Photo: K. Blom, T. Nordstad, B.E. Sandbakk, N. Yoccoz, J. Kohler

TUNDRA ECOSYSTEM RESPONSES TO CLIMATE CHANGE IN SVALBARD

Eva Fuglei & Åshild Ønvik Pedersen
Norwegian Polar Institute

Arctic Biodiversity Congress, Trondheim December 2-4, 2014.
Section: Consequences of interacting climate and non-climate drivers on Arctic biodivercity

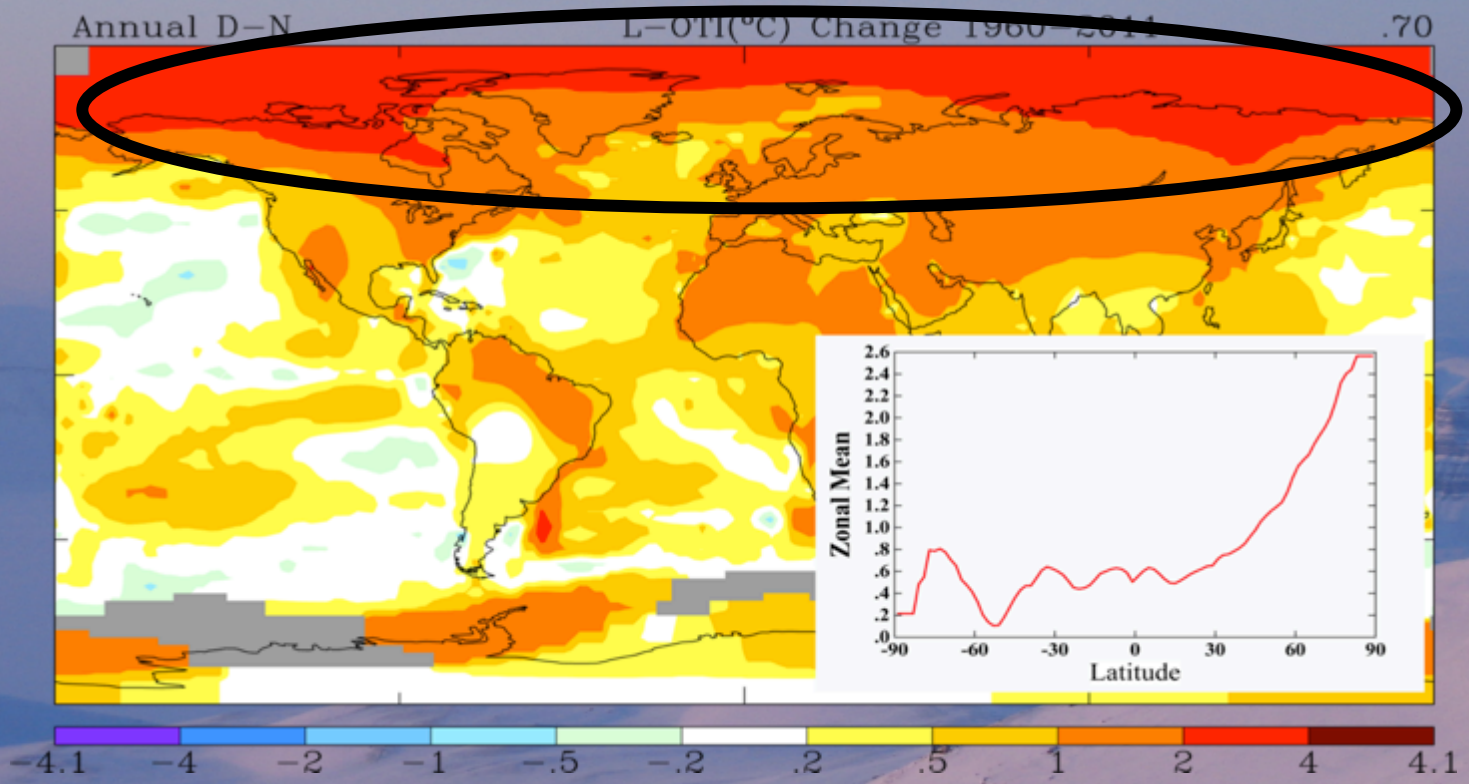
Photo: K. Blom, T. Nordstad, B.E. Sandbakk, N. Yoccoz, J. Kohler

Contents

- Drivers of climate change in the arctic
- The Svalbard tundra ecosystem
- Climate change and responses in the ecosystem
- Challenges in the future

The key challenge: Climate warming!!!

"The heat is already on"



Trends in annual mean temperature for the period 1960-2011.

http://data.gis.nasa.gov/gistemp

Photo: E. Fuglei

Marine impacts: reduced sea ice extents (Stroeve et al. 2012)

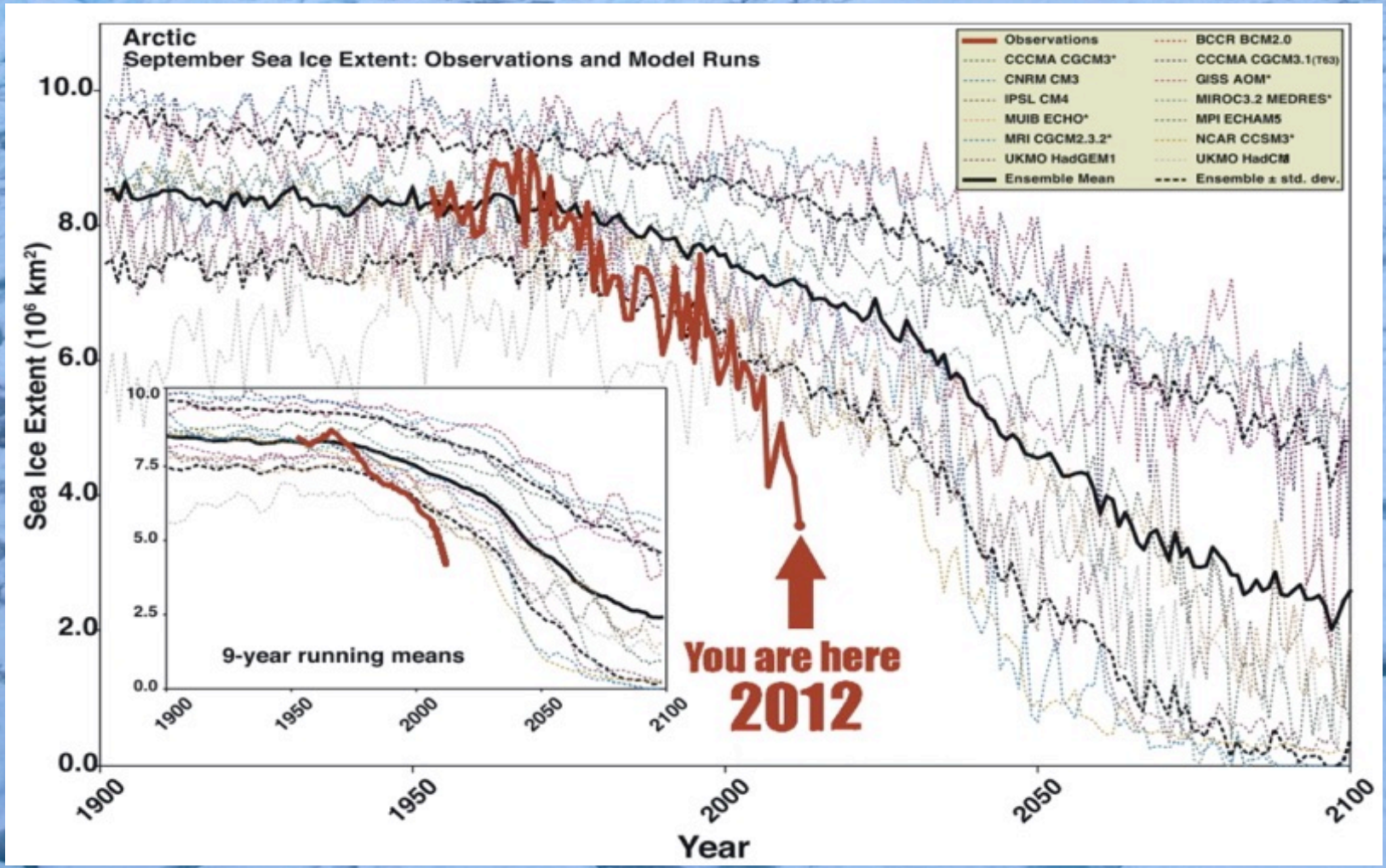
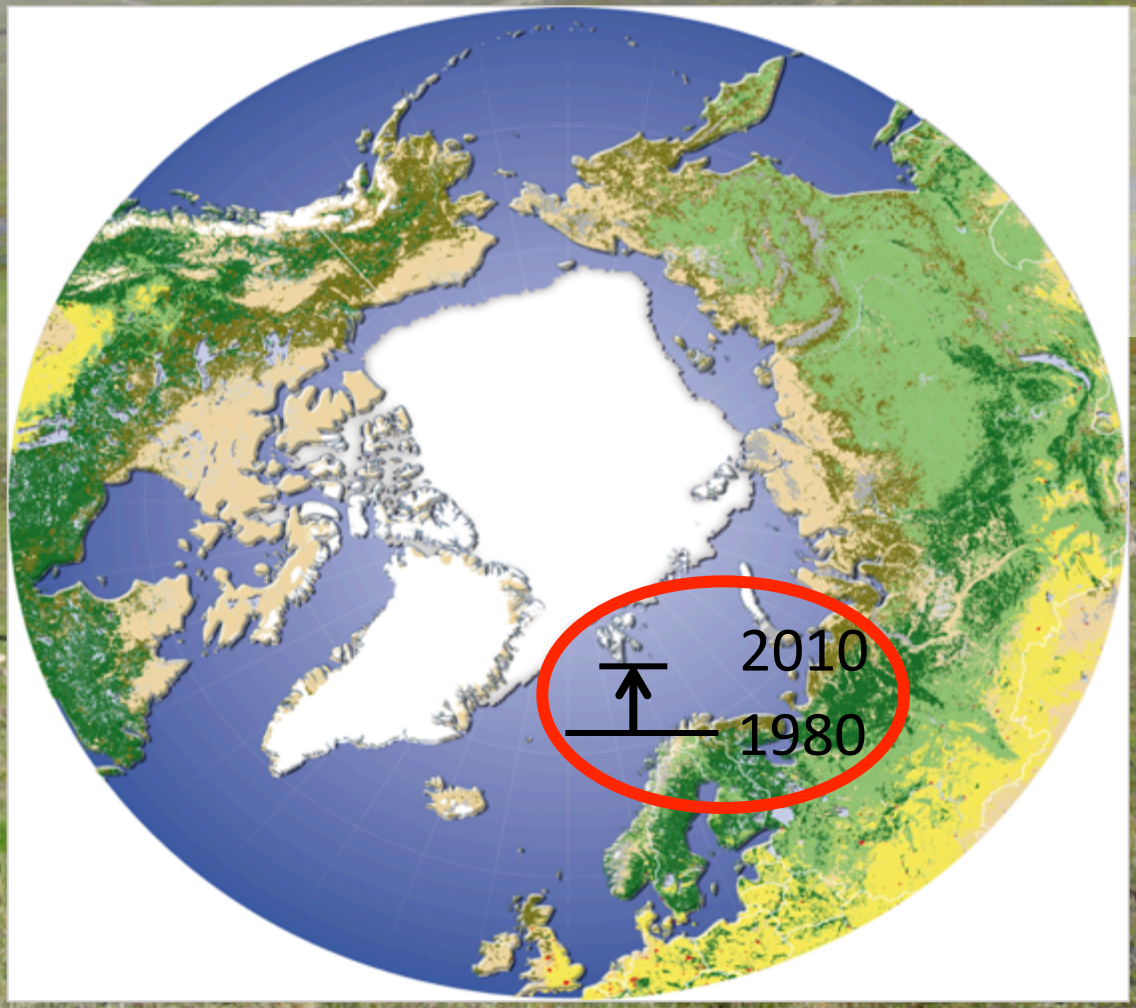


Photo: NPI

Terrestrial impacts: Tundra ecosystems

Longer vegetation growth season (Xu et al. 2013)

”Southern seasons has moved” 4-7 latitudinal degrees north over the last 30 years



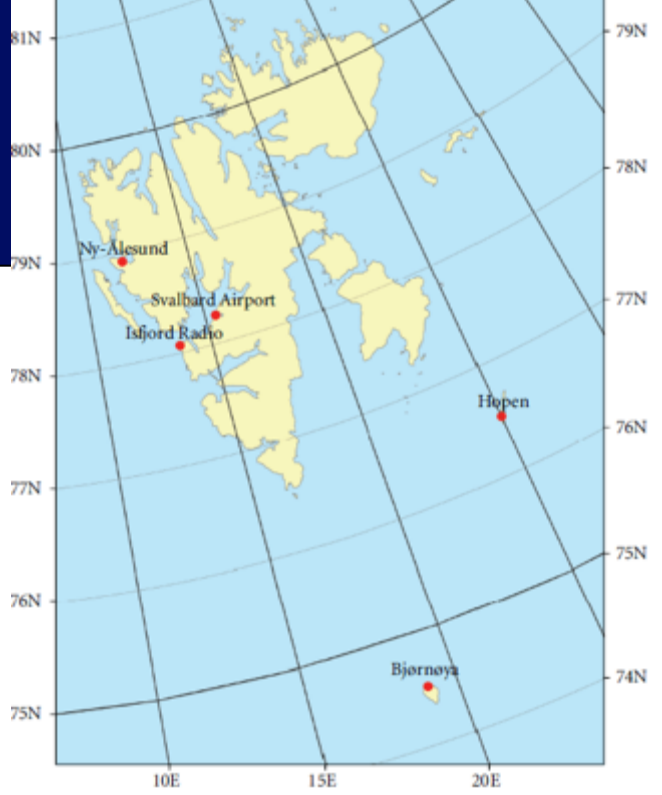
Leading to earlier onset of spring and a longer snow-free season

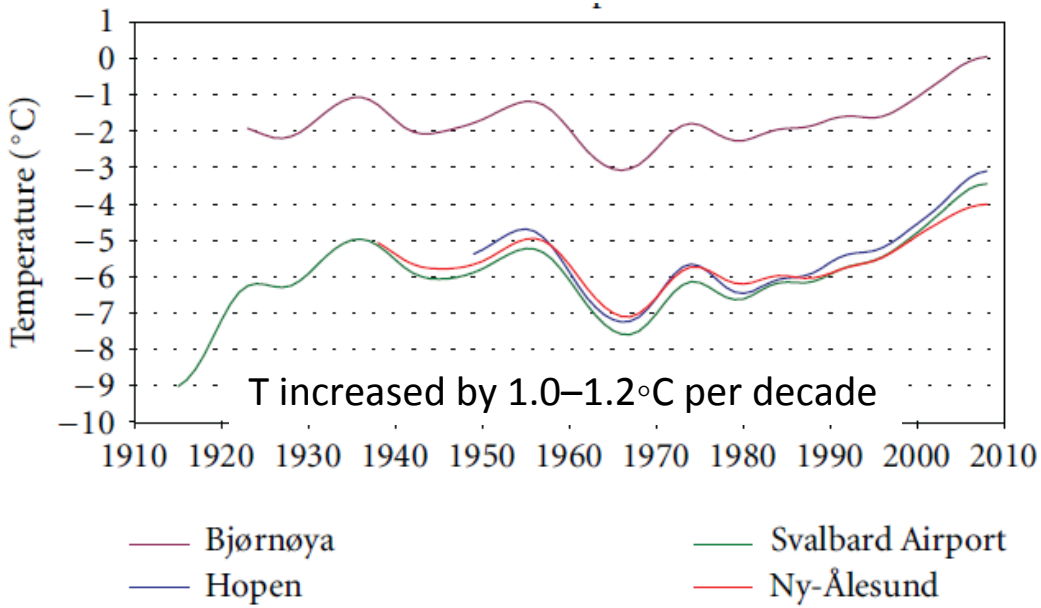
Photo: E. Fuglei

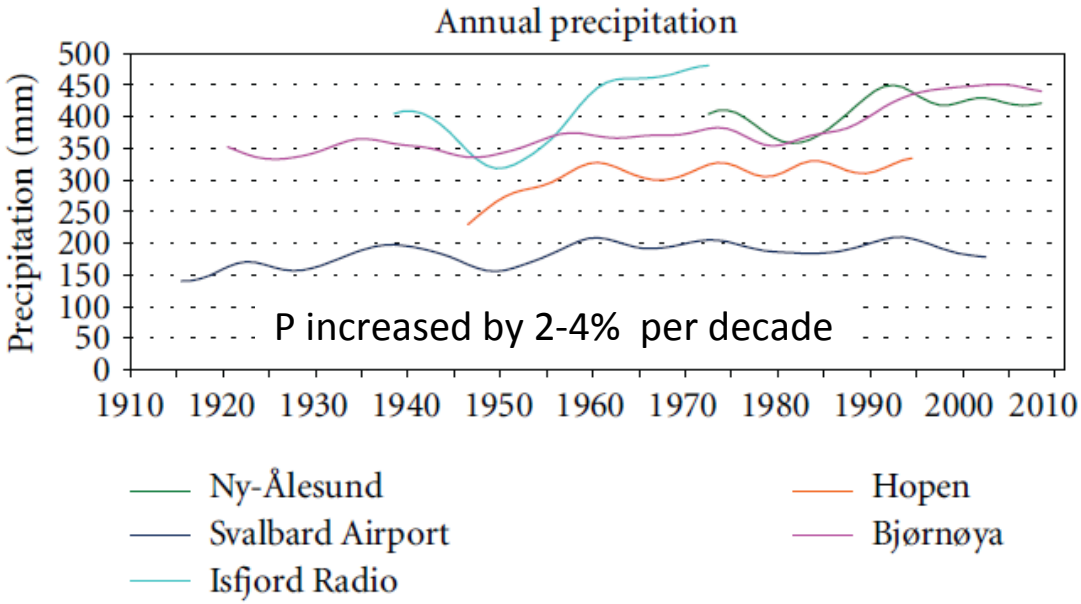
The large-scale warming in the Arctic during the latest decades is also recognized at the weather stations in Svalbard

Temperature and precipitation variability and extreme events are important for the terrestrial ecosystem. Important to describe trends in this variability for winter and summer seasons separately.

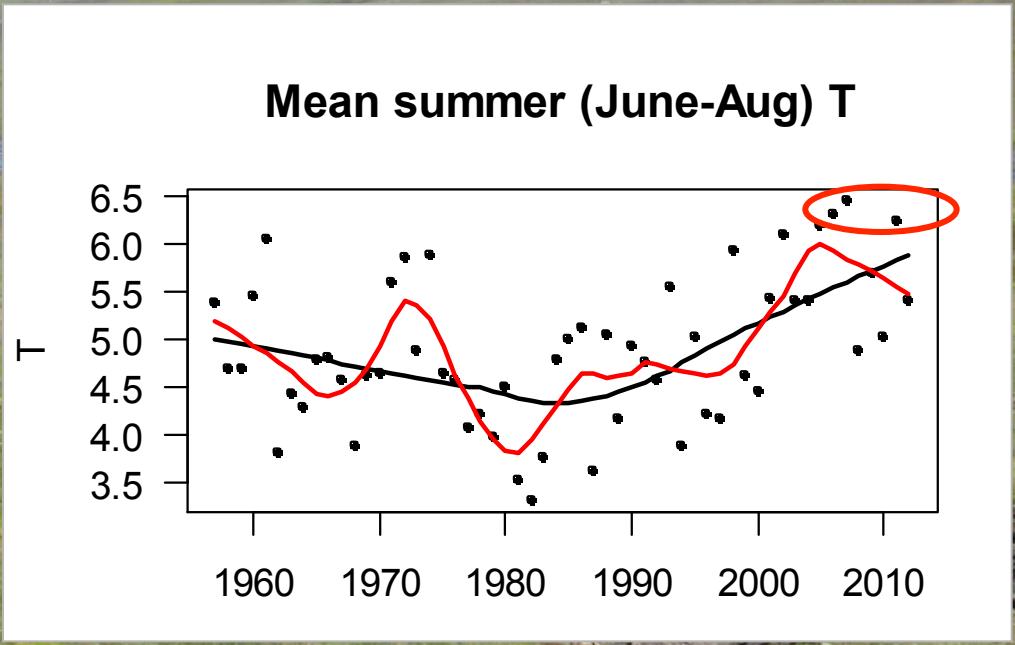
Giving biologically relevant climate variables (Ims et al. 2014).

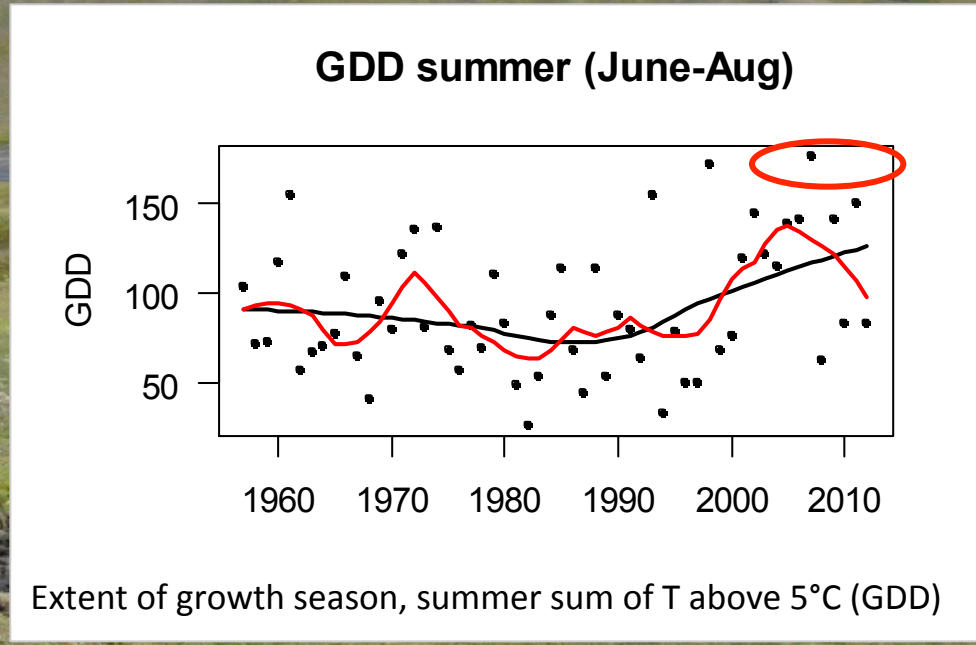






Summer: Climate and weather in Svalbard

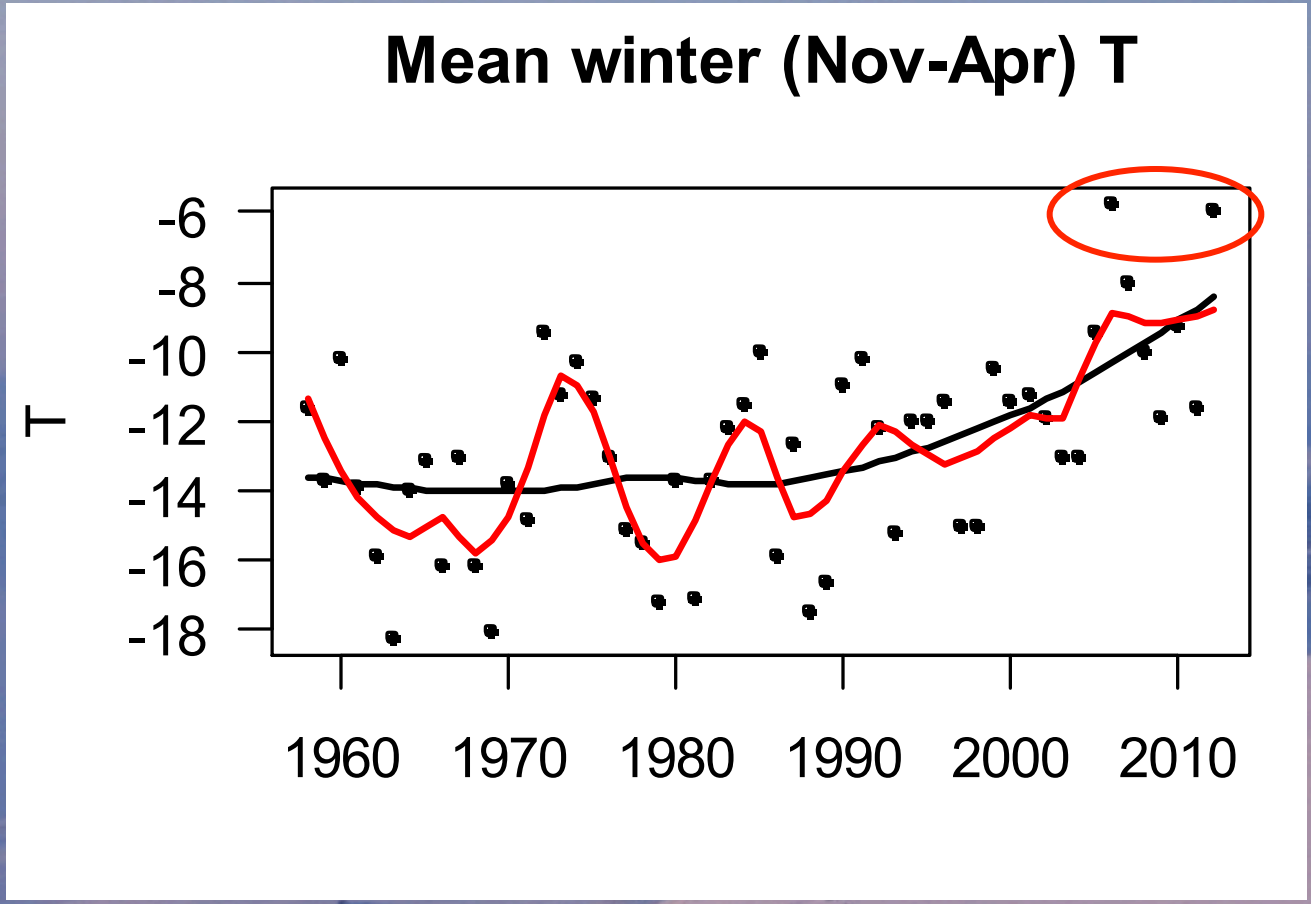




Extent of growth season, summer sum of T above 5°C (GDD)

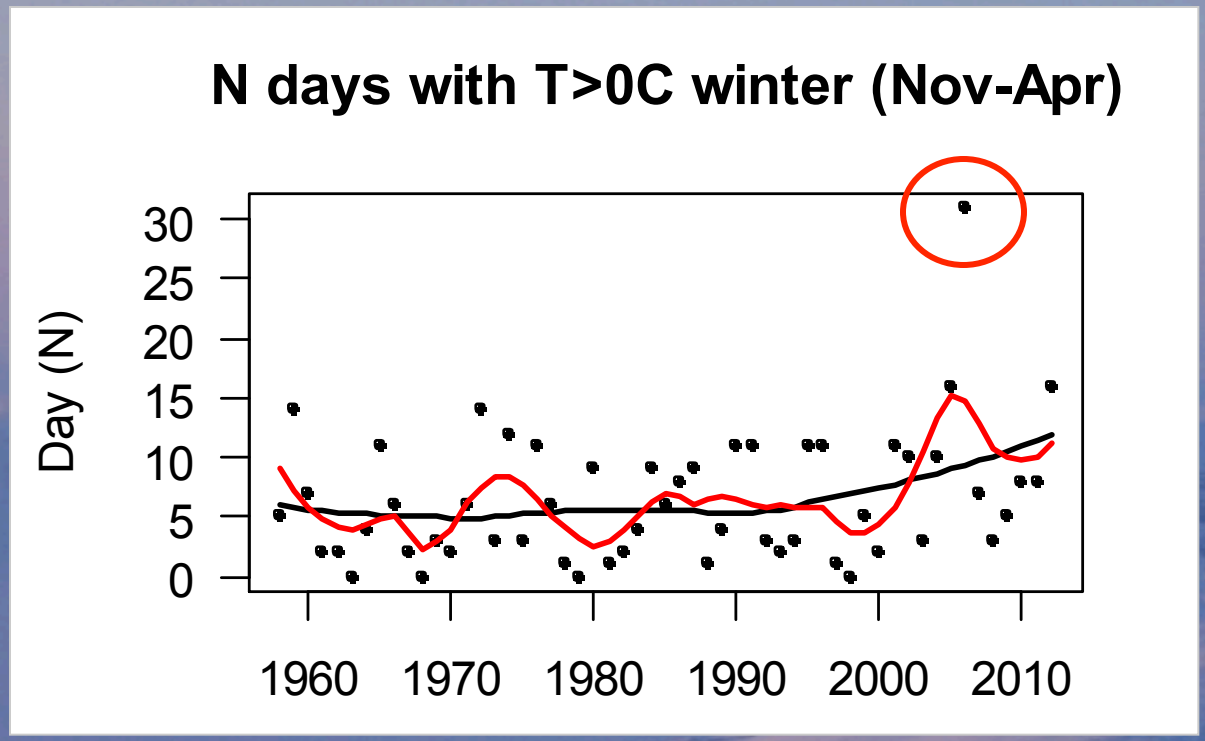
Ims et al. 2014; Photo: E. Fuglei

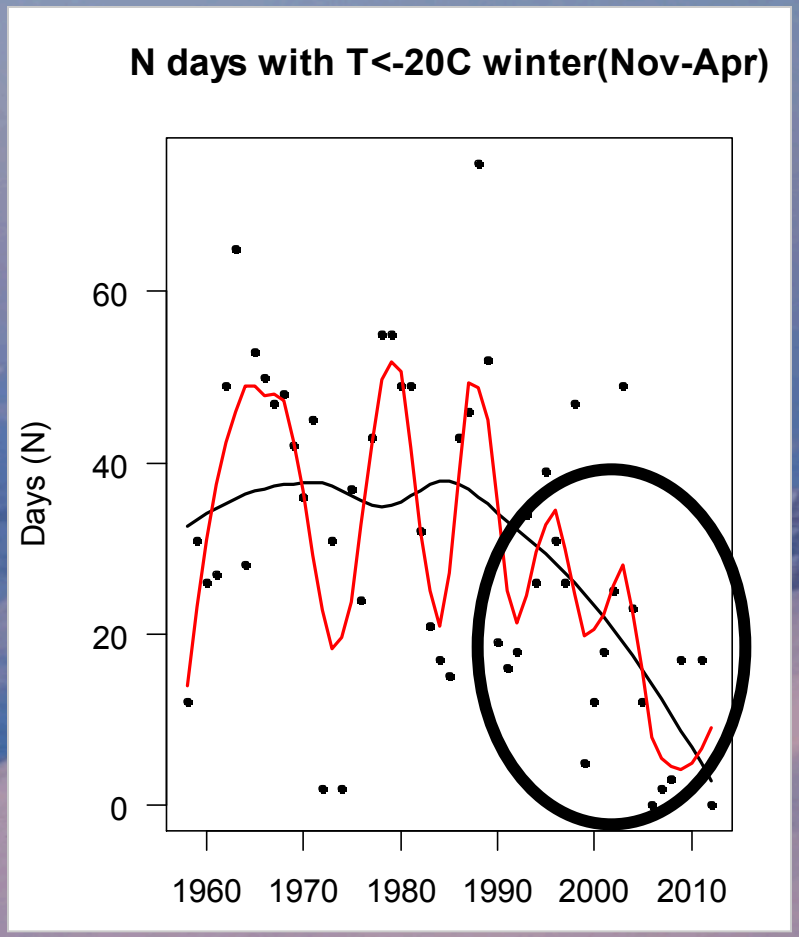
Winter: Climate and weather in Svalbard



Ims et al. 2014; Photo: E. Fuglei

Winter: Climate and weather in Svalbard

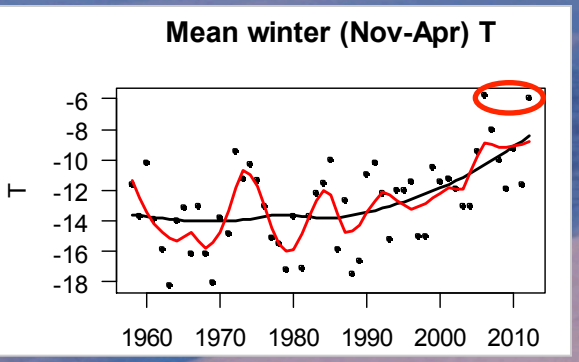


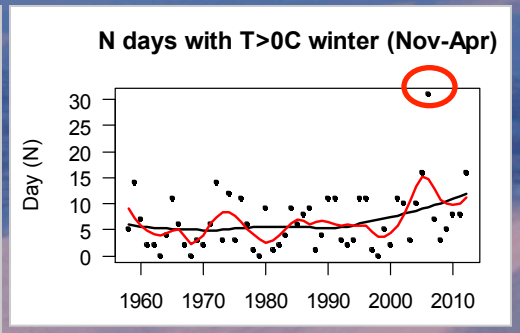


Ims et al. 2014; Photo: E. Fuglei

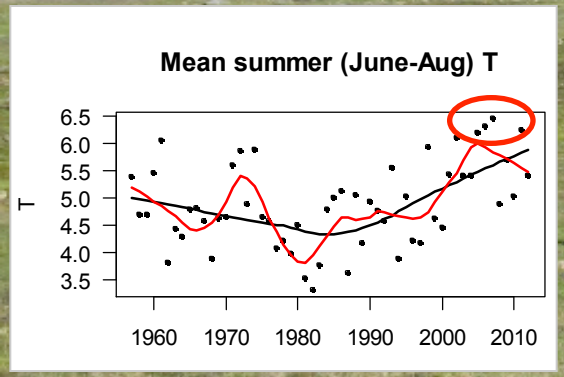
Trends in biologically relevant climate variables show that Svalbard is presently on the verge of “a novel climate” characterized by winters without very low temperatures (< -20°C) and summers with extended growth seasons (>5°C). Both seasons will experience «new climates» if current trends continues

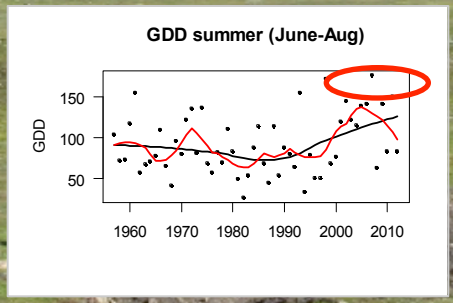
Winter





Summer



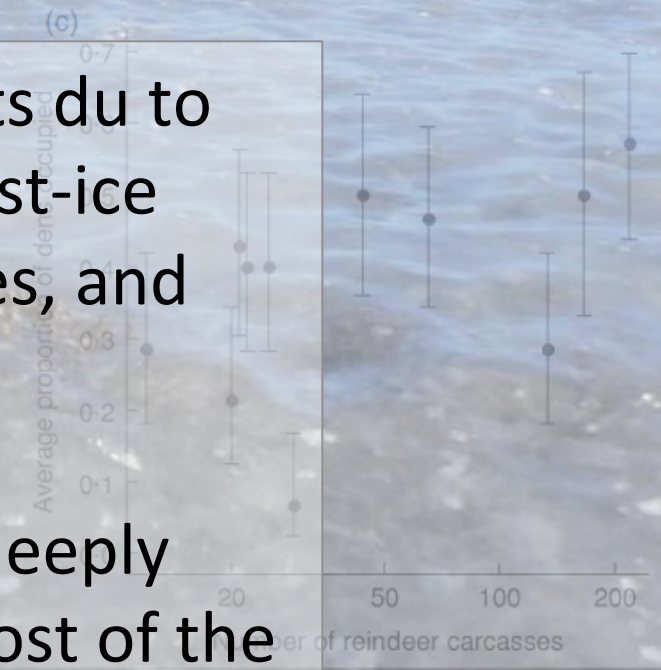


Ims et al. 2014; Photo: E. Fuglei


Changed winter climate
More frequent “rain-on-snow” events

Predator-prey dynamics

- Reproduction related to availability of reindeer carcasses (Fide et al. 2011)
- Higher densities of arctic fox can increase predation pressure on ground breeding birds, e.g. geese, ptarmigan and shorebirds (Fide et al. 2011)

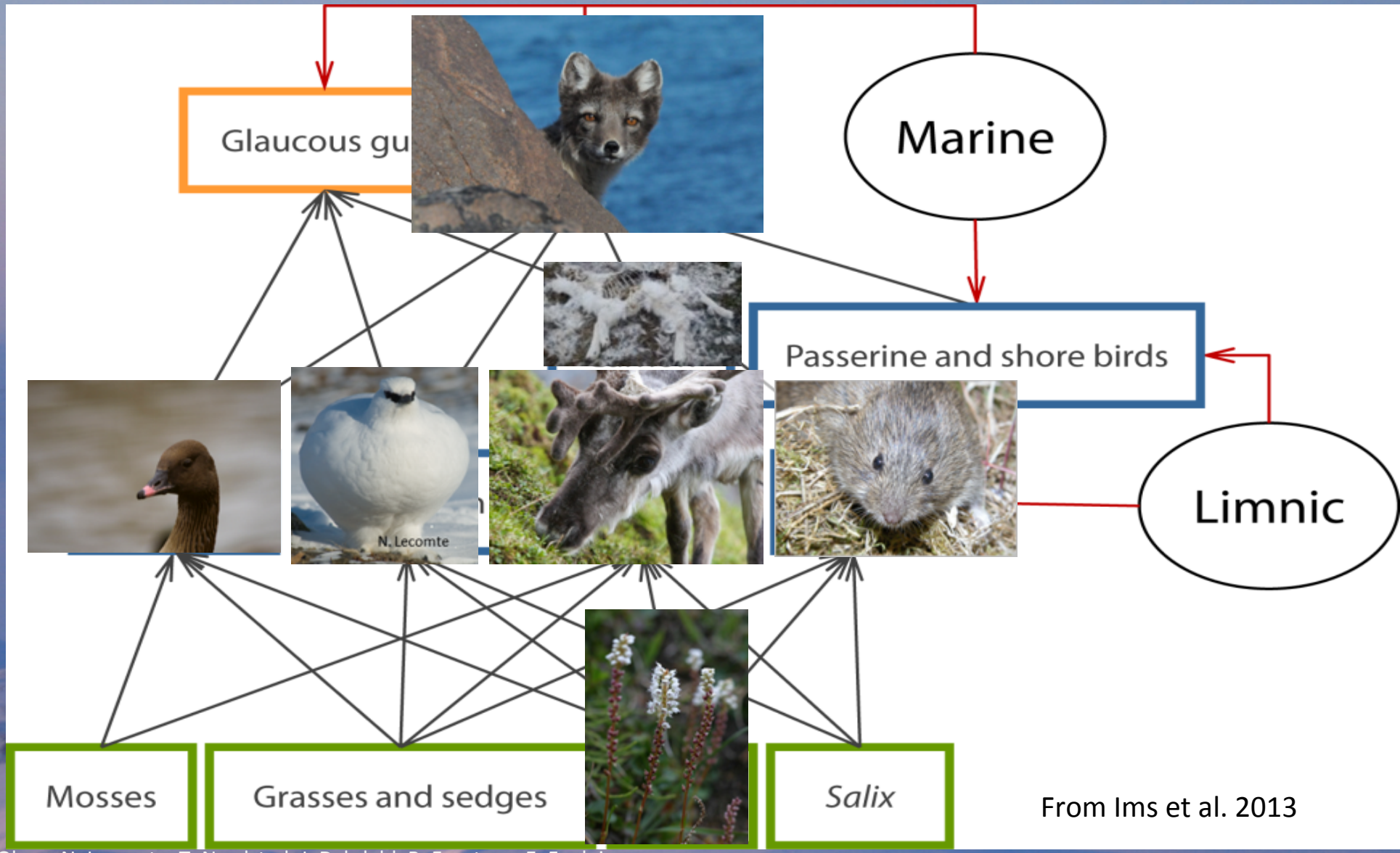


Episodes of «Rain-on snow» events du to warm spells and rain generate crust-ice layers through thaw-freezing cycles, and heavy rain go through the entire snowpack and cause ground icing.
A thick ice layer builds up on the deeply frozen ground and encapsulate most of the short-growing vegetation on the tundra blocking the vegetation.
Affecting the herbivores and the rest of the ecosystem in Svalbard

Photo: J. Kohler

Photo: K. Blom, Eva Fuglei

The tundra ecosystem in Svalbard



From Ims et al. 2013

Photo: T. Olsen, N. Lecomte, T. Nordstad, J. Dybdahl, B. Frantzen, E. Fuglei

Miljøovervåking Svalbard og Jan Mayen -MOSJ

Search

Norsk

Home

Climate
Atmosphere
Ocean
Land

Fauna
Terrestrial fauna
Marine fauna

Flora

Influence
Hunting
Fishing

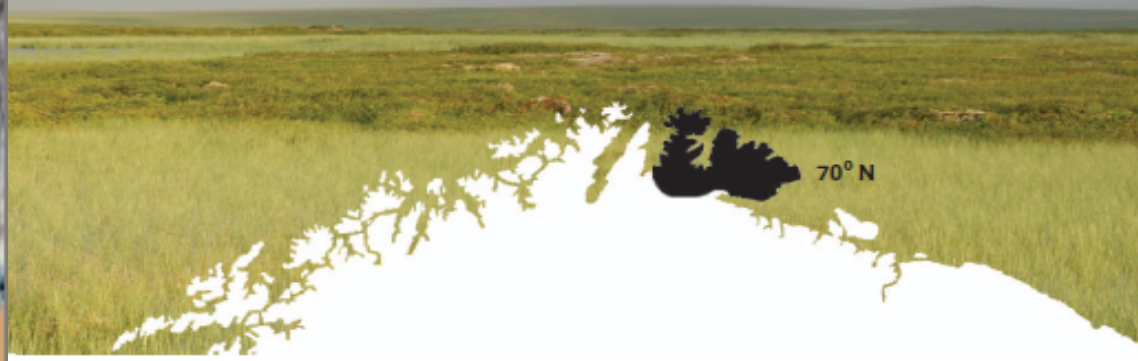
Environmental Monitoring of Svalbard and Jan Mayen (MOSJ)

– The state of the terrestrial environment in Svalbard

MOSJ

Science Plan for COAT:
Climate-Ecological Observatory for Arctic Tundra

- ✓ Continuous & Long-term
- ✓ State-of-the-art science
- ✓ Ecosystem-based
- ✓ Management oriented
- ✓ Stakeholder involvements



FRAM – High North Research Centre for Climate and the Environment

Photo: T. Nordstad

Some populations increases– other are stable or decreasing

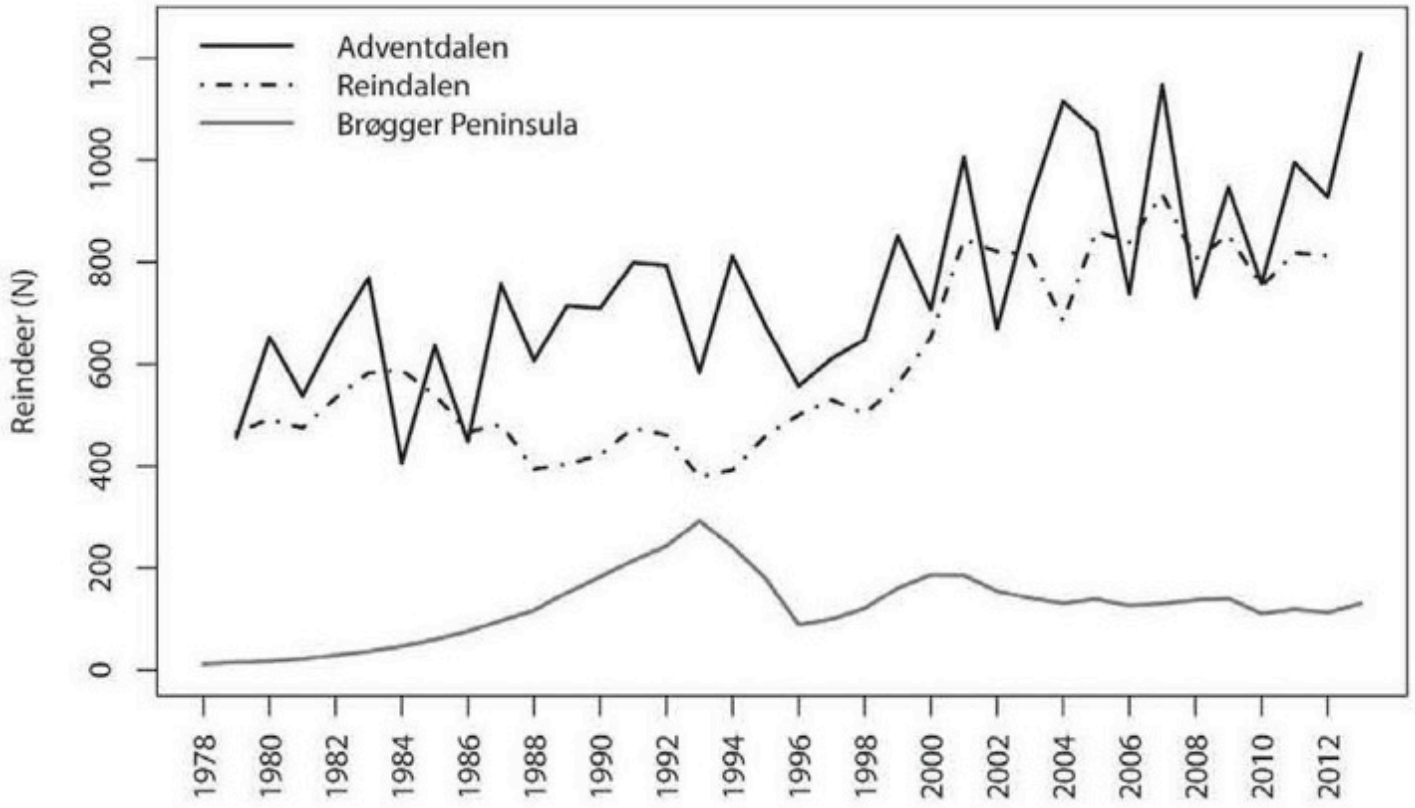
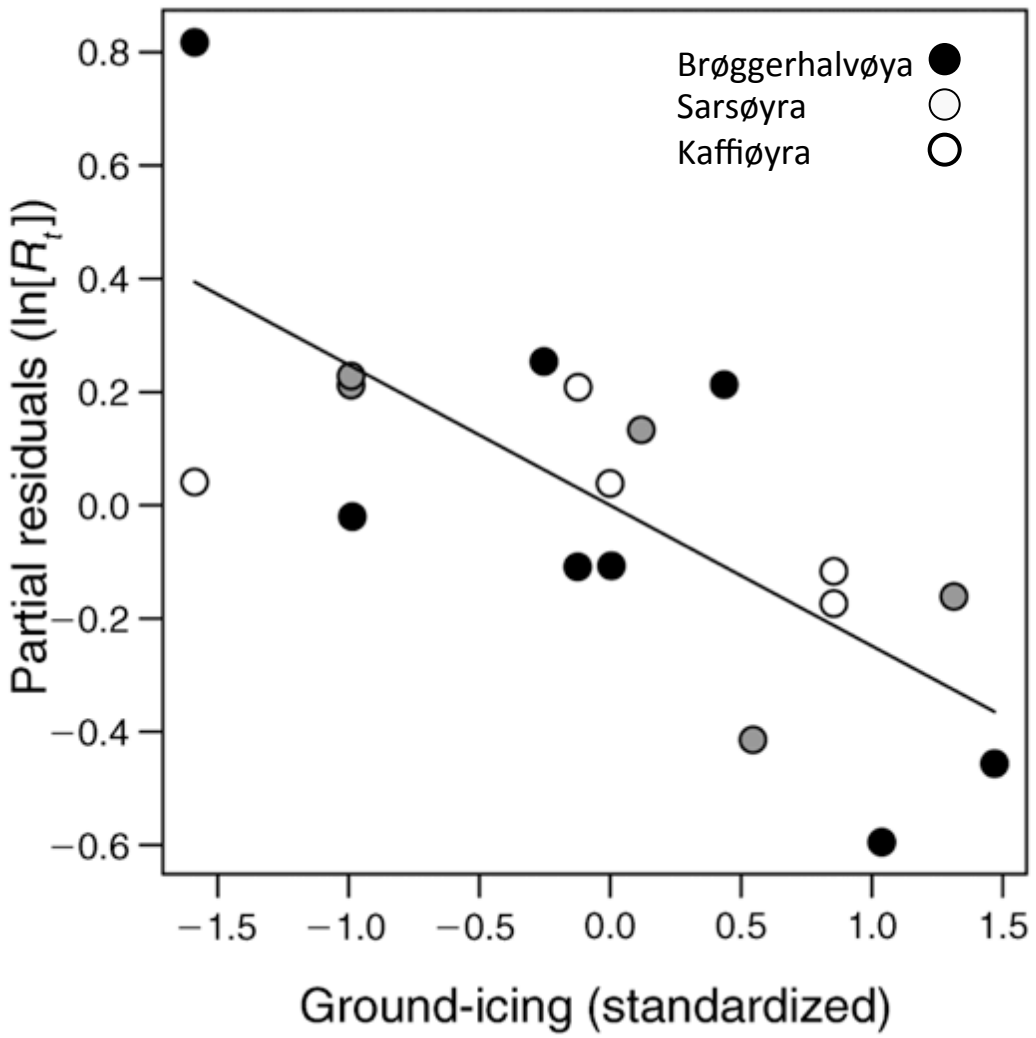


Figure 13
Population size of Svalbard reindeer in Adventdalen (annual 1979-2013) based on total counts, in Reindalen (3 year average; 1979-2013) based on transect counts and in Brøgger Peninsula (3 year average; 1978-2013) based on total counts.

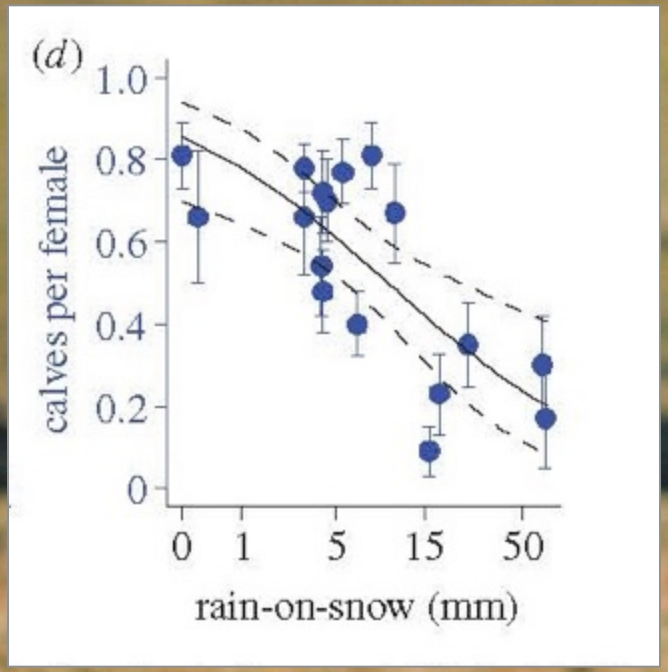
Ims et al. 2014; Photo: T. Nordstad

Negative relationship between ice on the tundra and the growth rate of the population



The reindeer are dying because of blocked pastures –
with the youngest and older animals most vulnerable

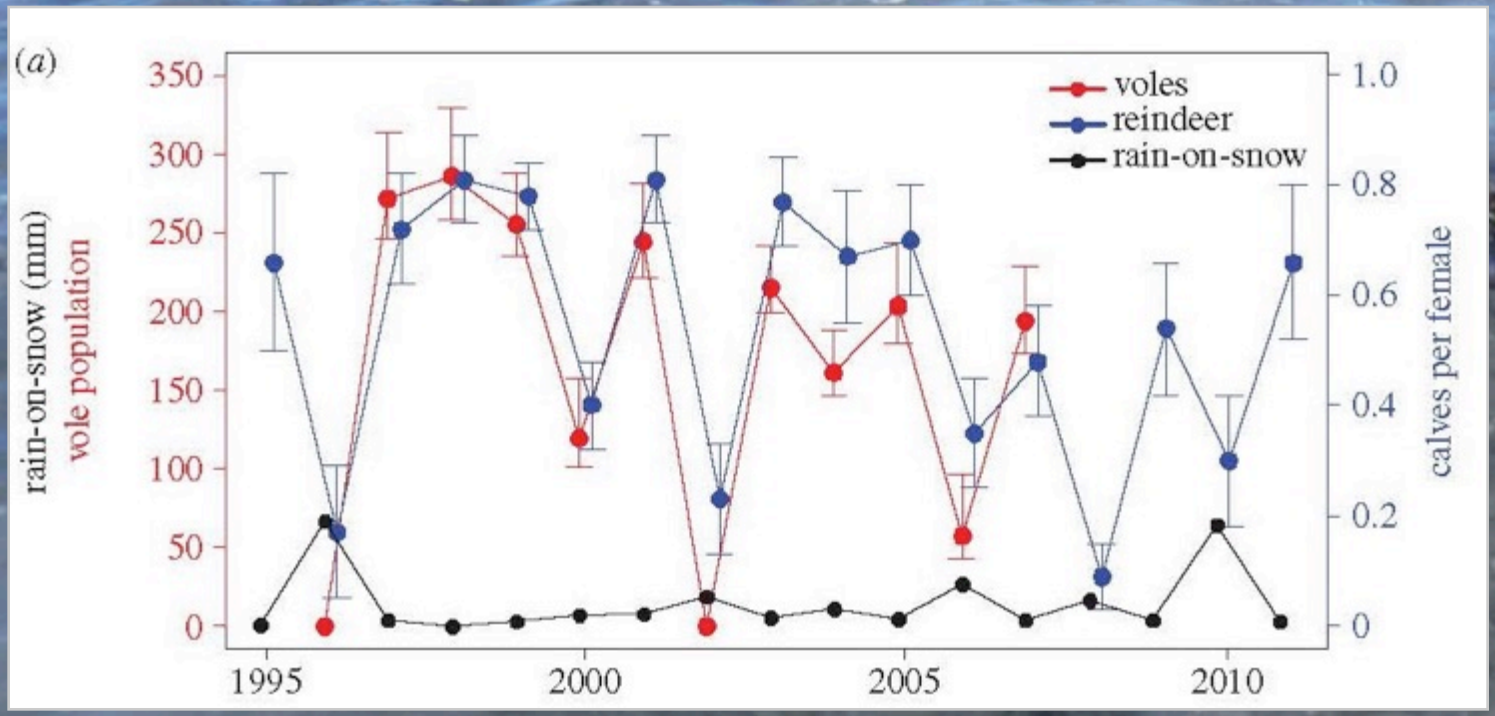
Hansen et al. 2011; see also Aanes et al. 2000, 2002; Kohler & Aanes 2004. Photo: J. Kohler



- The reproduction of the Svalbard reindeer varied extensively, affected by ground icing
- 0.16-0.80 calves per female reindeer

Stien et al. 2012; Photo: NPI

Voles and reindeer: Strongly fluctuating population dynamics in the mammalian herbivore species, strong synchrony



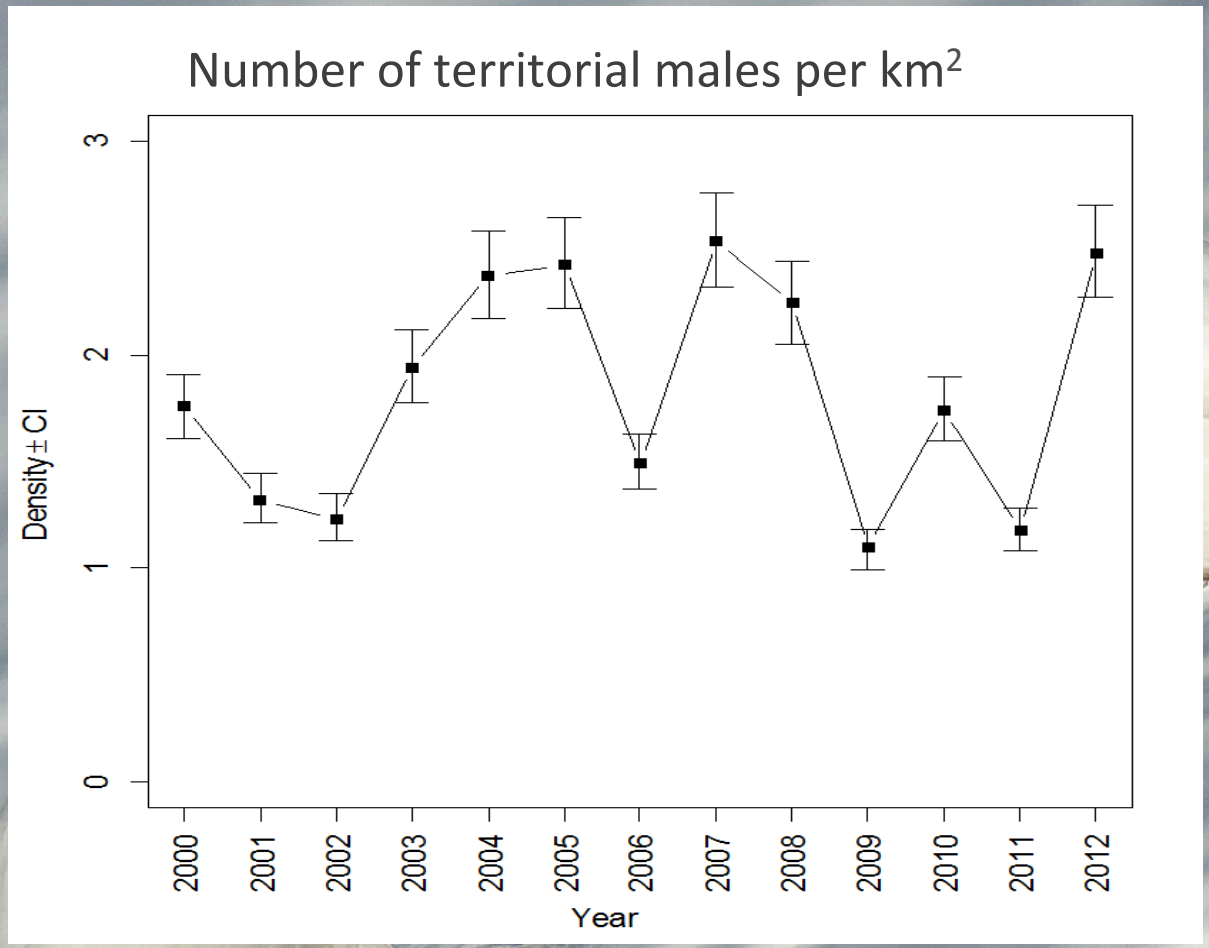
Climate forcing: icing events, drives the dynamics of resident vertebrates with highly contrasting life histories

Stien et al. 2012

Congruent responses to weather variability in high arctic herbivores

Audun Stien[1,*], Rolf A. Ims[3], Steve D. Albon[4], Eva Fuglei[2], R. Justin Irvine[4], Erik Ropstad[5], Odd Halvorsen[6], Rolf Langvatn[7,8], Leif Egil Loe[9,10], Vebjørn Veiberg[7] and Nigel G. Yoccoz[3]

Photo: N. Lecomte



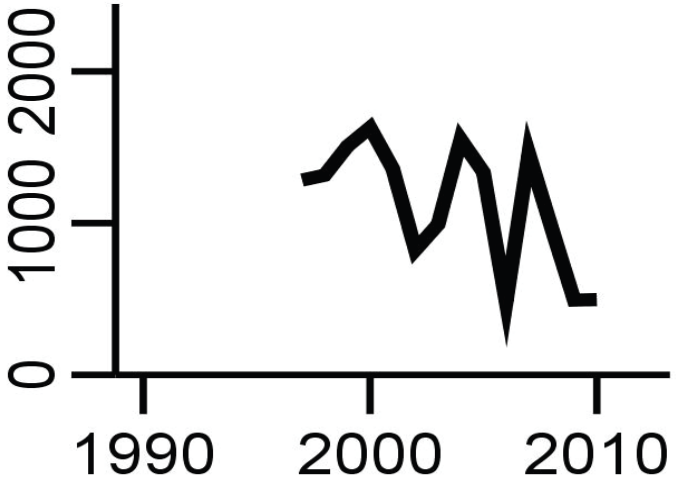
Low densities with little (non cyclic) temporal variability (Pedersen et al. 2012)

Pedersen et al. 2012; Photo: N. Lecomte

Science
AAAS
Climate Events Synchronize the Dynamics of a Resident Vertebrate Community in the High Arctic
Brage B. Hansen *et al.*
Science **339**, 313 (2013);
DOI: 10.1126/science.1226766

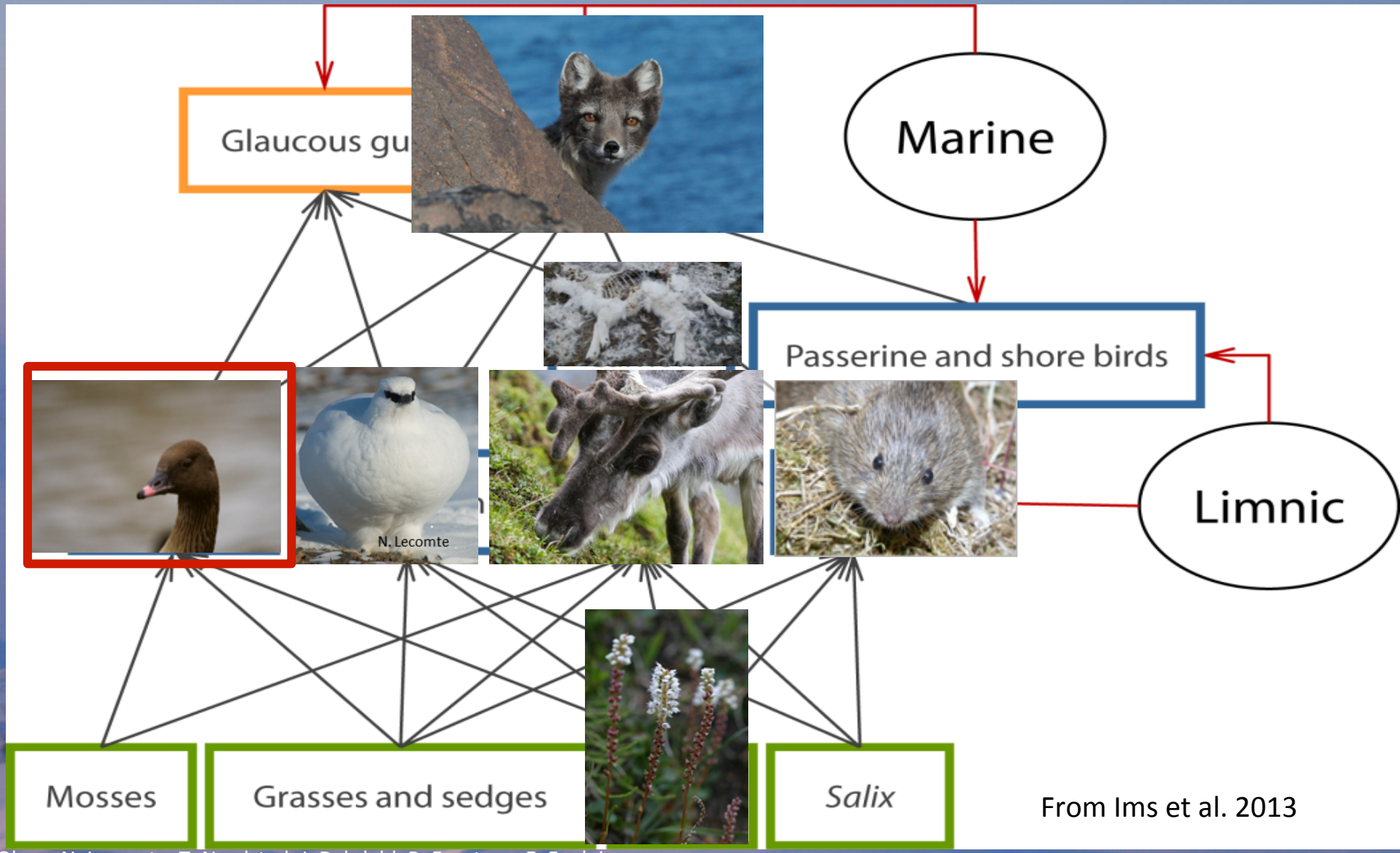
Climate influence the Svalbard rock ptarmigan by blocking the vegetation after rain-on-snow events. Icy winters generate population crashes.

Hansen et al. 2013



Hansen et al. 2013; Photo: R. Aanes, N. Lecomte

The tundra ecosystem in Svalbard



From Ims et al. 2013

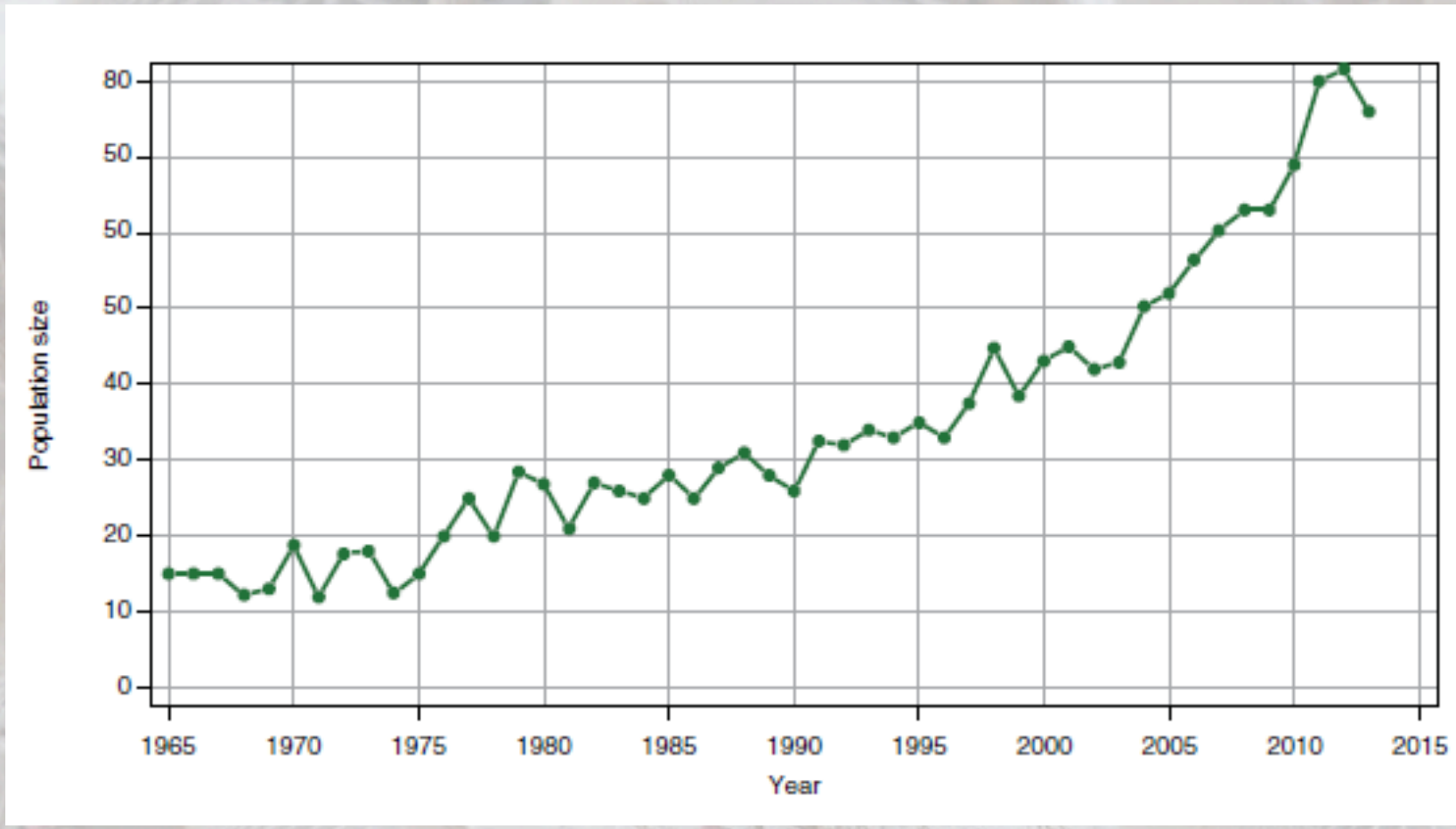
Photo: T. Olsen, N. Lecomte, T. Nordstad, J. Dybdahl, B. Frantzen, E. Fuglei

3 migratory goose species breed in Svalbard

- Pink-footed goose (ca. 76 000)
- Barnacle goose (ca. 35 000)
- Light-bellied brent goose (6-9000)

Ims et al. 2014; http://goosemap.nina.no/
Photo: NPI

Dramatic increase in pink-footed goose population



From 15 000 (1965) to 81 500 (2013)

Madsen and Williams 2012; Ims et al. 2013; Johnson et al. 2014; Photo: J. Madsen

Increased «Grubbing activity»

- Geese pull out moss and food plants, with the roots
- Creates holes or craters
- Degradation of the habitat (Speed et al. 2010)

Photo: C. Hübner

Photo: C. Hübner

«wholes and crates» - Erosion

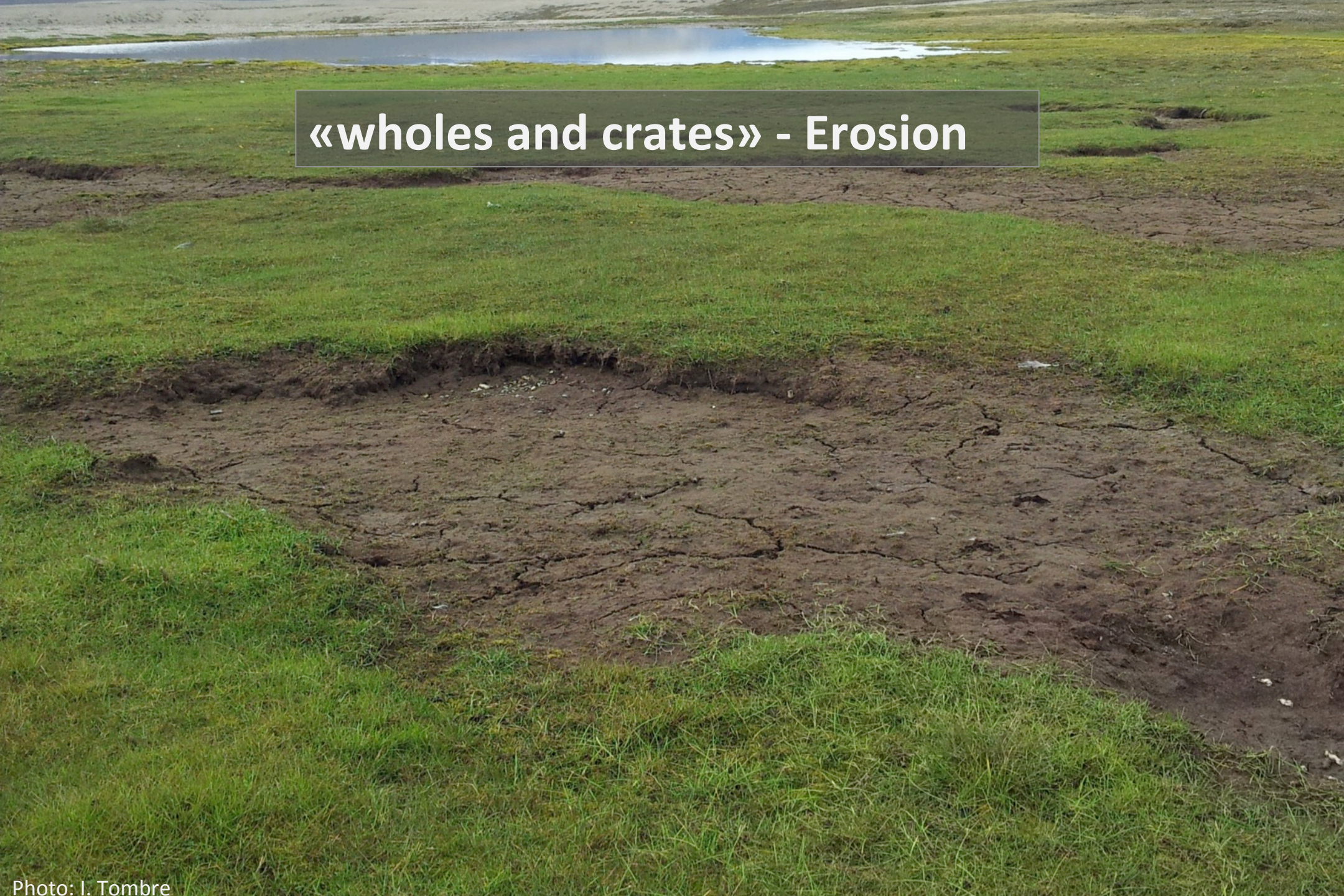
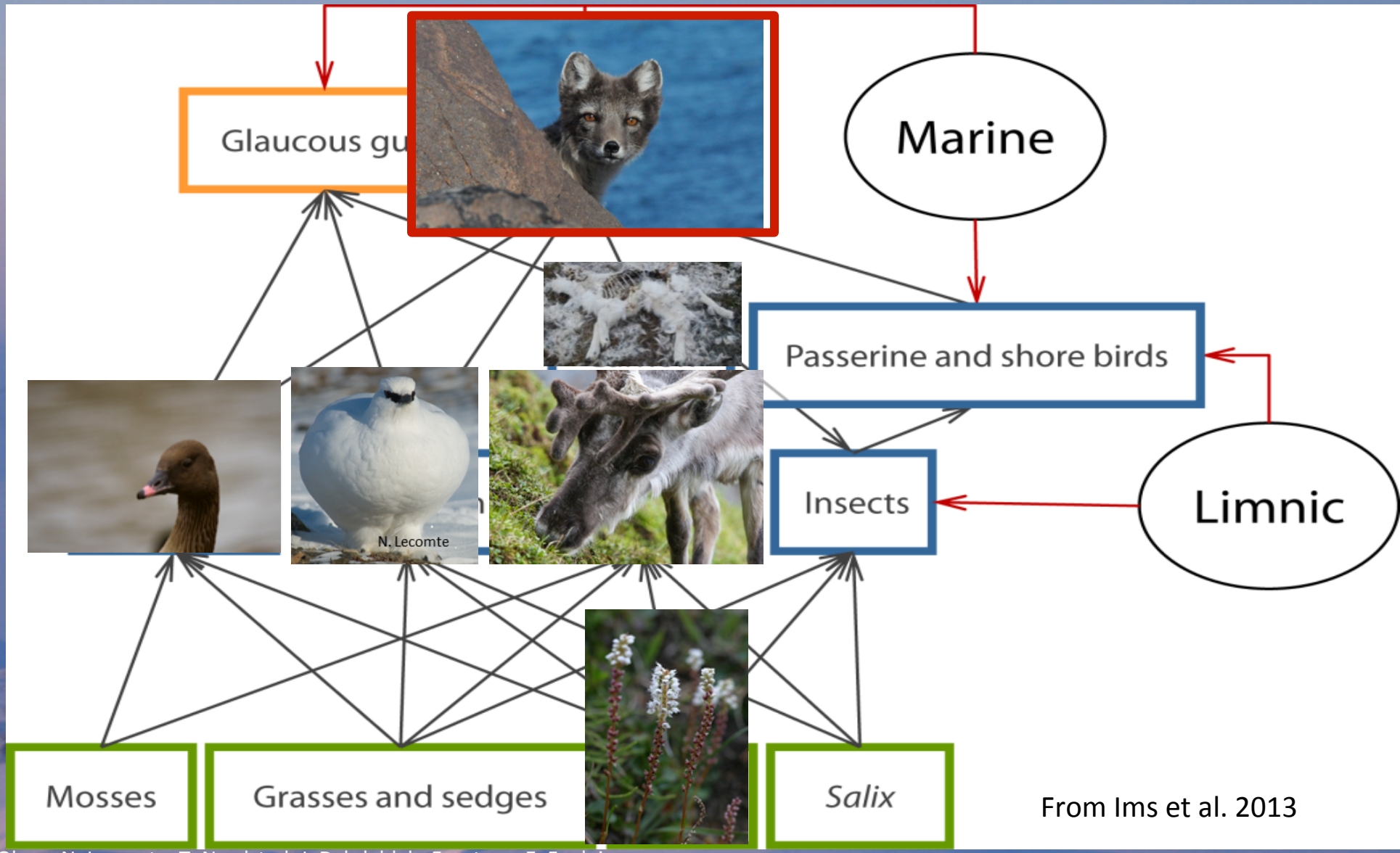


Photo: I. Tombre

The tundra ecosystem in Svalbard



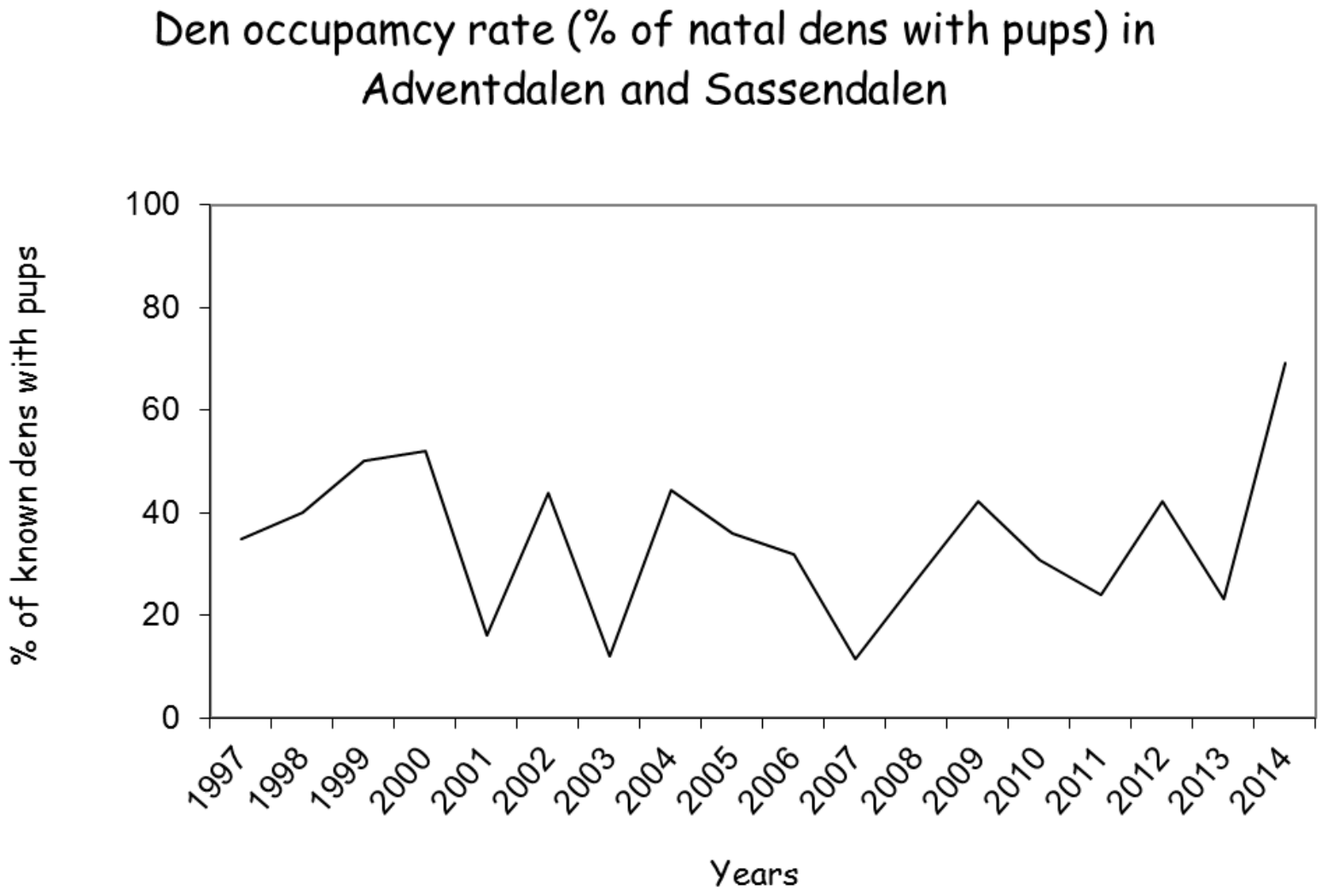
From Ims et al. 2013

Photo: T. Olsen, N. Lecomte, T. Nordstad, J. Dybdahl, b. Frantzen, E. Fuglei

Arctic fox

Photo: J. Doest

Significant year-to-year variation in population size in the monitoring areas, although without any obvious long-term trend.



Den occupancy – accounts for most of the variation in population dynamics of the arctic fox, which recent studies have shown to be mainly driven by availability of reindeer carrion and thus reindeer population

Journal of Animal Ecology

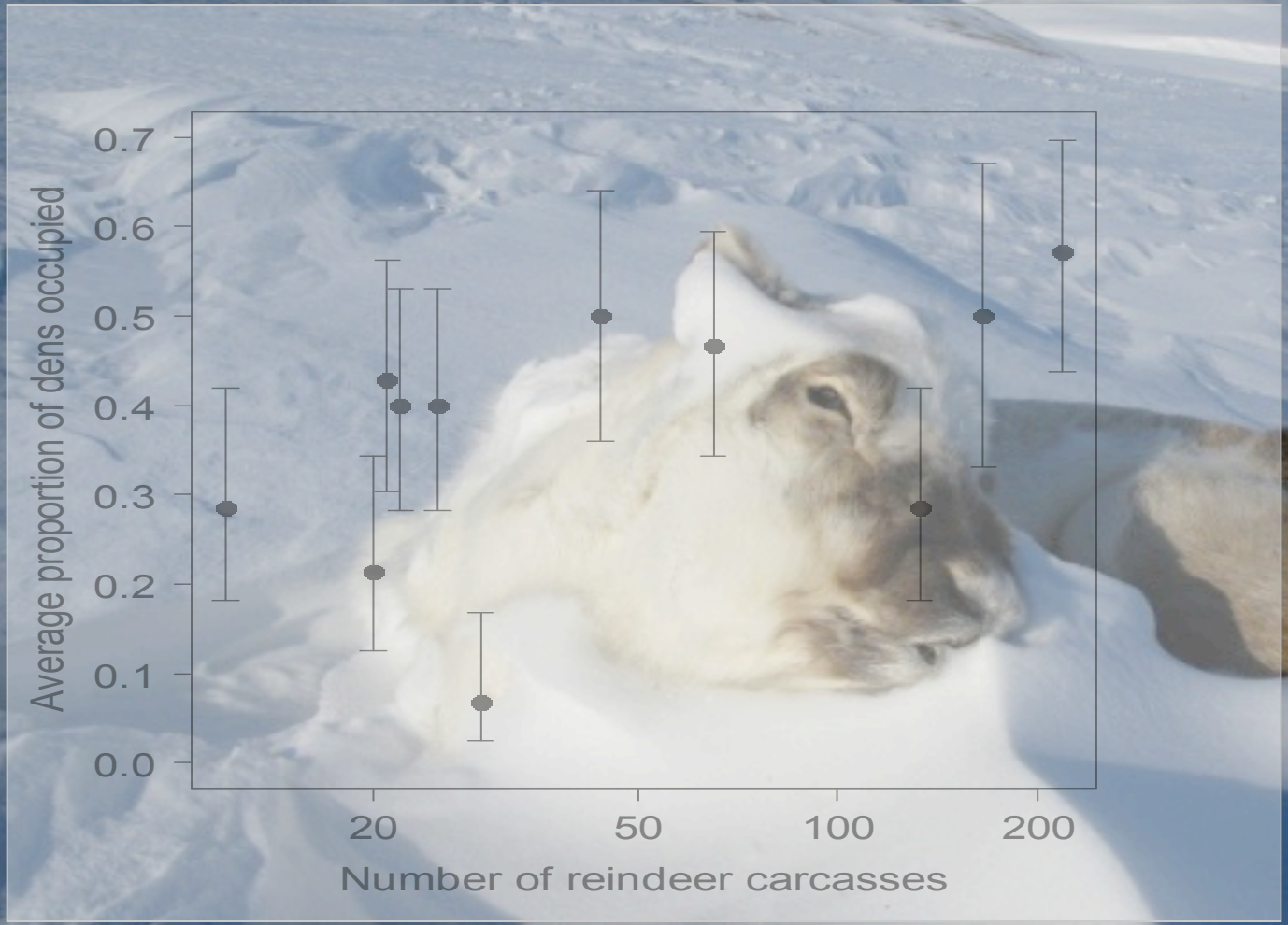
British Ecological Society

Journal of Animal Ecology 2012, **81**, 640–648 doi: 10.1111/j.1365-2656.2011.01936.x

Reproductive responses to spatial and temporal prey availability in a coastal Arctic fox population

Nina E. Eide[1,2*], Audun Stien[3], Pål Prestrud[2,4], Nigel G. Yoccoz[5] and Eva Fuglei[2]

Reindeer is important to arctic foxes in winter through production of carcasses at the time of onset of breeding for the foxes



Eide et al. 2012; Photo: E. Fuglei

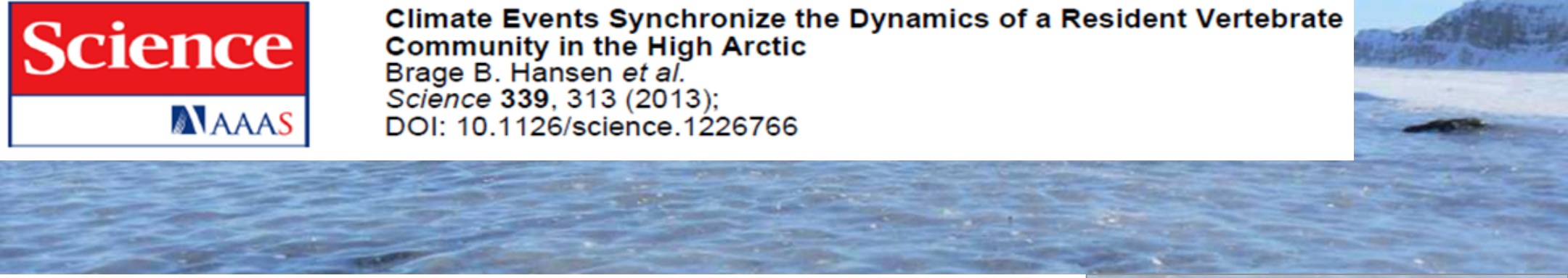

High reindeer carcass availability in one icy winter gives good reproduction for foxes the following summer.
Eide et al. 2012; Photo: J. Doest

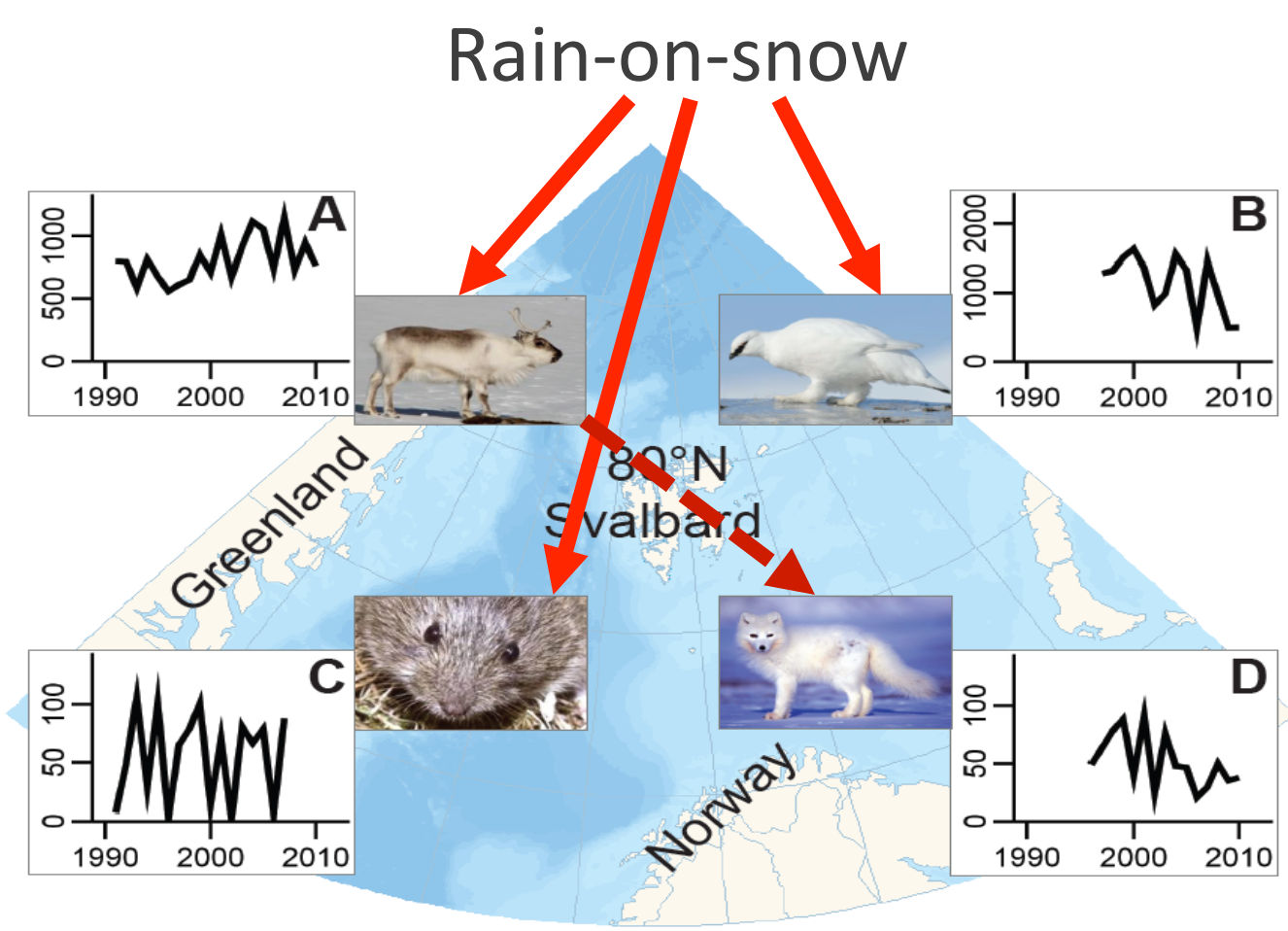
Science
AAAS

Climate Events Synchronize the Dynamics of a Resident Vertebrate Community in the High Arctic

Brage B. Hansen *et al.*

Science **339**, 313 (2013);
DOI: 10.1126/science.1226766





Indirect and bottom-up climate forcing

'Rain-on-snow' events synchronize the reduction in population growth for the resident herbivores, while the reduction in the growth rate of the arctic fox population was one year delayed.

Winners or losers?

The net effect of summer versus winter is not yet solved!

Climate impacts:

- We are only starting to see the beginning!

Model projections year 2100 for the arctic regions: +2-8°C

Projected vegetation growth season (Xu et al. 2013.):
Southern growth seasons to move > 20 latitudinal degrees north

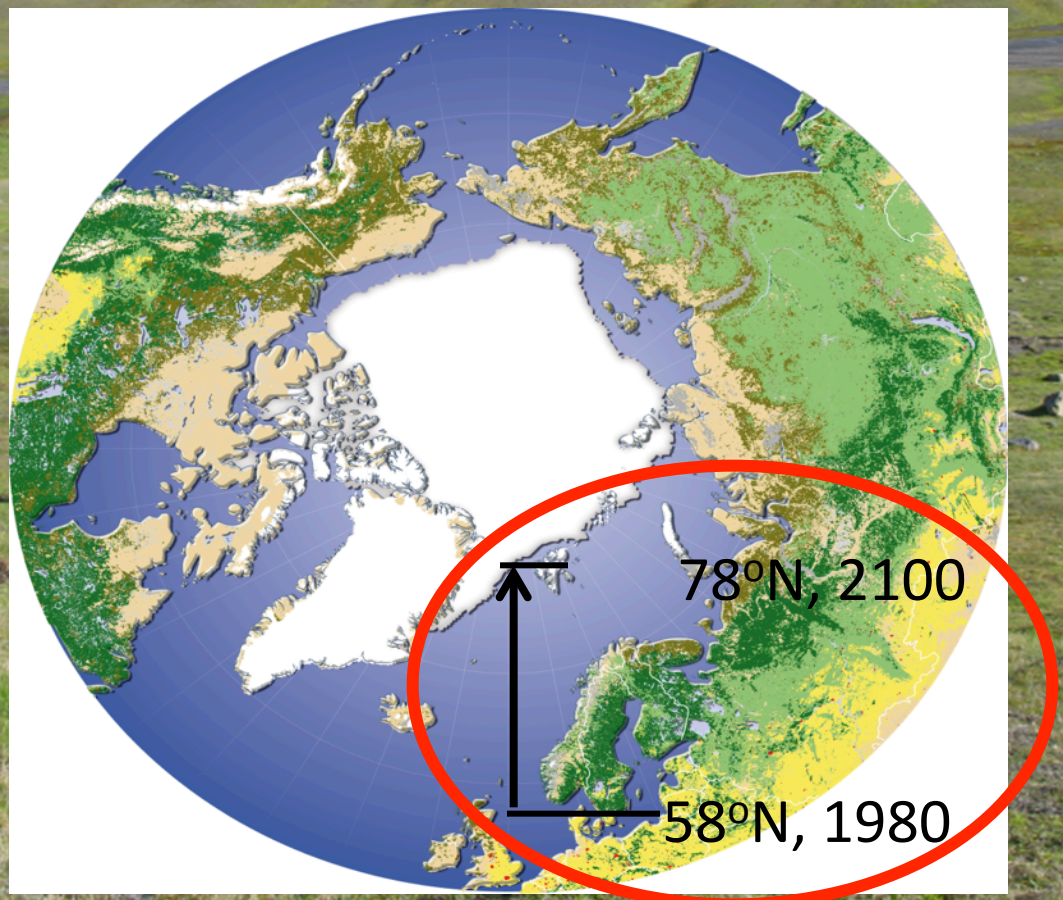


Photo: E. Fuglei

Huge challenges:

In face of the vast and fast changes

Science of arctic ecosystems and biodiversity - unable to predict the outcomes

- We are outside our “empirical range” – no historical analogues

- Ecological models : predictive ability for “equilibrium systems”
lack predictive “non-equilibrium systems”

Photo: E. Fuglei

Huge challenges:

In face of the vast and fast changes

Science of arctic ecosystems and biodiversity - unable to predict the outcomes

- "New and disturbed ecosystems" with unknown properties

- Climate change will come together with:
  - -New human infrastructure
  - -New & more industries in the Arctic
  - -Pollution

} **Cumulative impacts**: Notoriously difficult to predict!!!!

Photo: E. Fuglei

Science Plan for COAT:
Climate-Ecological Observatory
for Arctic Tundra

FRAM – High North Research Centre
for Climate and the Environment

Coordinated,
Circumpolar,
long term,
Ecosystem based
adaptive monitoring programs
to be able to document the changes
while the changes are going on

Thank you!!

Photo: N. Lecomte

Photo: N. Lecomte