Range suitability criteria for reindeer herding

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Aim: Identify relevant abiotic factors explaining variation in reindeer herd productivity for overall characterization of the herding area for reindeer husbandry using multivariate statistical methods.

The Swedish reindeer herding area, consisting of 51 reindeer herding districts, with a north-south extension of eight latitude degrees and an east-west extension from Gulf of Botnia to the border mountains towards Norway, includes a large variation in reindeer husbandry conditions. The natural attributes for reindeer husbandry in this area could be characterized in terms of topographical and spatial properties of the land, features of the vegetation cover and patterns of climate and weather in conjunction (Lundqvist, 2003). The topographical features in combination with climate particularly determine the properties of summer ranges via length of growing season, spatial and temporal distribution and quality of forage vegetation, and impacts of insect harassment. Length of snow-covered season and snow depths together with incidences of deep firn/hoar and ice crust formation determine the accessibilities and possibilities for sustainable management of winter range resources.

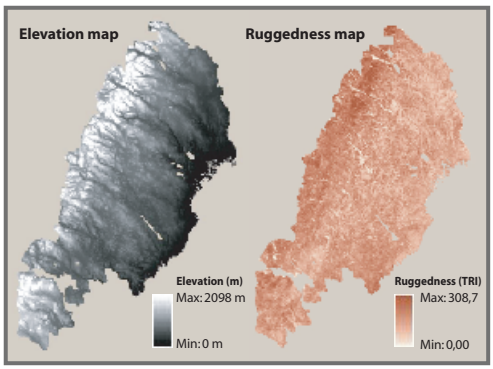

Figure 1. Topographical maps of the reindeer herding area showing altitude (left) and ruggedness (TRI)(right).

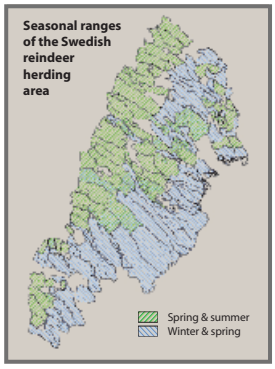

Figure 2. Grazing areas, cathegorized into winter-spring areas where ice-crust formation are relevant and spring-summer grazing areas where ruggedness is relevant.

Topography and ruggedness

The altitude and topographical features of a grazing area is determining factors on the quality. Topographical features can be fragmenting factors, or give opportunitiy to increase forage quality, and extend the period of available fresh herbs. The reindeer can better digest fresh green plants compared to mature wiltering plants with higher cellulose content. Rugged terrain gives more shaded localities and different biomes where plants ripe at different times (Klein, 1990; Lenart *et al.,* 2002; Mysterud *et al*., 2001). Snow patches and windy hilltops for insect relief (Hagemoen & Reimers 2002) also occur in a higher degree in a rugged area.

The Topographic Ruggedness Index (TRI) (Riley *et al.* 1999) (**Fig. 1**) captures the difference in elevation values from a center cell and the eight cells immidiately surrounding it according to the following formula:

$$\mathbf{TRI} = \ln \sqrt{\sum_{i=1}^{3}\sum_{j=1}^{3}\left(x_{ij} - x_{22}\right)^2}$$

Slope and aspect indicies are also investigated on spring and summer herding areas. A comparison between the herding districts on topographical features (**Table 1**) and productivity data can hence be achieved .

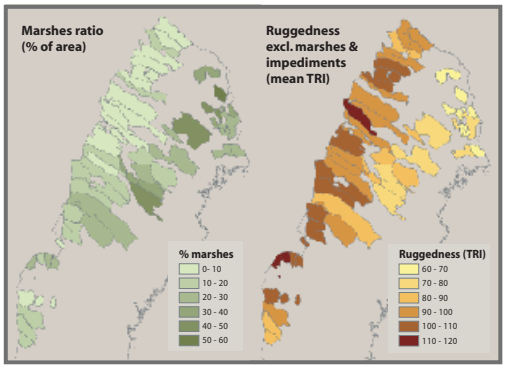

Figure 3. Spring and summer ranges of the herding districts.
Percent marshes (left).
Mean ruggedness (TRI) on ranges, impediments and marshes excluded (right).

Marshlands and ruggedness relations

The topography differs highly between the different herding districts as seen in **Table 1.** High ruggedness and large ratio of marshes are both positive for reindeer production, but are negatively correlated (r=0,75). **Fig. 3** shows some cases where both TRI and marshes ratio are high and presumably favourable.

Snow season length and ice crust/deep firn formation

Ice crust and deep firn are severe weather conditions for the reindeer especially during early winter and spring. Wet snow might freeze and incapsulate forage on which the reindeer are dependant upon during winter and feeding may be necessary (e.g. Nilsson 2003). The process of ice crust/firn formation is a complex process including altitude, air and ground temperature, humidity, air pressure, rain/snow fall and radiation fluxes (Colbeck 1989). This complex process is difficult to capture in an index on such large area on which the background data is scarce.
An ice crust probability index (ICPI) has been produced by using minimum, average and maximum temperatures every day during 35 years from 122 weather stations interpolated through universal kriging (**Fig. 4**).

Two conditions are used:

1) When min and max temperatures differs more than 10º C and min temp < -2ºC and max > 2ºC
2) When average temp has been > 1ºC for three days followed by two days with average temp < -1ºC

Altitude will be included since ICPI seems to correlate with altitude.

Other factors to be investigated

- Biotic factors
- Competitional factors
- Disturbance factors
- Handling factors

See Lundqvist H. *et al.*
"Multivariate Characterization of the Swedish Reindeer Herding Area"

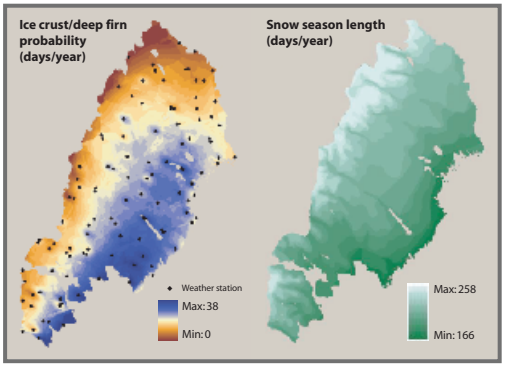

Figure 4. Number of days with high probability for ice-crust formation and deep firn (ICPI) (left).
Length of snow season (right).
Based on climatic data of from SMHI and National Atlas of Sweden.

Table 1. Topographic data calulated on each reindeer herding district's spring and summer grazing areas. Impediment areas such as glaciers and waters are excluded.

Topographic data on reindeer herding district level, impediments excluded

	Area (km2)	Altitude mean (m)	Slope mean (deg)	Northbound slopes (330 - 30 deg) (%)	Ruggedness mean (TRI) total	Ruggedness mean (TRI) excl. marshes	Ruggedness mean (TRI) marshes	Marshes area ratio (%)
Mean	1627	582	5,95	15,34	85,3	91,37	55,27	18,27
Max	5647	952	10,01	20,63	112,6	118,40	91,55	53,81
Min	269	95	2,03	7,51	43,8	60,08	29,28	1,64
STD	1146	239	2,29	3,38	18,9	15,73	16,75	12,38

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