Australia
State of the Environment 2011

Status and trends in soil acidification workshop – summary notes

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Cover image

Lower Murray Darling NRM region
Photo by John Baker

Preface

This report was developed for the Department of Sustainability, Environment, Water, Population and Communities to help inform the Australia State of the Environment (SoE) 2011 report.

The Minister for Environment is required, under the *Environment Protection and Biodiversity Conservation Act 1999*, to table a report in Parliament every five years on the State of the Environment.

The Australia State of the Environment (SoE) 2011 report is a substantive, hardcopy report compiled by an independent committee appointed by the Minister for Environment. The report is an assessment of the current condition of the Australian environment, the pressures on it and the drivers of those pressures. It details management initiatives in place to address environmental concerns and the effectiveness of those initiatives.

The main purpose of SoE 2011 is to provide relevant and useful information on environmental issues to the public and decision-makers, in order to raise awareness and support more informed environmental management decisions that lead to more sustainable use and effective conservation of environmental assets.

The 2011 SoE report, commissioned technical reports and other supplementary products are available online at www.environment.gov.au/soe.

Introduction

A group of experts in soil acidification and land resource assessment met in Brisbane on the 11th and 12th of April 2011 to provide input to the National State of the Environment Report. The meeting was convened to provide an assessment of the state and trends of soil acidification across Australia. The meeting was facilitated by Neil McKenzie and Mike Grundy from CSIRO and Rosemary Hook, an independent consultant.

The workshop attendees were briefed on the methods being used for the State of the Environment Report. Initial tasks included preparation of the grading statements and confirmation that the physiographic regions used in the Land Chapter were suitable for assessing acidification. The following grading statements were used:

- Very poor: Beyond recovery (economic). Yields no longer economic. Current system of land use untenable with limited options
- Poor: Urgent amelioration required. Yields and returns are compromised, returns currently threatened.
- Good: Needs management and monitoring otherwise returns will be threatened.
- Very Good: Current management adequate – low level monitoring required.

The physiographic regions are based on landform and they form part of the Australian Soil Resource Information System (ASRIS).[1] The ASRIS mapping hierarchy divides Australia into three physiographic divisions, which are further subdivided into 23 provinces and 220 regions. These broad-scale mapping units have similar geological origins and a characteristic suite of soils and landforms. Even then, a diversity of soils and land management systems often occurs within each region. It is therefore only possible to reach general conclusions about the state of the soil for each region—there are always local exceptions.

This report has been compiled from the notes and completed proformas supplied by the experts in the weeks following the workshop. Only minor editorial changes have been made to ensure an accurate record of the original assessments. Some of the rating conventions in the published Land Chapter differ from those presented here because modifications to the system for representing uncertainty changed after the workshop. Note also that the assessments were mostly done by state or territory. Some physiographic regions cross state and territory borders and the assessments for the portion in each jurisdiction often differed. The final rating for such regions was based on the balance of evidence available. The ratings in this report have been retained in their primary form

This report provides assessments for every one of the 220 physiographic regions. The assessment table in the Land Chapter only provides ratings for regions where significant changes in pH are occurring. The notes in the published assessment table are a summary of the longer notes presented below.

[1] www.asris.csiro.au

New South Wales

Greg Chapman, with input from David Morand, Soil Science Unit, Scientific Services Division, NSW Office of Environment and Heritage, Department of Premier and Cabinet.

Comments:

Assessments of soil pH grades and trends within the physiographic regions of NSW are based on data used in the Soils and Land Management section of the NSW State of Environment Report (2009). http://www.environment.nsw.gov.au/soe/soe2009/chapter5/. These data were derived from measurements taken within specific soil monitoring units (SMUs) which were identified during the NSW Soil Monitoring Project (Chapman e*t al.*, 2011) on the basis of soil – landform combinations. Sites selected for measurement had land uses that were typical for the unit, as well as some measurements being taken in relatively undisturbed native vegetation sites so as to provide a comparison. SMUs were selected as being important units with Catchment Management Authority areas and were not considered in relation to the Physiographic Regions of Australia that are being used in the Australian State of Environment Report. Full details of the soil monitoring program in NSW can be found within Chapman *et al.* 2011 and Bowman *et al.* 2009.

The tables below indicate the SMUs that occur within a Physiographic Region where applicable as not all regions include one or more SMU. Ratings for each Physiographic Region are based on data derived from the SMUs within it, where these occur. It needs to be noted that land uses and soils assessed using the SMU data need not necessarily be those which are typical for a region.

Bowman G, Chapman GA, Murphy BW, Wilson BR, Jenkins BR, Koen T, Gray JM, Morand DT, Atkinson G, Murphy CL, Murrell A, Milford HB (2009). *Protocols for soil condition and land capability monitoring. New South Wales natural resource monitoring, evaluation and reporting program.* NSW Department of Environment and Climate Change. http://www.environment.nsw.gov.au/soils/soilsprotocols.pdf

Possible major future pressures to land values

No major future changes/pressures specifically identified

References associated with soil pH in NSW

Chapman GA, Gray JM, Murphy BW, Atkinson G, Leys J, Muller R, Peasley B, Wilson BR, Bowman G, McInnes-Clarke SK, Tulau MJ, Morand DTand Yang X. (in press 2011). Monitoring, Evaluation and Reporting of Soil Condition in NSW, 2008 Program. Office of Environment and Heritage, Department of Premier and Cabinet. NSW Government. Sydney.

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Grey Range	Stony downs with gibber and predominantly Vertosol soils. Rangelands and conservation reserves. No soil pH data but a "very good" assessment grade is expected.				⊟	○	○
Bulloo Plain	Floodplain with Vertosols and Kandosols. Rangelands with extensive grazing. No soil pH data available but a "very good" assessment grade is expected.				⊟	○	○
Paroo Plain	Sandplain with Red Kandosols and Arenic Rudosols. Rangelands with extensive grazing. 50% of the region covered by the Waanaring Sand Plain NSW SMU.			⊟		◒	○
Warwick Lowland	Stony plains with mesas. Rangelands with extensive grazing. No soil pH data but alkaline soils expected to have steady pH.				⊟	○	○
Warrego Plains	Floodplains, sandplains and claypans with Brown Vertosols and Brown Dermosols. Rangelands and opportunity cropping. Breewarrina Clay Grasslands SMU. Steady pH trend expected.				⊟	◒	○
Nulty Springs Lowlands	Rolling downs and lowlands with predominantly Kandosols. Dry rangelands with alkaline soils. No soil pH data are available.				⊟	○	○
Upper Darling Plain	Predominantly floodplains with Brown and Grey Vertosols. Rangelands in the west and cropping (including cotton) and grazing in the east. Includes the Breewarina Clay Plain SMU with no pH decline detected; steady trend.				⊟	◒	○
Charleville Tableland and Lightening Ridge Lowlands	Low sandy tablelands, stony plains and mesas. Dry ranglelands with alkaline soils, mostly Kandosols. No soil pH data but pH expected to be stable.				⊟	○	○
Cunningham Slopes	Covers a wide range of parent materials (metasediments, sandstones and granites) and soils. Predominantly cropping and grazing. Partly monitored in the Duri Hills, Bingara Rises and Warialda Sands SMUs. Mostly sandy very poorly buffered topsoils. Land management practices at monitoring sites are appropriate for lands with low capability to maintain pH.				⊟	●	◒

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Tenterfield Plateau	Predominantly undulating granite plateau with some basalt cappings; mostly grazing, both modified and natural pastures, and conservation. Includes the Tenterfield Granites, part of the Bundara Granites, the Northern Tablelands Basalts and the eastern portion of the Inverell Basalts SMUs and, to the east, the Walcha Metasediments, Dorrigo-Comboyne Plateau and Granite Borderlands SMUs are included. Noticeable declines in pH are common throughout and likely to continue under present land management practices.			↘		●	◒
Clarence Fall	Dissected plateau margin on granites and metamorphic rocks and with a variety of soils that are moderately to poorly buffered. Mostly forestry, nature conservation or grazing natural pasture. Few monitoring data. Declines in pH may be expected for areas with long grazing histories but otherwise stable.			—		○	○
Clarence Lowlands	Coastal lowlands with a variety of soil types. Land uses including forestry, grazing, cropping and some nature conservation. Coincides with the Clarence Sodic Soil SMU and large portions of the North Coast Acid Sulfate Soils SMU. The Clarence Sodic Soils have a "very good" assessment grade for soil pH but there has been significant decline in pH on the floodplains (used to rate the region) due to intense land use. Further deterioration is expected under current land management.		↘			●	●
Toowoomba Plateau	Basaltic plateau with predominantly Ferrosols and Dermosols used mostly for grazing, perennial and seasonal horticulture and nature conservation. Includes the Alstonville Plateau and Casino Alluvials SMUs. There has been a widespread noticeable to locally significant decline in surface soil pH. Current land management falls just short of maintaining stable soil pH on the Alstonville Plateau while soil pH is not managed on the Casino Alluvials, so further deterioration can be expected.			↘		●	◒
Nandewar Peaks	Dissected volcanics with mostly Chromosols and Dermosols. Contains small portions of the Inverell Basalts and Liverpool Plains Red Earth SMUs. Mostly forest or national park				—	○	○

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
	with grazing. Few soil pH data are available.						
Cobar Plains	Sandy plains with predominantly extensively grazed Kandosols in the west; some nature conservation reserves. Sodosols and Chromosols in the east with cropping and grazing of modified and natural pastures. Almost entirely covered by the Girilambone Rises, the Cobar Peneplain Rises and the Cobar Peneplain Flats SMUs. Data from these SMUs show significant declines in soil pH and while data are patchy, land management practices generally do not take into account acidification hazards.		↘			◒	○
Lower Darling Plain	Floodplains on which well buffered grey Vertosols predominate and with extensive grazing. Includes Lower Darling River Alluvials and Mid Darling River Coolibah SMUs. Little evidence of decline in pH. Trend data are lacking.				?	◒	○
Strezelecki Desert Plains	A variety of land systems. Soil Monitoring Unit is the Simpson Strezlecki Swales which is mostly national park with some grazing. Slight drop in soil pH; trend is expected to be steady.				—	◒	◒
Eyre Frome Plains	Sandy alkaline soils in dry rangelands with a history of over-grazing. Decline in soil pH is not expected				—	○	○
Barrier Ranges	Variable landscapes and soils including Red Vertosols on gibber and dune and swale systems. Rangeland with extensive grazing. Includes the Southern Barrier Ranges SMU and small areas of the Broken Hill Fans SMU. Limited data suggest that soil pH has not declined and acidification is not considered to be an issue.				—	○	○
Warrumbungle Peaks	Mostly national park with sandy, naturally acidic volcanic rocky soils used for grazing. No soil pH data are available but a suspected pH decline due to land use and soils.			—		○	○
Mitchell Slopes	Western hills and slopes of the northern and central tablelands with a mix of parent materials, soil types and land uses including grazing both modified and natural pasture, cropping, production forestry and nature conservation. The large variability makes overall assessment difficult. Includes half the Binnaway Sandstones,		↘			●	●

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
	Yeoval Chromosols, Molong Rise and Cowra Chromosols SMUs. Soil pH has declined markedly, especially on soils with a long history of mixed farming. Downwards trend is expected to continue as land is not being managed sufficiently to address acidification.						
Gunnedah Lowlands	Predominantly self-mulching Vertosols used for cropping and Red Chromosols and Kandosols used for cropping and grazing. Includes Liverpool Plain Red Earths, Liverpool Black Plains and Liverpool Black Foot-slopes SMUs. There has been a slight but noticeable decline in surface pH for all but the Liverpool Black Plains SMU.						
Macleay Barrington Fall	Predominantly dissected plateau flank used for nature conservation and production forestry, some grazing. Includes parts of the Kempsey Hills, Wauchope Low Hills, North Coast Acid Sulphate Soils, Chichester Hills and Landsdowne Terrace SMUs. No soil pH data are available but acidification is not expected, except possibly under intensively managed plantations.						
Liverpool Barrington Plateau	Dissected plateaus with high rainfall, very steep slopes and a variety of soil types. Land uses predominantly conservation, forestry and grazing. Includes the Chichester Hills SMU, though this area has not been sampled. Despite high rainfall and naturally acidic soils no pH decline is expected.						
Merriwa Plateau	Basalt plateau with very well buffered Ferrosols and Vertosols that are mostly used for mixed farming. Coincides with the Merriwa Plateau SMU. Although soils are generally not managed well for acidification, monitoring results indicate little decline in pH. A slow decline may be expected in the future.						
Goulburn Corridor	Hills and broad valley floors commonly with Kandosols and Sodosols. Includes the Muswellbrook Valley Floor and Goulburn River Valley SMUs. Neither SMU shows evidence for acidification from recent monitoring but this may be an anomaly given						

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
	that land management in both SMUs is insufficient to prevent acidification; future declines can be expected.						
Hunter Valley	Low hills and undulating terrain with alluvial valleys and a variety of soils. Includes Hunter Valley Floodplains, Mined Areas and the Singleton Valley Floor SMUs. It appears that the mined areas and Hunter River floodplains are mostly managed sustainably for acidification, while management of the Singleton Valley floodplains is insufficient to maintain soil pH.		↘			◒	◒
Ivanhoe Plain	Predominantly sandplains with Calcarosols but also Sodosols, Chromosols and Vertosols. Land use mostly extensive grazing and nature conservation. Includes the Overnewton Flats, Arumpo Mallee Lands and the Border Mallee Lands SMUs. Monitoring results indicate no or a very slight increase in acidity.				—	◒	◒
West Turkey Plains	Rangeland plains with predominantly Calcarosols and some Chromosols. Encompasses the unsampled East Pooncarie Sands and the Southern Barrier Range Foot-slopes SMUs. No soil pH data are available but pH likely to be stable.				—	○	○
Riverine Plain	Predominantly alluvial sediments with Grey Vertosols and some Chromosols and Arenic Rudosols. Several important irrigation areas, extensive grazing and some dryland cropping particularly in the SE. Encompasses a number of SMUs with the Grey Box Plains, Boree Plains and Edward River Redgum Floodways in the east, and with the Moulamein Plain and the Lowbidgee Delta to the west. While most data suggest that there is little soil acidification, monitoring within the Boree Plains SMU indicates significant declines, especially for irrigated land. This is not surprising given that land management does not take acidification into account.				↘	◒	○
Hume Slopes	Western hills and slopes of the central and southern tablelands with a large variety of landscapes and soils. Parna deposits with deep Red Kandosols and Chromosols also occur. Mostly mixed farming with grazing of modified and natural pastures more common in		↘			●	●

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
	the SE. Numerous soil monitoring units which include the Ariah Park Plains, Wantabadgery Rises, part of the Murrumburrah-Harden Low Hills, and Murrumbidgee Alluvials, Yerong Creek Plains and the Coreinbob Low Hills. Virtually all soils show indications of significant declines in soil pH and as land management practices generally do not consider acidification, further declines can be expected.						
Condobolin Plains	Predominantly alluvial plains with Sodosols and Vertosols used for cropping and grazing. SMUs include the Bland Riverine Plains and the Mid Lachlan Flood Plain, both of which have significant issues with soil acidification associated with irrigation. Trend is towards slight further declines		↘			◒	◒
Bathurst Tablelands	Tablelands of mixed geology and soils but Sodosols, Chromosols, and Kandosols common. Grazing of modified and natural pastures is the predominant land use. Includes the Central West Tablelands and Hill End Trough SMUs. Both SMUs have experienced serious soil acidification and as land management is not addressing the issue, the trend will continue downwards.		↘			●	◒
Hawkesbury Shoalhaven Plateau	Deeply dissected sandstone plateau with Kandosols prevalent. Predominantly managed within National Parks with minor pine production, grazing, horticulture and cropping. Significant urban development with most of Sydney included in this region and the Cumberland Lowland. Includes several small SMUs, namely the Somersby Plateau, Wolgan and Capertee Valley Floors, Coxs River Granites, Wingecarribee Hills, Mid Wollondilly Lands, Sydney Urban Fringe Bushland and the Moss Vale Plateau SMUs, with most monitoring focussing on agricultural land uses which represent perhaps less than 20% of the area. Available results indicate significant to alarming declines in soil pH for areas other than bushland. Land management in the Wolgan and Capertee Valley SMUs generally gives little attention to acidification and it is only slightly better in the other SMUs.		↘			●	◒

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Cumberland Lowland	Mostly urban and industrial land use but includes the Wianamatta Urban Fringe and Nepean River Alluvials SMUs, both of which have noticeable declines in soil pH. The trend is considered to be towards deterioration due to high nutrient inputs and high intensity land uses such as vegetable production.			↘		○	●
Werriwa Tablelands	Encompasses the Bungonia Tablelands and the Cullarin and Muringo-Bevandale Metasediments SMUs. Soil acidification has been substantial and is alarming in some places. In all SMUs land is not being managed for acidification, sometimes to a large degree, so the expected trend is further deterioration.		↘			◒	◒
Tinderry Gourock Ranges	High hills commonly with Tenosols and Sodosols; land uses include production forestry and grazing. Includes the Braidwood Granites and Upper Shoalhaven Valley SMUs. The latter shows noticeable declines in pH whilst the former has declined significantly. Land management in both areas is not sufficient to prevent further acidification.			↘		◒	◒
Monaro Fall	Deeply dissected and steeply sloping plateau margins and alluvial valleys; Dermosols common. Predominantly forested and managed for conservation and timber production but also significant areas of grazing. Includes the Ulladulla Coast and Bega Valley SMUs. Declines in pH have been significant in both cases. Land management is not sufficient to prevent acidification and so further declines are expected.		↘			◒	◒
Monaro Tableland	Undulating upland plains commonly with Dermosols and basalt derived Ferrosols. Used predominantly for grazing modified and natural pastures. Includes the Bombala Metasediments, Jindabyne Hills and Monaro Basalts SMUs. Monitoring for all three SMUs shows significant decreases in soil pH. Land management practices are not sufficient to prevent further acidification, particularly in the Jindabyne Hills and Bombala Metasediments SMUs.			↘		◒	◒

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Australian Alps	Mostly high rainfall mountainous terrain with variable soils; used mostly for conservation. Grazing occurs in the lower hilly country in the north and east. Includes the Murrumbidgee Alps, Khancoban Granites and Tumbarumba Wet Granodiorites. All SMUs show alarming deterioration in pH and land management does not appear to take soil acidification into account. Further decline can be expected in areas outside nature reserves.		↘			◒	◒
East Victorian Uplands	A small part of this region occurs in NSW where grazing and production and plantation forestry are the main land uses. Also includes the Khancoban Granites and Tumbarumba Wet Granodiorites SMUs. Soil acidification comments as per the Australian Alps.		↘			◒	◒
Mallee Dunefields	Calcarosols are the predominant soil type, with the main land uses grazing and cropping; there are some small irrigation areas along the Murray River. Includes Tooleybuck Mallee Sands, Lower Murray River Alluvials and Guthul Sand Plains SMUs. Only the small irrigated areas show any indication of acidification – in these areas acidification can be significant and pH is continuing to decline.				—	○	◒
KEY **Grading Statements**	**Very poor:** Beyond recovery (economic) Yields no longer economic. Current system untenable with limited options						
	Poor: Urgent amelioration. Yields and returns are compromised, returns currently threatened.						
	Good: Needs management & monitoring otherwise returns will be threatened.						
	Very Good: Current management adequate – low level monitoring required.						
Indication of trend	↗ Improving ↘ Deteriorating — Stable ? Unknown						

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Level of Confidence	○ Evidence and consensus too low to make an assessment ◒ Limited or low quality evidence but high consensus ● Adequate high quality evidence and high consensus						

At a glance… soil pH acidity/acidification

- Soil pH is improving where the problem is recognized and addressed by addition of lime, but this would only be on a small proportion of the farms where there is an issue.
- Soil pH is mostly stable in the rangelands and areas of minimal use, such as nature conservation areas, and also where the soils are alkaline and well-buffered.
- Soil pH is in urgent need of amelioration and still decreasing in many of the cropping and grazing (non-pastoral) areas of the State due to insufficient awareness of the problem by land managers.

Victoria

Doug Crawford, Victorian Department of Primary Industries

Comments

No specific comments

Possible major future pressures to land values

None specifically identified

References associated with soil pH in Victoria:

None provided

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Australian Alps	Predominantly mountain terrain dominated by Dermosols, Rudosols, and Tenosols with minor but ecologically significant areas of Organosols. These are generally naturally acidic. The major land use is nature conservation (1.1). Changes in fire management (increased frequency of controlled burns) may result in variation in soil pH about a long term average. Changes in incidence of natural fire (due to climate change) and changes in fire management may result in more soil erosion to expose sub-soil which in turn changes the root zone pH. *Summary* The assessment of this region is based on the assumptions that local native vegetation is adapted to local soils, the soils are in equilibrium with current climate and management, so that only low level monitoring is required. Few data are available for assessment of condition or trend.				⊟	◒	◒
East Victorian Uplands	Predominantly hilly and mountainous terrain with minor valley flood plains. This region contains a wide range of naturally acidic soils but mainly Rudosols, Tenosols, and Dermosols. Kurosols, Chromosols and Sodosols are also present. There are minor but ecologically significant areas of Podosols and Organosols. The eastern part of the region is dominated by native forests for nature conservation (1.1) with previous grazing of the natural vegetation (2.1), and production forestry (2.2). Lower lying hills are used for grazing of natural (2.1) and modified pastures (3.2). Changes in fire management (increased frequency of controlled burns) may result in variation in soil pH about a long term average. Changes in incidence of natural fire (due to climate change) and changes in fire management may result in more soil erosion to expose sub-soil which in term changes the root zone pH. Slow acidification will have occurred under grazed modified pastures. *Summary* As for the Australian Alps region.				⊟	◒	◒

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Gippsland Plains	Plains and fans dominated by Sodosols and Chromosols. There are minor areas of Podosols, Organosols, Rudosols (coastal dunefields typically under nature conservation 1.1), Vertosols (flood plains) and Hydrosols. Land use is predominantly grazing of modified pasture (3.2.0) in beef and sheep enterprises (annual pastures with subclover the legume component) with minor but economically significant areas of more intensive higher input dairy enterprises in the higher rainfall areas supporting perennial pastures (the legume component is white clover). There are small economically significant areas of dairying with perennial pastures on modified land under flood or sprinkler irrigation using river water (4.2.0), and also minor areas of cropping, irrigated horticulture and native forests for nature conservation (1.1) and production forestry (2.2.0). Slow acidification in beef and sheep enterprises will have occurred in the slightly to moderately acidic soils under annual pastures. Dairy enterprises on naturally strongly to moderately acidic soils have high nitrogen inputs (as urea or ammonium sulphate) countered by high importation of stockfeed; soils under these perennial pastures have not acidified further. Acidification is easily ameliorated by local supplies of cheap lime. *Summary* The assessment of this region is based on the plains and fans dominated by Sodosols and Chromosols mostly used for grazing dryland annual pastures. Samples from farms, soil mapping and soil acidification surveys indicate that mostly they are naturally moderately acidic and that some have acidified further.			⊟		◒	◒

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
South Victorian Uplands	The soils of the hills and slopes of the Strzelecki and Otway Ranges, which dominate this region, are predominantly Dermosols and less extensive Ferrosols. This region mainly supports grazing of modified perennial pastures (3.2) by beef and dairy cattle. The Otway Ranges and the eastern Strzelecki Ranges also support production forestry (2.2) and nature conservation. The Dermosols are typically moderately acidic and have not shown further acidification under grazing. They continue to support strong production from the sown perennial pasture species that are suited to their inherent acidity. In addition to grazed modified perennial pastures (3.2) used for dairy and beef production, the Ferrosols also support potato production under supplementary irrigation. Minor areas of sandy soils (commonly Tenosols, Rudosols and Podosols) are found around Wilsons Promontory and coastal areas. These are typically within national parks (1.1) or are used for grazing modified pastures (2.2) for beef or dairy enterprises. Minor areas of former swamps which used to contain Organosols (i.e. the former Koo Wee Rup, Dalmore and Tobin Yallock swamps) are found in the Western Port Bay sunkland. Following draining, the peats have been lost or significantly reduced so that the soils are now classified as Humose Dermosols (but locally called peats) or Vertosols. These relict peaty soils and self-mulching clays are used for asparagus, potato, beef and dairy production. There are local easily obtained lime supplies in this region. *Summary* The assessment of this region is based on the Dermosols of the hills and slopes used for the grazing of dryland perennial pastures which are adapted to moderately acidic soils. Samples from farms, soil mapping and soil acidification surveys indicate that mostly the soils are naturally moderately acidic and that most have not acidified further.			⊟		◒	◒

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Mallee dunefields	The Mallee is dominated by Calcarosols with Rudosols and Tenosols being sub-dominant. There are minor areas of Sodosols and Vertosols. Cropping (3.3), grazing modified pasture (3.2) and nature conservation (1.1) are the main land uses. Minor but economically significant areas of irrigated perennial horticulture (4.4) occur along the dunefields next to the Murray River. The soils are alkaline and calcareous so that acidification is not an issue unless the reserves of carbonates dissolve. There has been little research investigating acidification of these soils; research is focused on managing alkalinity and related sub-soil constraints including sodicity, salinity and boron toxicity. Should root zones acidify, local lime supplies are available. In horticulture, root zone pH can be controlled by varying the form of nitrogen applied using fertigation. Within broad acre farming, more farmers are adopting continuous cropping using advanced techniques (e.g. controlled traffic, reduced tillage and targeted use of nitrogen) and are moving away from ley farming. This will reduce the potential for nitrate leaching (an acidifying process) and the likelihood of exposure of alkaline subsoils by wind erosion. Few data are available for assessment of condition or trends in pH. *Summary* The assessment of this region is based on the Calcarosols, Rudosols and Tenosols used for cropping in rotation with grazing for wool production. Samples from farms and soil mapping indicate that they are mostly slightly to moderately alkaline and calcareous. Most would have not acidified. The soils would be graded as poor if assessed for alkalinity.				⊟	◒	◒

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Wimmera Plain	The Wimmera plain comprises former beach ridges and aeolian and alluvial plains. The soils are mainly Vertosols and Sodosols, with Calcarosols and Tenosols being sub-dominant in the north. There are minor areas of Sodosols and Chromosols soils in the southwest. This region is predominantly cropping (3.3) in rotation with grazing modified pasture (3.2) for wool. Continuous cropping using advanced techniques (e.g. controlled traffic, reduced tillage and targeted use of nitrogen) is replacing ley farming. This change will reduce the potential for nitrate leaching (an acidifying process) and the likelihood of exposure of alkaline subsoils by wind erosion. The Wimmera Plain soils range from naturally slightly acidic to alkaline and calcareous. Acidification is not an issue in most of these soils (except for the Sodosols and Chromosols in the south-west) unless the reserves of carbonates dissolve. Little research has investigated soil acidification; research is focused on managing alkalinity and related sub-soil constraints including sodicity, salinity and boron toxicity. The Little Desert is a minor area dominated by Tenosols and Rudosols, and is mainly used for nature conservation (1.1). These soils are more acidic and less buffered by carbonates and where used for agriculture, will acidify. *Summary* The assessment of this region is based on the Vertosols and Sodosols used for cropping in rotation with grazing for wool production. Samples from farms and soil mapping indicate that they are mostly slightly to moderately alkaline and are calcareous. Most would have not acidified. Soils would be graded as poor if assessed for alkalinity.		.		⊟	◒	◒

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
West Victorian Uplands	The hills, slopes and plains of this region are dominated by inherently moderately to strongly acidic Sodosols on marine sediments. There are significant areas of Dermosols on the southern slopes of the Central Highlands and Chromosols on the Dundas Tablelands. Minor but significant soils include Ferrosols, Rudosols, Podosols and Tenosols. Land use is predominantly grazing modified annual pasture (3.2) with some cropping (3.3). Nature conservation (1.1) areas cover about 25% of the region. Minor but economically significant areas with Ferrosols surround the numerous volcanic cones and occur on the lava plains near Ballarat. These soils are used for potato production in rotation with beef grazing and field crops. The naturally acidic soils will have acidified further under subclover based pastures and cropping. Lime from the readily available supplies in the south is used to ameliorate conditions, with the naturally moderately to strongly acidic soils having required lime to establish pastures. Little pH change will have occurred under land used for nature conservation. *Summary* The assessment of this region is based on the plains and fans dominated by Sodosols and Chromosols mostly used for grazing of dryland annual pastures. Samples from farms, soil mapping and soil acidification surveys indicate that mostly they are naturally moderately to strongly acidic and have acidified further.		↘			◒	◒

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Riverine Plains	The alluvial and colluvial Riverine Plains are dominated by Sodosols. Sub-dominant soils include Calcarosols and Vertosols and minor areas of Chromosols. Land use is predominantly irrigated agriculture in the central and eastern parts (irrigated pastures for dairy production and perennial horticulture which is mainly fruit with some vegetables and grapes). Soils have been modified for flood irrigation, drainage and establishing orchards and vineyards. The western part is dominated by dry land cropping and grazing by sheep. Except for Calcarosols, soils are naturally slightly to moderately acidic and are acidifying further under dry-land agriculture where carbonate is absent from the root zone. Acidification is occurring under annual pastures (i.e. in which the legume component is subclover) and cropping with cereals, legumes and nitrogen applications. Smarter use of applied nitrogen will help mitigate acidification. There are no local supplies of lime. Few data on acidification trends are available for the larger area of irrigated agriculture, though there is a general tendency under higher value irrigated systems for, acidification to be ameliorated by lime addition or masked by the soil modification that has occurred . *Summary* The assessment of this region is based on the Sodosols used for dryland cropping and grazing of annual pastures, although irrigated agriculture is more extensive. Samples from farms, soil mapping and soil acidification surveys indicate that mostly the dry-land soils are naturally slightly to moderately acidic and that they have acidified further.		↘			◒	◒

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
West Victorian Plains	This region consists mostly of lava plains with Sodosols and sub-dominant Chromosols and Vertosols, all characterised by poor drainage. There are minor areas of Hydrosols in the drainage depressions and Ferrosols on the volcanic cones. The less common sedimentary materials are characterised by Dermosols, Sodosols and Chromosols in the north and mainly Chromosols, Dermosols, Kurosols and Podosols in the south. The northern part is mostly used for grazing of modified annual pastures (3.2) for sheep and cattle with some cropping. The wetter southern coastal fringe is mainly used for grazing beef and dairy cattle on modified perennial pastures (3.2). There is a small area of plantation forestry (3.1) mostly blue gum and pine. Cropping and plantation forestry have recently expanded in area from a low base. Soils are generally slightly to moderately acidic. Acidification has been observed in the drier less acidic areas under annual pastures but not the wetter areas under perennial pastures. The poorly drained soils of this region have a lower likelihood of nitrate leaching (an important cause of acidification) which may explain why acidification appears to be less prevalent in this region. Changes in farming systems in the drier areas, i.e. cropping on raised beds to improve drainage (increased likelihood of nitrate leaching), increased cropping and hence nitrogen application, and the inclusion of grain legumes in crop rotations, may have increased acidification rates. However, increased rates associated with these changes may be being mitigated by smarter use of applied nitrogen and increased soil testing and lime use given that Canola will not tolerate moderately acidic soil. Under dairying, smarter use of applied nitrogen, application of alkaline bore water from limestone aquifers , increased import of stockfeed , and the lime requirement at pasture establishment (particularly on the Podosols) will maintain or increase soil pH. *Summary* The variability in soil acidity and trends across the region make a generalized assessment difficult. The assessment of this region is			↘		◒	◒

	based on the poorly drained Sodosols and Vertosols of the lava plains used for dryland cropping and the grazing of annual pastures. Samples from farms, soil mapping and soil acidification surveys indicate that mostly these dry-land soils are naturally slightly to moderately acidic and that some have acidified further.						
KEY **Grading Statements**	**Very poor:** Beyond recovery (economic) Yields no longer economic. Current system untenable with limited options						
	Poor: Urgent amelioration. Yields and returns are compromised, returns currently threatened.						
	Good: Needs management & monitoring otherwise returns will be threatened.						
	Very Good: Current management adequate – low level monitoring required.						
Indication of trend	↗ Improving ↘ Deteriorating — Stable ? Unknown						
Level of Confidence	○ Evidence and consensus too low to make an assessment ◒ Limited or low quality evidence but high consensus ● Adequate high quality evidence and high consensus						

Tasmania

Bill Cotching, University of Tasmania

Comments

No specific comments

Possible major future pressures to land values

No major future changes/pressures specifically identified

References associated with soil pH in Tasmania

See tables

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Bass Coastal Platforms	Many drained swampy coastal plains (Hydrosols/Podosols) under dryland and irrigated grazing modified pasture; also sandy coastal dunes (Podosols) and quartzite/mudstone dominated hills (Organosols/Dermosols) in nature conservation reserves. Soils are naturally very strongly acidic although this does not require management under native vegetation. This acidity has mostly been addressed by farmers applying locally sourced lime or dolomite, but some can reduce inputs as pH targets have been exceeded.						
Midlands Plain	Mostly sandy loams (Kurosols/ Chromosols/Sodosols/Tenosols) and clay loams (Dermosols) on weathered sediments under dryland grazing modified pastures and increasing areas of irrigated cropping. Farmers apply locally sourced lime or dolomite to correct topsoil acidity, but some can reduce inputs as pH targets have been exceeded. Subsoils are naturally neutral to alkaline. Some dolerite/sedimentary/metamorphic rock hills with native and modified pastures and some production forestry, have naturally very strongly acidic soils (Dermosols/Kurosols) which do not require pH management under native vegetation. Cotching WE, Kidd DB, 2010. Soil quality evaluation and the interaction with land use and soil order in Tasmania, Australia. *Agriculture, Ecosystems & Environment* **137**, 358-366 Cotching,WE and Lynch, S and Kidd, D, 2009. Dominant soil orders in Tasmania: distribution and selected properties. *Australian Journal of Soil Research*, **47** pp. 537–548. Cotching, WE and Kidd, D, *Report Card : Soil condition in the Northern Region, Tasmania*, NRM North (2009)						
Lakes Plateau	Upland plateau on dolerite (Rudosols/Dermosols/Organosols) in nature conservation reserves with naturally very strongly acidic soils which do not require pH management under native vegetation.						

West Tasmanian Ridges	Southern areas dominated by quartzite and conglomerate (shallow Organosols and Tenosols) in nature conservation reserves. Northern areas dominated by production forestry (Dermosols/ Rudosols). Soils are naturally very strongly acidic although they do not require pH management under native vegetation.						
East Tasmanian Hills	Production and plantation forestry on soils derived from sedimentary rocks (Kurosols/Chromosols/Dermosols), dolerite (Dermosols/Ferrosols) and granite (Kurosols/Dermosols) with naturally strongly acidic soils which do not require pH management under native vegetation. Most farmers apply locally sourced lime or dolomite so that soil acidity is generally less than under native vegetation but some dryland pastures are below pH targets. Soil acidity is decreasing under cropping on north-eastern Ferrosols, but is increasing on some soils under irrigated cropping in the southeast. Subsoils in the southeast are naturally neutral to alkaline. Cotching, WE and Kidd, D, *Report Card : Soil condition in the Southern Region, Tasmania*, NRM South (2009) LA Sparrow, WE Cotching, J Parry-Jones, G Oliver, E White and RB Doyle 2011. Changes in carbon and soil fertility in agricultural soils in Tasmania, Australia. 12th International Symposium on Soil and Plant Analysis, Crete, Greece						
North West Ramp	Plantation forestry (Ferrosols/ Dermosols on basalt/mudstone/granite) has had little impact on naturally strongly acid soils. Most farmers apply locally sourced lime or dolomite so that soil acidity is generally less than under native vegetation. Irrigated cropping below 300 m altitude (Ferrosols) has generally resulted in decreasing soil acidity through application of lime or dolomite but some sites have increasing acidity. Cotching, WE and Kidd, D*, *Report Card : Soil condition in the Cradle Coast Region, Tasmania*, Cradle Coast NRM (2009)						
Bass Islands	Grazing modified pastures (Kurosols/ Podosols/Hydrosols on King Island; Kurosols/Podosols/Calcarosols on Flinders Island) with many naturally strongly acidic soils. Soils have been ameliorated by farmers applying locally sourced lime sand. Coastal dunes are neutral to alkaline. Areas of native vegetation do not require management.						

KEY **Grading Statements**	**Very poor:** Beyond recovery (economic) Yields no longer economic. Current system untenable with limited options						
	Poor: Urgent amelioration. Yields and returns are compromised, returns currently threatened.						
	Good: Needs management & monitoring otherwise returns will be threatened.						
	Very Good: Current management adequate – low level monitoring required.						
Indication of trend	↗ Improving ↘ Deteriorating — Stable ? Unknown						
Level of Confidence	○ Evidence and consensus too low to make an assessment ◒ Limited or low quality evidence but high consensus ● Adequate high quality evidence and high consensus						

South Australia

Jeff Baldock and Richard Merry, CSIRO Land and Water.

Comments

No specific comments

Risks to environmental values

No specific risks given

References associated with soil acidification in SA

Farhoodi, A and Coventry, D.R. (2008). Field crop responses to lime in the mid-north region of South Australia. *Field Crops Research*, **108**: 45-53

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Robinson, B., Merry, R., Reuter, D and Thomas, B (2004) Vineyard Acidification Audit. Final Report to Land and Water Australia, LWA Project No.: SRH12

Assessment Component	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Lincoln Hills	Predominantly dryland cropping (3.3) with smaller areas of grazing of modified pastures (3.2) and natural vegetation (2.1) and nature conservation (1.1). Soils include ironstone soil, sands and loams over clays (duplex soils, mostly Sodosols), and shallow soils on rock and calcrete as well as calcareous loams and deep carbonate rich sands. Most of the area needs management and monitoring with a small proportion requiring urgent amelioration. The overall assessment grade has been assigned to "good" with a deteriorating trend because rates of lime application are not sufficient to balance rates of acid addition under agriculture. Small areas where clay spreading, delving and spading have occurred may have pH values higher than native conditions.			↘		●	●
Ceduna Dunfield	Currently approximately equal areas of grazing natural vegetation (2.1) and dryland cropping (3.3) with smaller areas of grazing of modified pastures (3.2) and nature conservation (1.1). Soils are dominated equally by shallow loam on calcrete and highly calcareous sandy loams (Calcarosols), with smaller areas of deep siliceous or carbonate rich sands (often Tenosols). Most lands are calcareous and located near the coast and able to buffer any addition of acidity.				–	●	●
Eyre Dunefield	Predominant land use is dryland cropping (3.3), followed by grazing natural vegetation (2.1) and grazing modified pastures (3.2). Soils are predominantly calcareous loams (Calcarosols), loams and sands over clay (duplex soils, mostly Sodosols), siliceous sands (often Tenosols), and shallow soils on calcrete and rock. The majority of the area needs management and monitoring with a small proportion requiring urgent amelioration (non-calcareous soils). The overall assessment grade has been assigned to "good" with a deteriorating trend because on non-calcareous soils rates of lime application are not sufficient to balance rates of acid addition under agriculture. Small areas where clay spreading, delving and spading has occurred may have pH values			↘		●	●

	higher than native conditions.						
Gawler-Cleve Ranges	Current agricultural land use is almost all grazing natural vegetation. Soils of the region are dominated by shallow loams (mostly Tenosols). Soil pH should be stable with low rates of acidification. Current management is adequate to maintain soil pH.				⊖	○	○
Yorke Peninsula	Most of the region is used for dryland cropping (3.3) with the predominant soils calcareous loams (Calcarosols), hard loams over red clay (duplex soils, mostly Sodosols) and shallow soils on calcrete. Smaller areas of deep siliceous sands. The exception is in the south-west which has grazing natural vegetation (2.1) and conservation areas (1.1) on calcareous sands (deep carbonate-rich sands and shallow carbonate-rich sandy soils on calcrete). Non calcareous soils in this region require monitoring and management with regular lime addition to maintain pH. Lime applications are not sufficient to maintain soil pH resulting in a downward trend. In the Stansbury area, many of the deep siliceous sands and duplex soils have been clay spread or delved with alkaline material. Calcareous soil pH values are stable.			↘		●	●
Flinders-Lofty Ranges	The extent of this physiographic region makes characterization difficult. Although it encompasses most of the Adelaide Geosyncline and so constitutes a geological zone, land use and climate vary considerably giving three sub-regions: arid north, temperate central and cool-temperate south. In the north, soils are predominantly loams over red clay (mostly Sodosols), calcareous loam soils (Calcarosols) and shallow soils on rock. Grazing of natural vegetation is the predominant land use. Soil pH should be stable with low rates of acidification. Current management is adequate to maintain soil pH. In the central region soils are dominated by loams over clay (often Sodosols), gradational red soils and shallow soils on rock. Land use is mostly dryland cropping with a significant area also devoted to vineyards. The soils in this area are acidifying and addition of lime is insufficient. In the south, soils are predominantly acidic loams over clay (mostly Chromosols), ironstone soils and shallow soils on rock. Agriculture in the south is mostly grazing of modified pastures. High production horticulture (vineyards, orchards, vegetables) is also a significant land use. The soils are			↘		●	●

	acidifying and addition of lime is insufficient. Of these three areas, the middle and southern dominate and lead to a "good" assessment grade with monitoring and management required. The trend is to acidification due to insufficient lime application.						
Torrens-Gulf Plains.	Soils are dominated by calcareous loams (Calcarosols) and loams over clay (duplex soils, usually Sodosols or Chromosols) with significant areas of siliceous sands and shallow soils on calcrete in the south. Dryland cropping is predominant in the south and grazing natural vegetation in the north. Some regions of high intensity vegetable production under irrigation are also present in the south. Acidification of soils is occurring in the southern non-calcareous portion of this region. The calcareous soils are stable. On balance the assessment would be "very good" and stable, but with some patches of "good" with a downward trend for soils with non-calcareous surface layers.				⊖	●	●
West Turkey Plains	Approximately equal areas of shallow loams (Calcarosols) and crusty red duplex soils (Chromosols) used almost exclusively for grazing natural vegetation (3.2) except for a small area of cropping (3.3) in the southwest. In the south western cropping region it is likely that acidification has occurred with insufficient lime being applied to counter these changes. In the remainder soil pH values will not have changed significantly. A "very good" assessment grade and a stable trend have been indicated due to the dominance of grazing of native vegetation. A "good" assessment with a downward trend would apply for the smaller south west cropping area.				⊖	◒	◒
Ivanhoe Plains	This region is almost exclusively covered with calcareous earths (Calcarosols) with a sandy texture arranged in a dune/swale sequence. The dominant land uses are grazing native vegetation and nature conservation. The high prevalence of calcareous soils and native vegetation suggests a "very good" assessment grade and a stable trend.				⊖	◒	◒
Mallee-Dunefield	The main soils are calcareous loams (Calcarosols), siliceous sands (often Tenosols), shallow soils on calcrete, red sandy gradational soils, and sands and loams over clay (duplex soils, mostly Sodosols). Self-mulching cracking grey clays (Vertosols) and sodic duplex soils (Sodosols) are located along the			↘		●	●

	Murray River valley. The major land use is cereal cropping (3.3) often in rotation with pastures (3.2) but tending towards a greater dominance of cropping. Significant areas of irrigated horticulture (vineyards, almonds and citrus) occur close to the Murray River. Across most of the dryland cropping areas, declines in surface pH have occurred over calcareous subsoils. These areas would be assessed as "good" (requiring management and monitoring) with a downward trend. The horticultural areas have exhibited significant pH decline due to product removal and excess nitrogen fertiliser use. The horticultural soils require amelioration through the use of nitrate based fertilisers or lime application.						
Coorong Plain	Mainly shallow soils on calcrete, calcareous loams (Calcarosols), deep siliceous sands (often Tenosols) and sands over clay (duplex soils, mostly Sodosols) with modified pastures (3.2) the predominant land use and some dryland cropping (3.3). Little evidence for acidification exists with the possible exception of some cropping areas in the north. An overall "very good" assessment grade has been applied with a stable trend.				⊖	●	●
Wimmera Plain	Wide mixture of soil types including deep siliceous sands (some Podosols), sands and loams over clay (duplex soils, mostly Sodosols) and self-mulching cracking clays (Vertosols). The major land uses include dryland cropping and grazing of modified pastures along with some irrigation. Soil pH has declined leading to an assessment of "good" (requiring ongoing management and monitoring). Soil pH will continue to exhibit a downward trend due to an insufficient use of lime. Exceptions to this trend will include some, but not all, soils on which clay spreading, delving or spading has been practiced and soils that are irrigated with alkaline groundwater. These soils generally show increasing pH values.			↘		●	●
Millicent Plain	Wide mixture of soil types including shallow soils on calcrete, deep siliceous sands (often Tenosols), highly leached sand (Podosols), loams and sands over clay (duplex soils, often Sodosols) and cracking clays (Vertosols) as well as peat and other wet soils. The major land uses include dryland cropping, grazing of modified pastures, plantation forestry and some irrigation (dairy, vineyards, potatoes).			↘		●	●

	On the cropping and modified pasture soils, pH has declined leading to an assessment grade of "good" (requiring ongoing management and monitoring). Soil pH will continue to exhibit a downward trend due to an insufficient use of lime. Exceptions to this trend will include some, but not all, soils on which clay spreading, delving or spading has been practiced and soils that are irrigated with alkaline groundwater. These soils generally show increasing pH values.						
Olary Spur	Red massive soils used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.						
Eyre-Frome Plains	Crusty red duplex soils, shallow loams, and calcareous earths used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.						
Strzelecki Desert Plains	Deep sands and self-mulching cracking clays used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.						
Simpson Desert Plains	Deep sands and massive surfaced cracking clays (minor) used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.						
Innamincka Plains	Self-mulching cracking clays used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.						
Sturt Desert Plains	Deep sands and crusty red duplex soils used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.						
Simpson Desert Dunefield	Deep sands, self-mulching cracking clays and massive surfaced cracking clays used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.						

Alberga Dunefield	Deep sands used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.				⊖	◒	◒
Kulgera Hills	Shallow sands used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.				⊖	◒	◒
Western Desert Ranges	Shallow sands and red massive earths used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.				⊖	◒	◒
Great Victoria Desert Dunes	Deep sands, calcareous earths, shallow sands and red massive earths used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.				⊖	◒	◒
Carlisle Plane	Shallow sands and calcareous earths used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.				⊖	◒	◒
Bunda Plateau	Shallow loams used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.				⊖	◒	◒
Oodnadatta Tablelands	Crusty red duplex soils, calcareous earths, deep sands and shallow loams used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.				⊖	◒	◒
Denison Ranges	Calcareous earths used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.				⊖	◒	◒
Andamooka Tablelands	Crusty red duplex soils, Calcareous earths used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.				⊖	◒	◒

Gairdner Plain	Calcareous earths and shallow loams used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.				⊟	◒	◒
Torrens Gulf Plains	Crusty red soils, calcareous earths and shallow loams used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.				⊟	◒	◒
Diamantina Plain	Self-mulching cracking clays and crusty red soils used for grazing of natural vegetation. Soil pH values have not changed significantly. The assessment grade is "very good" with a stable trend requiring low level monitoring.				⊟	◒	◒
KEY	**Very poor:** Beyond recovery (economic) Yields no longer economic. Current system untenable with limited options						
	Poor: Urgent amelioration. Yields and returns are compromised, returns currently threatened.						
Grading Statements	**Good:** Needs management & monitoring otherwise returns will be threatened.						
	Very Good: Current management adequate – low level monitoring required.						
Indication of trend	↗ Improving ↘ Deteriorating ⊟ Stable ? Unknown						
Level of Confidence	○ Evidence and consensus too low to make an assessment ◒ Limited or low quality evidence but high consensus ● Adequate high quality evidence and high consensus						

Western Australia

Chris Gazey, Department of Agriculture and Food, WA

Comments:

- Soil acidification to critical levels has already occurred over large tracts of the SW agricultural area of Western Australia
- Upward and downward trends reflect nominal rates of change relative to pH at time of clearing (for agricultural areas)
- Major stress on up to 80% of the Western Australian agricultural landscape is associated with generally poor use of lime to counteract acidification.

Possible major future pressures to land values

No major future changes/pressures specifically identified

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Gazey, C and Andrew, J (2009). Optimising soil pH for sustainable farm practices, 2008–09. Final Report Project 04A1-07

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Assessment Component	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Warren-Denmark Slopes; Leeuwin Peninsula Donnybrook Lowland	Intensive animal production (5.2), production forestry (2.2), nature conservation (1.1) and to the east, dryland cropping (3.3). Relatively high rates of acidification due to higher rainfall and productive crop/pasture systems. Low rates of poorer quality lime used and usually with inadequate amounts to achieve soil pH targets.			↘		◒	◒
Albany Esperance Sandplain	Current agricultural land use predominantly grazing (3.2) and cropping systems (3.3), with some perennial pasture (2.1) and production forestry (2.2). Significant nature conservation (1.1) area (30%). Acidification associated with steep rainfall gradient and/or low soil water holding capacities due to sandy soil textures (sandplain with duplex soils, predominantly Sodosols) resulting in increased leaching of nitrogen. Rating applies to grazing and cropping systems. Conservation areas assumed to be pH stable. Low rates of poorer quality lime used and usually with inadequate amounts to achieve soil pH targets.		↘			◒	◒
Salmon Gums Plain	Predominantly cropping systems (3.3) in southern regions. Low rainfall with higher clay soils e.g. loams, clay loams, clays (predominantly Sodosols). Dominated by alkaline soils.			–		◒	◒
Roe Plain, Coonana-Ragged Plateau, Bunda Plateau, Carlisle Plain	Plains with predominantly Calcarosols. Minimal use and grazing native vegetation. No lime inputs in this area.				–	◒	◒
Southern goldfields plateau	Plains with a range of soils including Kandosols, Tenosols, Sodosols and Calcarosols. Extensive grazing of native vegetation (2.1) with significant nature conservation (1.1) areas. No fertiliser or lime inputs.				–	◒	◒
Avon Plateau	A range of soils - sandplain to gravelly, loam and duplex soils (mostly Sodosols and		↘			●	●

	Kandosols) - and medium to low rainfall. Predominantly cropping (3.3) and grazing 3.2), with the region producing approximately half the grain grown in WA. Winter dominated rainfall inputs of nitrogen, phosphate and increasingly potassium. Variable adoption of lime use, with usually inadequate amounts of lime applied to achieve targets. Significant production constraints due to surface and subsurface soil acidity.						
Northam Slopes	Loam soils (predominantly Sodosols and Chromosols) and reliable rainfall with agriculture dominated by cropping (3.3) and grazing systems (3.2). Variable adoption of lime use with usually inadequate amounts of lime applied to achieve targets. Significant production constraints due to surface and subsurface soil acidity.		↘			●	●
Darling Range	Almost exclusively Jarrah and Marri forests growing on predominantly Tenosols. Approximately 20% cropping and grazing. Rating applies to cropped area. Forrest areas assumed to be stable.		↘			◒	◒
Swan Plain	Predominantly sandy soils (Podosols, some Kurosols and Chromosols) with intensive agricultural uses such as high and low input intensive animal production (5.2) and irrigated seasonal horticulture (4.5). The urbanized Perth region is included. The inherently low soil pH's inland of coastal areas have declined further under irrigated modified pasture systems for dairy. Lime use has increased, however, due to proximity to sources and increased recognition of soil acidity as a constraint.		↘			◒	◒
Dandaragan Tablelands	Coastal nature conservation (1.1) areas on western edge and cropping (3.3) and grazing systems (3.2) dominant to the east. Steep rainfall gradient. Soils predominantly Tenosols and Chromosols Higher productivity with significant acidification of both surface and subsurface horizons on non-calcareous soils. Variable but increasing adoption of lime use. Access to high quality coastal deposits of lime.		↘			◒	◒
Greenough Hills	Reliable rainfall region with a range of soil types, though predominantly Chromosols. Dryland cropping (3.3).			↘		◒	◒

	Significant acidification of both surface and subsurface horizons on non-calcareous soils.						
Woodramung Hills	Heavier loam and clay loam soils, predominantly Kandosols and Tenosols. Medium to low rainfall region dominated by cropping (3.3) and grazing (3.2). Eastern areas grading into the pastoral region. Rating applies to significant acidification and low pH on non-pastoral sandy/sandy loam soils.						
Murchison Plateau, Leemans Sandplain, Carnegie Hills, Glengarry Hills, Augustus Ranges, Yaringa Sandplain	Varied landscapes and soils with predominantly Tenosols and Sodosols. Extensive grazing of native vegetation (2.1) with significant nature conservation areas (1.1). Low level of inputs, generally regarded as stable soil pH.						
Shark Bay Peninsulas	Sandy soils, primarily Rudosols, Calcarosols and Tenosols in an area used for nature conservation (1.1).						
Carnarvon Plain	Land use includes nature conservation (1.1), extensive grazing of natural vegetation (2.1) and intensive irrigated and seasonal horticulture in a plains region with Sodosols, Tenosols and Hydrosols predominant.						
Grouping of hills and ranges in the Hamersley area	Kennedy Range, North West Cape Ridge, Hamersley Plateaus, Chichester Range, Nullagine Hills, Rudall Tablelands. Nature conservation, grazing native vegetation (ferals).						
Fortescue valley	Alluvial valley with Kandosols, Vertosols, Sodosols and Calcarosols predominant. Land use grazing of natural vegetation (2.1).						
De Gray Lowlands, Onslow Plain, Yanrey-Cane Plain, Eighty Mile Plain	Predominantly plains and coastal dune systems, some low ranges; soils variable and including Sodosols, Vertosols, Tenosals and Calcarosols. Nature conservation (1.1) and extensive grazing (2.1) of native vegetation. No active input of nutrients or lime.						
Great Sandy Desert Dunefield, Anketell Hills, Little Sandy Desert, Gibson Desert Plains, Great Victoria Desert Dunes, Western Desert Ranges, Warburton Ranges	Sandy plains and dunes with areas of stony plains, stony rises, mesas, low tablelands and sandstone ranges. Soils predominantly Tenosols but also Rudosols and Kandosols. Grazing native vegetation and nature conservation areas.						

Stansmore Dunefield and Ranges, Sturt Creek Floodout, Tanami Sandplain and Tanami Sandplain and Ranges	Predominantly sandy soils (Rudosols and Tenosols, Kandosols) with some clays (Vertosols). Primarily a nature conservation (1.1) area, with some extensive grazing of native vegetation (2.1).				⊖	◒	◒
Dampier Tablelands	Low sandstone tableland with extensive sand sheets; soils predominantly Tenosols with some Kandosols. Mostly used for nature conservation (1.1) and increasingly for grazing native vegetation (2.1)				⊖	◒	◒
Fitzroy Plains	Alluvial and estuarine plains with a range of soils including Kandosols, Tenosols and Vertosols. Extensive grazing of native vegetation (2.1)				⊖	◒	◒
Grouping of hills and ranges in the Kimberley	Fitzroy Ranges, Napier Limestone Ranges, Springvale Foothills, Halls Creek Ridges, Leopold Durack Ranges, Richenda Foothills, Kimberley Plateau, Couchman Uplands Diverse landscapes with soils predominantly Tenosols, Rudosols and Ferrosols. Land use primarily nature conservation (1.1) and grazing of natural vegetation (2.1).				⊖	◒	◒
Top End Coastal Plain	Dissected lowlands with alluvial and estuarine plains. Soils predominantly Rudosols and coastal Hydrosols, however important areas of Vertosols and Kandosols. Mostly grazing natural vegetation (2.1) but the Ord River irrigation scheme has been developed on the Vertosols, with uses including irrigated cropping (4.3) and irrigated perennial (4.4) and seasonal (4.5) horticulture.			↘		◒	◒
KEY **Grading Statements**	**Very poor:** Beyond recovery (economic). Yields no longer economic. Current system untenable with limited options.						
	Poor: Urgent amelioration. Yields and returns are compromised, returns currently threatened.						
	Good: Needs management & monitoring otherwise returns will be threatened.						
	Very Good: Current management adequate– low level monitoring required.						
Indication of trend	↗ Improving ↘ Deteriorating ⊖ Stable ? Unknown						
Level of Confidence	○ Evidence and consensus too low to ◒ Limited or low quality evidence but high ● Adequate high quality evidence and						

	make an assessment	consensus	high consensus

At a glance… soil acidity/acidification

- Acidification trends reversed in a small number (~10%) of farms in the agricultural areas of SW Western Australia where lime applications are adequate.
- Soil pH stable across the conservation regions and the low/no input areas of the state used for extensive grazing.
- Soil acidity, particularly subsurface acidity below 10 cm, generally increasing in the agricultural areas of the South West of Western Australia due to inadequate use of lime except for some individual farms referred to above.

The Northern Territory

Peter Wilson, Manager, National Soil Information, CSIRO Land and Water; formerly with the Conservation Commission of the NT with inputs from Jason Hill and Brian Lynch, NT Department of Natural Resources, Environment, the Arts and Sport

Comments and summary

- There is no long-term monitoring data in the NT

Possible major future pressures to land values

None specifically identified

References associated with soil pH in the NT:

Smith, S. and Hill, J. A draft report is in preparation with the title: Supporting Sustainable Development – Risks and Impacts of Plant Industries on Soil Carbon.

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Top end coastal regions including Top End Coastal Plains, Pine Creek Ridges, Arnhem Plateau, Arnhem Ridges, Gulf Coastal Lowlands and Gulf Fall	Lowland coastal plains with deeper, naturally strong to moderately acidic soils and rocky inland ranges with shallow moderately acidic to neutral soils. Most of the area has minimal use or extensive grazing with little impact on soil acidity. Areas of coastal development, including small areas of horticultural tree cropping and pasture improvement may have some impact, particularly on lighter textured soils with low buffering capacity.						
Barkly Tablelands	Broad upland clay plains with extensive moderately alkaline Vertosols which have moderate pH buffering capacity. Extensive grazing not greatly affecting soil acidity.						
North-western regions including Ord-Victoria Plateaus, Whirlwind Plain and Birrundudu Plain	Diverse landscapes including rocky upland areas with mostly shallow, moderate to slightly acidic soils, and lowland plains with areas of moderate to strongly alkaline Vertosols. Extensive grazing not greatly affecting soil acidity.						
Daly Basin	Areas of light textured, deeper Red Kandosols, naturally mostly moderate to slightly acidic with low to moderate buffering capacity. Horticultural and more intensive pastoral development, including improvement with legumes, show some evidence of declining pH particularly in areas of continuous cropping (Smith & Hill 2011).						
Central and Southern Regions	Inland regions including Sturt Plateau, Tanami Sandplain and Ranges, Tanami Sandplain, Davenport Ranges, Sandover Sandplain, Tobermory Plain, Toko Plateaus, Northern Alice Ranges, Northern Alice Plains Redvers Dunefield, Macdonald Sandplain, Central Ranges, Todd Plains, Amadeus Plains, Great Sandy Desert Dunefield, Western Desert Ranges and Simpson Desert Dunefield Diverse rangelands landscapes with mostly neutral to slightly acidic soils. Low impact land use, mainly extensive grazing usually with minimal nutrient inputs or product removal not greatly affecting soil acidification.						
KEY	**Very poor:** Beyond recovery (economic) Yields no longer economic. Current						

Grading Statements	system untenable with limited options						
	Poor: Urgent amelioration. Yields and returns are compromised, returns currently threatened.						
	Good: Needs management & monitoring otherwise returns will be threatened.						
	Very Good: Current management adequate – low level monitoring required.						
Indication of trend	 Improving  Deteriorating  Stable  Unknown						
Level of Confidence	○ Evidence and consensus too low to make an assessment	◒ Limited or low quality evidence but high consensus	● Adequate high quality evidence and high consensus				

At a glance… soil acidity/acidification

- Soil pH mostly stable in areas of extensive grazing and minimal use and where soils well buffered.
- Localized areas of acidification due to more intensive use and, in some areas, the addition of legumes.

Queensland

Mike Grundy, CSIRO Land and Water and Phil Moody, Queensland Department Environment & Resource Management

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Condamine Lowlands and Upper Darling Plains	High intensity cropping on Vertosols, sometimes with irrigation; land management is moving to zero till and controlled traffic/ precision agriculture. Soils are highly buffered with no obvious acidification issues. Less intensive rainfed cropping on Sodosols with increased use of pulses in rotation and the potential for an increase in opportunity cropping with increased use of seasonal forecasts. These soils are also highly buffered with no obvious acidification issues. Areas with cattle on improved pastures. Small area of national parks.				⊟	●	●
Charleville Tablelands	Brigalow with box and belah on Vertosols and Dermosols, with some Sodosols - cattle grazing with some opportunity cropping; minimal sheep. Mulga with Kandosols and Chromosols – cattle and some sheep; variably cleared over the last 25 years.				⊟	◒	◒
St George Plain, Warrego Plains, Maranoa Lowland and Lightning Ridge Lowland	Vertosols and Sodosols with irrigated and dryland crops; Kandosols cleared for grazing cattle. Soils with lower buffer capacity in top 30 cm may develop pH stratification under minimum till with reduced acidification in the top few centimeters but continued acidification in the root zone; Vertosols are highly buffered and little change in pH is expected.			⊟		◒	◒
Taroom Hills and Springsure – Clermont Plateaus	Mostly cleared for pasture for cattle over the last 40 years, with some small areas of cropping and some areas uncleared. Soils are Chromosols, Kandosols and Sodosols with small areas of Vertosols.				⊟	◒	◒
Expedition scarplands,	Largely uncleared				⊟	◒	◒

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Connors Ranges and Carborough Ranges							
Toowoomba Plateau	Long cleared Ferrosols on Tertiary basalt, used for cropping and pasture with increasing agroforestry. Soils have acidified over the last century and are still declining in quality with land management not including routine lime addition.		↘			●	●
Bunya-Burnett Ranges	Most of the area is cleared grazing land with marginally improved pastures on Sodosols, with Kurosols and Kandosols. Vertosols and Dermosols with intensive small crops (seasonal horticulture) and perennial horticulture; subsoil acidification may be occuring under perennial horticulture. Some dairy and intensive cattle production on Ferrosols, Kandosols, Dermosols and Vertosols.			—		◒	◒
Moreton Lowlands	Urbanised						
Maryborough Lowland	Podosols, Kandosols and Kurosols with pine plantations are acidifying. Kandosols, Dermosols, Hydrosols and Ferrosols used for sugar cane; introduction of a legume break crop has changed management to increase lime use. Horticulture on Dermosols, Kandosols and some Ferrosols around Bundaberg – liming is part of management; however, there is some uncertainty about subsoil acidification under perennial horticulture.			↗		●	◒
Broadsound Plains	Land with inherently low fertility soils cleared for grazing.				—	◒	◒
Townshend Ranges and Lowlands, Burdekin Hills and Lowlands	Some grazing on the lowland plains with Hydrosols, Sodosols, Chromosols, Kandosols and Vertosols. Dermosols, Sodosols and Tenosols on the mountains with rainforest; no pH change.				—	◒	◒
Townsville Lowlands and	Irrigated and rainfed sugar production and horticulture on Vertosols, Sodosols, Hydrosols			—		●	●

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Cairns Ranges	and Dermosols . Green cane trash blanketing (in all areas except the Burdekin) and increased use of legume break crops in sugar producing areas, along with good lime management in horticulture, are all improving soil pH; some uncertainty about subsoil acidification in horticulture areas although heavier soils have high buffering capacity. Ponded pasture and aquaculture are small land uses for which no data are available.						
Hervey Tablelands, Alice Tableland, Scartwater Hills, Bulgonunna Tableland, Cotherstone Plateau, Drummond Uplands, Nogoa Scarplands and Buckland Plateau	Partially cleared grazing country with Kandosols, Chromosols and Sodosols. There are few data but soil pH is unlikely to be declining.				⊟	◒	◒
Atherton Tableland	A variety of land uses including improved nitrogen fertilized pastures on Ferrosols and Chromosols; intensive rainfed crops on Ferrosols; irrigated tree crops (irrigated perennial horticulture); irrigated small crops (irrigated seasonal horticulture) on Ferrosols, Chromosols and Kandosols; and irrigated sugar on a range of soils including Sodosols. Naturally acidic soils?? on the Atherton tableland have been an issue. Liming now occurs in most crop areas; some uncertainty about subsoil acidification under perennial horticulture.			⊟		●	◒
Garnet Uplands	Recently intensified land use after clearing; there are few data but likely acidification needs to be managed.				↘	◒	◒
All Cape and Gulf Regions	Torres High Islands, Jardine Uplands, Weipa Plateau, Merluna Plain, Wenlock Uplands, Coleman Plateau, Holroyd Plains, Laura Plain, Cooktown Ranges, Palmerville Hills, Bullimba Plateau, Karumba Plain, Clara-Mitchell Plains, Gregory Range, Gilbert Hills, Newcastle Ranges, Einasleigh Plains, Gilberton Plateau, Wondoola Plain, Normanton Tableland, Donors Tableland, Armraynald Plain,				⊟	◒	◒

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
	Manangoora Plains, Gulf Fall and Isa Ridges. Extensive cattle grazing with minimal clearing						
Burdekin Plateaus and Cape River Plains	Grazing on Chromosols, Ferrosols and Dermosols; management unlikely to be causing acidification.				⊟	◒	◒
Belyando Plains	Grazing on extensively cleared Vertosols, Kandosols, Dermosols and Chromosols with buffel grass; smaller areas of rainfed opportunity cropping and irrigated cropping on Vertosols and Dermosols. Subsoil acidification is likely to be an issue on soils with lower buffering capacity, such as the Chromosols.				⊟	◒	◒
Mackenzie Dawson Lowlands	Rainfed opportunity cropping on Vertosols and Dermosols. Similar areas of extensively cleared grazing lands with buffel grass on Vertosols, Kandosols, Dermosols, Chromosols. Small areas of irrigated cropping on Vertosols and Dermosols. Soils are highly buffered with little change in pH observed.				⊟	◒	◒
Jericho Plain	Mostly grazing on cleared Kandosols; small areas of cropping on Vertosols Little acidification but few data.				⊟	◒	◒
Winton Blackall Downs	Grazing but land not generally cleared; highly buffered soils. No acidification apparent.				⊟	◒	◒
Remaining southwest regions	Tobermory Plain, Boulia Downs, Eyre Creek Plain, Eromanga Lowlands, Whelen Lowlands, Diamantina Plain, Simpson Desert Dunefield, Diamantina Plain, Sturt Desert Plains, Cooper Plain, Strzelecki Desert Plains, Bulloo Plain, Paroo Plain Grazing; no acidification.				⊟	◒	◒
KEY	**Very poor:** Beyond recovery (economic) Yields no longer economic. Current system untenable with limited options						
	Poor: Urgent amelioration. Yields and returns are compromised, returns currently threatened.						
Grading	**Good:** Needs management & monitoring otherwise returns will be threatened.						

Physiographic Region	Summary	Assessment Grade				Confidence in grade	Confidence in trend
		Very poor	Poor	Good	Very good		
Statements	**Very Good:** Current management adequate – low level monitoring required.						
Indication of trend	↗ Improving ↘ Deteriorating — Stable ? Unknown						
Level of Confidence	○ Evidence and consensus too low to make an assessment ◒ Limited or low quality evidence but high consensus ● Adequate high quality evidence and high consensus						