# Landscape Change in the Russian Arctic: Ecological Implications of the Petroleum Industry for Nenets Reindeer Herding on the Yamal Peninsula

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## Introduction

Gas and oil exploration is growing rapidly in the Russian Arctic which causes increasing pressures to reindeer herding. The aim of the research is to investigate impacts of petroleum exploration on reindeer pastures and the overall nomadic Nenets economy. Natural changes due to the climatic or other factors are also examined.

The field research has taken place in the Yamal-Nenets Autonomous Okrug (YNAO) (Fig. 2). Nenets continue to practice migratory reindeer husbandry in the area. Pressures are environmental, social and economic. Extensive infrastructure like roads, pipelines, quarries and various garbage hinders the use of traditional migration routes.

Remote sensing is used to study how large are the areas that have been affected by industrial sites. Important questions are: what is the utility of affected areas to reindeer and reindeer herders and what is the general quality of pastures (Fig. 6). Very high-resolution (VHR) remote sensing data produce detailed information about the effects around the drilling sites. Even 5-15 year old all terrain vehicle tracks are visible in the images (Fig. 4).

## Remote sensing data

Research was carried out at the different scales (Fig. 1). Fine-scale data include ground truthing and false color camera photographs. The main data used to evaluate the current situation are derived from VHR Quickbird-2 satellite images (2,5 meter multispectral and 0,6m pan-chromatic resolution) (Fig. 1/4/5).

ASTER TERRA and Landsat TM images represents coarse and global scale data and are used to cover larger areas.

For the detection of the anthropogenic or natural changes the building of time series of satellite images since late 1960's is in progress. Corona spy satellite images provide the oldest data from 1969. Corona images are black and white with 10 meter resolution. Landsat, SPOT and ASTER images are from the period 1985-2005.
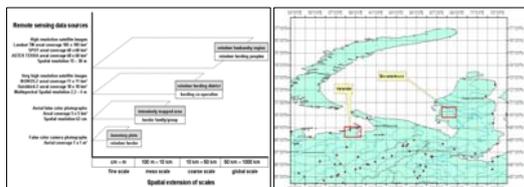


**Figures 1 & 2**. Reseach areas on the left and on the right the scales of investigations and relevant remote sensing data sources.

## Methods

Infrastructure, roads, quarries and all terrain vehicle tracks are digitized to respective map layers in ArcGIS software. After digitizing, buffers were created around roads, etc. and effected area around different objects were calculated.

ERDAS Imagine was used for image processing. Change detection between the images was produced with change detection module of ERDAS and by visual interpretation (Fig. 8).



**Figure 8.** Change detection between 1988-1999 Landsat TM images of Bovanenkovo gas field. Change detection has been done between NDVI's of 1988 and 1999. In 1 year much of those sites were vegetation was totally destroyed. As grasses invated area again and is seen as increase. Larger decreased area is new production site built in mid 1990's. Some changes in water and river banks are natural and/or due to the image rectification errors.
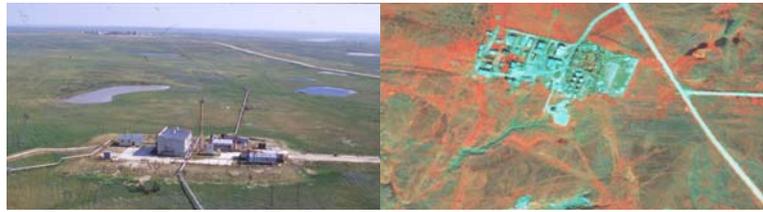


**Figures 3 and 4. On the left** Bovanenkovo gas field. **On the right** zoomed Quickbird-2 image showing drilling site and old all terrain vehicle tracks, which have been regrown. Road network was build in mid 1990's. Off road traffic is nowadays prohibited in summer period but violations occur.



**Figure 5.** Quicbird-2 panchromatic image (63 cm resolution) (Yamal). 2nd brigade of Yarsalinski sovhoz 15.7.2004. Photograghps: **Upper left:** Reindeer herd gathered for round up and to minimize the insect harrasment, **Upper right:** Reindeer brigade leader Vasili Serotetto (15.7.2005) from 2nd brigade interpreting his territory and migration routes from ASTER TERRA image. **Upper middle:** herders camp chums ( teepee) and sledges.

## Results

Data processing results indicate that it is possible to evaluate the disturbances from VHR-satellite images and calculate how much area in total has became unusable and also how much land has changed from one vegetation type to another due to the petroleum related activities.

With in Bovanenkovo gas field active the road network is 79 km and it covers 2,9km², infrastructure covers 2,1 km² and quarries or borrow pits cover 4,3 km² (Fig. 6/9). Already 450 km² is affected by the Bovanenkovo gas field, this has caused already problems for migratory reindeer herding brigades. Important summer pastures are at the risk from becoming degrated and/or inaccessible.



**Figures 6 and 7.** On the the left: Quickbird-2 zoom of abandoned sand quarry which has been used as dumping ground. On the right is a photograph from same site 3.8.2006

## Conclusions

- Petroleum industry affects strongly traditional livelihoods.

- Even though the industrial sites are relatively small-scale the pipeline, road and train networks constructions disturb the migration of nomadic herders and reindeer.

- Bovanenkovo gas field, which is still in the construction phase, will expand soon. The effects are expected to be be devasting to certain reindeer herding brigades crossing the gas field.

- Reindeer herders have direct observations on changes on tundra over a period of 30-50 years.

- Increasing accessibility to arctic drilling sites will increase the human impacts and can cause severe changes to the regions ecological conditions (increase of thermokarst in construction sites)

- Satellite imagery is essential data source in monitoring the implications

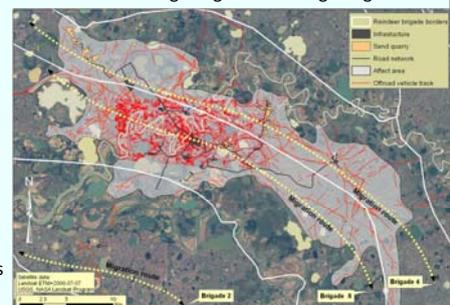- Anthopogenic impacts + possible climate warming may exacerbate the negative effects.



**Figure 9.** Bovanenkovo gas field affected area (450 km²). Reindeer herding brigades 4 and 8 are most affected by gas field. Through passage may be prohibited in near future.