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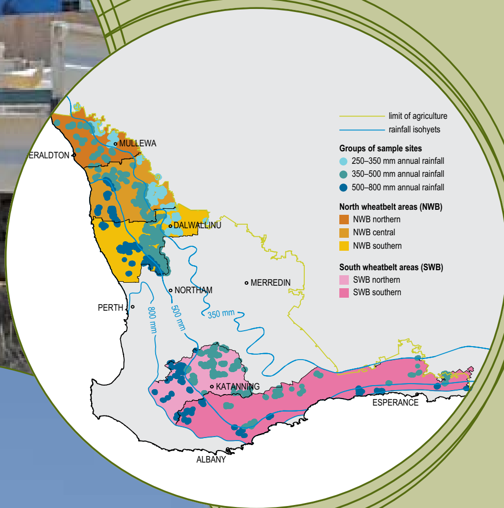

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Soil pH in northern and southern areas of the WA wheatbelt

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Contents

Summary

More than 80% of the topsoils sampled fall below the critical surface pH_{CaCl_2} of 5.5 in the northern and southern wheatbelt study areas, with more in the south than the north. These results confirm soil acidity is a serious concern throughout the WA wheatbelt when considered in conjunction with the more intensive analysis of current soil pH throughout the Avon River Basin (2005–2008).

With low topsoil pH, it is likely that subsurface acidity is also a problem. For soil acidity to be managed, subsurface pH also needs to be known. In the Avon River Basin study, about half of the subsurface samples fell below the critical subsurface pH of 4.8.

Maintaining soil pH above 5.5 in the topsoil and 4.8 in the subsurface will remove soil acidity and aluminium toxicity as a constraint to sustainable productive agriculture in the WA wheatbelt.

Introduction

Acidity is an inevitable consequence of productive agricultural systems. Unless managed, through the application of agricultural lime, the soil pH will decline (become more acid), resulting in:

- Poor nutrient availability
- Poor root growth (caused by aluminium toxicity in the subsurface soil layers), which leads to decreased nutrient uptake, water use and yield of crops.

State and Federal Governments have an interest in how well Australia's natural resources are being managed to ensure their sustainable use and to assist with prioritisation of on-ground works. The condition of the soil resource in terms of wind and water erosion, soil carbon and acidity has received much recent attention (Gazey *et al*., 2007). However, because there are no dedicated large scale monitoring programs in place for these areas, there is a lack of current data (<10 years old) available to determine the overall soil resource condition. One source of data that can be used is that derived from soil fertility testing (for fertiliser recommendations) which includes a measurement of soil pH.

Precision SoilTech is a commercial soil sampling company which holds soil testing data in trust on behalf of its clients in a comprehensive database containing more than 100,000 geo-located points of information for Western Australia. In this study we examined this database to provide a general summary of the regional soil pH. The data have been aggregated to ensure that no individual can be identified as a result of this investigation.

Incentive-based soil testing in the Avon River Basin through the Avon Catchment Council's Soil Acidity Project 2005–2008 showed that 80% of the 17,000 topsoil samples collected were below the target pH of 5.5, while almost half of the 20,000 subsurface soil samples (10–20 or 20–30 cm) had a pH below the target of 4.8.

This project adds to knowledge of the current topsoil pH for areas of the wheatbelt outside the Avon River Basin. Insufficient data was available to examine the comparable subsurface situation. The aim of this project is to report on the soil acidity situation in the topsoil for the northern and southern areas of the WA wheatbelt.

Methods

Data from 1998 to 2002 were extracted from the Precision SoilTech database and used in the analysis for three reasons:

1. This timeframe provided a sufficient number of samples for inclusion in the analysis using Geomedia GIS software (Intergraph).
2. Should subsequent monitoring on a broad scale be introduced, these samples could provide a baseline against which comparisons could be made to assess differences due to acidification and management, especially liming.
3. Due to seasonal impacts (drought) on soil testing, particularly in the north, fewer data points were available for more recent years. Data for this period were not used in the analysis as they could be skewed and misrepresent the true situation.

Approximately 13,000 topsoil (0–10 cm) pH data points were available for study in the northern and southern wheatbelt study areas and therefore further subdivisions were possible. The northern study area was divided into north, central and south and further divided by rainfall: 250–350 mm, 350–500 mm and 500–800 mm into eight subregions.

In the southern wheatbelt study area, fewer data points restricted divisions to north and south with 350–500 mm and 500–800 mm rainfall zones (see Figure 1). These divisions broadly represent different productivity zones. In the southern study area, the soil pH in areas receiving more than 800 mm per year rainfall was not considered because there were relatively few points around the Albany area that could be used.

The pH of all samples was measured using 1:5 soil:0.01 M calcium chloride as part of soil fertility testing by commercial laboratories. This overcomes the variations that can occur when pH is measured in water, especially in soils with low total salts.

Analysis of the data was designed to determine the number of sites with low topsoil pH, in particular, below the topsoil pH target of 5.5 set by the Avon Catchment Council for the Avon River Basin. Targets of pH 5.5 in the topsoil and 4.8 in the subsurface were developed in conjunction with the Department of Agriculture and Food, Western Australia (DAFWA) and are a good guide for the WA wheatbelt. At these levels, acidity does not constrain production and sufficient alkalinity is available to treat on-going acidification caused by agriculture in the topsoil and subsurface soils.

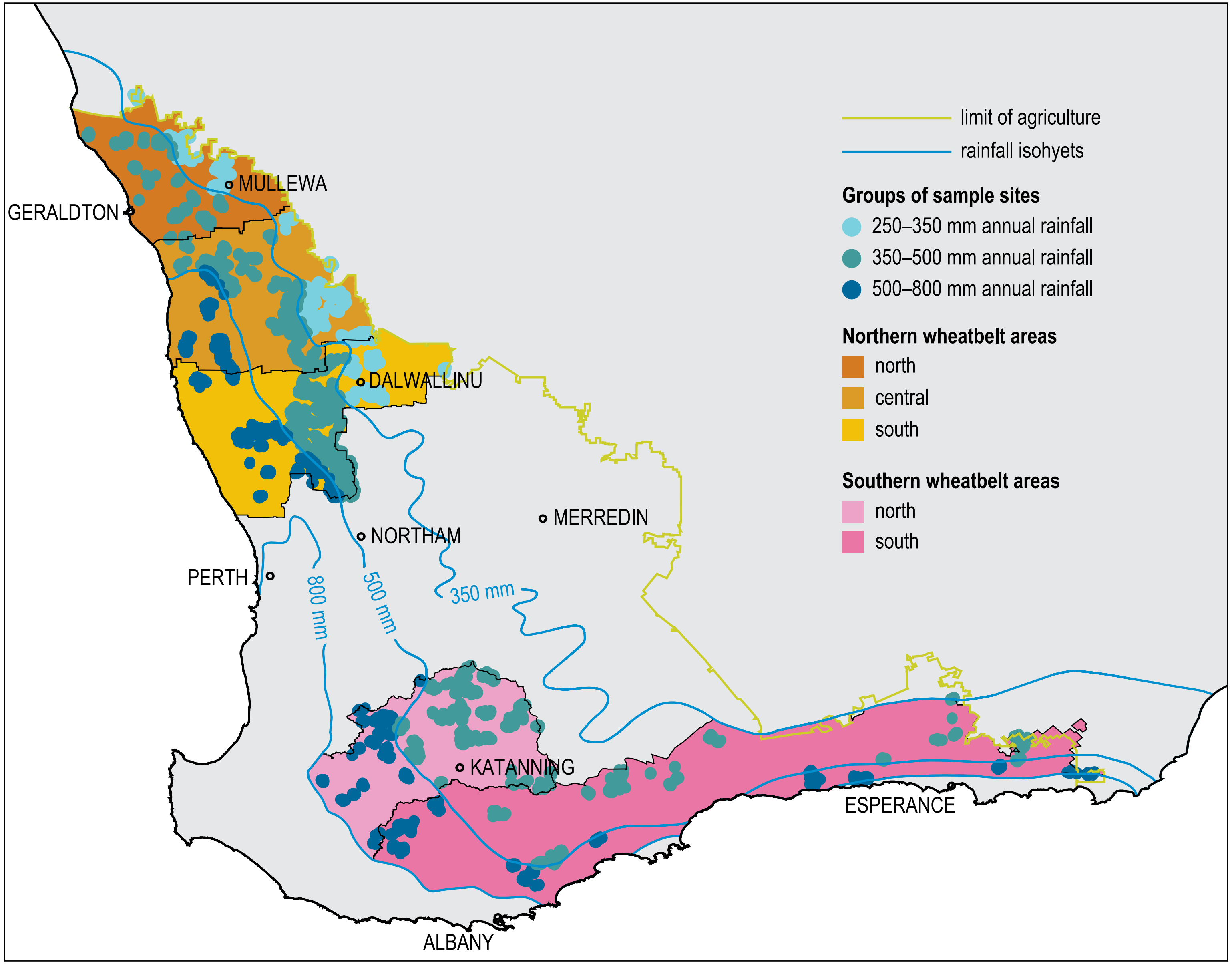

Figure 1. The south-west of Western Australia, showing the geographical division of samples (1998–2002) used in this study.

Results

Northern wheatbelt

For the northern wheatbelt a total of 8,676 topsoil pH data were analysed. The topsoil pH situation for most subregions was similar (see Figure 2)—about 80% of samples with topsoil pH below 5.5 (Table 1). The exceptions were the higher rainfall south subregion, having more (92%) of topsoils below 5.5, and the lower rainfall south subregion with less (67%), however, this area also had a higher proportion (8%) of neutral to alkaline soils compared with the other regions (0–4%).

Table 1. *Percentage of sites in the northern wheatbelt study area with soil pH below 5.5.*

Northern wheatbelt study area	Sites with topsoil pH below 5.5 (%)		
	500–800 mm*	350–500 mm*	250–350 mm*
North		77	72
Central	86	73	86
South	92	88	67

* Annual rainfall zones

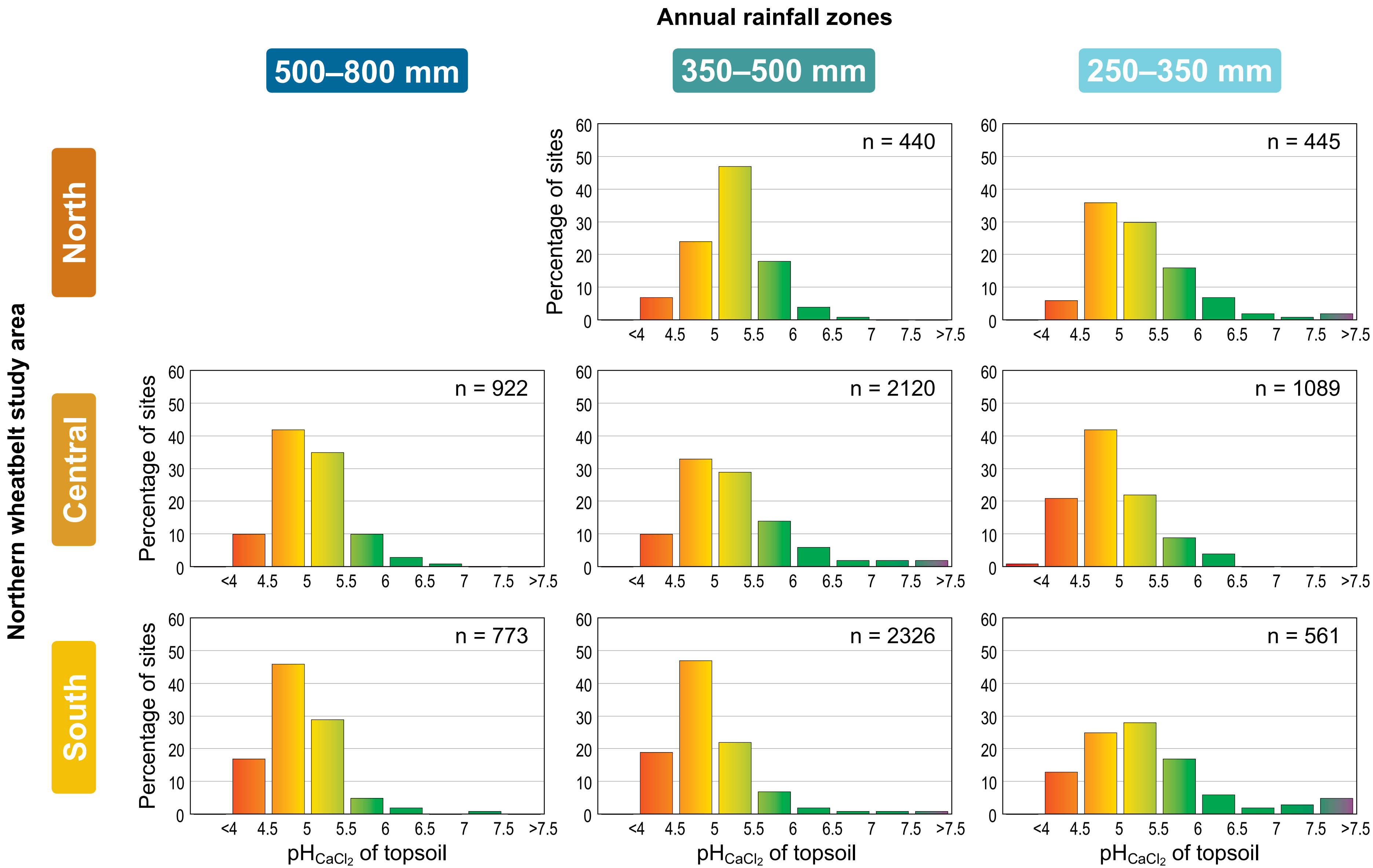

Figure 2. *Topsoil pH in the northern wheatbelt study area. The gradient shading represents the severity of the low soil pH values and provides further visual cues to the proportion of soils below the critical topsoil pH of 5.5. n = total number of sites in each sub-region.*

Southern wheatbelt

For the southern wheatbelt 4,153 topsoil pH data were analysed. Overall, 91% of topsoils had a pH below 5.5. The proportion of low pH topsoils was similar for the higher rainfall south and both north subregions, with approximately 95% below 5.5, but fewer in the lower rainfall south subregion at 78% (see Figure 3, Table 2).

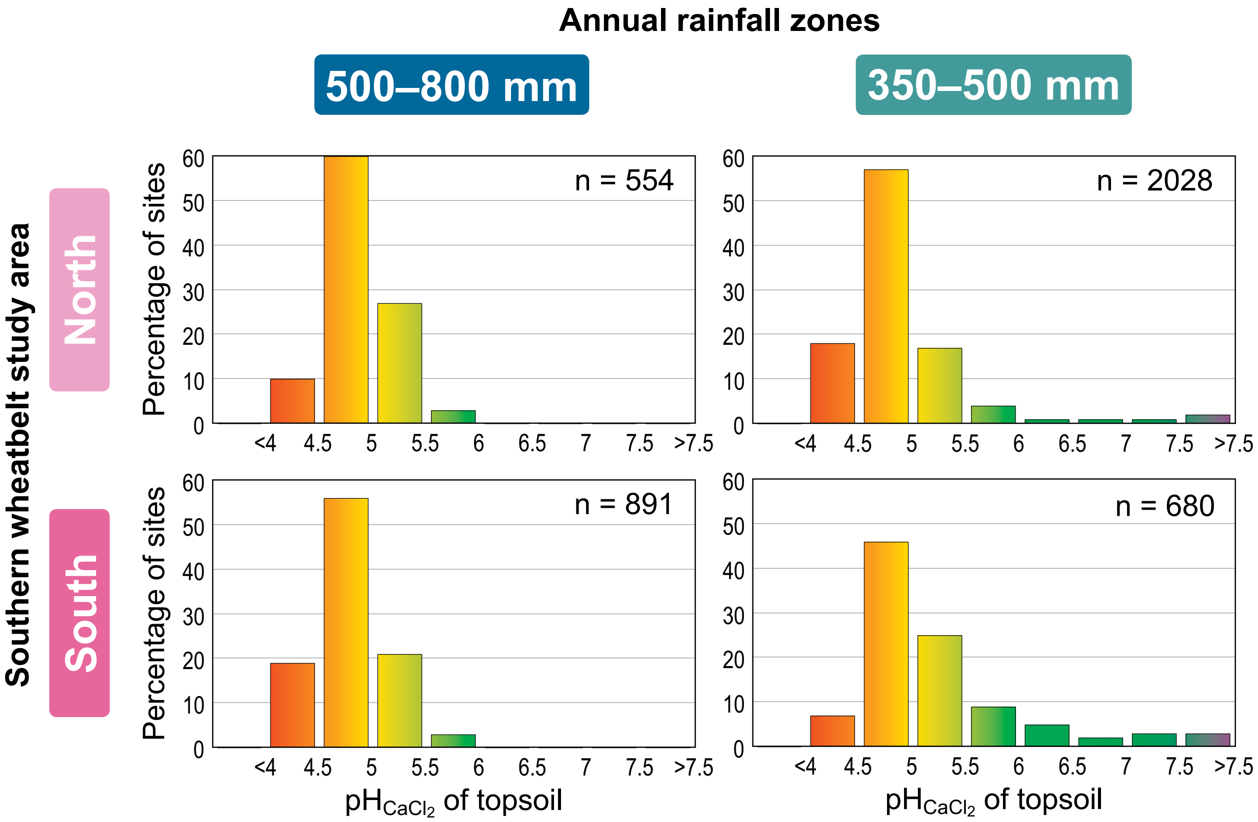

Figure 3. *Topsoil pH in the southern wheatbelt study area. The gradient shading represents the severity of the low soil pH values and provides further visual cues to the proportion of soils below the critical topsoil pH of 5.5.* n = *total number of sites in each sub-region.*

Table 2. *Percentage of sites in the southern wheatbelt study area with soil pH below 5.5.*

Southern wheatbelt study area	Sites with topsoil pH below 5.5 (%)	
	500–800 mm*	350–500 mm*
North	97	92
South	96	78

* Annual rainfall zones

Discussion and recommendations

Most topsoils in both the northern and southern wheatbelt are acidic. Many have pH so low that plant growth would be affected. More importantly, approximately 80% of topsoils in the northern wheatbelt and 90% in the southern wheatbelt are below pH 5.5. With topsoils below this critical level, subsurface soils continue to acidify because there is insufficient alkalinity available to move down to treat on-going acidification due to agriculture. Once acidified, recovery of subsurface soil pH to levels where plant root growth is not affected by aluminium toxicity can be difficult, requiring applications of several tonnes per hectare of lime and 5 to 10 years (Davies *et al*., 2008).

Overall, the northern wheatbelt had a similar proportion (80%) of topsoils with pH below 5.5 as the Avon River Basin (Carr *et al.*, 2008). The lower rainfall south subregion of the northern wheatbelt, which had 67% of topsoils below pH 5.5, has a greater proportion of loamy soils (Schoknecht, 2002) which have greater capacity to buffer pH change than sandy soils. The higher rainfall south subregion of the northern wheatbelt, which had 92% of topsoils below 5.5, is an area with gravelly and sandy soils (Schoknecht, 2002). This potentially leads to increased leaching of nitrogen fertilisers and therefore is likely to have greater rates of soil acidification.

The greatest proportion of acidic topsoils in this study was found in the higher rainfall subregions of the southern wheatbelt. These subregions probably have higher production which would lead to greater soil acidification while the lower rainfall subregions of the southern wheatbelt have more naturally occurring higher pH soils (Schoknecht, 2002).

The higher rainfall subregions of the southern wheatbelt are relatively close to agricultural lime supplies, however, the South Coast lime deposits are generally of lower quality than those supplying the northern wheatbelt (Gazey & Gartner, 2009) and it is possible that even where lime has been applied, quantities were insufficient to treat existing and on-going acidification. For more accurate interpretation of soil pH, better information on lime use is needed.

Information about the soil pH profile to 30 cm in 10 cm increments is necessary to produce a precise 10-year liming recommendation (Andrew *et al.*, 2008b). To date, subsurface soil sampling has not been widely practised in the northern and southern wheatbelt study areas. Subsurface soil samples have only been collected at about 20% of sites, however when information to 30 cm is considered, this value reduces to less than 5%. These are heavily biased towards a few growers and therefore unrepresentative of the study area.

Results from the Avon River Basin (2005–2008) established that acidity is below the regional targets of pH_{CaCl_2} 5.5 in 80% of all topsoil samples (17,021) collected and below the regional targets for subsurface (10–20 and 20–30 cm combined) of pH_{CaCl_2} 4.8 in 45% of all samples (21,199) collected (Andrew *et al*., 2008a). The study reported here focussed on topsoil data for the northern and southern wheatbelt and the proportion of samples below pH 5.5 was similar: 80% for the northern and 90% for the southern.

The process of acidification is similar across all regions and is exacerbated where high productivity is associated with sandy soil types and increased leaching of nitrogen fertilisers. These conditions exist in both the northern and southern wheatbelt. Coupled with DAFWA data (Penny & Gazey, 2002; Gazey unpublished) from a range of field trials and demonstration sites, information indicates that subsurface pH has continued to decline to levels similar to those found in the Avon River Basin.

It is essential for farmers to have a good understanding of their soil pH profiles in order to make appropriate management decisions. With knowledge of the pH profile, more precise liming recommendations are possible (Andrew *et al*., 2008b) ensuring that sufficient lime is applied where and when appropriate, leading to sustainable agricultural production.

This study of existing data highlights topsoil acidity as a cause for concern and also indicates that the levels of acidity are such that a concerted state-wide coordinated program of awareness-raising and education surrounding soil acidity should be developed as a matter of urgency. The background and model for a successful awareness campaign, particularly for subsurface acidity, have been developed and implemented in the Avon River Basin between 2005 and 2008 (Andrew *et al*., 2008a). In order to properly manage soil acidity throughout the wheatbelt, a similar campaign needs to be supported across the agricultural area. In addition, monitoring and assessment of liming practices and pH change should be assessed in the Avon River Basin so that lessons developed in this region can be transferred to the rest of the state.

If pH targets of 5.5 and 4.8 can be achieved over the next 10 to 15 years, there is a real possibility that acidity can be removed as a constraint to agricultural production in Western Australia. Removing acidity as a constraint in the topsoil will increase fertiliser efficiency and removing it in the subsurface will increase the efficiency of water use.

Results from this study could form a baseline for further monitoring of soil resource condition—acidity. A timeframe of seven years has been shown to be of sufficient length to detect both decline and increase in pH in Western Australian agriculture (Gazey *et al*., 2007).

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Appendix A

Topsoil pH statistics for shires in the northern and southern wheatbelt study areas.

Shire	Count	Maximum Topsoil pH	Minimum Topsoil pH	Average Topsoil pH	Mode* Topsoil pH
Carnamah	589	7.7	4.1	5.1	4.7
Chapman Valley	211	7.7	4.2	5.1	4.8
Coorow	900	8.0	4.0	5.0	5.0
Dalwallinu	627	8.1	3.8	5.3	4.6
Dandaragan	375	7.2	4.2	5.0	5.0
Gingin	114	8.0	4.3	5.3	5.1
Greenough	106	6.9	4.6	5.3	5.2
Irwin	42	7.6	4.5	5.7	4.9
Mingenew	976	7.8	4.2	5.3	5.2
Moora	1286	7.8	3.8	5.0	4.7
Morawa	166	7.7	3.9	5.3	5.0
Mullewa	359	7.8	4.2	5.5	5.2
Northampton	233	7.8	4.3	5.1	4.6
Perenjori	1169	8.1	3.8	5.0	4.7
Three Springs	253	7.9	4.3	5.5	5.2
Victoria Plains	1258	7.8	3.9	4.9	4.8
Albany	150	7.6	3.8	4.9	4.8
Cranbrook	180	5.6	4.2	4.9	4.9
Esperance	411	8.2	4.1	5.3	4.6
Jerramungup	301	8.1	4.3	5.1	4.7
Kojonup	43	5.8	4.2	5.0	4.8
Plantagenet	216	6.3	3.8	4.8	4.3
Ravensthorpe	170	8.0	4.5	5.1	4.9
Tambellup	172	7.9	4.2	5.0	4.8
Boyup Brook	66	5.6	4.3	4.9	4.9
Broomehill	36	6.2	4.4	5.2	4.9
Chittering	41	6.0	4.2	5.1	5.1
Dumbleyung	600	8.1	4.2	5.1	4.6
Gnowangerup	131	7.8	4.3	4.9	4.8
Kent	66	8.0	4.5	5.1	4.5
Kojonup	62	5.4	4.4	5.0	4.9
Narrogin	164	6.5	4.3	4.8	4.6
Serpentine-Jarrahdale	33	5.8	4.2	5.1	5.0
Swan	12	5.3	4.8	5.1	5.0
Wagin	355	6.9	4.2	4.8	4.6
West Arthur	434	6.2	4.2	4.9	4.9
Wickepin	271	7.0	4.2	4.9	4.8
Williams	40	5.6	4.4	5.1	4.8
Woodanilling	329	5.8	4.2	4.8	4.8

*Mode pH is the most commonly occurring pH.