Cumulative effects of rapid climate and land-use changes on the Yamal Peninsula, Russia

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Photos: D.A. Walker
The Greening of the Arctic Project: Two Arctic Transects

- North America Arctic Transect: Alaska-Canada.
- Eurasia Transect: Yamal Peninsula.
- Through all 5 Arctic bioclimate subzones.

Yamal Transect

2007
- Nadym
- Laborovaya
- Vaskiny Dachi

2008
- Kharasavey

2010 (proposed)
- Ostrov Belyy
- Russkaya Gavan (or Franz Josef Land)
- Marresale (or site in N. Yamal)
Collaborators

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Jiong Jia: REC-TEA, Chinese Academy of Science
Joey Comiso: NASA Goddard

Photo: D.A. Walker

NASA: Land Cover Land-Use Change program
- Funding NASA LCLUC program.
- NEESPI (CLPN) project.
The Yamal

Typical of the sorts of changes that are likely to become much more common in tundra areas of Russia and the circumpolar region within the next decade.

- Currently, large areas of wilderness with no roads or development, but...
- large-scale gas and oil potential,
- extraordinarily sensitive permafrost environment
- traditional pasturelands for the nomadic Yamal Nenets people,
- rapid changes in climate.

Goal: Develop tools using remote sensing and modeling to better predict the cumulative effects of resource development, climate change, reindeer herding, and the role of terrain factors in affecting changes in tundra regions.
Large-scale development will occur once road, railroad and pipeline links to the south are built.

Existing and designed pipelines

- "Gazprom" has accepted the Yamal hydrocarbons transportation scheme of main pipeline across the Baidarata Bay of the Kara Sea. Four pipelines will transport 50–60 billions m³ of gas each.
Relaxed Regulatory Environment

Photos: D.A. Walker
Extent of infrastructure of Bovanenkova Field compared to Prudhoe Bay

Currently, about 1/10 the roads and pads, 1/5 the area of Prudhoe Bay and about 1/2 the detectable impact.


Extent of the North Slope, AK development (2001)

Roads: 954 km
Pads: 24.2 km²
Total extent: 2,600 km²
Detectable disturbances: 70.5 km²

Roads: 79 km
Pads: 2.1 km²
Total extent: 448 km²
Detectable disturbances: 33.3 km²

The Nentsy and their reindeer

Increase of humans on Yamal

Euro-Nentsy escape to Yamal, early 1930s.

Dekulakization and prosecution of shamans under Stalin.

Steady growth after sovkhiz system stabilised.

Increase of private reindeer


Where do all these animals graze???
The Nentsy use the entire Yamal Peninsula.
Threats from industrial development are much greater than threats from climate change.

However, they currently generally view the gas development positively because of increased economic opportunities (e.g. markets for reindeer, some perks from the industry).

Moderate demands:
1. Complete and timely reclamation of lands used during the technical work that are not industrial and have no facilities on them.
2. Establishing and protecting corridors for movement between camps by people and reindeer herders.


However, there is a lack of equity in discussions regarding land-use.

- Despite an amazing ability to adapt to past climate, social, economic, and political upheavals in Russia, the Nentsy face difficult challenges with respect to adapting to industrial change because they lack title to their land.

- In Alaska and Canada, indigenous groups gained legal land claims. No such legal land rights exist for the Nentsy.

Pavel Orekhov and Nenets herder.
Photo: D.A. Walker

Analysis of sea-ice, land surface temperature and NDVI trends

- 50-km buffers seaward and landward along each sea coast.

- 1982-2007 AVHRR data to analyze trends in sea ice concentration, LST, and NDVI.

Bhatt et al., in progress, 2008.
Sea-ice, temperature and greening trends in Kara/Yamal region of Russia, 1982-2007

Sea ice: -25%)
Summer surface temperature: +4%
Maximum NDVI: +3%

None of the trends are significant at $p = 0.05$ because of high interannual variability.

Compared to other areas of the Arctic, the Yamal has shown comparable levels of sea-ice retreat, but less increase in temperature, and NDVI.

Circumpolar Analysis of NDVI patterns

Circumpolar Data Sets

AVHRR Land-surface Temp

Permafrost

Soils

Glacial Geology

NDVI

Primary controls at pan-Arctic scale:
- Summer temp
- Lake cover
- Glacial history
- Soil type


:Martha Raynolds Ph.D. thesis
NDVI vs. Summer Warmth on the Yamal compared to the Circumpolar Arctic

- Arctic as a whole has much stronger correlations between NDVI and SWI.

Areas with less NDVI than expected are brown, areas with more NDVI than expected are green.

Comparison of observed and predicted greening based on SWI / NDVI relationship for entire Arctic

Most of the peninsula is greener than we expected.

Effects of climate change: Analysis of biomass and NDVI trends across the climate gradient

Field data collected:

Soils

Plant Cover

NDVI & LAI

Ground temperatures

Active layer

Plant Biomass
High-ice Permafrost Landscapes and extraordinarily high natural disturbance regimes

Extensive nutrient-poor surface sands with lichens that are easily overgrazed by reindeer.

Underlain by permafrost with massive pure ice.

Extensive landslides are rapidly eroding the landscape.

Photos: D.A. Walker and M. Liebman (upper right)
Extensive willow shrublands due to landslide disturbances

- Landslides expose salt-rich and nutrient-rich clays.
- Complex vegetation succession process result in willow-shrub tundra in the interior parts of the peninsula.

- Natural disturbances are the largest control of vegetation change on the Yamal.
- Anthropogenic disturbances and climate change locally replicate and exacerbate these changes.
Cumulative effects on the Yamal

**Resource development:**
- Indirect (unplanned) impacts (such as ORV trails, flooding from roads) are greater than the direct (planned) impacts (infrastructure).
- Roads and pipelines: serious barriers to migration corridors.
- Effects will increase as new field are developed.

**Landscape factors and terrain sensitivity:**
- High potential for extensive landscape effects due to unstable sandy soils, and extremely ice-rich permafrost near the surface.

**Reindeer herding:**
- Land withdrawals by industry, increasing Nenets population, and larger reindeer herds are all increasing pressure on the rangelands.
- Herders view: Threats from industrial development much greater than threats from climate change. Big concern is lack of power during negotiations.
- They currently generally view the gas development positively because of increased economic opportunities.

**Climate change:**
- 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. (Trend is much stronger in other parts of the Arctic, e.g. Beaufort Sea.)
- Kara-Yamal: negative sea ice, positive summer warmth and positive NDVI are correlated with positive phases of the North Atlantic Oscillation and Arctic Oscillation.
Working with permafrost experts, sociologists, biologists, and soil scientists with long experience on the Yamal Peninsula

Earth Cryosphere Institute, Russian Academy of Science, Moscow organized the expeditions. Led by Marina Liebman and Nataliya Moskalenko.

Elina Karlejaärvi (Arctic Centre, graduate student, botanist), Nataliya Moskalenko (ECI, ecologist), Howie Epstein (U Va Co-PI, ecosystem ecologist), Marina Liebman (ECI, Permafrost, geomorphologist), Patrick Kuss (UAF, Post Doc, botanist), Anatoly Gubarkov (ECI, graduate student, permafrost, industrial impacts), Artem Khumotov (ECI, graduate student, GIS), George Mateyshak (MSU, Soil Scientist), D.A. Walker (Project PI, geobotanist)

Photo: D. A. Walker
Florian Stammler interviewing members of a Nenets brigade.
Combining remote sensing and traditional knowledge.

Photo: Bruce Forbes