Application of multi objective regression models to map the resilience characteristics of soil

M. Debeljak[1], W. Towers[2], M. Jones[2], B. S. Griffiths[3,4] & P. D. Hallett[3]

[1]Jozef Stefan Institute, Department of Knowledge Technologies, Jamova 39, 1000 Ljubljana, Slovenia.
[2]Macaulay Institute, Craigiebuckler, Aberdeen, AB15 8QH, UK and
[3]Scottish Crop Research Institute, Invergowrie, Dundee, DD2 5DA, UK,
[4]current address: Teagasc, Environment Research Centre, Johnstown Castle, Wexford, Ireland

The Problem

- Policy makers use risk-based maps to make soil decisions.
- Producing maps confounded if data extrapolation not possible with pedotransfer functions.
- Study of soil biological and physical resilience to stress found no clear relationship with other soil properties.
- How then to produce risk based maps of soil resilience?

Soil Measurements

- Wide range of soils sampled across Scotland
- Biological resilience measured as changes in substrate mineralisation over time following a transient (heat) or persistent (copper) stress.
- Physical resilience measured from the resistance and recovery of pore structure following either compaction or water-logging.
- Soil characterisitics measured – taxonomy, pH, texture, carbon & nitrogen

The Solution

- A machine learning technique of multiple regression tree induction used.
- Enabled simultaneous prediction of interdependent resilience variables.
- Models with highest Root Mean Squared Error and Correlation Coefficient selecetd.
- GIS techniques coupled with an existing soil dataset used to up-scale the results of the models to map resilience at a national level (Scotland).

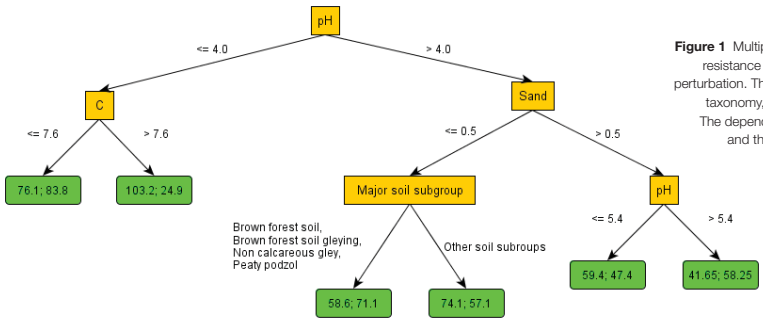
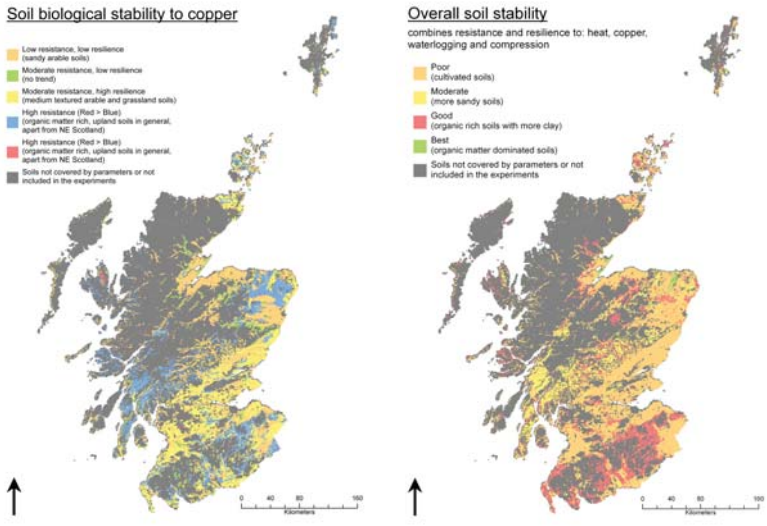


Figure 1 Multiple regression tree to predict the resistance and resilience of soils to copper perturbation. The independent variables are soil taxonomy, pH, texture, carbon & nitrogen. The dependent variables are the resistance and the resilience of the soil to copper stress. Quality measures of the model were RMSE 15.1 and 21.1 and Correlation Coefficient was 0.62 and 0.36 for Cu resistance and resilience respectively.

The Maps

- The maps produced defined remarkably distinct areas in terms of physical and biological resilience.
- Sandy arable soils were less biologically stable to copper than were the organic matter rich upland soils.
- Clay based arable soils were less physically stable to an overburden stress than were the organic matter rich and coarse textured soils.



Conclusions

- Multi objective regression modelling confirmed as an advanced technique to overcome problems of single attribute modelling.
- Models induced with data mining can be easily linked with techniques for analysing spatially related data by GIS.
- Even with limited data, the maps corresponded to expected behaviour based on expert knowledge. Greater data would improve the resolution of the maps.
- Resistance and resilience characteristics defined on maps, aiding potential decision making for soil protection.

Acknowledgement Research funded by the Scottish Government – Rural and Environment Research and Analysis Directorate. Soil resilience data from SCRI-Rothamsted collaborative study:

Reference Kuan, H.L, Hallett, P.D., Griffiths, B.S. Gregory, A.S., Watts, C.W. & Whitmore, A.P. 2007. The biological and physical stability and resilience of a selection of Scottish soils to stresses. *European Journal of Soil Science*, **58,** 811-821.