

**EPA STRIVE Programme 2007-2013**

# **Methodology for the Validation of Predictive Mapping**

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## **ISIS Final Technical Report 11**

Prepared for the Environmental Protection Agency  
by  
Teagasc and Cranfield University

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## Executive Summary

The Irish Soil Information System (ISIS) project was established in 2008, following a comprehensive inventory of Irish soil data compiled by Daly and Fealy (2007) which highlighted that soil data coverage of Ireland was incomplete in both detail and extent. The ISIS project is funded under the Environmental Protection Agency STRIVE Research Programme 2007-2013 and co-funded by Teagasc. It was led by Teagasc with the participation of researchers from Cranfield University (UK) and University College Dublin. The overall objective of the ISIS project was to conduct a programme of structured research into the national distribution of soil types and construct a soil map, at 1:250,000 scale, which will identify and describe the soils according to a harmonised national legend. This map is now available in digital format and forms the basis of a new soil information system for Ireland (<http://isis.teagasc.ie>).

The ISIS project has utilised existing data and maps from the previous National Soil Survey (NSS) conducted by An Foras Talúntais (forerunner organisation to Teagasc). The NSS produced: mapping at 1:126,720 scale for 44% of the country; a General Soil Map of Ireland and a National Peatland map, both at 1:575,000 scale and other miscellaneous large scale mapping of experimental farms. In addition, more recent map products have been included such as the Indicative Soil and Subsoil mapping (Fealy and Green, 2009) with national coverage using GIS and remote sensing techniques.

Comparison of soil information at European scale has led to the requirement for the harmonisation and coordination of soil data across Europe, and, in light of the demands for soil protection on a regional basis within member states there is a growing need to support policy with a harmonised soil information system. The European Soil Bureau Network (ESBN) Technical Working Group dealing with Soil Monitoring and Harmonisation recommended a soil map of Europe at a scale of 1:250,000 as an economically feasible intermediate scale that can identify specific problems at regional scale (Montanarella and Jones, 1999).

The ISIS project adopted a combined methodology of utilising novel predicted mapping techniques in tandem with traditional soil survey applications. This unique combination at a national scale has resulted in the development of a new national soil map for Ireland. Building upon the detailed work carried out by the An Foras Talúntais (AFT) survey (known as *Terra Cognita*), the ISIS project generated soil-landscape models at a generalised scale of 1:250,000 for the counties of Carlow, Clare, Kildare, Laois, Leitrim, Limerick, Meath, Offaly, Tipperary South, Waterford, Westmeath, Wexford, West Cork, West Mayo and West Donegal. These soil-landscape models (also referred to as soilscape) were used as the baseline data for statistical models (random forests, Bayesian belief networks and neural networks) to predict soil map units in counties where there was no map available (referred to as *Terra Incognita*). To validate the methodology, this work was supported by a 2.5 year field survey, in which 11,000 locations were evaluated for soil type, using an auger bore survey approach. These data were used to check the predicted soil mapping units (associations) for counties: Cavan, Dublin, East Cork, East Donegal, East Mayo, Galway, Kerry, Kilkenny, Louth, Monaghan, Roscommon, Sligo, Tipperary South and Wicklow, where a detailed soil

survey map was not available. Where new soil information was generated, due to previously unknown combinations of soil-landscape units, profile pits were selected at representative locations across the country. These 225 pits were described and sampled in detail and were used to generate a new soil classification system for the country. The final product is a unique combination of new and traditional methodologies and soils data from both the AFT and the ISIS project. The final, soil association map of Ireland consists of 58 associations (excluding areas of alluvium, peat, urban, rock or marsh) that are made up from 213 soil series. Associated representative profile information is available in the online soil information system.

A key component of the ISIS project has been the development of a soil and land information system and associated public web site. This system has been designed to hold the complete set of information deriving both from the ISIS field programme and modelling activity, as well as the previously existing legacy soils information available for Ireland. Drawing on this information system, the web site is designed to hold and disseminate this information online both in cartographic and tabular form to stakeholders. Prior to this development, there has been no harmonised computerised system in place to hold and manipulate national Irish soils data. The information system therefore addresses the pressing need and requirement for a publicly-accessible, integrated IT framework based upon contemporary informatics standards to serve the many and varied stakeholders having an interest in soils information in Ireland.

# Technical Note on Soil Classification

Two Irish soil classification systems were developed during the ISIS project. An **Interim Soil Classification** was developed in the early stages of the project to enable the harmonisation and generalisation of the county soil maps published by An Foras Talúntais (AFT) and the rationalisation of the original AFT soil series. The **Interim Soil Classification** was used during the development of Work Packages (WP): WP1 and WP2, to produce the training data for the predictive mapping and for most of the field programme in WP3. In 2013/4, **the Interim Soil Classification** was modified following a World Reference Base style hierarchical approach that recognises Great Soil Groups and defines sub-groups by supplementary diagnostic horizons. The **Final Soil Classification** System was developed to provide a more user-friendly classification system that adopts the approach of a hierarchical key for recognition of Great Soil Groups and diagnostic horizons to define the sub-groups.

The **Final Soil Classification** System was subsequently implemented during the description of representative soil profiles, final map production and is included in the updated soil profile handbook, and national soil series list. This modified system is the **Final Soil Classification** system for Ireland that appears in the map and associated information system on the ISIS website.

This Final Technical Report was developed using the **Interim Soil Classification**, and describes a significant contribution to the production of the final New Soil Map of Ireland. Table B below details the differences between the **Interim** and the **Final Soil Classification** Systems.

The **Final Soil Classification** System for Ireland has 3 hierarchical levels:

## 1. Great Soil Groups:

The classification criteria for the Great Soil Groups (GSG) were based on recognisable features used by An Foras Talúntais (National Soil Survey of Ireland) to classify the soils of Ireland at Great Soil Group level. Table A provides an overview of the key criteria for recognizing the Great Soil Groups. The sequence follows World Reference Base (WRB) principles.

## 2. Soil Sub-groups:

The Irish Soil Classification of soil sub-groups (SSG) is based on the recognition of diagnostic horizons, properties and materials which, where possible, should be observed and measured in the field. The selection of diagnostic characteristics takes into account their relationship with soil forming processes. Diagnostic features are selected that are significant to soil management. Subgroups are named with a maximum of two diagnostic features that represent the most important processes occurring in the soil profile. Table B provides a look-up table between the interim and the modified classification systems, listing the Great Soil Groups and Sub-groups.

## 3. Soil Series

The classification of series is based on the same principles as the interim classification system. Within a sub-group a series is further defined by the nature of the soil texture and parent material.

#### 4. Soil Associations

For mapping purposes, the soil series are combined to form soil associations that are identified by the most frequently occurring soil series and combinations of ancillary series. Each association is named after the key (lead) soil series, which is the most extensive soil in the association, e.g. Kilrush series is the dominant component in the Kilrush Association. To facilitate mapping, each soil association based on the Interim Classification is assigned an alphanumeric code that comprises the soil subgroup code (numeric) concatenated with a single alphabetic character, e.g. 711b for Kilrush Association. In the Final Soil Classification, the Kilrush Association is assigned the code 0700b in accordance with Tables A and B. With respect to classification terminology, the reports (3, 4, 5, 11 & 12) describing the predictive mapping programme refer only to soil association codes that relate to the Interim Soil Classification. However, the ISIS Soil Information System contains a translation table that links the interim soil association codes to the codes that relate to the Final Soil Classification. Thus the results of the predictive mapping can be linked to the final version of the New Soil Map of Ireland.

**Table A: Sequencing of the Great Soil Groups (GSG) in the Final Irish Soil Classification**

<b>Criteria</b>	<b>GSG code</b>	<b>Great Soil Group (GSG)</b>
Soils with thick organic layers	<b>1</b>	<b>OMBROTROPHIC PEAT</b>
	<b>2</b>	<b>MINEROTROPHIC PEAT</b>
Shallow or extremely gravelly soils	<b>3</b>	<b>RENDZINAS</b>
	<b>4</b>	<b>LITHOSOLS</b>
Soils influenced by water	<b>5</b>	<b>ALLUVIAL SOILS</b>
	<b>6</b>	<b>GROUNDWATER GLEYS</b>
	<b>7</b>	<b>SURFACE-WATER GLEYS</b>
Soils affected by Fe/Al chemistry increase	<b>8</b>	<b>PODZOLS</b>
	<b>9</b>	<b>BROWN PODZOLICS</b>
Soils with clay enriched subsoil	<b>10</b>	<b>LUVISOLS</b>
Relatively young or soils with limited profile development	<b>11</b>	<b>BROWN EARTHS</b>

For more details of the finalised Irish Soil Classification System please refer to the following documents:

*ISIS Final Technical Report 10: Simo et al. (2014). The Irish Field Handbook for Soil Profile Descriptions. Available from <http://erc.epa.ie.safer/reports>*

*ISIS Final Technical Report 13: Simo et al. (2014). The Irish Soil Information System Map and Legend. Available from <http://erc.epa.ie.safer/reports>*

*ISIS Final Technical Report 9: Creamer et al. (2014). The Irish Soil Information System National Soil Series - Description and Classification of Representative Profiles. Available from <http://erc.epa.ie.safer/reports>*

**Table B Linkage between the Interim and Final Irish Soil Classifications for Soil Subgroups**

<b>Interim SSG_code</b>	<b>Interim Soil Subgroup (SSG)</b>	<b>SSG code</b>	<b>Soil Subgroup (SSG)</b>
911	Raw Ombrotrophic Peat Soils	110	Natural Ombrotrophic Peat Soils
912	Earthy Ombrotrophic Peat Soils	170	Drained Ombrotrophic Peat Soils
913	Cut-over Ombrotrophic Peat Soils	180	Cut-over Ombrotrophic Peat Soils
914	Industrial Ombrotrophic Peat Soils	190	Industrial Ombrotrophic Peat Soils
921	Raw Minerotrophic Peat Soils	210	Natural Minerotrophic Peat Soils
922	Earthy Minerotrophic Peat Soils	270	Drained Minerotrophic Peat Soils
		280	Cut-over Minerotrophic Peat Soils
211	Typical Rendzinas	300	Typical Rendzinas
215	Histic Rendzinas	310	Histic Rendzinas
213	Humic Rendzinas	360	Humic Rendzinas
214	Stagnic Rendzinas		
212	Gleyic Rendzinas		
111	Typical Lithosols	400	Typical Lithosols
113	Histic Lithosols	410	Histic Lithosols
112	Humic Lithosols	460	Humic Lithosols
821	Typical Alluvial Gleys	500	Typical Alluvial Gley Soils
		510	Histic Alluvial Gley Soils
823	Typical Calcareous Alluvial Gleys	550	Typical Calcareous Alluvial Gley Soils
		551	Histic Calcareous Alluvial Gley Soils
824	Humic Calcareous Alluvial Gleys	556	Humic Calcareous Alluvial Gley Soils
822	Humic Alluvial Gleys	560	Humic Alluvial Gley Soils
811	Typical Brown Alluvial Soils	570	Typical Alluvial Soils
812	Gleyic Brown Alluvial Soils	572	Gleyic Alluvial Soils
813	Humic Brown Alluvial Soils	576	Humic Alluvial Soils
721	Typical Groundwater Gleys	600	Typical Groundwater Gleys
		610	Histic Groundwater Gleys
723	Calcareous Groundwater Gleys	650	Calcareous Groundwater Gleys
		651	Histic Calcareous Groundwater Gleys
724	Humic Calcareous Groundwater Gleys	656	Humic Calcareous Groundwater Gleys
722	Humic Groundwater Gleys	660	Humic Groundwater Gleys
		690	Anthropic Groundwater Gleys
711	Typical Surface-water Gleys	700	Typical Surface-water Gleys
712	Humic Surface-water Gleys	760	Humic Surface-water Gleys
		790	Anthropic Surface-water Gleys
611	Ferric Podzols	800	Typical Podzols
621	Typical Gley Podzols	820	Gleyic Podzols
622	Stagno-Gley Podzols	830	Stagnic Podzols
632	Iron-pan Stagno Podzols	843	Stagnic Iron-pan Podzols
612	HumoFerric Podzols	860	Humic Podzols
		890	Anthropic Podzols
631	Ferric Stagno Podzols		
511	Typical Brown Podzolics	900	Typical Brown Podzolics
512	Gleyic Brown Podzolics	920	Gleyic Brown Podzolics
514	Stagnic Brown Podzolics	930	Stagnic Brown Podzolics
		936	Humi-Stagnic Brown Podzolics
513	Humic Brown Podzolics	960	Humic Brown Podzolics
		990	Anthropic Brown Podzolics
411	Typical Luvisols	1000	Typical Luvisols
412	Gleyic Luvisols	1020	Gleyic Luvisols
		1026	Humi-Gleyic Luvisols
414	Stagnic Luvisols	1030	Stagnic Luvisols
		1036	Humi-Stagnic Luvisols
413	Humic Luvisols	1060	Humic Luvisols
1020	Technosols	1090	Anthropic Luvisols
311	Typical Brown Earths	1100	Typical Brown Earths
312	Gleyic Brown Earths	1120	Gleyic Brown Earths
		1126	Humi-Gleyic Brown Earths
314	Stagnic Brown Earths	1130	Stagnic Brown Earths
315	Humi-stagnic Brown Earths	1136	Humi-Stagnic Brown Earths
321	Typical Calcareous Brown Earths	1150	Typical Calcareous Brown Earths
322	Gleyic Calcareous Brown Earths	1152	Gleyic Calcareous Brown Earths
323	Stagnic Calcareous Brown Earths	1153	Stagnic Calcareous Brown Earths
		1156	Humic Calcareous Brown Earths
		1159	Anthropic Calcareous Brown Earths
313	Humic Brown Earths	1160	Humic Brown Earths
		1190	Anthropic Brown Earths
		1196	Humi-Anthropic Brown Earths

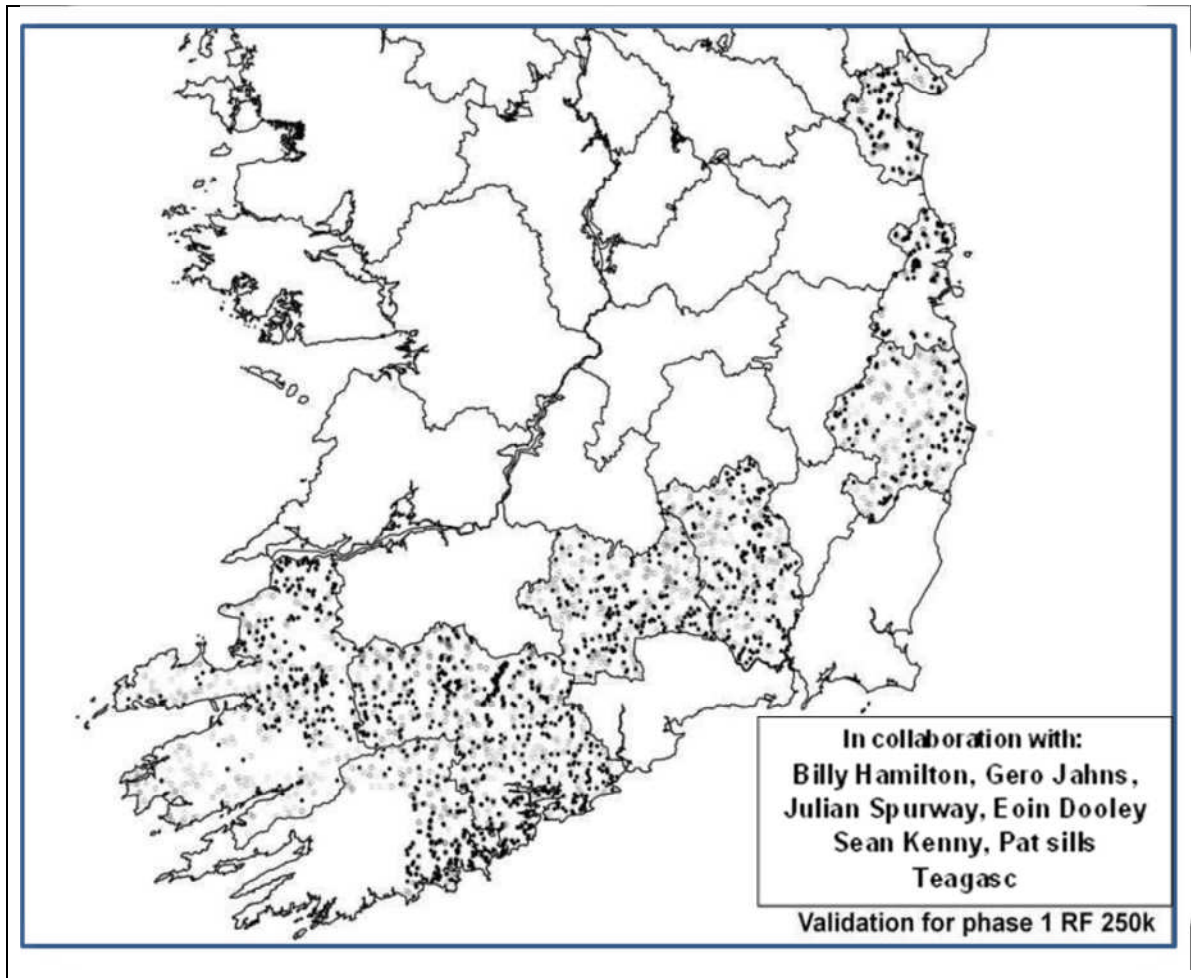


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By

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The auger bore data used in this report were derived from observations from the ISIS field programme in the counties of Cork East, Dublin, Kerry, Kilkenny, Louth, Tipperary South and Wicklow. The work of field technologists Billy Hamilton, Gero Jahns, Julian Spurway, Eoin Dooley, Sean Kenny in primary data collection are gratefully acknowledged. The support from Pat Sills during the field programme is also gratefully acknowledged.

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## 1. Purpose

Validation is the ratification or confirmation of the correctness of an observation or estimation.

The ISIS predictive mapping process (WP2) aims to delineate soil mapping units that consist of National Soil Associations, comprising a dominant soil series and a number (up to 5) ancillary or associated soil series. The predictive mapping effort in WP2 has produced a number of spatial outputs that delineate soil associations in 13 counties not previously surveyed under the former AFT soil survey programme. The outputs are predicted from inference models developed for previously surveyed areas (Terra Cognita) and thus represent the likelihood of the type and distribution of soil associations in unknown areas (Terra Incognita).

To assess the accuracy of the predictive maps a comparison with direct observation is necessary. During the WP3 field programme, the auger borehole survey identified the soil series at a given point. It was only possible to spend 3 days surveying each 10km x 10km map sheet area and thus soils were only examined in a small proportion of the soil mapping units (polygons). The field survey has focussed on nested sampling, to ascertain the composition of the main soil associations delineated on each field sheet, rather than auger boreholes more evenly distributed across the landscape.

Comparison between expected results (predictive maps) and observed points (auger borehole observations) are used to validate the predictive maps. This serves a number of purposes within the project:

1. Determination of best possible modelling approach for the predictive mapping (WP2).
2. Determine any changes to the current national legend composition (WP1/WP4)
3. Identifying areas that require additional information and support to ascertain map unit content or composition (WP4).

## 2. Approaches and datasets

The training data in Terra Cognita is comprised of soil information at 1:250 000 scale spatially delineated as soil mapping units attributed with a National Soil Association. The predictive mapping has similar output and thus the validation should be achieved on a National Soil Association basis to assess the accuracy of the predictive map. For validation, a direct comparison between the soil observation at the auger borehole and the composition of the national soil association is required. Other concepts such as similar/dissimilar soils and diagnostic features were considered but it was decided these were unsuitable approaches for validating the predictive mapping as they diverged from the National Soil Association concept.

### 2.1 Expanded National Soil Association Legend

A matrix was compiled based on the legend of the National Soil Associations (see Doc: ISIS\_WP1\_D1.1\_MapGen\_Ver2 & ibid D3.1\_FieldGuide) for comparison with the auger bore records. The original legend was expanded to include additional soils that show very similar characteristics to the core association composition. This fuzzy legend membership was derived to take into account some of the uncertainties in field observation and potential discrepancies between surveyors.

For example, it may be difficult to ascertain if the soil parent material is drift with limestones or drift with siliceous stones from material extracted by auger. Also where soils fall on the border between two textural classes, the same soil may be classified as coarse or fine loamy by different surveyors. Please refer to Appendix A for the matrix used in the initial assessment (prepared by R.J.A. Jones and J.A. Hannam).

### 2.2 Predicted soil maps

A detailed description of procedures used for producing the predicted soil maps are found in other project reports (Mayr, et. al., 2012a; Mayr, et. al., 2012b). To summarise the processes are briefly as follows:

1. The training data is stratified into large soilscape units that delineate landscape level changes in soil associations [ISIS\_WP2\_D2.1\_SoilsapesTC].
2. The soilscapes are extrapolated into Terra Incognita using two different methods, Feature Space (FS) Analysis and Bayesian Belief Networks (BBN) to ascertain the relationship between environmental covariates and the soilscape units [ISIS\_WP2\_D2.3\_SoilsapesExtraTI].
3. Inference and deployment of models within the soilscape units is carried out with the use of two different inference models Random Forests (RF) and BBNs. Both models predict soil mapping units (SMU) and their attributed National Soil Associations (NSA) – [see ISIS\_WP2\_D3.1\_DSMInferDeploy].

The outputs are five predictive maps using a combination of different approaches to soilscape extrapolation and inference of soil mapping units and national associations (Table 1). These were prepared by J.E. Zawadzka and T.R. Mayr.

**Table 1 Summary of predicted mapping outputs**

Output map	Soilscape extrapolation	Inference engine for SMU and NSA	Output Scale
ph1_RF_250k_v2	Feature Space	Random Forests (using all co-variates)	generalised to 1:250,000
ph1_BN_250k_v2	Feature Space	BBN (using all co-variates)	generalised to 1:250,000
ph2_BN2_1_250k_v2	Bayesian Belief Network	BBN (using all co-variates except climate)	generalised to 1:250,000
ph2_BN3_1_250k_v2	Bayesian Belief Network	BBN (using optimisation routine to select co-variates)	generalised to 1:250,000
ph2_RF_250k_v2	Bayesian Belief Network	Random Forests (using all co-variates)	generalised to 1:250,000

### **2.3 Auger borehole records**

Extracts from the field recording databases for the auger bore hole observations were supplied to Cranfield from Teagasc. The data sets had been compiled, and checked for errors, by R.E. Creamer and I. Simo. At the time of reporting, complete data were available for seven counties (Cork East, Dublin, Kerry, Kilkenny, Louth, Tipperary South and Wicklow) and these were used to develop the procedures and methodologies for validation, and thus results are reported on the basis of these seven counties only.

### 3. Implementation of procedures

In the first instance, the soil series identified by mini-pit or auger borehole is compared with soil series that comprise the association on the predicted map in which the auger borehole is located. This process has been automated using bespoke software written by A. Holden that operates on input files prepared by J.A. Hannam, I.G. Truckell and R.J.A. Jones.

#### 3.1 Running the comparison utilities

A series of utilities written in ArcGIS™ modelbuilder and VB.NET intersects predictive maps and the auger bore hole records.

The utilities require the following inputs:

- Predicted soil map with National Soil Association code attributed to each soil mapping unit (section 2.2) as a shapefile.
- Matrix for comparison of auger bore record with national association code and soil series codes for each extended association membership (section 2.1).
- Auger bore hole records with georeference and soil series code (section 2.3)

The procedure is detailed as follows:

1. Intersect auger bore observation with predicted soil map to obtain the predicted National Soil Association delineated for the site of the auger bore observation. This is performed using a tool written in model builder ArcGIS™ v10 called 'Intersect\_SoilPoly\_with\_Bores' (Figure 1).
2. The tool creates output files from the intersection that lists the georeference for the auger bore, series and predicted National Soil Association code from the predicted map.
3. Compare the auger bore soil series to the matrix to determine if it has membership to the extended legend. This is achieved through a bespoke utility "CompareSeries.exe" which compares the intersect output with the matrix (Figure 2).
4. The utility returns a score of '1' if the auger bore soil series code corresponds to any soil series code in extended legend for the intersected National Soil Association. It returns a score of '0' if the auger bore soil series code does not correspond to any soil series code in extended legend for the intersected National Soil Association.
5. The output returns the score (0 or 1) for each observation that has been intersected with the predicted map.
6. A routine (RunSummary.bas) creates a summary output that returns the count of score 0 and score 1 on an association basis for the county.
7. Repeat procedures above for all other counties

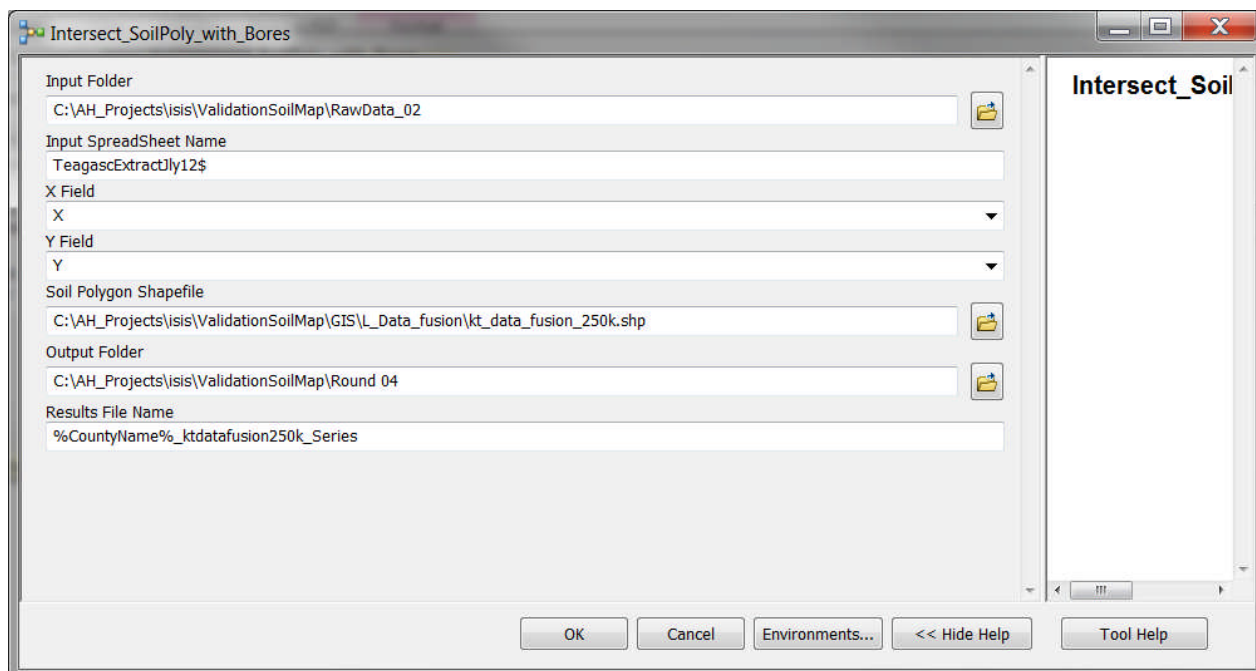


Figure 1 Entry screen for tool to combine auger bore points with predicted soil map shapefile

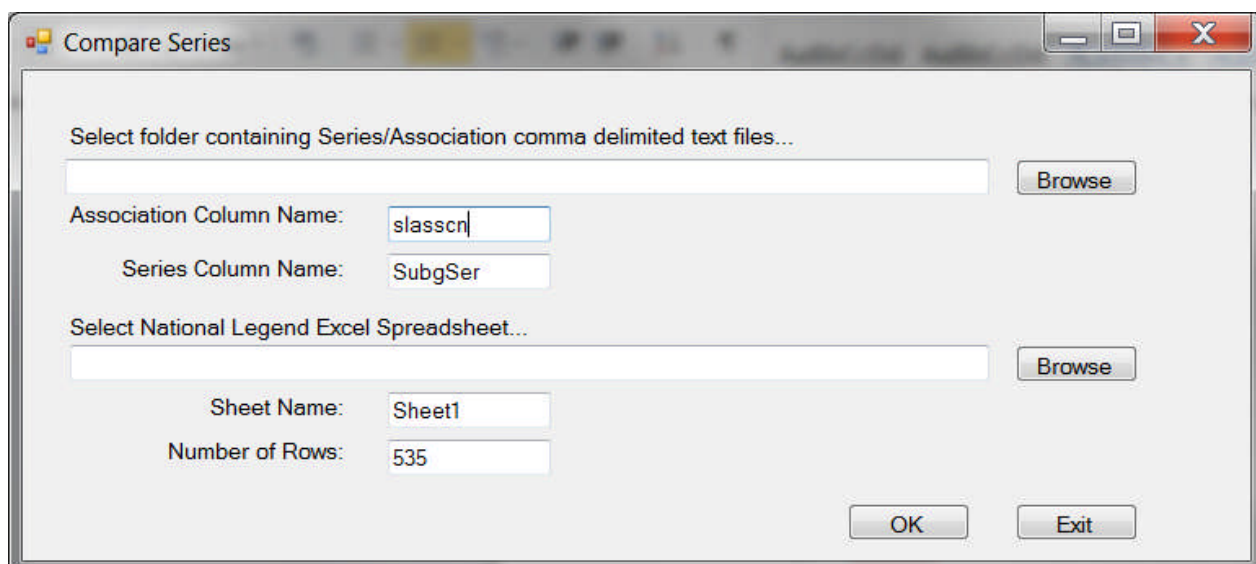


Figure 2 Input screen for validation utility (CompareSeries.exe)

### 3.2 Post-processing steps

The utility produces summaries on a county basis. Whilst this is useful for local assessment, there is a requirement for a broader level of assessment to determine the best predictive mapping approaches on a national level. In addition, some series identified in the field are not represented in the legend, or have yet to be recognised as nationally significant ("new" series).

Summary of post-processing steps:

1. Merge all county outputs with counts for score 1 and score 0 for each association.
2. Exclude all observations of soil series that do not appear in the matrix. This excludes some unnamed soil series and all series identified as 'new' in the field database.
3. Summarise the score counts for each association, resulting in total number of observations, number with score 1 and an accuracy for the association (derived below).
4. Repeat for each predicted soil map.

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.

$$\text{Association accuracy} = (\text{n bores with score 1 in association x}) / (\text{total number of bores in association x})$$

$$\text{Map accuracy} = (\text{total number of bores with score 1}) / (\text{total number of bores})$$

The accuracy assessments will be influenced by the total number of bores recorded for each association.

The results are reported on three levels

- 1) all observations
- 2) associations with > 50 observations, and
- 3) associations with > 100 observations.

## 4. Results

Overall map accuracy can be used to compare the relative accuracies of the predicted maps to aid selection of the appropriate predicted map to take forward to WP4new.

Table 2 details the overall accuracy of the five predicted maps. As expected, accuracy improves when the associations with fewest observations are excluded from the analysis. The best performing model when validated with the auger bore data is the random forest model using Feature Space to extrapolate the soilscapes (ph1\_RF\_250k\_v2). However, the RF model using BBN to extrapolate the soilscapes is the least accurate. Most of the BBN models have similar accuracies, although performance is better when soilscapes are extrapolated with BBN rather than feature space.

The breakdown of association accuracies for the ph1\_RF\_250k\_v2 predictive map is detailed in Table 3 for associations with > 100 observations. Accuracies approaching 0.5 or above are indicative of predictive associations that have good validation against observations in the field.

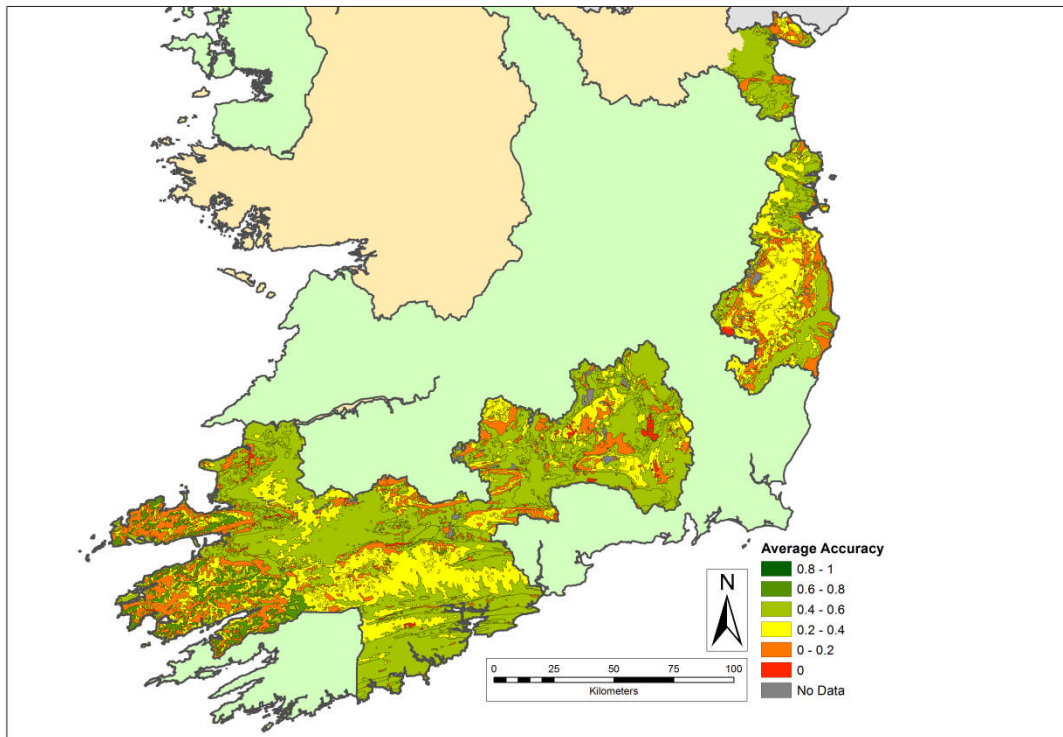
This is a considerable achievement when taking the following into account:

- the legend has been constructed from soils recognised in Terra Cognita alone;
- the scale of the predictive associations is different when compared with a point observation;
- the inherent spatial variability of soils that can occur over short distances;

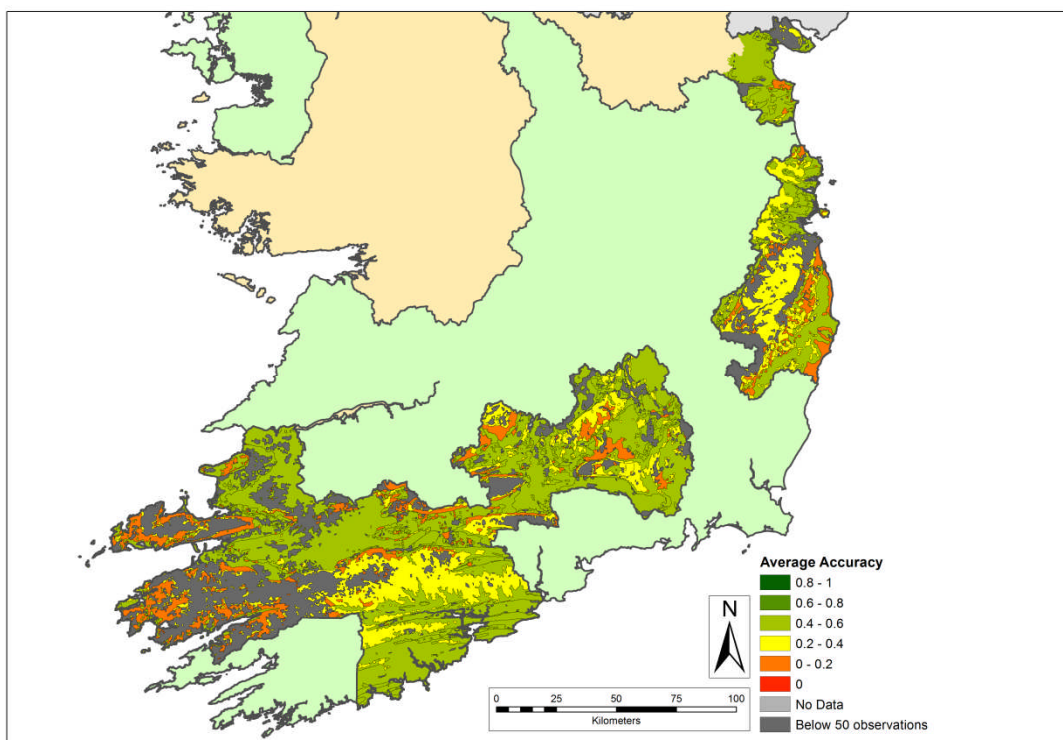
**Table 2 Overall map accuracy.**

Map	all	> 50	> 100	Total obs
ph1_RF_250k_v2	38.85	41.21	<b>43.30</b>	4296
ph1_BN_250k_v2	31.35	33.43	33.98	4073
ph2_BN2_1_250k_v2	33.67	37.21	39.20	4300
ph2_BN3_1_250k_v2	33.16	36.07	39.42	4300
ph2_RF_250k_v2	27.26	28.06	<b>28.95</b>	4300

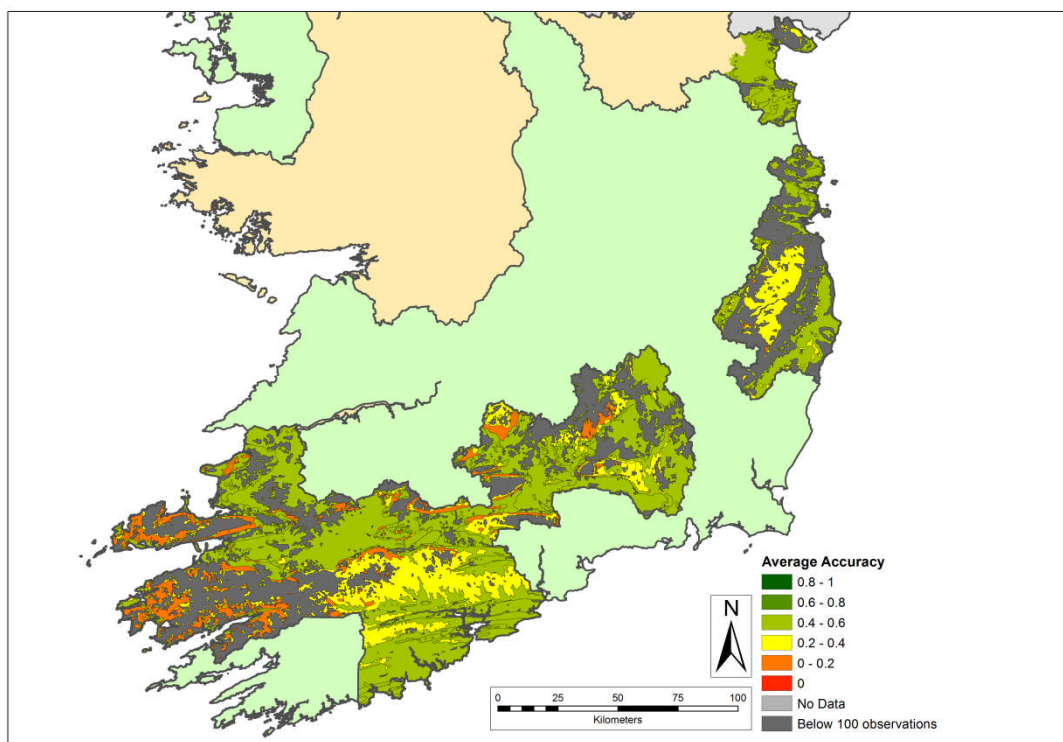
Total obs are the total number of auger bore points used in the validation process; all uses all associations on the map irrespective of the total number of observations within the association; > 50 includes only associations with > 50 observations; > 100 includes only associations with > 100 observations.



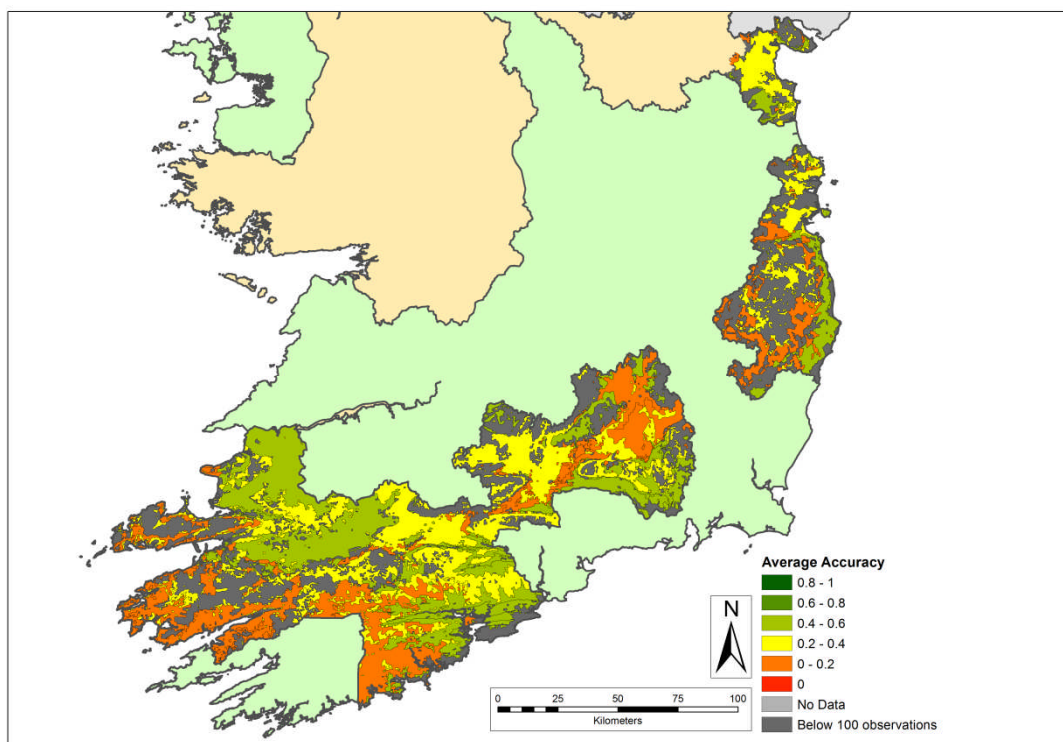
**Figure 3 Predictive map ph1\_RF\_250k\_v2 association accuracies using all auger bore observations.** Accuracy has been calculated across the 7-counties and projected onto the corresponding polygons.



**Figure 4 Predictive map ph1\_RF\_250k\_v2 association accuracies using only associations with > 50 auger bore observations.** Accuracy has been calculated across the 7-counties and projected onto the corresponding polygons.



**Figure 5 Predictive map ph1\_RF\_250k\_v2 association accuracies using only associations with > 100 auger bore observations.** Accuracy has been calculated across the 7 counties and projected onto the corresponding polygons.



**Figure 6 Predictive map ph2\_RF\_250k\_v2 association accuracies using only associations with > 100 auger bore observations.** Accuracy has been calculated across the 7 counties and projected onto the corresponding polygons.

Associations with large spatial coverage but poor accuracies (e.g. 0.2) indicate where the predictive map does not correlate well with observed features and thus there is less confidence in the predicted association.

**Table 3 Association accuracies for ph1\_RF\_250k\_v2 predictive map.**

Association	n bores	% total bores	n correct (score 1)	accuracy
513e	516	12.01	116	0.22
711b	516	12.01	255	0.49
311n	468	10.89	280	0.60
311c	410	9.54	167	0.41
411x	387	9.01	196	0.51
511e	302	7.03	162	0.54
311d	271	6.31	54	0.20
311a	216	5.03	105	0.49
311f	141	3.28	46	0.33
311e	129	3.00	72	0.56

(for associations with > 100 observations)

Figures 3 to 5 show the association accuracy calculated across the 7-counties attributed to the predicted soil mapping units for:

- all associations;
- associations with > 50 auger bore observations;
- associations with > 100 auger bore observations.

For comparison Figure 6 shows the ph1\_RF\_250k\_v2 predicted map association accuracies for > 100 auger bore observations per association.

## 5. Conclusions and next steps

An initial assessment using auger bore observations from seven counties indicates that the predicted map using Feature Space extrapolation of the soilscapes and Random Forest inference to predict soil association delineation has the best overall accuracy. However, this assessment is based on auger bore data from only 7 counties (Dublin, East Cork, Kerry, Kilkenny, Louth, Tipperary South and Wicklow).

### 6. 5.1 National assessment validation (WP2)

The validation procedure should be repeated when all auger bore data sets have been processed from the field programme by Teagasc, thus completing all counties classified as Terra Incognita (Cavan, Dublin, East Cork, East Mayo, Galway, Kerry, Kilkenny, Louth, Monaghan, Roscommon, Sligo, Tipperary South and Wicklow). In addition, the matrix is currently under review by the project team and a revised version will be included in the utility procedures.

### 5.2 Adjusting the composition of the legend (WP1/WP4new)

The current legend is based on information from Terra Cognita and therefore it would be expected that gaps exist in the association composition, these only becoming apparent as more field data was collected. Therefore, the expanded matrix can be used to assess if any changes are required to the current legend composition.

**Table 4 Expanded legend (validation matrix) for 311n.**

	<i>311CL</i>	<i>712GN</i>	<i>411DB</i>			
<b>311n</b>	<b>311CM</b>	<b>711KR</b>	<b>411DG</b>	NANA	NANA	NANA
	<i>313SH</i>	<i>311BV</i>	<i>411AT</i>	<i>414FE</i>		

Soil series in bold are the original legend entries, entries in italics represent fuzzy membership.  
NANA no further ancillary soils from Terra Cognita information.

Association 311n, which has a good overall predictive accuracy (0.6), is due primarily to the addition of the fuzzy members to the association during the validation process (Tables 4 and 5). Core legend entries contribute 17 % of the auger bore observations, but this proportion increased to 55% when selected fuzzy members from the validation matrix are included. This indicates that several additional soil series are consistently observed in the field and thus the legend composition for 311n association should be expanded to reflect this.

**Table 5 Proportion of auger core observations in predicted association 311n**

	Core legend series			Fuzzy members			
series	<b>311CM</b>	<b>711KR</b>	<b>411DG</b>	<i>311CL</i>	<i>414FE</i>	<i>411DB</i>	<i>new</i>
%	10.3	5.6	1.4	10.0	9.0	9.0	10.0
total %			17.3				55.3

### 5.3 Re-attributing the predicted soil association (WP4new)

The composition of the auger bore observations within poorly predicted associations can be used to ascertain whether an alternative association is better suited for the soil mapping unit. Running the validation procedure with the re-attributed predicted map would provide evidence for improved accuracy. Association 513e has poor prediction accuracy even after inclusion of the fuzzy series members (Table 6). Identifying other series from the auger bore observations can provide insight into the composition of the units and thus facilitate selection of an alternative or new National Soil Association.

**Table 6 Proportion of auger core observations in predicted association 511e**

core legend series		fuzzy series		other significant series	
	%		%		%
<b>513KB</b>	2.5	<i>311BL</i>	4.6	new	14.4
<b>611BN</b>	0.7	<i>313AS</i>	1.9	<i>311CL</i>	7.0
<b>711NW</b>	0.1	<i>513BE</i>	2.5	<i>311BY</i>	6.1
<b>722SB</b>	0.9	<i>721KO</i>	1.0	<i>311CM</i>	5.4
<b>Total</b>	<b>4.3</b>		<b>14.5</b>		<b>32.9</b>

(total is for fuzzy series included with core legend entries)

## 6.0 References

- Hannam, J.A., Jones, R.J.A., Zawadzka, R C Palmer, J. Truckell, I.G. & Mayr, T.R. (2011). Soilscales for Terra Cognita Ireland. ISIS Project Technical Report No2.2, 27pp. Cranfield University & Teagasc. [Doc: ISIS\_WP1\_D1.1\_MapGen\_Ver2]
- Jones, R.J.A., Hannam, J.A., Creamer, R.E. (2011). Description and classification of soils in the field in Ireland. ISIS Technical Monograph No.1.2, 71pp. Cranfield University & Teagasc.. [Doc: ISIS\_WP1\_D3.1\_FieldGuide]
- Mayr, T.R., Zawadzka, J.E., Corstanje, R., Lo Papa, G., Fealy, R. (2012). Soilscales Extrapolation (Terra Incognita) for Ireland. ISIS Project Technical Report No.2.4, 32pp. Cranfield University
- Mayr, T.R., Corstanje, R., Zawadzka, J.E., Lo Papa, G., Fealy, R. (2012). Inference Modelling and Deployment ISIS Project Technical Report No.2.2, Cranfield University.

## Appendix A: Matrix (v1.1) used for test validation of auger bore hole records for 7 counties (supplied Oct'12)

Asscn = National Soil Association in current legend.

Sercod-0 to sercod-5= Codes for individual National Soil Series.

Score= Used in validation to represent presence of series in the association either as a current legend entry or as a fuzzy member.

For each association= Middle line represents current legend entry, the lines above and below represent soil series with 'fuzzy' membership to the association.

NANA= not applicable – no further ancillary soils in the first draft of the legend based on Terra Cognita

NARK= subgroup not applicable + rock

Asscn	Sercod-0	Sercod-1	Sercod-2	Sercod-3	Sercod-4	Sercod-5	Score
112a	112KY	321BG	411PWL				1.0
112a	112RN	321BC	411ET	NANA	NANA	NANA	1.0
112a		321CH	414RA				1.0
112b	112KY						1.0
112b	112RN	314LO	711UN08	NANA	NANA	NANA	1.0
112b							1.0
112c	112KW	632MV					1.0
112c	112KY	632FC	NANA	NANA	NANA	NANA	1.0
112c	113BA	632KS					1.0
112d	112KW						1.0
112d	112KY	NARK	NANA	NANA	NANA	NANA	1.0
112d	113BA						1.0
112e	112KY						1.0
112e	112KW	311CL	NANA	NANA	NANA	NANA	1.0
112e	113BA	311CM					1.0
113a	911KM		632DS	722SB			1.0
113a	113CV	113BA	632BL	722BW	911AT	112KY	1.0
113a	112KW	632KS	722TK	913ATC			1.0
113b	112KW	911AT					1.0
113b	113BA	113CV	112KY	NANA	NANA	NANA	1.0
113b	911KM						1.0

Assocn	Sercod-0	Sercod-1	Sercod-2	Sercod-3	Sercod-4	Sercod-5	Score
211a							1.0
211a	211SE	311DY	722BK	NANA	NANA	NANA	1.0
211a							1.0
211b	321BC						1.0
211b	213KC	311KV	NANA	NANA	NANA	NANA	1.0
211b	321CH						1.0
213a	321KF						1.0
213a	213BU	NARK	112RN	321BC	213KC	NANA	1.0
213a	311KV						1.0
213b	NARK						1.0
213b	213BUR	213BU	NANA	NANA	NANA	NANA	1.0
213b	213KC						1.0
311a	311CM	311BG	511CU	712DY	UN09	NANA	1.0
311a	311CL	311BY	513BE	712GN	711KR	NANA	1.0
311a	411DB	311BL	513KB	712BN	711ST	NANA	1.0
311b	311CL	311BO	414FE				1.0
311b	311KI	311KIL	313CG	NANA	NANA	NANA	1.0
311b	311CM	311BG	313AS				1.0
311c	311CL	313AS	722TK				1.0
311c	311CM	312BY	722PU	NANA	NANA	NANA	1.0
311c	411DG	311KE	722SB	311BY			1.0
311d	311CL		612CB				1.0
311d	311BV	311CM	612PO	NANA	NANA	NANA	1.0
311d	312BY		631KD				1.0
311e	311BY	513BE	711CH				1.0
311e	311KE	513RK	711KR	NANA	NANA	NANA	1.0
311e	311CL	513KB	712GN				1.0
311f	311KE	513BE	313AS	311CM			1.0
311f	311BY	511CU	313UN04	311CL	NANA	NANA	1.0
311f	411UN23	511CO	312BY				1.0

Assocn	Sercod-0	Sercod-1	Sercod-2	Sercod-3	Sercod-4	Sercod-5	Score
311g	311BG						1.0
311g	311KS	NARK	NANA	NANA	NANA	NANA	1.0
311g	311KE						1.0
311h	311KS	722PU					1.0
311h	311BO	722BW	NANA	NANA	NANA	NANA	1.0
311h	311CM	722SB					1.0
311i	311CL	311KI					1.0
311i	311BL	311CM	1011MT	NANA	NANA	NANA	1.0
311i	311BG	311BY					1.0
311j	311CL						1.0
311j	311RM	NANA	NANA	NANA	NANA	NANA	1.0
311j	311BG						1.0
311k	321CH	311LA					1.0
311k	311BR	321BG	NANA	NANA	NANA	NANA	1.0
311k	311CM	0321UN05					1.0
311l	311UN65	311CM	0314UN52				1.0
311l	311KC	311CL	311BY	NANA	NANA	NANA	1.0
311l	311KE	321CH	311BG				1.0
311m	311KIL	722BW	611SP				1.0
311m	311KI	711TR	611BS	NANA	NANA	NANA	1.0
311m	311BO	722PU	611BN				1.0
311n	311CL	712GN	411DB				1.0
311n	311CM	711KR	411DG	NANA	NANA	NANA	1.0
311n	313SH	311BV	411AT	414FE			1.0
311o	311KC		712BN				1.0
311o	311DO	321BC	712HN	NANA	NANA	NANA	1.0
311o	311KV	321CH	711ST				1.0
311q	321BC	213BUR	311KC		511UN29		1.0
311q	311AL	213BU	311UN65	213CS	513CM	NANA	1.0
311q	321CH						1.0
313a	313SH	812RY	711ST				1.0
313a	313AS	811CN	711KR	NANA	NANA	NANA	1.0
313a	312BY	821LY	712GN				1.0

Assocn	Sercod-0	Sercod-1	Sercod-2	Sercod-3	Sercod-4	Sercod-5	Score
313b	313CG						1.0
313b	313WO	111UN01	113CV	NANA	NANA	NANA	1.0
313b	311KL						1.0
313c	313AS	1011MT	722PU	511CO			1.0
313c	313SH	1011AR	712DY	511RO	NANA	NANA	1.0
313c	312BY			511UN29			1.0
313d	313SH						1.0
313d	313BB	NANA	NANA	NANA	NANA	NANA	1.0
313d	313AS						1.0
314a	0314UN53	712CG	414FE				1.0
314a	314MO	712GN	711KR	NANA	NANA	NANA	1.0
314a	312BY	411ET	711ST				1.0
321a	311LA	321CH	213KC	411ET			1.0
321a	321BG	321UN05	213CS	411PW	NANA	NANA	1.0
321a	311BR	311KC		411PWL			1.0
321b	311AL	112KW	411PW				1.0
321b	321BC	112RN	411ET	321KF	NANA	NANA	1.0
321b	321CH		411PWL				1.0
321c	311KC	321BC					1.0
321c	311KV	321KF	311CM	NANA	NANA	NANA	1.0
321c	321KV		311CL				1.0
411a	411AT	321UN05	311KC	411MT			1.0
411a	411PW	321BG	311LA	411ET	NANA	NANA	1.0
411a	411PWL	321CH		414RA			1.0
411b	411ET	411MT	321CH				1.0
411b	411PW	411PWL	321BC	NANA	NANA	NANA	1.0
411b	311BR	321BG					1.0
411c	411ET	723CS		913TB			1.0
411c	411PW	723MT	411PWL	922BA	NANA	NANA	1.0
411c	414RA	414FE	724BT	921PT			1.0

Assocn	Sercod-0	Sercod-1	Sercod-2	Sercod-3	Sercod-4	Sercod-5	Score
411d	411PW	711TR	722TK				1.0
411d	411KL	722PU	722BW	NANA	NANA	NANA	1.0
411d	411AT	722SB	712RT				1.0
411e	411ET	414FE	314MO				1.0
411e	411MT	414RA	411PW	NANA	NANA	NANA	1.0
411e	411DB	412DA	311KC				1.0
411f	411ET	711ST	414FE	311KC			1.0
411f	411DB	711KR	414RA	311LA	NANA	NANA	1.0
411f	411PW	712GN	314MO	311BR			1.0
411g	411ET	414FE	311KC				1.0
411g	411MT	414RA	311KV	NANA	NANA	NANA	1.0
411g	411DB	314MO	311LA				1.0
411h	411PW	321CH	723UN46				1.0
411h	411AT	321BG	723CS	NANA	NANA	NANA	1.0
411h	411KL	321UN05	723MT				1.0
411x	411PWL	321CH	711ST	822CF	411DB		1.0
411x	411ET	321BG	711KR	822CA	411PW	213BU	1.0
411x	414RA	321UN05	712GN	821FA	311KC		1.0
414a	414FE	314MO	312BY	411PW			1.0
414a	414CO	412CB	412JH	411ET	NANA	NANA	1.0
414a	414RA	411DG	311CM				1.0
414b	411ET	311KC	711ST				1.0
414b	414RA	311LA	711KR	NANA	NANA	NANA	1.0
414b	414FE	0314UN52	712GN				1.0
414c	411ET	311KC	913TB				1.0
414c	414RA	311LA	922BA	NANA	NANA	NANA	1.0
414c	414FE	0314UN52	921PT				1.0
414d	314MO	722TK					1.0
414d	414FE	721KP	NANA	NANA	NANA	NANA	1.0
414d	412CB	711KR					1.0

Assocn	Sercod-0	Sercod-1	Sercod-2	Sercod-3	Sercod-4	Sercod-5	Score
511a	513RK	311SG	311CL	513KC	721KO		1.0
511a	511CO	511UN06	311CM	513KB	722PU	NANA	1.0
511a	511CU				712DY		1.0
511b	311KI	511CU	722TK	313WO			1.0
511b	511KY	512TO	722BW	313CG	NANA	NANA	1.0
511b	513BE	512CG	712RT	311BO			1.0
511c	311DY	721BM					1.0
511c	511SN	722BK	511CA	NANA	NANA	NANA	1.0
511c	311BV	721UN43					1.0
511d	0511UN29	113BA					1.0
511d	511CU	112KW	NANA	NANA	NANA	NANA	1.0
511d	0511UN31	112KY					1.0
511e	511UN29	513BE	721KO	811CN	511CU		1.0
511e	511RO	511CO	722PU	811IL	NANA	NANA	1.0
511e	513KB	313SH	712DY	821LY	311BY		1.0
511f	513RK	632GL	913ATC				1.0
511f	511CO	632KA	911AT	NANA	NANA	NANA	1.0
511f	511CU	632FC	911KM				1.0
512a	511CO	721KO					1.0
512a	512CG	722PU	NANA	NANA	NANA	NANA	1.0
512a	513KB	712DY					1.0
512b	513BE						1.0
512b	512TO	NANA	NANA	NANA	NANA	NANA	1.0
512b	511CU						1.0
513a	514CR	721KO	311CM				1.0
513a	513KB	722PU	311BV	NANA	NANA	NANA	1.0
513a	512CG	712DY	312BY				1.0
513b	513RK	311BY	513KB	711KR			1.0
513b	513RK	311KE	511UN31	712GN	NANA	NANA	1.0
513b	513RK	312BY	513KC	721KO			1.0
513c	512TO	311CM	112KY	612PO	712GN		1.0
513c	513BE	311CL	112KW	612CB	711KR	NANA	1.0

Assocn	Sercod-0	Sercod-1	Sercod-2	Sercod-3	Sercod-4	Sercod-5	Score
513c	513RK	312BY		611SP	721KO		1.0
513d		112KW	513UN32	632GL			1.0
513d	513KC	112KY	513KB	632FC	NANA	NANA	1.0
513d	511CN		511CU	631UN36			1.0
513e	514CR	612PO	722BW	722PU	513BE		1.0
513e	513KB	611BN	711NW	722SB	NANA	NANA	1.0
513e	512CG	631KD	712RT	721KO	313AS	311BL	1.0
514a	513KB	612PO	712GN				1.0
514a	514CR	611BN	711KR	NANA	NANA	NANA	1.0
514a	513RK		721KO				1.0
611a	611BS	511KY	112KW				1.0
611a	611BR	611SP	112UN02	NARK	NANA	NANA	1.0
611a	612CB	511RO	113CV				1.0
611b	611BR						1.0
611b	611SG	NANA	NANA	NANA	NANA	NANA	1.0
611b	612CB						1.0
612a	0612UN38	511CU	513RK	631KD			1.0
612a	612PO	513BE	513KB	611BN	NANA	NANA	1.0
612a	0621AH						1.0
621a	631KD	711KR	612UN58				1.0
621a	621AH	712GN	611DS	NANA	NANA	NANA	1.0
621a	514CR	712DY					1.0
631a	0621AH	513RK	511UN29	913ATC			1.0
631a	631KD	513KB	511CO	911AT	NANA	NANA	1.0
631a	632GL			911KW			1.0
632a	612CB	112UN02					1.0
632a	632BL	113CV	NARK	NANA	NANA	NANA	1.0
632a	632GL						1.0
632b	611SG	513BE	913ATC	112KW	711KR		1.0
632b	632KS	511CU	911AT	112KY	712GN	NANA	1.0
632b	632FC	511CO	911KW		712DY		1.0

Assocn	Sercod-0	Sercod-1	Sercod-2	Sercod-3	Sercod-4	Sercod-5	Score
632c	632KS	913ATC					1.0
632c	632FC	911AT	NARK	NANA	NANA	NANA	1.0
632c	631UN36	911KW					1.0
632d	612GB	632DS					1.0
632d	632MV	632GL	NANA	NANA	NANA	NANA	1.0
632d	0631UN37	611DS					1.0
632e	632GL	313SH	513RK	913ATC	511UN29		1.0
632e	632KA	511RO	513KB	911AT	511CO	NANA	1.0
632e	632KS	632FC		911KW			1.0
632f	631UN37	721KO	913ATC	612GB	112KW		1.0
632f	632DS	722PU	911AT	632KA	112KY	NANA	1.0
632f	632GL	712DY	911KW	632FC			1.0
711a	711ST	721UN42					1.0
711a	711MC	721KP	711UN09	NANA	NANA	NANA	1.0
711a	712HN	414UN56	711KR				1.0
711b	711ST	712DY	911AE	311CL	513RK	913ATC	1.0
711b	711KR	712GN	922BA	311LA	513BE	911AT	1.0
711b	414FE	711DK	912GN	311CM	511UN29	911KW	1.0
711c	711MC	712HN					1.0
711c	711DK	712CG	NANA	NANA	NANA	NANA	1.0
711c	0712GN	712BN					1.0
711d	711KR	712HN	411PW				1.0
711d	711ST	723MT	411ET	NANA	NANA	NANA	1.0
711d	712BN	723CS	411MT				1.0
711e	711KR	311CM					1.0
711e	711CH	311CL	NANA	NANA	NANA	NANA	1.0
711e	712GN	313AS					1.0
711f	711KR	722PU	511CO				1.0
711f	711NW	722SB	513KB	NANA	NANA	NANA	1.0
711f	712DY	721KO	513RK				1.0

Assocn	Sercod-0	Sercod-1	Sercod-2	Sercod-3	Sercod-4	Sercod-5	Score
711g	712RT	311CL	311BO				1.0
711g	711TR	311CM	311KI	NANA	NANA	NANA	1.0
711g	711NW	313AS	313CG				1.0
712a	712DY	711ST	822CL	922BA	513RK		1.0
712a	712GN	722NT	822CA	911AE	513KB	NANA	1.0
712a	0711UN09	711KR	822CF	912GN	511CO		1.0
712b	0711UN09	711KR					1.0
712b	712CG	414CO	NANA	NANA	NANA	NANA	1.0
712b	712GN	414FE					1.0
712c	712CG	724BT	411ET	911AE			1.0
712c	712HN	724BS	411PW	922BR	NANA	NANA	1.0
712c	711ST	723MT	411PWL	912GN			1.0
712d	712DY	513RK	711KR				1.0
712d	712GN	514CR	712BL	NANA	NANA	NANA	1.0
712d	0711UN09	513KB	712BN				1.0
712e	711MC		922BA				1.0
712e	712BN	711ST	911AE	NANA	NANA	NANA	1.0
712e	712HN	711KR	912GN				1.0
712f	712GN	911ATC	913GM	513KB	311CM		1.0
712f	712DY	911AT	913TB	511RO	313SH	NANA	1.0
712f	711NW	911KW	912GN	512CG			1.0
712g	712DY	711KR	311CM				1.0
712g	712GN	414CO	312BY	NANA	NANA	NANA	1.0
712g	0711UN09	414FE	313AS				1.0
721a	722TK	711UN59	712CG	712GN	821FA		1.0
721a	721KP	721UN10	711UN09	711KR	820FN	NANA	1.0
721a	721KO			414FE	821LY		1.0
721b	721KP						1.0
721b	721KO	NANA	NANA	NANA	NANA	NANA	1.0
721b	721TK						1.0
722a	0721UN42		412JH	731UN47			1.0
722a	722NT	722PU	411KL	731GE	NANA	NANA	1.0
722a	721KP	721KO	414CO	711KR			1.0

Assocn	Sercod-0	Sercod-1	Sercod-2	Sercod-3	Sercod-4	Sercod-5	Score
722b	722SB	721KO	711ST	922BR			1.0
722b	722PU	721KP	712GN	911AE	NANA	NANA	1.0
722b	722TK		414FE	912GN			1.0
722c	722SB	112KW	311BG	513RK			1.0
722c	722PU	112KY	311CM	513KB	NANA	NANA	1.0
722c	722TK		311CL	511CO			1.0
722d	722PU	632KA	511UN29	913ATC			1.0
722d	722SB	632KS	511CO	911AT	NANA	NANA	1.0
722d	722TK	632GL	513KB	911KW			1.0
722e	722PU	511KY	911AT				1.0
722e	722BW	711TR	913ATC	NANA	NANA	NANA	1.0
722e	722SB	721KO	911KW				1.0
722f	722SB	711ST	311BG				1.0
722f	722PU	712GN	311CM	NANA	NANA	NANA	1.0
722f	722TK	414FE	311CL				1.0
723a	724BT	922BA	411ET	724BT			1.0
723a	723MT	911AE	411PW	724BS	NANA	NANA	1.0
723a	0723UN45	912GN	411PWL	723CS			1.0
724a	723UN45	723CS		411PW			1.0
724a	724BS	724BT	723MT	411ET	NANA	NANA	1.0
724a	723UN46		722TK	411PWL			1.0
811a	811IL	821FA		822CA			1.0
811a	811CN	821LY	812RY	821VI	NANA	NANA	1.0
811a	0822UN49						1.0
812a	811IL		811SU	821BO			1.0
812a	812RY	812UN13	811UN12	821KK	811CN	NANA	1.0
812a	821FA						1.0
813a	821LY						1.0
813a	813MP	811CN	NANA	NANA	NANA	NANA	1.0
813a	821KG						1.0

Assocn	Sercod-0	Sercod-1	Sercod-2	Sercod-3	Sercod-4	Sercod-5	Score
820a	820FN						1.0
820a	820FN	NANA	NANA	NANA	NANA	NANA	1.0
820a	820FN						1.0
821x	820FN						1.0
821x	820FN	NANA	NANA	NANA	NANA	NANA	1.0
821x	820FN						1.0
821a	821KK						1.0
821a	821KK	NANA	NANA	NANA	NANA	NANA	1.0
821a	821KK						1.0
821b	822CA	821LY					1.0
821b	821VI	821FA	821KK	NANA	NANA	NANA	1.0
821b	0822CL		822SH				1.0
821c	812RY	822CF	822CA				1.0
821c	821FA	821BO	821VI	NANA	NANA	NANA	1.0
821c	0821UN48						1.0
821d	821LY	813MT					1.0
821d	821KG	811AH	NANA	NANA	NANA	NANA	1.0
821d	0822UN49	822GR					1.0
821e	821FA	821LY	812UN13	311SG			1.0
821e	821BO	822UN49	811CN	311UN03	NANA	NANA	1.0
821e	822MQ		811SU				1.0
821f	811AH	812UN13					1.0
821f	821LY	811CN	822UN49	NANA	NANA	NANA	1.0
821f	813MP	811SU					1.0
822a	822CF	823DU					1.0
822a	822CL	824CN	NANA	NANA	NANA	NANA	1.0
822a	822MQ						1.0
822b	822CF						1.0
822b	822MQ	NANA	NANA	NANA	NANA	NANA	1.0
822b	822CL						1.0
822c	821KG						1.0
822c	822GR	NANA	NANA	NANA	NANA	NANA	1.0
822c	822MQ						1.0

Assocn	Sercod-0	Sercod-1	Sercod-2	Sercod-3	Sercod-4	Sercod-5	Score
822d	822KS						1.0
822d	822WS	NANA	NANA	NANA	NANA	NANA	1.0
822d	821KK						1.0
822e	821KK	822CA	911AE	921KR			1.0
822e	822SH	821VI	922BR	824DR	NANA	NANA	1.0
822e	822CF		912GN	823DU			1.0
822f	823DU	822MQ	811FI	821KG			1.0
822f	822CA	822CF	822UN50	813MP	NANA	NANA	1.0
822f	821VI			811AH			1.0
822g	822CA	821BO	824DR	811CN			1.0
822g	822CF	811SU	921KR	811FI	NANA	NANA	1.0
822g	822MQ	824CN	921PT	821LY			1.0
823a	822WS						1.0
823a	823KS	823KSV	NANA	NANA	NANA	NANA	1.0
823a	821KK						1.0
824a	812UN62	921KR					0.8
824a	824DR	823DU	212CY	NANA	NANA	NANA	1.0
824a	822MQ						0.8
911a	913GN	914CS					1.0
911a	911AE	913TB	922BR	912GN	NANA	NANA	1.0
911a							1.0
911b	912ATD	911KM					1.0
911b	911AT	913ATC	913TB	NANA	NANA	NANA	1.0
911b	911KM	911AE					1.0
911c	911AT	632KA	113BA				1.0
911c	911KM	632GL	113CV	NANA	NANA	NANA	1.0
911c	913ATC	632KS					1.0
911d	912ATD	113CV	632KS	632BL			1.0
911d	911AT	113BA	632KA	632DS	NARK	NANA	1.0
911d	911KM		632GL	631KD			1.0

Assocn	Sercod-0	Sercod-1	Sercod-2	Sercod-3	Sercod-4	Sercod-5	Score
921a	921KR						1.0
921a	921PT	922BR	913GM	NANA	NANA	NANA	1.0
921a	912GN						1.0
913a	922BR						1.0
913a	913TB	911AE	913GM	912GM	921PT	913ATC	1.0
913a	921KB						1.0
913b	911AT	113BA					1.0
913b	913ATC	113CV	NANA	NANA	NANA	NANA	1.0
913b	912ATD	911KM					1.0
922a	912GN		911AEC				1.0
922a	922BR	913TB	911AE	NANA	NANA	NANA	1.0
922a	913GM						1.0
922b	912GN						1.0
922b	922BR	NANA	NANA	NANA	NANA	NANA	1.0
922b	913GM						1.0
914a	912GN	911AT		911AEC			1.0
914a	914CS	913TB	913GM	911AE	NANA	NANA	1.0
914a	913ATC						1.0
1011a	311CL						1.0
1011a	1011MT	1012AR	1011CU	1011SHP	NANA	NANA	1.0
1011a	211SE						1.0

