# Targeted Geoengineering: Conserving the Cryosphere

**Permafrost conservation through land-use modification - are potential solutions practicable and scalable?**

**John Moore**

Photo T. Kumpula

Mitigation
Adaptation
Solar Geoengineering

The 3 standard paradigms

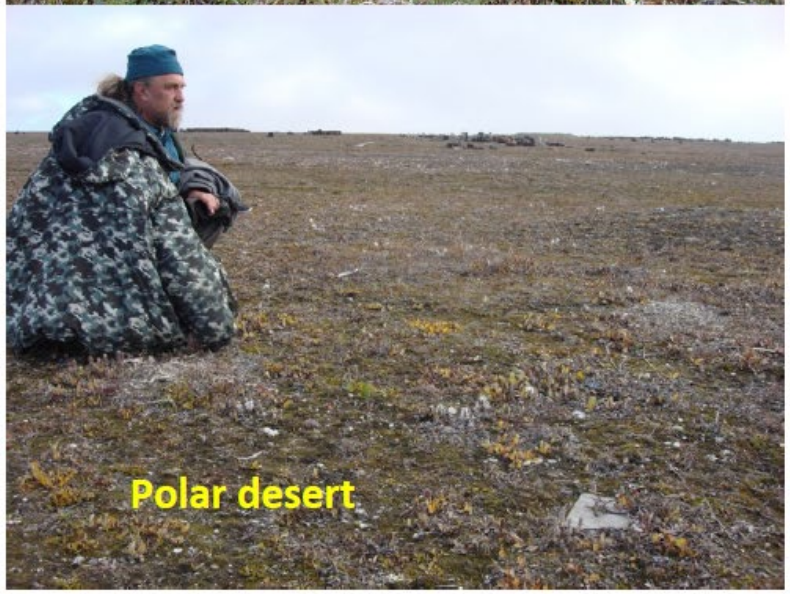
## Can anything else be done?

- In some cases **Targeted Geoengineering** might provide partial solutions
- Land surface albedo: Pleistocene Park in Siberia for permafrost
- Arctic ice management for sea ice
- Glacier geoengineering for sea level – by far the most realistic

# Pleistocene Park

megafaunamystery.blogspot.com/2011/12/pleistocene-park.html

## Most common modern northern ecosystems



Courtesy N. Zimov www. https://pleistocenepark.ru/

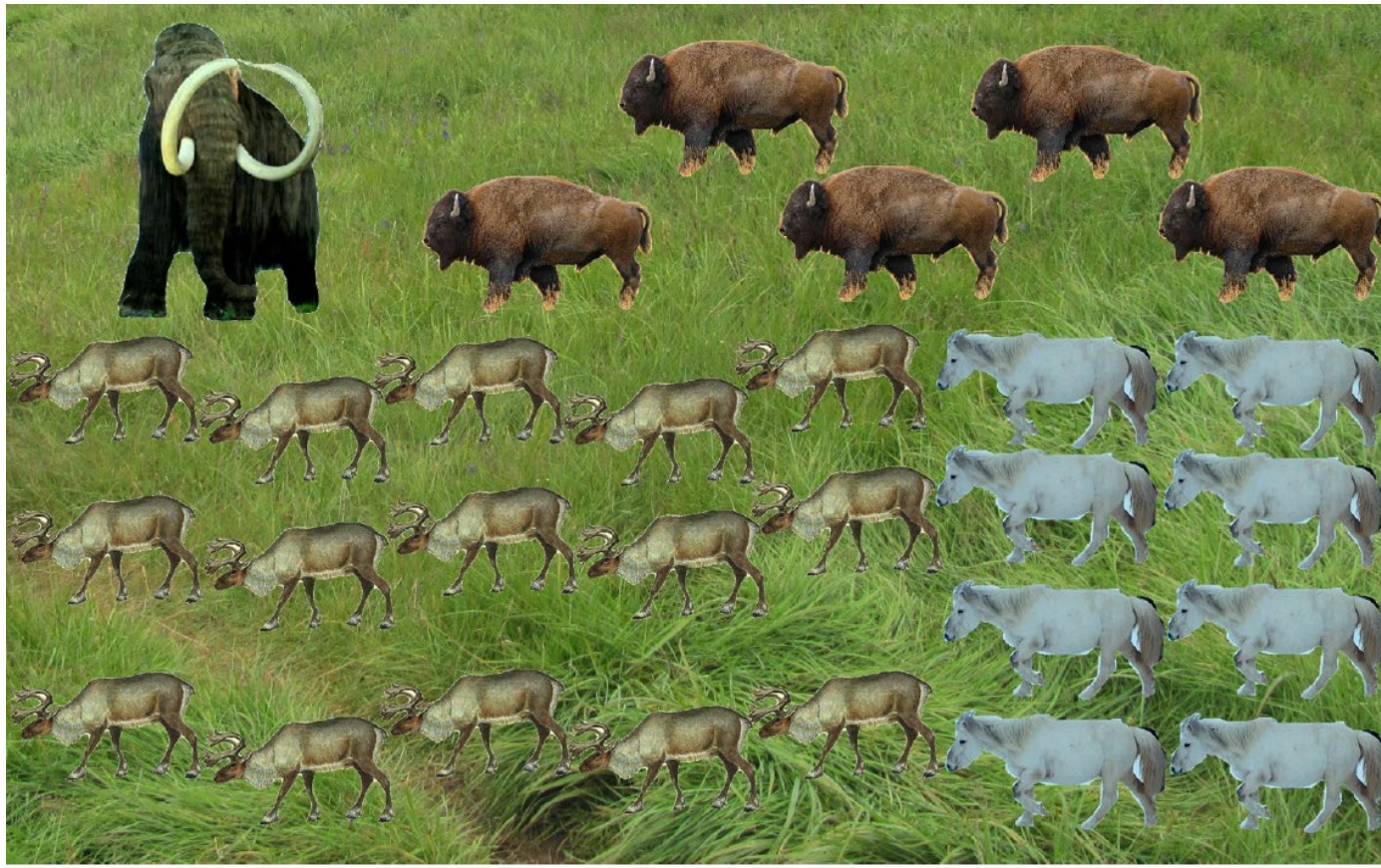
# Erosion, grazing, or nutrient introduction allow new highly productive ecosystems to appear

Courtesy N. Zimov www. https://pleistocenepark.ru/



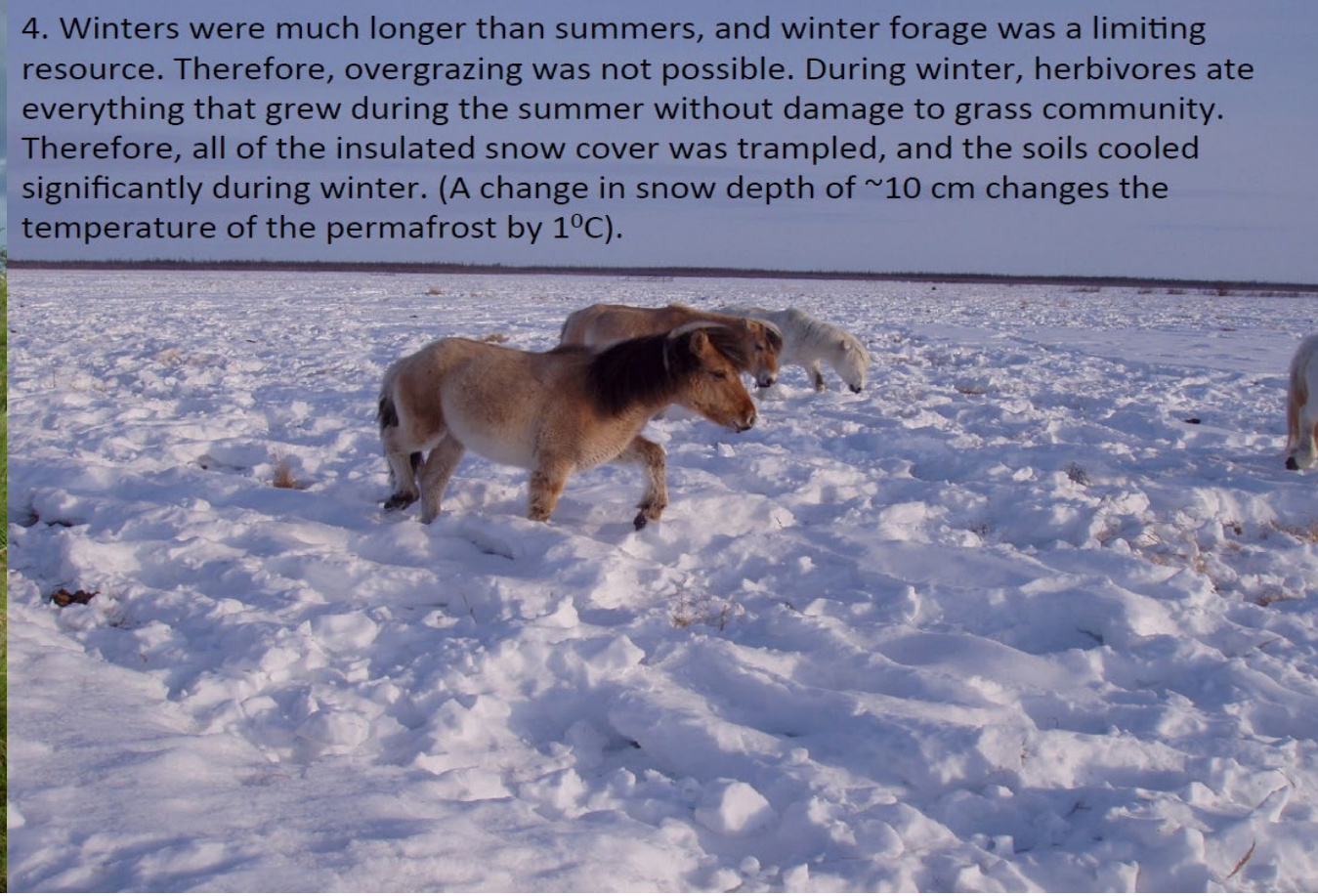


Typical number of bones stored on 1 hectare of Yedoma



Number of main herbivores on each square kilometer of North Siberian lowland pastures in late Pleistocene

Courtesy N. Zimov www. https://pleistocenepark.ru/


The albedo of the steppe grassland is much higher than the forest or shrub lands, especially in winter

# Hence the Permafrost is cooler

Courtesy N. Zimov www. https://pleistocenepark.ru/

# Pleistocene Park



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# Pleistocene Park

***Target MEG density***. Assuming that animal density in the mammoth steppe can be estimated from the number of bones found in the permafrost, an estimated average of 1 mammoth, 5 bison, 7.5 horses, 15 reindeer, 0.25 cave lions, and 1 wolf per 1km$^2$
1 MEG costs $383,000

***MEG growth rate***. 10% / yr

Assuming a constant animal introduction rate of 10 MEG/yr after 30 years, an area of 3100 km$^2$ would be converted to grassland.
0.03% of permafrost area
Conversion of 1 million km$^2$ of Arctic tundra (10% of the Arctic permafrost zone) in 30 years would require an introduction rate of 7,000 MEGs /yr which is unrealistic.

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Pleistocene Arctic megafaunal ecological engineering as a natural climate solution?

Marc Macias-Fauria[1], Paul Jepson[1,2], Nikita Zimov[3] and Yadvinder Malhi[1]

39° Silverdale, WA

Fri, Feb 14, 2020

Newsweek

U.S. | World | Business | Tech & Science | Culture | Newsgeek | Sports | Health | The Del

OPINION

# RESTORING THE ARCTIC LANDSCAPE TO A TIME WHEN MAMMOTHS ROAMED COULD PROTECT THAWING PERMAFROST | OPINION

MARC MACIAS-FAURIA

ON 1/28/20 AT 9:41 AM EST

Assuming that animal density
ope can be estimated
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of 1 mammoth, 5
reindeer, 0.25 cave lions, and 1

0

% / yr

animal introduction rate of 10
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# CHARTER – Drivers and Feedbacks of Changes in Arctic Terrestrial Biodiversity

**From the EC's first Cryosphere call (LC-CLA-07-2019), CHARTER addresses Sub-topic B (Changes in Arctic biodiversity)**

CHARTER

CHARTER intends to advance the adaptive capacity of Arctic communities to climatic and biodiversity changes through state-of-the-art synthesis via data collection, analysis and modeling of Arctic change with major socio-economic implications and feedbacks. The project has three central aims:

- Work with Arctic communities to co-develop strategies and policy pathways for livelihoods such as herding, hunting and fishing
- Simulate the effects of social-ecological changes for indigenous and local communities and traditional livelihoods
- Better understand responses of Arctic terrestrial social-ecological systems to changes in the cryosphere across decadal and centennial timescales

## Consortium

9 European countries

21 Research Institutions

## Coordinator

Arctic Centre

University of Lapland

Finland

## Duration

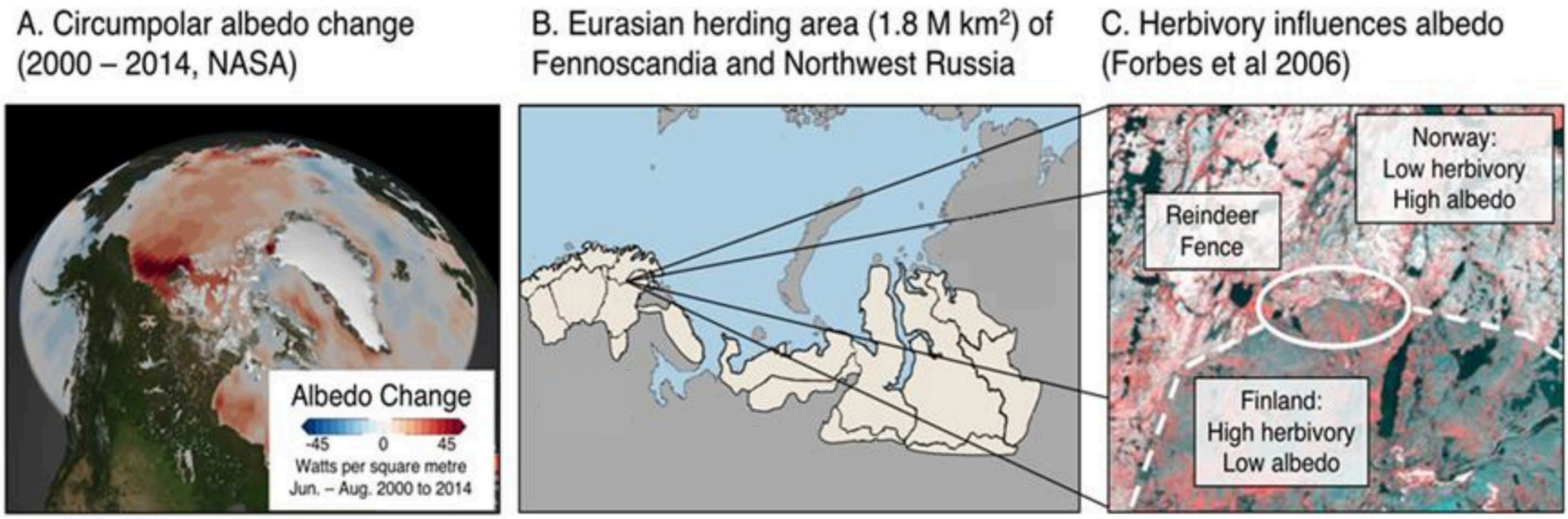
08.2020 – 07.2024

## Budget

5.9 M Euro

EU Polar Cluster

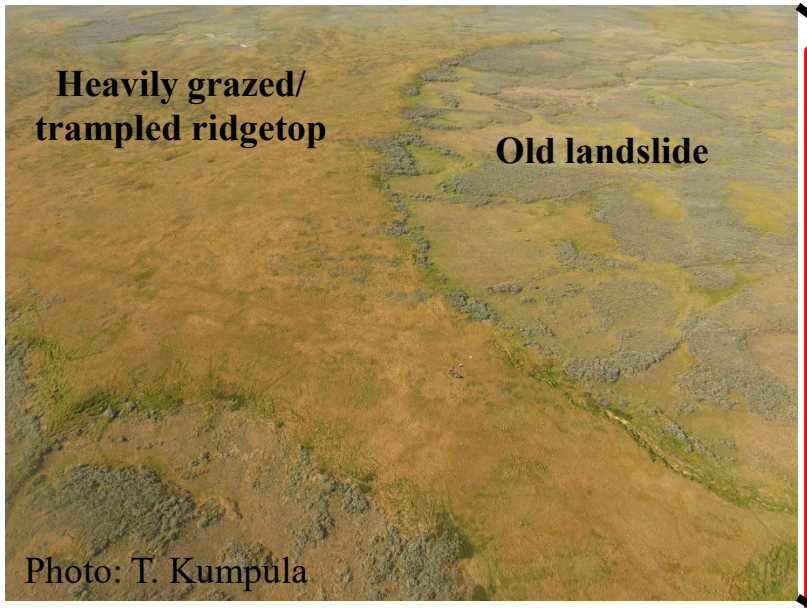
www.charter-arctic.org



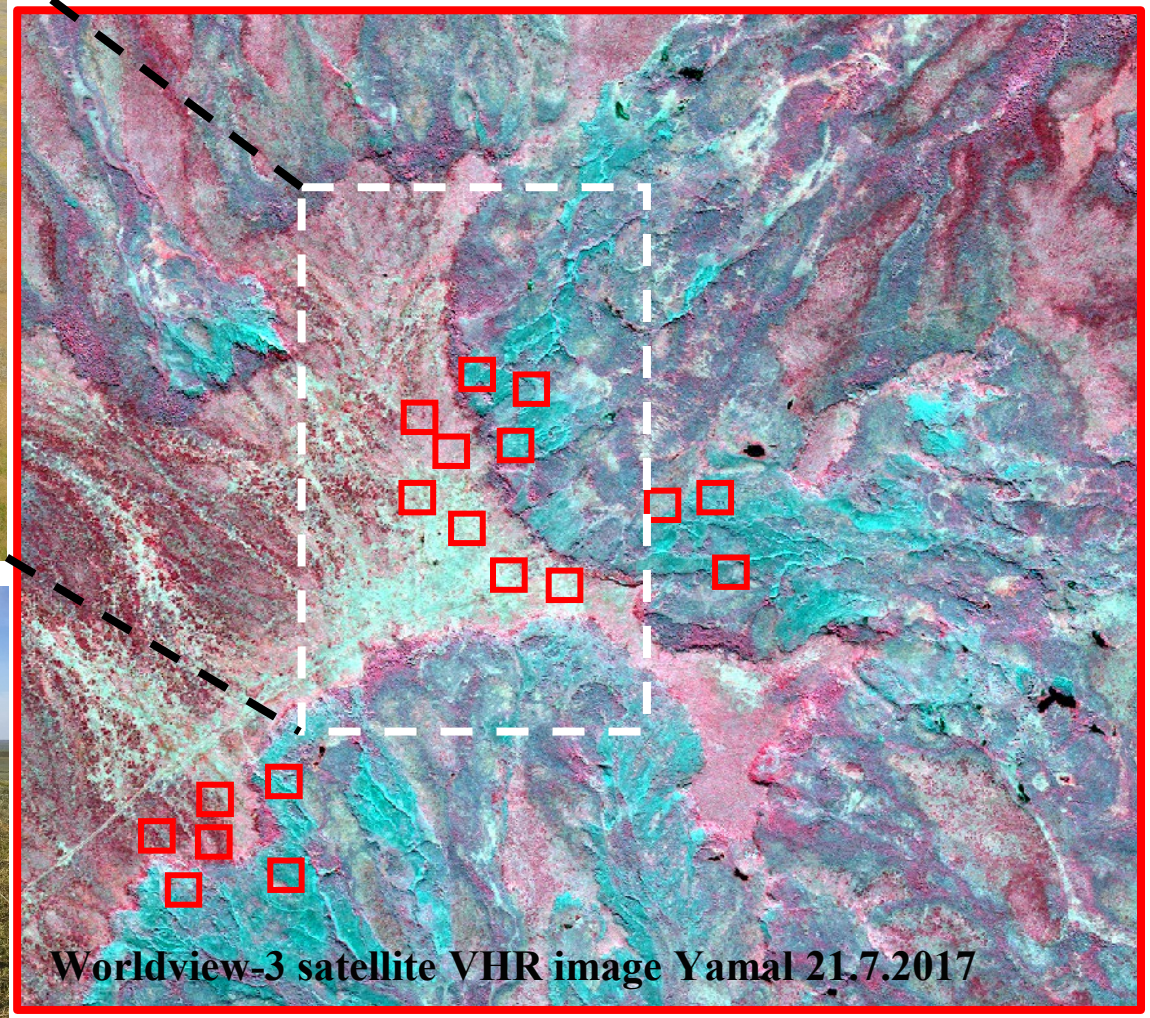

*A) Circumpolar albedo change (2000-2014, NASA) shows mainly sea ice decline;*
*B) Eurasian reindeer management area for 1.8M privately or collectively owned reindeer (1.8Mkm²) spread across Fennoscandia and Northwest Russia; and*
*C) Herbivory influences albedo*

# 3-level factorial exclosure experiment initiated July 2017

Aim is to partition role of climate vs. herbivory vs. topography on tundra productivity







# Participatory methods & co-production of knowledge

- Co-documentation of different ways of knowing (workshops, interviews…)
- Contributing to co-development of local planning & policies
- Indigenous scholars included within the consortium
- Co-development achieved during project planning
- Synthesize existing datasets alongside new fieldwork


Photo T. Kumpula


Photo B. Forbes


Photo B. Forbes

Global Policy (2020) doi: 10.1111/1758-5899.12867

Global Policy

# Targeted Geoengineering: Local Interventions with Global Implications

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Ilona Mettiäinen
*University of Lapland*
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*Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai)*
Rupert Gladstone,
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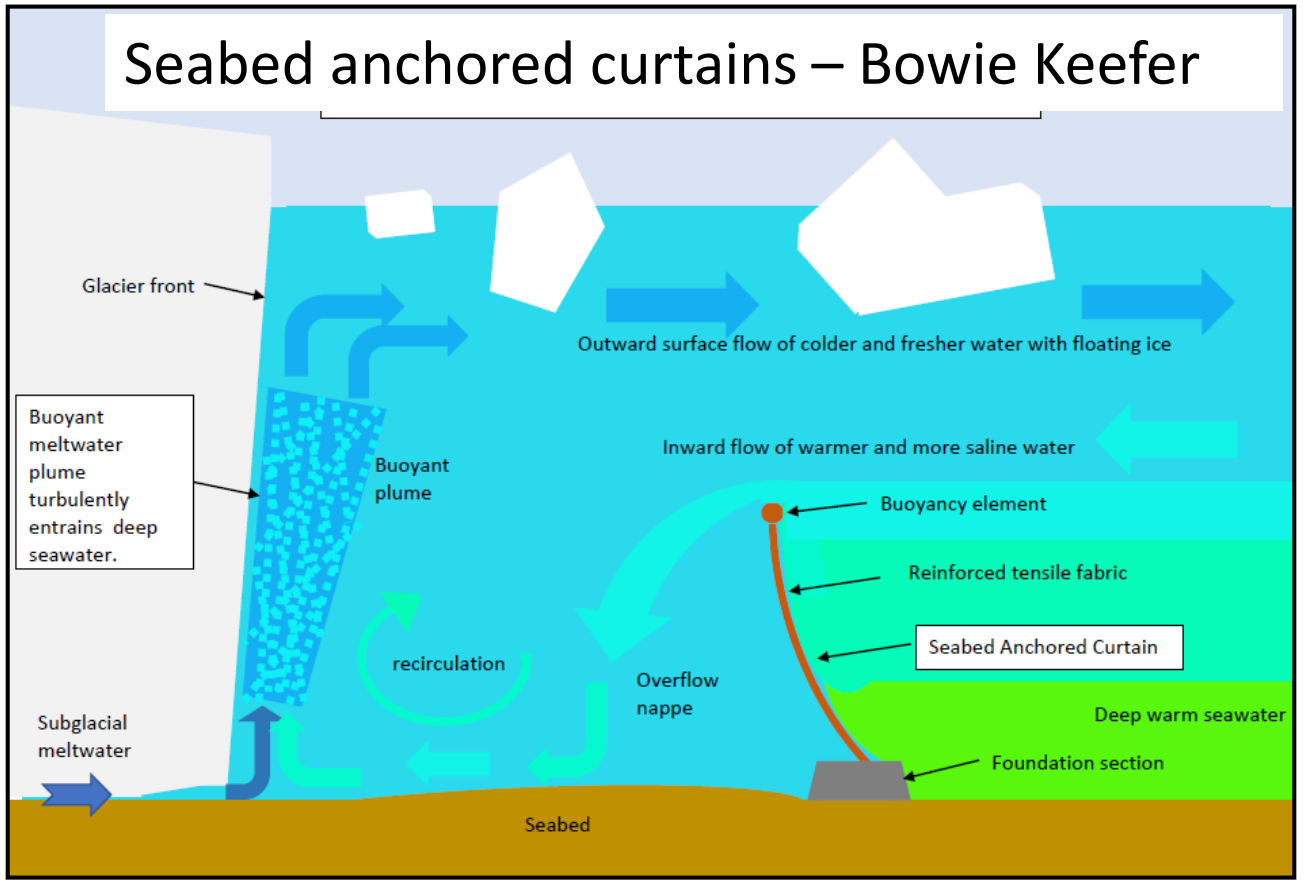


**About $1/year/person that would be flooded by the collapse of Thwaites Glacier and unstable West Antarctica**

**Coastal protection costs at 2100: $50 billion/yr**

c2g2.net/could-climate-interventions-slow-the-melting-of-the-cryosphere/

C2G

About Governance Issues

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2020 https://doi.org/10.1098/rstb.2019.0122
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COMMENT · 14 MARCH 2018 nature

# Geoengineer polar glaciers to slow sea-level rise

John C. Moore ✉, Rupert Gladstone, Thomas Zwinger & Michael Wolovick