Mapping the air pollution impact to reindeer range areas in Pasvik, Northern Norway using satellite imageries

Kartlegging av forurensningsskader på lavbeitene i Østre Sør-Varanger reinbeitedistrikt ved hjelp av satellittbilder

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Abstract: The aim of this study has been to test the utility of Landsat 1 MSS and Landsat 5 TM to detect and map the air pollution impact to reindeer range areas in the Pasvik area, located in the northeasternmost part of Norway close to the USSR border. The study area cover a area of 780 km^2. The major sources for the air pollution in this area clearly points to the metal melting factories in Nikel and Zapolyarnij in USSR, located only a few miles from the Norwegian/Russian border. Three scenes from 1973 (Landsat 1 MSS), 1985 (Landsat 5 TM) and 1987 (Landsat 5 TM) were applied in this study. A satellite based vegetation map was produced for both the 1973 situation and the 1985 situation. A non-supervised classification routine was applied for this purpose. The initial stage was an analysis of various spectral band combinations, and the TM 451 band combination was selected for the Landsat 5 TM satellite image. For the Landsat 1 MSS satellite image, all four bands were applied in the subsequent analysis. A «cluster» algorithm was used for classification of the satellite images. The result of the clustering was thematic images, comprising 16 classes (Landsat 1 MSS) and 24 classes (Landsat 5 TM). A median filter was used to smooth the thematic images. The overall classification accuracy for the Landsat 1 MSS image from 1973 was 83.4 %. The analysis of the classification accuracy for the Landsat 1 MSS-scene was based on a comparison of satellite data and field data, comprising 1065 field data points (ground truth), registered in 1970.

The classification of the Landsat 5 TM scene from 1985 was successful with a classification accuracy of 96 % for *pine forests with lichen in the bottom layer and *extreme dry heath with lichen. For the vegetation cover types: dry heath, *dry heath with lichen and blueberry heaths, the accuracy were between 80 and 90 %. *Birch forests with lichen cover and birch forests with blueberry, showed a classification accuracy of 89 % and 100 % respectively. The vegetation cover types which were most loaded by air pollution (marked with *), were well mapped on the basis of the Landsat 5 TM satellite image. The overall classification accuracy for the Landsat 5 TM image was 93.3 %. The analysis of the classification accuracy for the Landsat 5 TM-scene was based on a comparison of satellite data and field data, comprising 344 field data points (ground truth), registered in 1988.

Further analysis on the basis of the two vegetation maps for the 1973-situation and the 1985-situation compared with field investigations, showed that the lichen cover in the mountain areas had almost disappeared in 1985/88, compared with the situation in 1973. Only one lichen species *Cetraria nivalis* had survived in the mountain areas. In the forest areas, the reindeer lichens (*Cladonia* ssp) have survived, but they are vanishing in these areas too. Other vegeta-

tion types which has been affected by air pollution are situated on rather poor soil types and moraines. The most influenced areas comprise 62.9 % of the vegetated area, and in the rest of the vegetated area (37.1 %) beginning damage can be registered. As a result of the air pollution, the maximum capacity of reindeer in the area has decreased since 1973. On the basis of this study the capacity has decreased from a maximum of 1860 reindeer in the winter range area in 1973, to 208 reindeer in the winter range area in 1988. The summer capacity of reindeer in this area has decreased from a maximum of 1140 reindeer in 1973 to a maximum of 797 reindeer in 1988. The most influenced area - the Karpelv area - has lost its potential being a winter range area for the reindeer as a result of the air pollution.

For the situation in 1987 preliminary vegetation maps based on Landsat 5 TM (1987-07-20) were produced in the Western part of the investigation area (Neiden and Færdesmyra). As a result of analysis the field data and satellitedata, we can state that air pollution impact on the reindeer range areas is low in the area of Neiden.