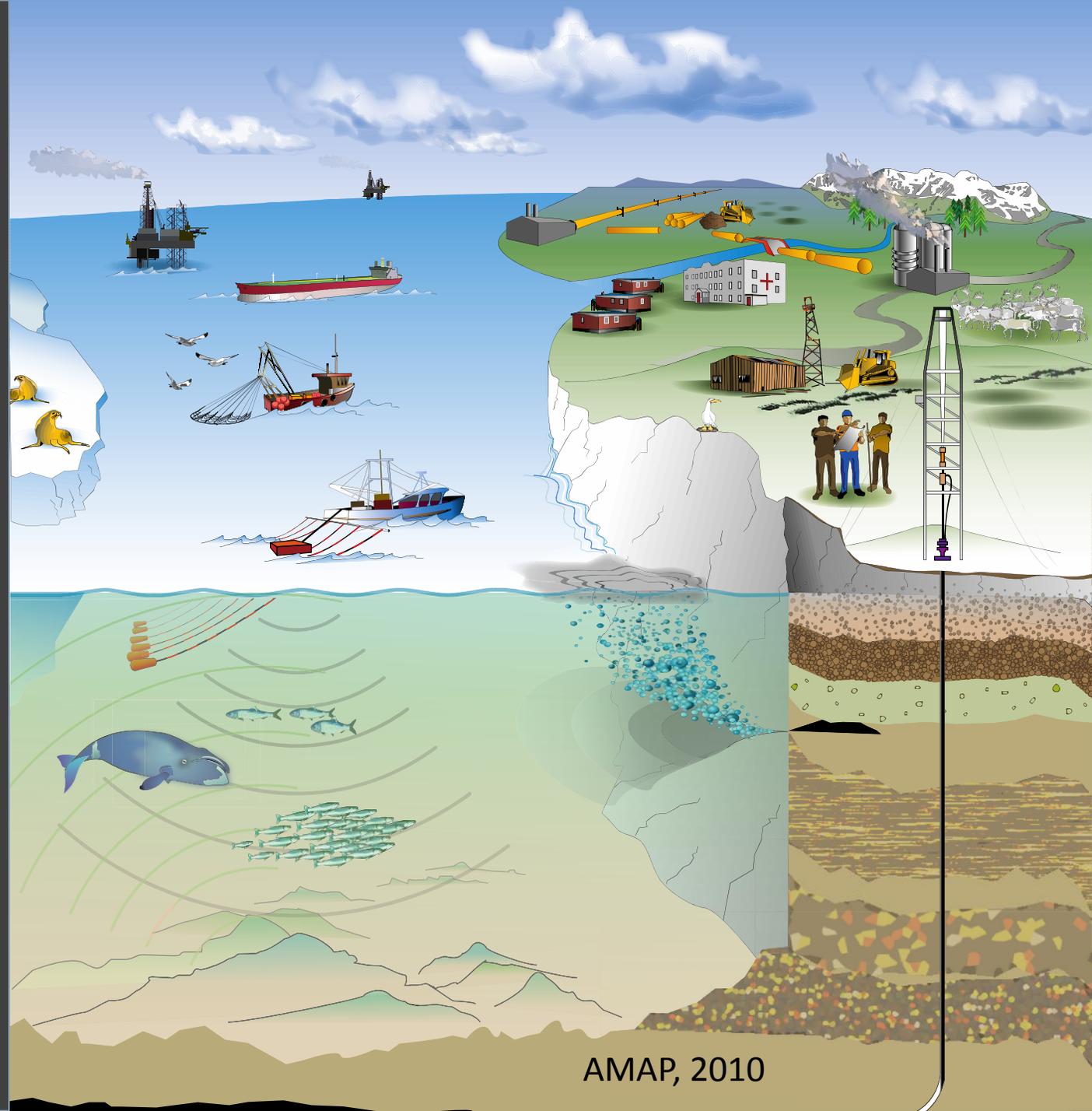


# RATIC 2017

## Sustainable Arctic Infrastructure Forum

Prague CZ / 6 April 2017



AMAP, 2010



✧ 39 Participants

✧ Introductory talks (Walker, Kumpula, Schweitzer, Kofinas)

✧ Keynote student presentation (Will Tyson)

✧ Breakout sessions to address scientific and policy issues related to major types of infrastructure

## Background

Key literature

Relevant case studies

Important historical references

## The System: Drivers and effects of change

Key components, linkages and feedbacks

Impacts of climate change

Social-ecological impacts of the infrastructure itself

Climate-infrastructure interactions

## Vulnerability and Resilience

Social/ecological vulnerabilities to infrastructure or climate change?

Examples of resilience

Possible thresholds leading to regime change

Examples of heterogeneity

## Policy Issues

Policy or regulatory issues

Ideas for involving local communities, government, and industry

Examples of successful adaptation or adaptive management

Barriers to successful adaptation or adaptive management of change

## Tools, Approaches and Institutions

Examples of promising strategies or case studies for adaptation

Scientific tools or approaches for monitoring change

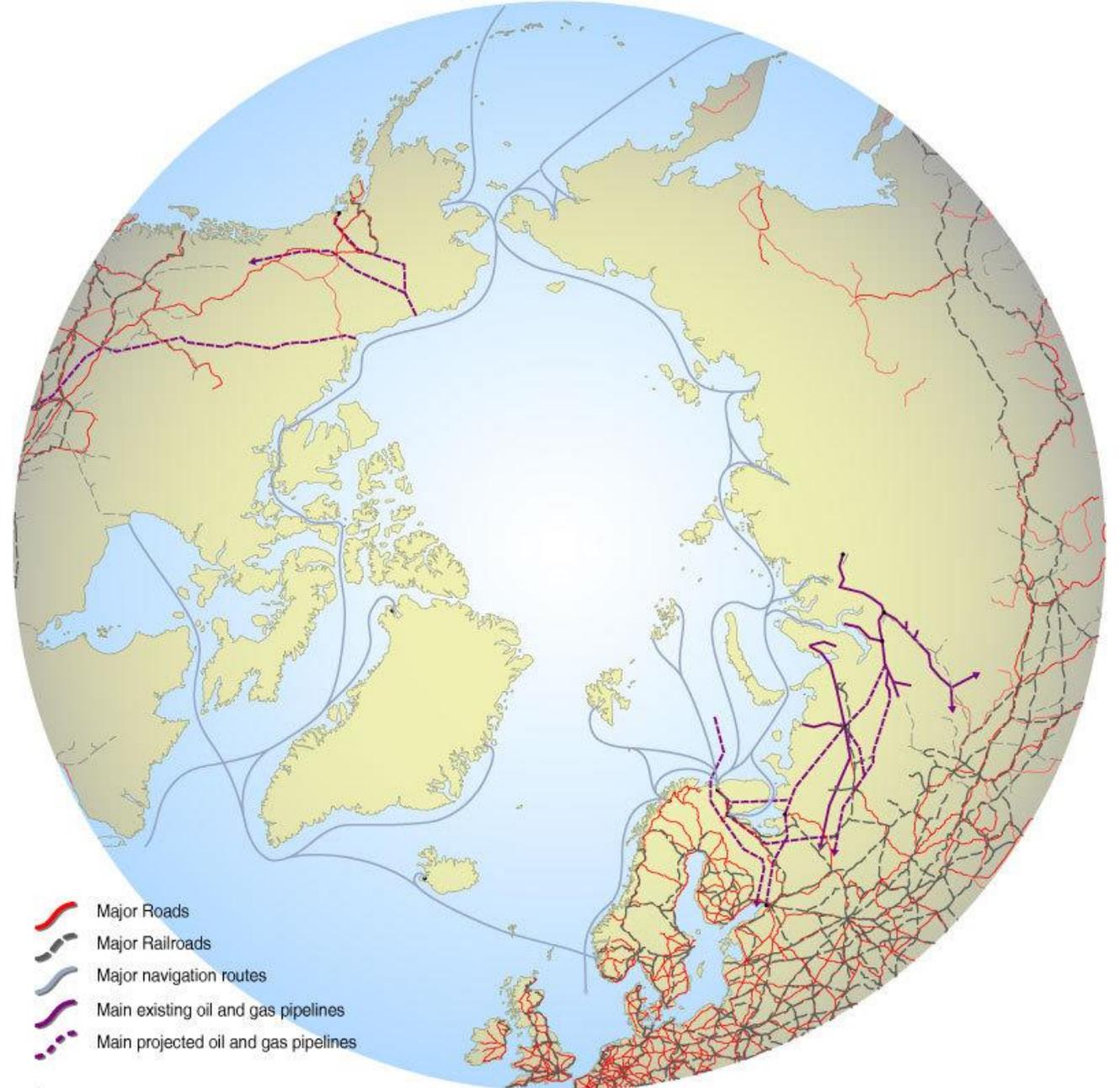
Groups or institutions studying climate impacts and adaptation

Other groups who might support or collaborate on this work

IASC working groups to involve

## Corridors:

Permanent and temporary linear structures connecting communities or important natural monuments and sites



### Sources:

United States Geological Survey (USGS); AMAP 1997, 1998 and 2002; CAFF, 2001; UNEP/ World Conservation Monitoring Centre (WCMC); United States Energy Information Administration (EIA); International Energy Agency (IEA); Barents Euro-Arctic Council (BEAC); Comité professionnel du pétrole (CPDP), Paris; Institut français du pétrole (IFP), Paris; National Oceanic and Atmospheric Administration (NOAA); The World Bank; Alaska Department of Environmental conservation, Division of Spill Prevention and Response; United States Coast Guard (USCG); ESRI Data & Maps 2000.

## Remote Communities:

Lack of  
“connectedness.”  
No year-round  
road access.  
Distant from  
decision making  
bodies.



Teacher's House  
Lost foundation.

Andrew Baldwin  
at the edge of  
the bank.

## Indigenous Infrastructure:

Connected with subsistence and other forms of traditional resource use (Corrals, trails, camps)



# Onshore Oil & Gas Infrastructure:

Roads,  
pipelines,  
drilling and  
facility pads



**Urban  
Infrastructure:**  
(Cities)  
Characterized  
by density and  
complexity.





**“10,000 meter”**

**view:**

We will fly over the  
details.

**Remote Communities + Corridors** → A lot is in technical reports, less in scientific literature. In Russian (pipelines) and Chinese (railways).

**Indigenous Infrastructure** → Aporta, Davydov, Forbes, Ford, Habeck, Istomin, Jordan, Kumpula, Povaroznyuk, Stammer, Schweitzer, et al.

**Onshore Oil & Gas** → Cumulative effects

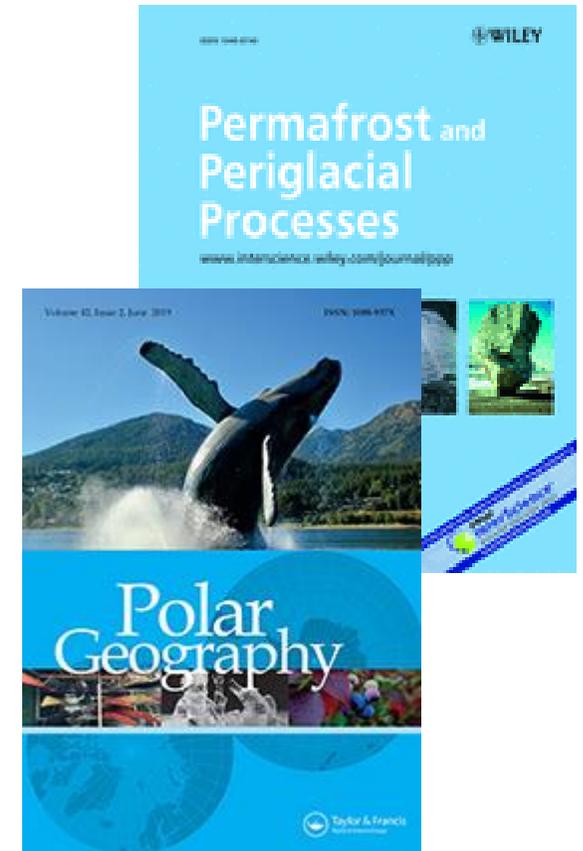
- Kumpula, Reynolds, Walker et al.
- AMAP 2010. Oil and Gas Activities in the Arctic
- U.S. National Research Council 2003. CE of oil and gas activities on Alaska's North Slope.

**Urban Infrastructure** →

- Polar Geography, Oct. 2017 special issue on Norilsk, Russia

**And much more...**

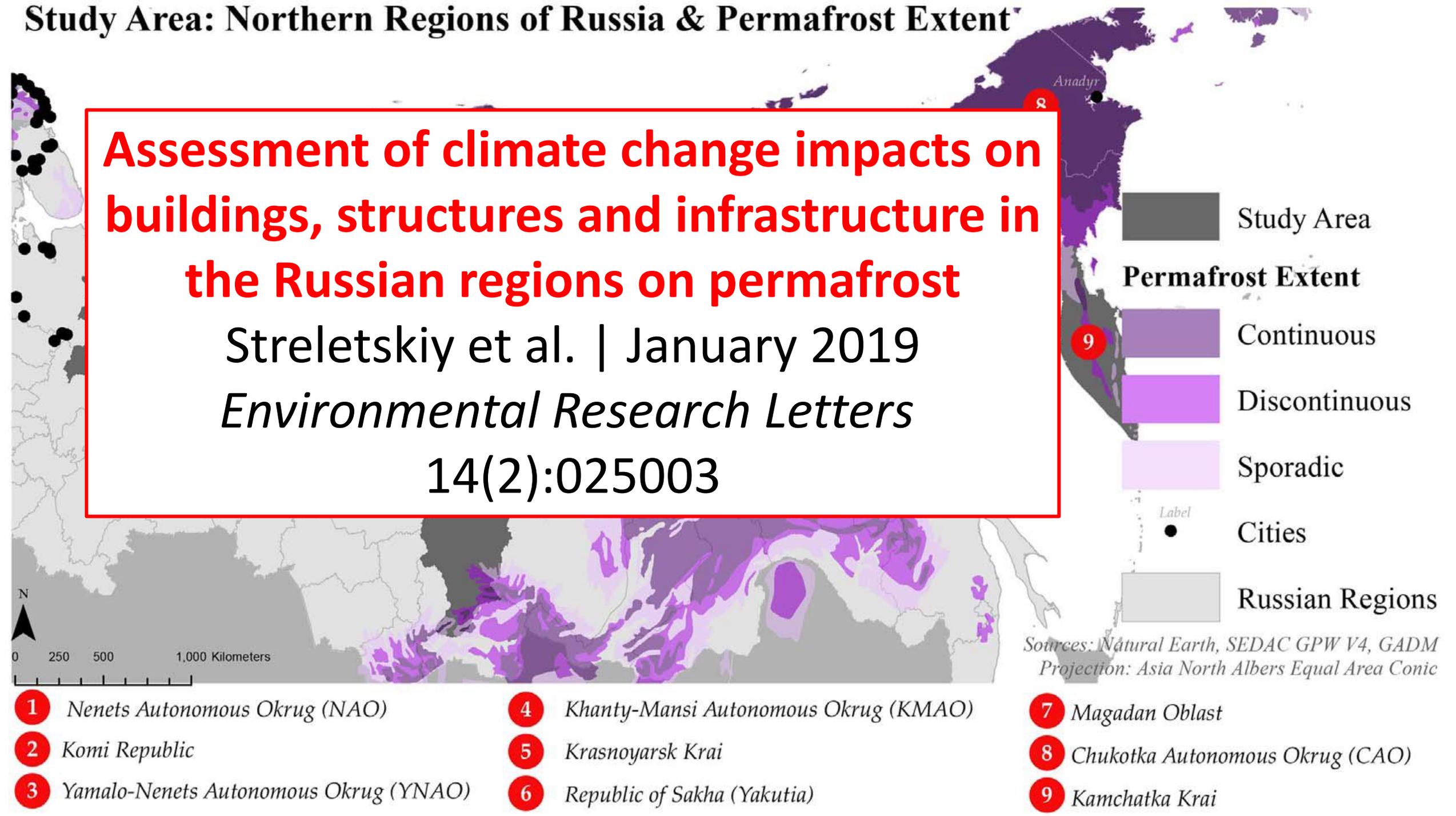
- Limited by time & who was in the room
- Need a more comprehensive list of key studies



# Study Area: Northern Regions of Russia & Permafrost Extent

## Assessment of climate change impacts on buildings, structures and infrastructure in the Russian regions on permafrost

Streletskiy et al. | January 2019  
*Environmental Research Letters*  
14(2):025003



1 Nenets Autonomous Okrug (NAO)

2 Komi Republic

3 Yamalo-Nenets Autonomous Okrug (YNAO)

4 Khanty-Mansi Autonomous Okrug (KMAO)

5 Krasnoyarsk Krai

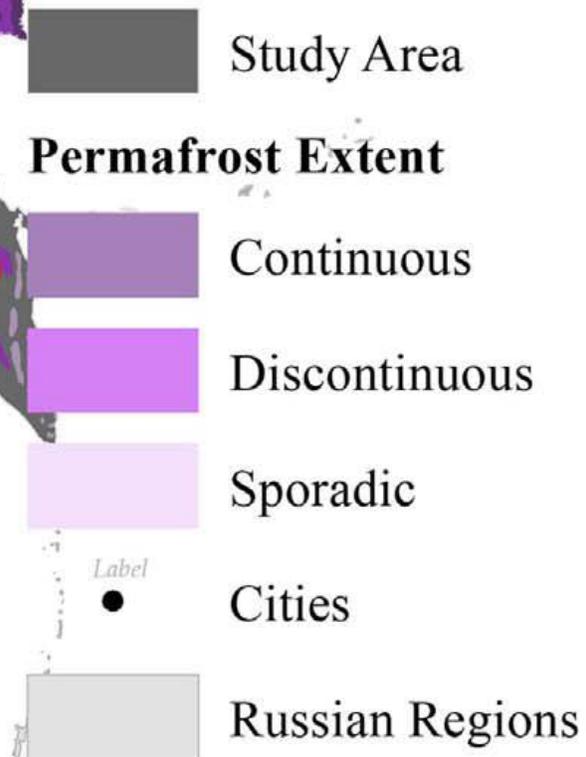
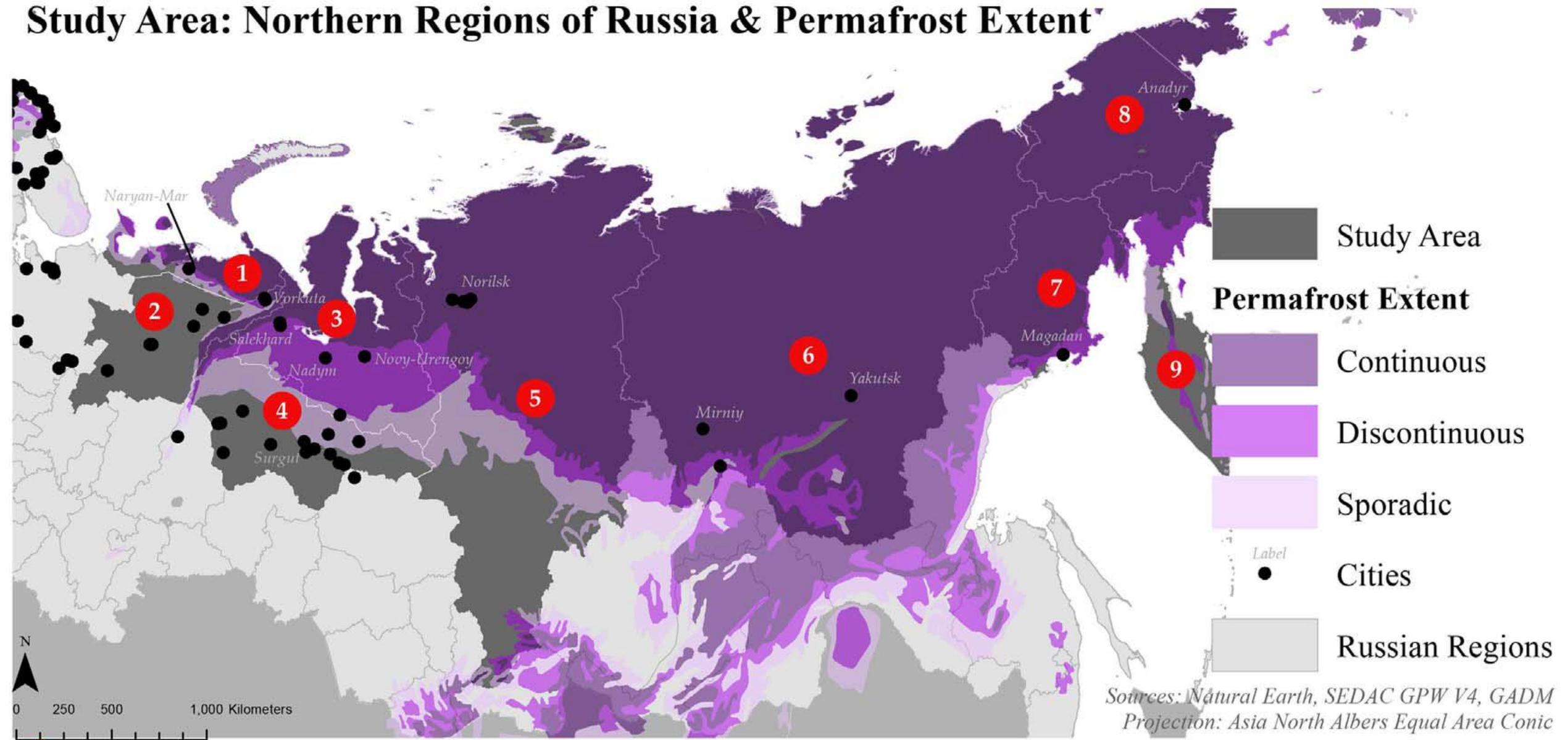
6 Republic of Sakha (Yakutia)

7 Magadan Oblast

8 Chukotka Autonomous Okrug (CAO)

9 Kamchatka Krai

# Study Area: Northern Regions of Russia & Permafrost Extent



Sources: Natural Earth, SEDAC GPW V4, GADM  
Projection: Asia North Albers Equal Area Conic

- |   |  |                                   |
|---|--|-----------------------------------|
| 1 Nenets Autonomous Okrug (NAO)         | 4 Khanty-Mansi Autonomous Okrug (KMAO) | 7 Magadan Oblast                  |
| 2 Komi Republic                         | 5 Krasnoyarsk Krai                     | 8 Chukotka Autonomous Okrug (CAO) |
| 3 Yamalo-Nenets Autonomous Okrug (YNAO) | 6 Republic of Sakha (Yakutia)          | 9 Kamchatka Krai                  |



# Drivers & Effects of Change

- Key components, linkages and feedbacks
- Impacts of climate change
- Social-ecological impacts of the infrastructure itself
- Climate-infrastructure interactions



# Corridors



# Remote Communities



## Mass Reindeer Deaths Linked to Extreme Climate Events on Yamal

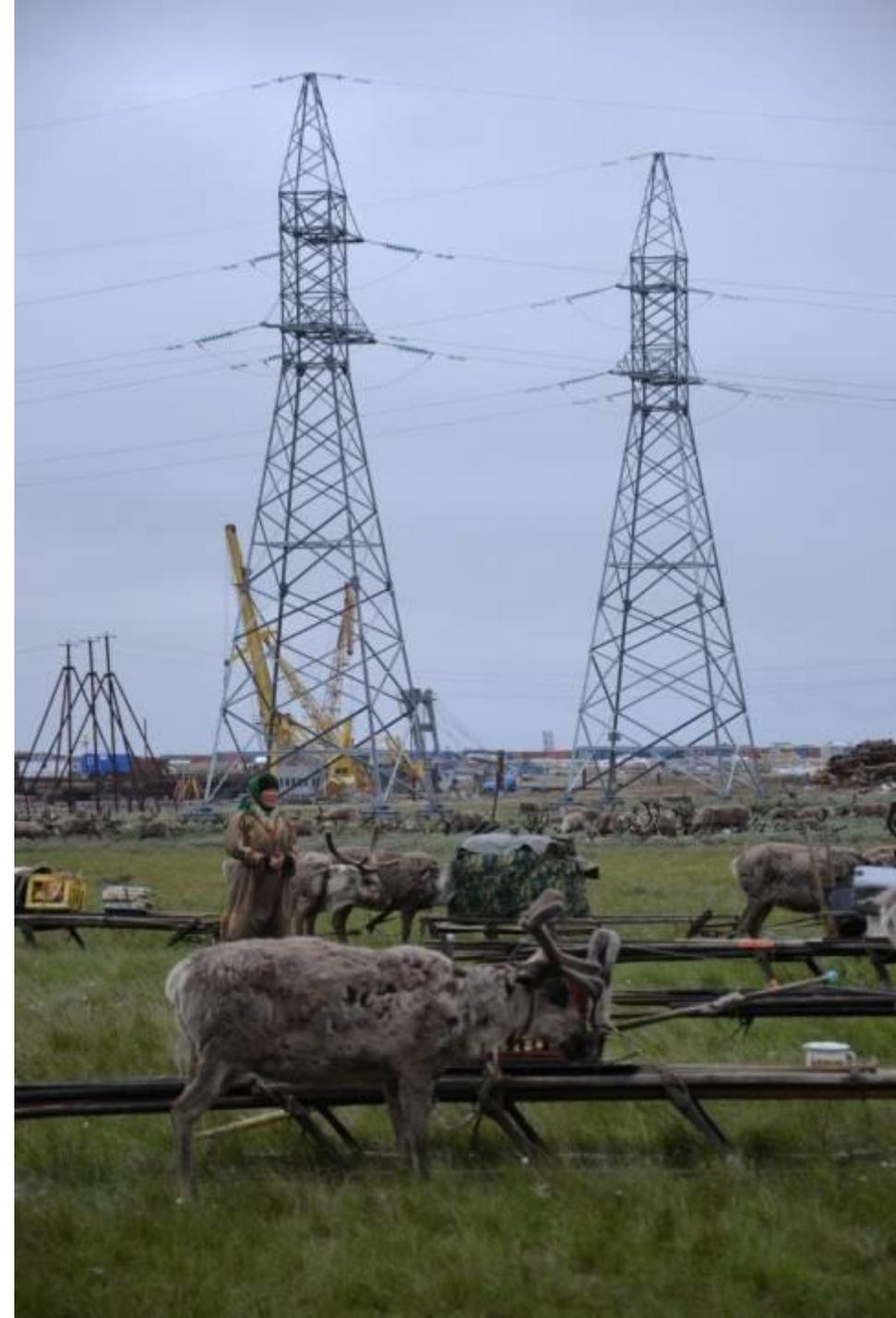
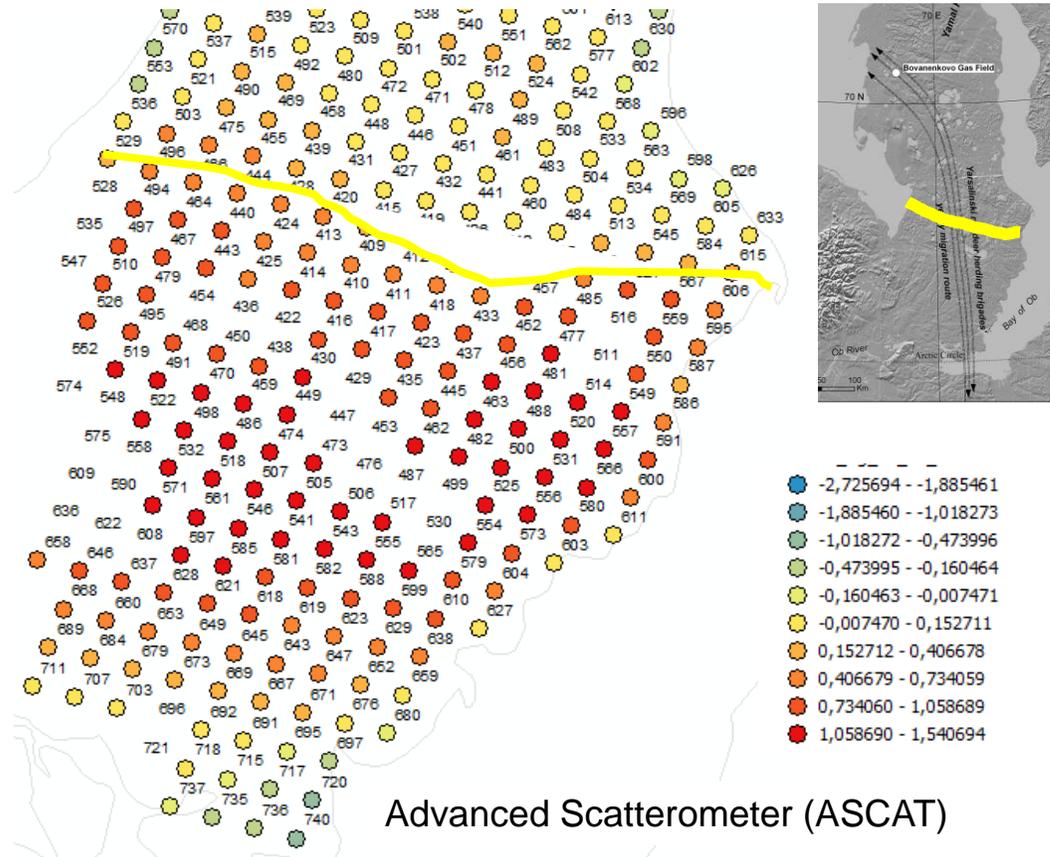
November 16, 2016 • Philip Burgess • Blog, Challenges, Reindeer, Reindeer Herders



Dead Reindeer,

From the press release announcing a new paper entitled 'Sea ice, and tundra reindeer nomadism in Arctic Russia' published today *Biology Letters*. You can read the article in full [here](#).

Scientists have interviewed nomadic reindeer herders in the Yamal Autonomous Okrug of West Siberia, the world's most productive



# Onshore Oil & Gas



# Urban Infrastructure



**“It’s not just permafrost”**

# How do climate & infrastructure impacts INTERACT?

- Dust effects on local vegetation.
- Dust effects from roads impact timing of spring melt leading to changes in spring wildlife distribution (e.g. snow-free corridors along roads in spring)
- Warming + roads lead to ice dams and potentially catastrophic flooding



## ...more interactions

- Warming temperatures affect permafrost regimes and stability of infrastructure
- Changes in snow regimes and redistribution of snow lead to warmer permafrost temperatures
- Flooding-hydrology coupled with permafrost heaves caused by increased snow accumulation and general warming





- **Vulnerabilities**
- **Resilience**
- **Barriers to successful adaptation**
- **Policy and regulatory issues**
- **Potential case studies**
- **Institutions**

## Observation and Monitoring

Field research & remote sensing monitoring of change

New sensor systems

- Fiber-optic systems to identify hotspots
- Higher resolution and temporal availability of satellite monitoring

Observations systems

- Innovation and integration to take a whole system approach with an accessible clearinghouse/hub

Water safety management and testing

- At a variety of levels (e.g. municipal services)
- Planning and decision-making integrated in monitoring systems

## Modeling and Mapping

- Mapping infrastructure
- 3D models of cities
- Infrastructure network modeling  
(Sandia Lab in New Mexico)
- Future scenarios models and scenarios planning  
(e.g. Tyson et al. 2016; Pembia Institute in Alberta)
- Risk hazard mapping
- Econometric modeling

## Cumulative Impact Assessment

- Historical data and reconnaissance
- Annual catalog (increased footprint of roads, pads, etc.)
- Cumulative impact assessment  
(e.g. Reynolds et al. 2014, Kumpula et al. 2010)
- Cumulative effects of ground thermal regimes

## Collaboration

- Interdisciplinary collaboration
- Participatory GIS
- Participatory photo mapping
- Capacity building in communities for long-term monitoring that includes adequate resources

## Indigenous Infrastructure & Governance

- Co-management, devolution  
(Be aware of informal arrangements)
- Provide economic incentives for involvement of industry and indigenous communities



# Key Science Questions

(in your handout)