Project information

Project title

TUNDRAscape II: Analyzing the effect of human uses and climate on tundra ecosystems by remote sensing

Year

2012/2013

Project leader

Dorothee Ehrich, UiT

Participants

Project leader:

- Dorothee Ehrich, Institute of Arctic and Marine Biology, Research Group Northern populations and ecosystems, University of Tromsø, Tromsø

Project participants:

- Hans Tømmervik and Per Fauchald, Norwegian Institute for Nature Research, Fram Centre, Tromsø
- Alma Thuestad, Norwegian Institute for Cultural Heritage Research, Fram Centre, Tromsø
- Vera H. Hausner, Institute of Arctic and Marine Biology, Research Group Northern populations and ecosystems, University of Tromsø, Tromsø
- Jakob Iglhaut, a student from Hochschule für nachhaltige Entwicklung, Eberswalde, Germany, worked with image analyses for two month in the frame of his internship at NINA.

Flagship

Terrestrial, Theme: Vegetation state change and herbivore management

Funding Source

Fram Centre

Summary of Results

This project aimed at investigating how grazing regime and present habitat transformation caused by human use interact with climate to determine vegetation states in areas surrounding arctic settlements. To achieve this, we chose a large scale comparative approach and analyzed high resolution remote sensing images of the landscape surrounding selected settlements in the tundra regions of Russia, Alaska and Canada. For each settlement, one image covering the settlement itself (intense use area) and one image taken 30 km from the settlement at a random place (extensive use area) were obtained. The settlements have been chosen according to the design of nested spatial contrasts used in the related NRC funded project TUNDRA (Fig. 1). In this design, regions with contrasting governance systems were selected, and within each region we chose settlements with a contrasting income structure. The selected sample comprised 28 settlements located in three regions in Russia, 2 regions in Canada and Alaska.

In summer 2012 all missing images have been taken and were delivered, resulting in a complete set of 56 high resolution images. All images were searched systematically for traces of human use such as ATV-tracks, land-fills, fences, camps, buildings, garbage deposits, activity areas and mines. All observed objects were digitized using ArcGIS (Fig. 2a). This comprehensive mapping dataset will provide the basis for quantitative analyses relating the direct impact human activities have on the tundra landscape to the context of each settlement – both with respect to the design variables of TUNDRA and to the detailed information gathered during the interviews carried out by that project. Preliminary inspection of the data indicates that human activity showed a clear connection to settlements. Outside of the settlements, ORV-tracks are the main traces of human use identified, but also tracks from reindeer sledges were detected and identified as linear tracks with grasses and sedges. Generally ORV-tracks tended to be connected to water bodies such as river and lakes. In a subset of images the total length of tracks varied between 26.7 km and 130.3 km, and the tracks covered between 0.2% and 3.5% of the surface of the image indicating highly variable impact. Given the importance of ORV tracks, TUNDRAscape is also developing protocols for monitoring ORV tracks by remote sensing which will allow taking into account variable visibility in different vegetation types.

For vegetation mapping, we tested satellite image classification using both unsupervised (clustering) and supervised (max-log-likelihood and spectral un-mixing) classification algorithms. Supervised classification was then applied to all images (Fig. 2b). The classification was guided by pictures available from different sources including the internet as well as by visually identifying elements on the high resolution images. For Russia, series of “ground truth” pictures were taken in spring and fall 2012, when the settlements were visited for the interviews (TUNDRA), and used in the classification and interpretation of the images. Obtaining comparable vegetation classes over such a large study area based on high resolution pictures has been a challenging task, which may need some further adjustments. We focussed on vegetation and land cover types which are predicted to represent different states in transitions induced by grazing or physical disturbance such as driving. Thus in productive parts of the landscape such as river valleys, grazing may limit the expansion of willow thickets, which are replaced by meadows. On slopes and elevated parts lichen tundra is replaced by moss and dwarf shrub tundra or, under strong impact, by grass tundra. Results from the vegetation classification indicate that there are tendencies of wear to lichen and dwarf shrub tundra and a transition to grass dominated tundra around the settlements compared to the extensive use areas, in agreement with the predicted changes. Also bogs and fen vegetation especially around settlements show wear or injuries.

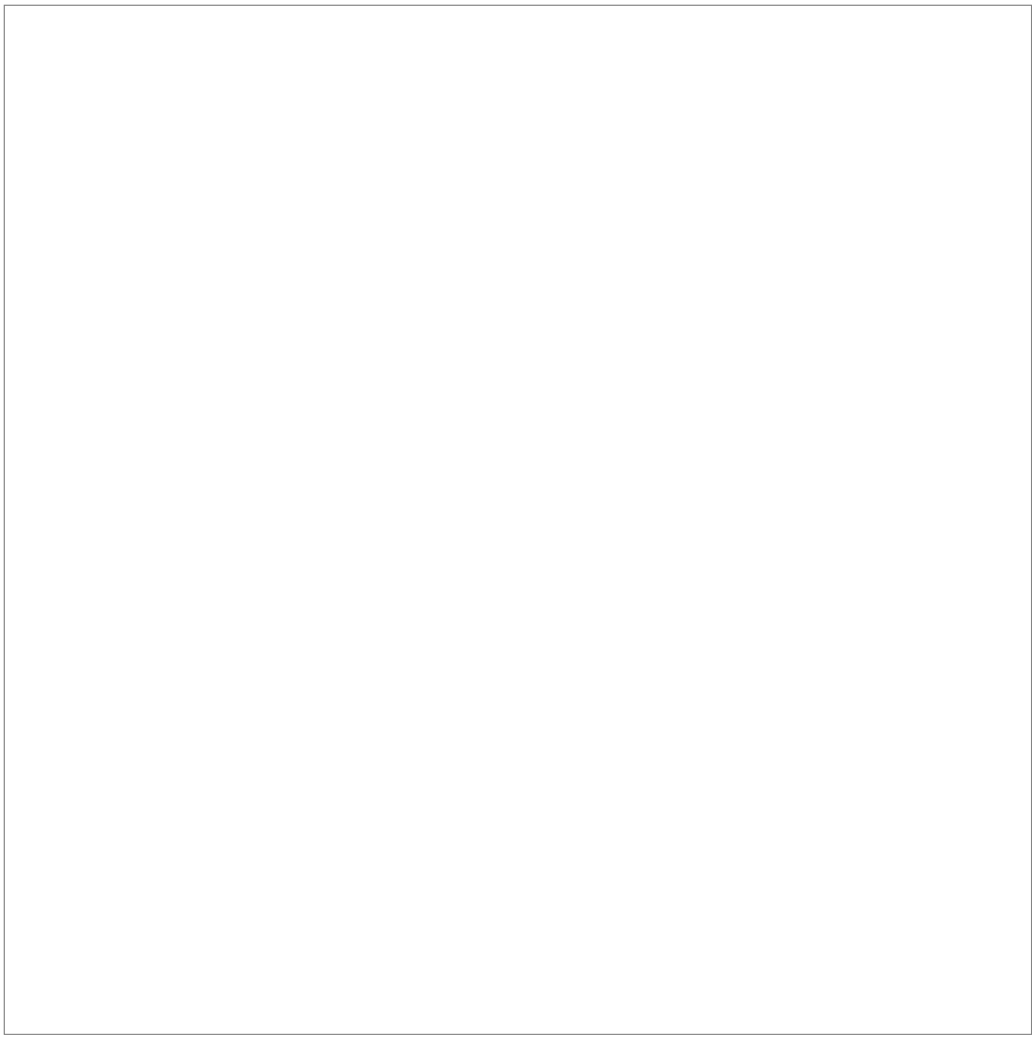
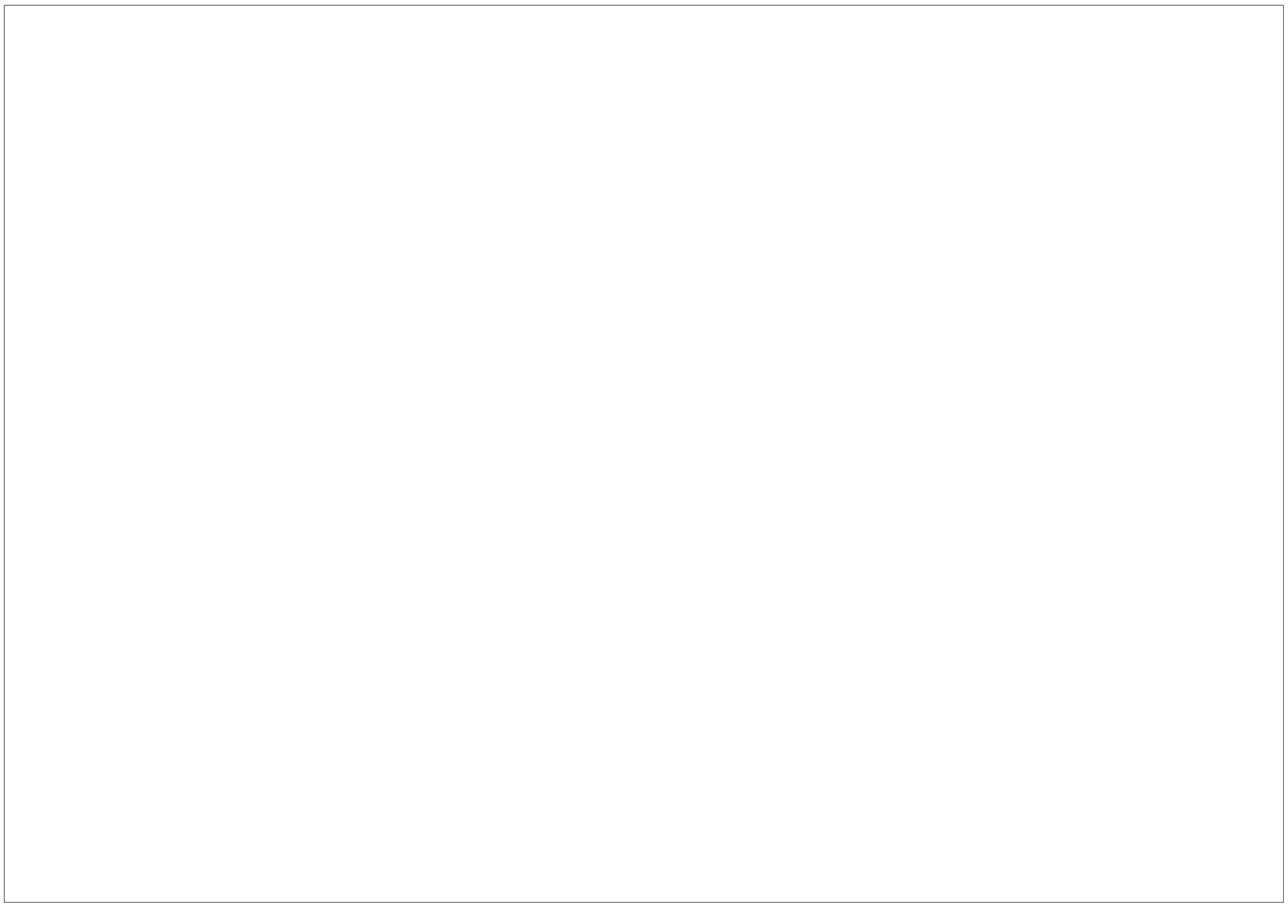


Fig. 1. Map showing the model settlements studied in TUNDRA. Settlements were chosen in adminstrative regions with contrasting governance systems (Taimyr / Yamal; Murmansk Obl. / Finnmark; Nunavut / Labrador; and Alaska). Within the regions settlements were chosen to have a contrast in economic structure with more (black dots) or less (white dots) opportunities
for wage income. In TUNDRAscape satellite images of all settlements in Alaska, Canada and Russia have been analysed (intensive and extensive use areas, ie. 56 images). Areas surrounding the settlements in Norway will be analysed in a future project.



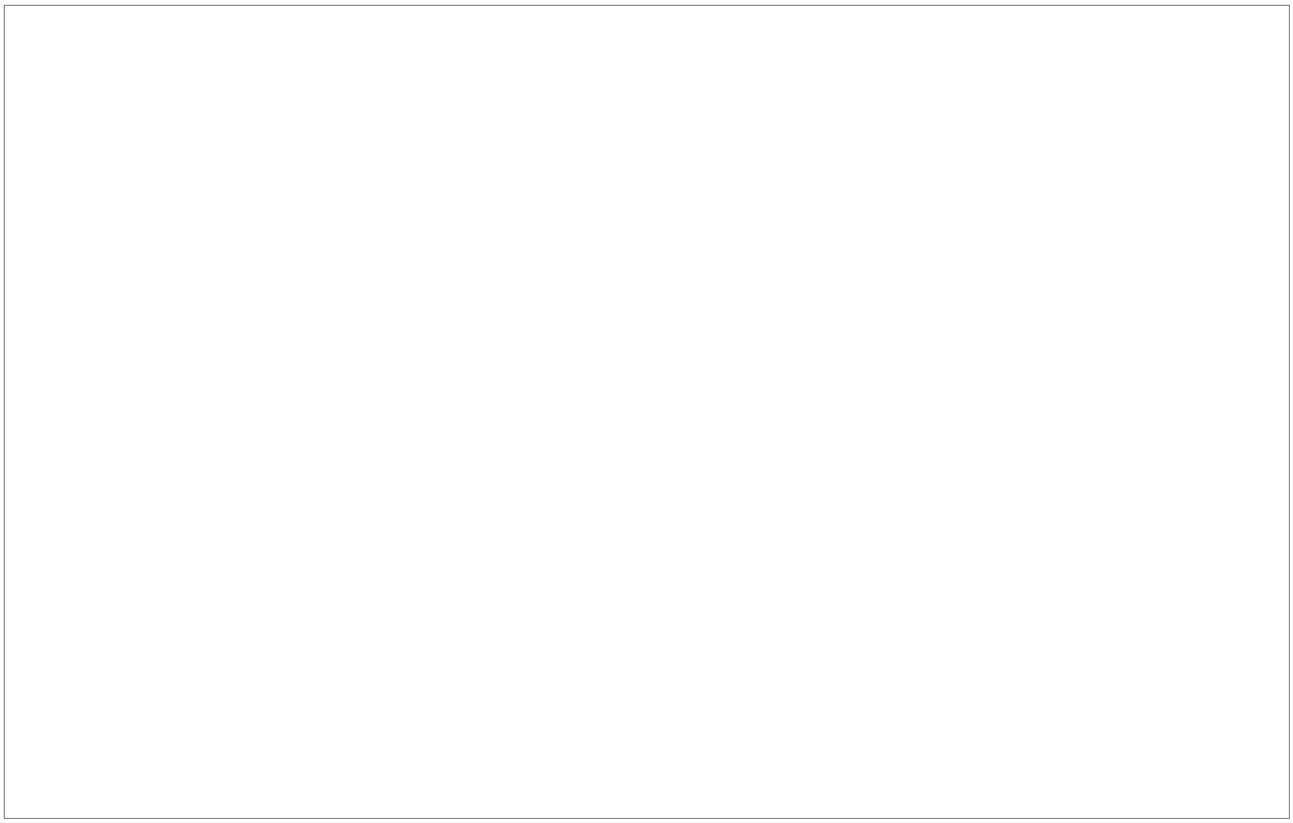


Fig. 2 Examples of analysed satellite images. a) Human traces mapped on the images from the settlement area of Noatak in Alaska. b)

Vegetation classification of the area surrounding the settlement of Noatak based on the supervised maximum likelihood algorithm.

Published Results/Planned Publications

- Thuestad A, Tømmervik H, Ehrich D, Fauchald P, Hausner V. *Detection of human induced disturbances and grazing impacts on tundra vegetation state: preliminary results of a large scale comparative remote sensing study*. Poster presentation at 12th International Circumpolar Remote Sensing Symposium in Levi, Finland 14-18.05.2012. Book of Abstracts, page 83.
- Thuestad A, Tømmervik H, Ehrich D, Iglhaut J, Fauchald P, Hausner V. *Impact of human use and grazing on tundra vegetation state: preliminary results of a large scale comparative remote sensing study*. Poster presented at the EcoSummit 2012 Conference in Columbus, Ohio, USA 30.09-5.10.2012.
- Thuestad A, Tømmervik H, BroderstadEG, Ehrich D, Fauchald P, Hausner V. *Mapping land cover and land use in Arctic regions: a large scale comparative study*. Poster to be presented at the workshop: "Negotiating Space, Arranging the Land. A workshop on Mapping in the Nordic Countries, 1720 until today" to be held 7.-9. December 2012 in Oslo.
- Thuestad A, Tømmervik H, Ehrich D, Fauchald P, Hausner V. *Effects of motorized traffic in tundra regions: methods and classification techniques.* Manuscript in preparation.

Communicated Results

The results have been presented at two international conferences and on internal seminars at the Fram Centre. In addition, the project will be presented at an international workshop in December 2012.

The classified satellite images and mapped traces of human use will be available to other researchers at the Fram Centre and represent a valuable base line dataset for future monitoring of changes.

Interdisciplinary Cooperation

The project involves researchers with background in different disciplines including expertise in remote sensing, cultural traces identification, archeology, vegetation science, ecology and social sciences. TUNDRA and TUNDRAscape are interdisciplinary projects and address questions which could not be answered without an interdisciplinary approach. Collaboration across disciplines is more time consuming, but in our case such an approach is absolutely essential.

Budget in accordance to results

The funding from the Fram Centre was essential for the work accomplished by TUNDRAscape II. In the first place this funding financed the working hours of Alma Thuestad and Hans Tømmervik, who developed the protocol for analyzing the satellite images and did the work. The funding allowed us also to purchase the remaining images to cover all settlements in which interviews have been (most interviews in Russia were carried out in 2012) or will be carried out (interviews in North America will be carried out in 2013) in the frame of TUNDRA.

The dataset we have created through TUNDRAscape will contribute significantly to answer some of the major research question in TUNDRA but also for future research on socio-ecological systems in Arctic areas. The next step in 2013 will be to couple the satellite data to socioeconomic drivers and governance.

Could results from the project be subject for any commercial utilization

No

Conclusions

The datasets obtained from the satellite images in TUNDRAscape will provide a solid basis for a quantitative analysis of some of the important research questions to be addressed in TUNDRA. They will also form the basis for future research on a wide array of questions related to vegetation changes under the impact of land use and climate change in the circumpolar tundra areas.

Specifically the data will be used in analyses of

1. Human use of the landscape under different socio-economic conditions and governance systems. Here the data provided by TUNDRAscape will be directly analyzed with respect to the design variables in TUNDRA
2. How local people on the tundra use and value the landscape. Here the data provided by TUNDRAscape will be related to the information collected during the interviews carried out in the frame of TUNDRA.
3. Vegetation transitions due to historic and contemporary human use, including a planned comparison with historical satellite pictures (e.g. Corona)
4. Effects of grazing pressure versus climate on the state of the vegetation.