Is changing pathogen biodiversity in muskoxen influencing human health, economies, socio-cultural well-being, and wildlife conservation?

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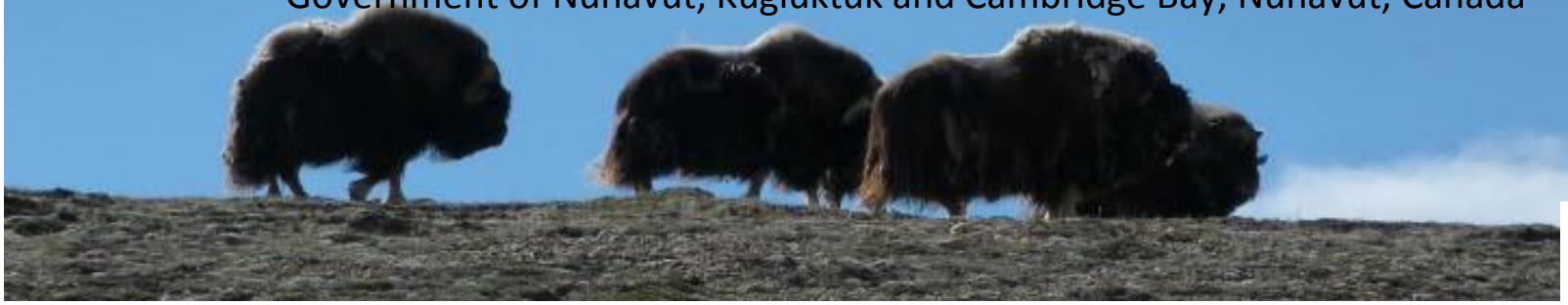

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Contemplating biodiversity….

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…in muskox feces

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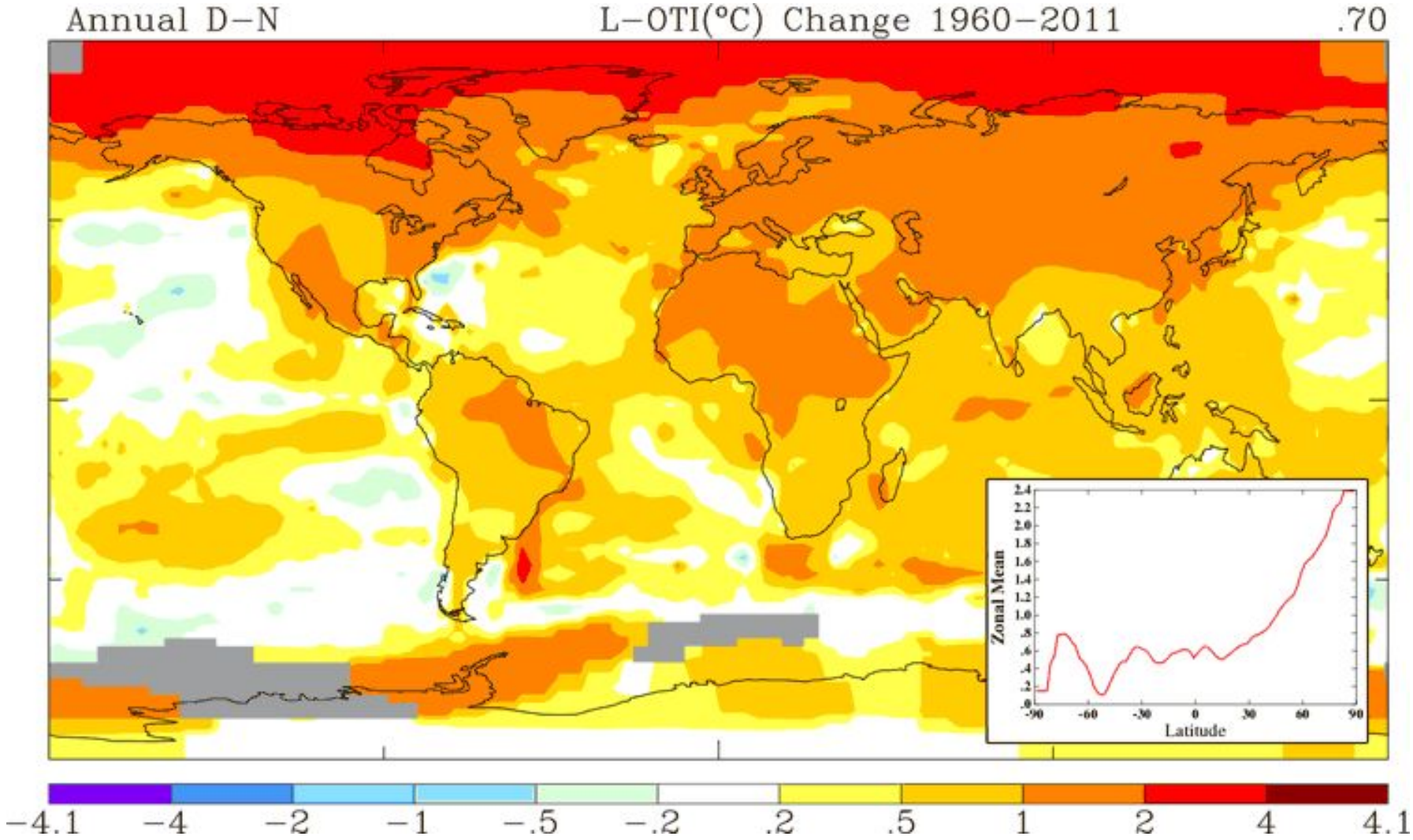
Moniezia ?

Novel pathogens in muskoxen since 1995

New Genus/species	
*Umingmakstrongylus pallikuukensis***	Lungworm
Teladorsagia boreoarcticus	Abomasal nematode
*Varestrongylus eleguneniensis***	Lungworm
Orf-like virus**	Virus
Pesti virus	Virus
Herpes virus	Virus

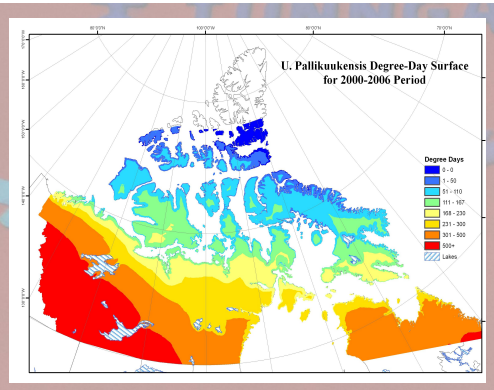
New Host and/or Geographic Records	
Protostrongylus stilesi	Lungworm
Muellerius capillaris	Lungworm
Taenia arctos (?)	tapeworm
Giardia duodenalis	Intestinal protozoa
Toxoplasma gondii	Tissue protozoa
Mycoplasma ovipneumonia	Lung bacteria
*Erysipelothrix rhusiopathiae***	Bacteria
Gamma herpes virus	Virus

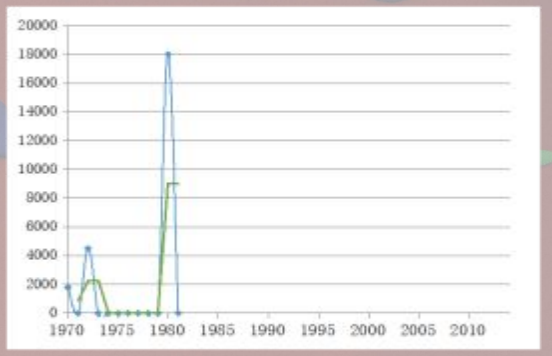
Changes in mean surface Temperature 1960-2011

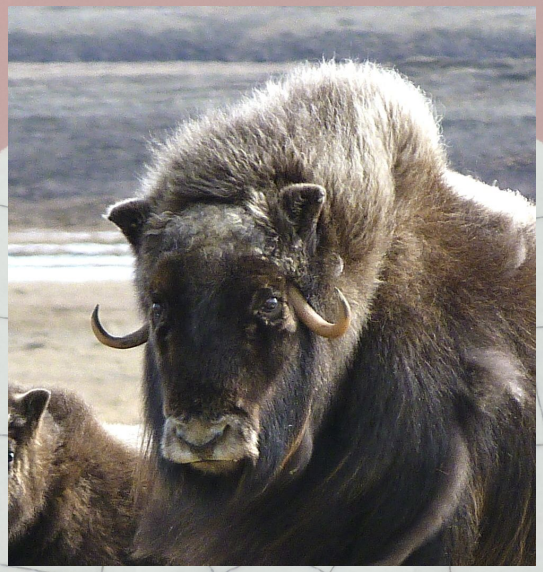


https://nsidc.org/cryosphere/arctic-meteorology/climate_change.html

‘Umingmak’, the Bearded One, and pathogen biodiversity

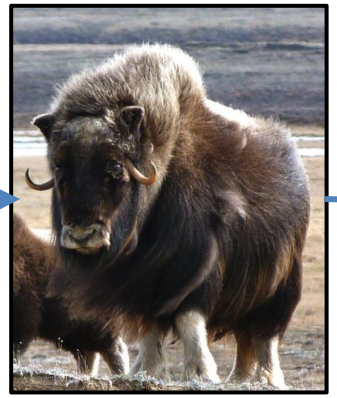

U. Pallikuukensis Degree-Day Surface
for 2000-2006 Period
Degree Days
0 - 0
1 - 50
51 - 110
111 - 167
168 - 230
231 - 300
301 - 500
500+
Lakes


20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
1970
1975
1980
1985
1990
1995
2000
2005
2010



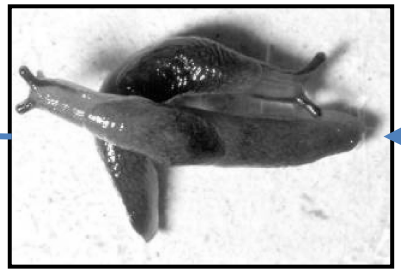
Protostrongylid Lungworms: *Umingmakstrongylus pallikuukensis* (Hoberg et al., 1995)

Adult worms (60cm+)
live for years

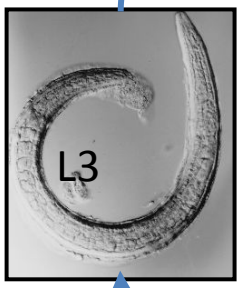


Muskox eats L3 in slug
or on vegetation

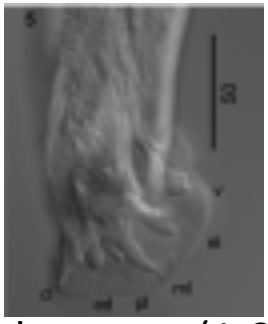
L1 in feces
(millions)



L1 develops to L3 in slug
Depends on Temperature (167 Degree Days)



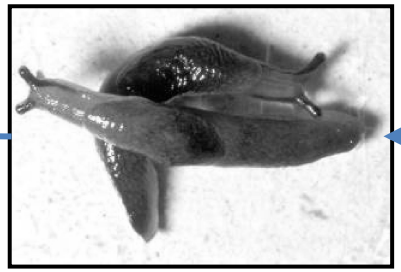
Protostrongylid Lungworms: *Varestrongylus eleguneniensis* (Verocai et al., In press)



Adult worms (1-2cm)
live months

Muskox/caribou eats L3
in slug or on vegetation

L1 in feces



L1 develops to L3 in slug
Depends on Temperature (unknown Degree Days)

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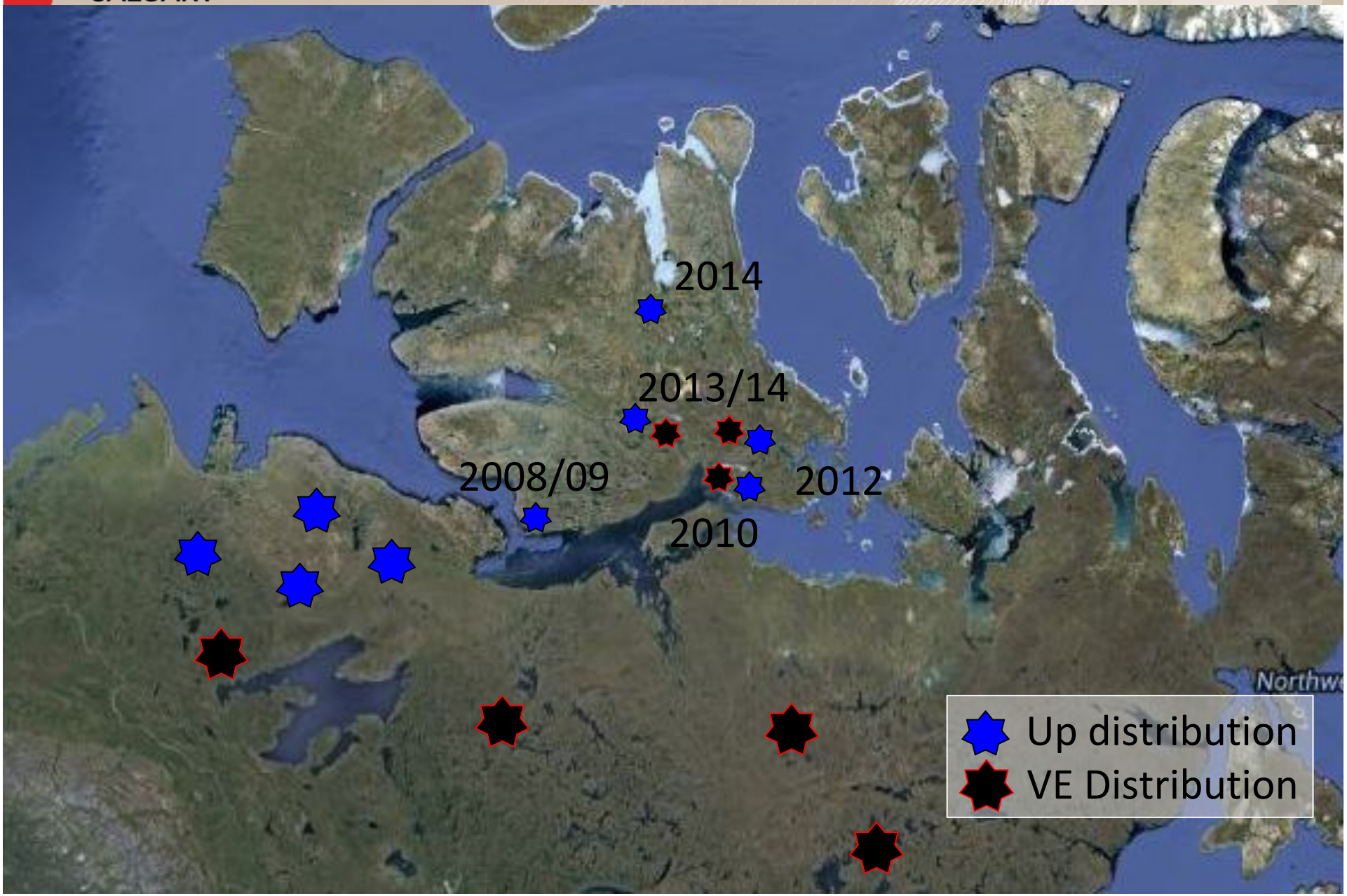
Range Expansion of Lungworms



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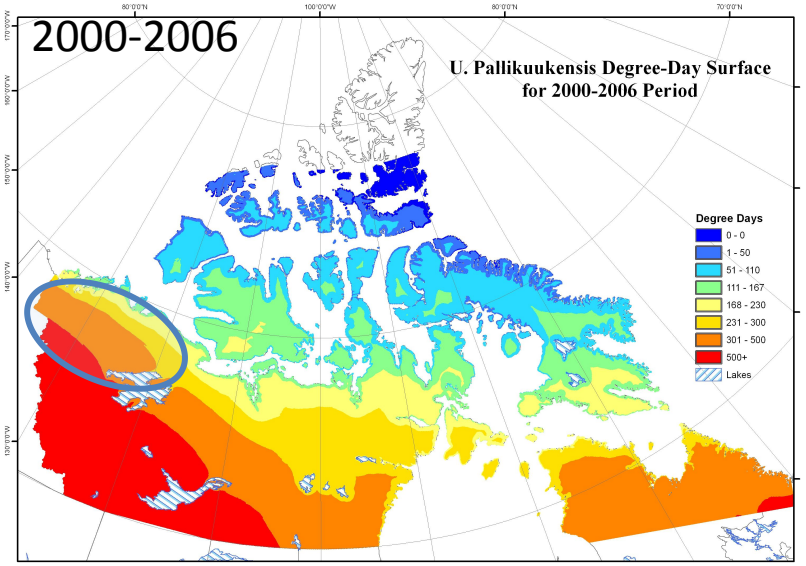
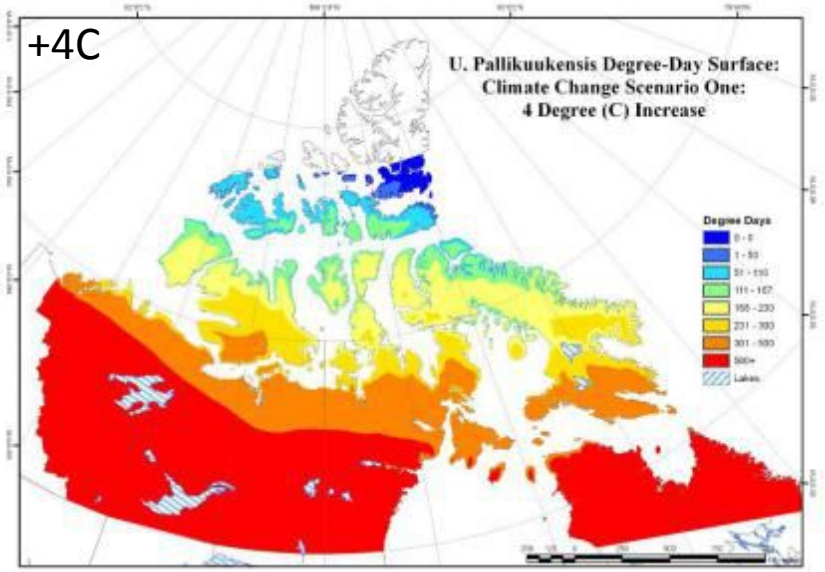
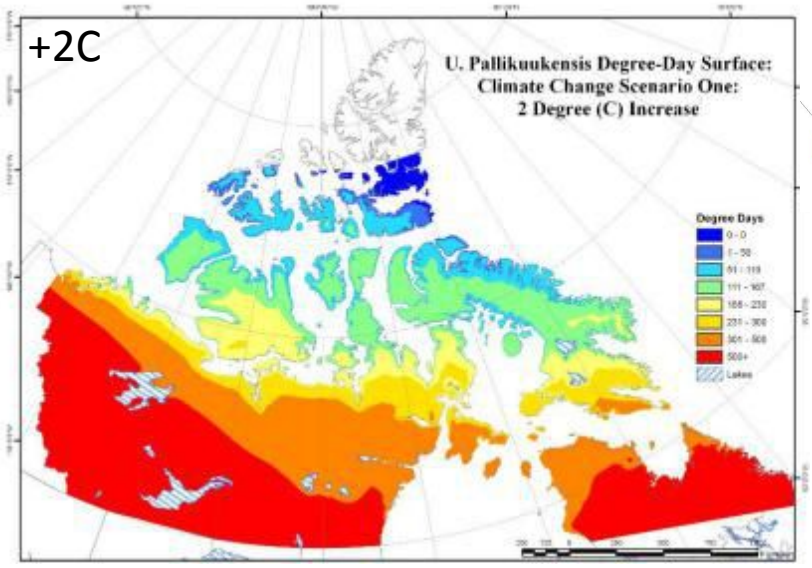
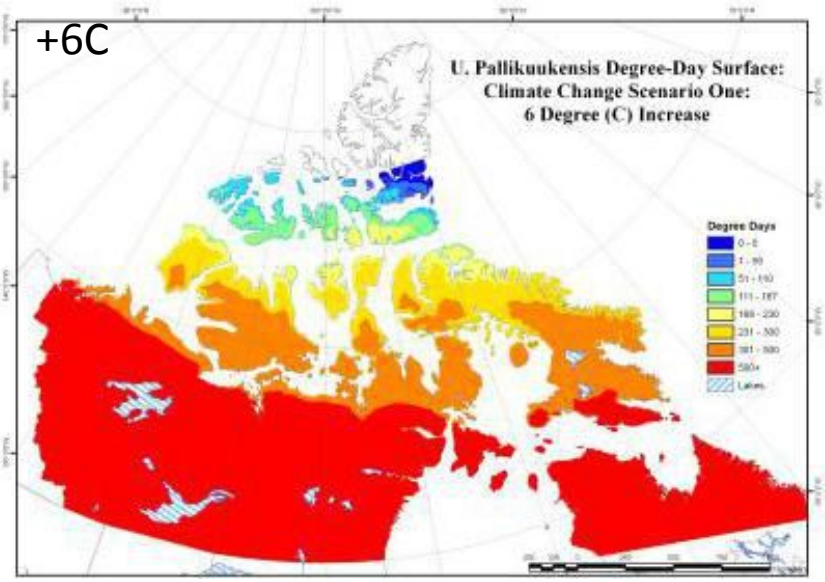
Range Expansion of Lungworms

Lungworm Range Expansion





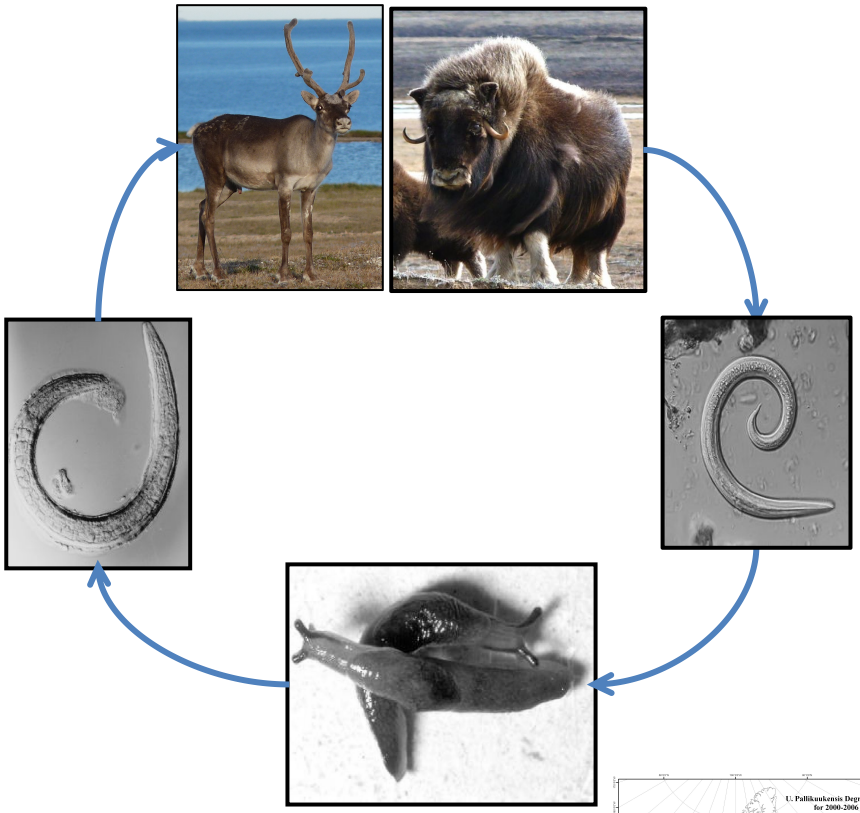


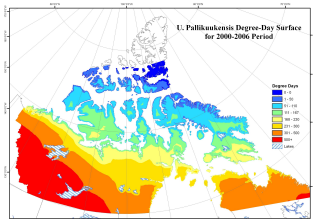


Degree Days
0 - 0
1 - 50
51 - 110
111 - 167
168 - 230
231 - 300
301 - 500
500+
Lakes

What does range expansion tell us?

- Pathogen movement from mainland (2 ways)
- Gastropod hosts present
- Climate suitable for establishment
- Different patterns/rates of expansion





What else has changed?

Widespread Muskox mortality events, 2010-2013
Banks and Victoria Islands

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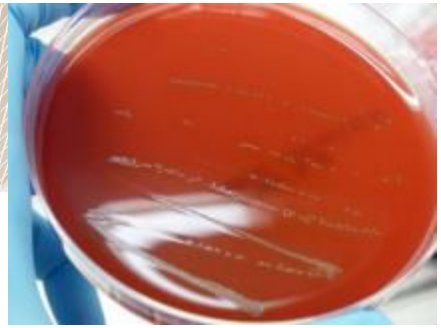
Erysipelothrix rhusiopathiae



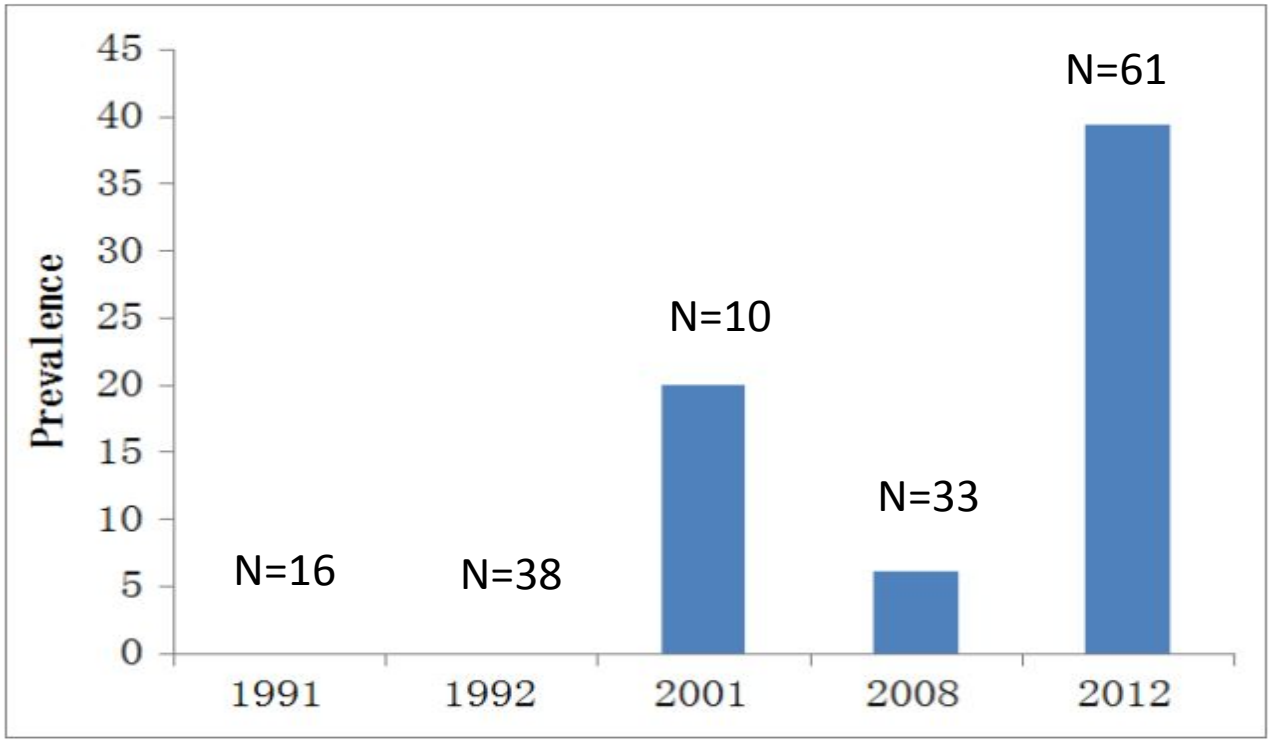
- Bacteria common in domestic pigs, environment
- Can infect all warm blooded animals
- Can infect people: skin rash, endocarditis, septicemia and death

- Never reported in Arctic or muskoxen
- Recently finding in woodland caribou

- New pathogen or new conditions? Or both?

Archived sera from Banks Island: absent historically?

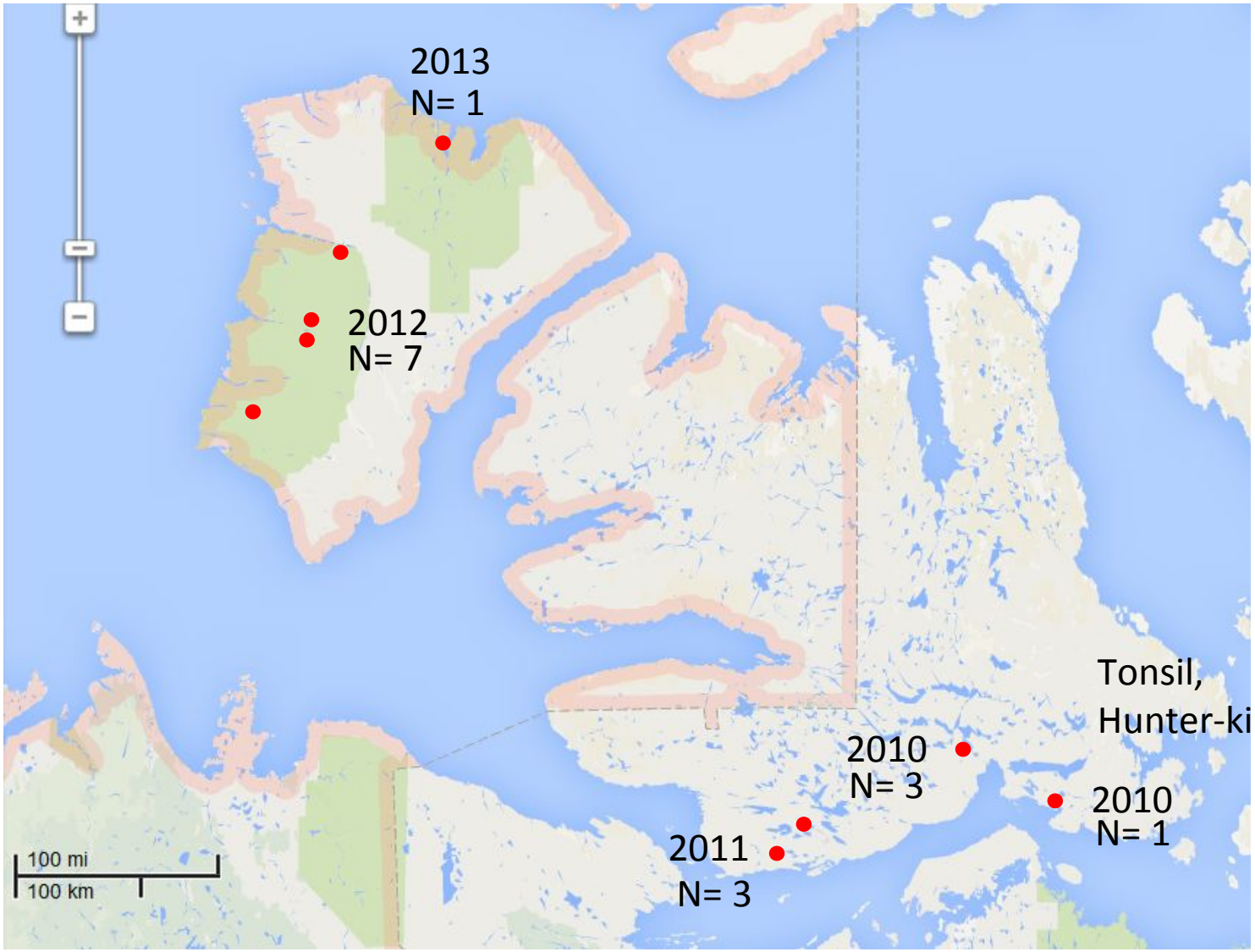
Sample prevalence for *Erysipelothrix*



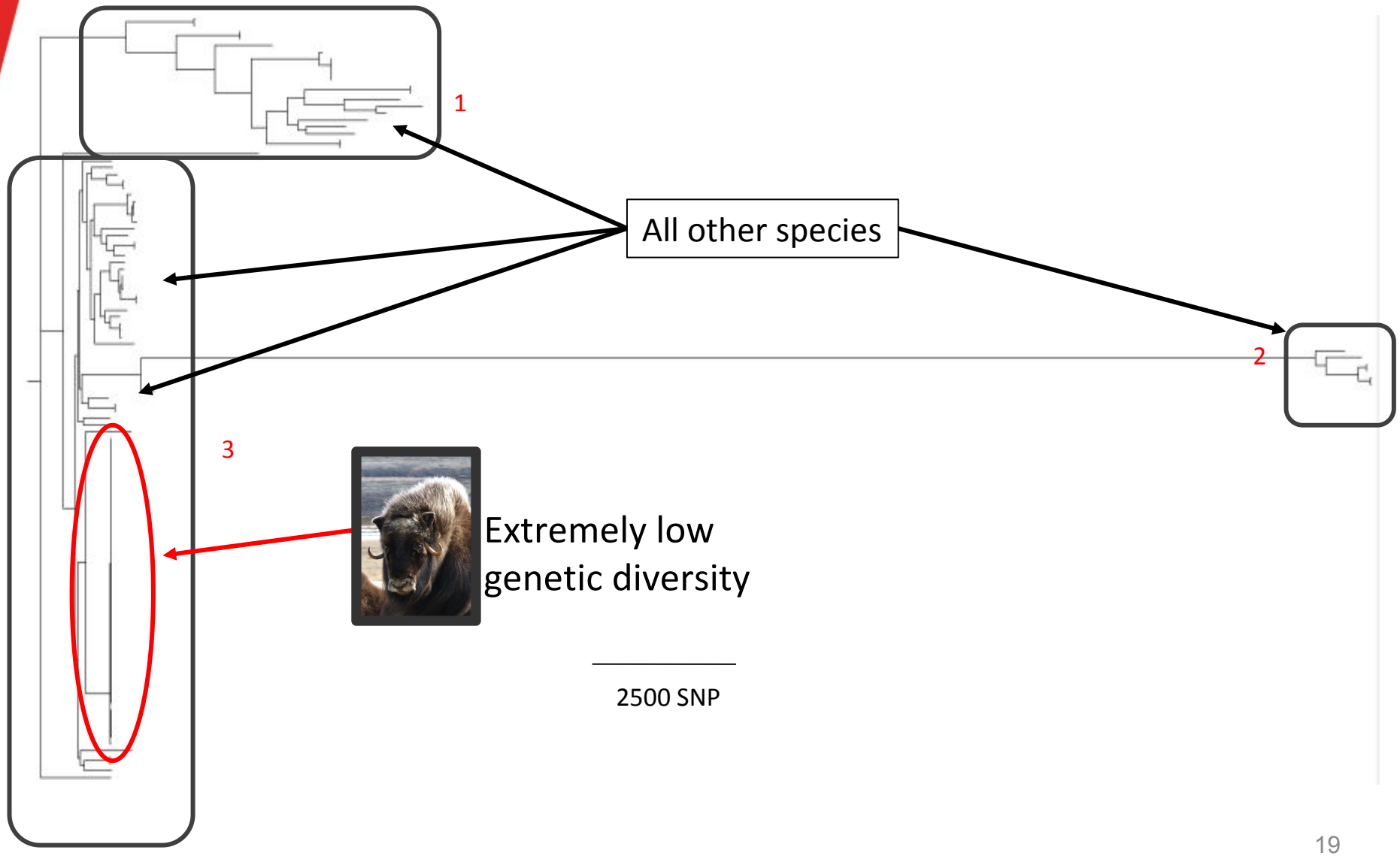
Hutchins, Blake, Elkin, Kutz, et al., unpubl. data

Genetic diversity of *Erysipelothrix?*
(Taya Forde, PhD Candidate)

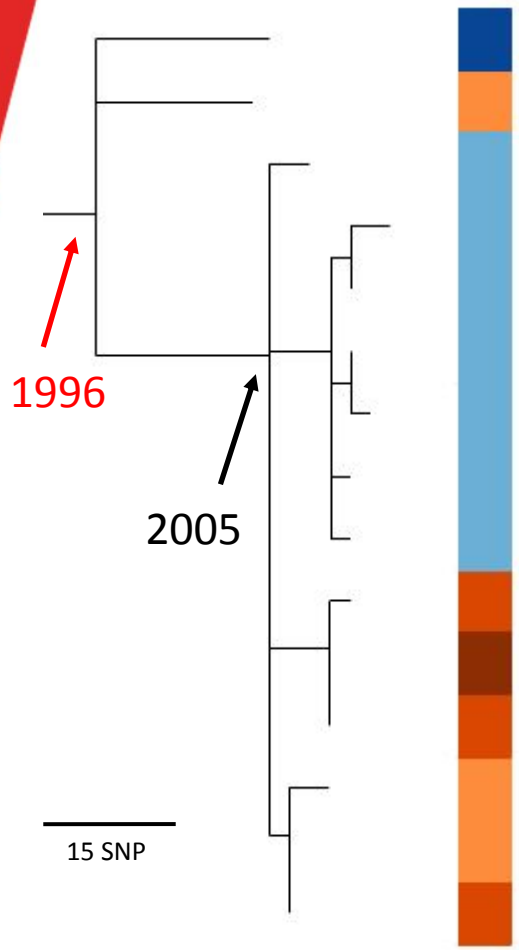
Samples cultured and sequenced from 15 muskoxen

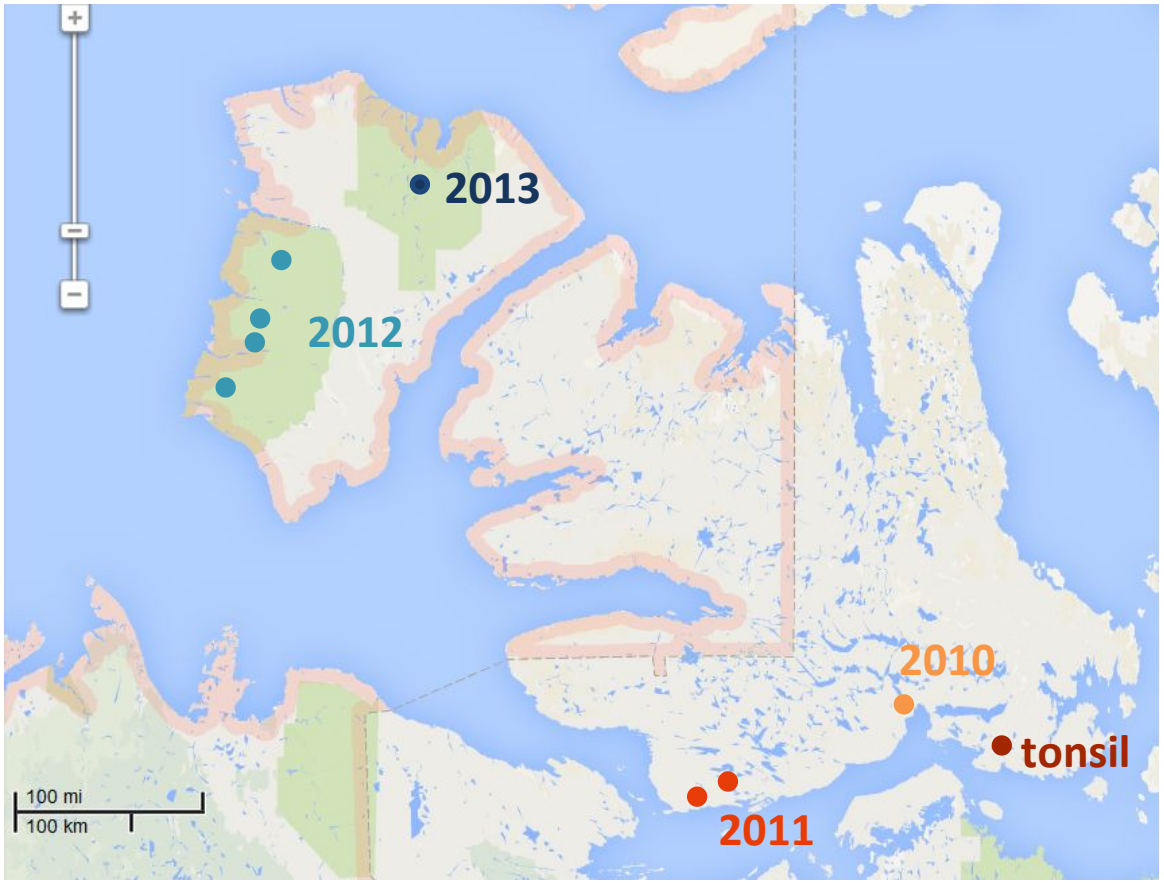


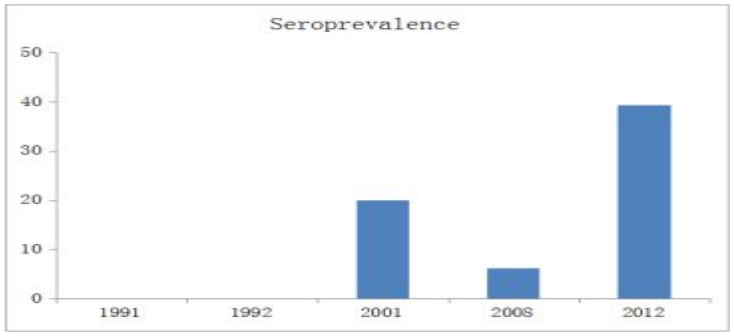
Whole genome sequencing of muskox isolates and from other species and geographic regions



Estimated time of most recent common ancestor (using the program *'Beast'*)





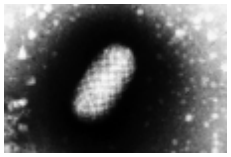


What does the finding of *Erysipelothrix* tell us?

- Novel, highly pathogenic, generalist pathogen
  - Ecosystem effects!
- Some survivors (seropositive)
- Zoonosis

- Unknown: source, how it cycles in the Arctic environment, ultimate impacts/muskox resilience
  - Consider reservoir hosts
  - Consider long range transport

Increasing observations of Orf-like lesions, both islands



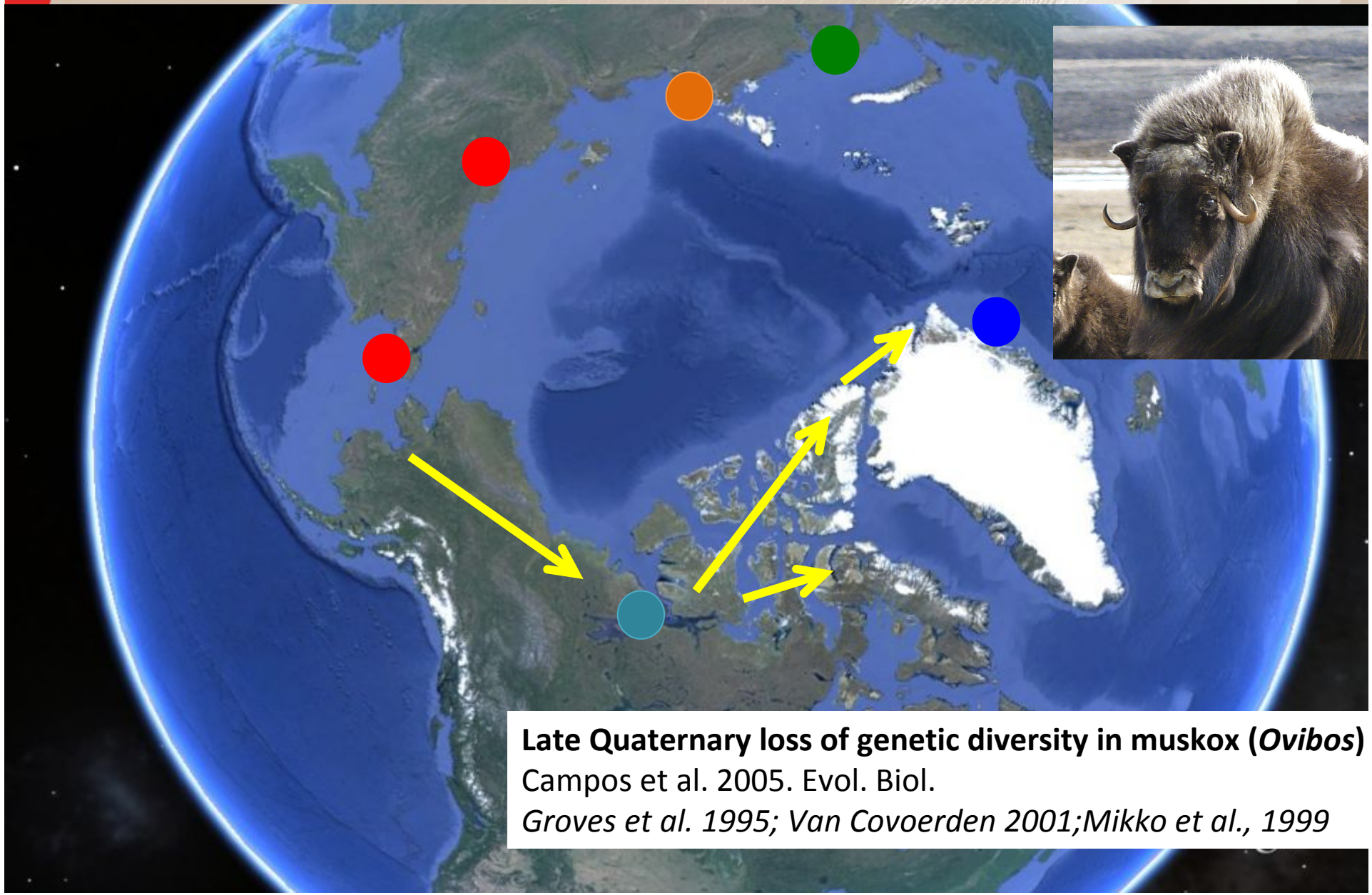
- Parapox virus
  - Closest to a parapox from Bangladesh cattle (C. Dalton, M. Tomaselli, F. van der Meer 2014)

- Zoonotic
- Usually young animals, associated with stress in adult animals

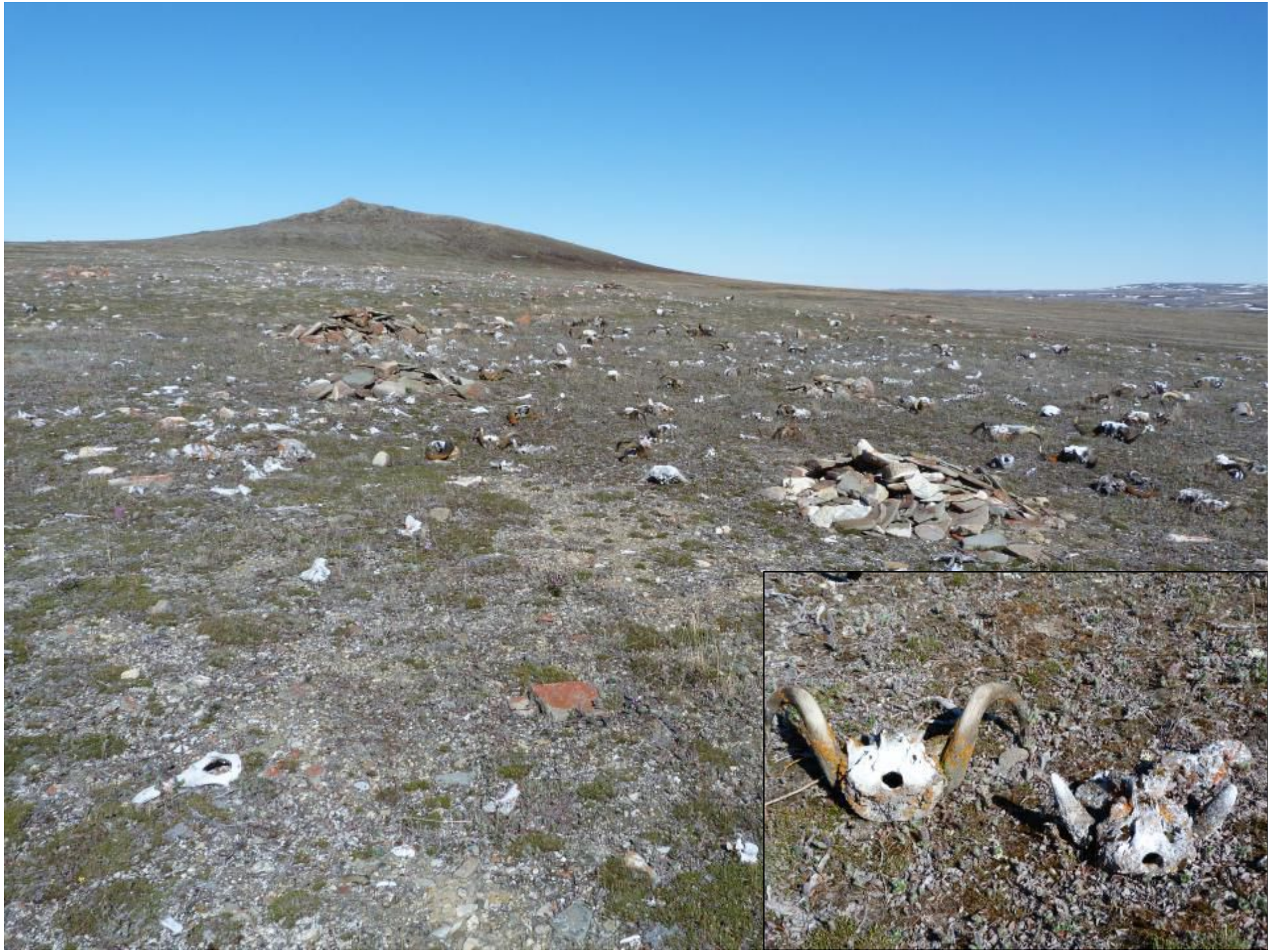
Reflect increased vulnerability/ill-health of muskoxen?

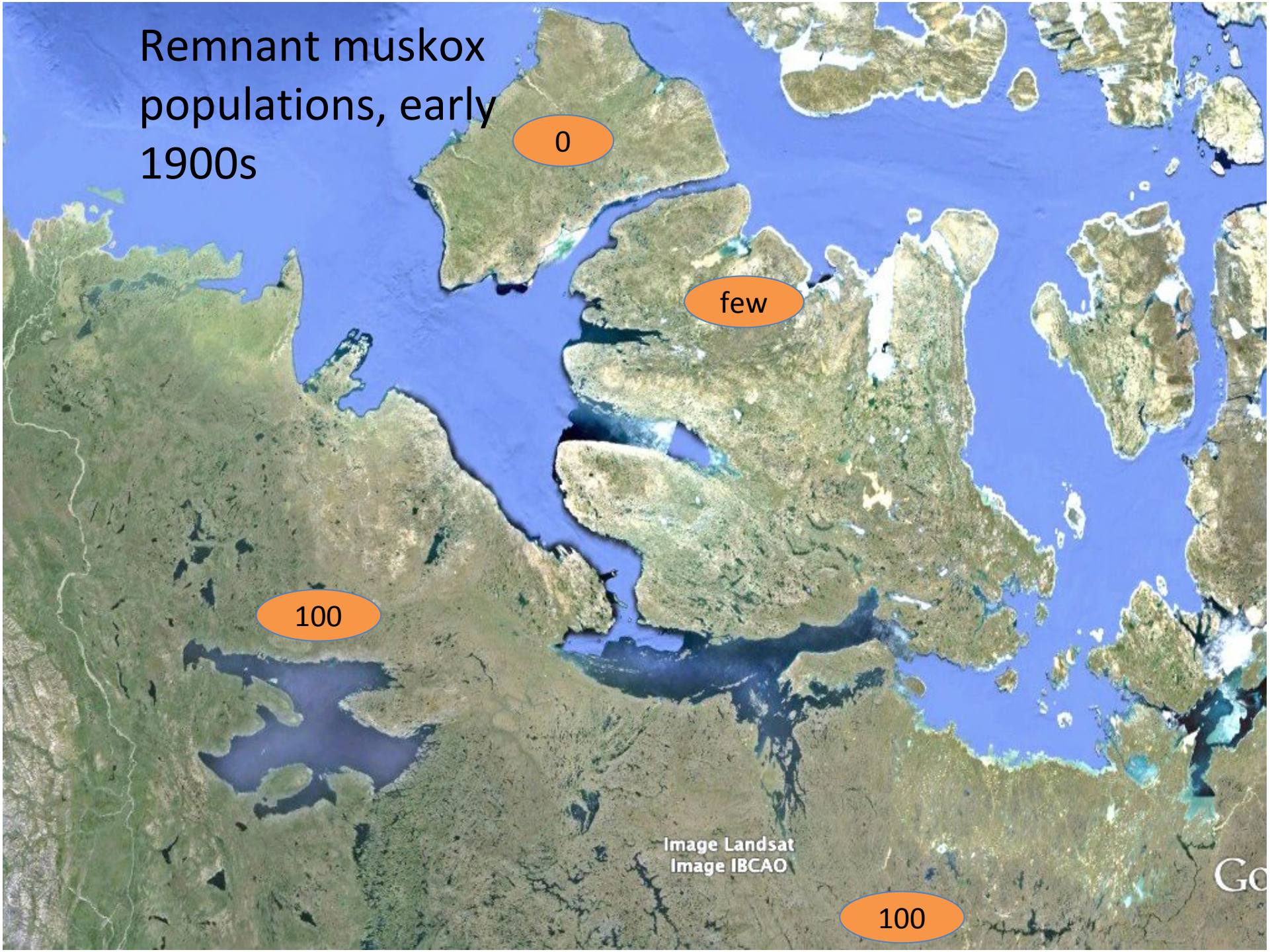

So what does this mean for conservation,
human health, food security?

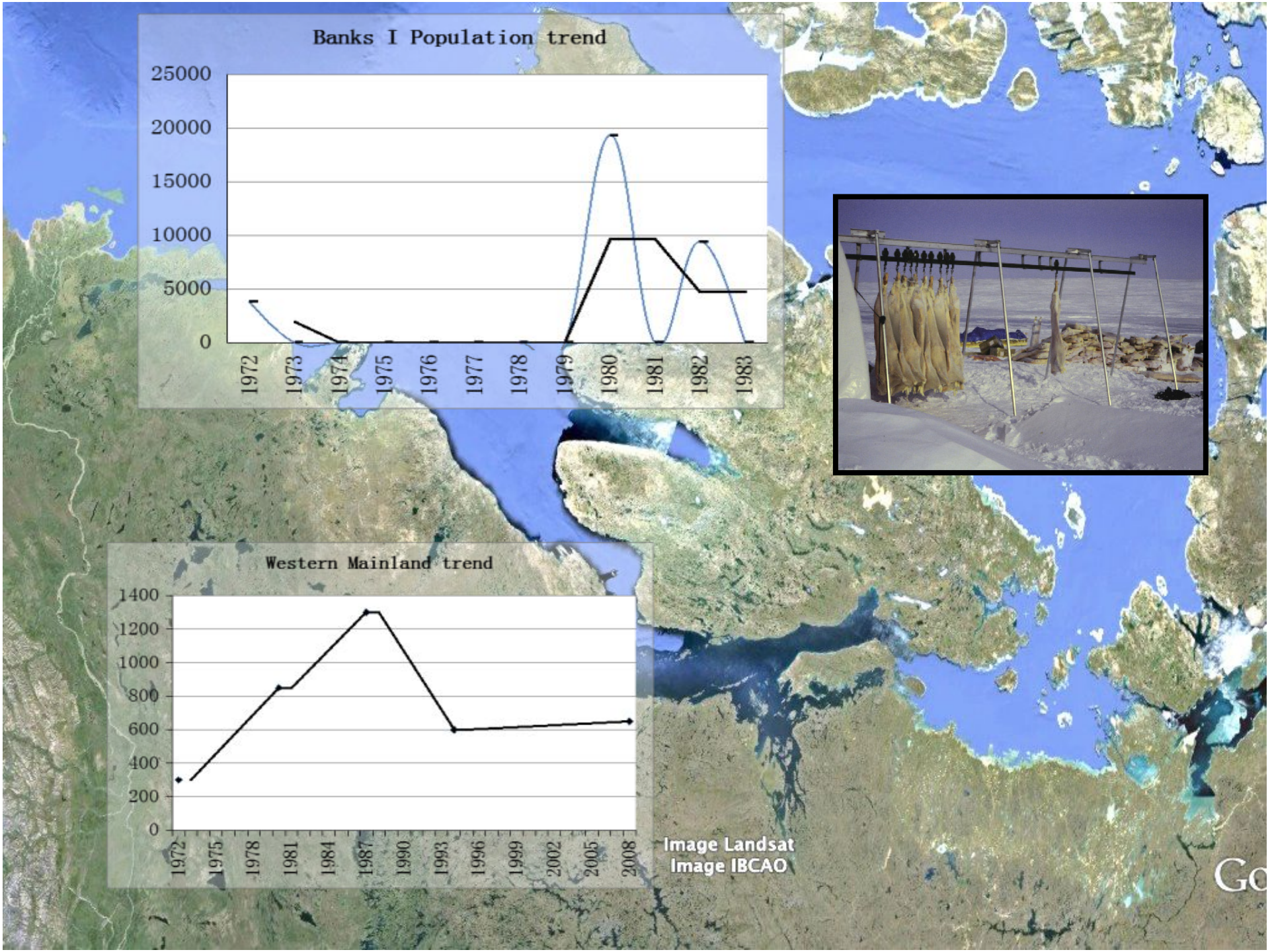
The Muskox: A Survivor of the Pleistocene extinctions, but, not unscathed



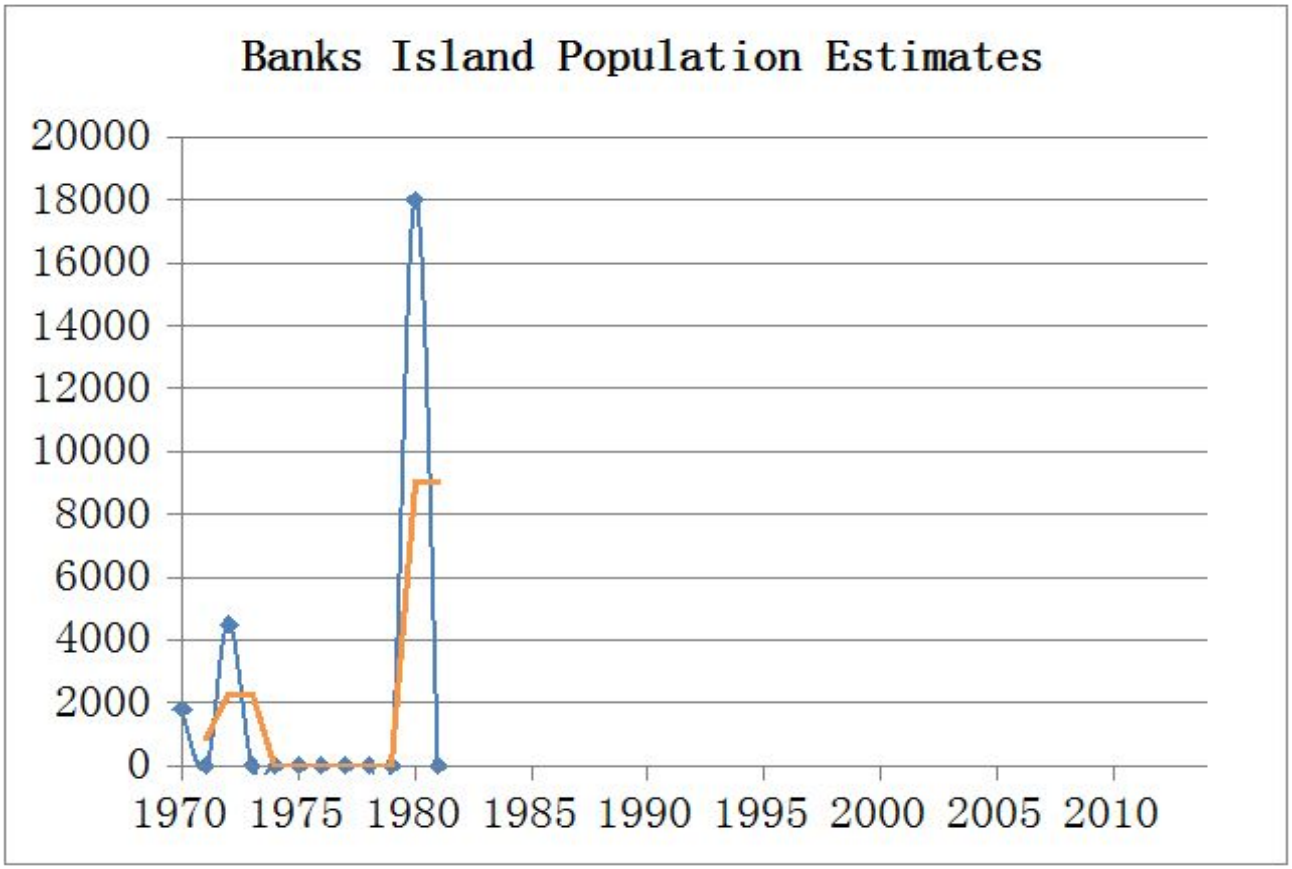
Late Quaternary loss of genetic diversity in muskox (*Ovibos*)
Campos et al. 2005. Evol. Biol.
Groves et al. 1995; Van Covoerden 2001;Mikko et al., 1999




Remnant muskox populations, early 1900s
0
few
100
Image Landsat
Image IBCAO
100

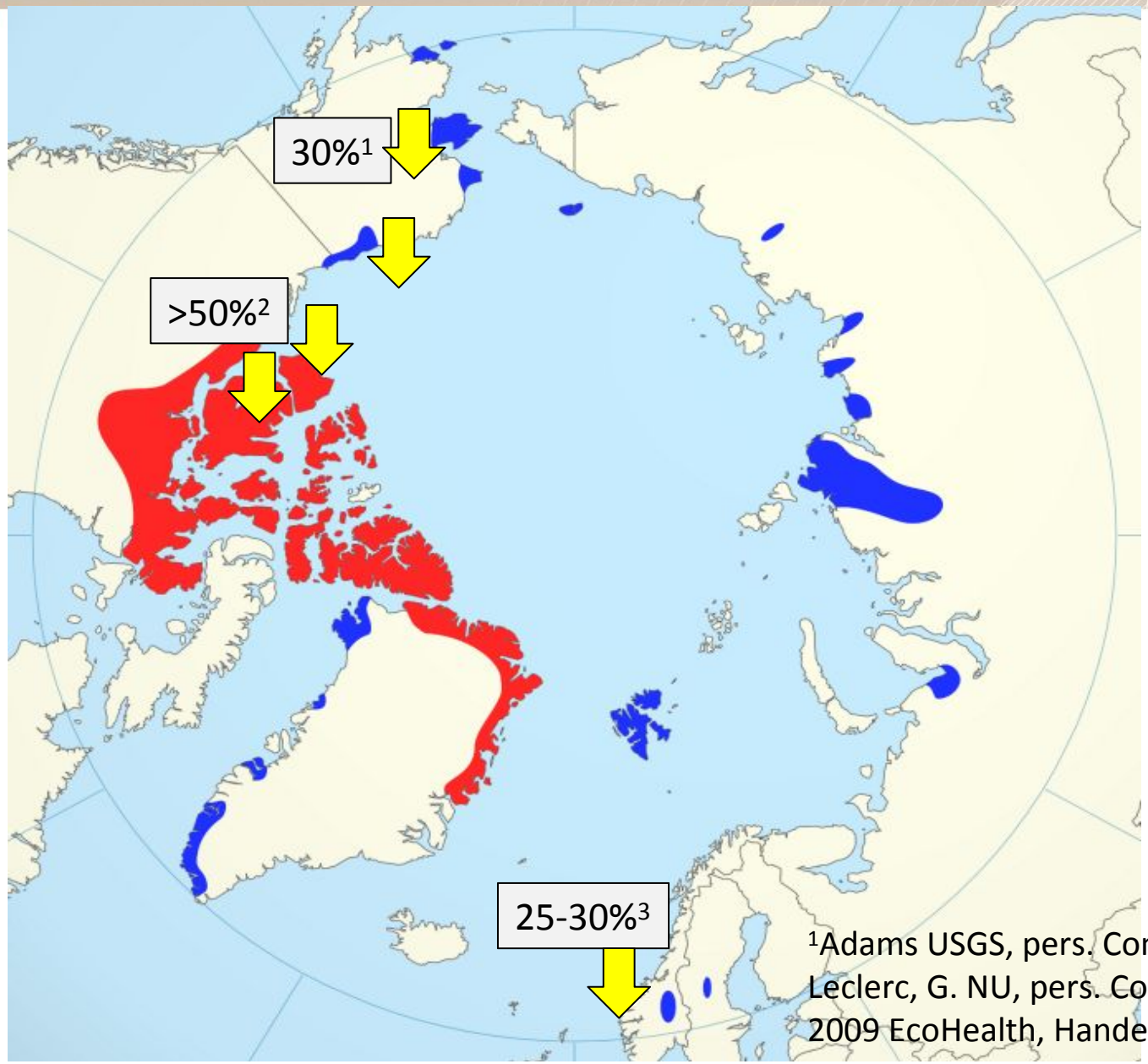

Banks I Population trend
25000
20000
15000
10000
5000
0
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
Western Mainland trend
1400
1200
1000
800
600
400
200
0
1972
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008
Image Landsat
Image IBCAO

Recent muskox population declines



Victoria Island:
2000 = 42,000
2014 = 15,000

Global muskox distribution and population trends



Introduced

Native

Recent declines

[1]Adams USGS, pers. Comm 2014; [2]Davison G.NWT, Leclerc, G. NU, pers. Comm 2014; [3]Ytrehus et al. 2009 EcoHealth, Handeland et al. 2014 Plos One

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Ecological consequences?

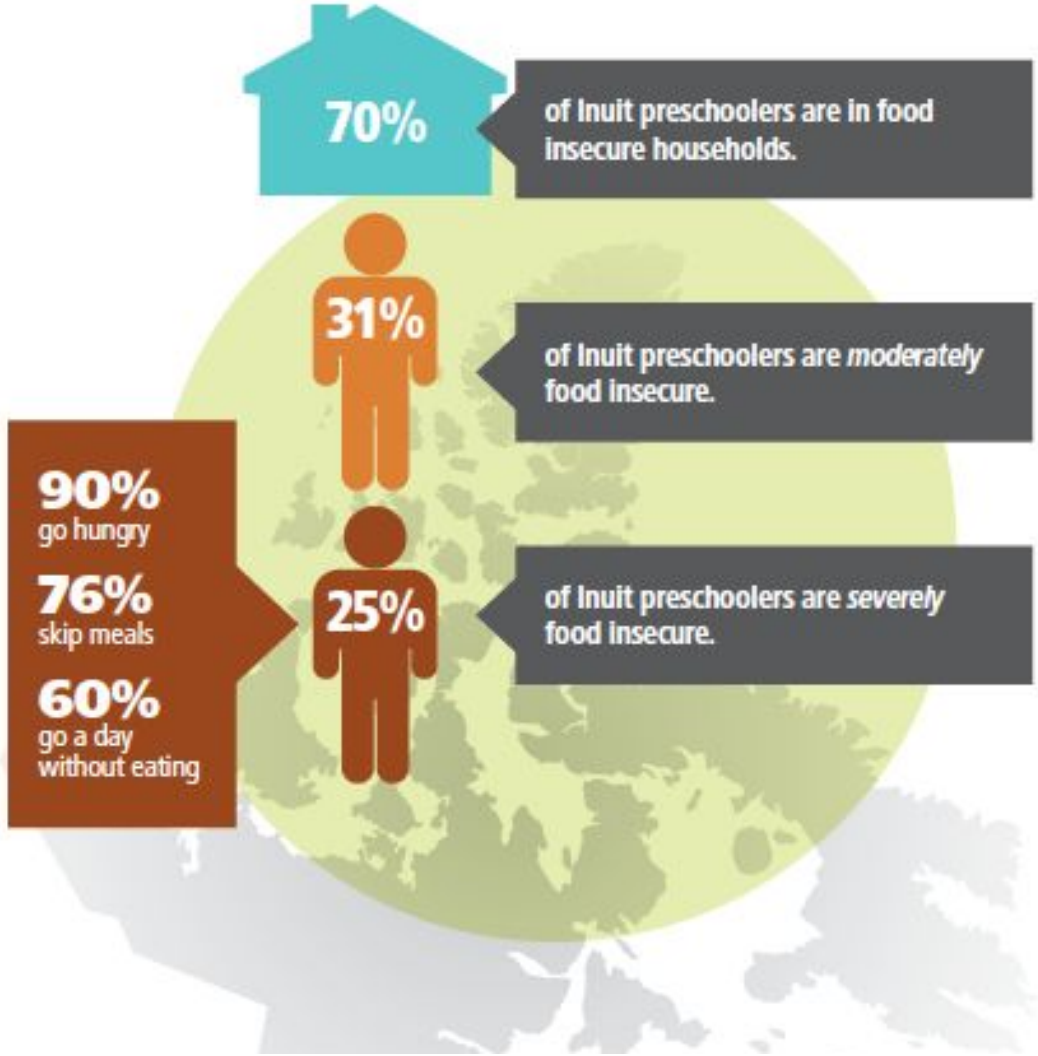
Consequences: Economic

- Commercial harvests on Victoria and Banks Island cancelled

Outfitted sport hunts, tourism continues, but, zoonotic risks?

Food Security

Aboriginal Food Security in Northern Canada: An Assessment of the State of Knowledge

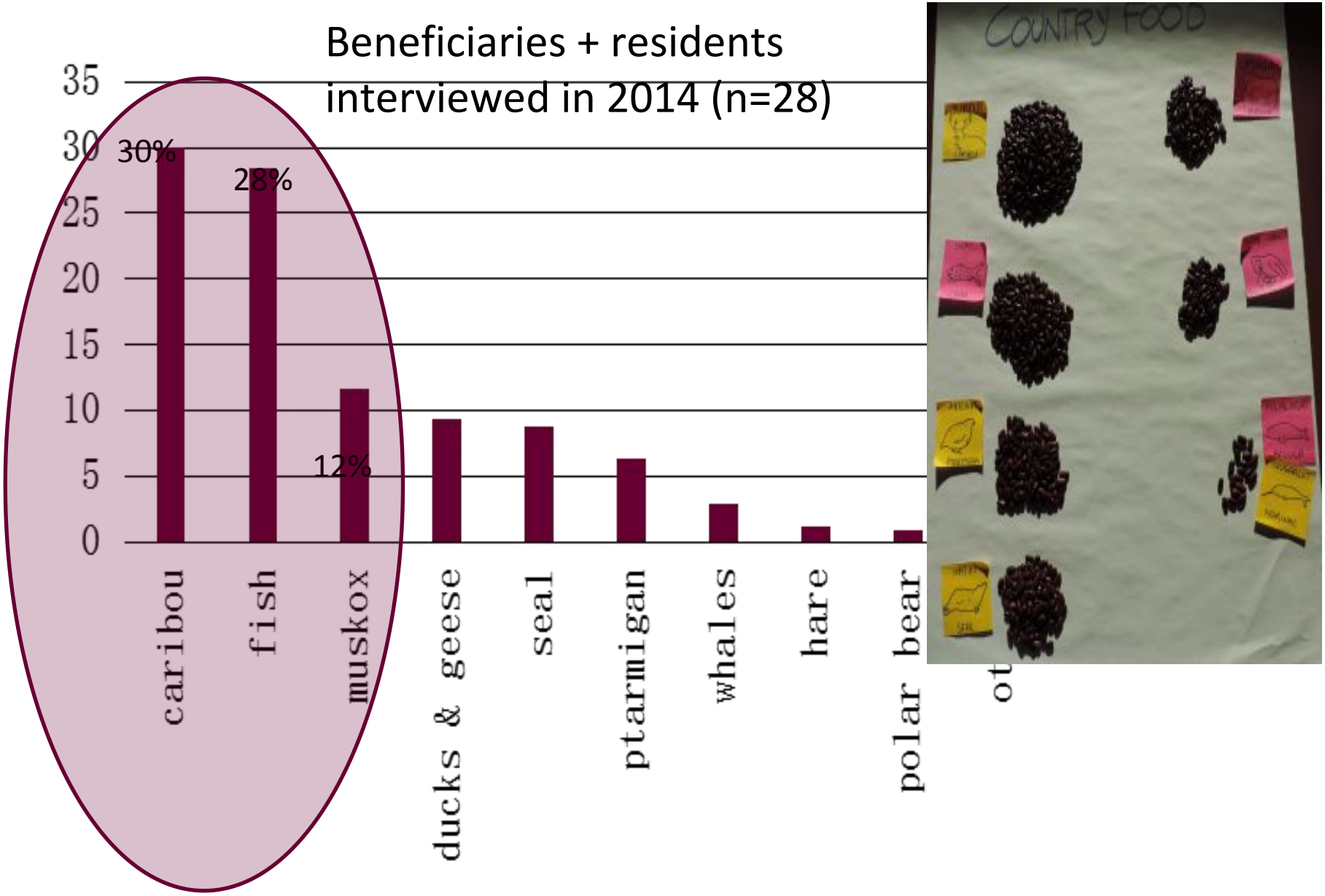



CONES
WAFFLE CONES
NO BREAD
UNTIL THE
PLANE
COMES IN!
SORRY FOR
THE INCONVENIANCE!

Country food preferences in Ikaluktutiak, NU

(Matilde Tomaselli, MSc student)

Beneficiaries + residents interviewed in 2014 (n=28)



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Understanding and tracking existing pathogen biodiversity, and
Anticipating emerging pathogen risks, will guide
Pro-active management and policy, that
Promote resilient muskox populations, and
Healthy and sustainable arctic communities

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Thank you!

Supporters, funders and partners

Ekaluktutiak Hunters and Trappers Association
Kugluktuk Angoniatit Association
Sachs Harbour Hunters and Trappers Committee
Paulatuk Hunter and Trappers Committee
Nunavut Harvesters Association
Nunavut General Monitoring Plan