Mapping Soils in Ireland

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ABSTRACT: Harmonised soil data across Europe with a 1:250 000 geo-referenced soil database will allow for exchange of data across member states and the provide the information needed for reporting on issues relating to soil quality under a future Soil Framework Directive. The current status of soils data available in Europe is inconsistent at best. The Irish Soil Information System (ISIS) project is currently developing a national soil map of 1:250,000 and an associated digital soil information system, providing both spatial and quantitative information on soil types and properties across Ireland. Both the map and the information system will be freely available to the public through a designated website.

1 BACKGROUND

Comparison of soil information at a European scale has led to the requirement for the harmonisation and coordination of soil data across Europe. Harmonised geo-referenced soil data across Europe at a scale of 1:250 000 will allow for the exchange and comparison data across member states and will provide the European Commission and European Environment Agency with the data required for reporting on issues relating to soil quality under a future Soil Framework Directive. Following the INSPIRE Directive implemented in 2007, there has been a large emphasis on provision of soils data at a recommended scale of 1:250,000, in addition to harmonisation of soil classification laboratory methodologies and meta-data production to facilitate comparison of data and maps between countries. The current status of soils data available in Europe is inconsistent at best. In Ireland, a complete set of soil information at the target scale identified at European level (1:250 000) is under preparation. In 2008 the Environmental Protection Agency (EPA) and Teagasc (Agricultural Research Authority) of the Republic of Ireland commissioned a project to produce a 1:250 000 soil map of the Republic of Ireland. This project included collaboration between Teagasc, University College Dublin and Cranfield University, in the UK.

The resulting soil map of Ireland at 1:250,000 scale, and associated digital soil information system, will supersede the current General Soil Map of Ireland that only provides a highly generalised and often inappropriate level of information for the many national applications for which it is used. Furthermore, it will make a significant contribution towards a georeferenced 1:250,000 scale European Soil Information System. The most recent projects of a parallel nature in Europe include the Carta Ecopedologica d'Italia (Rusco et al., 2003) and the Soil Information System for Malta (Vella, 2005). Jones *et al*. (2005) summarised the status of soil information for the European Union and some neighbouring countries.

The work being undertaken in this project moves a national soil classification system into a new digital generation. This work is ground-breaking, as no other country has adopted such a complementary approach of combining novel digital techniques with ground truthing using traditional soil survey methodologies at a national scale.

2 METHODS

The National Soil Survey was initiated in 1959, and to date an estimated 44% of Ireland was surveyed at a scale of 1:126,720, identifying over 450 soil series with varying properties and different environmental and agronomic responses. This data was used as the basis of a national Soil Map of Ireland created in 1980. The national map therefore incorporates 56% of the country, which had only been surveyed at general reconnaissance scale, resulting in the development of a national map (General Soil Map of Ireland) at a scale of 1:575,000. The General Soils Map was initially created as an educational resource, which explained through soil associations at landscape scale the range of soil types (Great Groups) found in Ireland. The General Soil Map of Ireland only provides a highly generalised and often inappropriate level of information for the many national applications for which it is used. With the increasing use of Geographical Information System (GIS) in research and planning, the map was being utilised at scales for which it was never created.

The proposed methodology of the new Irish soil map at 1:250,000 scale and associated database had several phases:

2.1 *Rationalisation of the historical data*

Reappraisal, rationalisation and data capture for surveyed areas (terra cognita). The detailed surveys of 12 counties completed for the General Soil Map of Ireland (1980) comprised of approximately 450 soil series, an additional four counties, have been surveyed since the production of the GSM, identifying a further 112 soil series. This classification has been rationalized and harmonised across county boundaries to produce a consistent, robust soil classification on which to base the 1:250,000 soil map. The classification is being correlated to wider international soil classification standards, principally the World Reference Base classification (WRB) (WRB, 2006).

2.2 *Developing the predicted map*

Predictive mapping has been completed for unsurveyed areas (terra incognita), based on soil-landscape geo-statistical models utilising datasets on; terrain, geology (parent material), climate, land use and soil data (small scale) from terra cognita. A set of 30 environmental co-variables data layers was used to apply two different geo-statistical models (random forest and belief networks). The models sample existing data on soil associations (based on soil series) and the associated landscape parameter co-variables in Terra Cognita and project this into similar landscape scenarios in Terra Incognita. From this process the project produced five different predicted maps based upon the inference engine applied and the detail of the co-variable data used. These 5 predicted maps were validated using field data assessing the accuracy of the predictive maps..

2.3 *Ground Truthing*

The soil survey, organized by Teagasc, was focussed on map unit composition by examining and describing auger bores from across the remaining 56% of the country previously not surveyed.

Teagasc had 4 teams of soil surveyors and each team applied traditional techniques to characterise soils. The intensity of this soil survey was about 30 augers described in each 10 km x 10 km map sheet, this resulted in more than 10,000 augers which were described and verified during 2.5 years of intensive sampling (Figure 1). The field survey applied a fee survey, where surveyors used knowledge of the landscape and geology to determine sampling loca-

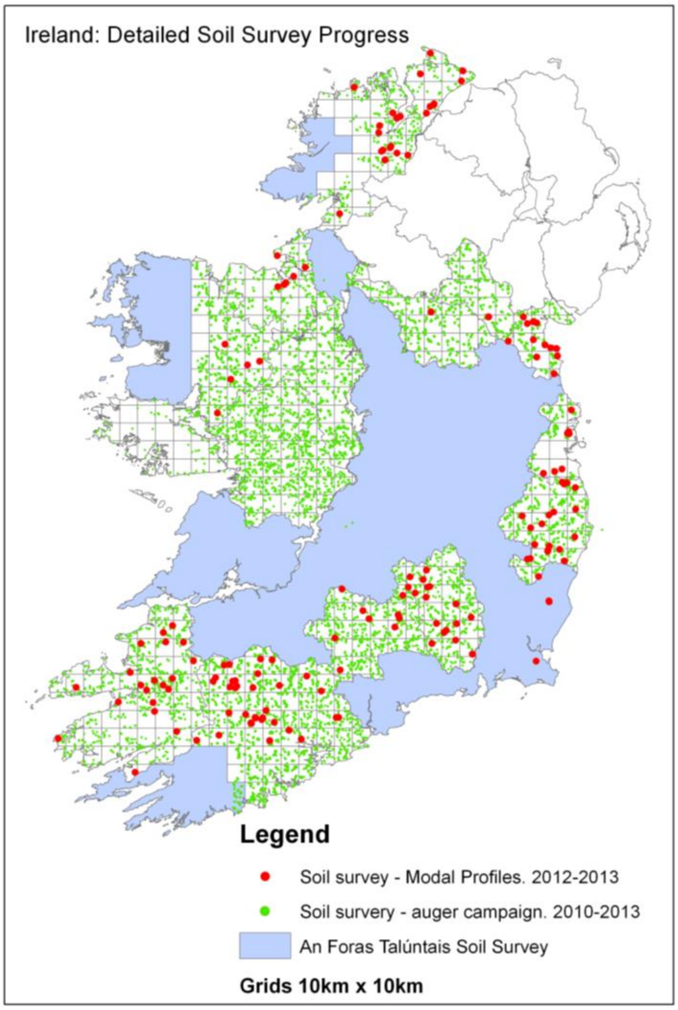

Figure 1: Detailed soil survey process during the project.

tions, to ascertain the composition of the main soil associations delineated on each field sheet, rather

than a pre-defined grid system. This was to allow for capture of landscape parameters as much as possible. All the information has been recorded in a Soil Geodatabase (SGDB), which is needed for calibrating and verifying models applied during predictive model phase.

In addition to the augerbore campaign, a second field campaign was initiated in 2011 to describe 250 new modal profiles, based upon the findings of the augerbore survey. These modal profiles were excavated and sampled to a depth of approximately 1 m. All horizons were sampled for a full pedological, chemical, physical and biological characterisation (Figure 1).

2.4 *Expanded National Soil Association Legend*

To facilitate the development of the final map and legend of National Soil Associations, the project team developed three soil matrix models to assess the predicted map in comparison to the field auger bore records. The original legend (developed from historical data) was expanded to include additional soil series which were defined in the field as a core component of that soil landscape association and new soil associations describing soils and landscapes which had not been surveyed in the original NSS.

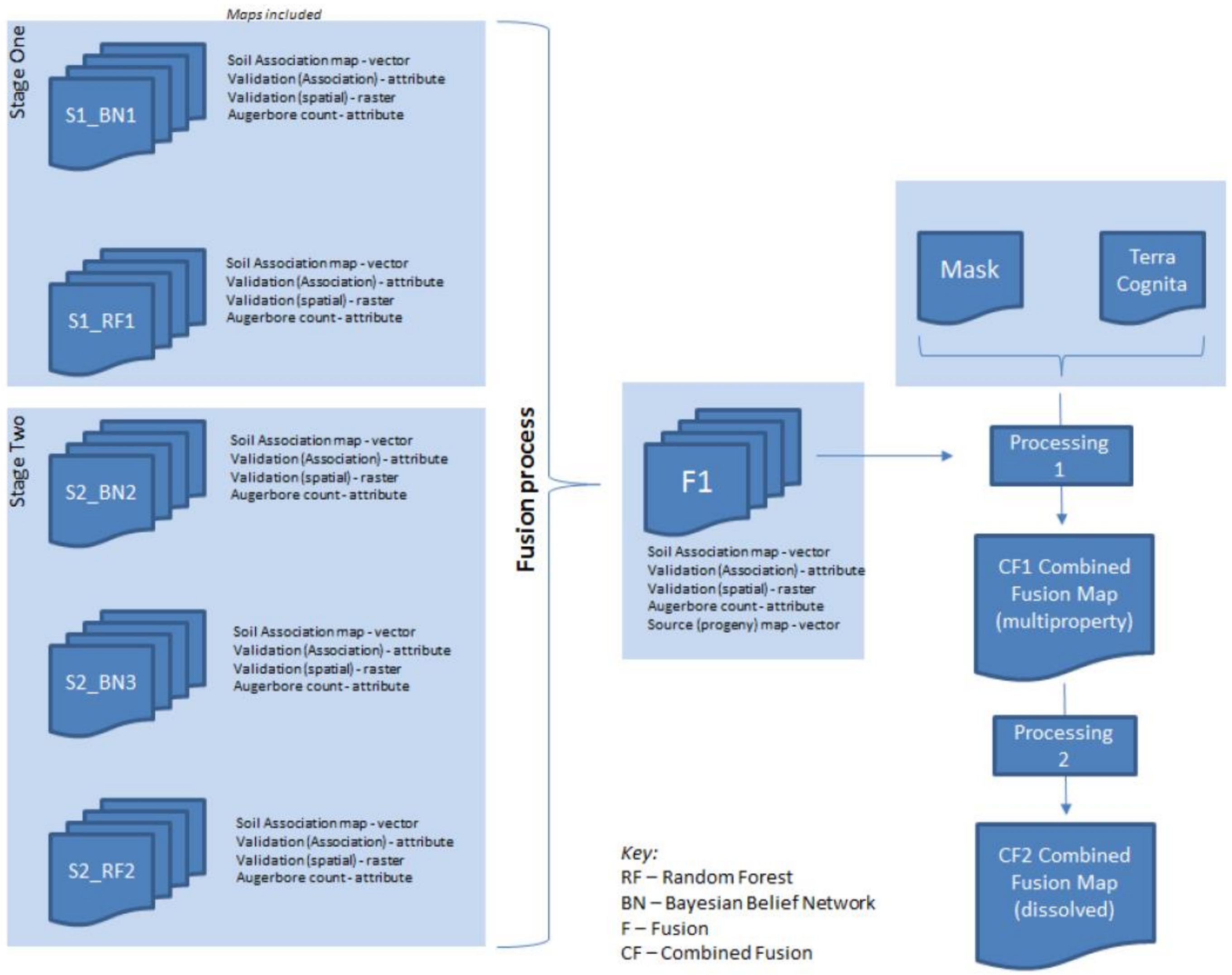

Figure 2: Predicted maps assemblage in work package 2 in ISIS project. (Mayr, 2013)

2.5 *Using auger data for testing the model*

The validation of the predictive mapping was primarily assessed using matrix 1 – similarity model. This checks the proposed soil series component members of a predicted soil association against soil series identified at within the predicted map polygons for that association.

For this purpose an intersect of the spatial auger bore observations with predicted soil map was applied to obtain the predicted National Soil Association delineated for the site of the auger bore observation. A score of '1' was given to the auger if the auger bore soil series code corresponded to any soil series in proposed legend or a score of '0' if the auger bore soil series code did not correspond.

Assessment of the accuracy of the predicted maps is achieved on an association basis and for the whole mapped area. This is represented simply as the ratio of the number of bores that match the extended matrix (those with score 1) to the total number of bores.

Association accuracy = (n bores with score 1 in association x)/(total number of bores in association x)

Map accuracy = (total number of bores with score 1)/(total number of bores)

This process was completed initially looking at national representation, but then repeated using regional datasets, as this found common repeating patterns in the data.

Matrix 2 model assess the diagnostic components of the augerbore records compared to those of the soil association components. This model checks whether the major pedological drivers of drainage, humose status, calcareous nature and depth are important in the prediction of map units.

Finally matrix 3 assesses the effect of landscape and major soil formation on the distribution and prediction of soil series. This utilizes the Esoter approach to assess the major soil formation factors on the spatial distribution of soils in Ireland and whether this pattern is captured using the predicted mapping techniques.

2.6 *Fusion Process*

To create the final map a ‘fusion process’ was then undertaken (F1, Figure 2), which selects the most appropriate predicted association from the five original predicted map products. There is a spatial validation ‘hotspot’ raster output included.

In the first production processing stage (Processing 1 on Figure 2), these data were ‘combined’ with the various mask layers, namely: islands, peats, rock outcrops, sand/dunes, salt marshes, tidal marshes, urban areas and water bodies. The final draft map combines the unified ‘Terra Cognita’ soil association map with Terra Incognita and the mask (Figure 3).

The first resultant ‘combined fusion’ map (CF1) holds attribution for all of the source layers, allowing future analysis. A second processing task (Processing 2 on Figure 2) derived from this a dissolved ‘combined fusion’ (CF2) map, holding multipart polygons, dissolved on the attribute ‘Association_Unit’.

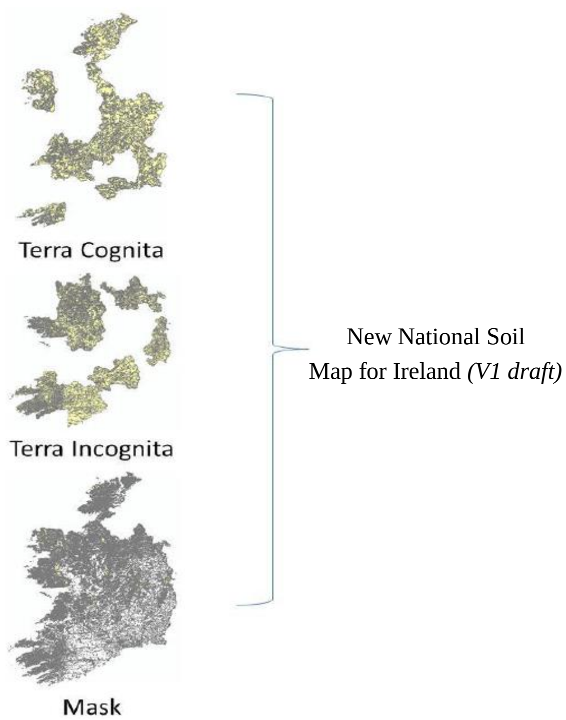

Figure 3: Process of map fusion (Mayr, 2013)

2.7 *Constructing the Soil Information System (SIS) for Ireland*

This SIS will provide a data infrastructure for organising, managing and disseminating soil information at national and international level.

This project will form the basis for more accurate soil spatial and attribute data in Ireland at a national scale and will provide the opportunity for soil specific nutrient advice and better research opportunities in spatial soil mapping and modelling in the future. The project is now coming to completion and the data and maps will be available online in February 2014. This paper will present the first viewing of final draft map and associated database.

3 RESULTS

Through the application of physiographic modeling, relationships have been sought between variables such as the slope, landform, vegetation and that of the individual soil unit (e.g. soil series). In addition traditional soil survey techniques have been applied, whereby soil unit rationalisation has been undertaken taking into account expert soil surveyors’ judgment on the relationships described above and the soil units.

4 DISCUSSION

To complete a national soil map of Ireland, at a scale of 1:250,000, through the application of traditional soil survey techniques only, was estimated to cost in excess of 12 million euros (Daly & Fealy, 2007). Through the introduction of digital techniques, this cost has been reduced to approximately 5 million euros.

All the data generated during the project has been integrated in a digital format, including 40 years of historical soils data. This geodatabase, which will provide data behind the soil map of Ireland, will be freely available, as it is intended that this system will add to the capabilities of soil survey, rather than take from it, providing a modern and clear soil classification system for Ireland.

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