Project information

Project title
ECOTONE - Vegetation changes at the forest-tundra ecotone: evidence from repeat photography?
Year
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Project leader
Jane Uhd Jepsen
Participants

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Flagship
Terrestrial
Funding Source

FRAM, NINA, NIKU, UIT, Statens Kartverk

Summary of Results

The objectives of the project are three-fold:

Objective 1: To evaluate the technical quality of a historical (1970) series of aerial photographs covering the tundra-forest ecotone of the Varanger peninsula and the potential of the series to serve as reference material of past distribution of woody vegetation states in the region for multidisciplinary purposes.

Objective 2: To compare the distribution of vegetation states in the 1970 imagery with present-day (2005-2012) orthophotos to allow for a preliminary analysis of observed vegetation state changes over four decades with respect to three targets of particular relevance for climate change studies in the low-arctic:

a. The distribution of riparian tall shrub-grassland mosaic
b. The elevational tree and shrub line
c. Known cultural heritage sites sensitive to encroachment

Objective 3: Based on the results of objectives *2a* and *2b* to provide an assessment of suitable sites and a recommendation for methodologies for long term monitoring of woody vegetation dynamics in Varanger.

In the following we briefly summarize the main results towards each of the objectives. We refer to appendix 1 below for figures and tables.

Objective 1

A total of 392 historical panchromatic images from 4 series were ortho-rectified (Table A1). The main set of images used for evaluating vegetation state transitions were 2 series with a ground resolution of 40-50 cm which is comparable to the resolution of present day

imagery (Table A1). The quality of the historical imagery was generally judged sufficient for evaluation of coarse vegetation state classes. Out of 2959 random sampling points distributed in all river catchments in the study area (see Obj. 2), only 1.5% (43 points) were discharged on the grounds of poor image quality. Another 3% (89 points) were discharged due to shadow or snow. The technical documentation tables as well as maps of the spatial extent for each image series can be obtained from the project leader at request.

Main deliverables: i) The full set of historical images will be made publicly available at norgeibilder.no at the end of the project. ii) a set of vegetation states (Table A2) which are identifiable from both historical panchromatic and present color images.

Objectives 2 & 3

A set of images representing the present day vegetation states was compiled to cover the same geographical extent as the historical images. This set consisted of images taken during the years 2005-2012 and we always used the newest image available (Table A1). The time period during which vegetation state changes could have occurred hence varies from 35-42 years depending on the availability of present day imagery. To address sub-objective 2a-c we sampled the imagery in three different ways: i) a sample of 2959 random points covering the entire region, but stratified to ensure a denser coverage of points closer to rivers and creeks, since this is where most vegetation state changes are likely to occur. ii) A sample of 405 points at known cultural heritage sites. The cultural sites contain mapped objects dating to the Iron Age and up until the early 1900s, many of which are representative of land use related to a still visible resource situation. iii) A systematic grid of 6457 points along 47 elevational transects distributed every 500 m along the Syltefjord river. For each point in all three samples we visually evaluated the dominating vegetation state (Table A2) in a 20 x 20 m neighborhood for the 1970 and present day images separately. A transition matrix was constructed for each of the three samples showing the fraction of points that change from one vegetation state to another during the study period (Fig. A1). Our results reveal a complex picture of vegetation transitions occurring during the last 4 decades. While the overall trend is towards more vegetation and more and denser woody cover, there is also evidence of the opposite trend occurring. Vegetation changes occurred in 19% of the sample points. The vast majority (15%) changed towards a more vegetated state, while 4% changed towards a less vegetated state. Not surprisingly the most resilient states (those that change the least) were non-vegetated and non-canopy covered states (Fig. A1). It is noteworthy though that the *Shrub* state showed considerable resilience (> 0.80 in all three samples). On a regional scale the *Closed canopy* state showed surprisingly low resilience (0.56), mostly due to a large number of transitions towards a more open canopy. A likely contributor to this is the recent outbreaks by canopy-feeding moth that have occurred in the region. This is supported also by the spatial distribution of state changes (Fig. A2). Most of the transitions towards less vegetated states occurred in the western forested valleys including Tana – coinciding with the areas most severely impacted during the last moth outbreak. State changes were recorded at just 10% of the cultural sites, but the majority of changes were woody encroachment towards more shrub and open canopy forest.

The detailed sampling along elevational transects in Syltefjord permitted an evaluation of vegetation state changes along the entire gradient as an alternative to the conventional recording of changes in the upper limits of trees (forest and/or tree line changes). Our approach revealed that most state changes, resulting in an increase in forest canopy cover, occurred well below the upper elevational limits of forest (Fig. A3). Comparing the elevational distribution of state changes to a conventional line based estimation of the upper limit of trees and continuous forest, showed that none of the approaches gave evidence of a change in the upper limits of forest during the last 4 decades. The main change in the forest states is hence in the form of densification and spread of trees in the lower parts of the elevational gradients. Similarly, for the shrub mosaic at the valley bottom, our results show that the main vegetation changes are in the form of a densification on the alluvial plains which occurs independent of elevation. This densification involves transitions both from *Non-vegetated* and *Non-canopy* to *Shrub*. State transitions are locally highly variable and occur in a mosaic-like fashion (Fig. A4). Transitions towards less vegetated states in Syltefjorden were almost all caused by substantial river erosion in the lower parts of the valley.

The main trends in vegetation changes are summarized at the level of river valleys in Table A3. The valleys selected for monitoring in COAT show highly diverging patterns of vegetation change. Valleys in **COAT region I** (see Table A3 for roman numerals) all show very low levels of change (> 90% unchanged on average), while valleys in **COAT region II** and **III** show very high, but diverse levels of change. Valleys in the southern part of **COAT region IV** (Komag, Sandfjordelva East) show very low levels of change, but this may not be representative since these valleys only had coverage of historical imagery in the lower sections of the valley. Analysis unit 237E (containing both Skogåselva (COAT) and Syltefjordelva) is in the same region, has coverage also at the upper sections of the valley and show substantially higher levels of change.

Main deliverables: i) a preliminary quantification of the direction, spatial distribution and type of vegetation state changes occurring regionally and locally at natural and cultural sites over the last 4 decades in Varanger. ii) A demonstration of how a gradient based sampling of coarse vegetation states can be used to characterize elevational distributions of woody state changes. iii) An overview of the main trends in vegetation state transitions in the river valleys selected for inclusion in COAT.

Appendix 1: Figures and tables

For the Management

Cultural heritage management: The Varanger peninsula represents a valuable and diverse cultural heritage, and local and national forces are presently seeking to include the region on Norway's tentative list of nominees for UNESCO world heritage sites. Vegetation encroachment has been shown to be a threat to cultural heritage sites in the north. We have provided a test of methodologies and an initial assessment of the level to which various types of cultural heritage sites are subject to encroachment by woody vegetation. We show that while a relatively low proportion of examined cultural sites have been subject to vegetation state changes during the last four decades, almost all changes are in the form of woody encroachment. Our results lay the basis for designing a more comprehensive field-based survey of the encroached sites to evaluate the extent to which the observed encroachment is a threat to the long-term preservation of the sites.

Published Results/Planned Publications

Given that this is an incentive project, publications in this category were not planned for in the project period. However, we expect that the results obtained will form the basis of one scientific paper in 2015.

Communicated Results

The project leader has contributed a chapter to a new issue of OTTAR in part based on this project ("Varanger – et lite stykke Arktis", Ottar 4-2014, Nr 302)

Other:

Agreement has been made with Statens kartverk, that all the historical images will be made available for the public at www.norgeibilder.no at the end of the project (approx. Dec. 1st 2014). The publication of the imagery as well as a highlight of the results subsequently will be published as a Fram Centre news piece.

Interdisciplinary Cooperation

The project team consist of two ecologists and an archeologist, and both disciplines have contributed both in the design of sampling protocol, classification of images and in the analysis of results. Increasing our understanding of encroachment processes and improving ways of monitoring them is central in both disciplines, but we have met no major challenges in this collaboration.

Budget in accordance to results

Since ECOTONE is a project in the incentive support category, the activities could not have been completed without support from the Fram Centre. The funding obtained

from the Terrestrial Flagship has allowed us make available an important, and complete series of historical images for lowland areas on the Varanger peninsula. This will hopefully be a resource for other disciplines as well as of interest to the local communities. It has further allowed us to test the suitability of the historical imagery for vegetation change studies, and to produce a first evaluation of the nature and extent of vegetation state changes in the forest-tundra ecotone on Varanger, as well as an evaluation of methodological approaches. This will be valuable input to the forest-tundra ecotone monitoring module in COAT.

The funding from the flagship has covered researcher salaries for team members in the institute sector, as well as the orthocorrection of the imagery. The entire amount allocated from the Fram center will be used according to budget before Dec. 31st.

Could results from the project be subject for any commercial utilization

No

Conclusions

By utilizing the same valley-based spatial design used in COAT (WP5), our results are directly transferable to the planned monitoring of woody vegetation changes in COAT. We provide a framework (both in terms of methodological approach, and R-scripting) for repeat photography analysis that can be used both to track future vegetation changes as new aerial imagery becomes available over time, and to perform more detailed analysis of historical changes for individual river valleys following the example devised here for Syltefjorden.

Our results will also be used to guide future research on vegetation dynamics in COAT. For instance our analysis has shown, somewhat unexpected, that the *Closed canopy* state is subject to more changes than any of the other vegetation states in Varanger. We suggest that this is caused by recent mass outbreaks by moth in the regions during the 2000's. Based on the imagery used here (dating from 2005-2012) is not possible however, to judge the extent to which the decrease in woody cover observed here is part of a permanent transition towards a more open forest at the sites in question. It ought to be a priority for future research to evaluate the nature of this transition both through field surveys and by adding to the time series of aerial imagery initiated here.