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Ground Truthing a GIS of the best estimate of profile pH, Mt Torrens, South Australia

I. Preliminary soil sampling and analysis



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Introduction

An ACIAR funded research project to investigate methods for the improvement of soil and water conservation by reducing acidity, waterlogging, salinity and erosion began in 1998. Sites in China (Loess Plateau and North China Plain) and Australia (Adelaide Hills, SA, Loddon-Campaspe, ACT and Dundas Tablelands, Vic) were chosen.

Firstly, the areas at risk to these degradation processes needed to be accurately delineated. For part of the Adelaide Hills, spatial analysis methods (Fitzpatrick *et al.*, 1999) were developed within a GIS framework to more accurately predict soil profile pH, salinity and waterlogging. This involved upscaling of detailed profile investigations at point scale to the regional scale using field validation techniques at the intermediate catchment scale. This approach resulted in a series of map products that estimated the extent of the above degradation processes at the regional scale.

Initial validation of the regional map products has involved ground truthing of data from newly selected sites and archival datasets within the upscaled area. The first of these methodologies to be validated is the best estimate of profile pH (acidity/alkalinity).

Methods

Best Estimate of pH

The best estimate map of pH at the regional scale was constructed from soil profile data into five classes. These predicted pH classes are intended to show the progression from very high pH (extreme alkalinity) to very low pH (extreme acidity). The former can cause dispersion, salinity, and erosion (usually gullying or similar), and the latter aluminium toxicity which can result in poor surface cover and erosion (usually sheet).

Soil sampling locations

Using 1:50 000 scale topographic maps and GPS equipment, five sites were chosen within the upscaled area (Figure 1). Samples were taken from a range of positions in the landscape (eg gullies, hilltops and mid slopes). Previous soil investigations of the area by Billing (1975) provided a useful means to verify the methodology. These sites were located using 1:50 000 scale maps. In both cases positional errors were estimated to be as large as 100 m due to the method of site location. To overcome the uncertainty in sample location, each site was buffered to 100 m for verification purposes.

Soil preparation

Soils were dried at 35°C and sieved to 2 mm.

pH and EC meter measurements

A recently purchased combined pH/EC meter, suitable for laboratory and field use, was calibrated as required using commercial pH buffers, pH 4.0, 7.0, and 10.0 and EC 1.41 dS/cm solution.

For the soil suspensions, 60 ml of aerated de-ionised H₂O was added to 12 g of soil (1:5 soil:water) and shaken in an end-over-end shaker for 1 hour and settled for 15 minutes. EC and pH were measured in the laboratory using the standard procedure (Rayment and Higginson, 1992).

Control soil samples are included routinely in each batch of unknowns to monitor between batch variation. In this set, the control soils were also used to validate analyses with the recently purchased combined pH/EC meter against results from laboratory pH and EC equipment routinely used in this laboratory.

Variation in pH measurements using a range of laboratory and field pH equipment were investigated by Spouncer *et al.* (1996). In that study variation of up to 0.4 pH units were found. Analysis of the control soils using the combined pH/EC meter agreed well (within 0.1 pH units and 0.02 dS/m) with the long-term average of those soils obtained previously using the routinely used pH and EC meters (Table 1).

Table 1. Comparison of meter readings.

Soil	pH (w)	EC (dS/m)
Control 1 (combined pH/EC meter)	5.55	0.08
Control 1 (Long-term average)	5.50	0.06
Control 4 (combined pH/EC meter)	8.38	0.19
Control 4 (Long-term average)	8.55	0.18

Carbon

Carbon was measured on soils by ignition using a Leco CR-12 carbon analyser (Merry and Spouncer 1988).

Dispersion measurements

Sodicity status of the soils was estimated using the SASKIT dispersion method developed by Rengasamy and Bourne (1997).

Results

Predicted pH Classes

The pH classes and percentage area of those classes within the 80 km² area are shown in Table 2.

Table 2. pH Classes (pHw 1:5 soil:water)

Class	% Area	pH Class
1	3	Very acidic throughout (pHw < 5.5)
2	52	Moderately acidic throughout (pHw < 6.5)
3	17	Moderately acidic surface (pHw < 6.5), neutral to alkaline at depth
4	19	Neutral throughout (pHw 6.5-7.5)
5	9	Alkaline (pHw > 7.5) (50%) or neutral (pHw 6.5-7.5) throughout (50%)

pH, EC and sodicity data measured from soil profiles collected within the catchment are presented in Table 3. Soils from the two gully sites had acidic surfaces and were alkaline at depth. One was saline at depth (N24) and the other was sodic (N29). The soils outside (N26) and inside (N27) of the fence line were moderately acidic throughout and highly sodic at depth. The soil sampled near the top of a hill (N28) was moderately acidic throughout. The archival datasets of pH, EC are shown in Table 4. Most profiles were moderately acidic throughout or had moderately acidic surfaces. Depending on farm management practices, these sites may have acidified further in the last 25 years (Merry 1997).

Table 3. pHw, EC, carbon and sodicity measurements of selected sites

Site No	Site Description	Easting	Northing	Soil Colour (dry)	Depth (cm)	pH (W)	EC (dS/m)	C (%)	Sodicity *
N24	Inside gully	319785	6138359	green/grey	0-10	6.00	0.06	4.44	0
N24		319785	6138359	green/grey	10-30	5.09	0.15	1.21	0
N24		319785	6138359	grey	30-50	6.30	0.02	0.18	0
N24		319785	6138359	pale yellow/grey	50-65	6.13	0.06	0.28	0
N24		319785	6138359	green/yellow	80-100	6.62	0.45	0.18	0
N24		319785	6138359	pale yellow	100-120	8.00	1.04	0.40	0
N24		319785	6138359	yellow grey	120-130	7.05	11.3	0.40	0
N26	Outside fence	315187	6138362	brown	0-20	6.20	0.16	3.20	0
N26		315187	6138362	brown	20-30	5.53	0.06	2.87	0
N26		315187	6138362	yellow/orange	B horizon	4.78	0.10	0.69	2
N27	Inside fence	315187	6138362	grey/brown	0-10	5.35	0.09	6.68	0
N27		315187	6138362	pale orange/brown	10-20	5.71	0.06	1.56	2
N28	Top of hill	312146	6139251	dark grey/brown	0-10	5.36	0.12	4.94	0
N28		312146	6139251	dark grey/brown	10-20	5.55	0.08	2.57	0
N28		312146	6139251	orange/yellow	B horizon	5.75	0.06	1.10	0
N29	Inside gully	311413	6140502	green/grey	0-10	5.76	0.04	1.99	0
N29		311413	6140502	green/grey	10-20	6.13	0.04	1.40	1
N29		311413	6140502	green/yellow grey	20-50	6.48	0.07	0.61	1
N29	Close to road	311413	6140502	green/yellow grey	100-110	7.85	0.23	0.20	1
N29	5m upstream	311413	6140502	dark grey(black)	100-120	7.86	0.19	1.33	1

*0=non sodic, 1=sodic, 2=highly sodic

Table 4. pH and EC measurements of archival Soils

Sample No.	Horizon	Depth (cm)	PPF	pH(w)	EC dS/m
EC52	A1	0-10	Dy3.21	5.1	0.07
		10-20		4.8	0.15
	A2	20-30		5.5	<0.06
		30-40		5.7	<0.06
		40-50		6.1	<0.06
	B	50-60		6.1	<0.06
		60-70		6.6	<0.06
		70-80		6.7	<0.06
	C	80-90		6.9	<0.06
		90-100		6.7	<0.06
EC152	A1	0-10	Uc4.13	5.4	0.1
		A2		10-20	4.9
		20-30		5.6	0.11
		30-40		5.7	0.09
	C	40-50		5.7	0.16
EC153	A1	50-65	Dy3.41	6.6	0.23
		A1		0-10	4.8
		10-20		4.8	0.1
	A2	20-30		5.3	0.06
		30-43		5.7	<0.06
	B	43-53		5.8	<0.06
		53-60		5.8	0.07
		60-70		5.7	0.09
	70-80	5.8	<0.06		
C	80-90	5.9	<0.06		
	90-100	6			

Table 4. pH and EC measurements of archival Soils

Sample No.	Horizon	Depth (cm)	PPF	pH(w)	EC dS/m
EC154	A1	0-10	Dy3.41	4.9	0.06
	A2	10-13		5.3	
	B	13-23		5	<0.06
		23-30		5.5	
		30-40		5.6	<0.06
		40-50		5.9	0.07
		50-60		6	<0.06
		60-70		6	<0.06
	70-84	5.7	<0.06		
EC155	A1	0-10	Dy3.41	4.8	0.15
		10-20		4.6	0.13
	A2	20-32		5	0.06
	B	32-42		5.4	
		40-50		5.6	<0.06
		50-60		6.1	<0.06
		60-70		6.1	<0.06
	C	70-80		6.4	<0.06
80-90		6	<0.06		
EC157	A1	0-10	Dd1.13	5.6	
		10-20		7.1	0.23
		20-26		8.4	
	B	26-36		8.9	0.23
		40-50		9.3	0.47
		50-60		9.3	0.59
		60-70		9.1	0.53
		70-80		9.2	0.54
		80-90		8.8	0.46
				90-100	9.4
EC184	A1	0-10	Dy3.32	5.4	0.11
	A2	10-20		5	0.17
	B	20-30		6.1	0.06
		30-40		5.7	0.06
		40-50		5.7	0.07
		50-60		5.9	<0.06
		60-70		6.1	<0.06
		70-80		6.3	<0.06
		80-90		6.5	<0.06
		C		90-100	7
EC185	A1	0-10	Dy3.41	5.1	0.09
	A2	10-20		4.8	0.1
		20-26		6.1	
	B	26-36		6.3	<0.06
		36-46		6.3	<0.06
		46-56		6.3	<0.06
		BC		56-67	6.6
EC186	A1	0-10	Dy3.41	5.6	
	A2	10-20		4.6	0.07
	B	20-30		5.9	<0.06
		30-40		5.5	<0.06
		40-50		5.6	<0.06
		50-60		5.6	<0.06
		60-70		5.8	<0.06
		70-80		5.9	<0.06
		80-90		6.9	0.25
				90-100	6

Table 4 (cont). pH and EC and measurements of archival Soils

Sample No.	Horizon	Depth (cm)	PPF	pH(w)	EC dS/m
EC210	A1	0-10	Dy2.21	5.3	
		10-20		5.3	0.11
	A2	20-30		5.6	0.07
	B	30-40		6.1	0.07
		40-50		6	
		50-60		5.7	
EC211	A1	0-13	Dy3.41	5.2	0.09
	A2	13-20		4.6	0.07
	B	20-30		5.3	<0.06
		30-40		5.4	<0.06
		40-50		5.5	<0.06
		50-60		5.6	<0.06
		60-70		5.7	<0.06
	BC	70-80		5.7	<0.06
		80-90		5.9	<0.06
	C	90-100		5.9	<0.06
EC212	A1	0-10	Dy3.33	7.6	0.35
	A2	10-21		4.9	0.22
		21-31		7.6	0.2
	B	30-40		7	<0.06
		40-50		7.4	0.06
		50-60		7.9	0.07
		60-70		8.3	0.07
		70-80		8.5	0.09
		80-87		8.5	0.1
Sandy	lens	87-91		8.3	0.09
		91-100		8.7	0.19
EC213	A1	0-10	Dy3.61	5.1	
		10-20		4.8	0.09
		20-30		5	<0.06
		30-40		5.4	<0.06
	A2	40-50		5.8	<0.06
	B	50-60		5.7	
		60-70		6.5	<0.06
	C	70-80		6.2	
EC214	A1	0-10	Dy3.41	4.6	
	A2	10-20		4.5	0.27
		20-30		4.9	<0.06
		30-40		5.5	<0.06
		40-48		6.2	<0.06
	B	48-58		5.7	
		60-70		6	<0.06
	C	70-80		6.2	<0.06
		80-90		6.3	<0.06
		90-100		6.7	
EC289	A1	0-12	Dy3.42	5.1	
	A2	12-22		6	
	B	22-30		6.4	
		30-40		7	0.09
		40-50		6.9	0.1
		50-60		6.8	0.18
		60-70		7	
		70-80		7.1	0.42
		80-90		7.6	0.33
		90-100		7.3	

Table 4 (cont). pH and EC and measurements of archival Soils

Sample No.	Horizon	Depth (cm)	PPF	pH(w)	EC dS/m
EC290	A1	0-10	Uc2.21	5.8	
		10-20		5.5	<0.06
	A2	20-30		5.6	
		30-40		5.4	
	B	40-50		5.6	
		50-55		5.2	
		55-70		5.5	
		70-80		5.7	
EC305	A1	0-10	Dd1.53	5.2	
		10-20		5.3	0.19
	B	20-30		6.8	
		30-40		6.5	0.12
		40-50		7.8	0.07
		50-60		8.1	0.13
		60-70		8.9	0.18
		70-80		9	0.23
		80-90		9	0.26
		90-100		8.6	
EC306	A1	0-10	Dy3.41	5.3	
		10-20		4.6	0.17
	A2	20-28		5.5	
	B	28-38		5.7	
		38-50		6	<0.06
		50-60		6.1	<0.06
				60-70	5.4
EC307	A1	0-10	Um4.24	5.3	
		10-20		4.7	0.19
		20-30		4.5	0.21
		30-40		5	
	A2	40-50		4.9	0.06
		50-60		5.4	<0.06
		60-70		5.8	<0.06
		70-80		6.1	<0.06
		80-90		6.2	<0.06
		90-100		6.2	
EC308	A1	0-15	Dy3.41	4.5	
		A2		10-20	5
		20-29		5.8	<0.06
	B	29-39		5.8	
		40-50		6.1	<0.06
		50-60		6.4	<0.06
		60-70		6.6	<0.06
		70-80		6.6	<0.06
		80-90		6.6	<0.06
90-100		6.6			

Table 4 (cont). pH and EC measurements of archival Soils

Sample No.	Horizon	Depth (cm)	PPF	pH(w)	EC dS/m
EC309	A1	0-10	Dy3.41	5.3	
	A2	10-19		4.8	0.1
	B	19-29		5.3	
		29-40		5.9	0.07
		40-50		6.2	<0.06
		50-60		6.3	0.06
		60-70		6.2	<0.06
	CD	70-80		6.1	<0.06
		80-90		6.1	<0.06
		90-100		6	
EC310	A1	0-10	Dy3.41	5.8	
	A2	10-20		6	0.07
		20-30		6.5	<0.06
		30-42		7	<0.06
		42-52		7	
	B	50-60		6.4	0.38
		60-70		6.1	0.43
		70-80		6	0.5
		80-90		5.9	0.47
		90-100		5.6	
EC465	A1	0-10	Dy3.41	5.1	
	A2	10-23		5.6	<0.06
	B	23-33		5.8	
		30-40		6.2	<0.06
		40-50		6.3	<0.06
		50-60		6.3	<0.06
		60-70		6.3	<0.06
		70-80		6.2	<0.06
		80-90		6.1	<0.06
		90-100		5.7	
EC467	A1	0-10	Dy3.41	5	
	A2	10-20		5	0.09
	B	20-30		5.5	
		30-40		5.5	<0.06
		40-50		5.9	<0.06
		50-60		6.4	0.08
		60-70		5.9	0.07
		70-80		5.8	<0.06
	C	80-90		5.7	<0.06
		90-100		5.6	
EC494	A1	0-10	Uc4.12	5.6	
	A2	10-20		5.1	0.11
		20-30		5.9	<0.06
		30-40		6	
		40-50		6.4	<0.06
		50-60		8.4	0.24
	C	60-70		7.2	0.06
		70-80		6.5	<0.06
		80-90		6.4	<0.06
		90-100		5.9	

Table 4 (cont). pH and EC measurements of archival Soils

Sample No.	Horizon	Depth (cm)	PPF	pH(w)	EC dS/m	
EC495	A1	0-10	Dy2.81	4.7		
		10-20		4.6	0.34	
	A2	20-30		5.5		
		B		30-40	5.5	
	40-50			5.7	<0.06	
	50-60			5.7	<0.06	
	60-70			5.9	<0.06	
	70-80			6.0	<0.06	
	80-90			6.0	<0.06	
	90-100			5.0		
EC654	A1		0-10	Dr2.41	5.3	
	A2	10-20	4.8			
	B	20-30	5.7			
EC659	A1	0-10	Dy3.81	6.1		
		10-20		5.3	0.19	
	A2	20-30		6.6		
		30-40		6.8		
		40-50		7.2		
	B	50-60		6.6		
		60-70		6.8	0.12	
		70-80		6.2	0.18	
		80-90		6.4	0.25	
		C		90-100	6.3	
EC660	A1	0-10	Dy3.41	4.6		
		10-20		4.6	0.11	
	A2	20-30		5.0	<0.06	
		B		30-40	4.4	
				40-50	5.6	0.12
	50-60			5.8	0.09	
	60-70			6.1	0.08	
	70-80			7.2	0.31	
	80-90			6.0	0.07	
	90-100			4.3		
EC701	A1		0-10	Dy3.71	5.8	
		A2	10-15		5.7	0.1
	B	15-25	6.3			
		30-40	5.9		0.14	
		40-50	6.1		0.17	
		50-60	6.4		0.16	
		60-70	6.7		0.24	
		70-80	6.5		0.49	
		80-90	6.2		0.28	
90-100	6					
EC702	A1	0-10	Dy3.42	5.1		
		10-20		5.9	0.39	
	A2	20-30		6.7	0.27	
		B		30-40	5.7	
	40-50			7.2	0.53	
	50-60			7.2	0.6	
	60-70			8.1	0.71	
	70-80			7.8	0.37	
	80-90			6.2		

Table 4 (cont). pH and EC of archival Soils

Sample No.	Horizon	Depth (cm)	PPF	pH(w)	EC dS/m	
EC722	A1	0-10	Dy3.41	5.9		
		10-20		4.8	0.66	
	A2	20-30		5.4	0.13	
		30-43		6.1	0.06	
	B	43-53		6.4		
		50-60		6.3	0.19	
		60-70		6.2	0.23	
		70-80		6.1	0.21	
				80-90	6	0.23
		C		90-100	6.4	
EC723	A1	0-10	Dr2.41	5.3		
	A2	10-20		4.4	0.17	
		20-36		5.2	0.08	
	B	36-46		6.4		
		40-50		6.4		
		50-60		6.3	0.08	
				60-70	6.5	0.08
		C		70-80	6.8	
EC724	A1	0-10	Dy3.41	5.5		
	A2	10-20		4.8	0.07	
		20-30		5.8	<0.06	
	B	30-40		6.4		
		40-50		6.3	0.06	
		50-60		6.4	0.06	
		60-75		6.5		
	EC732	A1		0-10	Dy3.41	4.3
10-20			4.9	0.18		
		20-30	5.5	0.09		
A2		30-40	5.6	0.06		
		B	40-50	5		
50-60			6.1	0.11		
60-70			5.9	0.13		
70-80			5.6	0.12		
			80-90	5.5		0.13
			90-100	4.4		

Discussion

Table 5 shows the actual pH class and the predicted pH classes (within 100 m of the site) obtained from the best estimation of acidity. Overlaying the point coverage of the sites with the best estimation of acidity revealed that all 40 sites had some percentage (4-100%) of the expected class within 100m. At 18 sites more than 50% of the buffered area was classified as predicted by the model. Of the five classes of acidity/alkalinity likely to be found within the upscaled area only three classes (2,3 and 5) were measured in this sampling. Classes 1 (very acidic throughout) and 4 (neutral throughout) were not identified at any site. The areas predicted to contain these classes need to be sampled to further verify the model.

Table 5. Comparison of actual and predicted pH classes.

Sample No.	Actual pH Classes	Predicted pH Classes (%) within buffer				
		1	2	3	4	5
N24	3	6	41	32	13	7
N26	2		73	17	10	
N27	2		73	17	10	
N28	2		100			
N29	3		46	23	16	15
EC52	3		81	4	7	8
EC152	2		100			
EC153	2		92	8		
EC154	2		61	16	10	3
EC155	2		81	19		
EC157	5			1		99
EC184	3		80	20		
EC185	2		64	33	3	
EC186	2		72	20	7	1
EC210	2		26	18	56	
EC211	2		10	25	65	
EC212	5		2	7	61	30
EC213	2		19	24	28	29
EC214	2		81	18	1	
EC289	3		5	11	43	41
EC290	2		100			
EC305	3		1	22	30	47
EC306	2		24	22	35	19
EC307	2		26	12	52	10
EC308	3		82	18		
EC309	2		21	60	19	
EC310	3		28	29	39	4
EC465	2	43	39	15	3	
EC467	2		95	5		
EC494	3	21	67	11		
EC495	2		90	10		
EC654	2		37	34	29	
EC659	3		17	25	46	12
EC660	3		41	44	15	
EC701	2		86	14		
EC702	3		11	13	53	23
EC722	2		95	5		
EC723	2	15	84	1		
EC724	3		10	18	64	8
EC732	2		82	17	1	

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