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From Knowledge to Action

Dynamics of Circum-Arctic Tundra Plant Communities in Response to Climate Warming and Grazing Pressure

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OUTLINE OF TALK

Research background

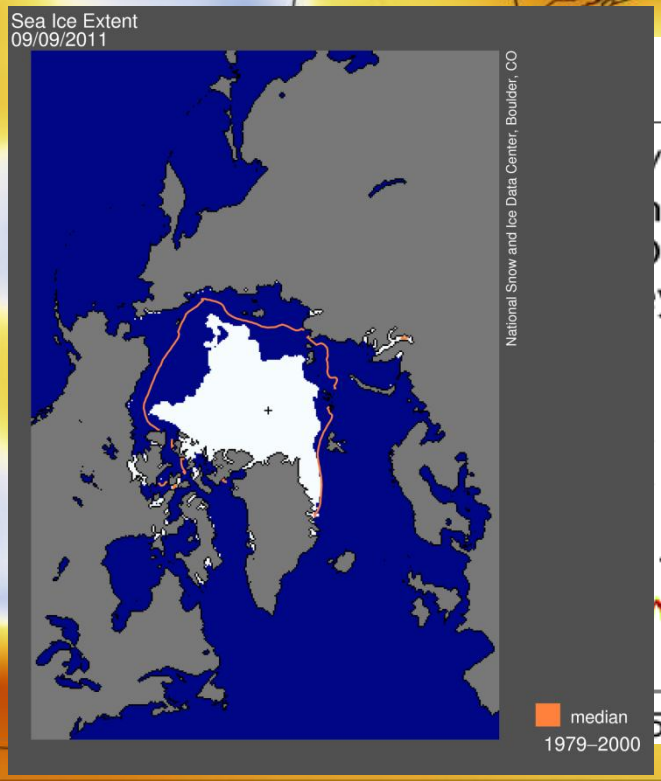
Data and methods

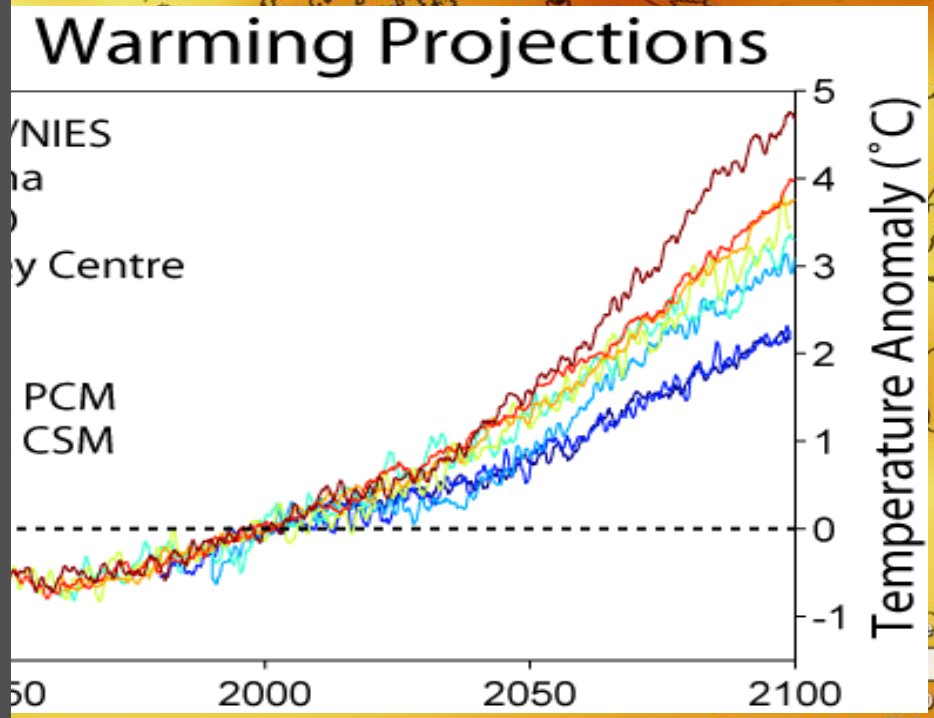
Results:

- Climate change effects vs. grazing effects
- difference between climate change and grazing
- comparison of simple difference and combined effects on tundra vegetation

Discussion

CURRENT AND FUTURE CLIMATE WARMING





IPCC 2007

(Hansen et al. Rev. Geophys. 2010)

GRAZING BY REINDEER AND CARIBOU (*RANGIFER TARANDUS*)

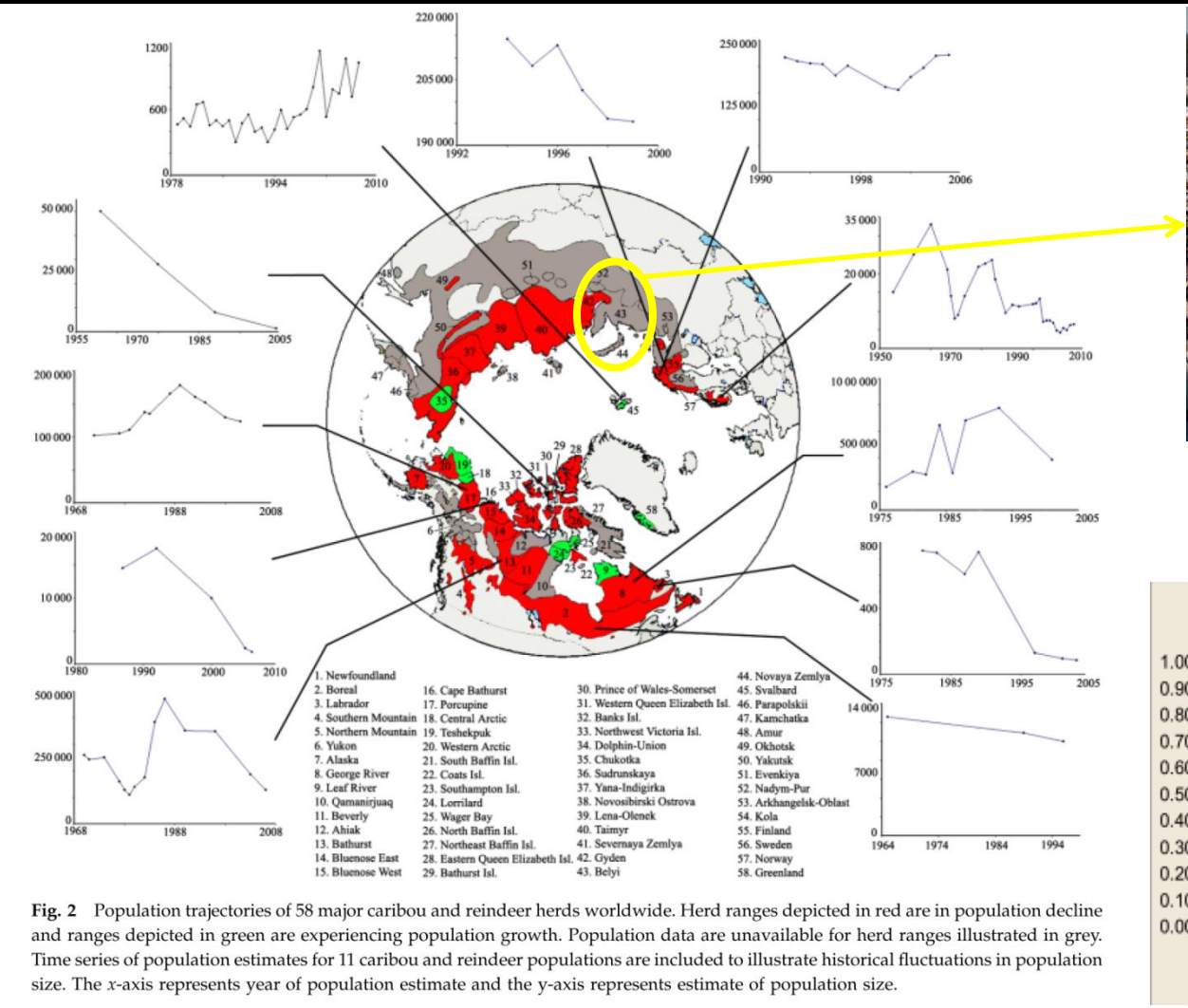
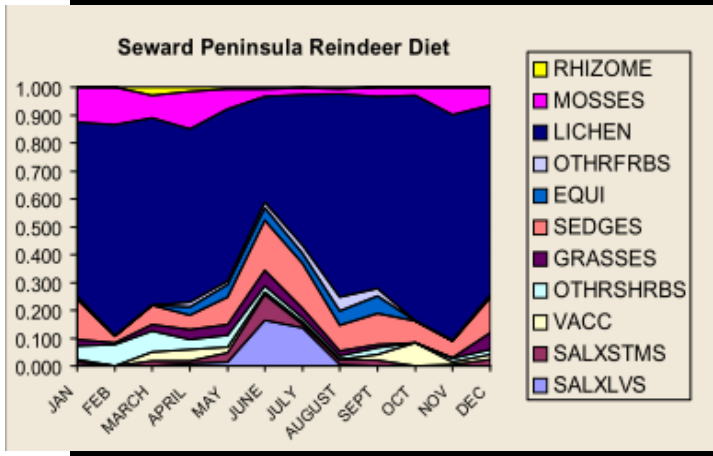


Fig. 2 Population trajectories of 58 major caribou and reindeer herds worldwide. Herd ranges depicted in red are in population decline and ranges depicted in green are experiencing population growth. Population data are unavailable for herd ranges illustrated in grey. Time series of population estimates for 11 caribou and reindeer populations are included to illustrate historical fluctuations in population size. The *x*-axis represents year of population estimate and the y-axis represents estimate of population size.

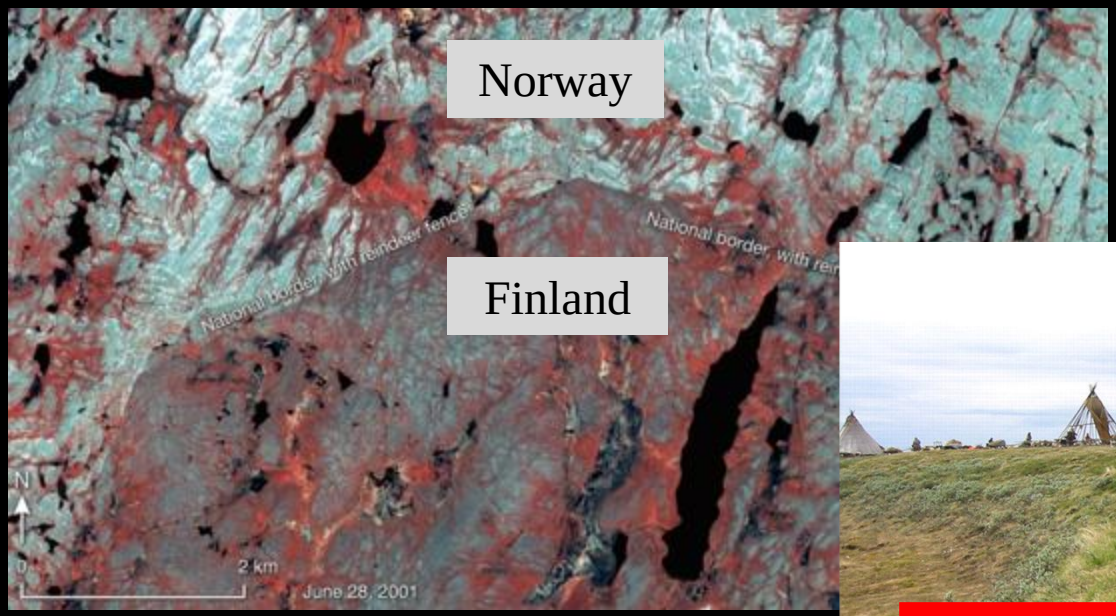
(Vors and Boyce, 2009 GCB)

Reindeer near camping ground



Reindeer diet (Flenniken, 2007)

GRAZING BY REINDEER AND CARIBOU (*RANGIFER TARANDUS*)

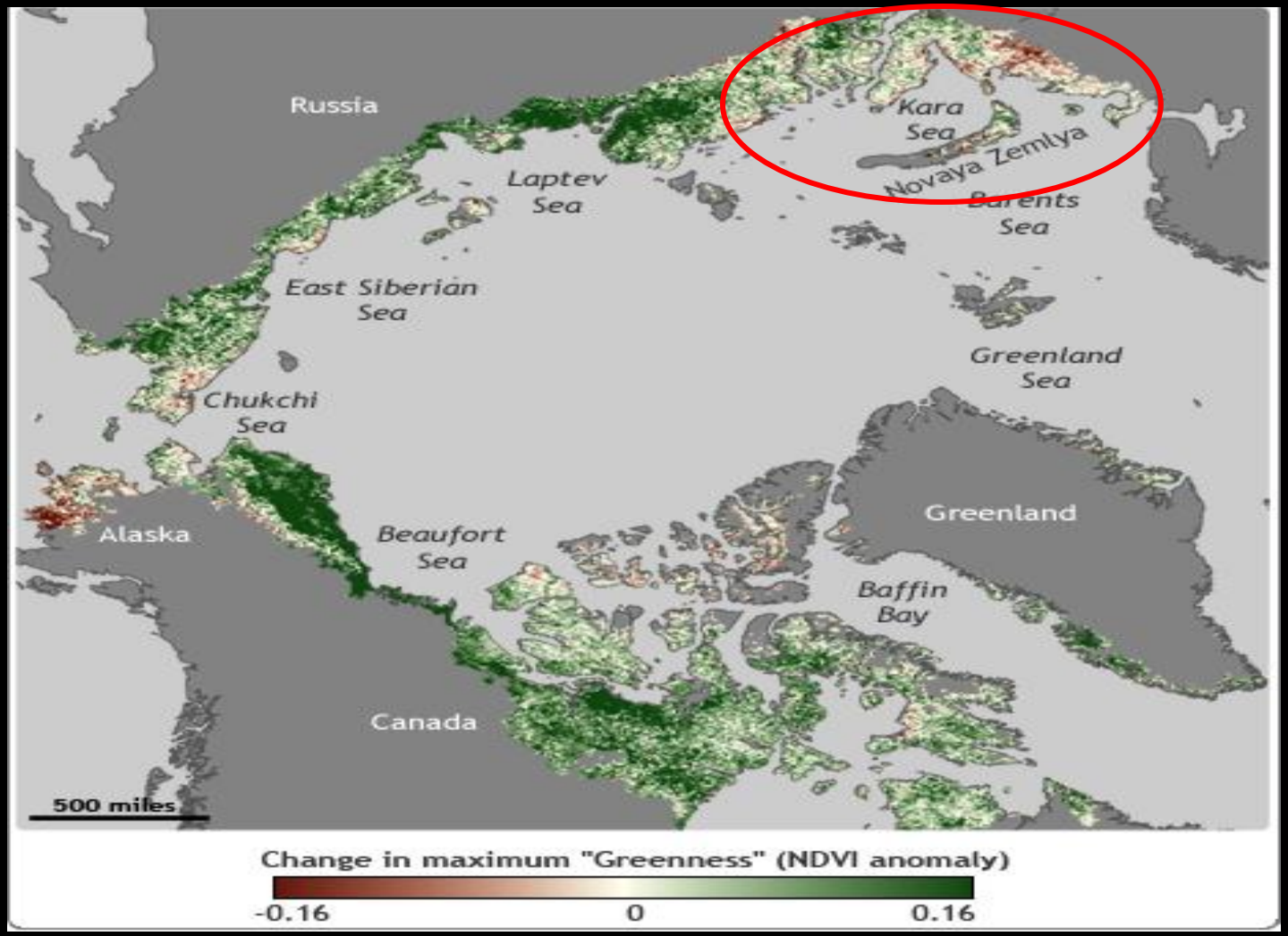


Forbes et al. 2009 PNAS

- Differences in herding practices can make big differences in tundra plant community composition

GREENING OF THE ARCTIC

Change in maximum "greenness"

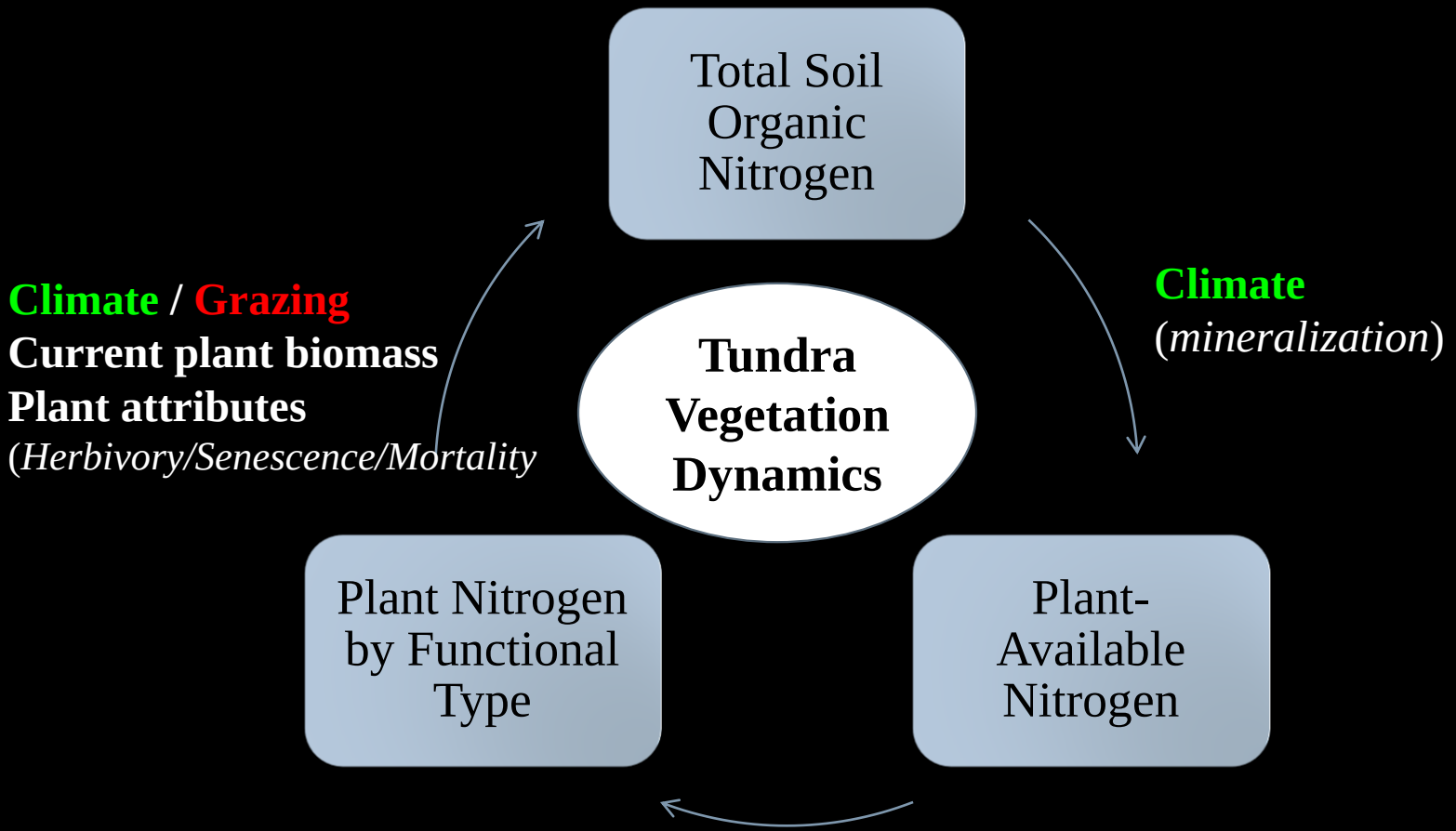


Data provided by Uma Bhatt. Maps by climate.gov team.

CIRCUMPOLAR SCALE EFFECTS OF WARMING AND GRAZING ON ARCTIC TUNDRA VEGETATION

- How does **projected climate warming** affect tundra plant community biomass and productivity?
- How do **reindeer and caribou grazing** across the Arctic affect tundra plant biomass and productivity?
- How do **grazing and warming interact** to affect tundra plant communities across the pan-Arctic?

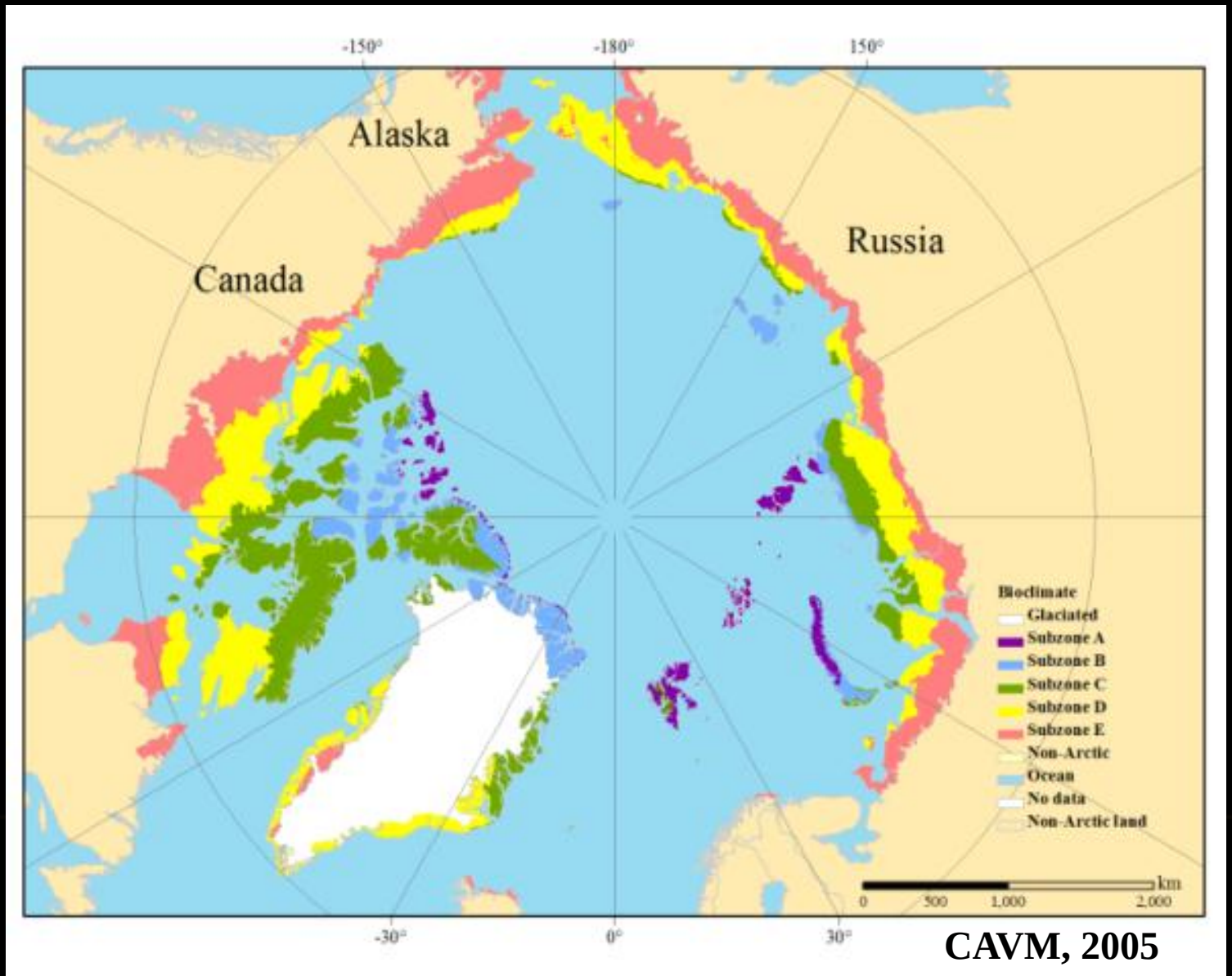
ARCVEG – ARCTIC TUNDRA VEGETATION DYNAMICS MODEL



Epstein et al. (2000, 2001, 2004, 2007)
Yu et al. (2009, 2011)

MODEL SETTING- PAN ARCTIC

- Bioclimate subzones

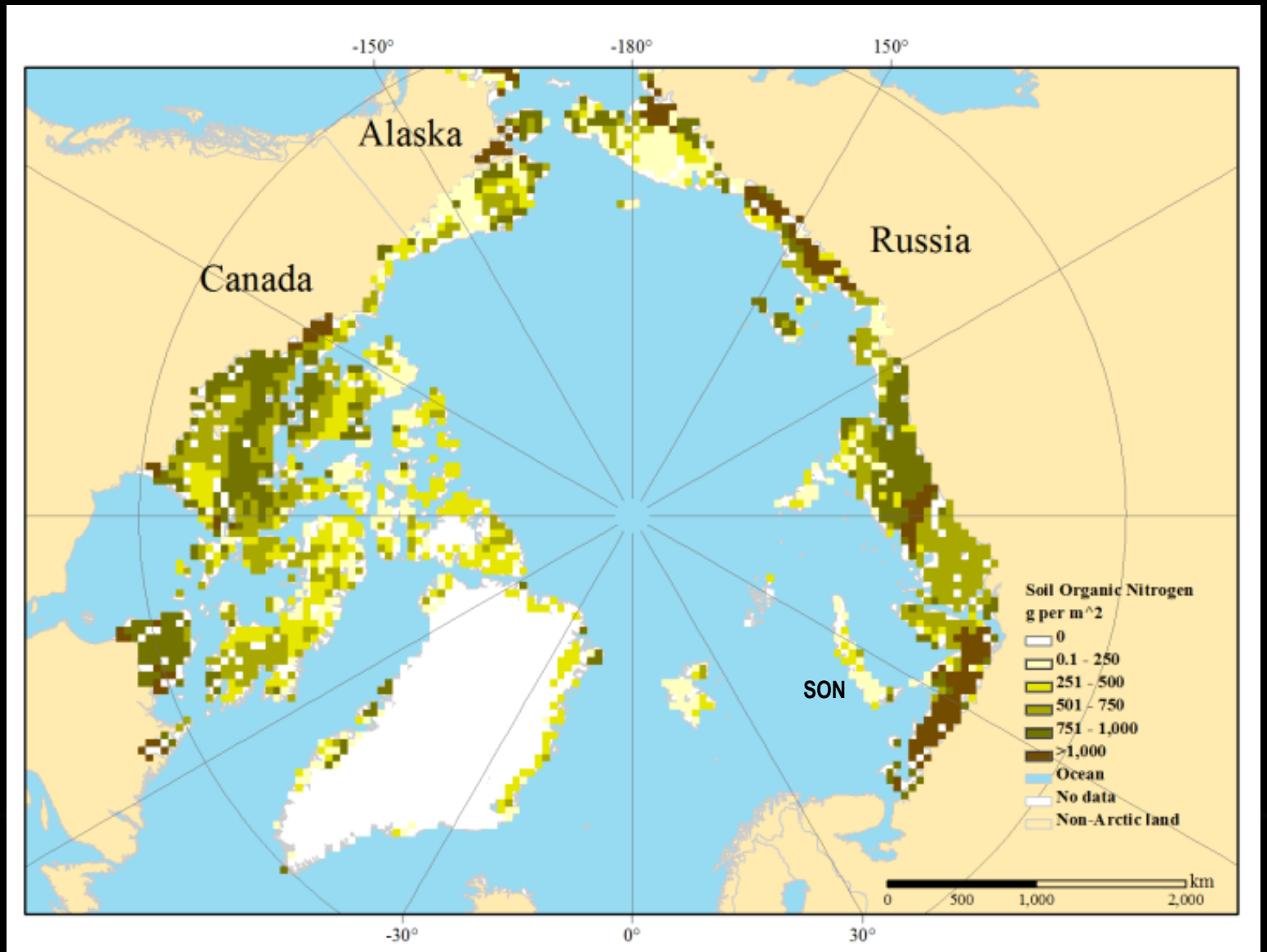


CAVM, 2005

Model Input

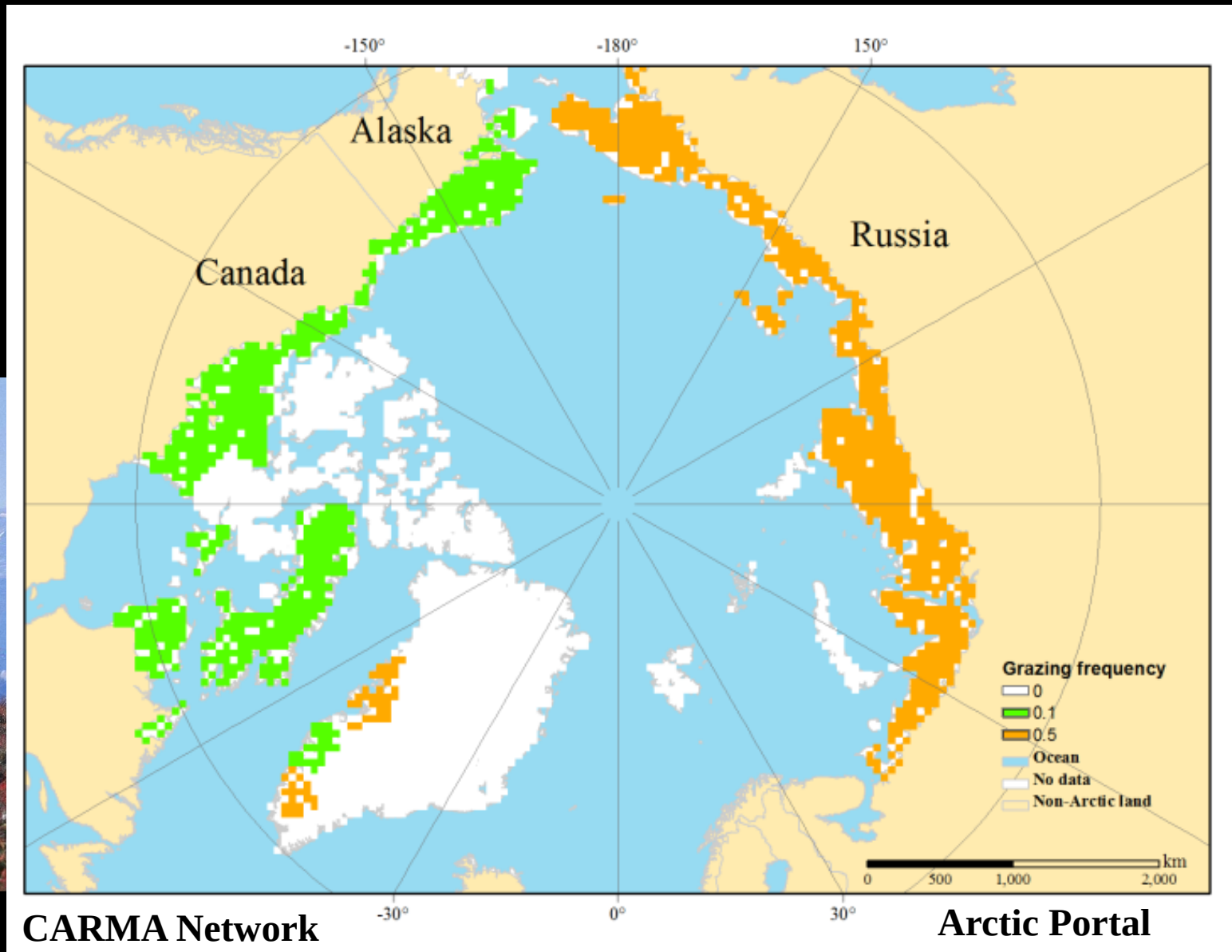
MODEL SETTING- PAN ARCTIC

- Soil organic nitrogen: output from Terrestrial Ecosystem Model



MODEL SETTING- PAN ARCTIC

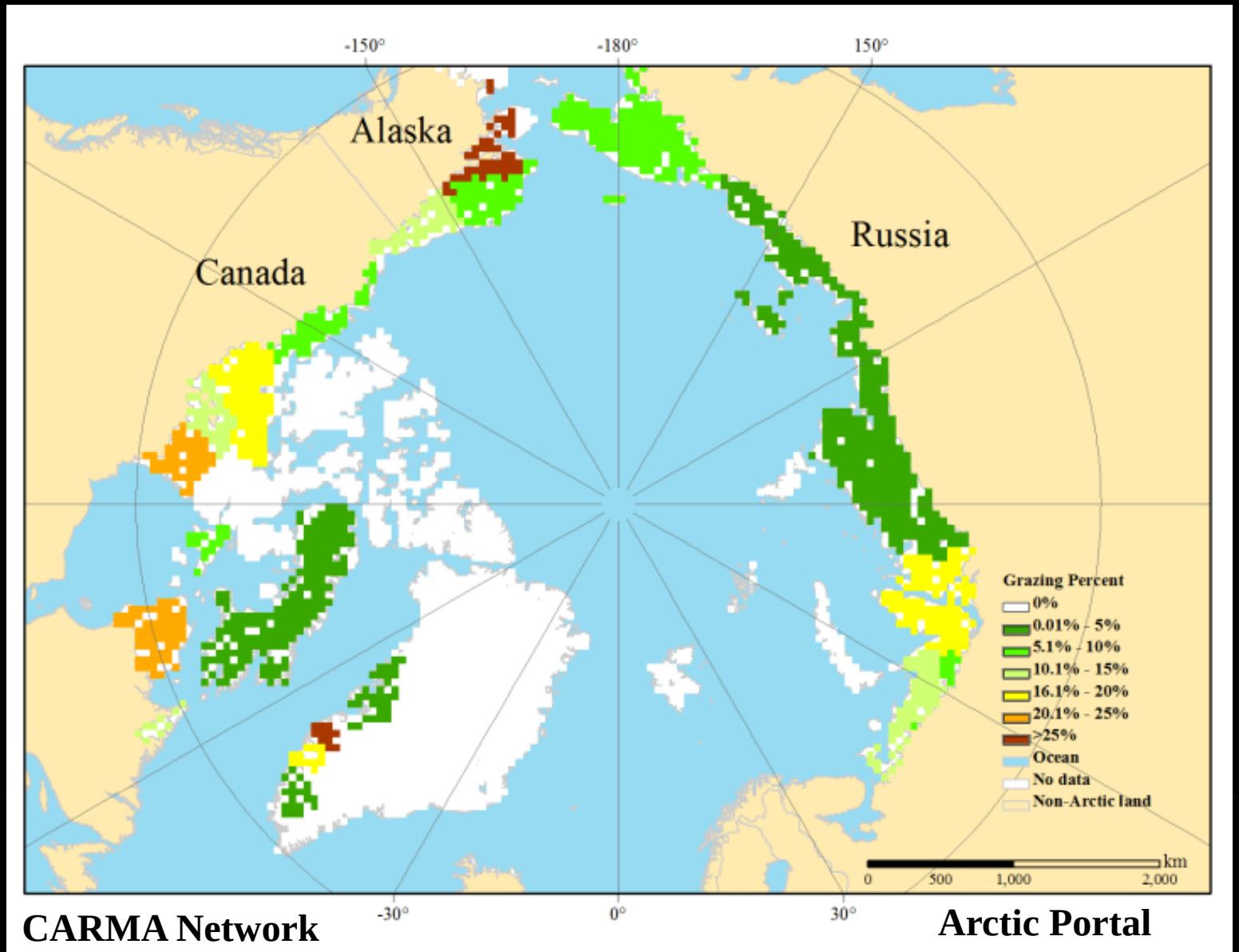
- Grazing: frequency



CARMA Network **Arctic Portal**

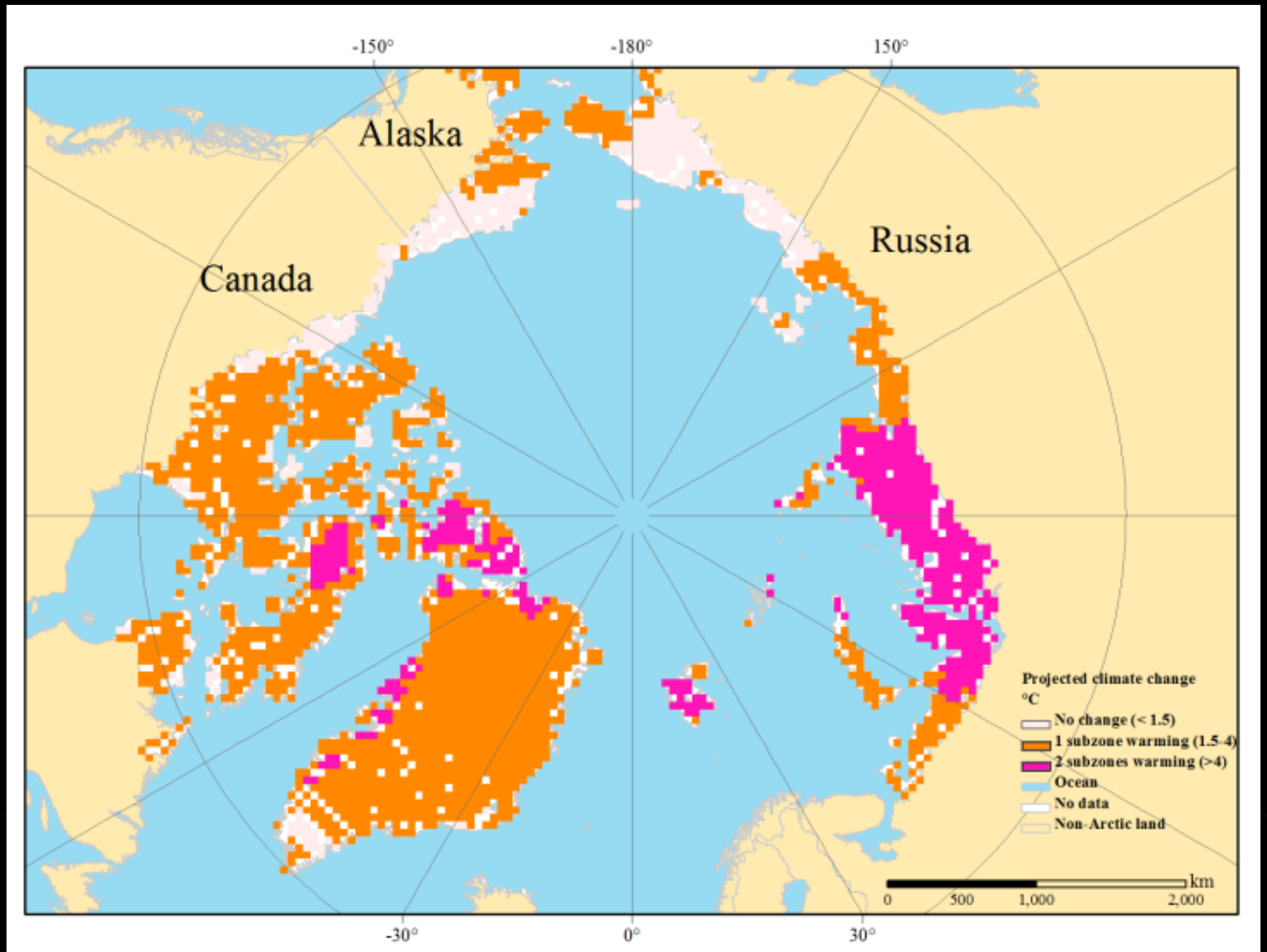
MODEL SETTING- PAN ARCTIC

- Grazing: percent - based on population density

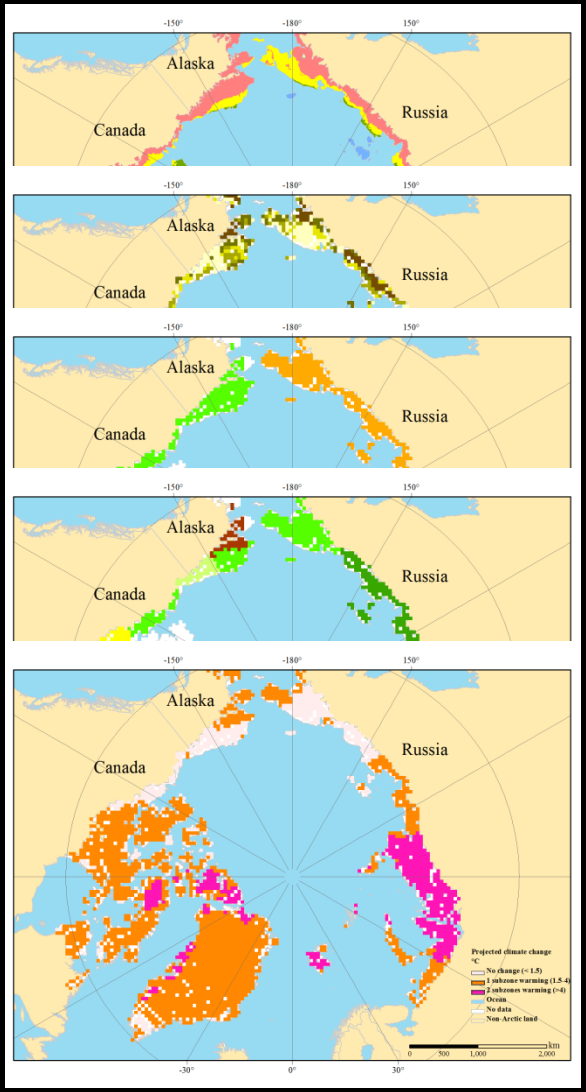


MODEL SETTING- PAN ARCTIC

- Projected climate change – CCSM 3.0 A1B scenario



Methods



- Simulated for 600 years, at year 500, impose projected climate change for each grid

ArcVeg

Above-ground biomass

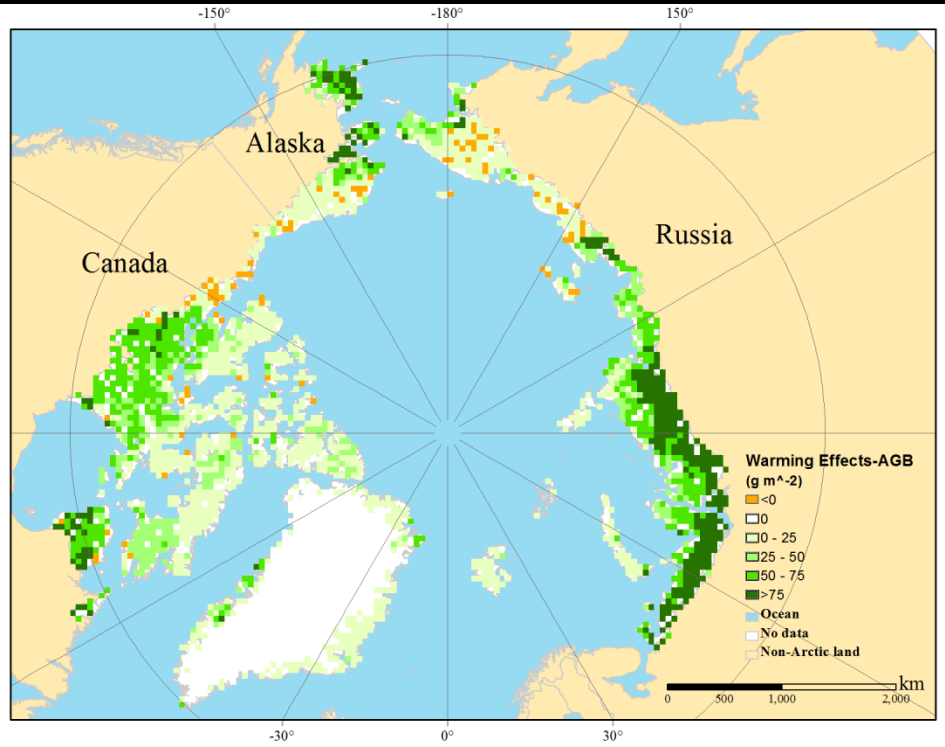
NPP

Simulation scenario
Control
Grazing only
Warming only
Combined effects

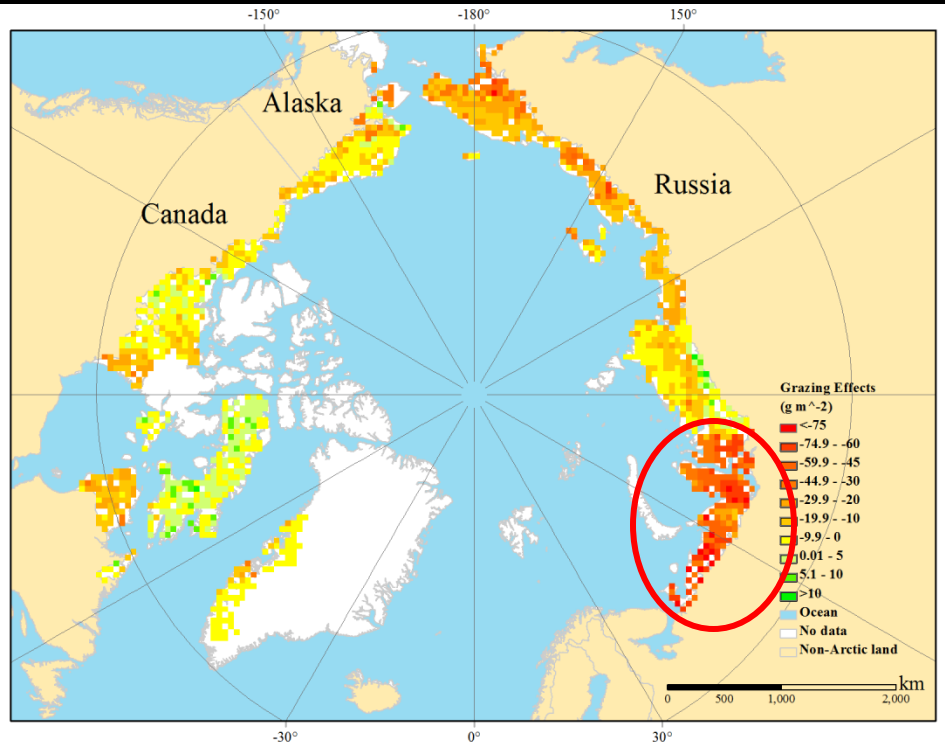
Results

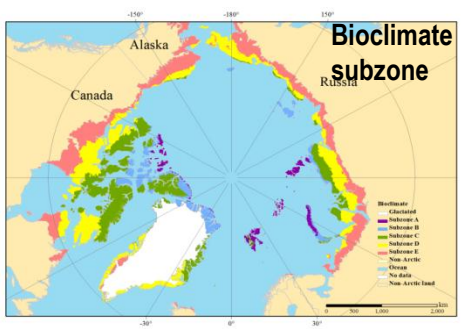
CLIMATE CHANGE VS. GRAZING

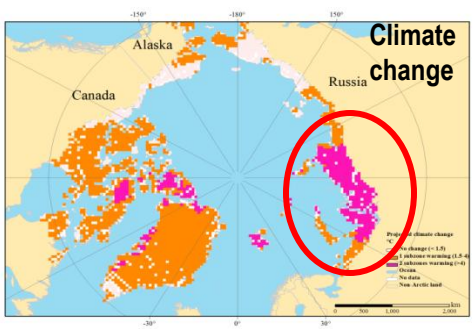
Projected Temperature caused change

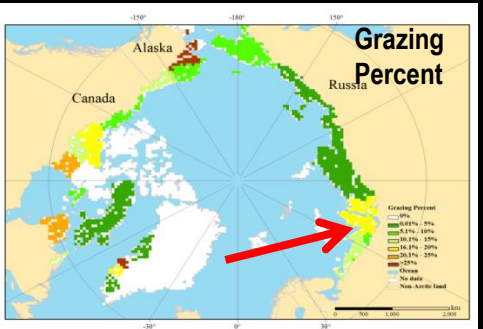


Reindeer/caribou grazing caused change



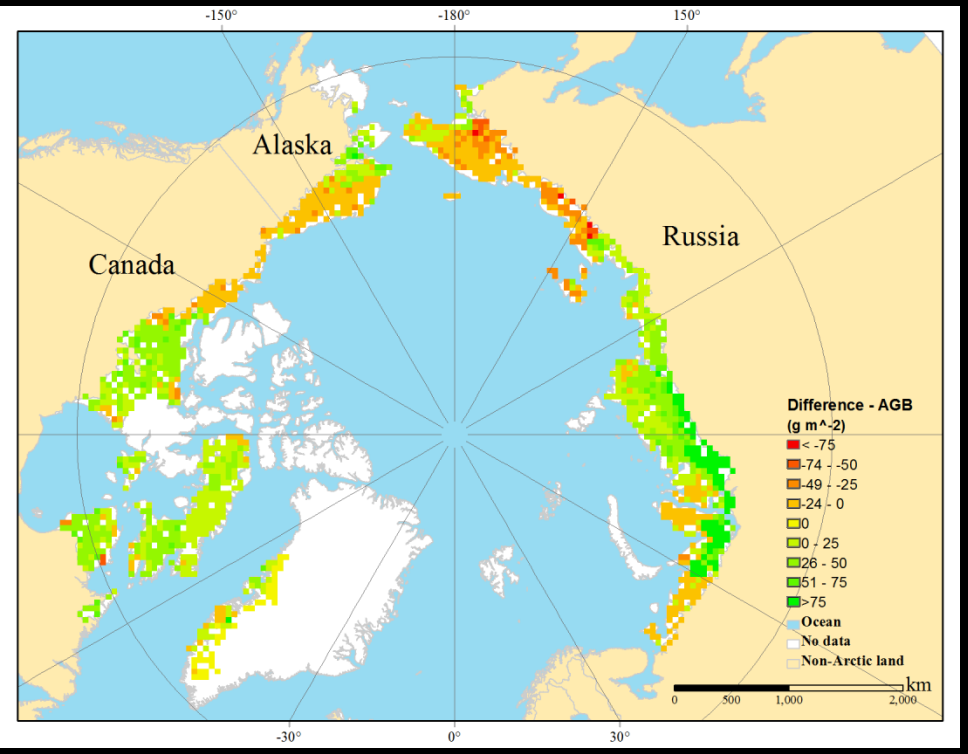


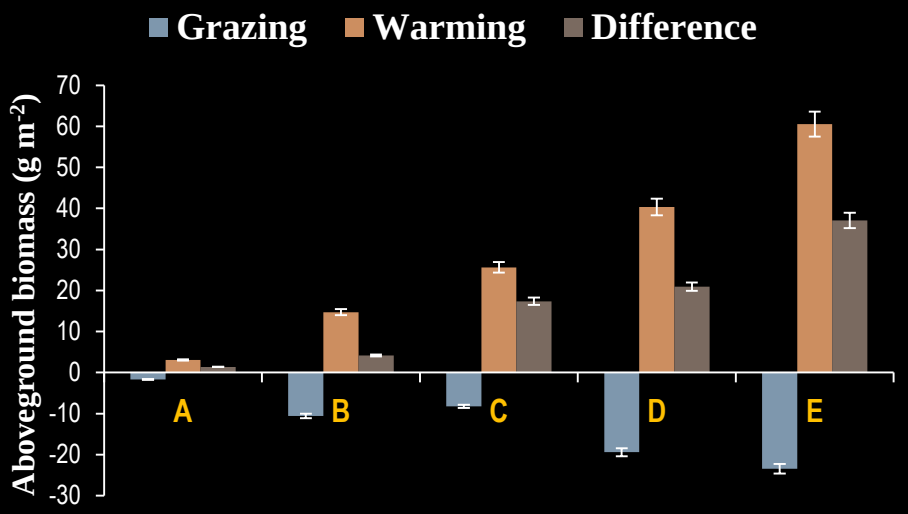




DIFFERENCE IN INDIVIDUAL EFFECTS

Simple difference between climate change and grazing caused biomass change





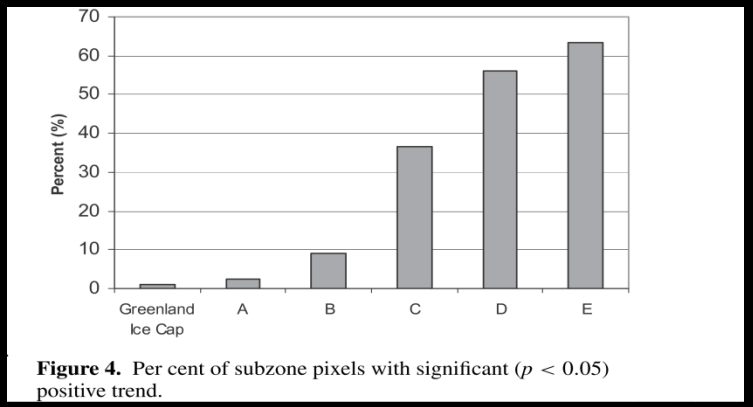


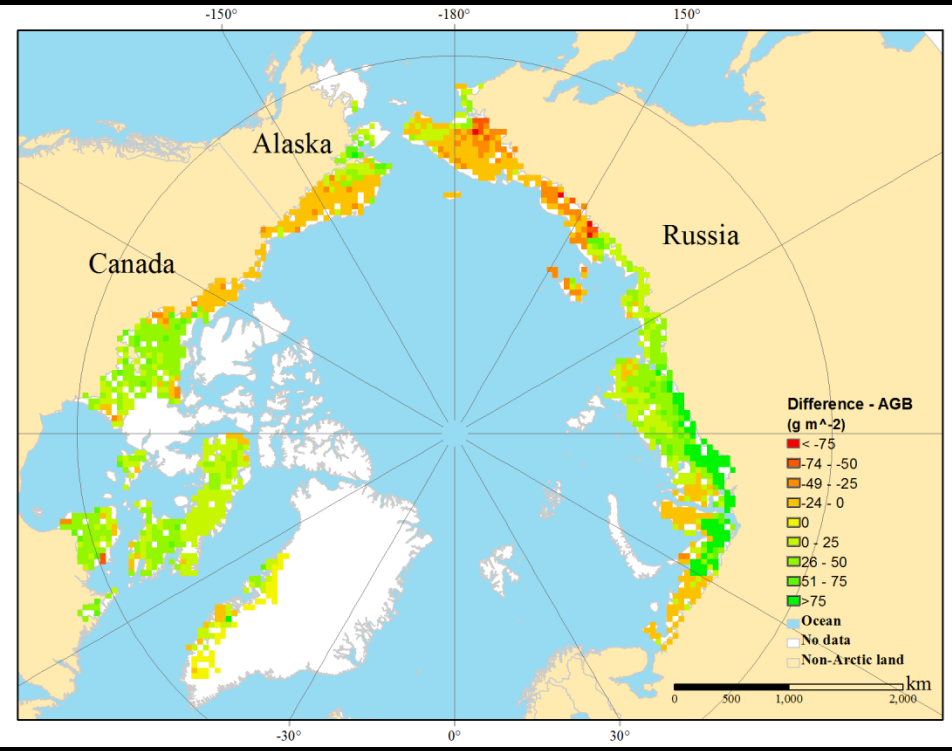
Figure 4. Per cent of subzone pixels with significant ($p < 0.05$) positive trend.

Epstein et al. 2012

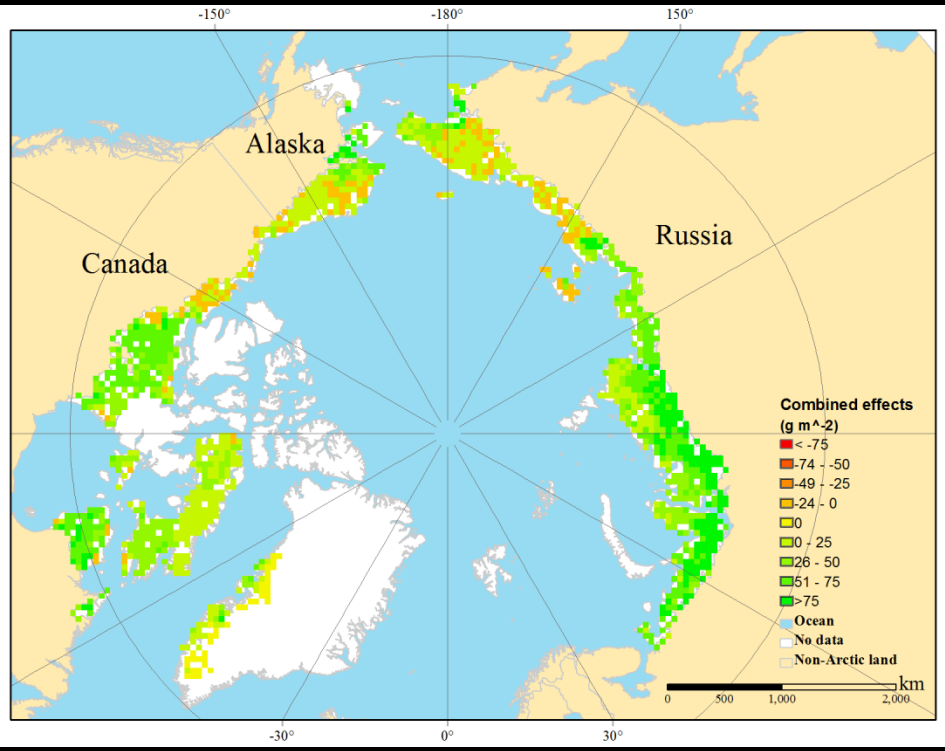
- **Most of the biomass changes in the three southernmost subzones**
- **very little change in subzones A (2.1%) and B (6.4%)**

INDIVIDUAL EFFECTS VS. COMBINED EFFECTS

Simple difference between climate change and grazing caused biomass change



Combined effects of climate change and reindeer/caribou grazing caused change



DISCUSSION AND FUTURE RESEARCH

- Grazing can abate tundra plant response to climate warming in terms of aboveground biomass
- Both climate change and grazing caused greater absolute aboveground biomass change in southern subzones and the Russian arctic tundra
- Interpretation of “greening of the Arctic” can be complicated given the integrated nature in the system

ACKNOWLEDGMENTS

MERCI !