Investigation of soil pH variability

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June 2011

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1 INTRODUCTION

When farmers sample the soil in their paddocks to test for soil pH they generally only do a small number of sub-samples and then a soil sample is taken from this and sent to the laboratory for testing. If the soil test result has a low soil pH then farmers generally apply an application of lime across the whole paddock. The soil pH can vary across the paddock and therefore in some cases only part of the paddock may require lime or some areas of the paddock may require more lime than other parts of the paddock.

As part of the Department of Environment and Natural Resources (DENR) and the Advisory Board of Agriculture's project *Taking action on soil acidity in South Australia* an investigation was carried out to determine the variability of soil pH in the surface (0-10 cm) and sub-surface (10 – 20 cm) across a paddock.

2 METHODOLOGY

This pH variability investigation was carried out on Section 48 Hundred Saddleworth, approximately 2 km SW of Waterloo. Rainfall is approximately 450 mm per annum.

The soil has been characterised as a red-brown earth with a hard-setting brown sandy loam surface overlying a red, yellow and brown mottled columnar structured clay sub-soil, calcareous at depth (Soil and Land Program, 2007). Further information is outlined in Appendix I. The soil pH ($CaCl_2$) from the soil pit was 4.8 at 0-12 cm and 5.2 at 12-15 cm.

A small sampling area in 2010 showed that the surface soil (0-10 cm) had a pH of 4.8 ($CaCl_2$) and that the sub-surface soil (10-20 cm) had a pH of 5.7. The aluminium levels were low with the top-soil and sub-surface having an aluminium level of 1.18 and 0.37 mg/kg respectively.

To sample the paddock for soil pH variability three transects were established on the southern half of the paddock from east to west. Each transect was approximately 500 metres long and the transects were approximately 100 metres apart. The gps co-ordinates at the start and the end of each transect were recorded. A composite soil sample (made up of four samples) was taken at 0-10 and 10-20 cm at each site, every 100 metres along each transect. There were 18 sites with each site representing a hectare.

The samples were sent to the CSBP laboratory in WA and analysed for soil pH ($CaCl_2$ and water) and $CaCl_2$ aluminium extraction.

The site numbers and transects were overlaid over an aerial photo (Figure 1).

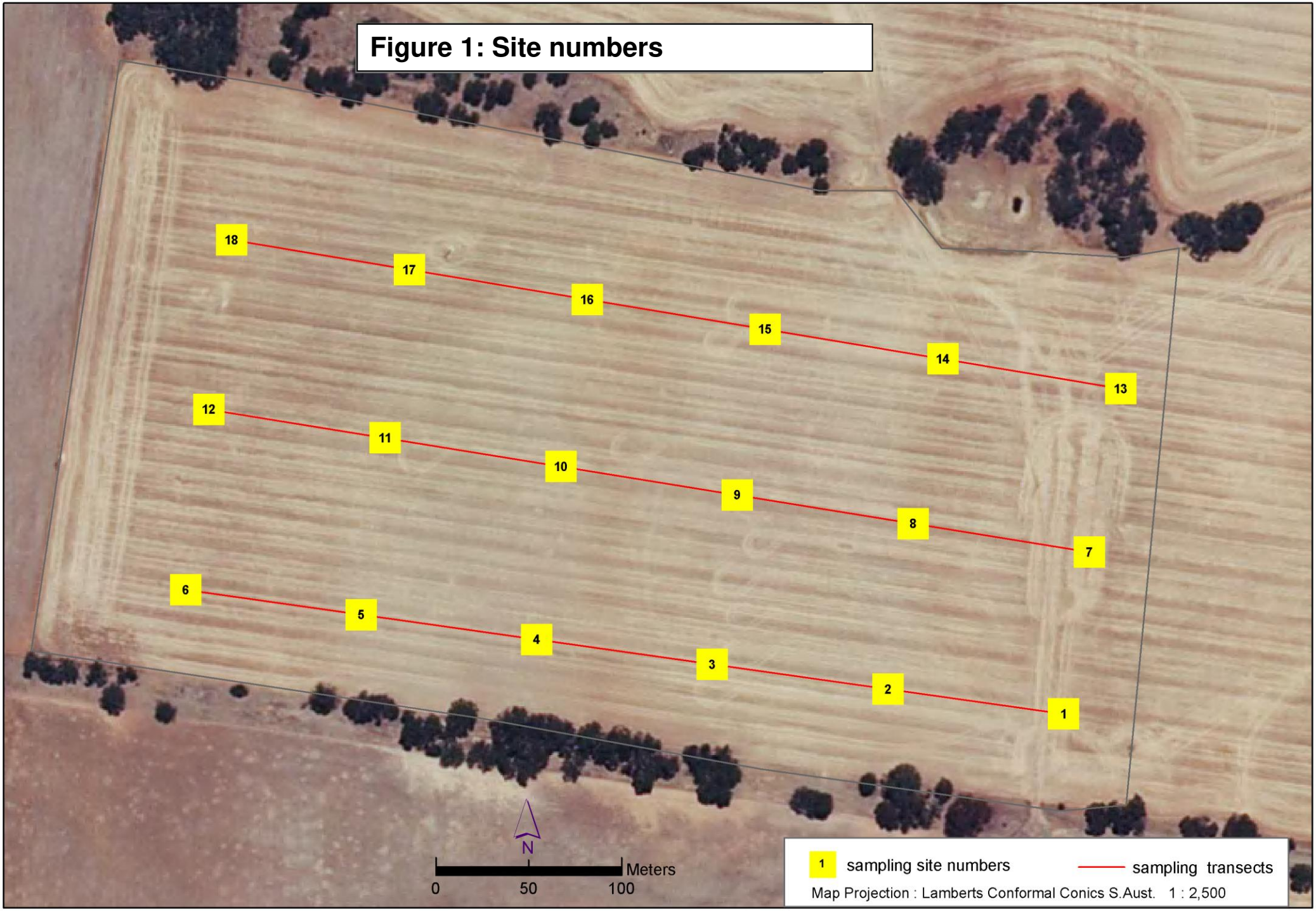


Figure 1: Site numbers
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
N
0
50
100
Meters
1 sampling site numbers
sampling transects
Map Projection : Lamberts Conformal Conics S.Aust. 1 : 2,500

The surface and sub-surface spatial pH maps (Figure 2 & 3) were generated by Spatial Analyst using the IDW (inverse distance weighted) method of interpolation.

Figure 2: View of the paddock (looking west).

3 RESULTS

The results are shown in Table 1 and Figures 3 and 4.

The results showed that 14 of the 18 sites (78%) of the top-soil had a pH equal to or less than pH 5.5 ($CaCl_2$) and that 8 of the 18 sites (44%) of the sub-surface soil had a pH equal to or less than pH 5.0 ($CaCl_2$).

Transect 2 has a lower average than the other two transects. The soil pit to characterise the site as well as the preliminary investigation in 2010 were carried out in the central part of the paddock and therefore the pH results of these investigations particularly the top-soil are similar to those shown in Table 1.

As the pH falls below pH 5.0 ($CaCl_2$) then the concentration of aluminium increases in the soil solution. When aluminium increases above 2 mg/kg then aluminium can become toxic to root growth. There were only two sites in the top-soil and one site in the sub-surface soil where the aluminium was above 2 mg/kg. These sites were in the central part of the paddock.

Table 1: Results of the top-soil (0-10 cm) and sub-surface soil (10-20 cm)

Transect	Site No.	Top-soil (0-10 cm)		Sub-soil (10 – 20 cm)	
		pH (CaCl2)	Aluminium (mg/kg)	pH (CaCl2)	Aluminium (mg/kg)
Transect 1	1	5.0	1.32	5.0	0.91
Closest to gate	2	5.8	<0.20	5.8	<0.20
	3	5.6	<0.2	5.4	0.77
	4	5.3	0.90	5.0	0.67
	5	5.0	1.35	5.5	0.48
	6	5.4	1.03	5.3	1.13
Average		**5.3**		**5.3**	
Transect 2	7	4.9	1.72	4.8	1.02
	8	5.0	1.20	5.5	<0.20
	9	5.4	0.59	5.2	1.16
	10	4.7	3.39	4.7	2.04
	11	4.6	2.46	4.9	1.26
	12	4.7	1.90	4.8	1.18
Average		**4.9**		**5.0**	
Transect 3	13	4.8	0.86	5.0	0.43
	14	5.2	0.32	5.7	<0.20
	15	5.6	<0.20	5.3	0.74
	16	5.1	0.95	4.8	1.38
	17	5.3	0.72	6.4	<0.20
	18	6.1	<0.20	5.7	<0.20
Average		**5.4**		**5.5**	
Overall Average		**5.20**		**5.3**	
SD		**±0.41**		**±0.45**	
Minimum			**<0.20**		**<0.20**
Maximum			**3.39**		**2.04**

A standard deviation of the overall pH results of the top-soil and sub-soil showed that there was a large variation between readings. The top-soil had an average pH of 5.20 with a standard deviation of ±0.41 (4.8 – 5.6) and the sub-surface soil had an average pH of 5.3 with a standard deviation of ±0.45 (4.8 – 5.7). There is not a large difference in the average soil pH between the surface and sub-surface soil.

Liming is the most effective way to treat soil acidification. The amount of lime required is based on the current pH, target pH and a soil texture factor. Figure 4 shows an approximate map of zones and the amount of lime to apply within each zone to raise the surface pH to 5.5 ($CaCl_2$) and the sub-surface pH to 5.0 This is assuming the soil texture across the whole paddock is a sandy loam with a texture conversion factor of 3. The Lime requirement was based on the formula:

Lime requirement (t/ha) = (target pH – current pH) x soil texture factor of 3.

When lime is applied on the soil surface it reacts slowly through the top-soil and over time can have an effect in improving the sub-surface soil pH. Where the sub-surface was more acidic than the surface soil e.g. site 16 then a higher rate of lime was recommended.

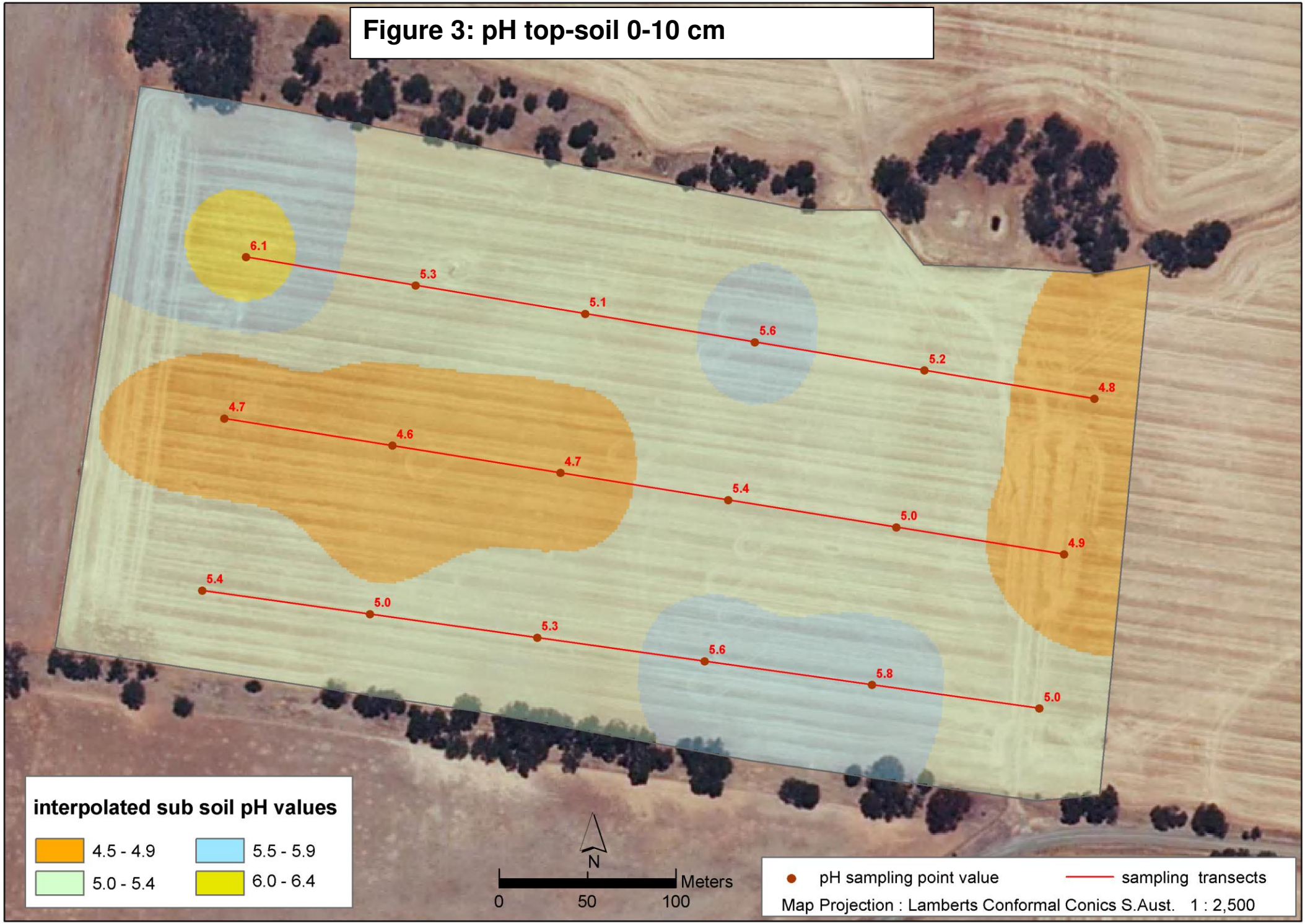


Figure 3: pH top-soil 0-10 cm
6.1
5.3
5.1
5.6
5.2
4.8
4.7
4.6
4.7
5.4
5.0
4.9
5.4
5.0
5.3
5.6
5.8
5.0
interpolated sub soil pH values
4.5 - 4.9
5.5 - 5.9
5.0 - 5.4
6.0 - 6.4
N
0
50
100
Meters
pH sampling point value
sampling transects
Map Projection : Lamberts Conformal Conics S.Aust. 1 : 2,500

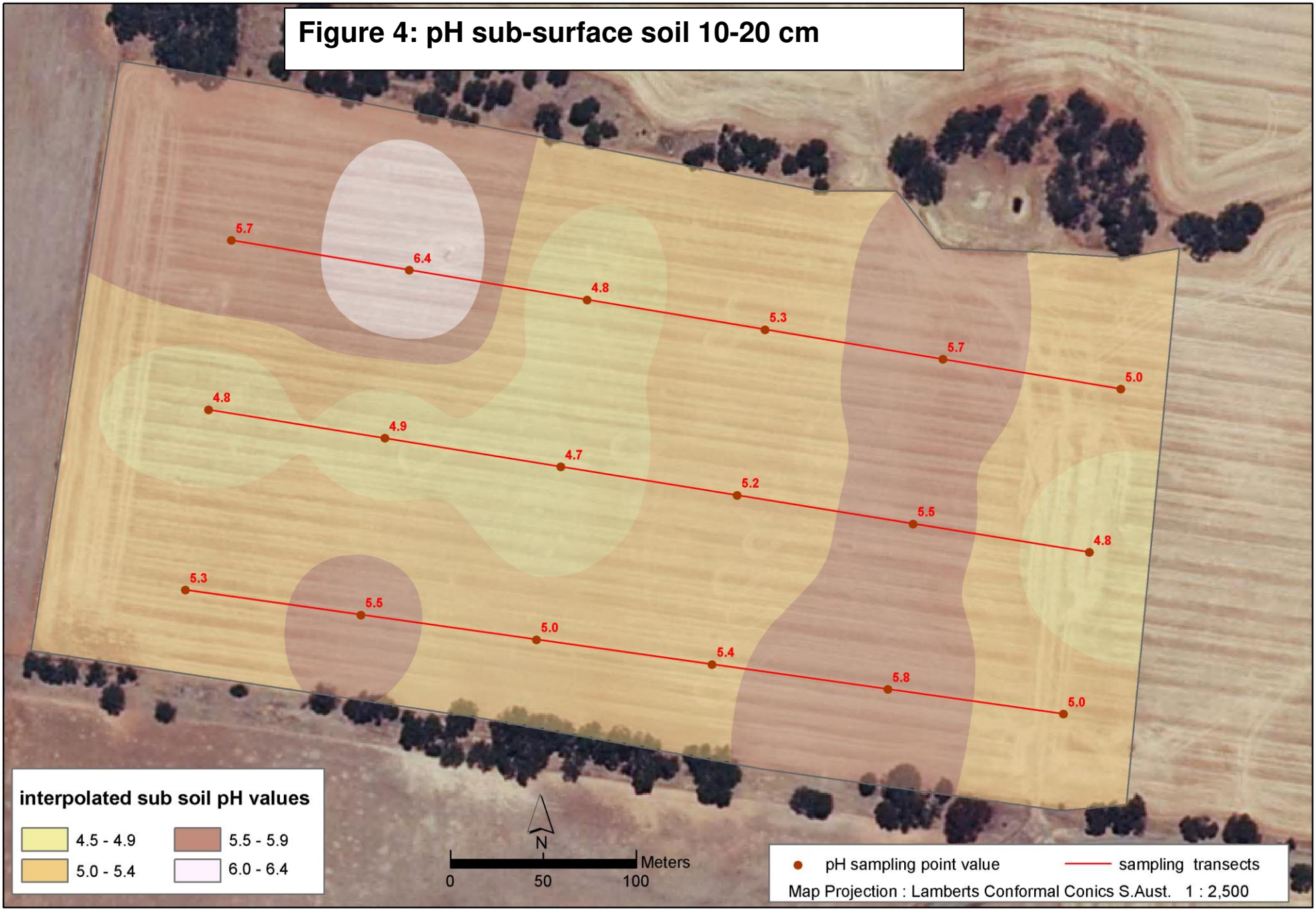
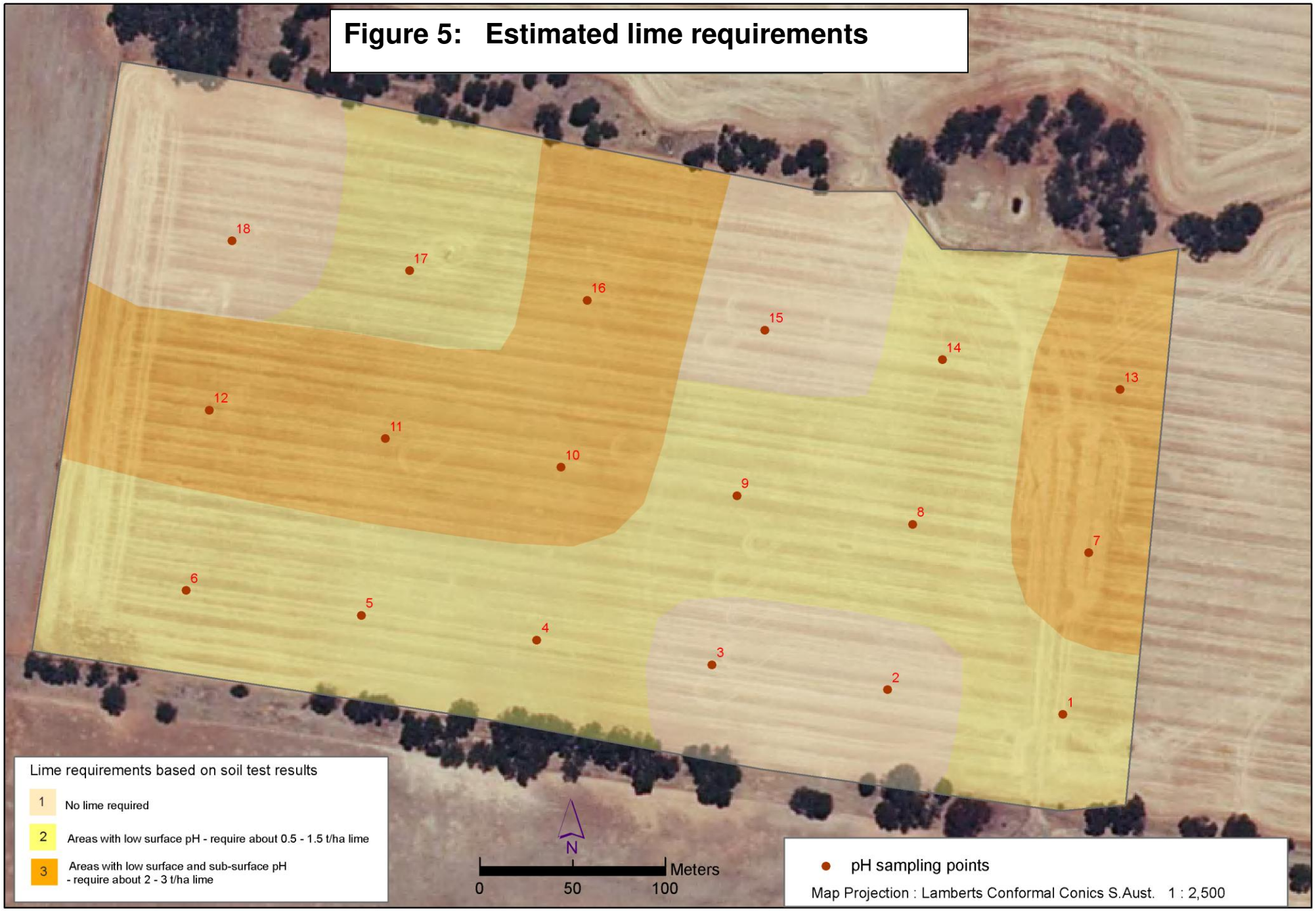


Figure 4: pH sub-surface soil 10-20 cm
5.7
6.4
4.8
5.3
5.7
5.0
4.8
4.9
4.7
5.2
5.5
4.8
5.3
5.5
5.0
5.4
5.8
5.0
interpolated sub soil pH values
4.5 - 4.9
5.5 - 5.9
5.0 - 5.4
6.0 - 6.4
N
0
50
100
Meters
pH sampling point value
sampling transects
Map Projection : Lamberts Conformal Conics S.Aust. 1 : 2,500

Figure 5: Estimated lime requirements



Of the 18 sites, 4 sites do not require lime (4 ha) as the surface pH and sub-surface pH is at 5.5 ($CaCl_2$) or above and 5.0 ($CaCl_2$) or above respectively.

Eight sites had a low surface pH only and only require a small rate of lime 0.5 – 1.5 t/ha (8 ha) to raise the pH to 5.5 ($CaCl_2$). Six sites (6 ha) require a rate of 2- 3 t/ha of lime to influence the soil pH in the surface and sub-surface.

4 DISCUSSION

There can be a natural variation in soil pH across a paddock due to soil texture, soil depth and organic matter and this can vary with seasonal conditions.

Land management practices can reduce the soil pH and accelerate soil acidification through: the removal of farm products such as hay, grain and animal products; addition from nitrogen from fertilisers and pasture legumes; leaching of nitrates and other products and the accumulation of organic matter through pastures.

The results showed that the surface soil and sub-surface was acidic with a large variation of pH across the paddock. It is certain that land management practices over a period of time have had an effect on soil acidification. The lowest pH measurement for the top-soil and sub-surface soil was in the central and western part of the paddock and this could be due to lighter texture soils having a lower organic content and a lower buffering capacity.

Lime is a cost-effective way to manage low soil pH and reduce associated. aluminium toxicity. The amount of lime to apply is based on the current pH, the target pH and soil texture. If lime was based on the average pH of the surface soil pH 5.20 ($CaCl_2$) and assuming that the paddock was a consistent sandy loam then about 0.9 t/ha of lime (16.2 tonnes / 18 hectares) would have been spread across the paddock to raise the soil pH to 5.5 ($CaCl_2$). Lime would have been applied on areas that didn't need it and other areas would not have received enough lime to bring the pH up to the target level.

The amount of lime is based on the soil texture so it is important to also know the variation of the soil texture across the paddock.

Sampling at various sites across the paddock will provide an indication of the variation of soil pH (and soil texture) across the paddock. These areas can then be zoned and estimated rates of lime calculated to raise the soil pH to a target level. When applying lime the contractor(s) with variable rate technology can apply lime where it is needed and at recommended rates.

In this case, it will be more costly in the short term with about 20% more lime required compared to a blanket application however, in the long term this will help to raise the soil pH in the surface and sub-surface and improve crop and pasture growth.

If lime is applied on the surface soil it reacts and moves slowly through the top-soil and may have an effect in improving the sub-surface soil pH. If the lime was incorporated rather than spread on the surface it would be more effective in the top-soil and likely to have a greater impact on improving the sub-surface pH.

It is important to monitor the surface and sub-surface pH of the paddock over time. A further application of lime in three to four years may be required

REFERENCES

Soil and Land Program (2007) Regional land resource information for Southern South Australia. Government of South Australia. DVD ROM.

ACKNOWLEDGEMENTS

The following people are acknowledged:

- Nick and Daniel Schoenberg for the use of their paddock for this project.

APPENDIX I

Soil pit information.