Technical information supporting the 2023 Soil acidity environmental trend and condition report card

Department for Environment and Water
August, 2023

DEW Technical note 2023/54

Government of South Australia
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Acknowledgement of Country

We acknowledge and respect the Traditional Custodians whose ancestral lands we live and work upon and we pay our respects to their Elders past and present. We acknowledge and respect their deep spiritual connection and the relationship that Aboriginal and Torres Strait Islanders people have to Country. We also pay our respects to the cultural authority of Aboriginal and Torres Strait Islander people and their nations in South Australia, as well as those across Australia.

Acknowledgements

This document was prepared by Giles Forward (DEW). Tim Herrmann (DEW) provided principal oversight throughout and technical review of this report. Improvements were made to this report and associated report card based on reviews by Tim Herrmann, Amy Ide, and mapping support from Brady Stead.

Contents

List of figures

List of tables

Summary

The 2023 release of South Australia's environmental trend and condition report cards summarises our understanding of the current condition of the South Australian environment, and how it is changing over time.

This document describes the indicators, information sources, analysis methods and results used to develop this report and the associated 2023 Soil acidity report card. The reliability of information sources used in the report card is also described.

The Soil acidity report card sits within the report card Land theme and Agricultural land sub-theme. Report cards are published by the Department for Environment and Water and can be accessed at www.environment.sa.gov.au.

1 Introduction

1.1 Environmental trend and condition reporting in SA

The Minister for Climate, Environment and Water under the *Landscape South Australia Act 2019* is required to 'monitor, evaluate and audit the state and condition of the State's natural resources, coasts and seas; and to report on the state and condition of the State's natural resources, coasts and seas' (9(1(a-b)). Environmental trend and condition report cards are produced as the primary means for the Minister to undertake this reporting. Trend and condition report cards are also a key input into the State of the Environment Report for South Australia, which must be prepared under the *Environment Protection Act 1993*. This Act states that the State of the Environment Report must:

- include an assessment of the condition of the major environmental resources of South Australia (112(3(a))), and
- include a specific assessment of the state of the River Murray, especially taking into account the Objectives for a Healthy River Murray under the *River Murray Act 2003* (112(3(ab))), and
- identify significant trends in environmental quality based on an analysis of indicators of environmental quality (112(3(b))).

1.2 Purpose and benefits of SA's trend and condition report cards

South Australia's environmental trend and condition report cards focus on the state's priority environmental assets and the pressures that impact on these assets. The report cards present information on trend, condition, and information reliability in a succinct visual summary.

The full suite of report cards captures patterns in trend and condition, generally at a state scale, and gives insight to changes in a particular asset over time. They also highlight gaps in our knowledge on priority assets that prevent us from assessing trend and condition and might impede our ability to make evidence-based decisions.

Although both trend and condition are considered important, the report cards give particular emphasis to trend. Trend shows how the environment has responded to past drivers, decisions, and actions, and is what we seek to influence through future decisions and actions.

The benefits of trend and condition report cards include to:

- provide insight into our environment by tracking its change over time
- interpret complex information in a simple and accessible format
- provide a transparent and open evidence base for decision-making
- provide consistent messages on the trend and condition of the environment in South Australia
- highlight critical knowledge gaps in our understanding of South Australia's environment
- support alignment of environmental reporting, ensuring we 'do once, use many times'.

Environmental trend and condition report cards are designed to align with and inform state of the environment reporting at both the South Australian and national level. The format, design and accessibly of the report cards has been reviewed and improved with each release.

1.3 Soil acidity on agricultural land

Soil acidity is a high priority threat to the sustainable management of agricultural soils in South Australia (SA) (DEW unpubl.). Approximately 1.9 million hectares of agricultural land (20%) in SA are estimated to be currently affected by soil acidity (DEW State Land and Soil Information Framework (SLASIF)). The estimated value of lost agricultural production in SA due to acid soils (2017) is approximately $88 million per year (DEW 2017). Many soils in the higher rainfall areas of the state are naturally acidic (see map in Appendix A).

On agricultural land, soil is considered acidic where the pH_{CaCl} (measured in calcium chloride) is less than 5.5.

Soil acidification can be significantly accelerated by agricultural practices including removal of grain, hay and livestock products from the paddock, use of ammonium-containing or ammonium-forming fertilisers, and leaching of nitrate nitrogen derived from legume plants or fertilisers. Increased levels of production lead to higher acidification rates. Sandy textured soils are at highest risk of acidification due to their lower pH buffering capacity.

The consequences of untreated highly acid soils include:

- reduced growth and production of most agricultural plants
- reduced soil biological activity and overall soil health
- increased soil salinity due to increased drainage of rainfall to groundwater
- increased leaching of iron, aluminium and some nutrients leading to contamination of surface and ground water
- structural breakdown of the soil.

Soil pH testing including spatial paddock pH mapping has shown that acidification is occurring at a much faster rate than previously measured (including in the subsurface and subsoil layers), due to higher production cropping systems (Hughes et al. 2017; Harding & Hughes 2021). It also confirms that the affected area is expanding to susceptible soils outside districts previously recognised as acidic, as predicted by the DEW SLASIF.

Soil pH 'stratification' is an increasing issue under no-till cropping and pastures, particularly where acid sensitive crops and pasture species are grown. Stratification refers to the development of a relatively high pH in the top few centimetres of soil due to surface lime application and slow downward movement of lime in the soil profile. There is consequent development of a sharp gradient to lower pH levels in the subsurface (soil horizon layer directly beneath topsoil layer) and subsoil (soil layer below subsurface layer) layers.

Surface soil acidity can be readily treated by application of liming products, but subsurface and subsoil acidity is more difficult and expensive to treat. If acidic topsoils are not adequately treated over time, there is an increased risk of subsurface acidification. Acidity can also be ameliorated by incorporation of calcareous or alkaline clay or by use of alkaline irrigation water. The use of deeper rooted perennial plants and effective management of soil nitrogen can reduce the rate of acidification.

Soil acidification will continue to increase unless the level of remedial action is significantly improved.

Correction of soil acidity is fundamental to maintaining and improving soil health.

This report card specifically covers soil acidity on agricultural lands of SA (Figure 2.1), and not in the grazed rangelands of the state.

2 Methods

2.1 Indicator

The indicator used to assess the trend in soil acidity in the Soil acidity report card is the 'cumulative lime balance'. This is the amount of lime used annually since 1999 compared to the amount of lime needed to neutralise the estimated rate of soil acidification over this time period (Section 2.5.1).

The indicator used for soil acidity condition is an 'area by severity' index using the extent of acidic soils multiplied by the proportion of agricultural land that is projected to become potentially acidic by an approximate timescale of 2050 (Section 2.5.2).

2.2 Data sources

Department for Environment and Water (DEW) Annual lime use surveys in SA

Department for Environment and Water (DEW) Cost of soil acidity calculator spreadsheet 2017 Soil Acidity – AG Excellence Acid-Cost-May2017.xls (live.com)

Department for Environment and Water (DEW) Soil acidification spreadsheet model

Department for Environment and Water (DEW) State Land and Soil Information Framework (SLASIF)

Department of Primary Industries and Regions (PIRSA) Crop Harvest Reports https://pir.sa.gov.au/primary_industry/grains/crop_and_pasture_reports

Department of Primary Industries and Regions (PIRSA) (2023) *Primary Industries Scorecard 2021–22*, PIRSA, Adelaide, accessed February 2023.

Land Use Survey 2008, South Australia, Australian Land Use and Management (ALUM) classification version 8, Australian Collaborative Land Use and Management Program (ACLUMP) Land Use (ACLUMP) - Dataset - data.sa.gov.au

MODIS Fractional Cover (Guerschman et al. 2009) monthly data from Index of /remotesensing/v310/australia/monthly/cover (csiro.au)

2.3 Data collection

DEW collects annual lime sales data (tonnage) from lime sellers throughout the agricultural areas in the state. These lime use tonnages are apportioned to the various landscape regions and agricultural districts (Table 2.1, Figure 2.1) using best available local knowledge of PIRSA regionally-based soil and land management staff.

2.4 Data analysis

Trend

The 'cumulative lime balance' (lime deficit or lime surplus) is calculated from the additive annual lime use minus the additive estimated annual lime requirement (acidification rate) for the period 1999 to 2022. Lime use data before 1999 were not collected, and therefore back-projected lime balance before 1999 has not been estimated. A reference year (baseline) of 1998 was used for lime balance calculations.

The annual lime requirement is calculated using a spreadsheet model calculator that uses:

- Published/documented acidification rates for various agricultural land use types and land use intensity (productivity level) in SA (e.g. dryland cropping, pastures, horticulture, forestry).
- Land use types on agricultural land in SA (ALUM Land Use Survey South Australia 2008) spatially intersected with acidic soils.
- Extent of current (baseline year 2010) acidic soils in SA including projection of potentially acidic soils by 2050 (SLASIF).
- Soil texture classes (0–10 cm, 10–20 cm depths) and presence of alkaline subsoil clay on acidic soils (SLASIF).
- Proportion of acidic soils below critical soil pH levels, from targeted soil pH test data sampled by PIRSA/DEW from agricultural properties in SA's landscape regions 2008–2013, then updated by expert opinion.
- Mean fractional photosynthetic vegetation (MODIS Fractional Cover) 2012–2021 for agricultural districts.
- Wheat yields 2012–2021 (PIRSA Crop Harvest Reports) for districts.

Cumulative lime balance data (in tonnes of lime used minus tonnes of lime required) were calculated for agricultural districts and the agricultural zone.

The trend metric was the 5 year annual change in cumulative lime balance (2018–2022). The trend rating thresholds were based on expert opinion, drawing on thresholds set in the 2020 SA trend and condition report card for soil acidity.

A 5 year data period for the trend was chosen for the current report card instead of the 10 year period used in the previous 2020 report card. Over the last 5 years to 2022 (i.e. July 2017 to June 2022), lime use in SA's agricultural areas overall has been increasing substantially compared to previous years. The lime balance data also clearly show this upward trend. In the previous 2020 soil acidity report card which used lime use data up to 2019, a 10 year period was chosen for trend, because at that time, it was not known whether initial increases seen in lime use in one region in the previous 1–2 years would be sustained or not, and using a 5 year trend period might have given a misleading interpretation of the data. It appears that the 5 year upward trend in lime use is likely to continue to a longer term trend. If a 10 year period were to be used for trend in the 2023 report card, this improving trend would not be captured. Comparative trend data using a 10 year period are included in Section 4.1.

Condition

The condition indicator used for soil acidity was an '*area multiplied by severity*' index. This was calculated from the current (2022) estimated extent of acidic soils (from the acidity spreadsheet model) multiplied by the proportion of agricultural land that will be potentially acidic in the future (2050) (SLASIF database).

The condition rating for the state (agricultural zone) was calculated by area weighted condition indices of agricultural districts. The condition rating thresholds were based on expert opinion.

This method of estimating soil acidity condition was considered more robust than the method used in the previous 2020 report card, which used a soil pH test data set sampled over 2008–2013 to estimate current acidic area. These data are considered too out of date for the 2023 report card, and more up-to-date soil pH data sampled systematically over acid prone soils in the agricultural zone are not available. The 'extent by severity' index also factors in the 'extent' of current acidity within districts, not just the 'proportion' of acid prone land that is currently acidic, thereby providing a more realistic estimate of condition.

Agricultural districts

The data for this report card have been analysed for the state (agricultural zone) and geographical areas of agricultural districts (or sub-regions, based on PIRSA crop reporting districts with minor modifications) (Table 2.1, Figure 2.1). The districts fit mostly, but not entirely, within landscape regions in the agricultural zone of SA.

Data analysis at the district scale has been done to report in more detail the local extent and severity of soil acidity and lime use, which is otherwise not revealed when the data are presented at the landscape region scale.

Table 2.1. South Australian agricultural districts

Agricultural district	Abbreviation
Western Eyre Peninsula	WEP
Eastern Eyre Peninsula	EEP
Lower Eyre Peninsula	LEP
Upper North	UN
Mid North	MN
Lower North	LN
Yorke Peninsula	YP
Central Hills and Fleurieu	CHF
Kangaroo Island	KI
Northern Mallee	NM
Southern Mallee	SM
Lower Murray	LM
Upper South East	USE
Lower South East	LSE

Figure 2.1. Location of agricultural districts in SA's agricultural zone

2.5 Methods to assign trend, condition and reliablity

2.5.1 Trend

Trends were classified as stable, getting better or getting worse if the 5 year cumulative lime balance (annualised) was equal to or within +/- 3 (thousands of tonnes), lime use surplus > 3, or lime use deficit < negative 3, respectively (Table 2.2).

Table 2.2. Definition of trend classes used

Trend	Description
Getting better	Over a scale relevant to tracking change in the indicator it is improving in status with good confidence
Stable	Over a scale relevant to tracking change in the indicator it is neither improving nor declining in status
Getting worse	Over a scale relevant to tracking change in the indicator it is declining in status with good confidence
Unknown	Data are not available, or are not available at relevant temporal scales, to determine any trend in the status of this resource
Not applicable	This indicator of the natural resource does not lend itself to being classified into one of the above trend classes

2.5.2 Condition

The 'area multiplied by severity' condition ratings used for soil acidity based on the index are shown in Table 2.3.

Table 2.3. Definition of condition classes used

Condition	Description	Threshold
Very good	The natural resource is in a state that meets all environmental, economic and social expectations, based on this indicator. Thus, desirable function can be expected for all processes/services expected of this resource, now and into the future, even during times of stress (e.g. prolonged drought)	<2
Good	The natural resource is in a state that meets most environmental, economic and social expectations, based on this indicator. Thus, desirable function can be expected for only some processes/services expected of this resource, now and into the future, even during times of stress (e.g. prolonged drought)	$\geq$2–25
Fair	The natural resource is in a state that does not meet some environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from many processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought)	$\geq$25–100
Poor	The natural resource is in a state that does not meet most environmental, economic and social expectations, based on this indicator. Thus, desirable function cannot be expected from most processes/services expected of this resource, now and into the future, particularly during times of stress (e.g. prolonged drought)	≥ 100
Unknown	Data are not available to determine the state of this natural resource, based on this indicator	-
Not applicable	This indicator of the natural resource does not lend itself to being classified into one of the above condition classes	-

2.5.3 Limitation

The updated soil acidification spreadsheet calculator used for this report card is considered to provide better estimations of trend and condition than that used for the previous 2020 report card. However, it still has limitations. It is recommended that a spatial model be developed in future that can utilise detailed information inputs to better estimate soil acidification, and at a much finer geographic scale.

2.5.4 Reliability

Information is scored for reliability based on the minimum of subjective scores (1 [worst] to 5 [best]) given for information currency, applicability, level of spatial representation and accuracy. Definitions guiding the application of these scores are provided in Table 2.44 for currency, Table 2.55 for applicability, Table 2.66 for spatial representation and Table 2.77 for accuracy.

Table 2.4. Guides for applying information currency

Currency score	Criteria
1	Most recent information >10 years old
2	Most recent information up to 10 years old
3	Most recent information up to 7 years old
4	Most recent information up to 5 years old
5	Most recent information up to 3 years old

Table 2.5. Guides for applying information applicability

Applicability score	Criteria
1	Data are based on expert opinion of the measure
2	All data based on indirect indicators of the measure
3	Most data based on indirect indicators of the measure
4	Most data based on direct indicators of the measure
5	All data based on direct indicators of the measure

Table 2.6. Guides for applying spatial representation of information (sampling design)

Spatial score	Criteria
1	From an area that represents less than 5% the spatial distribution of the asset within the region/state or spatial representation unknown
2	From an area that represents less than 25% the spatial distribution of the asset within the region/state
3	From an area that represents less than half the spatial distribution of the asset within the region/state
4	From across the whole region/state (or whole distribution of asset within the region/state) using a sampling design that is not stratified
5	From across the whole region/state (or whole distribution of asset within the region/state) using a stratified sampling design

Table 2.7. Guides for applying accuracy information

Accuracy score	Criteria
1	Better than could be expected by chance
2	> 60% better than could be expected by chance
3	> 70 % better than could be expected by chance
4	> 80 % better than could be expected by chance
5	> 90 % better than could be expected by chance

2.6 Data transparency

Data transparency for this report card is represented in Appendix B.

3 Results

3.1 Trend

The state trend in soil acidity (last 5 years 2018–2022) is getting better according to the trend definitions and thresholds set out in Section 2.5.1 (Table 3.1, Figure 3.2). This positive trend in cumulative lime balance started in 2018, after a largely negative trend over the period 1998–2017 (Figure 3.2). Annual lime use from 1999–2015 was relatively stable, and generally below the estimated lime requirement (Figure 3.3). Lime use began to increase in 2016, and has exceeded the lime requirement since 2018. The gradual increase in the annual lime requirement over this period reflects the observed and modelled increase in the area of land affected by soil acidity.

In comparison, using a 10 year trend period gives generally poorer trend ratings (Table 3.1) as it partially spans years prior to 2018 when the cumulative lime balance was in deficit.

The 5 year trend is improving in 4 of the 14 agricultural sub-regions, and stable in the other 10 sub-regions (Table 3.1, Figure 3.1). Plots of the cumulative lime balance for the sub-regions show considerable variability over the 1998–2022 period (Figure 3.4). The more marked year-by-year changes in cumulative lime balance reflect changes in lime use, particularly the lime use increases since 2016 which have occurred at different times for some districts (e.g. LEP since 2016, USE since 2018).

Table 3.1. Trend values (annual change in cumulative lime balance) and ratings for the past 5 year period (2018–2022), and comparative trend scores for the last 10 year period (2013–2022), for the state agricultural zone and agricultural districts

Agricultural district	5 year trend score 2018–2022 ('000 t)	5 year trend rating	10 year trend score 2013–2022 ('000 t)	10 year trend rating
State (agricultural zone)	41.4	Getting better	-1.2	Stable
Western Eyre Peninsula	-0.9	Stable	-0.2	Stable
Eastern Eyre Peninsula	-1.9	Stable	-2.5	Stable
Lower Eyre Peninsula	19.8	Getting better	8.2	Getting better
Upper North	-0.5	Stable	-3.3	Getting worse
Mid North	1.6	Stable	-5.2	Getting worse
Lower North	-2.6	Stable	-5.8	Getting worse
Yorke Peninsula	-0.7	Stable	-2.3	Stable
Central Hills and Fleurieu	3.0	Stable	1.6	Stable
Kangaroo Island	8.9	Getting better	6.3	Getting better
Northern Mallee	0.0	Stable	-0.1	Stable
Southern Mallee	-2.6	Stable	-3.2	Getting worse
Lower Murray	0.9	Stable	1.0	Stable
Upper South East	12.7	Getting better	5.3	Getting better
Lower South East	3.8	Getting better	-1.1	Stable

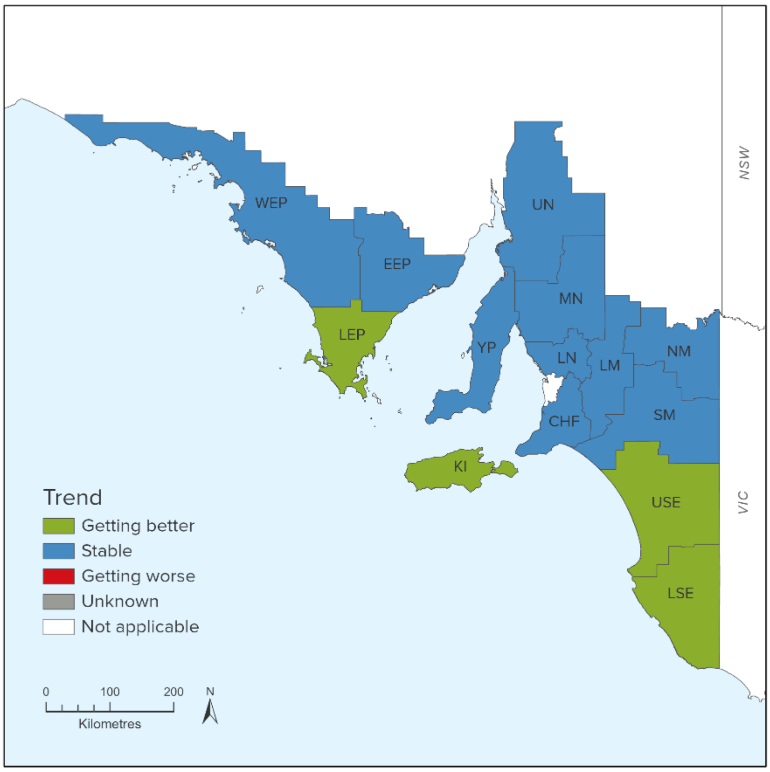


Figure 3.1. Map of soil acidity trend ratings for agricultural districts. See Table 2.1 for agricultural district names and abbreviations.

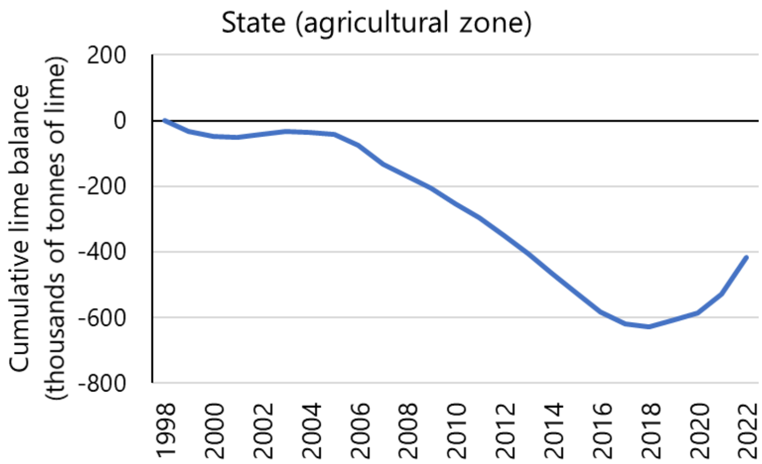


Figure 3.2. Cumulative lime balance in SA's agricultural zone (thousands of tonnes of lime), 1998–2022

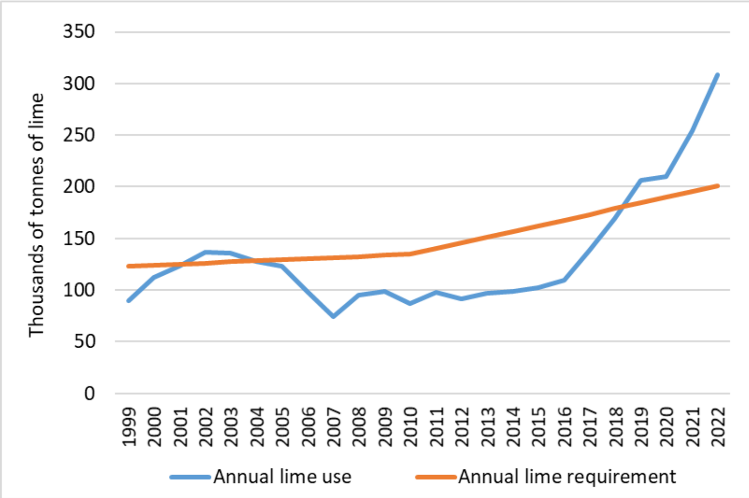


Figure 3.3. Annual lime use and estimated annual lime requirement in SA's agricultural zone, 1999–2022

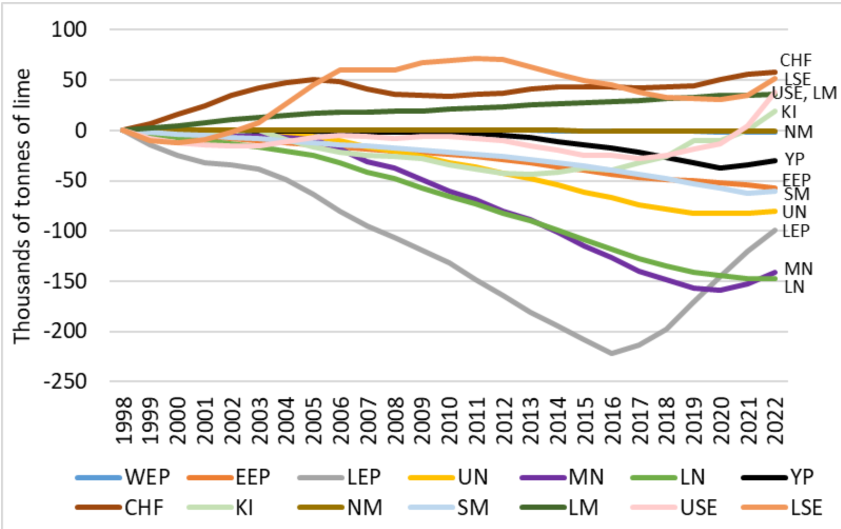


Figure 3.4. Cumulative lime balance in SA's agricultural districts, 1998–2022. See Table 2.1 for agricultural district names and abbreviations.

3.2 Condition

The soil acidity condition rating for the state in 2022 was 'fair', according to the condition definitions and thresholds set out in Section 2.5.2 (Table 3.2).

In the Central Hills and Fleurieu, Kangaroo Island, Upper and Lower South East districts the condition rating was 'poor' (Figure 3.5; Table 3.2). This is a product of the relatively extensive area of inherently acidic soils in these districts. In contrast, the condition rating was 'very good' in the Western Eyre Peninsula and Northern Mallee districts, which have very little currently acidic soils.

In Kangaroo Island, the Upper and Lower South East which have a 'poor' condition rating, the trend is 'getting better' due to recent increases in annual lime use. The Central Hills and Fleurieu district has a 'poor' condition but the trend is 'stable' because the rate of lime use has not increased much in the last 5 years. Large increases in lime use in the Lower Eyre Peninsula district, which has a condition score just below 100 (i.e. 'fair' condition), align with a 'getting better' trend.

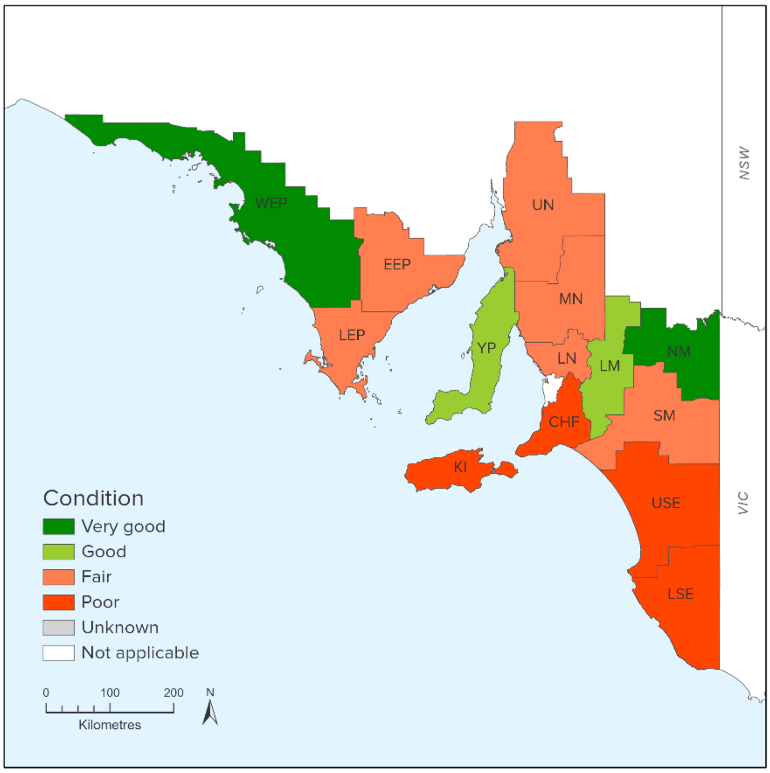


Figure 3.5. Map of soil acidity condition ratings for SA's agricultural districts. See Table 2.1 for agricultural district names and abbreviations.

Table 3.2. Condition score and rating, with trend rating for agricultural districts and the state (agricultural zone)

Agricultural district	Condition index score (acidic soils extent by severity)	Condition rating	Trend rating
State (agricultural zone)	87	Fair	Getting better
Western Eyre Peninsula	1	Very good	Stable
Eastern Eyre Peninsula	30	Fair	Stable
Lower Eyre Peninsula	98	Fair	Getting better
Upper North	57	Fair	Stable
Mid North	99.8	Fair	Stable
Lower North	69	Fair	Stable
Yorke Peninsula	9	Good	Stable
Central Hills and Fleurieu	175	Poor	Stable
Kangaroo Island	138	Poor	Getting better
Northern Mallee	0	Very good	Stable
Southern Mallee	42	Fair	Stable
Lower Murray	5	Good	Stable
Upper South East	278	Poor	Getting better
Lower South East	225	Poor	Getting better

3.3 Reliability

The overall reliability score for this report card is 3 out of 5 based on definitions in Section 2.5.4 and Table 3.3. This is considered to be 'Good' reliability.

Table 3.3. Information reliability scores for soil acidity

Indicator	Applicability	Currency	Spatial	Accuracy	Reliability
Soil acidity	3	5	4	3	3

3.3.1 Notes on reliability

The 'applicability' score of 3 was determined based on the lowest of individual applicability scores for the various data elements used in the report card. Annual lime use data is 'all direct' (score 5), ALUM agricultural land use data is 'most direct' (score 4), while the trend and condition indicator metrics are generally 'most indirect' (score 3).

The annual lime use data and extent of soil acidity (SLASIF) have a currency score of 5 (up to 3 years old). The ALUM land use 2008 dataset is more than 10 years old, score 1, however the land use data is unlikely to have changed significantly since this survey so this score is not used for determination of the overall reliability score.

The spatial representation of the key data inputs for this report card was given a score of 4 '100% not stratified' as the data cover the full extent of agricultural soils.

The accuracy score of 3 'moderate accuracy' reflects accuracy scores considered to be 3 to 4 for the various data inputs for this report card.

4 Discussion

4.1 Trend

Using a 5 year trend period (2018–2022), the data indicate an improving ('getting better') trend in the state agricultural zone and 4 agricultural districts, which result from substantial increases in annual lime use that have occurred within this period. Annual lime use for the state was around 90,000 to 100,000 tonnes over the period 2006 to 2015, then has steadily increased to 308,000 tonnes in 2022 (Figure 3.2). Prior to 2018 lime use was below the estimated lime requirement, but has exceeded it since then (Figure 3.3).

The increase in lime use is considered to be due to a number of factors:

- Targeted extension programs involving government (including DEW programs) and agricultural industry in the past 5 or so years have been underway to raise land manager awareness and increase liming of acidic soils, particularly in areas where acidity is expanding.
- The agricultural industry has been proactive in promoting the use of lime on acidic soils over the last few years.
- Improved tools and technologies for soil testing (such as spatial paddock pH mapping) and liming have been developed, and are being adopted. In recent years, increased profitability of crops such as lentils and faba beans which are less tolerant of low soil pH has highlighted acidifying soils, prompting increased lime use.

It is anticipated that the recent trend in increased lime use on acid soils is likely to continue in future years (although possibly at a slower rate of increase), and is not just a short-term rise.

Over the period since collection of annual lime use data began, there have been some temporary shortages of lime availability from various lime sources. This has reduced the amount of lime used in some districts, in some years. Future increases in lime use will rely on continued availability and quality of lime, and reasonable cost of lime.

Low financial returns following dry seasons, and the impact of bushfires such as in 2020 have also tended to temporarily reduce expenditure on lime.

4.2 Condition

The overall soil acidity condition rating for the SA agricultural zone in 2022 was assessed as 'fair' and varied across the agricultural districts. This current condition assessment of soil acidity takes into account that some soils were already acidic before agricultural development, and that acidity has increased considerably since then. The historic cumulative lime deficit from commencement of agricultural land use up to 1998 is likely to be significant, particularly for the more productive agricultural land use systems. This lime deficit has not yet been properly quantified.

Using the 'extent by severity' condition rating, districts that have a large proportion of land that is inherently acidic (e.g. KI, CHF, USE, LSE) will generally have poorer ratings into the future, but this could be moderated where lime use rates continue to exceed the annual lime requirement. High lime use rates would also help reduce the extent of soils already acidic (i.e. with pH_{CaCl} levels below 5.5).

In districts that have a lower proportion of inherently acidic land (e.g. NM, WEP) and therefore better condition ratings, acidification is still an issue on those soils that could become potentially acidic, and need to be managed accordingly to avert production losses due to low pH.

The ongoing and future risks to mitigation of soil acidity on agricultural land in SA include:

- Ongoing availability of good quality, affordable lime in all districts.
- Lime needs to be applied at locations where surface soils are acidifying to below critical pH levels for full productivity and where subsurface soils are acidifying, and at appropriate rates to overcome acidity.
- Lime use rates need to increase in the future to counteract increasing levels of agricultural production (particularly cropping) and higher nitrogen fertiliser use rates, which are increasing acidification rates.

5 Appendices

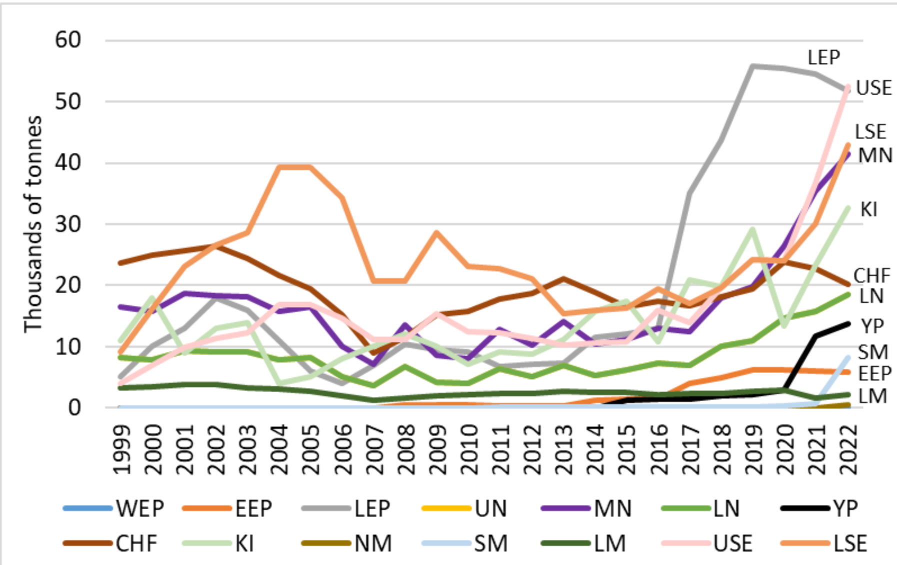
A. Lime use and soil acidity data

State annual lime use, lime requirement and cumulative lime balance

Thousands of tonnes	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Annual lime use	90	112	123	137	136	128	123	99	74	96	99	87	98	91	97	98	102	110	138	169	207	210	254	309
Annual lime requirement	123	124	125	126	127	128	129	130	132	133	134	135	140	146	151	156	162	167	173	178	184	189	194	200
Cumulative lime balance	-34	-47	-51	-41	-34	-35	-42	-74	-132	-170	-205	-253	-296	-351	-406	-465	-525	-583	-618	-628	-606	-587	-527	-418

Annual lime use in agricultural districts, 1999–2022

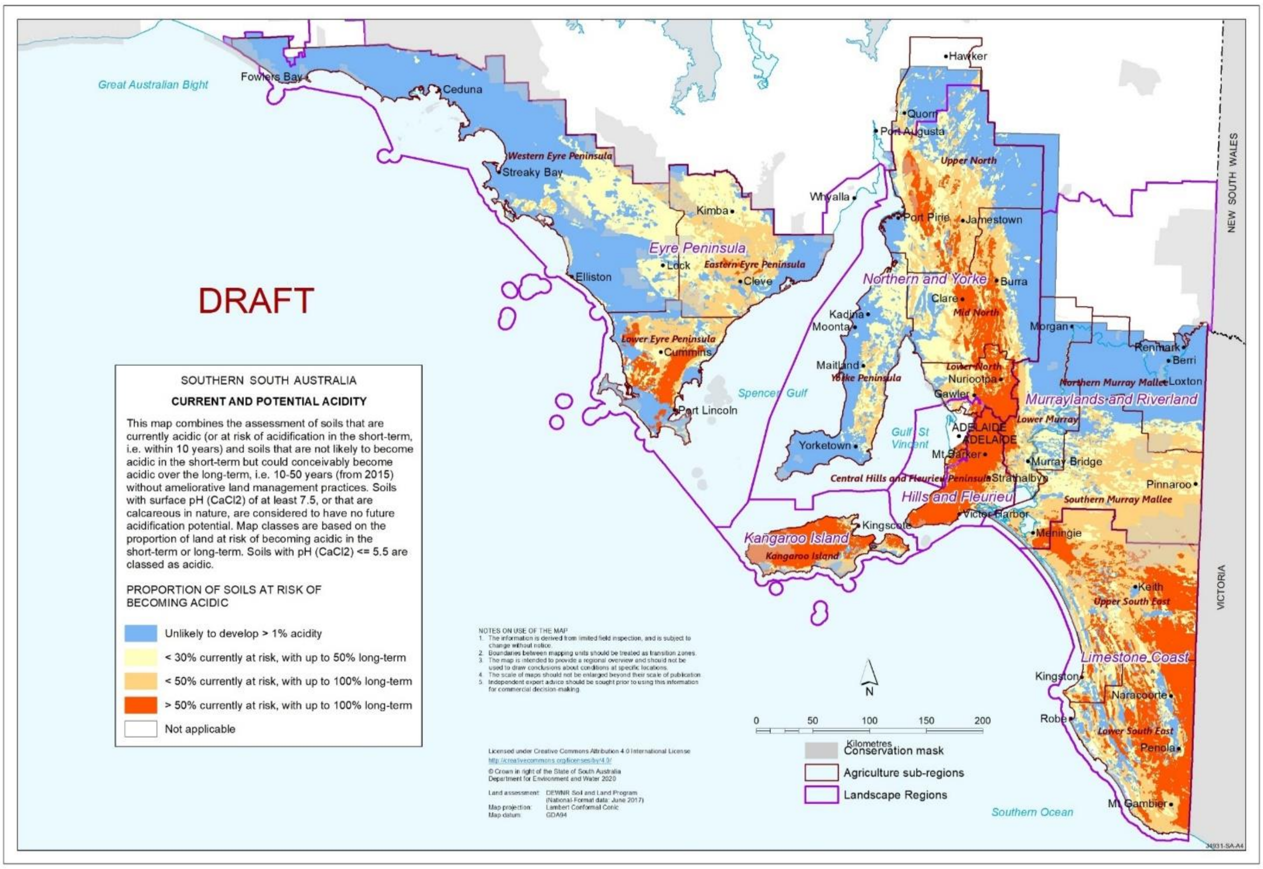
See Table 2.1 for agricultural district names and abbreviations.



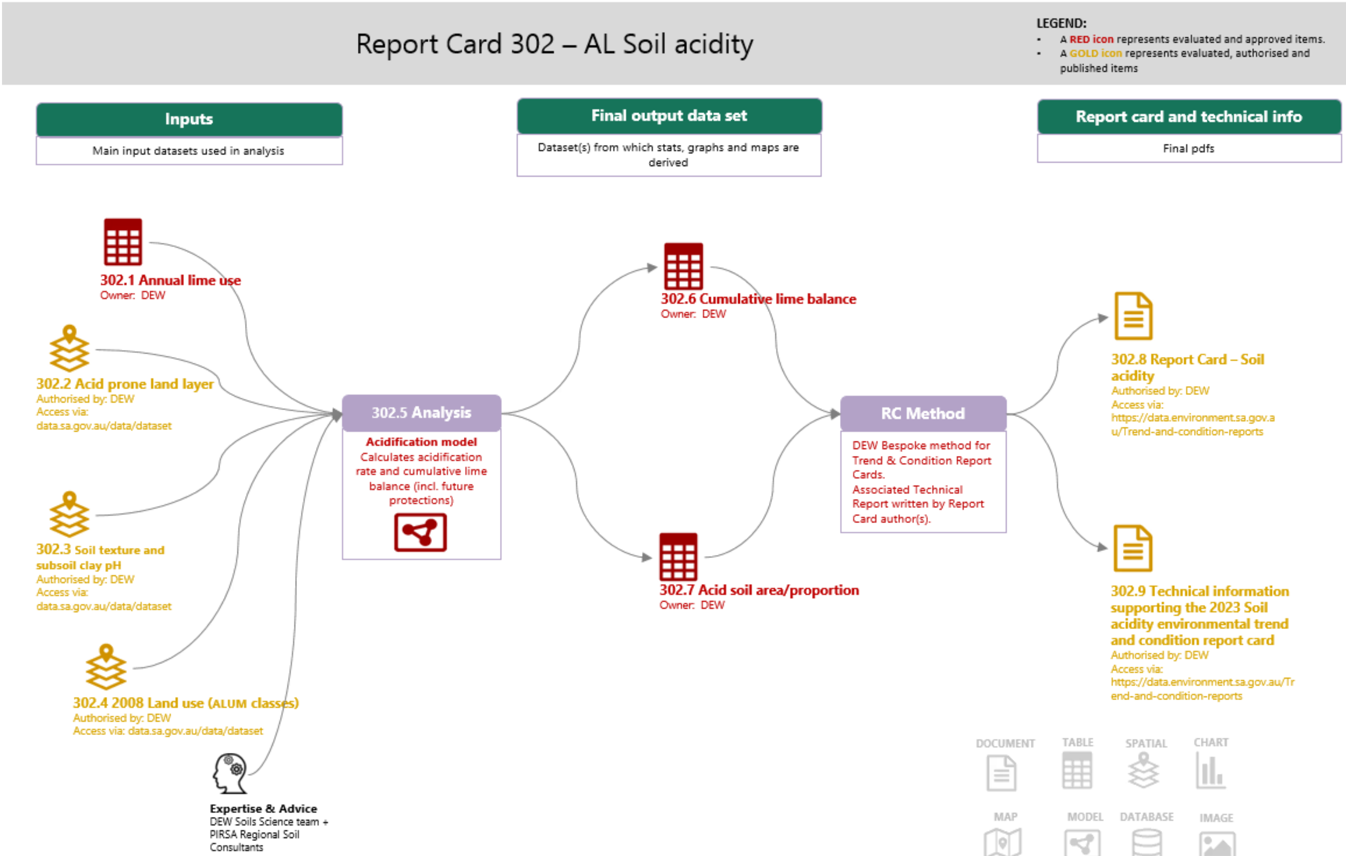
Proportion of potentially acidic land, currently acidic soil area and condition score in agricultural districts and the state

Agricultural district	Potentially acidic area as percentage of total cleared area	Estimated area acidic 2022 (ha)	Condition score
State (weighted score)	44	1,888,963	87
Western Eyre Peninsula	8	3,393	0.3
Eastern Eyre Peninsula	40	74,981	30
Lower Eyre Peninsula	63	155,854	98
Upper North	40	140,726	57
Mid North	49	203,130	100
Lower North	67	102,402	69
Yorke Peninsula	16	56,427	9
Central Hills and Fleurieu	88	199,774	175
Kangaroo Island	92	149,361	138
Northern Mallee	4	3,020	0.1
Southern Mallee	57	74,252	42
Lower Murray	32	16,497	5
Upper South East	75	368,720	278
Lower South East	66	340,425	225

Draft map of general extent of current and potentially acidic soils, agricultural districts and landscape regions in South Australia (data from SLASIF)



B. Managing environmental knowledge chart for Soil acidity



6 References

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