Maximising value from investment in soil data resources

Eric Paterson[1], Nikki Baggaley[1], Ernest Afriyie[1], Urmi Ghosh[1], Jackie Potts[2], Nia Gray-Wannell[1] and Zisis Gagkas[1]

1. The James Hutton Institute, Aberdeen

2. Biomathematics and Statistics Scotland, Aberdeen

eric.paterson@hutton.ac.uk

SEFARI
LEADING IDEAS FOR BETTER LIVES

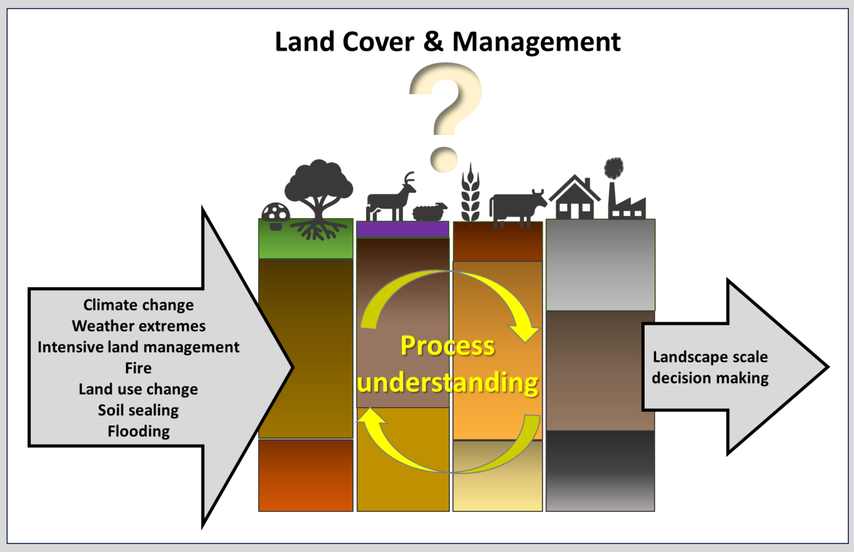
The James Hutton Institute

BioSS

HEALTHY SOILS FOR A GREEN RECOVERY

Introduction

- The National Soil Archive and Scottish Soils Database represent valuable physical and digital resources underpinning our understanding of the diversity of soils in Scotland.
- Within this, the National Soil Inventory of Scotland is a systematic grid sampling of soils across Scotland (NSIS 1978-87; NSIS2 2007-9).
- A current challenge is to make optimal use of this point-data in the context of the need to understand impacts of climate and land management on dynamic soil functions that underpin essential soil ecosystem services.
- Combining point soil data and functional measures with maps of soil types, soil properties (e.g., texture, carbon stocks) or risks (e.g., erosion), allows scaling of the changes in soils and can inform landscape scale decision making.

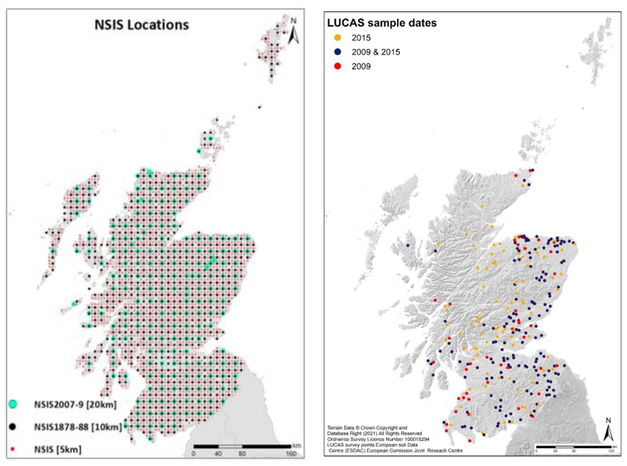


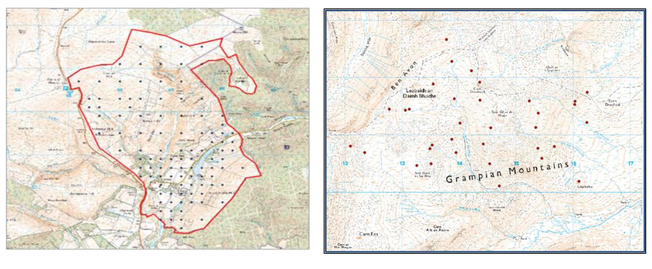
Opportunity

- As research approaches have advanced, iterations of the Strategic Research Programme have generated a wealth of supplementary data on physical, chemical and biological properties.
- Much of this information is complex and multivariate (so called 'big data'), that can now be interpreted using advanced statistical and machine learning models.
- To 'train' these models, outcomes (i.e., policy objectives) need to be defined, such that key characteristics (i.e., indicators) of soil functions can be identified.

Soil data & monitoring

The National Soil Inventory Surveys (NSIS 1 and 2) were designed to provide national-scale assessments of Scotland's soils. These data provide an invaluable baseline for the diversity of the national soil resource and to monitor change at that scale. To support policies such as Agricultural Reform, higher spatial resolutions will be required (e.g., verification of farm / field-scale regenerative management practices). This will require co-development of soil sampling and data stewardship strategies with definitions of desired policy outcomes, that go beyond '*soil health*'.





Soil processes

- Soil functions, underpinning ecosystem services, are mediated and constrained by soils' physical, chemical and biological characteristics, with interactions between these soil characteristics impacted by environmental conditions and land management.
- The soil depth profile of carbon stable isotopes (Epsilon, ε) is a proxy for the dynamic process of soil organic matter decomposition.
- Epsilon was used as an outcome to train models using clay mineralogical (XRD), chemical (FT-IR) and biological (PLFA) analyses as data-inputs to predict a dynamic soil function.
- Soil C-cycling rates discriminated into soil type and management classes, with fine-scale interactions between physical, chemical and biological properties within classes.

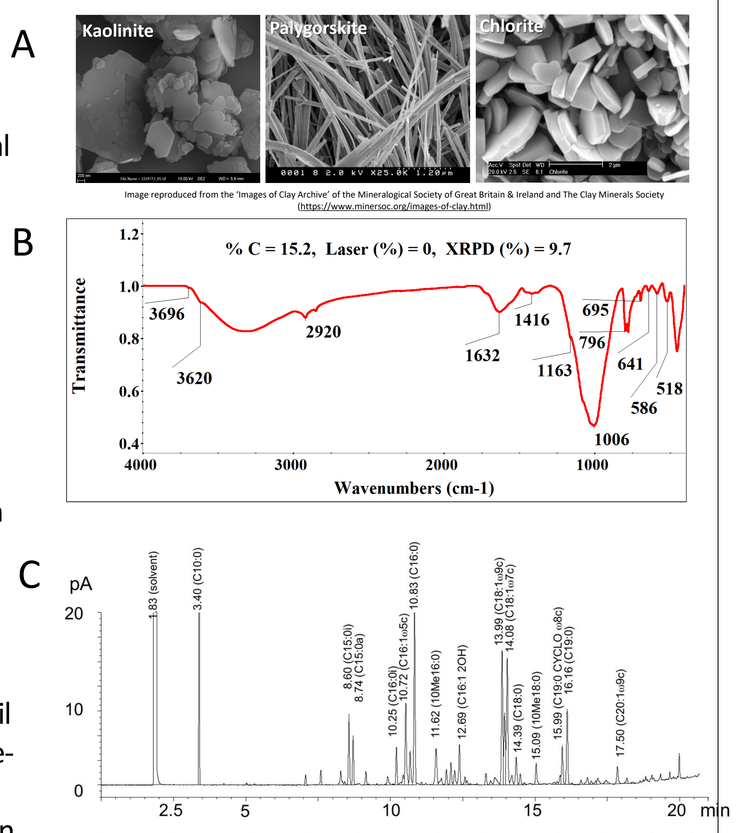
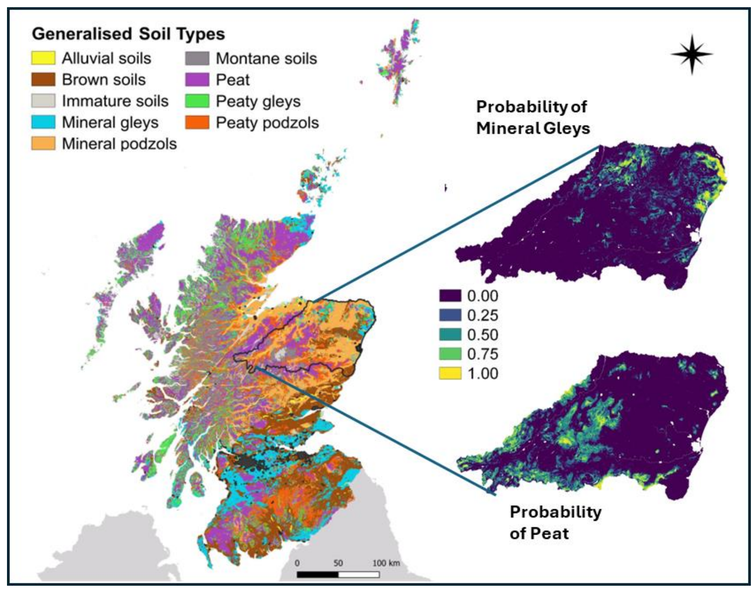


Illustration of soil physical (A), chemical (B) and biological (C) soil attributes.

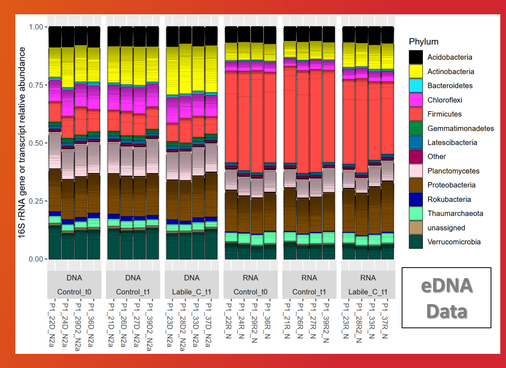
Soil mapping & modelling

- Legacy soil maps, providing soil association and series classifications, provide a means to increase the spatial resolution provided by systematic NSIS sampling.
- Machine learning approaches, to generate probability layers of soil series occurrence from legacy soil maps, allows integration with spatial frameworks for higher resolution representations of soil properties and soil ecosystem functions.



Conclusions

- The diversity of soil types in Scotland creates strong context-specificity in the ecosystem services that they can support. This represents an opportunity to refine land use policies by defining the bounds of what is possible, and where.
- Soil functions, which by definition are dynamic, can be predicted from point sampling, given sufficient input data and clearly defined output criteria.
- Combining all monitoring data and mapping with soil functional measures can quantify the status of Scotland's soils; and understand changes that occur as a result of increasing pressures on them.



- New 'big data' sources such as eDNA and LiDAR provide opportunities to identify, refine and monitor indices of soil function in the context of outcomes from land use policy.

Acknowledgements: We would like to acknowledge and thank Barry Thornton and Ben Butler for their work on this project during their time at the JHI. The authors acknowledge the Research/Scientific Computing teams at The James Hutton Institute and NIAB for providing computational resources and technical support for the "UK's Crop Diversity Bioinformatics HPC" (BBSRC grant BB/S019669/1), use of which has contributed to the results reported in this work. The authors would like to thank the soil surveyors and many staff that assisted in the sampling and analysis for the National Soil Inventory of Scotland and the analysis of archived samples in recent years. We are grateful to Helen Pendlowski for support with XRPD analysis and to Gillian Martin for stable isotope analysis of soils.