ILWIS GIS for monitoring landscapes in tundra ecosystems: Yamal Peninsula, Russia

Polina Lemenkova

Dresden University of Technology (TU Dresden)

✉: Polina.Lemenkova@mailbox.tu-dresden.de

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Outline

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Brief Summary

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Research aim:

- distribution of various land cover types in Yamal Peninsula
- monitoring changes in tundra landscapes
- analysis of the landscape dynamics during the past two decades (1988-2011).

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Landsat TM scenes for 1988 and 2011 years.

Originality:
Application of ILWIS GIS spatial analysis tools and Landsat imagery for Bovanenkovo region in Yamal.

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Technical tools:
The RS data processing was performed in ILWIS GIS software: Fig.1

Research method:
Image interpretation applied to Landsat TM scenes, and supervised classification

Figure: 1. ILWIS GIS.
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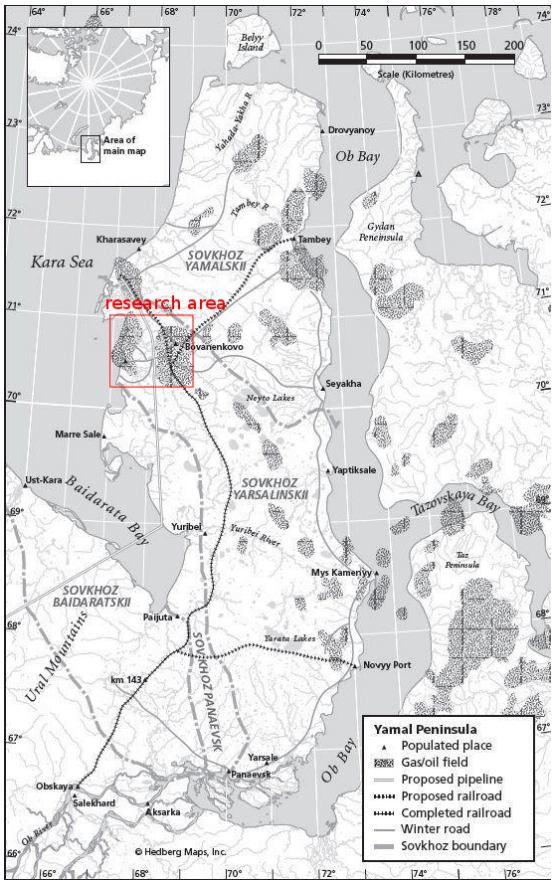
Research Area

Geographic location: Yamal Peninsula, north Russia

(a) Geographic location of Yamal Peninsula Map source: google.com



(b) Location of the study area on Yamal (western coast). Source: Bruce Forbes

Environment of Yamal, part 1

Yamal Peninsula: geomorphology

Specific climatic-environmental settings of Yamal Peninsula:
flat geomorphology, elevations < 90 m.
Processes:

- seasonal flooding,
- active erosion processing,
- permafrost distribution and
- intensive local landslides formation.

Figure: 4. Landscapes of Yamal. Source: http://pixtale.net/

Environment of Yamal, part 2

Yamal Peninsula: environmental settings

One of the typical process in Yamal tundra: cryogenic landslides. Landslides affect local ecosystem structure, because they change vegetation types recovering after the disaster.

Figure: 5. Landscapes of Yamal.

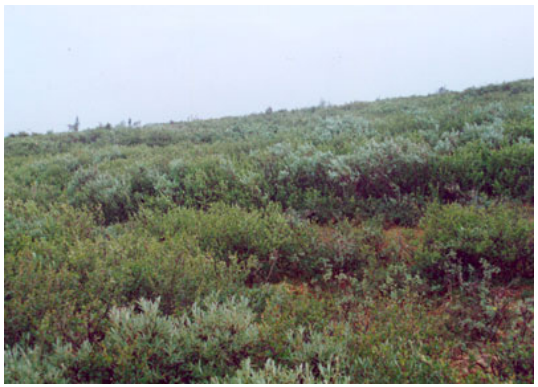
Landscapes of Yamal Peninsula

Land cover classes: 1-4 from 11

(a) Type 1. Shrub tundra.
Source: www.novaonline.nvcc.edu/

(b) 2. Dwarf willows.
from: www.travelanguist.com

(c) Type 3. Arctic willows.
Source: http://nature-plants.com



(d) 4. Sparse short shrub tundra. (www.polarfield.com)

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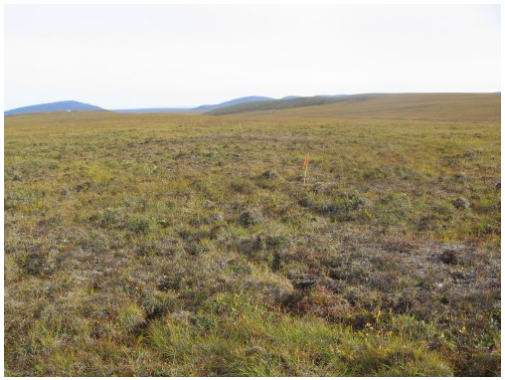
Landscapes of Yamal Peninsula (continue)

Land cover classes (5-8 from 11)



(e) Type 5. Dry grass heath tundra. (from polarfield.com)

(f) 6. Sedge grass tundra. Source: arcticatlas.org

(g) 7. Dry short shrub tundra. (www.arcticatlas.org)

(h) Sphagnum moss. Source: google.com

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Landscapes of Yamal Peninsula (continue)

Land cover classes (9 to 11 from 11)

(i) Type 9. Dry short shrub sedge tundra.
Source: www.britannica.com

(j) Type 10. Wetlands.
Source: google.com

(k) Type 11. Short shrub tundra.
(Image source: www.arctic-predators.uit.no)

Human activities on Yamal: part 1

Yamal Peninsula: reindeer herding

The most typical anthropogenic activity on Yamal Peninsula is reindeer herding (Fig.3). Yamal is a homeland for ca 5000 nomadic Nenets tribes migrating with herds up to 1200 km annually.

(l) Tundra landscape: reindeer herds. Source: environmentalresearchweb.org

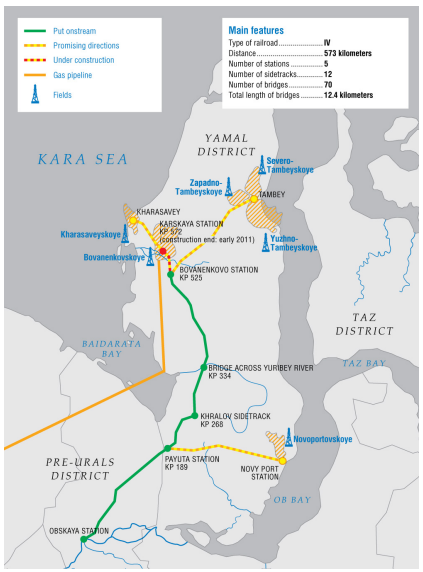
(m) Typical scene of reindeer grazing. Photo: Bryan Alexander

Herding is natural process. However, it may have negative effects: pasture overgrazing and pressure on vegetation coverage.

Human activities on Yamal: part 2

Yamal Peninsula: gas exploration

Yamal Peninsula is a place where the gas field "Bovanenkovo" is being explored (Fig.3). Geological gas exploration cause serious anthropogenic pressure on the environment. Indirectly it also includes additional construction of roads, settlements, human facilities, etc.



(n) Yamal: scheme of gas exploration.
(www.reindeerblog.org)

(o) View on the gas exploration station.
Photo: http://barentsobserver.com

Research Methods: Step 1.

Data pre-processing

a) import .img into ASCII raster format (GDAL).
After converting, each image contained collection of 7 raster bands
b) visual color and contrast enhancement
c) geographic referencing of Landsat scenes, initially based on WGS 1984 datum: UTM (Universal Transverse Mercator) Projection, Eastern Zone 42, Northern Zone W, (Georeference Corner Editor, ILWIS).
d) crop of study area The area of interest (AOI) was identified and cropped on the raw images. This area shows Bovanenkovo region in a large scale and best represents typical tundra landscapes.

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Research Methods: Step 2.

Image classification

- The key research method is supervised classification (Minimal Distance), which is based on the spatial analysis of spectral signatures of object variables, i.e. vegetation types.
- The classes sampling was performed using Sample Set tool in ILWIS GIS.
- The training pixels for each land cover type were selected as representative samples and stored as classification key.
- Requirement for training pixels: they have contrasting colors, visually visible and distinguishable on the image.

Research Methods: Step 3.

Thematic mapping

Layouts
of main research results represent maps of the land cover classes.

The created domain Land classes includes legend with representation colors visualizing each category.

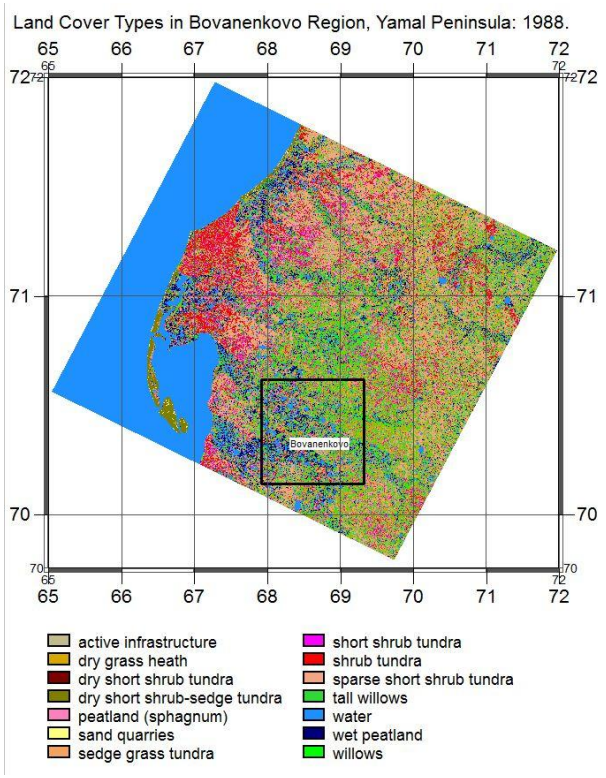

Figure: 21. Thematic mapping

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GIS Mapping (1988)

Classified study area (from image 1988)

Landsat TM scene

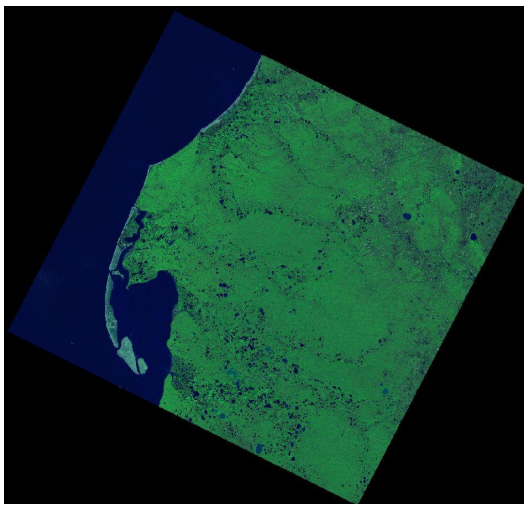

Figure: 22. Landsat TM, 1988

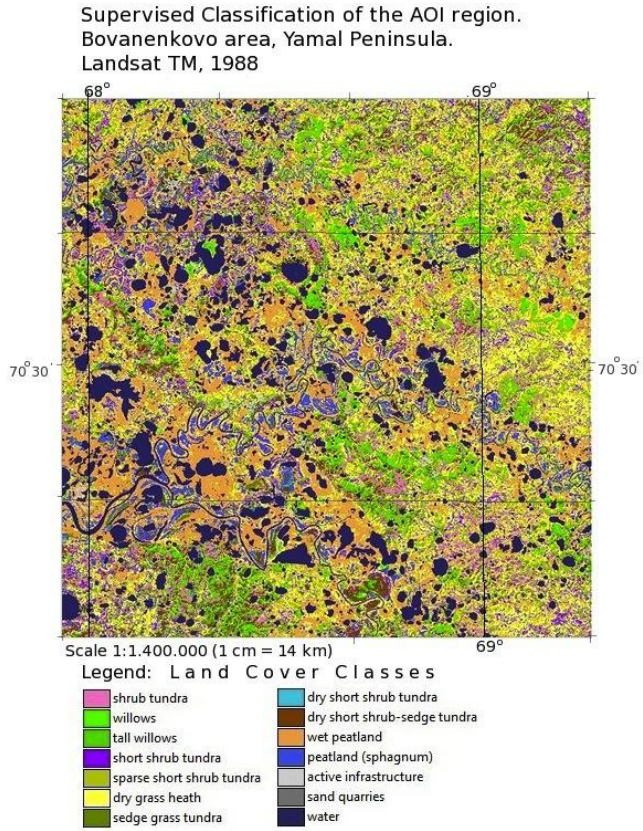

Figure: 23. Map of land cover classes, 1988

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GIS Mapping (2011)

Classified study area (from image 2011)

Landsat TM scene

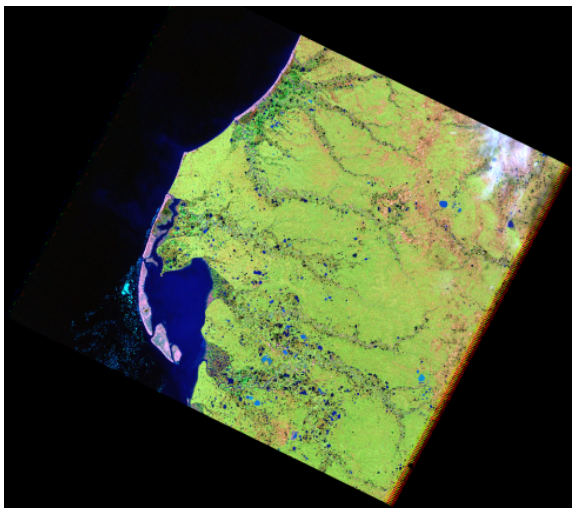

Figure: 24. Landsat TM, 2011

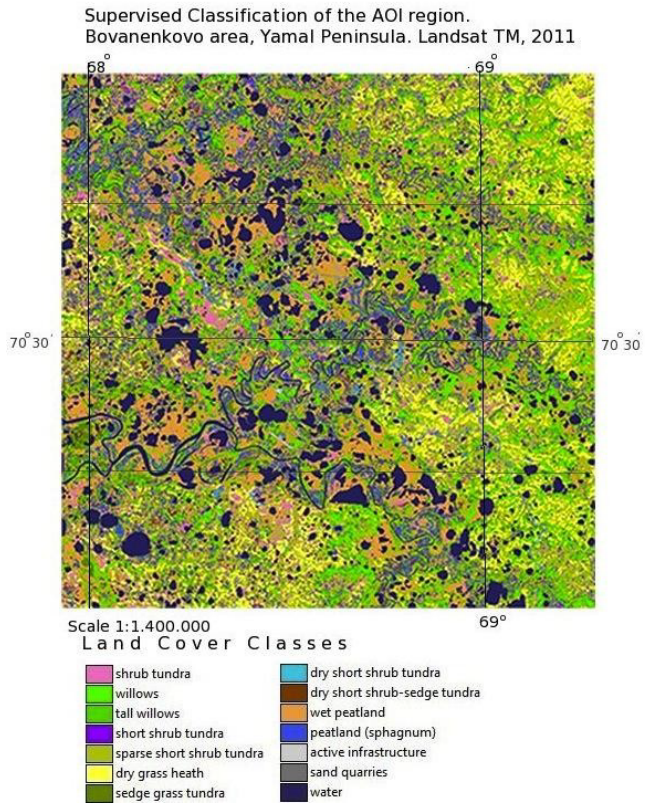

Figure: 25. Land cover classes

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Results

Land cover classes: assessment of changes

Table: 1. Statistics on land cover classes, Bovanenkovo region, Yamal

Land Cover Class	1988, # pixels	2011, # pixels	1988, ha	2011, ha
Shrub tundra	220447	168226	1146.3244	874.7752
Short shrub tundra	165079	270158	858.4108	1404.8216
Willows	193645	457004	1006.954	2376.4208
Tall willows	103954	71952	540.5608	374.1504
Sparse short shrub tundra	176511	759380	917.8572	3948.776
Dry grass heath	641420	231719	3335.384	1204.9388
Sedge grass tundra	27545	57052	143.234	296.6704
Dry short shrub tundra	8984	16993	46.7168	88.3636
Wet peatland	761231	531809	3958.4012	2765.4068
Peatland (sphagnum)	120328	93979	625.7056	488.6908
Dry short shrub-sedge tundra	173693	92242	903.2036	479.6584

Discussion

Environmental Analysis

Results show:

- overall increase of woody vegetation (willows and shrubs)
- decrease of peatlands, grass and heath areas.

This illustrates environmental process of greening in Arctic, i.e. the unnatural increase of woody plants. The gradual changes in patterns and distribution of plant species affect landscape structure in Yamal.
Triggering factors:

- complex environmental changes in Arctic
- local cryogenic processes (e.g. successive change in vegetation recovering after cryogenic landslides)

Résumé

Summary

* Current research details changes in spatial distribution of land cover types in selected area of western Yamal Peninsula
* The time span covers past 2 decades (1988 - 2011)
* The research is technically performed by means of ILWIS GIS, based on spatial analysis of classified Landsat TM images.
* The results of spatial analysis are presented as thematic maps illustrating changes in land cover types on Yamal Peninsula. GIS mapping is based on the image classification.
* As a result of climate and environmental impacts, there are detected changes in the vegetation structure.
* Main outcome: overall increase in woody plants, e.g. *"short shrub tundra"*, *"sparse short shrub tundra"* and *"dry short shrub tundra"*), and slight decrease in grasses, heath and peatland.
* There is process of greening detected in Yamal tundra. It indicates structural variations in ecosystems.

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Conclusion

...to conclude:

- GIS-based mapping (e.g. ILWIS GIS) is important tool for the landscape monitoring and management.
- Processing of remote sensing data (e.g. Landsat TM scenes) by means of GIS improves technical aspects of the landscape studies.
- Application of RS data is especially important for studies of northern ecosystems, since it enables to perform spatial analysis of remotely located areas in Arctic regions.
- Spatial analysis of land cover types can help to detect local environmental changes.

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The End