FACTORS ASSOCIATED WITH TRENDS IN BARE GROUND IN HIGH COUNTRY

Environment Canterbury, Christchurch

Industry Contacts:
Jeromy Cuff, Environment Canterbury, Timaru, New Zealand

Project Moderators:
Heather North, Landcare Research, Lincoln, New Zealand
Ken Russell, University of Wollongong, New South Wales, Australia
Rodney Weber, University of New South Wales, Sydney, Australia

Student Moderator:
Joanne Mann, Massey University, Auckland, New Zealand

Environment Canterbury Problem overview and dataset

Environment Canterbury has responsibility for promoting sustainable management of the region's natural resources. Soil erosion in the Canterbury high country has been a long-term concern, and was the subject of the problem brought to MISG. Pre-European and early European burning and grazing not only induced large tracts of tussock grassland in areas that were previously wooded, but also exposed areas of soil to further erosion by wind, rain and frost. In the 1960s to 1980s the government encouraged de-stocking on some properties, with the aim of restoring vegetative cover. In the late 1970s, a monitoring programme was set up in parts of the Canterbury high country to track the effects of lowered grazing levels.

The problem posed at MISG was to analyse the monitoring programme dataset to determine the factors associated with improvement or degradation in vegetative cover. A model resulting from this analysis would assist Environment Canterbury in recommending appropriate management strategies for different land types. Percent bare ground has been monitored at approximately 140 sites throughout the high country, at intervals of one to seven years. Record length varies from 12 to 27 years. Site characteristics specified in the dataset include soil type, topographic position and general management history. Initial analysis at Environment Canterbury suggested that soil fertility and altitude were important factors in recovery of vegetation, but that removal of the already low level of grazing had little effect.

Progress at MISG

The response variable to be studied and subsequently managed is the change in percent bare ground over time[1]. While the absolute amount of bare ground at the start of the monitoring period is informative for studying the processes by which the land first became bare, it is the change that is informative for studying the processes of subsequent revegetation (or failure of revegetation).

The group's initial data exploration included regression tree analysis. This first selects the independent variable that explains most variation in the response variable, and then clusters the values of this independent variable. The analysis produced clusters of soil series[2], where two clusters were associated with reduction in bare ground, one with increase, and two with stability (starting from extensive and

[1] Calculated as the slope coefficient of a linear regression of percent bare ground against time.
[2] Soil series are categories of soil classification.

minimal bare ground, respectively). Thus the group identified early that soil type is important (soil cluster alone explained 55% of the variation in bare ground change). Interpretation remained difficult, however, as soil series is strongly confounded with topographic position and land use. So it was unclear whether bare ground change was being affected by the inherent chemistry and physical properties of the soil, by the climate and topography in which that soil tends to occur, or by the land use management practices common on that soil type.

In addition, the group recognised that:

- Not all soil series are represented in the dataset, so a model based on these names would not be sufficiently general to be applied throughout the Canterbury high country.
- The model needed to answer questions about what land management practices are appropriate in what areas, and thus the effects of land management needed to be untangled from the effects of landform, soils and climate.

Therefore efforts were focused in two areas. One was to characterise the soil series in terms of their chemistry, topographic position and climatic zone. The other was to isolate the effects of individual management practices, specifically those of fertiliser application and oversowing, stocking intensity and rabbit control.

The four soil clusters where bare ground was decreasing or remaining stable were well characterised by soil nutrient status and general plant growing conditions. But the fifth cluster, where bare ground was increasing, was not. The data available did not explain why growing conditions were so poor in these areas, despite their being reasonably flat and at lower altitude. Across all the clusters, soil chemistry data was available for 74 of the 143 sites.

Each management factor was studied separately. For each, records were selected from the database where both levels of the factor were present in the same environment, e.g., sites with and without fertiliser application in a similar geographic area and on the same soil type. Five data blocks (regions/soil types) were available for fertiliser analysis and two for grazing analysis. Two-way analysis of variance (ANOVA) showed that fertilising/oversowing was effective in increasing vegetative cover on all soil types, though the magnitude of that change was greater at low altitude than at high. No difference in revegetation rate could be detected between low intensity grazing (less than one stock unit/ha) and no grazing. No comparison was available between "high" intensity grazing (1–4 stock unit/ha) and no grazing.

The effects of rabbit management had to be investigated in a different way, as this treatment is applied over broad areas, meaning no side-by-side comparison of treatment versus no treatment is available. In a simple comparison of mean change in bare ground, revegetation proceeded more quickly when rabbits were controlled on sites that were also fertilised. However, of the non-fertilised sites, degradation of vegetation cover appeared to be faster on sites where rabbits were controlled. It was thought that this was due to another (undefined) factor on those particular soils where rabbit control (but not fertiliser application) had taken place. No definite conclusion could be reached on the effects of rabbit control though it did appear to help on some sites.

A final model was developed which depended on fertiliser application, percent bare ground at the start of the monitoring period, annual average temperature (strongly correlated with altitude) and winter rain (probably supplying moisture for the spring growth flush). Several interactions of variables were also significant. This model explained 63% of the variation in bare ground change, compared with an earlier model that contained the soil series names plus other factors, which explained 77%

of the variation. However, the final model was generic (not dependent on soil names). In addition, the group is aware that soil chemistry and physical properties are important, but this information was not available for all sites so it was not included in the model.

Conclusions and future work

- A general model was developed for change in percent bare ground, where the significant factors include fertiliser application, starting percent bare ground, annual average temperature and winter rainfall.
- Soil chemistry and physical properties also appear to be important. Further data gathering and analysis is needed to include these in the model.
- Fertiliser application and oversowing has a strong positive effect on revegetation on all soils tested, with the effect strongest at low altitude.
- Little effect on revegetation was observed from de-stocking (from low intensity grazing to none).
- The effects of rabbit control were difficult to interpret, though there seemed to be some extra positive effect on the better soils that were also fertilised.