MAPPING SURFACE AND SUBSURFACE SOIL PROPERTIES USING GEOPHYSICAL REMOTE SENSING AND REGOLITH INFORMATION

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BACKGROUND

Widespread removal of native vegetation in Australia has caused groundwater to rise. Mobilisation of stored ground salts has led to decreased crop yields, waterlogging, development of saline crusts and plant death. One of the most effective ways to manage this problem is to reduce groundwater recharge by re-introduction of perennials into the landscape. However, to be able to implement such strategies, more information on soil and the sub-surface is required.

This study addresses some of the shortcomings of traditional soil mapping in providing adequate information about soils for management at property and catchment scales. These limitations relate to the amount of spatial variation in soils that is portrayed by conventional mapping methodologies, as well as the range of soil properties that are generally recorded during soil surveys, and hence are encapsulated in the mapping units.

Most current soil mapping programs are based on the soil-landscape paradigm (outlined by Hudson 1992), which assumes that similar soils develop in similar environments. Similar environments or soil zones are delineated through interpretation of imagery, generally aerial photography, with field samples at representative sites being used to characterize the mapping units. At common mapping scales (e.g., 1:50,000), typical sampling densities may be 1 km^2 (Gunn *et al.* 1998), meaning that considerable interpolation and inference from sample points is involved, and localized variation is not captured. While denser field sampling as part of larger scale surveys may detail more of these variations, the costs are usually prohibitive. In the resultant soil map, the soil mapping units, generally soil classes conforming to an accepted soil classification system, are represented by homogeneous polygons with sharp boundaries. Soil variation within the polygon may be described, but is not spatially represented.

Current research within the CRC for Plant Based Management of Dryland Salinity is developing plant growth models and hydrological models as tools for assisting appropriate placement of perennial plants in agricultural landscapes. Both these tools call for higher resolution information about soil variation than is available from existing mapping programs (e.g., PIRSA 2001), and for detail about surface and subsurface attributes that are not well represented in these surveys. These include soil texture and structure, depth of rootzone, depth to impeding layers, and hydraulic conductivity. This project addresses these needs by developing methods for increasing the resolution and spatial variation captured by soil maps, and for prediction of these key subsurface soil properties.

STUDY OVERVIEW

This study aims to enhance spatial accuracy and precision in mapping surface and subsurface soil attributes. It will adopt a raster approach to soil class and attribute mapping as a means of improving representation of soil variation in the landscape, and explore the use of geophysical data for prediction of soil properties. Recent regolith research has pointed to the potential geophysical methods have for mapping soils, individual soil variables, parent materials and subsurface structures and conditions.

The study develops the Soil Land Inference Model (SoLIM) presented by Zhu (2000). This model uses readily available environmental data, such as digital elevation models and land cover mapped from satellite imagery predict and to map soil classes in a raster format. An Artificial Neural Network (ANN) is used to develop relationships between the input variables and soil classes using discrete soil sample data, and these relationships then used to map the soil classes at fine resolution across the broader study area. An advantage of the SoLIM approach is that soil variation is portrayed as a raster of grid cells, rather than as homogeneous polygons, and that the resulting map has similar resolution to the input data (Zhu 2000). Increases in mapping accuracy from 17 to 71% and resolutions as fine as 30 metres have been reported using this method (Zhu *et al.* 2001).

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The present study will firstly evaluate the potential of geophysical and topographic data to predict and refine existing soil landscape unit maps, using the SoLIM approach. The inclusion of geophysical data (radiometrics, electromagnetics and magnetics) as inputs to the ANN will considerably extend the range and nature of data for prediction of soil classes beyond those used by Zhu (2000). Importantly, these data provide information about subsurface as well as near-surface soil and regolith properties. Preliminary qualitative interpretations suggest strong spatial relationships between radiometric data and soil units mapped through air photo interpretation and soil survey by an expert pedologist.

Secondly, this study will evaluate the efficacy of geophysical data and topographic indices in predicting the soil properties of texture, structure, depth of topsoil, depth of rootzone and depth of impeding layer. Review of current literature has found that the following geophysical data are indicative of these properties (Table 1). Water holding capacity and hydraulic conductivity can be calculated from these soil variables, giving modelers a powerful tool in understanding hydrology. Thus, land management benefits as the movement of water through the soil and into groundwater can be monitored, in the context of planting options available in reducing recharge.

Preliminary evaluations of the geophysics will use simple linear regression models to identify the best predictors, progressing to a feed-forward ANN network for multivariate prediction. Data on structure, texture, depth of rootzone, and impeding layer recorded for field sample pits and cores will be used to train the ANN, with independent samples used to evaluate its mapping accuracy. .

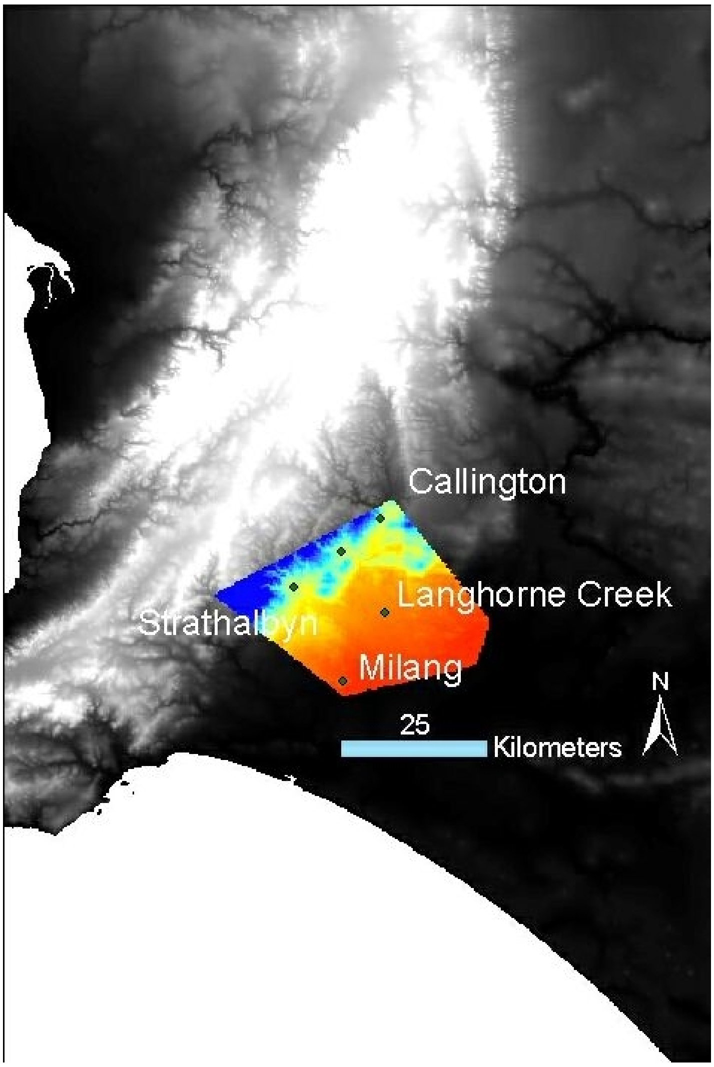

Figure 1: DEM of the Lower Mount Lofty Ranges with inlay of the Angas-Bremer Plains geophysics.

STUDY AREA

The study is based in the Angas-Bremer Plains, 80 km southwest of Adelaide, extending from the western shore of Lake Alexandrina (Figure 1). This is a highly productive region for viticulture and is important environmentally for its wetlands, swamps, and aquatic habitats (Walker 2003). The area is one of the detailed study sites for the South Australian Salinity Mapping and Management Support Program.

Airborne geophysical data acquired as part of SASMMSP, and to be used in the present study include TEMPEST electromagnetic, radiometric and magnetic surveys interpolated to 20 m resolution. In addition, the study will use attribute data for more than 1,500 previously collected soil samples. These samples were originally collected for the development of the PIRSA soil-landscape map series and the soil-landscape database (PIRSA 2001).

When complete, the outputs of this study are intended highlight the need for a raster style mapping approach, and the need for additional datasets in soil mapping. The provision of more useful and detailed information on soil type and soil variables will promote further options in the management of dryland salinity.

Table 1: Geophysical method and application to soil properties.

GEOPHYSICAL METHOD	APPLICATION	REFERENCE
Electromagnetic	Modelling saline groundwater – subsurface structure and impeding layers	Buselli *et al*. (1991), Cook & Walker (1992), Cook *et al*. (1992), DeBrokert (1996), Coppa *et al*. (1995), George *et al*. (1998), Newnham *et al*. (1998), West & Linford (1998), George (1999).
Radiometric	Describing clay affinities (soil structure) and age, particle size of clay (soil texture), mapping soils	Wilford *et al*. (1997, 2001) Taylor *et al*. (2002) Wilford *et al*. (1997)

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