ERIC RESOURCE APPLICATIONS

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SoilSelect

INTRODUCTION

The SoilSelect methodology was developed to provide soils information to address land use and management. The aspects of the methodology addressed are:

- Procedures used to map soil patterns.
- Methods for describing soils according to their physical and chemical properties.
- Evaluation of reliability.
- Benefits of the approach.

Cost, efficiency, and reliability were key considerations in the development.

SoilSelect is generally implemented using airborne gamma radiation data (radiometrics) to map soil patterns. These data have been available for more than 30 years and so are not new. However, developments associated with computers, particularly techniques for numerically processing and displaying raster imagery, have allowed production of results not previously possible. Together with improvements in the quality and availability of radiometric data this has made practical the use of these data in mapping soils.

Requirements

Soils represent a major constraint to land use and affect all agricultural and engineering activities. In consequence, fine scale soil mapping has been undertaken for most of the USA but such detailed information is rarely available for Australia. The small population, often low land productivity, and the cost of traditional soil mapping have severely restricted the availability of soils information.

Despite the detailed soil mapping in the USA the information has proved to be limiting. The information has been presented as soil types identified by way of a prior classification when information on soil properties is required for effective application. This deficiency has been addressed by identifying relationships between soil types and properties but this approach increases costs and introduces significant limitations.

The requirements for effective application of soil information are:

- The identification and mapping of soil properties at scales appropriate to management.
- Evaluation of map reliability.
- Derivation of the mapped information independently of other baseline information.

The first objective represents a basic requirement for improving land use and management. The key requirements are the identification of soil properties, such as salinity and pH, and the provision of information at high spatial detail across large areas. Spatial detail is essential as management is based on site specific information.

The second and third objectives relate to effectiveness in application. Reliability is needed to compare benefits with costs and risks. Independent derivation of the different mapped layers is required for effective application of the information, particularly when using GIS.

Technology Package

SoilSelect is an integrated package containing three main modules that address:

- Mapping of soil related patterns.
- Field sampling, soil property measurement, and statistical analysis.
- Production of thematic and feature maps, and reports.

It is also designed to allow client participation where this reduces costs and improves application of the information.

MAPPING

Mapping is based on the numerical analysis of radiometrics to identify and map patterns of soils. The soil attributes or properties associated with the mapped spatial patterns are determined through field sampling and laboratory analysis. The use of radiometrics has advantages over other methods in the efficiency of mapping, the detail provided, the ability to test reliability, and the derivation of the mapped soils information independently of other information used in land evaluation.

Mapping can be based on other data, such as a lithological interpretation of satellite imagery or by fitting surfaces to a regular grid of field observations. The lithological interpretation provides considerably lower resolution than the radiometrics and requires time consuming visual interpretation. Surface fitting field observations is expensive because of the requirement for a very high density of field observations.

The Radiometric Measurement

The radiometric signal represents the natural emissions of gamma radiation emanating from around the surface 30 cm of soil where these depend on parent material and its alteration through weathering (the leaching and accumulation clay and ions). As these factors determine the development of soils, the radiometric patterns reflect patterns of soils identified by chemical and physical properties.

The radiometric signal is normally partitioned into energy bands indicative of potassium, thorium, uranium, and total count (K, Th, U, TC). Surface fitting routines applied to the flight line data produce a digital image of intensity levels for each band. The cell size or spatial resolution in the image is nominally one quarter the flight line spacing and is around 100 m for the lowest resolution data now being acquired. A 25 m resolution can readily be achieved with high resolution data.

The amount of information obtained from the radiometrics depends on its quality (survey specification) and the form of analysis. The data can be used to identify general mineral types, geological anomalies, lineaments, or fine spatial patterns in surface materials. The information can be used to identify areas of potential mineralisation, geological structure, prospectivity for groundwater, pathways for salt movement, and variations in soil properties including salinity.

Radiometric Processing

Radiometrics have typically been presented as visually enhanced three band colour images, and these can be used to identify major geological features. Individual bands can be examined to identify characteristics of the landscapes, as with the use of potassium to identify areas with recent clay deposition.

SoilSelect is based on numerical analysis to maximise the discrimination of radiometric patterns. The data are iteratively processed using spatial and spectral statistics to enhance the discrimination of features and accurately locate feature boundaries. A second classification is then produced to remove ambiguities identified from an initial field sampling.

SOIL ANALYSIS

Field Sampling

An initial field sampling checks the consistency of soil properties associated with the radiometric classes. This information is used to produce a second iteration classification that forms the basis for comprehensive field sampling.

The comprehensive field sampling provides detailed information on the relationships between the radiometric classes and soil properties and thereby provides soil property labels for the radiometric map. This labeled map identifies the distribution of soil types identified by their physical and chemical properties.

Field sample sites must be carefully located due to the spatial characteristics of the radiometric measurement and the number of field samples should be similar for each class. The strong relationship between the radiometric patterns and soil properties means that relatively few field samples are required to produce reliable maps. Much fewer field samples are required than with other survey methods.

Efficiency in soil characterisation requires the recognition of soil horizons while efficiency in analysis is provided by a balanced design incorporating a set number of horizons. Most information has been found to derive from the A2 and B2 horizons hence efficiencies can be gained by only sampling these horizons.

Soil Description

SoilSelect uses objective measurement of soil properties that represent continuous variables such as pH and salinity rather than categories such as peds. This facilitates analysis and the information is readily interpreted and applied in management.

The soil properties routinely determined are pH, pe (oxidation-reduction potential), specific conductivity (salinity), colour, texture, and gravel content. Soil Heat of Hydration is now also available. Horizon thickness is measured but effectively only for the A and B1 horizons.

The properties that usually best discriminate between the mapped soil classes are texture and the ratio pe/pH for the A2 and B2 horizons. Texture and pe/pH respectively provide the most general physical and chemical descriptions of soils.

Reliability Testing

Statistical analysis allows determination of:

- The significance of different properties in identifying soil types.
- The significance of factors in determining soils.
- The reliability of mapping.

The mean values from the analysis identify the levels of properties for each soil class and provide a description of soil type as defined by its chemical and physical properties. The variance identifies the level of discrimination between soil types. The statistical analysis allows production of maps where each mapped category is significantly different at the 95% level.

MAP PRODUCTION

Grouping radiometric classes where particular soil properties do not differ maps the statistically significant patterns for each soil property. Grouped classes are then labeled according to the level of the property. Classes that are not significantly different are retained where they identify patterns useful for management. The mapped patterns are real but the variance associated with regional sampling can mask local differences. Classes can be grouped to highlight potential risks, such as salinity.

The main use of the soil property information lies in analysis of the data for specific applications. For example, the requirement may be for deep clay soils with low salinity and dispersibility. Classes having the specified soil properties can be identified and presented as a thematic map.

PROJECT IMPLEMENTATION

Projects range from individual landholdings to large regions. For large projects management is required to coordinate activities, transfer results, and facilitate application.

With large projects the objectives, outputs and schedule are first confirmed with clients. An interim report is produced following the initial field sampling with a presentation to stakeholders to allow for review and feedback. This meeting demonstrates the nature of results and identifies potential deficiencies. The meeting also allows stakeholders to identify specific products considered useful for planning and management.

The final report contains the results, including maps of soil properties, and feature maps identifying sites having characteristics either favourable or unsuitable for particular applications. A prime purpose of this report is to relate the results to applications identified during the initial presentation.

The services for landholdings range from provision of the map detailing the radiometric classes / patterns to a full implementation. Typically the service includes identification of the sample sites, prescription of the sampling method, soil property analysis, and production of soil property maps and a report. Conduct of the field sampling by the client typically reduces costs by around 50%. This involvement of clients and stakeholders is only possible because of the objective nature of the method and has the benefit of facilitating the transfer of the information.

COMPARISON OF METHODS

The SoilSelect approach is compared with other regional methods in the table below. Uncertainties exist with such assessments because of differences between implementations. Landscape analysis, for example, can be conducted in analytical or predictive modes, and for soil types or soil properties. Also, costs depend on the availability of data and whether they are calculated on commercial or marginal rates. The latter is normally used by public agencies.

The main difference in costs invariably derives from differences in the amount of field work required to produce a useful result. The figure often given for field truthing a 1:100,000 soil landscape map is between 1,000 and 2,000 sites although the basis for this estimate has not been located.

A soil map derived from radiometrics can usually be reliably labeled using 150 accurately located sites but even so the field sampling constitutes at least half the full cost of implementation. As detailed statistical analysis of the results generally requires increased field sampling it has not been conducted with commercial applications. Clients do not see benefit in expending the considerable funds needed for statistically testing and prefer to evaluate the results through comparison with their knowledge of patterns of soils, native vegetation and crop performance.

The differences in requirements for field sampling mainly relate to how well the maps reflect the distribution of soils. The radiometrics reliably reflect patterns of soil properties hence few samples are required. Patterns in soil landscape maps represent a subjective interpretation of expected patterns. Where this interpretation does not reasonably reflect soil patterns any amount of field sampling cannot produce a good result.

While the assessments below are partially subjective the main differences between perceptions will relate to the attributes considered significant rather than the ratings. Those not using numerical analysis seldom consider independence in the derivation of information layers to be of consequence when it is usually critical for application, particularly when using GIS.

The main dichotomy in perceptions relates to whether the soil map is perceived as the final product or whether the soil mapping is provided as a tool to support land use and management. A pedologic focus typically has the main objective as being the production of a map of soil types with application being an assumed automatic extension. The output is generally something less as the mapped areas usually contain mixtures of soils (soil landscapes). This, and the use of soil types, severely limits application in land management.

SoilSelect directly maps soil properties throughout the landscape and hence provides the information needed for land management. The information also improves understanding of the processes important in generating the patterns of soils.

SUMMARY OF BENEFITS

Benefits provided by SoilSelect include:

- Measurement of soil properties relevant to management.
- High resolution mapping with tests of reliability.
- Analysis of factors determining soil properties.
- Involvement of stakeholders promoting application.
- Cost efficiency.

	Air Photo Interpretation	Satellite Imagery Interpretation	Landscape analysis	Landscape analysis with radiometrics	Numerical analysis of radiometrics
Analysis	Visual	Combined numerical, visual			Numerical
Soil Properties	No	No	Yes / No	Yes / No	Yes
Independent Derivation	No	No	No	No	Yes
Determine Associations	No	No	Yes (often by definition)	Yes (often by definition)	Yes (by analysis)
Error with associations	No	No	Possible	Possible	Yes
Estimate of spatial error	No	No	No	No	Yes
Objectivity of methodology	Low	Low	Moderate to High	Moderate to High	High
Generic method	Location dependent	Location dependant	Location dependant	Location dependant	Data dependant
Cost effectiveness	Only for small areas	Moderate for large areas	Low	Low	High, especially where data exist
Cost effective extension	No	No	No	No	Yes

SoilSelect Achievements

SoilSelect has received a number of awards relating to innovation. These are:

1. Finalist in the 1999 Australian Technology Awards

SoilSelect was one of three finalists in the category Excellence in the Development of Technology for the Enhancement of the Environment.

2. Showcased by Business Australia and Environment Australia

SoilSelect was showcased at special presentations during the Sydney Olympics. Presenters were selected on the innovation and environmental benefits of the technologies.

3. Australian Technology Showcase.

The SoilSelect technology placed ERIC as a member of the Australian Technology Showcase. This was a competitive process to select leading edge technologies.

4. Support under the COMET scheme.

SoilSelect was selected for support under the COMET which is competitive Commonwealth Government scheme designed to promote Australian technology.

5. Nominated by Murdock University as a Sunrise Technology

SoilSelect is listed in the 2000 Environment Australia report identifying Australia's Leading Edge Environmental Technologies

6. 2001 ACT R&D Grants Scheme Awards, Best Emerging Product designed to promote Australian technology.

SoilSelect was central to the winning of the environmental category of this award. This study, supported by the ACT Government, developed information to promote viticulture in the ACT District Wine Region.

Developments

Application of SoilSelect resulted in the development of a method for direct mapping of soil salinity that is subject to a patent application.

Applications

The SoilSelect procedure was first fully applied on the Singleton Training Area for Defence in 1992. Since then elements of the procedure have been applied on four large military training areas across Australia, and in a number of major commercial applications. The applications include:

1. Numerous landholdings.
2. Regional soil mapping to evaluate the environmental effects of irrigation, Jemalong – Wyldes Plains.
3. Salinity mapping, Konong Wootong, Western Victoria. The soil mapping addressed the environmental implications of soils on the water supply.
4. Soil mapping for agricultural purposes, Harden Shire.
5. Soil mapping for rural subdivision, Yass.
6. Distribution of soils in the Coonawarra region.
7. Soil Mapping for existing and proposed viticultural areas, various locations.
8. Land capability/suitability study for rural residential development in the Lake Wyangan Basin, Griffith.
9. Regional soil mapping for environmental and land use consultancy, Northeast Gippsland.
10. Soil mapping for the Mallee Catchment, NW Victoria.