

Cumulative effects of industrial development, reindeer herding, and climate change on the Yamal Peninsula Russia

Bruce C. Forbes, Florian Stammer, Anu Pajunen, Elina Kaarlejärvi: Arctic Centre, University of Lapland, bforbes@ulapland.fi

Timo Kumpula: Department of Geography, University of Joensuu, timo.kumpula@joensuu.fi
 Nina Meschtyb: Institute of Ethnology and Anthropology RAS, Moscow, meschtyb@mail.ru
 Artem Khomutov: Earth Cryosphere Institute SB RAS, Tyumen, Russia, akhomutov@gmail.com
 Anatoli Gubarkov: Tyumen State Oil and Gas University, Tyumen, Russia, agubarkov@mail.ru
 Marina Leibman: Earth Cryosphere Institute SB RAS, Moscow, Russia, moleibman@gmail.com
 Donald A. (Skip) Walker: Institute of Arctic Biology, University of Alaska Fairbanks, fdaw@uaf.edu



Photo credit: Bryan and Cherry Alexander

Abstract:

Oil and gas activities over the past 30+ years have had profound impacts on the social-ecological systems of northwestern Russia. The region has also been undergoing rapid climatic warming, with important ramifications for tundra vegetation and permafrost soils. We are investigating the extent of visible and perceived changes by using a case study approach in two areas of intensive oil and gas development. Migratory Nenets reindeer herders, whose 'brigades' (herding units) interact directly with oil and gas infrastructure and workers, are active participants in the project. Our aim is the co-production of knowledge relevant to assessing the overall impacts – both positive and negative – from past exploration and current production phases. This approach combines state-of-the-art quantitative methods, such as very high-resolution satellite image analysis, with the qualitative 'traditional' knowledge that comes from the collective experience of herding, hunting, fishing, and gathering

throughout the same territories for centuries. Gross changes in land cover, such as desertification and expanding infrastructure, are relatively easy to detect via remote sensing. However, understanding how contemporary livelihoods actually are affected by and respond to these processes requires extensive participant observation and interviews with Nenets herders both in the tundra and in the villages. Important findings to date include: (1) Large areas of terrain have switched from shrub-dominated to graminoid-dominated. (2) Mechanical disturbance can lead either to erosion, on sandy substrates, or to highly productive swards on more organic soils. (3) Herders recognize weather patterns interpreted by scientists as clear signals of a warming climate, e.g. later freeze-up, earlier thaw, increasing shrubs, mid-winter icing events. (4) They feel that changes associated with petroleum development present more serious short- and long-term threats due to losses of pastureland and a lack of meaningful input into development-related decision-making.

Greening of the Arctic An IPY Initiative

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Effects of industrial development:

Satellite-based analysis of extent of gas-field impacts



Vehicle trails created by "vezdekhod" off-road vehicles.

Analysis of detectability of impacts by different satellite sensors.

Impact	Detectability	Field survey	Quikbird-2	Quikbird-2	ASTER TERRA VHR	Landsat TM	Landsat MERIS
Soil contamination, oil & chemicals	X	X	X	X	X	X	X
Removal of top soil and vegetation	X	X	X	X	X	X	X
Quarries	X	X	X	X	X	X	X
Garbage	X	X	X	X	X	X	X
- metal	X	X	X	X	X	X	X
- glass	X	X	X	X	X	X	X
- concrete	X	X	X	X	X	X	X
- wood	X	X	X	X	X	X	X
Pipelines	X	X	X	X	X	X	X
Powerlines	X	X	X	X	X	X	X
Roads	X	X	X	X	X	X	X
Offroad tracks	X	X	X	X	X	X	X
Winter roads	X	X	X	X	X	X	X
Drill towers	X	X	X	X	X	X	X
Baracks	X	X	X	X	X	X	X
Trucks/Vehicles	X	X	X	X	X	X	X
Changes in hydrology	X	X	X	X	X	X	X

Extent of industrial effects

Permanently changed:
 Infrastructure 2.1 km²
 Quarries 4.3 km²
 Roads 2.9 km² (79 km)
TOTAL 9.3 km²

Changed vegetation (mainly shrubs to graminoids):
 Off-road vehicle tracks 24 km² (2500 km)

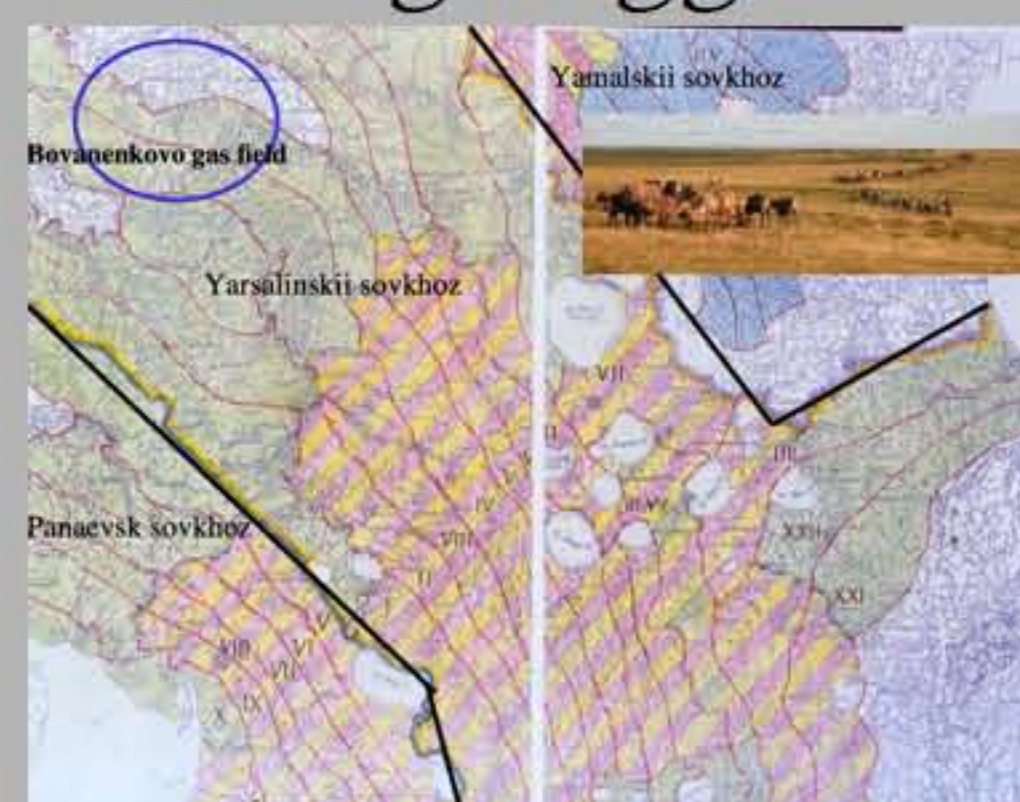
TOTAL CHANGED AREA 33 km²

Total extent of the gas field (perimeter) including currently enclosed unimpacted areas **448 km²**

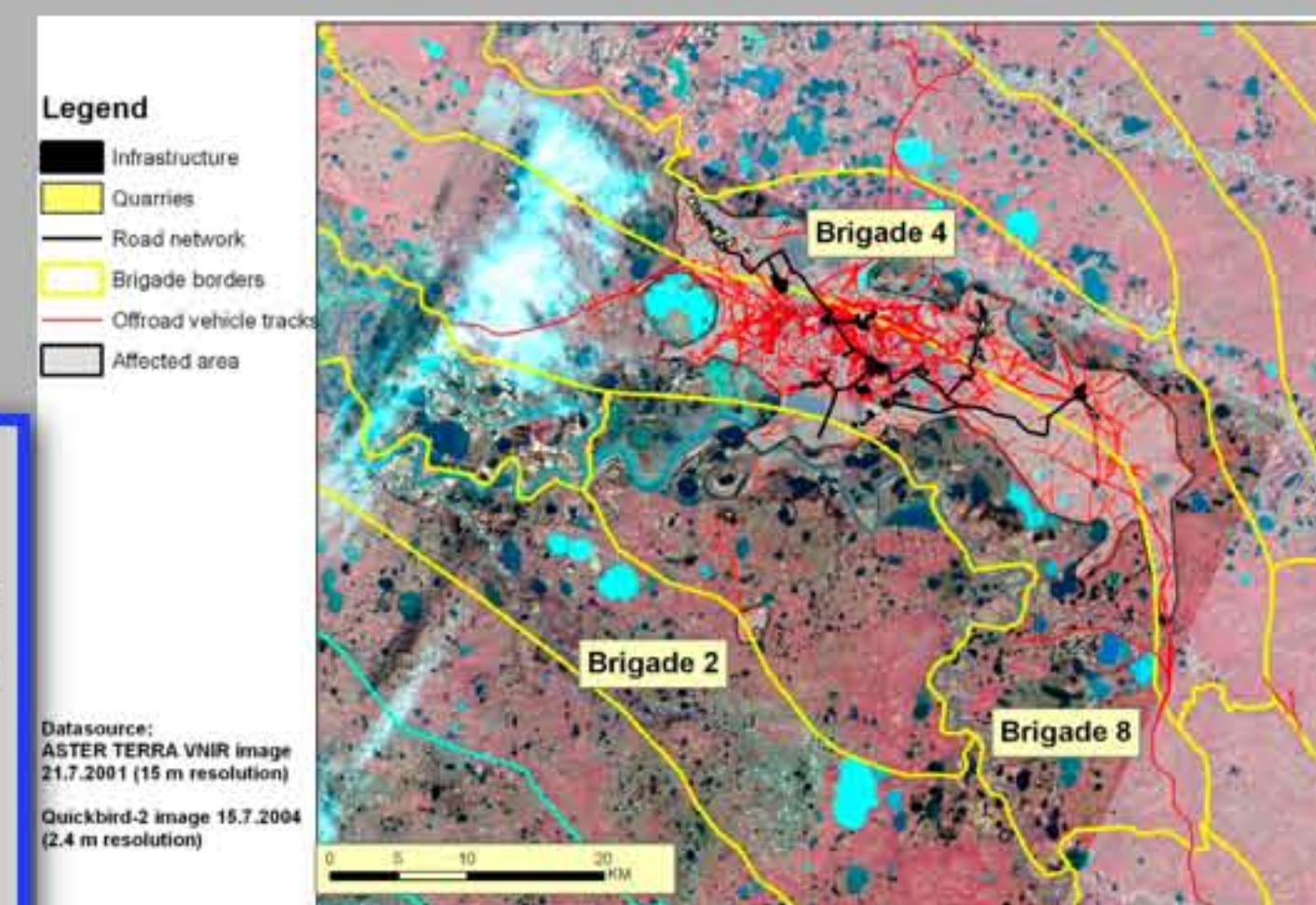
Conclusions:

- Direct (planned) impacts of industrial activities are currently local and limited in extent, but this is changing rapidly as extensive gas fields are developed.
- Indirect impacts (such as ORV trails and road dust) are much more extensive than the direct impacts.
- Industrial development (mainly roads and pipelines) is creating serious barriers to migration corridors and limiting the areas of summer pasture.
- Herders generally view the threats from industrial development to be much greater than threats from climate change, but they generally view the gas development positively because of increased economic opportunities.
- Land withdrawals by industry, increasing Nenets population, and larger reindeer herds are also increasing pressure on the rangelands.
- Climate change effects are currently hard to document because of lack of long-term ground observations. Satellite data suggest that there has been only modest summer land-surface warming and only slight greening changes across the Yamal during the past 24 years.
- However, there is high potential for extensive landscape effects due to unstable sandy soils, and extremely ice-rich permafrost near the surface.

Satellite-based analysis of impact to reindeer grazing grounds



Corridors for Nenets brigades moving to and from summer pastures



Impacts of Bovanenkovo gas field to summer pasture of Brigades 4 and 8:
 • Brigade 4: 225 km² out of total 1019 km² summer pasture
 • Brigade 8: 200 km² out of total 796 km² summer pasture

GIS database collection

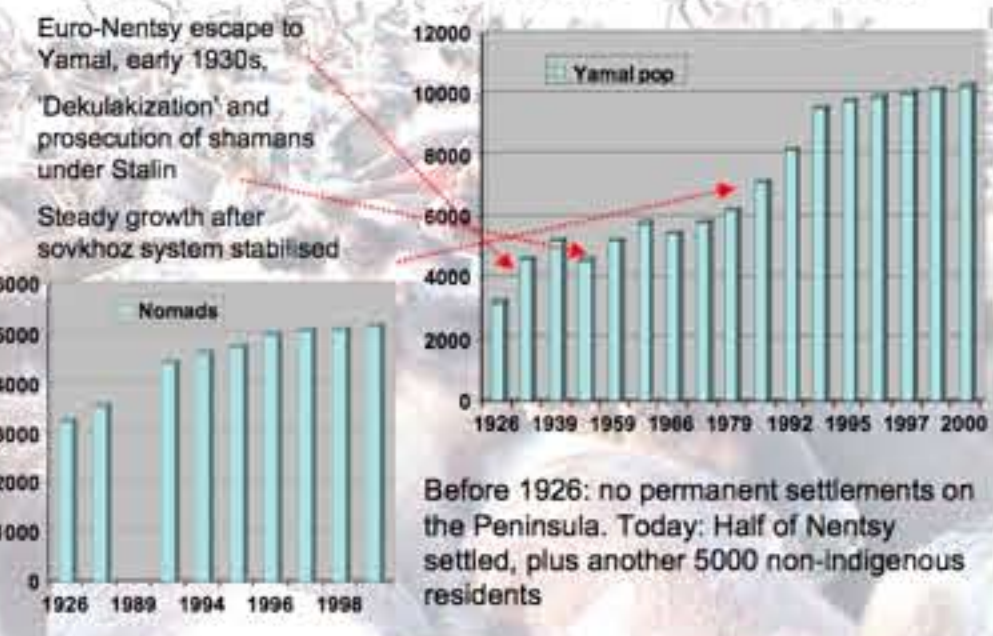
- Visual interpretation of impacts, digitizing:
 - Digital elevation model from 1: 100 000 maps
 - Road network
 - Pipeline network
 - Off road vehicle track network
 - Infrastructure
 - Quarries



Kumpula, in prep.

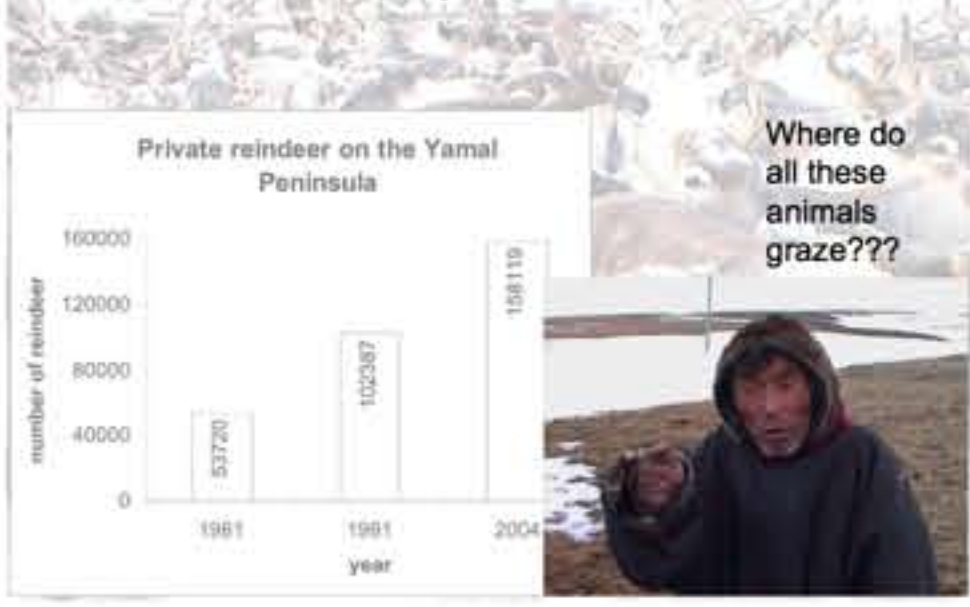
Effects of reindeer herding:

Increase of humans on Yamal



Stammer et al. in prep.

Increase of private reindeer



Nenets brigadier and children playing volleyball in front of herded reindeer.

Barren area due to trampling caused by concentrated reindeer activity.

Grassification: Replacement of shrub-vegetation with grassland (foreground) following heavy grazing and trampling.

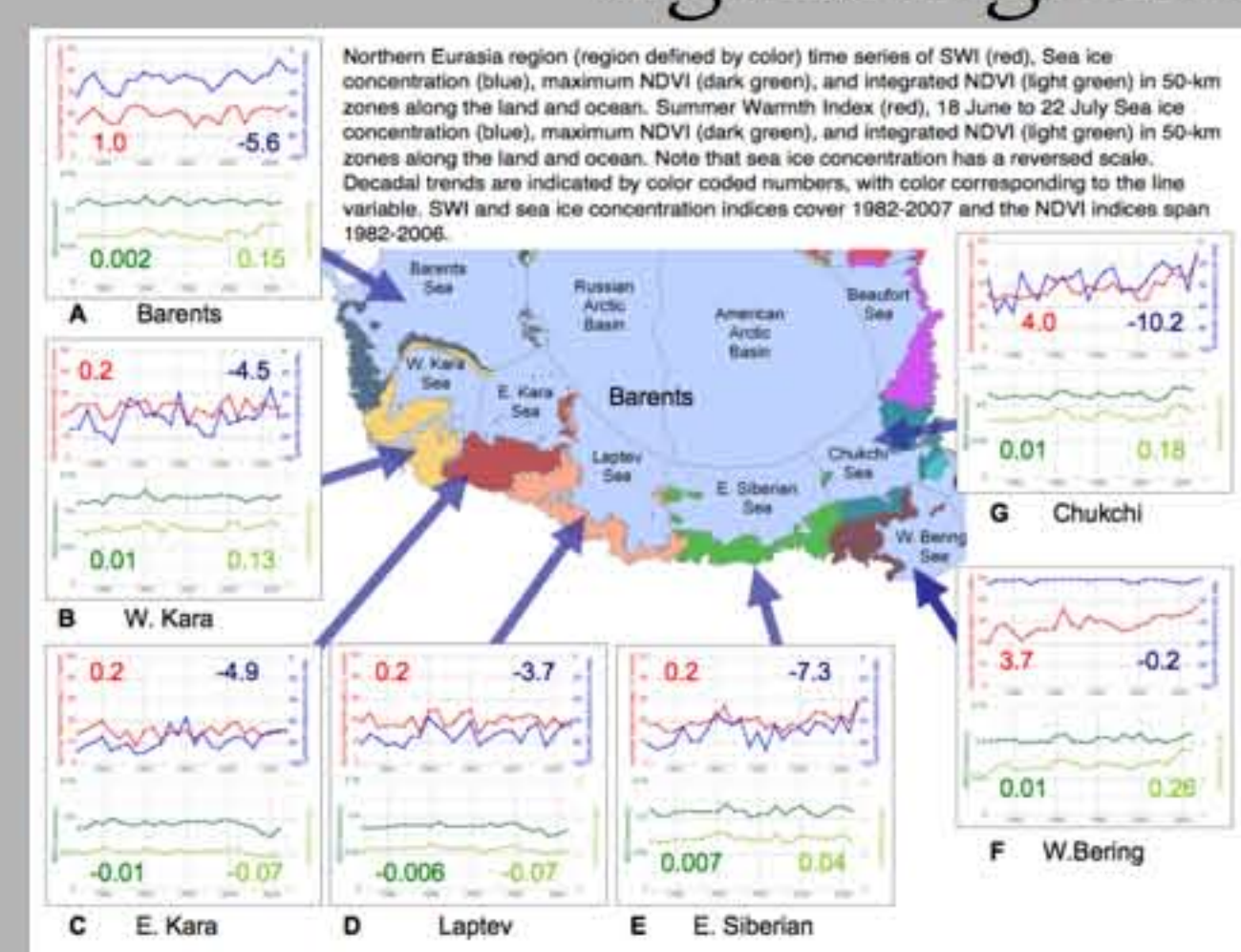
Wind erosion aggravated by heavy trampling.



"...in addition to taking part in daily life and seeing with our own eyes exactly how the animals are managed we ... do more formal semi-structured interviews. Some of these are recorded on either digital tape or film, or both. In these cases we have medium or very high resolution satellite imagery of the areas we are discussing to focus on specific places and features that the herders can recognize easily."
 —Bruce Forbes

Effects of climate change:

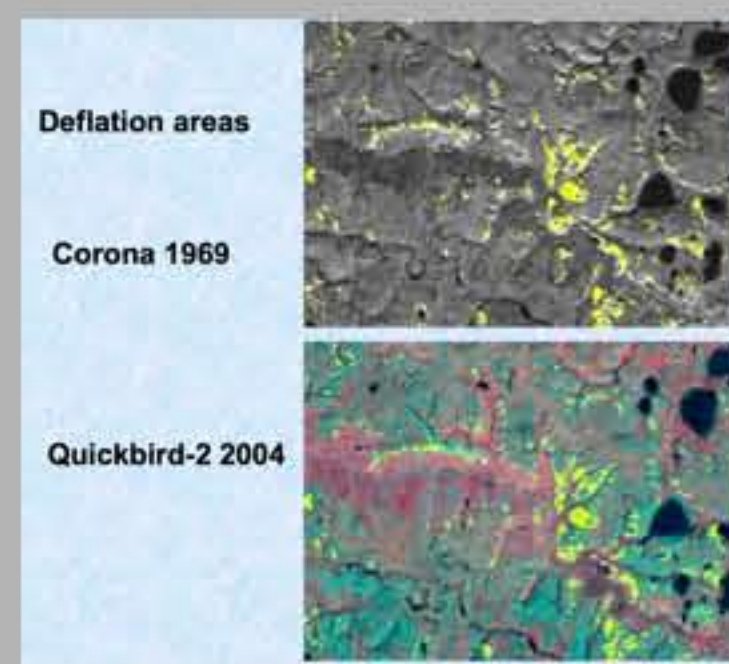
Sea-ice retreat, land-surface temperatures and vegetation greenness



Bhatt et al. in prep.

- Sea ice in the Kara Sea has retreated somewhat earlier over the past 24 years, but not as strongly as in the E. Siberian and Chukchi seas.
- Land surface temperatures on the Yamal have shown only a slight increase.
- Greenness has not increased, whereas it has in other areas of northern Eurasia (e.g. W. Bering, and Chukchi seas regions).

Possible landscape effects of climate change

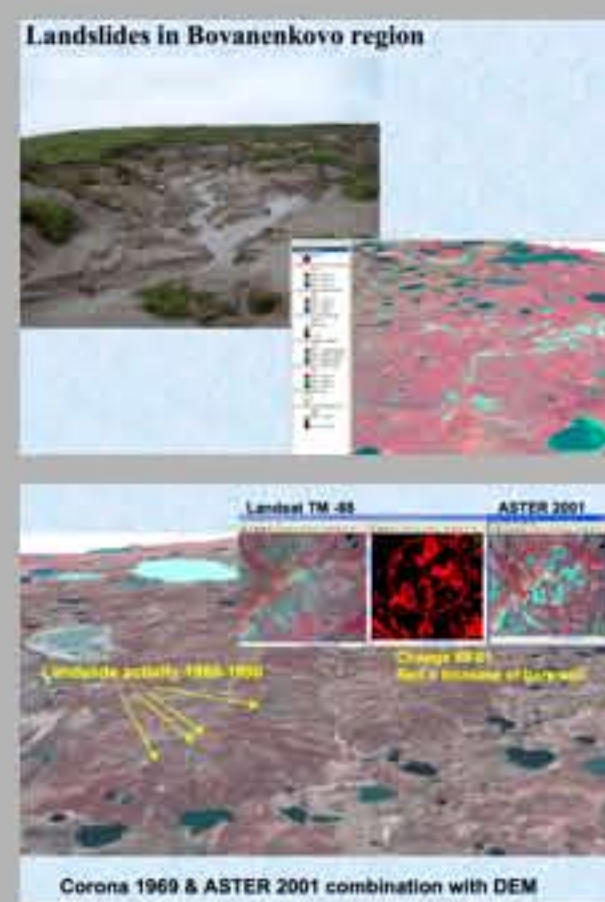


Eolian erosion

- Sandy substrates highly susceptible to wind erosion.
- Exacerbated by stronger winds near the coast and increased reindeer activity.
- Drier, warmer conditions could increase activity.

Landslides

- Extreme ice-rich permafrost near the surface makes the region very susceptible to landslides.
- Extensive landslides in unusually wet year of 1999.



Shrubification

- Increased shrubs due to warmer summer temperatures – mainly on landslides.
- Documented in other areas of the Arctic, but long-term observations needed on the Yamal.