PREDICTION OF FINE SCALE SOIL ATTRIBUTES AND DEEP DRAINAGE

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Abstract

Secondary salinity is an important land and water conservation issue in Australia. An understanding of the processes contributing to salinity and the land management options to deal with it are critical for developing effective management solutions. Secondary salinity is generally caused by land use changes, which lead to increased fluxes past the rooting zone. There is a need to understand how land use choice can potentially impact on salinity risk. In this study, point based estimates of deep drainage from a range of soil type and land use combinations are applied spatially to improve our understanding at a landscape level of potential ground water recharge and salinity risk.

Soils data are vital for understanding natural systems in general and systems prone to salinity in particular. There is strong demand for fine scale soil attribute information for both point (eg crop models) and landscape modelling (eg soil erosion models). This study uses decision trees as an environmental correlation approach to spatially predict fine scale soil attributes. A deep drainage surface is then created using these attributes by matching them to deep drainage estimates from validated modelling on the appropriate soil type.

This study uses site data to predict soil properties with decision trees. Statistical techniques such as ‘bagging’ and strategies including the buffering of sites to capture more environmental variability are used to improve the accuracy and robustness of models. Most soil attributes were predicted with an accuracy of greater than 50% using explanatory data including digital elevation models and derivatives, gamma-ray spectrometric and remotely sensed data.

Additional Keywords: salinity, deep drainage, landscape modelling, soil properties

Introduction

In Australia there is increasing demand for soil data required to meet natural resource management objectives. As part of the National Action Plan for salinity and water quality, information is needed to model salinity risk through a variety of methods. This information includes data on surface and groundwaters, characterisation of the landscapes (ie through digital terrain analysis) and soil attributes that are used to drive a range of land and water salinity risk models.

Secondary dryland salinity is generally caused by the clearing of native vegetation for shallow rooted pastures and crops leading to a decrease in transpiration and an increase in the volume of water draining below the root zone (ie deep drainage). This excess water can lead to rising water tables or discharge at a local hill slope scale causing wetness and/or salinity depending on the quality of the water and mobilisation of stored salts. The calculation of deep drainage is therefore an important part of determining salinity risk. The investigation of changing land use patterns on deep drainage and the possible contribution to salinity is a valuable management tool in determining salinity management options. This study develops a fine scale prediction of soil attributes driving deep drainage for an area of 8800 km^2 in south-western Queensland.

Prior to this study the existing soils information consisted of Land Systems mapping at a scale of 1:500 000 (Galloway *et al.* 1974) and a few small areas mapped in more detail (Manning *et al.* unpublished). While the small areas of finer mapping were intended as key areas to better inform the content of the broader scale land system mapping, this information had not been incorporated into a spatial coverage across the whole area. Given the needs for integrated modelling there is a requirement for raster soil surfaces with a known degree of reliability.

This paper examines the use of environmental correlation methods for this form of spatial prediction. These predicted soil attributes are then matched to soil types and a matrix of soil type and land use is used to spatially estimate deep drainage for a range of land uses.

Materials and Methods

The study area is located in the Balonne catchment, and is approximately 100 km both north to south and east to west (Figure 1). The land use of the area is primarily grazing with lesser areas used for dryland and irrigated cropping, and forestry. Much of the irrigated cropping is cotton. The land use of the area has been mapped at 1:100,000 scale by Land and Environmental Assessment, NRM&E to national standards based on 1999 remotely sensed data (www.nrm.qld.gov.au/science/lump). The geology of the area consists primarily of Cretaceous sedimentary rocks that have been mostly buried by younger sediments. The whole Balonne catchment consists of a deeply weathered erosion surface sloping gently to the south, and has significant alluvial plains of varying ages that may overlap due to the migration of river channels.

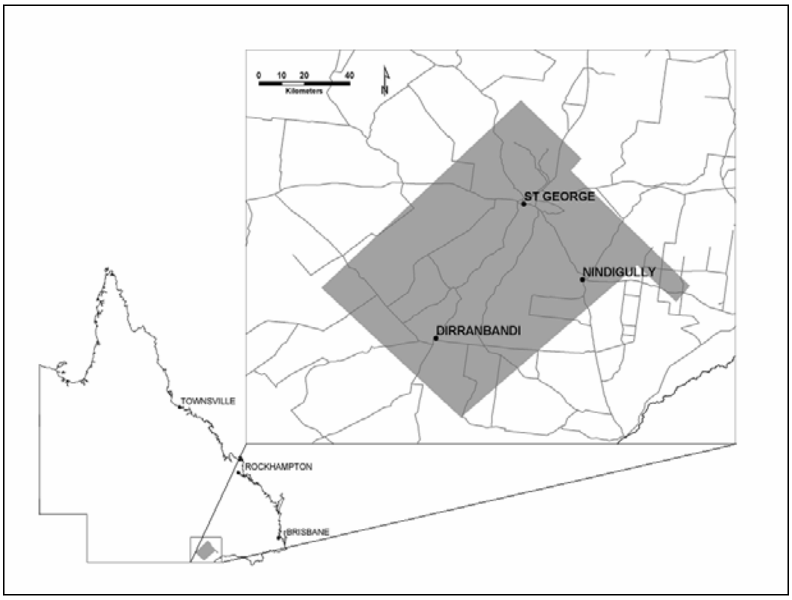

Figure 1. Location of the Lower Balonne airborne geophysics area.

The variables in Table 1 were the major explanatory variables used in the environmental correlation work. In addition to the site data from existing land resource projects (428 sites) a supplementary sampling exercise was undertaken. 130 sites were located to more effectively capture the variation and range of environmental conditions, feature and geographic space, constrained by access restrictions. Gamma radiometric, land systems mapping and road network were the main layers used in the sampling design.

Table 1. Full set of explanatory data used in the analysis

Variable	Explanation
k_55	Radiometric potassium
th_55	Radiometric thorium
u_55	Radiometric uranium
Cti	Compound Topographic Index
Dem	Elevation
mrvbf6	Valley bottom flatness – radius 18 cells
Slp	Slope %
Tan	Tangential curvature
ls32	Landsat (band 3 / band 2)
ls57	Landsat (band 5 / band 7)
NDVI	Landsat index (band 4 - band 3 / band 4 + band 3)
landsys_grid	Balonne land systems mapping
surface	Surface process (regolith) map

Comprehensive exploratory data analysis was carried out before deciding on the methods used to produce the final soil attribute surfaces. A test set consisting of 10% of the sites were randomly extracted and used to assess the accuracy of the final soil attribute surfaces. Each site was buffered by a radius of 30 meters to capture the range of environmental variation (or 'footprint') that occurs within the concept of a site. Soil attributes for each buffered site were then gridded using a cell size of 25m. From these grids the cells were then randomly split into a training (90%) and test (10%) dataset before models were constructed. This occurred ten times with each model applied spatially. The final soil attribute surface was the median value of the 10 grids (on a cell by cell basis). The accuracy of this final model was assessed using the test dataset. Buffering sites before sampling the environmental data layers was found to significantly improve model accuracy and some soil attributes that were unable to be predicted using un-buffered points were predicted with accuracies over 30%.

A matrix of deep drainage estimates was developed using various land uses including, native vegetation, pastures, summer and winter crops for a range of soils in the study area (Table 2). Deep drainage was calculated using the models GRASP (Littleboy and McKeon 1997), PERFECT (Littleboy *et al.* 1989) and APSIM (Keating *et al.* 2001).

Table 2. Matrix of deep drainage (mm/yr) for different soil types and land uses at St George

	Opportunity cropping	**Wheat**	**Pasture**	**Irrigated cropping**	**Native vegetation**
Vertosol one	1	5	0	38	0
Vertosol two	10	17	3	33	0
Dermosol two	1	4	0	38	0
Dermosol one	10	20	6	30	2
Kandosol	55	59	7	62	0
Sodosol one	4	7	7	16	1
Sodosol two	3	9	0	53	0
Chromosol	48	52	14	63	4
Tenosol		131	35	142	39

The spatial predictions of soil type and A and B horizon textures were used to create a spatial coverage of soils that were modelled for deep drainage. The land use coverage was then combined with the modelled soils and deep drainage estimates to produce a spatial deep drainage surface. In addition a range of other land use scenarios were also evaluated for their effect on deep drainage across the study area.

Results and Discussion

Model accuracy for the soil attributes predicted using site data can be seen in Table 3. For most soil properties the mis-classifications were clustered around the correct class. Judicious choice of explanatory variables is important for the successful prediction of robust surfaces.

Table 3. Accuracies of soil attribute surfaces

Variable	**Accuracies of final models**
Drainage	42
ASC order*	46
A texture	36
B texture	54
EC at 60cm	80

*ASC order – Australian Soil Classification Soil Order

The deep drainage surface for the 'current' land use can be seen in Figure 2. The areas that have the highest deep drainage are the areas cropped with irrigated cotton on Vertosols[1] and dryland cropping on freely draining Kandosols[2].

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[1] Vertosols – cracking clay soils (Isbell 2002)

[2] Kandosols – freely draining loam to light clay soils (Isbell 2002)

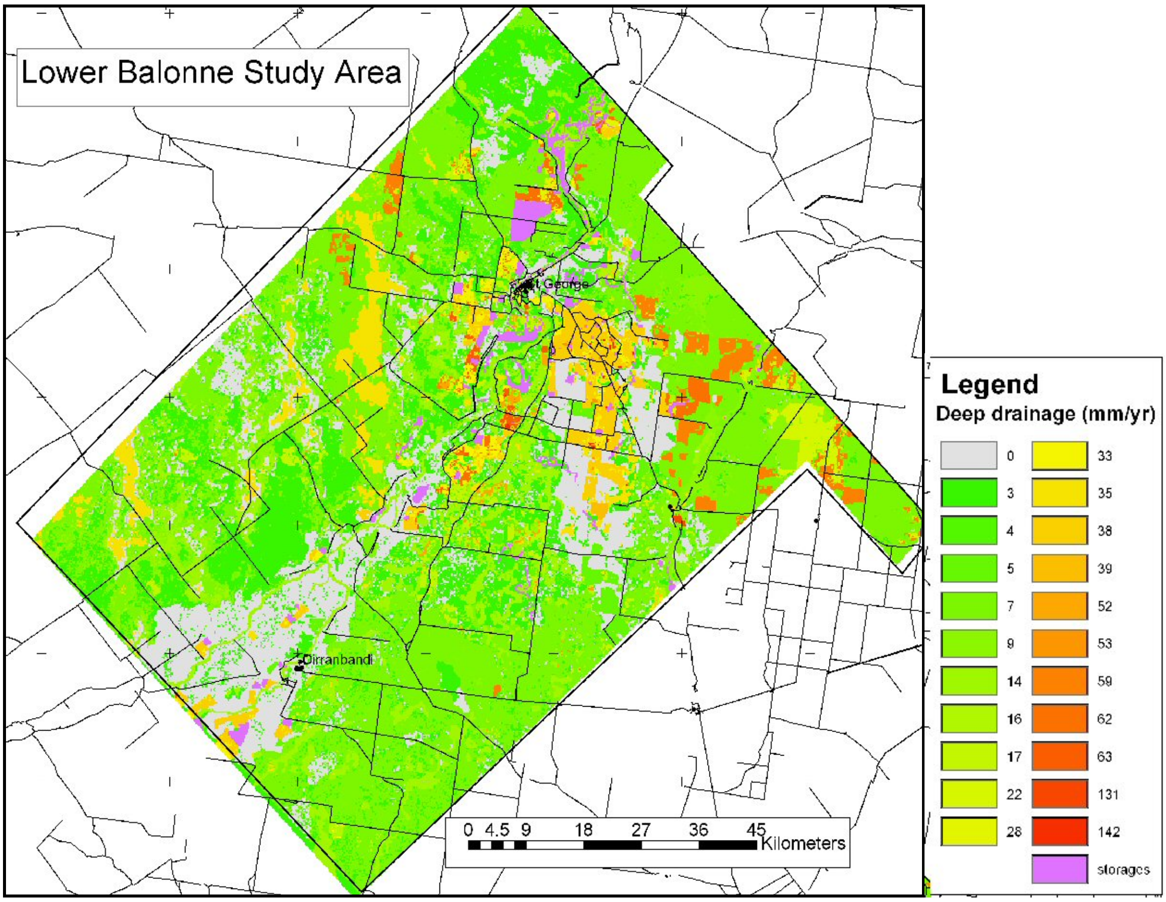

Figure 2. Annual deep drainage for the current land use in mm / year.

Conclusions

A range of soil attributes were successfully predicted using sites buffered by 30m and using a series of models to create a more robust final surface. Soil attributes were predicted with accuracies mostly greater than 40%. Mis-classifications were clustered around the correct class for most ordered soil attributes, so most classifications were broadly accurate.

Deep drainage estimates were successfully applied as raster surfaces in a landscape context using soil type and land use. The deep drainage surfaces produced play an important role in understanding how the landscape functions and the potential salinity risk associated with different land use choices.

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