Vegetation mapping of Northern Fennoscandia and Kola Peninsula, using Landsat TM/ETM+ data.

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Northern Fennoscandia and Kola Peninsula

- Represent a transition area between humid, oceanic parts in the west and drier, more flat, continental areas towards the east.
- The area includes a transition from boreal forest in the south to treeless Arctic tundra in the north, interrupted by several large, treeless mountains.
- The major bioclimatic zones have been agreed upon within the Nordic countries.
- However, different criteria for defining zones/sections have been used within Russia and the former Soviet Union, which is easily seen when comparing these two territories in the European Vegetation Map.
Objectives

- The overall aim of the performed mapping has been to generate a generalized, consistent, and seamless vegetation map for the study area.
- Develop methods for creating large-area vegetation maps based on Landsat TM/ETM+ images
- Create a reasonably accurate land-cover data set appropriate for a wide variety of end-users
- Point out some improvements to the map by combining different satellite data resources
The study area

- Kola Peninsula
- Barents sea
- FINLAND
- SWEDEN
- NORWAY
- Finnmark
- Troms
- Atlantic ocean
- RUSSIA
- Kola Peninsula
- Vegetation sections:
  - Highly oceanic section (O3)
  - Markedly oceanic section (O2)
  - Slightly oceanic section (O1)
  - Slightly continental section (C1)
  - Highly continental section (C2)

Vegetation community models

a) Geology (mountain vegetation)

b) Slope/aspects (forests)

c) Subsoil and water conditions (forests)
Vegetation classes – spectral characteristics

Reflectance (%)

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Wavelength (µm)

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Channels

1 2 3 4 5 7 TM Channels
Border areas – Norway-Finland
Border areas- spectral differences
Classification processing scheme

1. "Master" image classification
   - Landsat TM / ETM+ image
   - Unsupervised classification
   - First order classified image
   - Similarity / separability analysis
   - Aggregation of classes

2. Classification - "slave" images
   - Landsat image
   - Classified image
   - Preclassified master image
   - Image mosaicing
   - Seamless image mosaic

3. Image mosaicing

4. Ancillary data integration
   - DEM
   - Land cover data
   - Geological data
   - Field data
   - Land use data
   - Geographical zones / sections
   - Other geo-data...

5. Contextual correction
   - Decision rules for merging or splitting of classes

6. Standardization
   - Standardized vegetation map
   - Colouring / Map legend description
   - Vegetation scheme valid for the study area
   - First order vegetation map

- Pre-classification: Image classification, spectral analysis, separability analysis, description of spectral classes
- Post-classification: Integration of ancillary data (DEM, land cover data, field inventory data)
- Standardization. Relate the map units to a classification system valid for the area
Available data layers

• Several Landsat TM/ETM+ images collected from different years in the period 1994-2002

• Ancillary data sources used in this study comprises digital elevation models, digital topographic maps containing separate cover layers of forests, mires, agricultural areas, water, and open areas

• For parts of the mountain regions of Norway a snow cover mask was developed and used in order to differentiate ridge and snow-patch communities in the mountain region

• The map created has been compared to available vegetation maps based on traditional methods (aerial photos/field studies)
Accuracy assessment

Note: The availability and the quality of the ancillary highly influence the quality of the final map product

- **Norway**: 5 vegetation maps created using traditional methods (aerial photos/field investigations)
- **Sweden**: a) Several traditional maps along the Norwegian/Swedish mountain range based on traditional methods;  
  b) Corine Land Cover maps
- **Finland**: Maps from Corine Land Cover
Map products

Vegetation maps:
- For areas in Norway ancillary data were available with a resolution of 30 m.
- For areas in Sweden and Finland cover layers of 100 m were used.
- Areas on Kola Peninsula are not undertaken any contextual correction due to lack of ancillary data.

Derived products:
- Eco-regional map
- Snow cover analysis
- Vegetation change maps for Finnmarksvidda
- Map improvements – using SAR data
Map products – Norway (30m resolution)
Map product – class description

1. Coniferous forest - dense canopy layer
2. Coniferous forest – open canopy layer
3. Pine forests - lichen type
4. Mixed forests – pine/birch
5. Lichen birch woodland
6. Mountain birch woodland
7. Empetrum birch forests
8. Grass-rich birch forest
9. Bilberry birch forests
10. Meadow birch and grey alder forest
11. Low herb birch forests
12. Hummock mire complex
13. Lawn and carpet mire complex
14. Wooded mire complex
15. Mud-bottom fens
16. Sedge marches
17. Exposed gravel ridges
18. Open heather communities
19. Lichen heaths
20. Dwarf shrub heaths/established heaths
21. Moist heather communities
22. Wet heather communities
23. Grass heaths
24. Mountain meadows
25. Sedge and grass snow-bed
26. Dwarf willow/moss snow-bed
27. Mid-alpine snow-beds/boulder fields
28. Gravel ridges and bedrock outcrops
29. Snow and glaciers
30. Water
31. Cultivated areas
32. Impediment
33. Wetland, shadow effects
34. Shallow water
Vegetation maps – Finnmarksvidda
Map products – Norway/Sweden/Finland
Map comparisons – Abisko/Sweden


Vegetation map based on traditional methods (L. Anderson 1981)
Northern Fennoscandia/Kola – overall map
Example of use (1): Definition of eco-regions
Eco-regions - outlined

Western coast- and fjord region
Eastern coast- and fjord region
Arctic shrub-tundra region
Mountain birch region
Mountain region
Coniferous forest region
Example of use (2a): Regional snow pattern
Troms/Finnmark – snow pattern

Landsat TM images – late May 1994
Example of use (2b): Snow cover analysis

a) Snowfree areas

b) Snowcovered areas
Example of use (3): Analysis of geology/vegetation cover

Vegetation map

Geological map
Example of use (4): Vegetation changes Finnmarksvidda

- **Summer ranges** - on the islands and peninsulas near the coast
- **Spring/fall areas** – middle parts of Finnmarksvidda
- **Winter ranges** – southern, continental parts of Finnmarksvidda

- **Arrows**: Migration routes
## Changes in lichen cover
- percent of the total area

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Example of use (5): Phenological studies

Length of the growing season, mean 2000 - 2005

- ≤ 80 days
- 80 - 90 days
- 90 - 100 days
- 100 - 110 days
- 110 - 120 days
- 120 - 130 days
- 130 - 140 days
- > 140 days
Conclusions

- Remote Sensing data is highly relevant for vegetation mapping of large areas like northern Fennoscandia
- Based on satellite data we can perform mapping at different levels: 1) - global (zones/sections) 2) - national level (landscape) and 3) regional/local level (community)
- Based on created maps vegetation monitoring can be performed within selected areas (Finnmarksvidda)
- Remote sensing data are well suited for analyzing changes and trends within vegetation communities
- Use of satellite data are well suited for co-operation within different research areas
Conclusions

• The reindeer herding in northern Fennoscandia is adapted to use of large areas
• There is a challenge to create overviews over these areas
• Satellite data can create these overviews at different levels
Improvements/Further Works

• PC Transform of the SAR time series (cross polarized channel).

• Color composition **Overall High BS. Varying BS. Overall Low BS**

Vegetation map  PC transformed SAR data
Comparison of Map and SAR Data

- Mires are located to depressions in the landscape.
- Coniferous forest are located in moraine areas.
- Good correspondence between the vegetation map and SAR data.
Conclusions

• Difficult to distinguish between mires and dense coniferous forest in Landsat images.
• During the snow-melt season there is a significant change in backscatter for mires. In comparison, the backscatter from forested areas can be regarded constant.
• PC Transformation of a SAR time series in the snowmelt season is a nice tool for visualizing mires and forested areas.