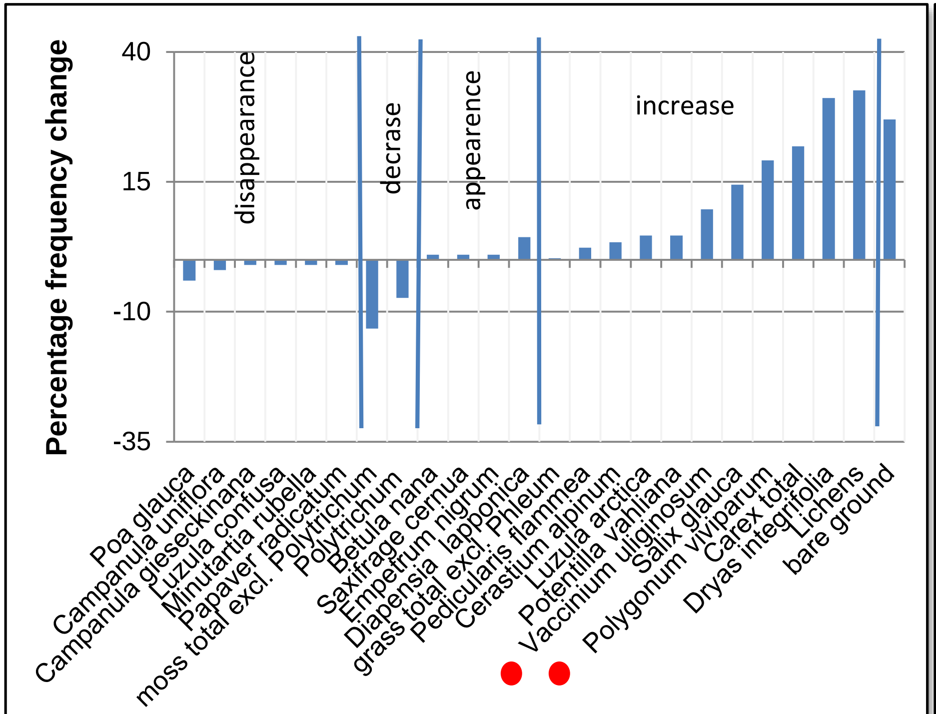
- deterministic form (sensitive to invasion)

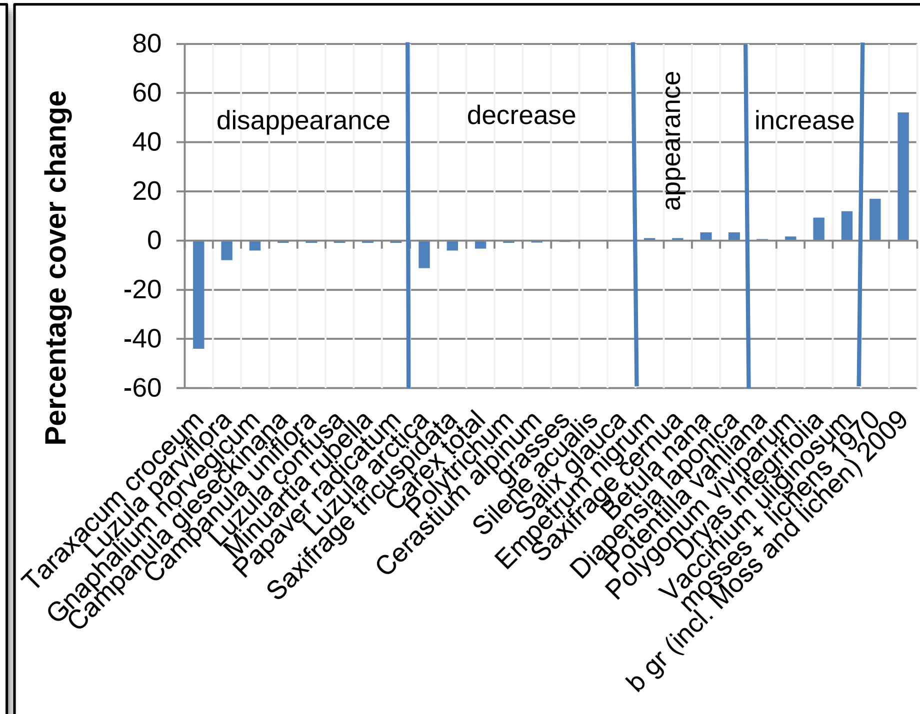
Disko Island Fell-field site:
No substantive change in landscape or species.



1967 8 mm cine film frames and 2009 digital photo.

Fell field Site





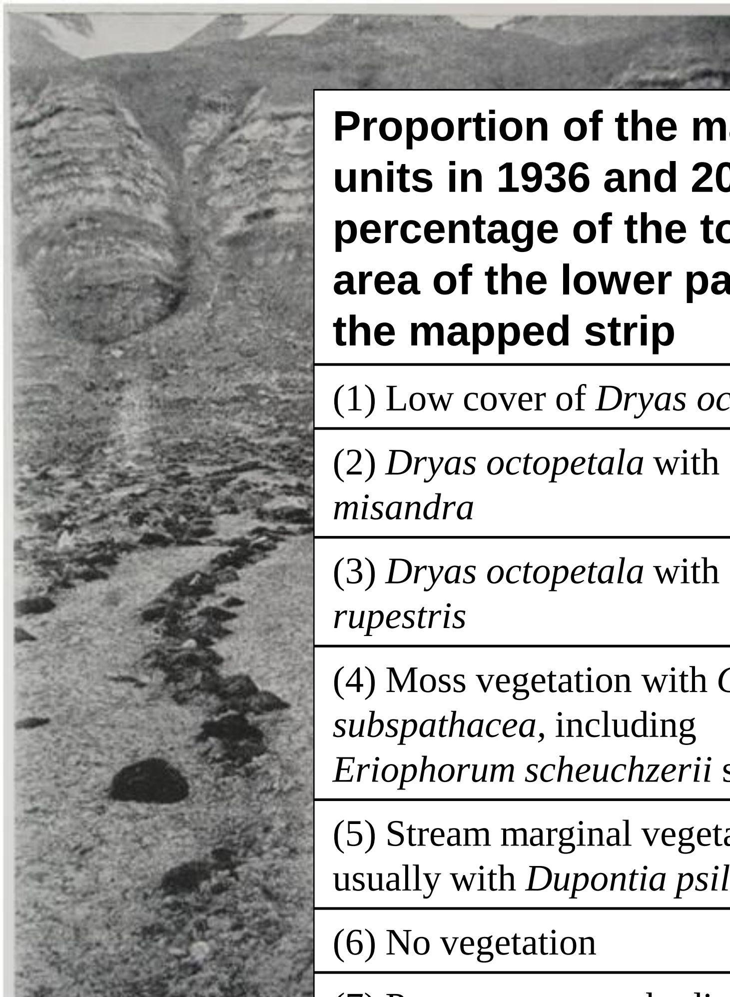
Percentage frequency change

Percentage cover change

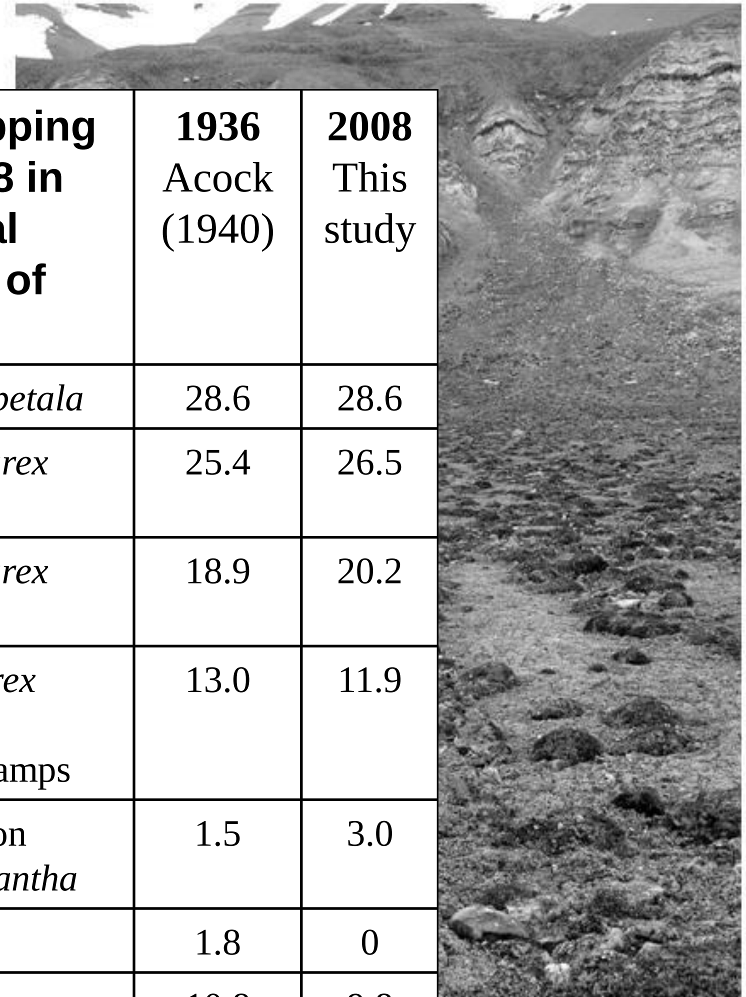
Callaghan et al., 2011

Ultimate stability? Svalbard

Proportion of the mapping units in 1936 and 2008 in percentage of the total area of the lower part of the mapped strip	**1936** Acock (1940)	**2008** This study
(1) Low cover of *Dryas octopetala*	28.6	28.6
(2) *Dryas octopetala* with *Carex misandra*	25.4	26.5
(3) *Dryas octopetala* with *Carex rupestris*	18.9	20.2
(4) Moss vegetation with *Carex subspathacea*, including *Eriophorum scheuchzerii* swamps	13.0	11.9
(5) Stream marginal vegetation usually with *Dupontia psilosantha*	1.5	3.0
(6) No vegetation	1.8	0
(7) Permanent water bodies	10.8	9.8



Acock 1936



Prach, Klimešová, Košnar 2008

Rapid landscape change – little vegetation change

Tareya, Taimyr
1967-2010

General greening in newly-formed depressions due to a lower accumulation of dead matter rather than to any changes in composition or species abundance.

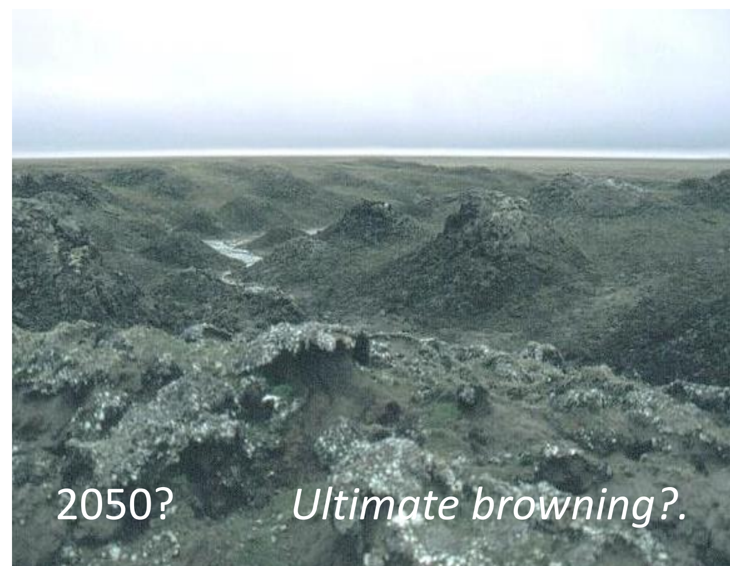
162 species of the former 213 had the same local distribution and abundance as earlier

Dickson
1980-2012

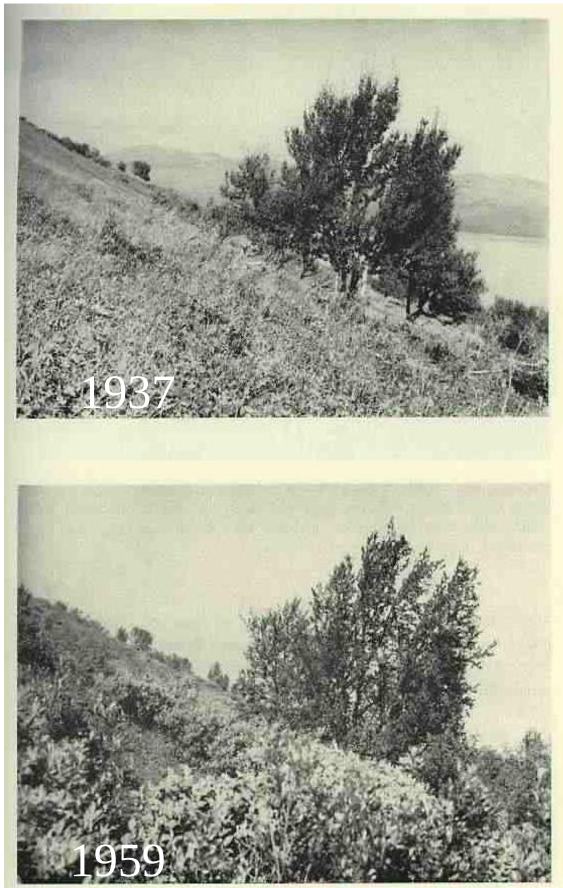
Of the 117 species recorded in 2012, 24 species had slight differences in pattern within the landscape

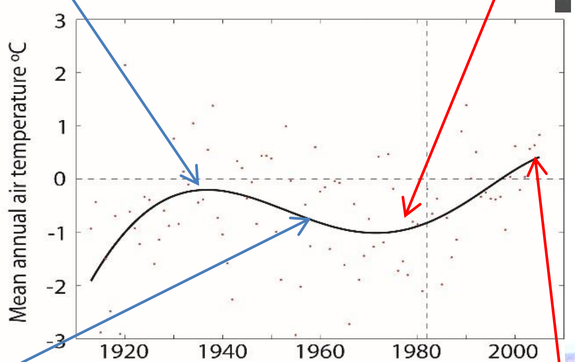
93 were distributed as earlier.

N.Matveyeeva

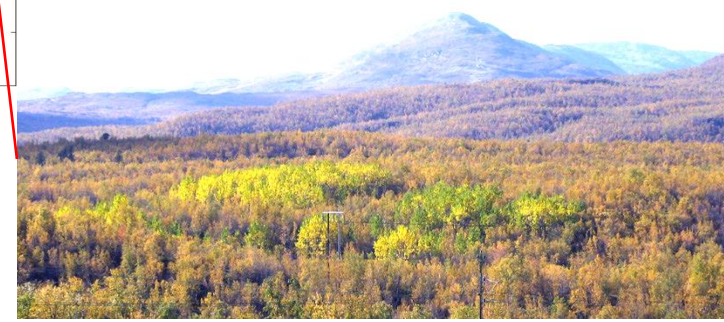


Counter-intuitive responses





Aspen stand, September 9, 1978.
Photo: Abisko Station.



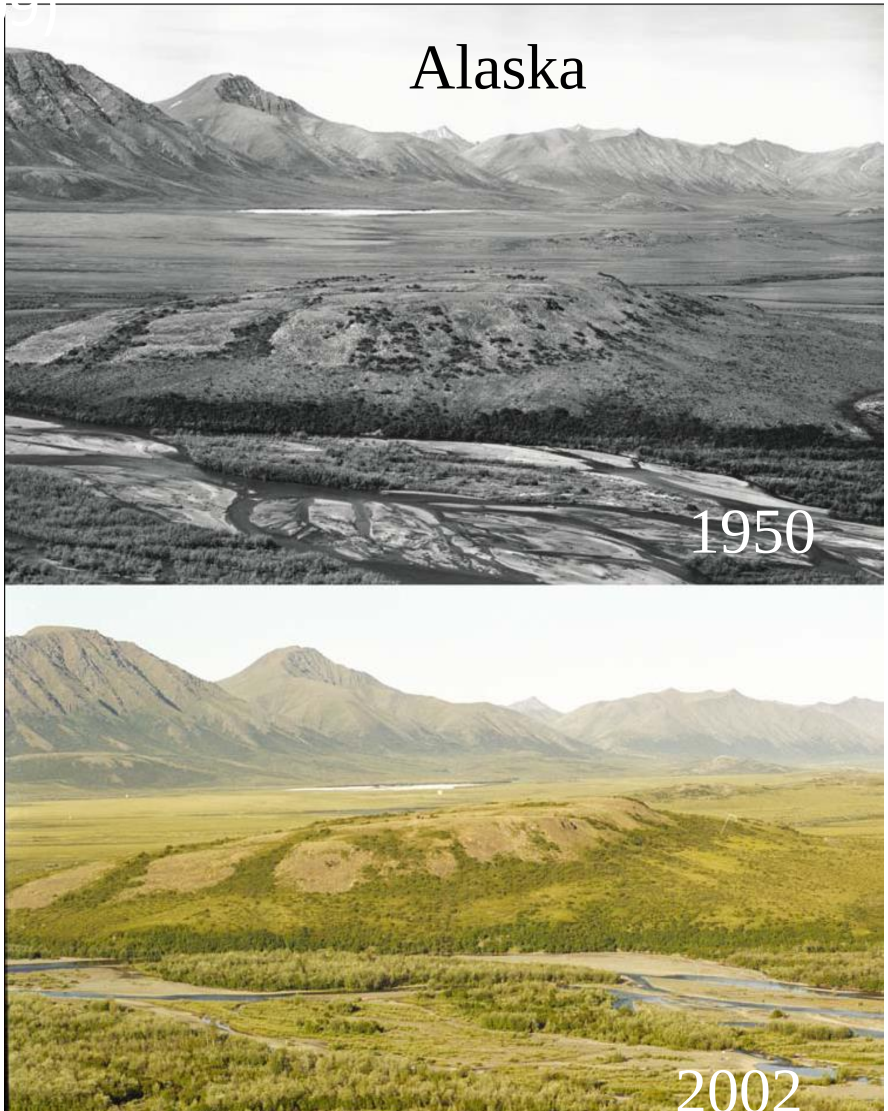
Abisko treeline
Photo: Sandberg, 1963

Aspen stand, September 9, 2008.
Photo: Abisko Station.

Shrubification during cooling

Homeostasis during warming

But first step is to correlate with climate



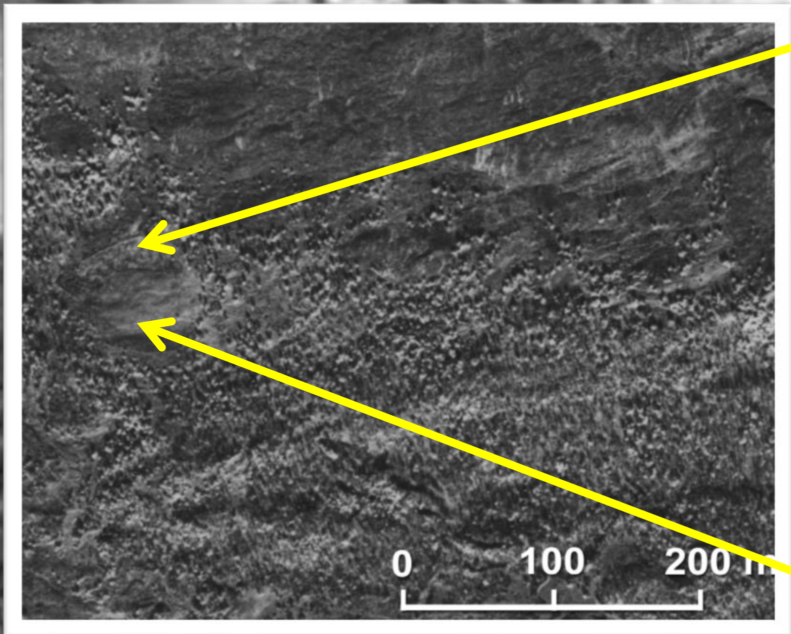
Sturm, Tape, 2002

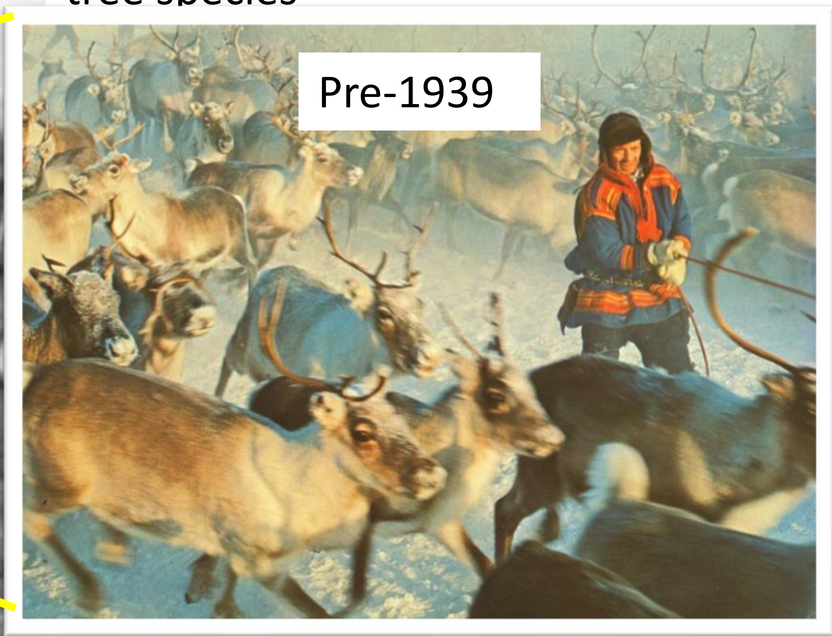
Experiments might help to understand causes

Pathology of change

1977, Swedish Lapland

2009, 600% increase in cover + new tree species





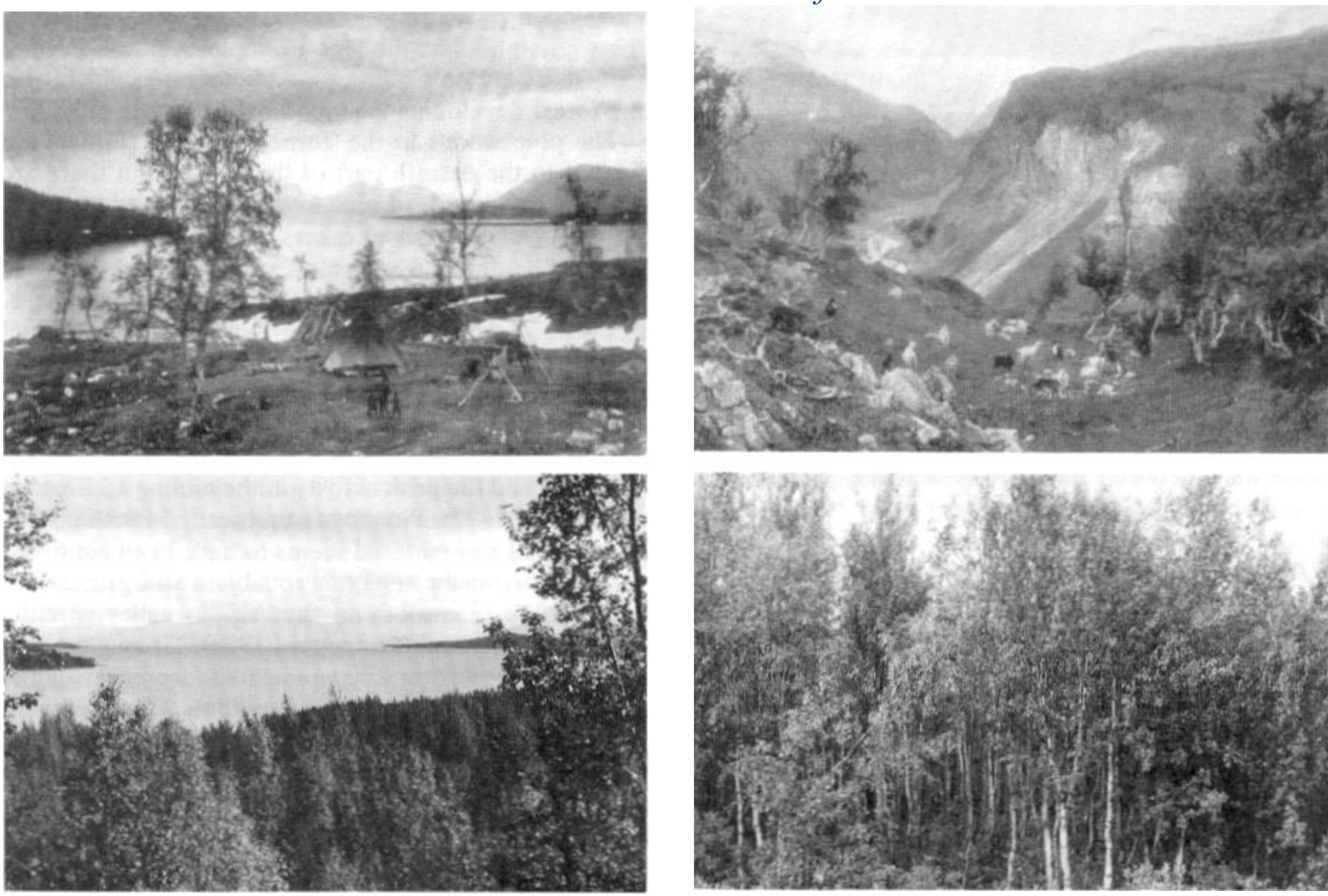
Pre-1939

Land use changes reinforce climate impacts

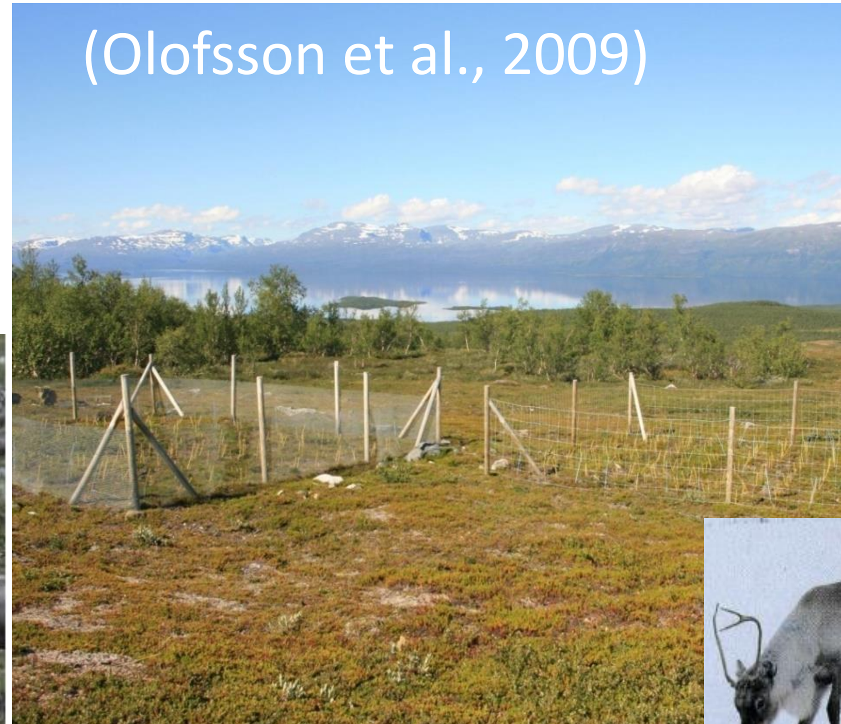
Pålnoviken | *North of Pålnoviken*

1906

1986



Pathology – role of animals



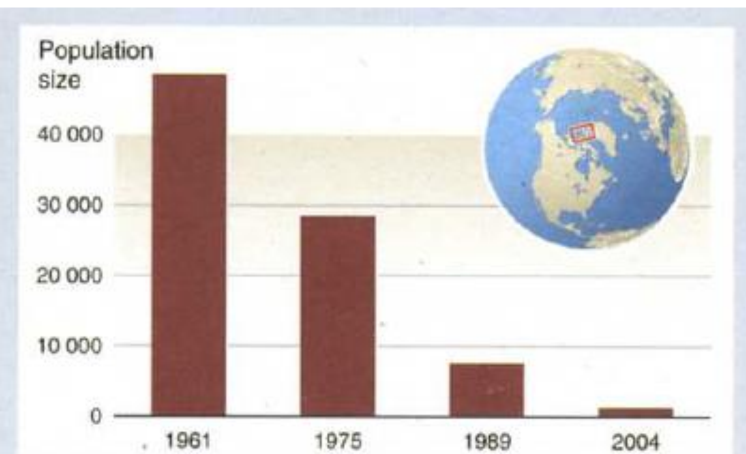
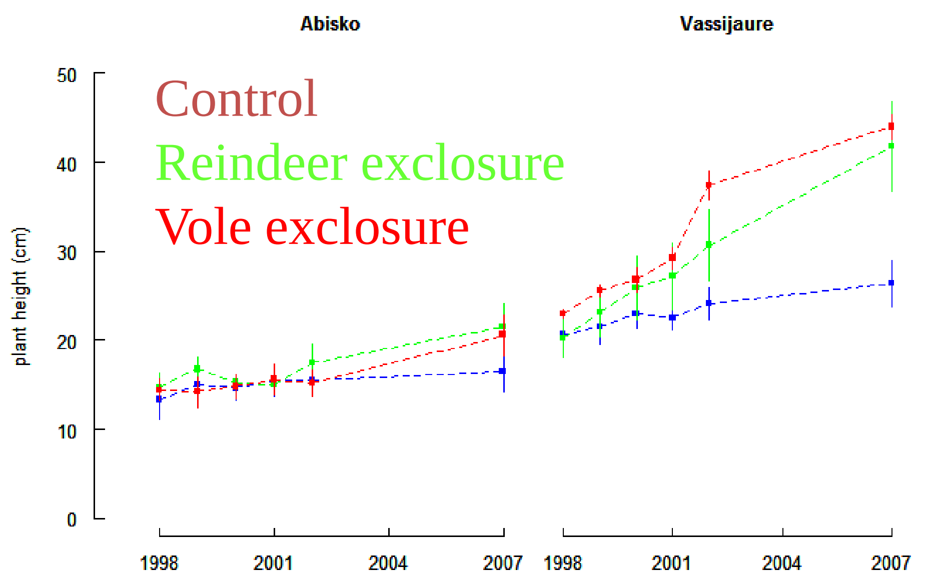
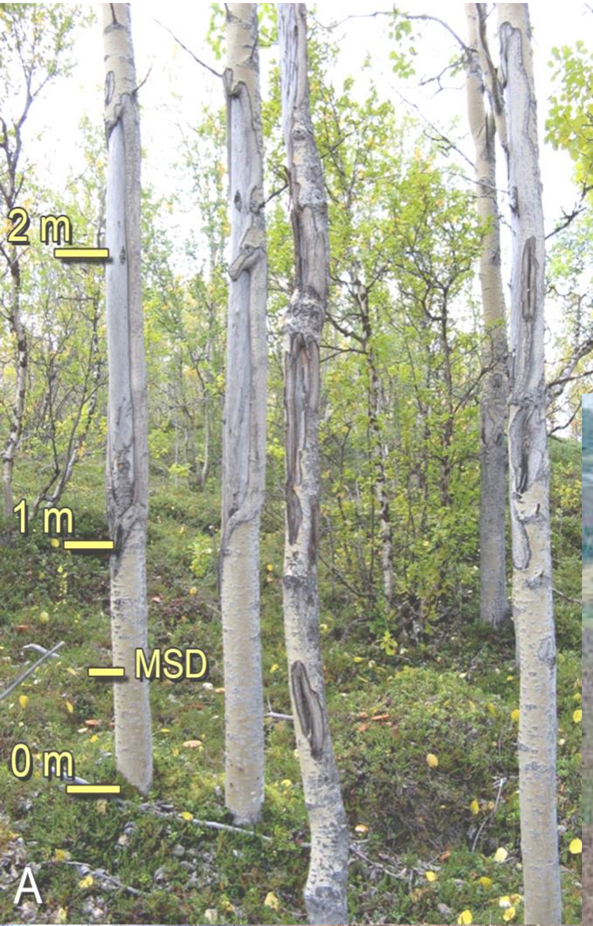


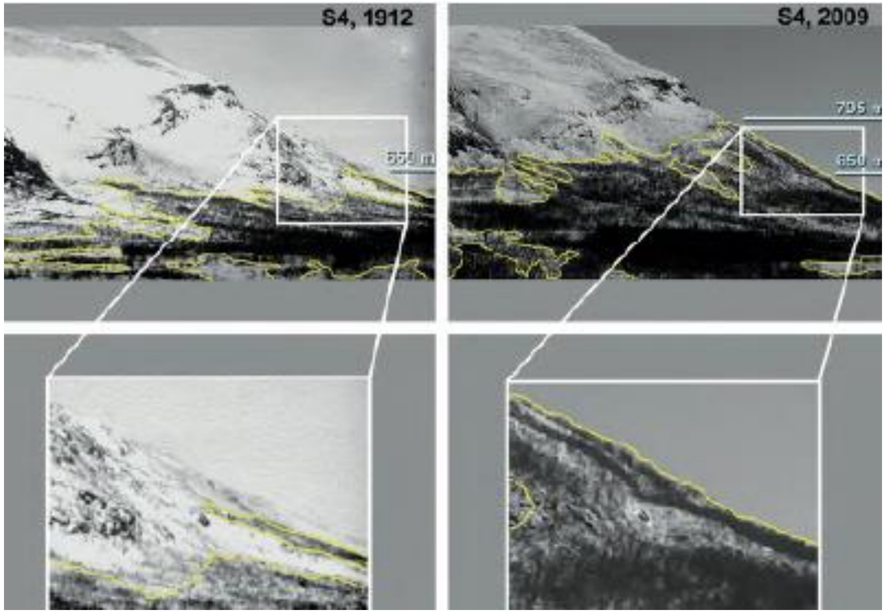
Figure 4.9: Population size of Peary caribou in the Canadian Arctic islands from 1961 to 2004, showing major declines.



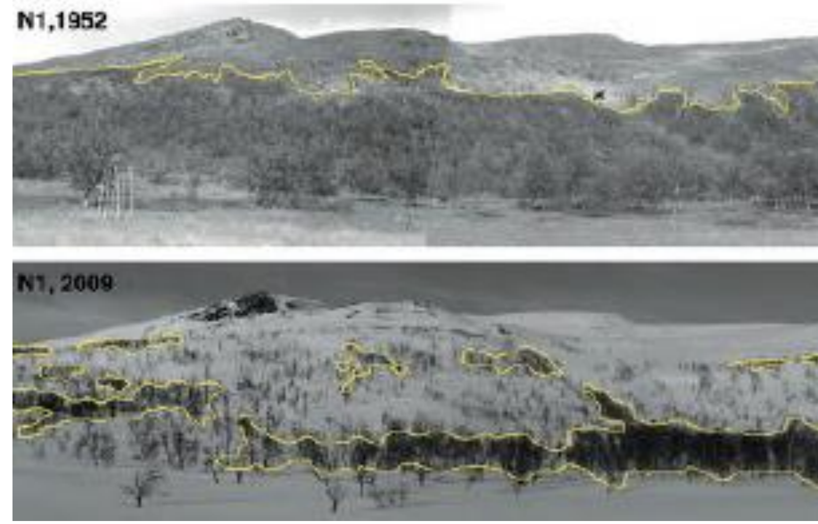


The outcome of the tree competition is determined by moose and caterpillars which are themselves impacted by climate change (below is birch forest damage in 2004. Such events allow aspen to colonise)

Multiple changes can be seen in one area experiencing the same climate changes

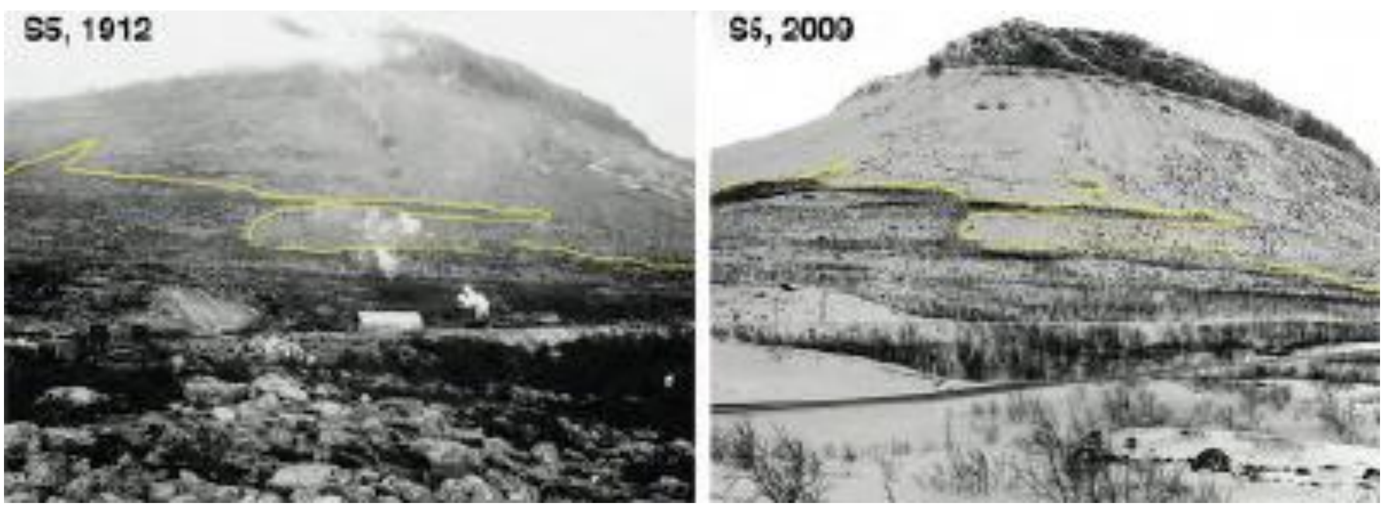


up



down

And stays stable

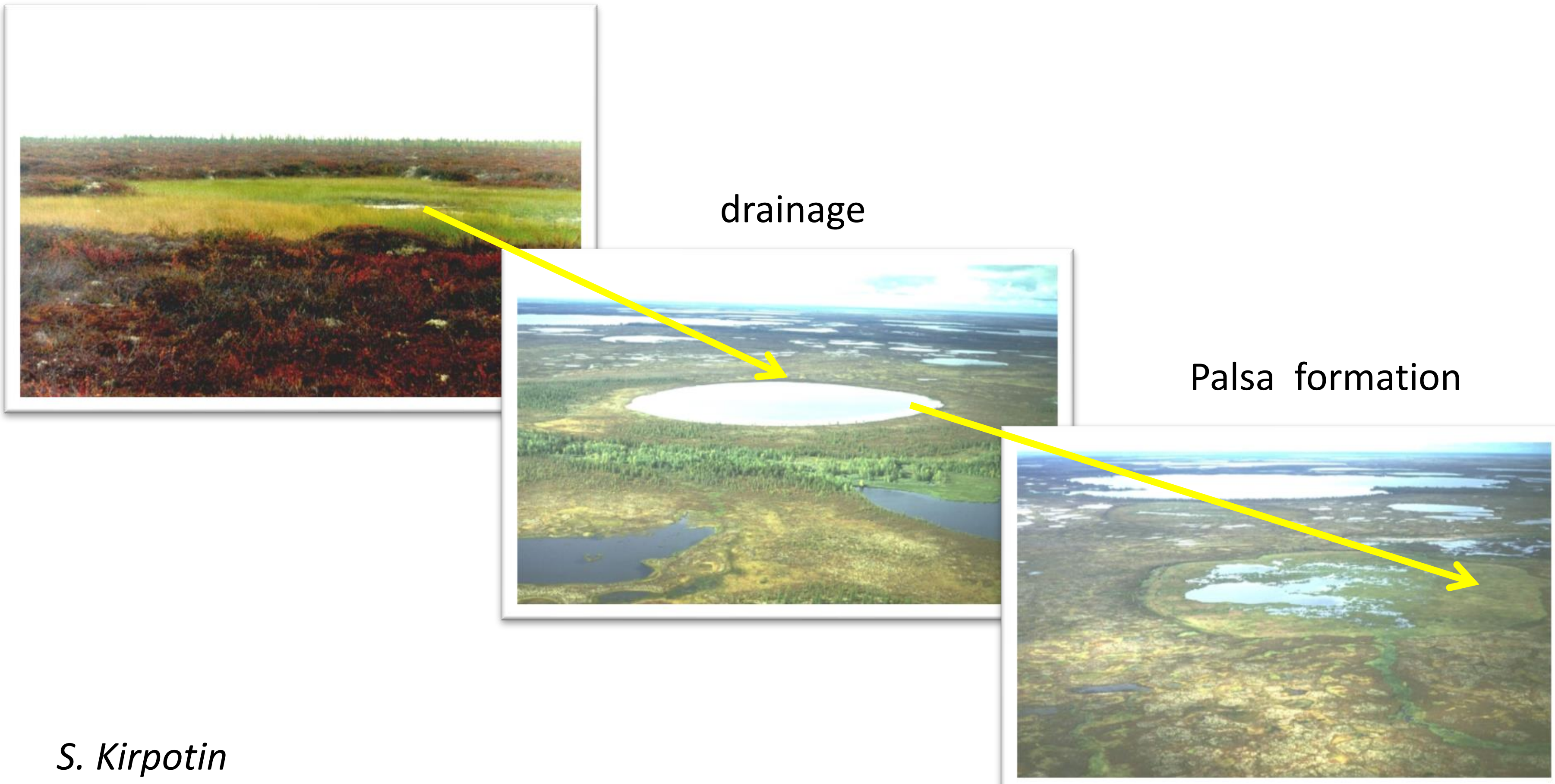


Van Bogaert et al., 2011

Confusing effects of time scale: cycles? We don't live long enough!

"khasyrei" cycles 10's to 100's of years: greening then browning

thermokarst



S. Kirpotin

Biology is driven by events: we are poor at observing these

Births

Deaths

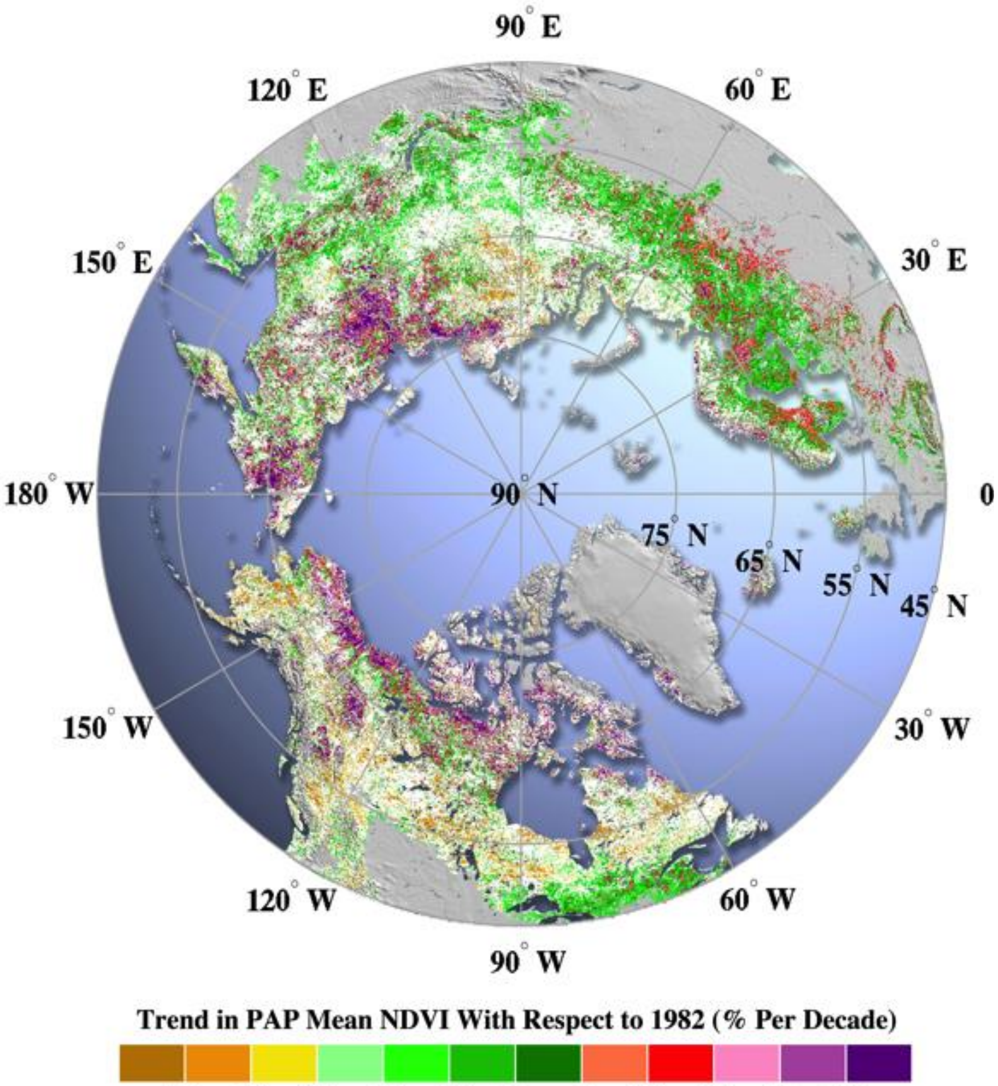
Relocation

Mutation/evolution

Extinction

Duration and magnitude of events is a human perspective

Re-visiting greening in 2016



Xu et al., 2013

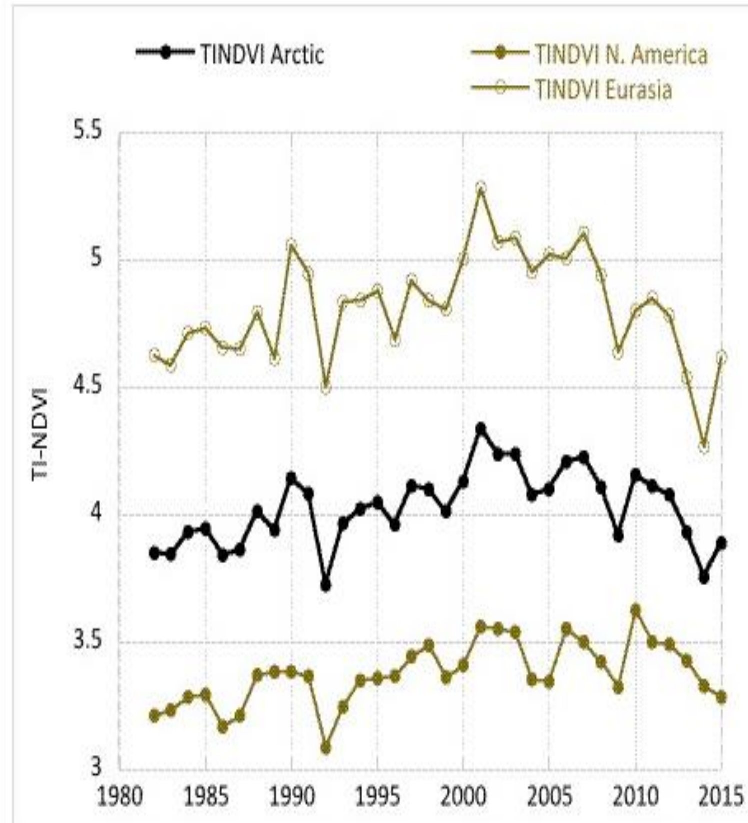
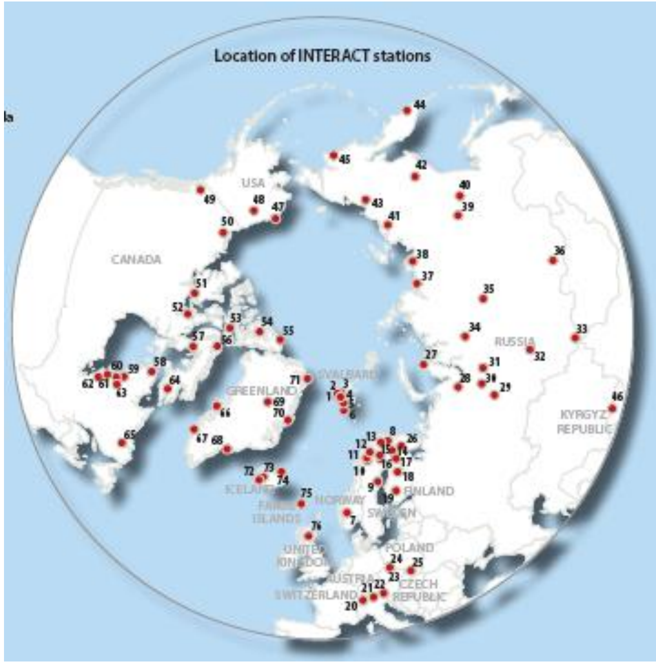


Fig. 7.2b. Time-integrated (TI)-NDVI from 1982 to 2015 for North America (bottom), Eurasia (top), and the Arctic as a whole (middle).

Recent vegetation browning: Epstein et al, 2016

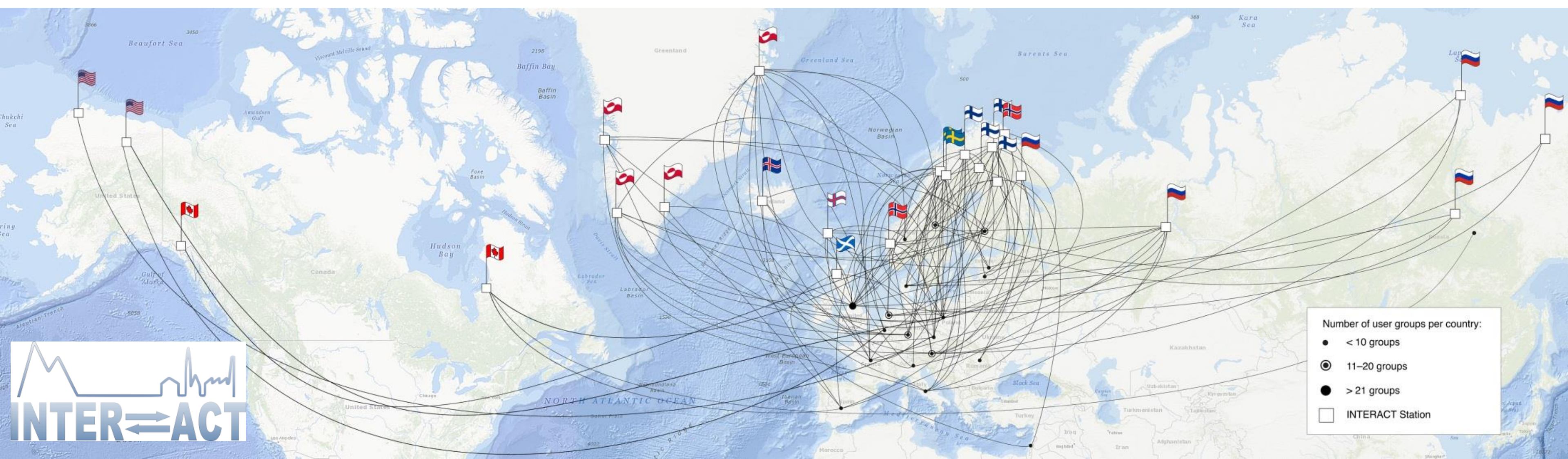
INTERACT Trans-national access: ca. 600 researchers given access 2010-2017 (www.eu-interact.org)



Physical access - *feet on the ground*

Remote access – *tasks by station staff*

Virtual access - *requests for data*



Welcome to Salekhard, September 2018, "Building a large scale northern infrastructure" – contact Olga Morozova

Thank you for your attention!

SecNET