The ecology of natural and livestock grazing at high latitudes - similarities and differences

Grazing in a Changing Nordic Region,

Reykjavík 12 – 15 September 2016

Ingibjörg Svala Jónsdóttir

University Centre in Svalbard and University of Iceland

Questions addressed

- ✓ Are there any basic differences between the ecology of wild and livestock grazing?
- ✓ Is there a difference in ecosystem resilience to high grazing pressure
  - ✓ along latitudes, i.e. from the sub-Arctic to the high Arctic?
  - ✓ between island and mainland ecosystems?
- ✓ [Impacts of climate warming – modulated by grazing]

Ecosystem resilience - ER

Definition:

The capacity of a system to absorb disturbance without shifting to an alternative state and loosing function and services. Encompasses resistance and recovery

e.g. *Holling1973, Carpender et al. 2001*

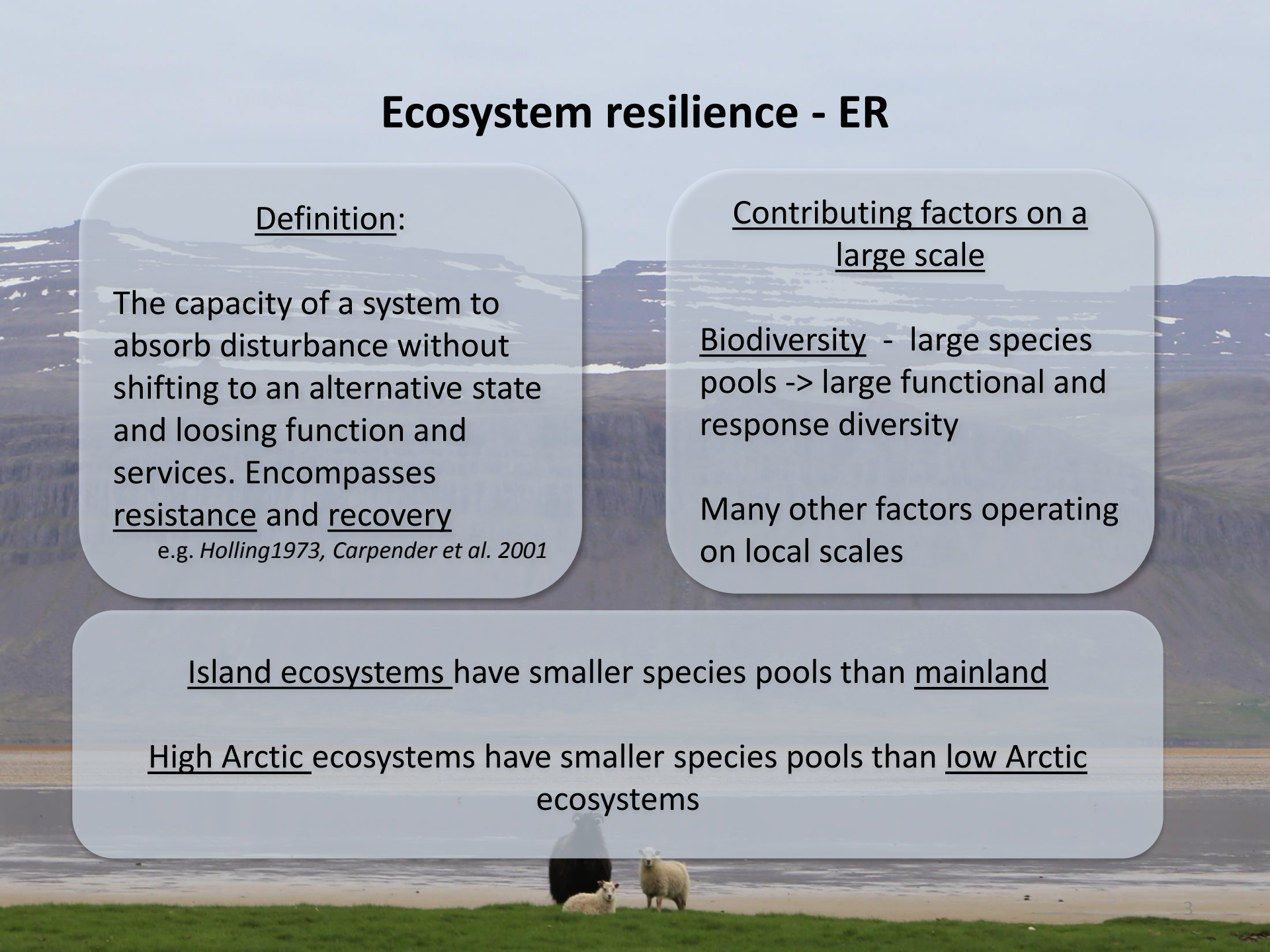
Contributing factors on a large scale

Biodiversity - large species pools -> large functional and response diversity

Many other factors operating on local scales

Island ecosystems have smaller species pools than mainland

High Arctic ecosystems have smaller species pools than low Arctic ecosystems



The role of large vertebrate herbivores in terrestrial ecosystems

- ✓ Structuring the vegetation through selective grazing and trampling
- ✓ Consumption of large quantities of primary production
- ✓ Increased rate of nutrient turnover
- ✓ Increased rate of decomposition
- ✓ Increased primary productivity – at intermediate grazing
- ✓ Reduced carbon stocks in plant biomass and soils

- May drive the vegetation into alternative stable vegetation states
- Depending on the grazing intensity and local conditions the states may differ in terms of vegetation structure and plant species diversity
  - Frequently grass / graminoid dominated vegetation

The Serengeti

- ✓ Tropical savanna
- ✓ High diversity of both migratory and resident grazers

The Arctic tundra

- ✓ **Highly seasonal – 8-10 months of winter**
- ✓ **Few species of vertebrate herbivores, often at high densities**

Photo: Christiane Hübner

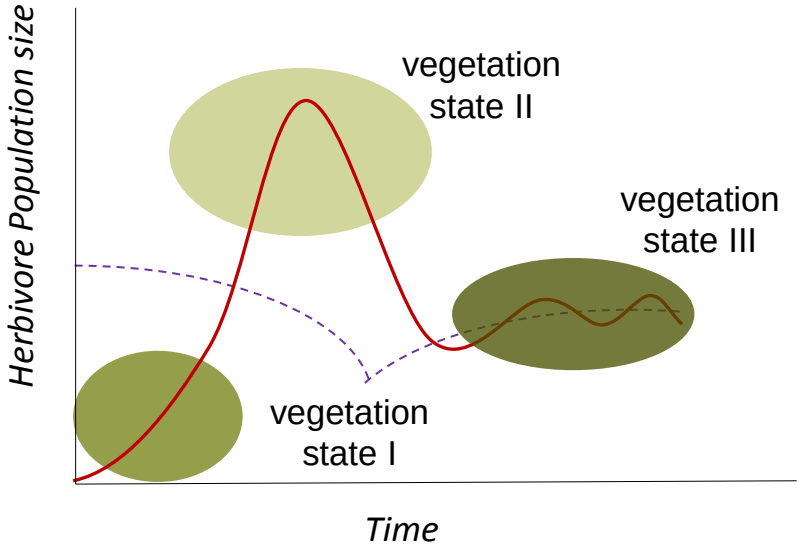
Regulation and limitation of wild herbivore populations

- Regulating factors – density dependent and act on mortality and or birth rate.
  - Food availability, competition, predation and disease are examples of potential regulating factors.

- Limiting factors – determines the average density at population equilibrium such as
  - Primary productivity of the area
  - Food availability at sever seasons (winter) in seasonal environments

Vegetation state shifts in response to grazing

Populations regulated and limited by natural factors



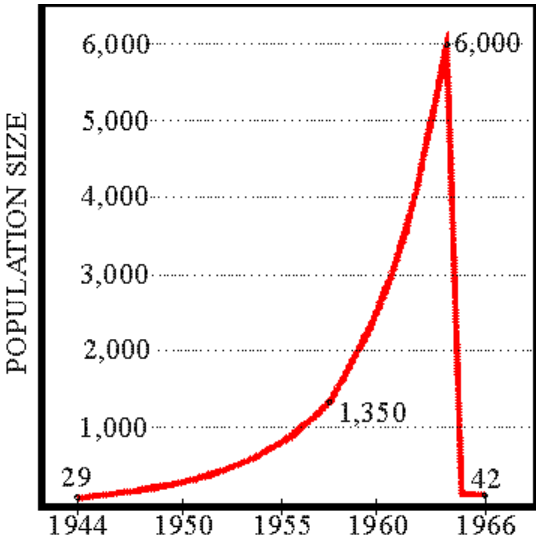
If the population crashes the **vegetation** either stays in state II or reverses to state I.
Alternatively the population reaches a new equilibrium and the vegetation shifts to state III

---

carrying capacity for wild herbivores is dynamic. Vegetation state II allows for a lower carrying capacity, but when the herbivore population crashes, it increases again

population's **carrying capacity** = the size at which a population can no longer grow due to lack of supporting resources.

What happens when large (wild) grazers are introduced to (island) tundra ecosystems?



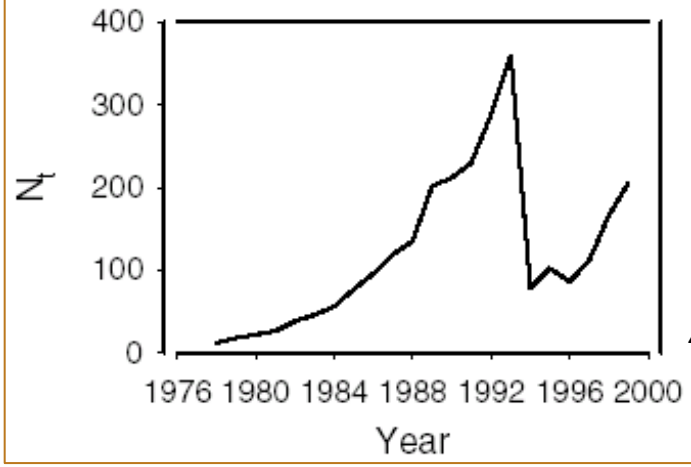
St. Matthew Island, Bering Sea

29 reindeer introduced 1944.

Lichens and mosses declined, graminoids increased

Klein 1968, 1987

Slow transition to original state after the reindeer population collapsed



Brøggerhalvøya, Svalbard

12 reindeer Introduced in 1978.

Aanes et al. 2000

All macro-lichen disappeared in the following years, the vegetation shifted towards moss tundra

Tundra vegetation state shifts from lichen dominated tundra to moss dominated and eventually to grass dominated tundra in response to increasing reindeer grazing pressure

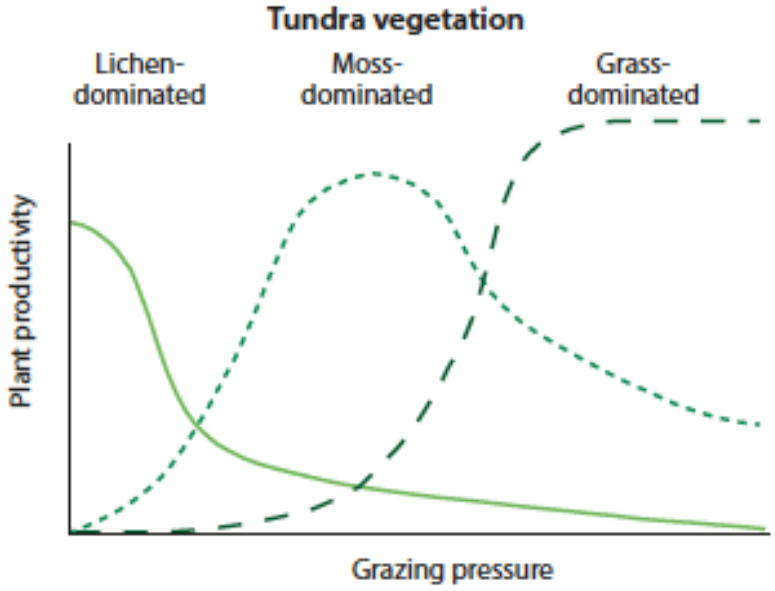
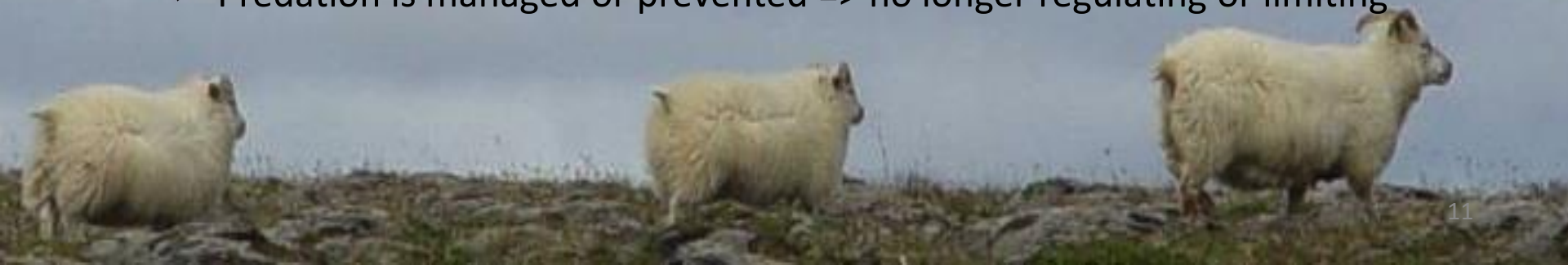


Figure 12.7. Predicted transitions between tundra vegetation states with increased grazing impact (from van der Wal 2006).

Does the role of livestock grazers differ from wild grazers in tundra ecosystems?

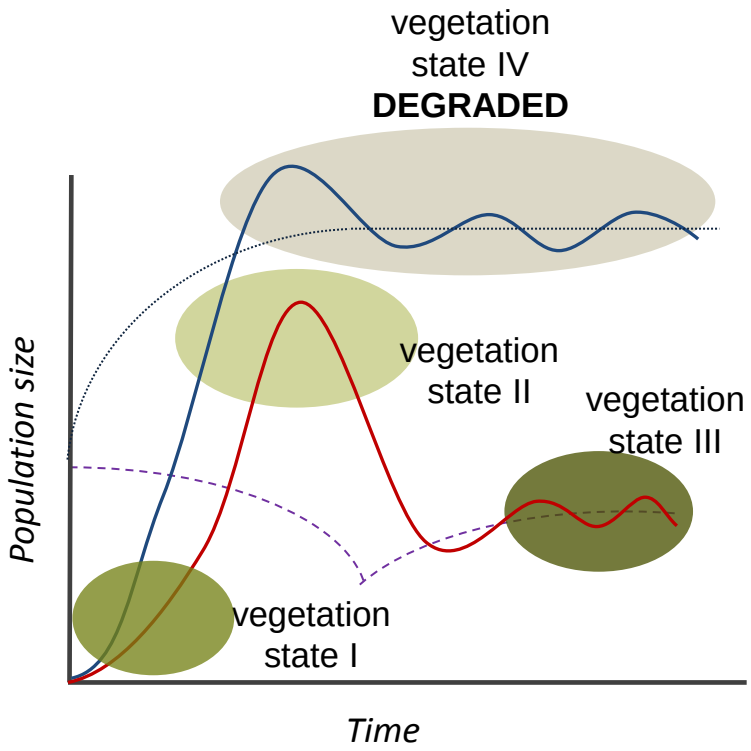
- ✓ Nutrients bound in animal bodies are constantly removed out of the ecosystem through harvesting
  - ✓ If the rate of replenishment is slower than the rate of input through weathering, aeolian deposition and biological fixation (nitrogen) the totoal nutrient pool will gradually decline

- ✓ Population regulation and limitation is decoupled from natural factors by humans
  - ✓ Forage supplements in winter => Productivity of the area is no longer limiting – **subsidised grazes**
  - ✓ Disease are treated => no longer regulating or limiting
  - ✓ Predation is managed or prevented => no longer regulating or limiting



What happens when livestock is introduced?

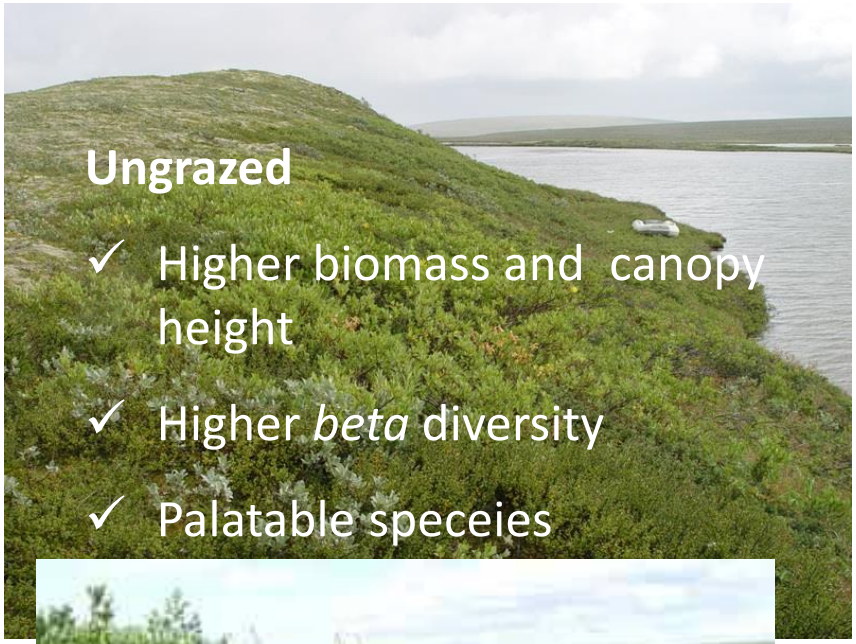
Population regulation is <u>decoupled</u> from natural factors by human -> subsidised grazers

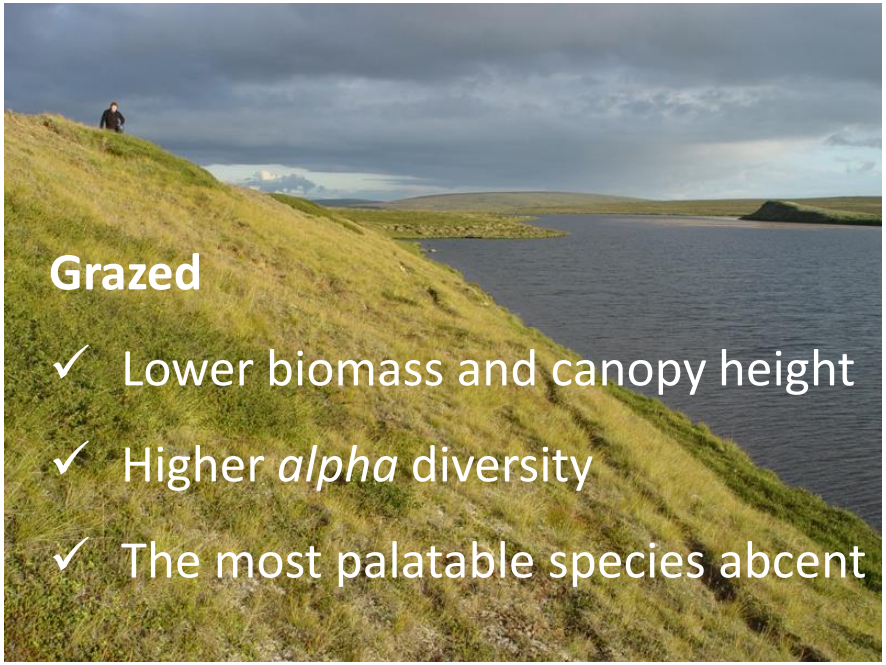


Vegetation is pushed into a degraded state IV by high intensity of grazing due to decoupling of regulating and limiting factors

carrying capacity for livestock is initially the same as for wild populations, but then rapidly increases artificially because of human management (e.g. winter feeding)

Audkúluheidi – extensive grazing common in the Icelandic highlands, long grazing history

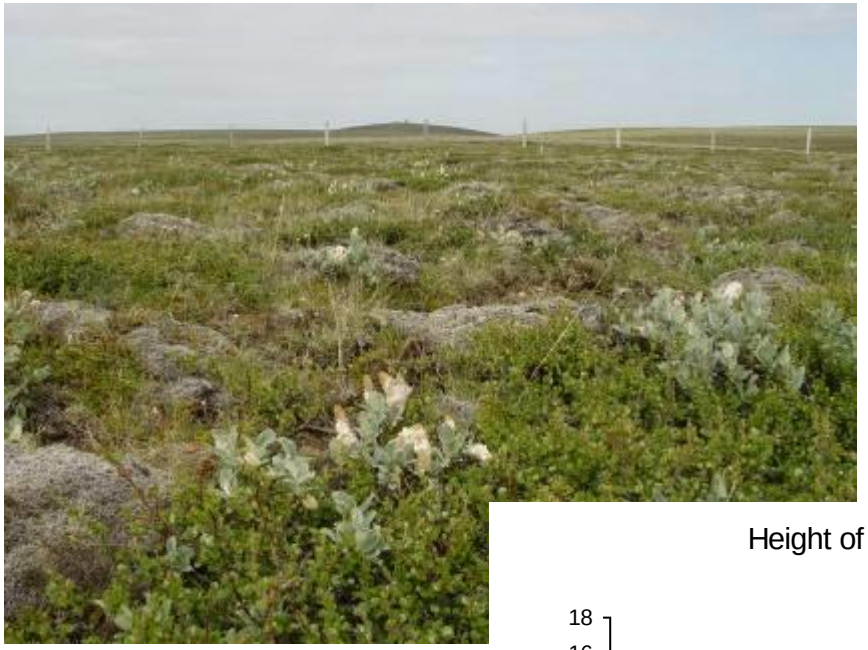




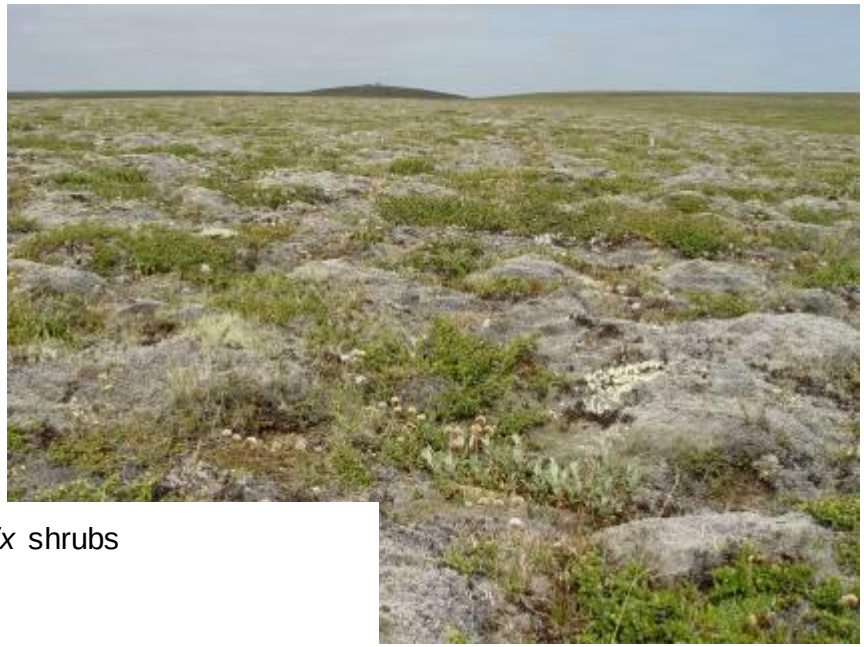
Jónsdóttir 1984

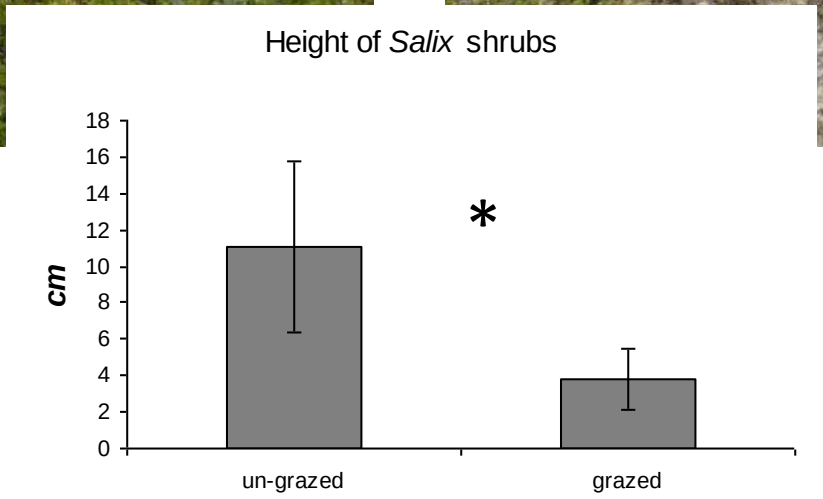
Audkúluheidi - *Betula nana* dwarf shrub heath

Exclosure – 20 years



Grazed





No exclosure effect plant community composition detected after the first 12 years

No difference in species composition

Arrested in a (degraded) stable state?

Jónsdóttir et al. 2005, Elmendorf et al. 2012

Effects of grazing cessation on plant diversity:

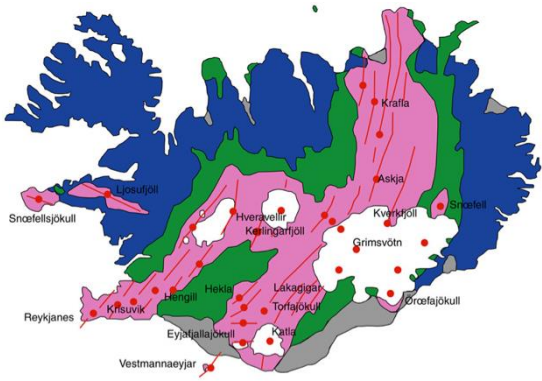
Comparison of grazed and ungrazed valleys in northern Iceland

- ✓ No effects of decades (up to 60 years) of grazing cessation on either *alpha* or *beta* diversity at any spatial scale!

- ✓ Persistence of historical grazing effects?
- ✓ Arrested in a degraded alternative state?

Mörsdorf et al. , in preparation.

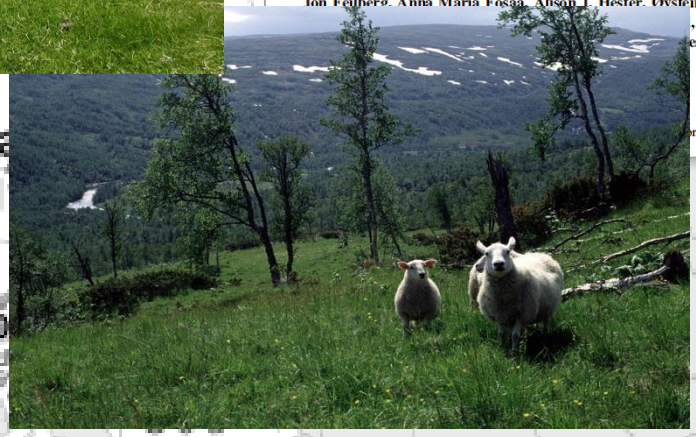
The most sever degradation and total ecosystem collapse found within the volcanic active zone of Iceland



Ecosystems less resilient to grazing due to

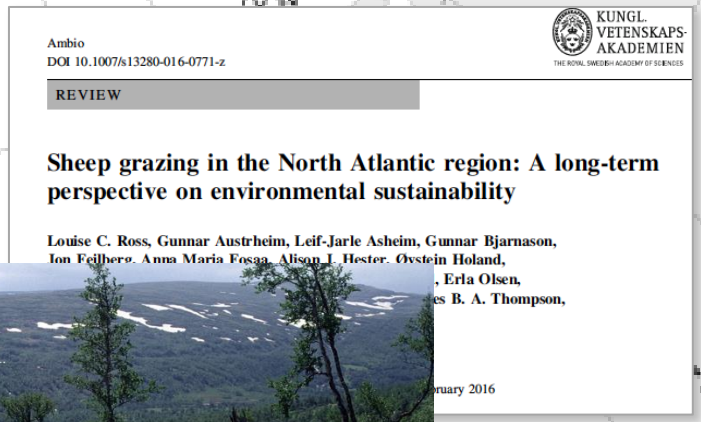
- ✓ Sensitive soils – susceptible to erosion
- ✓ Lower plant species diversity
- ✓ Recovery of eroded areas extremely slow

North-Atlantic ecosystems grazed by sheep – the island-mainland contrast



Recent review shows that overgrazing by sheep causes more extensive erosion (ecosystem degradation / collapse) on islands (Iceland, Faroe Islands) than mainland (Norway, Scotland)

Ross et al. 2016. Ambio



Ambio
DOI 10.1007/s13280-016-0771-z

KUNGL. VETENSKAPS-AKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

REVIEW

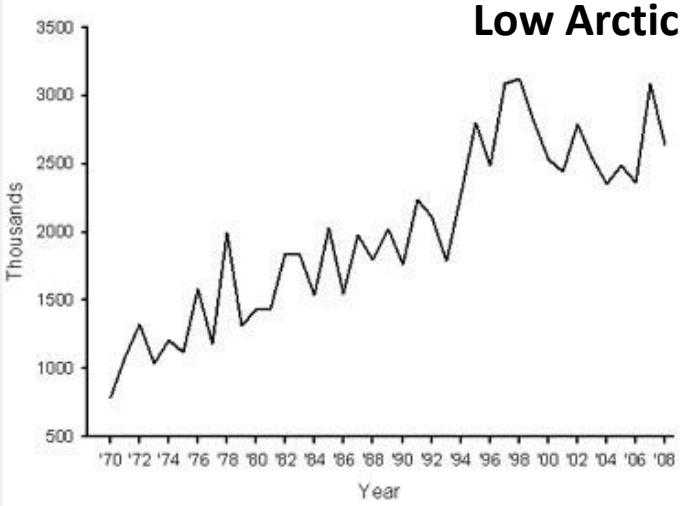
Sheep grazing in the North Atlantic region: A long-term perspective on environmental sustainability

Louise C. Ross, Gunnar Austrheim, Leif-Jarle Asheim, Gunnar Bjarnason, Jon Eeilberg, Anna Maria Fosaa, Alison J. Hester, Øystein Holand, , Erla Olsen, es B. A. Thompson,

ruary 2016

Are there any examples of ecosystem degradation/collapse caused by wild populations?

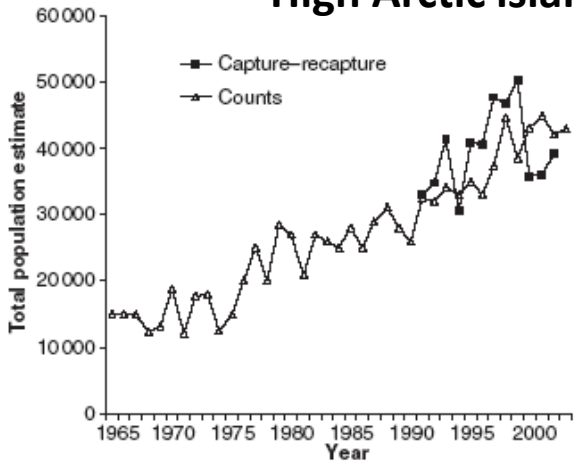
Low Arctic mainland Canada: salt marsh ecosystem collapse



Western Central Flyway and Midcontinent population light goose populations in the US and Canada 1970-2008

http://www.agjv.ca/

High Arctic island tundra, Svalbard: no ecosystem collapse evident - yet



Pink footed goose population breedng in Svalbard 1995-2005

Fox et al 2005

Spring foraging by Arctic breeding migratory geese

Grubbing hole – foraging *Bistorta* rhizomes

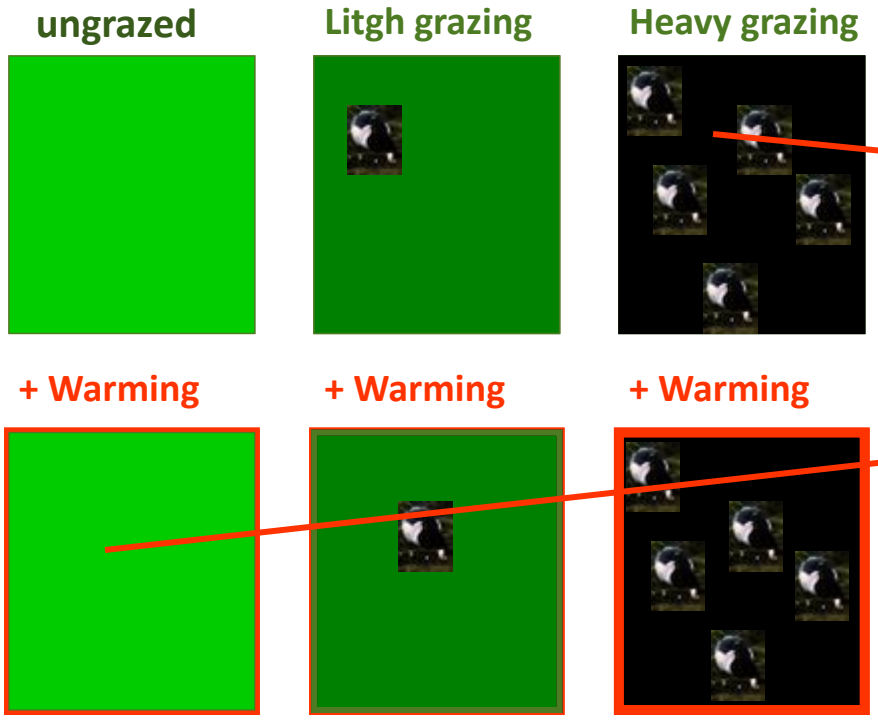
- Grubbing for belowground plant organs
- Moss disturbance

Foraging for grass and sedge rhizomes –

FRagility of **A**rctic **G**oose habitat: **I**mpacts of **L**and use, conservation and **E**levated temperatures

FRAGILE

Factorial experiment:
Grazing intensity x warming in wet and mesic tundra



Plant community responses to goose grazing and warming in high Arctic wet tundra.

Why this increase in Artic breeding goose populations?

- Change in conservation measures

- Increased food availability during winter due to land use change in the overwintering regions – pastures, crop fields

-> **subsidised grazers!**

Latitudinal contrast in ecosystem resilience?

- No livestock grazing in the high Arctic!

- A gradient of management intensity of vertebrate herbivores – from livestock to wild – trough:

✓ Hunting

✓ Various degrees of food subsidy :

Livestock winter feeding > domesticated reindeer > goose winter feeding on pastures > wild reindeer > ptarmigan?

Are there good answers to the questions addressed?

- ✓ Are there any basic differences between the ecology of wild and livestock grazing?
  - ➢ Subsidised grazers, decoupled from natural population regulation, demands strong human management
- ✓ Is there a difference in ecosystem resilience to high grazing pressure
- ✓ along latitudes, i.e. from the sub-Arctic to the high Arctic?
  - ➢ No clear evidence – more research needed
- ✓ between island and mainland ecosystems?
  - ➢ Some evidence – more research need

The geographic research framework

Svalbard, high Arctic islands

184 Vascular species

Iceland, low Arctic island

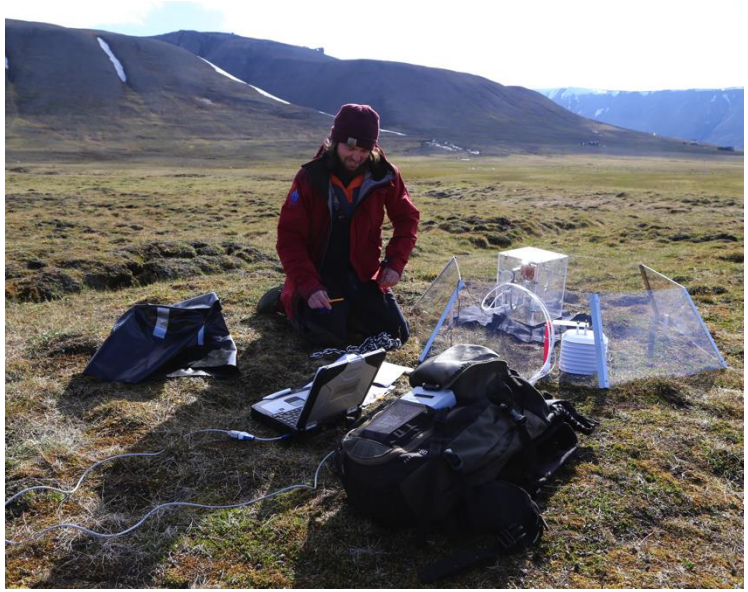
480 vascular plant species

Northern Norway, low Arctic mainland

2890 vascular plant species

Generally larger vascular plant species pool size in mainland Norway than at similar environmental conditions in Iceland. *Mörsdorf et al. unpublished*

Ecosystem resilience to grazing in a warming climate



- ✓ Long-term ITEX sites (warming-exclosures) in Svalbard and Iceland
- ✓ Goose grubbing and warming experiment in Svalbard - PhD project – Matteo Petit Bon

Herbivore diversity: herbivore-herbivore-plant interactions

- Addressed in Isabel Barrio's studies in Iceland
- The Herbivory Network –

  http://herbivory.biology.ualberta.ca/

Photo: Maite Gartzia

Thank you ….

Acknowledgement:

Past and present students and research collaborators