# DEGRADATION OF ICELANDIC RANGELANDS: PROCESSES AND PROPERTIES

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## Abstract and Introduction

Since Iceland was settled 1100 y ago, declines in vegetated land cover has been accompanied by severe wind and water erosion. Interaction of four reinforcing factors appears to have contributed to the erosion problem: soil (Andisol) properties, cold climate, vegetation poorly adapted to herbivory, and livestock grazing. Andisols, with their low bulk density and particle cohesion, are intrinsically susceptible to erosion (Figure 1). The high soil water holding capacity causes them to expand when soils freeze, thus destabilizing soil surfaces. We hypothesized that grazing, by reducing plant biomass, root growth, and sward thickness, would magnify these instabilities and increase Andisol susceptibility to erosion. To test this hypothesis, soil surface movement was quantified in treatments simulating grazing. Results indicate that grazing exacerbates soil surface instability, the magnitude varying with vegetative ground cover properties. Properties of degraded landscapes were also studied on sites randomly selected from satellite imagery. These landscapes were grouped based on NDVI values and stage of erosion, and species abundance, vegetation cover, microtopography and sward thickness, -strength and –type quantified. Preliminary results show that low sward strength was positively correlated with low NDVI values and rougher microtopography (i.e. hummock shape and size).


***Figure 1.*** ***A.*** *Grazing-induced erosion often start as inconspicuous erosion spots.* ***B.*** *Small isolated erosion spots may grow and coalesce due to frost action.* ***C.*** *Erosion fronts develop and cause total loss of the whole soil profile in extreme cases.*

## Objectives and Hypotheses

- Compare surface properties over a gradient of land types, ranging from being highly eroded with low vegetation, to land types with good vegetation cover (as defined by NDVI reflectance).
  *Hypothesis:* Vegetation in eroded areas is characterized by low, or reduced, root density or biomass. Surface strength is thus reduced in degraded areas which may increase freeze-thaw dynamics, and thus increase hummock densities and morphology, e.g. side steepness.
- Quantify grazing effects on microtopography and surface stability.
  *Hypothesis:* Disruption of vegetation thermal cover will amplify freeze-thaw dynamics and reduce surface stability.

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## Study Area and Methods

Sites were selected based on Normalized Difference Vegetation Index (NDVI) obtained from Landsat TM satellite imagery covering South-West Iceland (10th July 2000). The resulting NDVI values were split up into 4 equal groups, yielding areas with low to high vegetation cover. Sites were selected within those areas and within each, three 34m transects established at randomly selected points on each site. Data on sward thickness and type, cover, microtopography, soil surface strength (using Proctor Penetrometer, Model CN-419, Soiltest, Inc.) and number of hummocks (per $m^{-2}$).

Plots were established in five vegetation types to test grazing effects on surface stability. Treatments, simulating grazing effects were assigned: clipped; trampled; clipped and trampled; and control (not clipped, not trampled). Soil erosion bridges (SEB) were used to monitor changes in microtopography to the nearest mm (Figure 2).

***Figure 2.*** *Soil Erosion Bridge (SEB). Two horizontal bars are placed between fixed vertical steel rods. Pins are then used to measure microtopo-graphy and surface changes (inserted image).*

## Results and conclusions

- NDVI is a measure of green biomass. It is used here to categorize different land types and thus there will be a correlation between bare soil vs. vegetation for the different land categories (Figure 3a). The observed difference in vegetation cover (e.g. grass) may thus be caused by the method used for selection. It is also noteworthy that some areas with high NDVI values also have high bare soil cover. This indicates that this index does not necessarily reflect vegetation cover vs. bare soils under all circumstances, or indicates a non-linear relationship. (Figure 3b).
- Surface strength was highest for grass and dwarf shrub cover, but lowest for moss and lichens cover. Bare soil had higher surface strength than both moss and lichens (Figure 4 left). Sward strength generally increases as NDVI increases, but this is reversed for surface strength of bare soils (Figure 4 right).
- No relationship was found between number of hummocks per $m^2$, size (basal diameter) and shape (side steepness).
- Soil stability, as indicated by changes in surface microtopography over nine months, was highest in trampled plots and tended to be lowest in clipped plots but followed the control plots (Figure 5). Trampling effects were comparable to trampling + clipping effects, indicating that trampling overrides and negates instabilities that would otherwise be promoted by disruption of thermal cover, caused by defoliation.
- The fact that trampling stabilized soil surfaces was unexpected and may reflect an initial short-term response. We are therefore continuing monitoring to determine if the pattern in Figure 5 persist over a longer term.

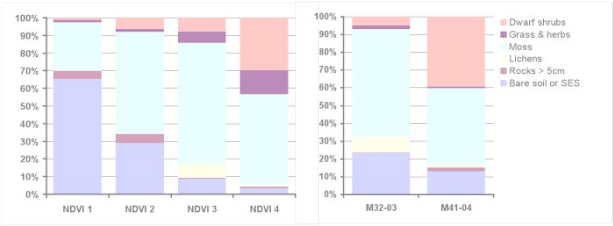


***Figure 3a.*** *Cover classes for the four NDVI categories (NDVI 1 = lowest, NDVI 4 = highest). Dwarf shrubs and grasses increase with higher NDVI values, but such trend is not observed for moss cover.*

***Figure 3b.*** *Cover classes for two sites belonging to NDVI 3 (left) and NDVI 4 (right). Despite falling into the higher NDVI categories, they have high bare soil cover. This indicates that other vegetation properties than just cover are affecting the NDVI values.*

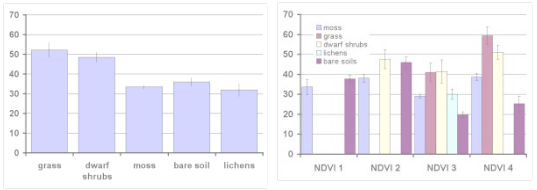


***Figure 4.*** *Surface strength for five cover classes across all sites (left) and for all cover classes within each NDVI category (right). Communities that form dense or strong root layers are represented by stronger surfaces (left), and higher NDVI values (left) are generally reflected by stronger, and thus more stable, surfaces. Vertical bars represent 95% CI of the mean.*

***Figure 5.*** *Soil stability between treatments, measured as difference between fall and spring. Stability tended to be low in clipped plots, indicating importance of thermal cover, but highest in trampled (N=2124).*