



**Australian Government**  
**National Land & Water Resources Audit**



## Soil condition

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Status of information for reporting against indicators under the National Natural Resource Management Monitoring and Evaluation Framework

## About the National Land & Water Resources Audit

The National Land & Water Resources Audit ('the Audit') provides data, information and nationwide assessments of Australia's land, water and biological resources to support sustainable development. The Audit commenced in 1997 and published the first set of detailed assessment reports in 2002.

The Audit (2003–08) has six key areas of activity:

- developing a consistent national reporting mechanism for collating natural resource information collected under the National Natural Resource Management Monitoring and Evaluation Framework
- collating information to support the national State of the Environment (SoE) reports
- developing nationally consistent, but regionally relevant integrated resource condition reports
- facilitating reporting on the ongoing collection of natural resource information for key theme areas, including those related to the National Natural Resource Management Monitoring and Evaluation Framework
- reporting on national data and information management (in collaboration with ANZLIC — the Spatial Information Council)
- developing national assessments (as requested) and supporting program evaluations.

For further information see <http://www.nlwra.gov.au>

### The Audit's mission

To provide data, information and nationwide assessments of Australia's land, water and biological resources to support sustainable development.



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Published by:  
National Land & Water Resources Audit

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Publication data: National Land & Water Resources Audit (2008). *Soil condition — Status of information for reporting against indicators under the National Natural Resource Management Monitoring and Evaluation Framework*, NLWRA, Canberra.

ISBN: 978 0 642 37157 7

Product number: PN21200

Acknowledgment: With thanks to the significant input from a range of stakeholders, particularly members of the National Committee on Soil and Terrain.

Author: Jim Dixon

Editors: Biotext Pty Ltd

Graphic Design: Design ONE

Printing: Finsbury Green

Cover photo: Young crop in soil (photo by Mark Imhof)

August 2008

Printed with vegetable-based inks on stock that comprises 80% recycled fibre from postconsumer waste and 20% totally chlorine-free pulp, sourced from sustainable forests.

## Foreword

Three key global challenges are associated with soil and its degradation:

- the food crisis — we will need to feed twice as many people from the same area of land by 2050
- conflicting land use trends — land is increasingly being used for purposes other than food production
- soil health — linked with global greenhouse cycles through emissions, sequestration or mitigation programs.

To respond to these challenges, it is vital that we gather data about the condition of Australian soils. We need to know:

- benchmark values for key natural resources
- the existence of and rate of any degradation processes
- the state or condition of natural resources at any point in time.

Such knowledge will enable us to design intervention strategies for the management of soil condition and to judge the effectiveness of the strategies after they have been implemented. Effective management of Australia's soil resources requires that quality information at the appropriate scale is available to those who need it.

The National Land & Water Resources Audit has coordinated, collated and reported on resource condition in conjunction with the Australian Government, state and territory governments, natural resource management regions, the private sector and community organisations since 1997.

This booklet is part of a series that describes the status of soil information to enable reporting on change in soil condition, a matter for target identified under the National Natural Resource Management Monitoring and Evaluation Framework.



Geoff Gorrie  
Chair, Audit Advisory Council





## Acronyms and abbreviations

ASRIS	Australian Soil Resource Information System
National M&E Framework	National Natural Resource Management Monitoring and Evaluation Framework
NCST	National Committee on Soil and Terrain
NLWRA	National Land & Water Resources Audit (the Audit)

## Contents

Foreword . . . . .	3
Acronyms and abbreviations . . . . .	4
Executive summary . . . . .	6
Introduction . . . . .	7
National indicators . . . . .	9
Monitoring techniques . . . . .	12
Data requirements for monitoring soil condition . . . . .	15
Data and information systems . . . . .	19
Data availability . . . . .	20
Indicator development . . . . .	21
Data and information products . . . . .	22
Examples of information products for wind erosion . . . . .	22
Discussion and way forward . . . . .	24
Appendix 1   The National Monitoring and Evaluation Framework . . . . .	25
Appendix 2   Current state and territory soil condition monitoring activities across Australia . . . . .	27
References . . . . .	36





## Executive summary

In mid-2006 the National Land & Water Resources Audit, via the National Committee on Soil and Terrain, convened four expert panels to discuss how best to monitor four soil condition indicators:

- Soil erosion by wind
- Soil erosion by water
- Soil acidification
- Soil carbon change.

Late in 2006, a series of experimental trials was initiated to investigate the recommendations of the expert panels and to explore operational issues associated with implementing the recommendations. Soil erosion, acidification and carbon change are processes that occur over decades. Monitoring timescales should reflect this, although substitute indicators may be used in the shorter term. Geographic areas of interest range from local to national. A range of monitoring techniques is therefore required for different combinations of temporal and geographical scales.

Several contextual datasets are important inputs to soil condition monitoring. The most important of these are derivatives of soils, land use, vegetation, climate and topography.

Data information systems, such as the Australian Soil Resource Information System,<sup>1</sup> require further development to become efficient and safe repositories for soil monitoring data over many decades.

A state and territory-based assessment of monitoring activities found that coverage of soil data has been patchy; however, several states and territories are about to commence substantial soil monitoring programs.



Soil erosion in an area near the Lynde Junction, Queensland (photo by Arthur Mostead)

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<sup>1</sup> <http://www.asris.csiro.au>

## Introduction

In 2001, the National Land & Water Resources Audit (the Audit) published the *Australian Agricultural Assessment*. Today, the Audit is responsible for the ongoing development of the indicators used for tracking resource condition and trends, as identified in the National Natural Resource Management Monitoring and Evaluation Framework (National M&E Framework) (see also Appendix 1). To achieve this, the Audit works with theme-based national coordinating committees, including the National Committee on Soil and Terrain (NCST), which is sponsored by the Australian Government Department of Agriculture Fisheries and Forestry (Table 1).

The Audit Advisory Council has endorsed four principal indicators for monitoring soil condition: Soil erosion by wind, Soil erosion by water, Soil acidification and Soil carbon change.

These indicators are being monitored to:

- track resource condition
- better define soil condition problems (and identify existing or potential problem areas)
- assess the effectiveness of management responses
- prioritise investment.



**Table 1 Agencies represented on the National Committee on Soil and Terrain (NCST)**

Jurisdiction	Agency
NSW	Department of Environment and Climate Change
NT	Department of Natural Resources, Environment and the Arts
Qld	Department of Natural Resources and Water
SA	Department of Water, Land and Biodiversity Conservation
Tas	Department of Primary Industries and Water
Vic	Department of Sustainability and Environment
WA	Department of Agriculture and Food
Australian Government	Department of Agriculture, Fisheries and Forestry
National	Commonwealth Scientific and Industrial Research Organisation (CSIRO) Land and Water
	National Land & Water Resources Audit



During 2006 and 2007, a series of trials was conducted nationally to explore the usefulness, applicability and scalability of the indicators. The results highlighted the importance of:

- clear monitoring objectives, so that resource monitoring objectives are not confused with extension or project management objectives
- the selection of representative sampling sites to enable spatial extrapolation of results
- robust statistical analyses to provide confidence in monitoring strategies and subsequent results
- carefully considered reporting products that effectively communicate the results or outcomes of monitoring
- adequate numbers of suitably skilled personnel
- stable institutional settings to support long-term monitoring programs
- common infrastructure across jurisdictions, including data definitions and databases.



Acid soil profile (photo by Chris Gazey)

## National indicators

Monitoring establishes a local, regional or national baseline so that trends away from the baseline can be observed over time. De Gruijter (2006) defines monitoring as 'collecting information on an object through repeated or continuous observation in order to determine possible changes in that object'.

Although several states and territories have comprehensive soil mapping information, which is an invaluable resource for planning monitoring programs, soil maps seldom provide an adequate baseline from which to observe trends (McKenzie et al 2002).

*Soil erosion by wind* is the process by which soil is detached and transported from the land surface by the action of wind. Transport occurs by creep, saltation or in suspension. Wind erosion hazard is defined as the natural vulnerability of soil to erosion by wind as further influenced by human activity (Houghton and Charman 1986).

*Soil erosion by water* is the detachment and transport of soil due to raindrop impact or flowing water. Hillslope (sheet and rill) erosion, gully erosion, and streambank erosion are the most significant forms of

water erosion in Australia. Only a small proportion of the detached material (the delivery ratio) is delivered to stream outlets. Water erosion hazard is defined as the risk of water erosion further modified by human activity (Houghton and Charman 1986).

*Soil acidification* is a natural process that is generally accelerated by agriculture, where the accumulation of hydrogen ions accompanies the removal of agricultural produce.

*Soil carbon change* is change in the soil organic carbon, which is typically approximately 58% of the soil organic matter. The soil organic matter comprises components derived from plants and animals.

These four processes may occur as spatially and temporally irregular catastrophic (patchy) events or may progress very slowly (Figure 1). Because of this, monitoring programs must occur over timeframes measured in decades rather than years.

Monitoring may be at a local, regional, state, territory or national level. Because monitoring often involves geophysically based stratified random sampling, the Australian Soil Resource Information System (ASRIS) hierarchy is recommended as the reporting



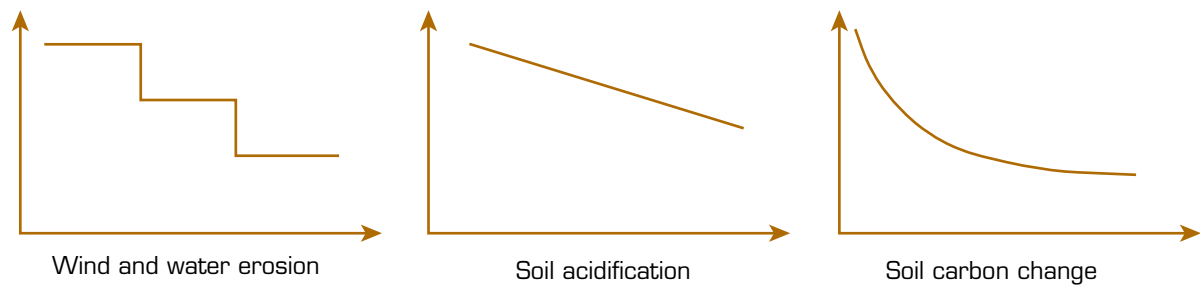


framework for the four soil condition indicators. From the national level through to a single point, ASRIS uses divisions, provinces, zones, districts, systems, facets and sites (Figure 2).

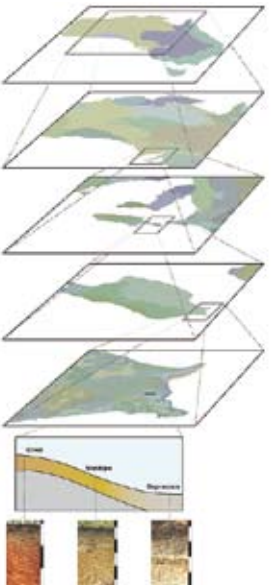
As a precursor to a second Australian agricultural assessment and for an appreciation of the condition of Australia's soil resources, it is appropriate to examine:

- monitoring techniques
- data requirements for monitoring soil condition
- data and information systems
- availability of monitoring data
- indicator development
- information products.

**Figure 1 Progress of soil indicators over time**



**Figure 2 The ASRIS mapping hierarchy**



Level and tract name	Mapping window	Main attributes used for mapping	Typical uses for the soil information	Area of Australia to be covered (Dec 2006)
Level 1 Division	30km	Broad landform (slope and relief) and geology	Broad geographic context	ILUZ: 100% Rangelands: 100%
Level 2 Province	10 km	Landform, water balance, dominant soil order and substrate	National natural resource policy	ILUZ: 100% Rangelands: 100%
Level 3 Zone	3 km	Landform, regolith materials, age of land surface, water balance, dominant soil suborder	Regional natural resource policy	ILUZ: 100% Rangelands: 100%
Level 4 District	1 km	Groupings of geomorphically related systems	Catchment planning, location of new industries	ILUZ: 60% Rangelands: 70%
Level 5 System	300 m	Local climate, relief, modal slope, lithology, drainage network, related soil profile class	Catchment management hydrological modelling, land conservation strategies, infrastructure planning	ILUZ: 60% Rangelands: < 5%
Level 6 Facet	30 m	Slope, aspect, land curvature, soil profile class	Farm management, land use planning, on-ground works	ILUZ: 60% Rangelands: < 5%
Level 7 Site	10 m	Soil properties, surface condition, microrelief	Precision agriculture, site development	

ILUZ = intensive land use zone

Source: [http://www.asris.csiro.au/methods.html#ASRIS\\_Levels](http://www.asris.csiro.au/methods.html#ASRIS_Levels)



## Monitoring techniques

The monitoring techniques used will reflect different monitoring objectives across temporal and geographical scales.

At the national level, the goals are to monitor long-term trends in the physical condition of the soil and land resources, and to identify problem areas early on so these can be addressed with appropriate policy and funding. National level monitoring techniques often

involve modelling with large and complex datasets, powerful computers, a high level of training and long-term commitment.

At the local level, short-term trends in soil condition and land resources are monitored. Monitoring techniques tend to be simpler and are typically directed towards judging the effectiveness of project efforts. Table 2 shows the levels and timescales for monitoring soil condition indicators.



Soil scientists gather soil cores in alluvial plains in the Gulf Country, northwest Queensland (photo by the Queensland Department of Natural Resources and Water)

**Table 2 Techniques and timescales for monitoring the four soil condition indicators**

a Wind erosion

	Short term	Medium term	Long term
National	Computed dust flux (CEMSYS) DustWatch dust concentration mapping	Computed dust flux (CEMSYS) DustWatch dust concentration mapping	Computed dust flux (CEMSYS) DustWatch dust concentration mapping
Regional	'Clip' of national CEMSYS DustWatch including PM <sup>10</sup> Roadside survey	'Clip' of national CEMSYS DustWatch including PM <sup>10</sup> Roadside survey	'Clip' of national CEMSYS DustWatch including PM <sup>10</sup>
Local	Models (eg WEAM) Survey land use and land management practices (projects)	Models (eg WEAM) Survey land use and land management practices (ABS)	Survey land use and land management practices (ABS)

b Water erosion

	Short term	Medium term	Long term
National	National erosion hazard models (eg SedNet)	National erosion hazard models (eg SedNet)	National erosion hazard models (eg SedNet)
Regional	'Clip' of national erosion hazard models Roadside survey	'Clip' of national erosion hazard models Roadside survey	'Clip' of national erosion hazard models
Local	Models (eg USLE, RUSLE, PERFECT, APSIM) Survey land use and land management practices (projects)	Models (eg USLE, RUSLE, PERFECT, APSIM) Survey land use and land management practices (ABS)	Models (eg USLE, RUSLE, PERFECT, APSIM) Survey land use and land management practices (ABS)





**Table 2 (Continued)**

**c Soil acidification**

	Short term	Medium term	Long term
National	Survey land use and land management practices (ABS)	Model pH status, NAAR and time to critical pH	Model pH status, NAAR and time to critical pH
Regional	na	'Clip' of national models Sample baseline pH and ΔpH in permanent monitoring catchments Survey land use and land management practices (ABS)	'Clip' of national models Sample baseline pH and ΔpH in permanent monitoring catchments Survey land use and land management practices (ABS)
Local	Apply pH calculators Survey land use and land management practices (projects)	Sample baseline pH and ΔpH in project catchments Survey land use and land management practices (projects)	na

**d Soil carbon**

	Short term	Medium term	Long term
National	Survey land use and land management practices (ABS)	National soil carbon models	National soil carbon models
Regional	na	'Clip' of national soil carbon models Sample ΔSOC at benchmark sites Survey land use and land management practices (ABS)	'Clip' of national soil carbon models Sample ΔSOC at benchmark sites Survey land use and land management practices (ABS)
Local	Apply carbon calculators Survey land use and land management practices (projects)	Apply carbon calculators Survey land use and land management practices (projects)	na

ΔpH = change in soil pH; ΔSOC = change in soil organic carbon; ABS = Australian Bureau of Statistics; APSIM = Agricultural Production Systems sIMulator; CEMSYS = Computational Environmental Management System; na = not applicable; NAAR = net acid addition rate; PERFECT = productivity, erosion and runoff functions to evaluate conservation techniques; PM<sub>10</sub> = particulate matter 10 microns or less in diameter; RUSLE = revised universal soil loss equation; SedNet = Sediment and river Network; USLE = universal soil loss equation; WEAM = wind erosion assessment model

## Data requirements for monitoring soil condition

Soil condition can be monitored by modelling, direct observation, or a combination of the two. In all cases, a variety of data is needed (Table 3). Some datasets are useful in planning a monitoring program or to

place results in context, while other datasets are specific requirements of the method used (eg the parameters for the universal soil loss equation model).

Data such as slope and slope length are static, while other data referring to land use, land management practices or ground cover are dynamic and must be updated frequently.



**Table 3 Categories of data required for monitoring soil condition**

Data required	Soil erosion by wind	Soil erosion by water	Soil acidification	Soil carbon change
Soil profile data (depth, texture, CEC, etc)	***	***	***	***
Soil polygon data (distribution, landform, etc)	**	***	***	***
Land use	**	**	**	**
Land management practices	***	***	***	***
Crop yields	**	***	**	**
Land use and land management statistics	*	*	*	*
Annual vegetation type, % cover, extent	***	***	**	**
Perennial vegetation type, % cover, extent	***	***	*	*
Climatic parameters (rainfall, temperature, wind, evaporation, visibility)	***	***	**	**
Parameters estimated from soil and climatic data (soil moisture, soil temperature)	**	**	*	**
Digital elevation models, including surface hydrology	*	***		
'Microtopography' (boundary layer roughness, ground surface particle size)	***	*		

CEC = cation exchange capacity

Key:

\*\*\* = specific data needed for the indicator measurement as defined in the protocol

\*\* = critical contextual data needed to understand the indicator

\* = useful contextual data that helps to understand the indicator



**Table 4 Agencies supplying national monitoring input data**

Main system (responsible agency)	Description	Website
Australian Soil Resource Information System (ASRIS) (CSIRO)	Information on soil and land resources	<a href="http://www.asris.csiro.au">http://www.asris.csiro.au</a>
Australian Collaborative Land Use Mapping Program (Bureau of Rural Sciences)	Land use and land management practice information	<a href="http://www.brs.gov.au/landuse">http://www.brs.gov.au/landuse</a>
Australian Bureau of Statistics	Statistics relevant to agricultural industries, data on area and production of crops, livestock numbers, livestock products and land management. The information is used by governments for planning, budgeting and policy making.	<a href="http://www.abs.gov.au/ausstats/abs@.nsf/web+pages/statistics?opendocument">http://www.abs.gov.au/ausstats/abs@.nsf/web+pages/statistics?opendocument</a>
NVIS (Australian Government Department of the Environment, Heritage, Water and the Arts; Environmental Resources Information Network)	Regional to national scale vegetation data	<a href="http://www.environment.gov.au/erin/nvis/data-products.html">http://www.environment.gov.au/erin/nvis/data-products.html</a>
Australian Climate Archive (Bureau of Meteorology)	Rainfall, evaporation and temperature	<a href="http://www.bom.gov.au/silo">http://www.bom.gov.au/silo</a> or <a href="http://www.bom.gov.au/climate">http://www.bom.gov.au/climate</a>
SILO (Queensland Department of Natural Resources and Water)	Spatially interpolated point and gridded national climatic data	<a href="http://www.nrw.qld.gov.au/silo">http://www.nrw.qld.gov.au/silo</a> or <a href="http://www.bom.gov.au/silo">http://www.bom.gov.au/silo</a>
Geoscience Australia	A gridded digital elevation model includes point elevation data, elevation contours, stream lines and cliff lines. The grid spacing is 9 seconds in longitude and latitude. Useful for surface shape and drainage structure. A 3-second grid will be available shortly.	<a href="http://www.ga.gov.au/nmd/products/digidat/dem_9s.html">http://www.ga.gov.au/nmd/products/digidat/dem_9s.html</a>

CSIRO = Commonwealth Scientific and Industrial Research Organisation; NVIS = National Vegetation Information System

The importance of these specific, critical contextual or useful contextual data needs cannot be overestimated. Several agencies play a role in providing these data to monitoring groups (Table 4).

The continuously updated ASRIS website provides a significant amount of specific, critical contextual or useful contextual data for monitoring. It includes land use, vegetation, climatic and topographical information, in addition to the best available soils information at a nested level of detail. Figures 3a, 3b and 3c are examples of ASRIS land use, rainfall and relief datasets, which are valuable tools for wind and water erosion modelling and for anticipating changes in soil pH and soil organic carbon.

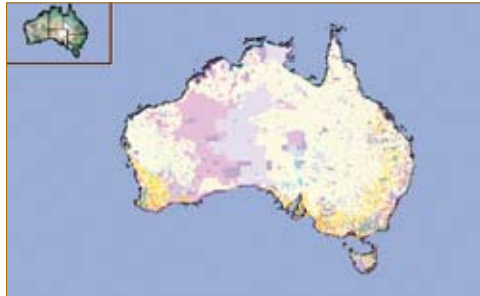
Figures 4a and 4b demonstrate some of the soil texture and soil pH information held in ASRIS while Figure 4c shows the location of reference profiles. These are among the extensive soils and soils-related information ASRIS makes available.





**Figure 3 Typical datasets available from ASRIS**

a ASRIS land use



b ASRIS precipitation



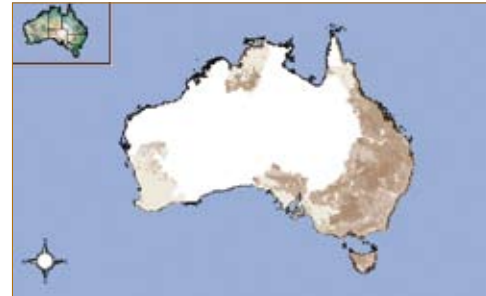
c ASRIS relief



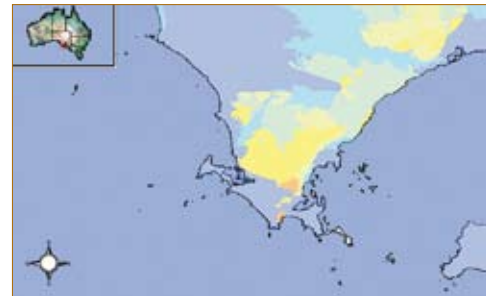
Source: <http://www.asris.csiro.au>

**Figure 4 Typical ASRIS soils and soil-related information**

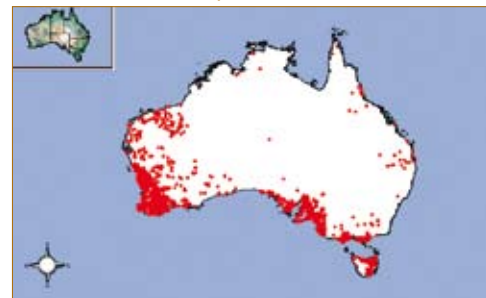
a ASRIS topsoil texture



b ASRIS pH Eyre Peninsula



c ASRIS reference profiles



Source: <http://www.asris.csiro.au>

## Data and information systems

Monitoring itself generates new data that must be standardised, quality assured, stored in well-managed database systems and made available to multiple users. There is currently no national soil condition database; however, the National Land & Water Resource Audit and the NCST have been working to establish national monitoring protocols. These, if adopted, will produce datasets to a common standard. ASRIS, which is managed by the Commonwealth Scientific and Industrial Research Organisation, is being upgraded to receive these new data fields and to accommodate time-series information from soil condition monitoring programs.

Establishing national monitoring protocols and an associated database is a major task that will take many years because agreement must be reached on minimum datasets and acceptable data definitions for all four indicators. The task is further complicated by variations in the actual monitoring techniques according to whether the scale is local, regional or national. However, the iconic *Australian Soil and Land Survey Field Handbook*, first published in 1984 (McDonald et al 1984) and revised in 1990 (McDonald et al 1990), is evidence that such a task can be achieved.

ASRIS will be able to be used to provide soil condition information directly or to provide attribute information, which can be fed into models or commissioned assessments. The way that ASRIS is set up will safeguard against the loss of data if any participating agency ceases its monitoring activity.





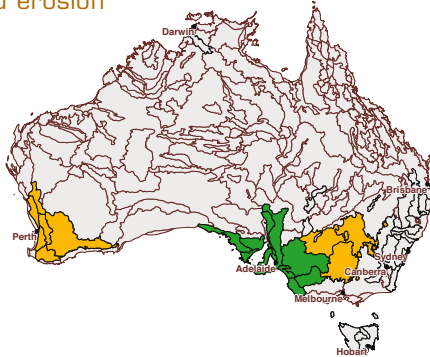
## Data availability

For most parts of Australia, only limited monitoring output data are available. Appendix 2 lists historic,

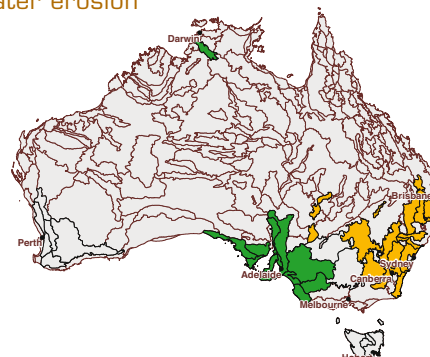
ongoing and commencing monitoring activities. Significantly, a large proportion of this is 'commencing'. The thumbnail diagrams in Figure 5 show where output data are currently available.

Figure 5 Extent and quality of soil monitoring information

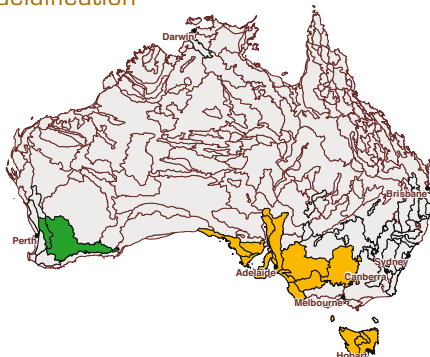
### Wind erosion



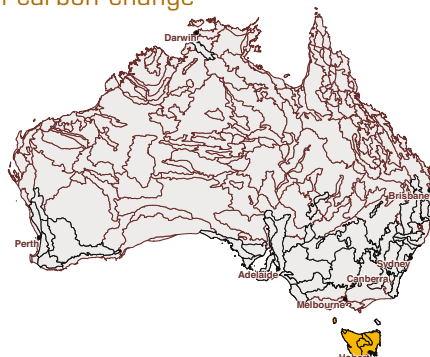
### Water erosion



### Soil acidification



### Soil carbon change



• Capital city

3 - A significant amount of monitoring data available

2 - A limited amount of monitoring data available, or of restricted scale, attribution or currency

1 - Very limited or no monitoring data available

Source: National Committee on Soil and Terrain

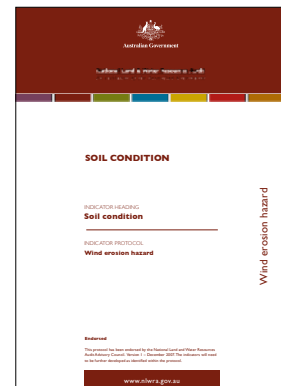
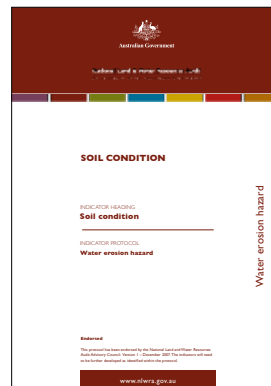
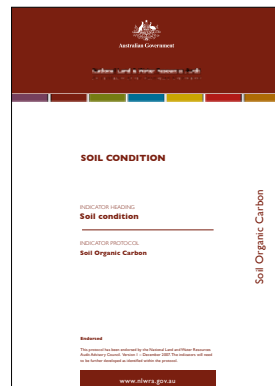
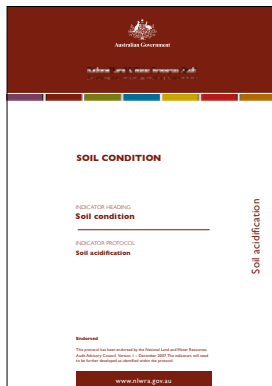
## Indicator development

Following the NCST expert panel consultations (McKenzie and Dixon 2007) and a series of monitoring trials, the NCST drafted and endorsed monitoring protocols for each of the four indicators. These protocols are 'live' documents to be updated regularly. They are intended for use at the regional level; protocols will be drafted for use at the national or local levels as the need arises.

The goal is for all agencies engaged in monitoring to adopt the same protocols, thus facilitating the entry of primary data into ASRIS. National scale analysis and reporting will be possible when uniform data are in a single repository.



Arid and eroded landscape in the Wannon catchment, flock of sheep in the background, Victoria (photo by Alison Pouliot)



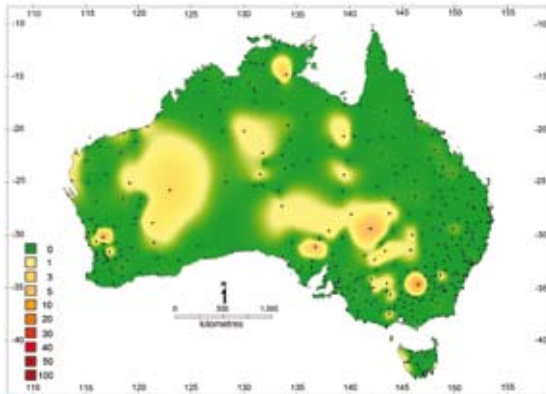
Indicator profiles for soil condition have been developed by the National Committee for Soil and Terrain and are available from [www.nlwra.gov.au](http://www.nlwra.gov.au)



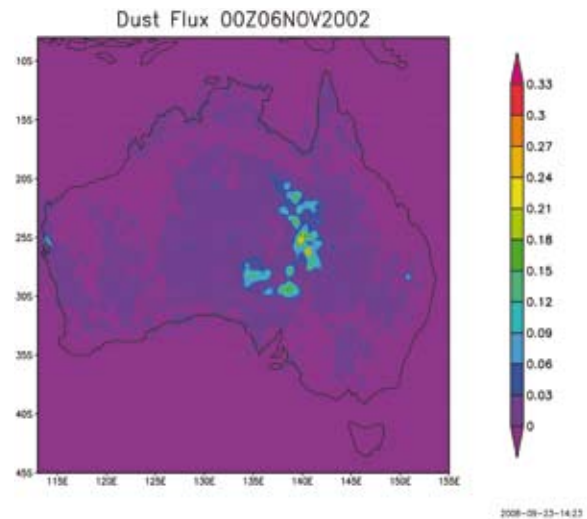
## Data and information products

Information products are often designed specifically to communicate results to funding providers and decision makers (eg maps, tables, histograms, pie charts) rather than basic, partly transformed or processed field measurements. A good example of an information product that uses 'traffic light' colours to illustrate catchment condition is the *Wet Tropics Catchment Condition Report Card*.<sup>2</sup>

### Examples of information products for wind erosion



Wind erosion across Australia in 2001, represented by the annual dust storm index (Source: McTainsh and Tews 2007)

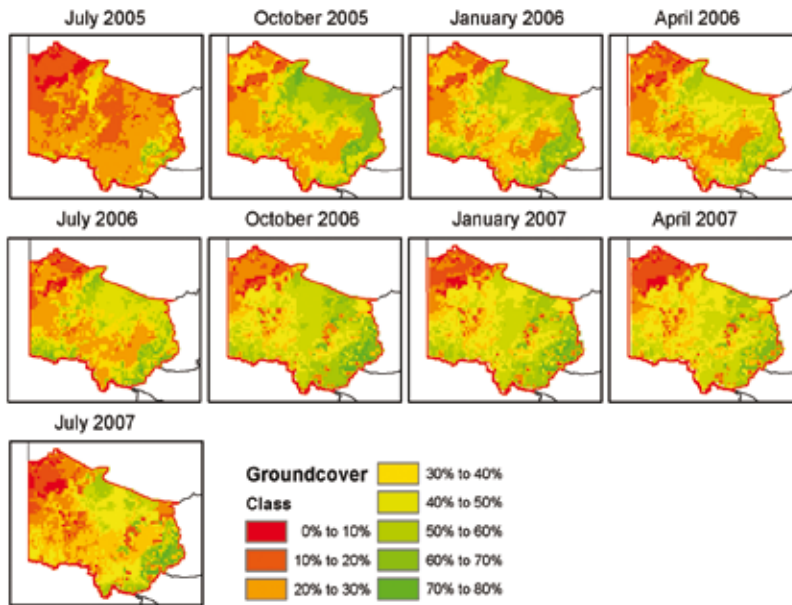


Simulated 6-hour average dust flux across Australia in November 2002, using the Computational Environmental Management System (CEMSYS) model (Source: Butler et al 2007)

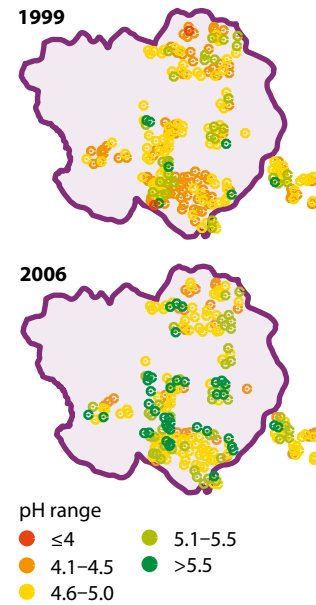
Like data, information products also need to be standardised, quality assured, stored in a well-managed repository and be accessible to users — these aspects need to be developed further. Information products could be made available through the Australian Natural Resources Atlas (which includes Map Maker, an online tool for creating maps at regional and national levels) or on Australia's Resources Online,<sup>3</sup> which has been developed by the Audit for reporting on the National M&E Framework indicators.

<sup>2</sup> <http://www.nlwra.gov.au>

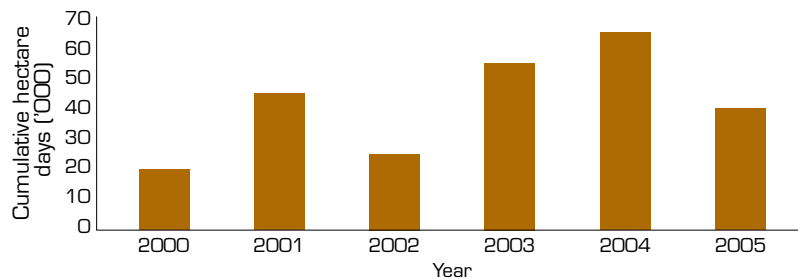
<sup>3</sup> <http://www.anra.gov.au/aro>



Time series of predicted ground cover from AussieGRASS (http://www.longpaddock.qld.gov.au/AboutUs/ResearchProjects/AussieGRASS/index.html) for lower Murray Darling CMA.



Topsoil (0–10 cm) pH measured in 1999 and 2006 in the Gabby Guoi Guoi catchment (Source: Gazey et al 2007)



Wind erosion risk in the Western Australian wheatbelt (Source: Carter et al 2007)



## Discussion and way forward

Making regular national soil condition accounts available to the Australian Government and the Australian people requires a long-term commitment from many agencies.

The Audit and its partner organisations have consulted the experts, conducted trials, developed protocols and reviewed existing data for monitoring the soil condition indicators.

Recommendations for the improvement of availability and quality of soil monitoring information include:

- review indicator protocols regularly and promote their widespread use
- develop and test information products to ensure that they meet the needs of decision makers at all levels

- develop ASRIS to accommodate time-series monitoring data
- make available quality contextual datasets (on soils, land use, vegetation, climate, topography)
- develop the capacity to model future soil condition in response to climate change or new farming practices
- rebuild the national soil knowledge base.

Australia has a relatively small scientific community, so the best monitoring outcomes can be achieved by nominating a lead agency for each indicator. The next step is to establish the level of investment required to achieve the desired monitoring outcome.

## Appendix 1 The National Monitoring and Evaluation Framework

The National Natural Resource Management Monitoring and Evaluation Framework (referred to in this series as 'the National M&E Framework') was endorsed by the Natural Resource Management Ministerial Council in 2002. It was developed to assess progress towards improved natural resource condition through the development of accurate, cost-effective and timely information on:

- the health of Australia's land, water, vegetation and biological resources
- the performance of programs, strategies and policies that provide national approaches to the conservation, sustainable use and management of these resources.

Assessment of information collated under the National M&E Framework will assist the Ministerial Council to 'identify areas of concern and to better target the use of resources'.

The framework identifies three key requirements for monitoring natural resource condition:

1. a set of natural resource condition indicators (including those for the 'matters for target' identified in the National Framework for Natural Resource Management Standards and Targets) to measure progress towards agreed national outcomes on a medium and long term basis
2. a set of indicators for monitoring community and social processes relevant to or affected by natural resource management programs, as well as measures of the adoption of sustainable development and production techniques
3. contextual data pertinent to the indicator being considered.

The National Land & Water Resources Audit ('the Audit') is responsible for ongoing development of these indicators, as well as supporting the national collection and collation of data, and reporting against each indicator.

Such reporting will help to answer questions such as:

- What is the nature and extent of the issue?
- Is the existing or proposed intervention appropriate for the size of the issue?





- What types of intervention work best, are most cost effective, and have the best transferability across regions?
- What was the impact of the policy or program investment — in the intermediate and long term?

Monitoring and evaluation of core indicators supports evidence-based decision making at national, state and territory, and regional levels. However, each level may have a wide variety of data and information needs, in terms of content, context or scale. There is also complexity across the three levels of use associated with multiple needs, values, preferences and timeframes.



Handful of soil (photo by Mark Imhof)

## Appendix 2 Current state and territory soil condition monitoring activities across Australia



### Australian Capital Territory

Indicator	Responsible agency	Status of monitoring	Scale of monitoring	Extent of monitoring	Start date (end date, if applicable)	Information system	Where available
Wind erosion	NSW DECC	Commencing	–	–	Jan 2008	–	SMU when arrangements have been made
Water erosion	NSW DECC	Commencing	Windscreen survey of ground cover overlaid on USLE 25 m × 25 m pixel map	Three SMUs, each with about 50 points	Jan 2008	SALIS and DECC Geodatabase	SMU when arrangements have been made
Soil acidification	NSW DECC	Commencing	–	Three SMUs, each with 40 samples from 10 sites	Jan 2008	SALIS	SMU when arrangements have been made
Soil carbon change	NSW DECC	Commencing	–	Three SMUs, each with 40 samples from 10 sites	Jan 2008	SALIS	SMU when arrangements have been made

– = data not available; NSW DECC = New South Wales Department of Environment and Climate Change; SALIS = Soil and Land Information System; SMU = soil monitoring unit; USLE = universal soil loss equation



## New South Wales

Indicator	Responsible agency	Status of monitoring	Scale of monitoring	Extent of monitoring	Start date (end date, if applicable)	Information system	Where available
Wind erosion (DustWatch) <sup>a</sup>	DECC	Ongoing	–	Expanding to areas of NSW where wind erosion is an issue	2004	DustWatch MADD	DECC
Wind erosion (Roadside survey) <sup>b</sup>	DECC	Ongoing	Within-CMA, five SMUs per CMA anticipated	Seven (not all) CMAs have wind erosion as an issue for monitoring	–	LandMAPT	DECC
Wind erosion (PM <sub>10</sub> ) <sup>c</sup>	DECC	Ongoing	21 sites as of 2008	Expanding to areas of NSW where wind erosion is an issue	–	MADD	DECC
Water erosion <sup>d</sup>	DECC	Commencing	Three SMUs, each with about 50 points per unit	–	Jan 2008	EDB	DECC
Soil acidification <sup>e</sup>	DECC	Commencing	Three SMUs, each with 10 sites and 4 samples per site	–	Jan 2008	SALIS	DECC

## New South Wales (continued)

Indicator	Responsible agency	Status of monitoring	Scale of monitoring	Extent of monitoring	Start date (end date, if applicable)	Information system	Where available
Soil carbon change <sup>e</sup>	DECC	Commencing	Three SMUs, each with 10 sites and 4 samples per site	Five CMAs	Jan 2008	SALIS	DECC

– = data not available; CMA = Catchment Management Authority; DECC = Department of Environment and Climate Change; EDB = event database; GPS = global positioning system; MADD = meteorological and dust data; PM<sub>10</sub> = particulate matter 10 microns or less in diameter; SALIS = Soil and Land Information System; SMU = soil monitoring unit; USLE = universal soil loss equation

<sup>a</sup> From community supplied observations

<sup>b</sup> From windscreen survey

<sup>c</sup> From instrumented dust collector network

<sup>d</sup> Gully erosion by digital airborne imagery plus differential GPS

<sup>e</sup> Field work

## Northern Territory

Indicator	Responsible agency	Status of monitoring	Scale of monitoring	Extent of monitoring	Start date (end date, if applicable)	Information system	Where available
Wind erosion	–	–	–	–	–	–	–
Water erosion	DNREA	Ongoing	–	Daly Lowlands	–	–	Land and Vegetation DNREA
Soil acidification	–	–	–	–	–	–	–
Soil carbon change	–	–	–	–	–	–	–

– = data not available; DNREA = Department of Natural Resources, Environment and the Arts



## Queensland

Indicator	Responsible agency	Status of monitoring	Scale of monitoring	Extent of monitoring	Start date (end date, if applicable)	Information system	Where available
Wind erosion <sup>a</sup>	Griffith University School of Environment	Ongoing	–	National	Various (continuing)	CEMSYS, DSI	Griffith University
Water erosion	NRW	Research sites only	–	–	–	–	–
Soil acidification	NRW	Research sites only	–	–	–	SALI	NRW
Soil carbon change	NRW	Research sites only	–	–	–	SALI	NRW

– = data not available; CEMSYS = Computational Environmental Management System; DSI = dust storm index; NRW = Natural Resources and Water (Department of); SALI = Soil and Land Information

<sup>a</sup> Both systems rely on Bureau of Meteorology records with various start dates and observation densities

## South Australia

Indicator	Responsible agency	Status of monitoring	Scale of monitoring	Extent of monitoring	Start date (end date, if applicable)	Information system	Where available
Wind erosion <sup>a</sup>	DWLBC	Ongoing	Representative transects across land zones	Agricultural region of SA	1999 (program to run until at least 2014)	–	DWLBC Knowledge and Information Division, Resource Monitoring

## South Australia (continued)

Indicator	Responsible agency	Status of monitoring	Scale of monitoring	Extent of monitoring	Start date (end date, if applicable)	Information system	Where available
Water erosion <sup>b</sup>	DWLBC	Ongoing	Representative transects across land zones	Agricultural region of SA	1999 (program to run until at least 2014)	–	DWLBC Knowledge and Information Division, Resource Monitoring
Soil acidification	DWLBC	Ongoing, updated annually	–	Agricultural region of SA	1976 (ongoing)	SASPAS soil analysis database	DWLBC
Soil carbon change	–	–	–	–	–	–	–

– = data not available; DWLBC = Department of Water, Land and Biodiversity Conservation; SASPAS = South Australian Soil and Plant Analysis Service

<sup>a</sup> Windscreen field survey

<sup>b</sup> Resampling of some long-term soil pH monitoring sites

## Tasmania

Indicator	Responsible agency	Status of monitoring	Scale of monitoring	Extent of monitoring	Start date (end date, if applicable)	Information system	Where available
Wind erosion	DPIW	Commenced and ongoing	Not specifically monitored, but inferences may be made from long-term reference sites (ASRIS) and representative transects	Regional (300 sites statewide)	Site establishment commenced 2004 with planned, indefinite 5-yearly monitoring	SCEAM	DPIW Sustainable Land Use Section



### Tasmania (continued)

Indicator	Responsible agency	Status of monitoring	Scale of monitoring	Extent of monitoring	Start date (end date, if applicable)	Information system	Where available
Water erosion	DPIW	Commenced and ongoing	Not specifically monitored, but inferences may be made from long-term reference sites (ASRIS) and representative transects	Regional (300 sites statewide)	Site establishment commenced 2004 with planned, indefinite 5-yearly monitoring	SCEAM	DPIW Sustainable Land Use Section
Soil acidification	DPIW	Commenced and ongoing	Long-term reference sites (ASRIS) and representative transects	Regional (300 sites statewide)	Site establishment commenced 2004 with planned, indefinite 5-yearly monitoring	SCEAM	DPIW Sustainable Land Use Section
Soil carbon change	DPIW	Commenced and ongoing	Long-term reference sites (ASRIS) and representative transects	Regional (300 sites statewide)	Site establishment commenced 2004 with planned, indefinite 5-yearly monitoring	SCEAM	DPIW Sustainable Land Use Section

ASRIS = Australian Soil Resource Information System; DPIW = Department of Primary Industries and Water; SCEAM = soil condition evaluation and monitoring

## Victoria

Indicator	Responsible agency	Status of monitoring	Scale of monitoring	Extent of monitoring	Start date (end date, if applicable)	Information system	Where available
Wind erosion	DPI	Ongoing, remote sensing currently being assessed to enhance monitoring program	2006–08: twice per year (Jan–Mar and Aug–Sept) 160 georeferenced sites assessed in the Mallee region as representative of key land systems. Estimates are made of ground-cover and erosion (visual assessment).  1986–2006: yearly roadside visual assessments, not georeferenced	Agricultural areas of Mallee region	Monitoring with georeferencing has only been undertaken in the Mallee region for past 2 years; previous 20-year program was not georeferenced	No formalised system, spreadsheets and Word documents	Lara Wakefield (DPI Walpeup)
Water erosion	–	–	–	–	–	–	–





## Victoria (continued)

Indicator	Responsible agency	Status of monitoring	Scale of monitoring	Extent of monitoring	Start date (end date, if applicable)	Information system	Where available
Soil acidification	DPI, research	Not currently operational	Long-term benchmark sites to assess pH change. In 1993, 54 former NSFP pasture sites (measured 1970–72) resampled for pH; transponders located at sites for potential reassessment	Pasture sites in all regions of Victoria, except Wimmera and Mallee	1970 (1993)	No formalised system, spreadsheets	DPI Werribee
	DPI, research	Not currently operational	Fenceline sites to assess pH changes under Victorian pastures; 107 pasture sites assessed in 1990s (each included a reference area, eg native vegetation or cemetery site)	Pasture sites across Victoria in > 450 mm rainfall zone	Early 1990s	No formalised system, spreadsheets	DPI Werribee
	DPI, research	Not currently operational	117 soil condition monitoring sites (1995–97); annual measurements of soil properties including pH and soil carbon change	Northern and north-western Victoria, cropping region	1995 (1997)	No formalised system, spreadsheets	DPI Rutherglen

## Victoria (continued)

Indicator	Responsible agency	Status of monitoring	Scale of monitoring	Extent of monitoring	Start date (end date, if applicable)	Information system	Where available
Soil carbon change	DPI, research	Terminated	117 soil condition monitoring sites (1995–97); annual measurements of properties including pH and soil carbon change	Northern and north-western Victorian cropping regions	1995 (1997)	No formalised system, spreadsheets	Archived at DPI Rutherglen
	DPI, research	Terminated	20 soil carbon change monitoring sites, 2004–07	Northern Victoria, irrigated cropping	2004 (2007)	No formalised system	Current GRDC project, archived at DPI Tatura

– = data not available; DPI = Department of Primary Industries; GRDC = Grains Research and Development Corporation; NSFP = National Soil Fertility Project

## Western Australia

Indicator	Responsible agency	Status of monitoring	Scale of monitoring	Extent of monitoring	Start date (end date, if applicable)	Information system	Where available
Wind erosion	DAFWA	To commence 2008	Representative transects	Agricultural zone of WA	To commence 2008	ASRIS-WA	–
Water erosion	DAFWA	To commence 2008	Representative transects	Agricultural zone of WA	To commence 2008	ASRIS-WA	–
Soil acidification	DAFWA	To commence 2008	Representative catchments	Agricultural zone of WA	To commence 2008	ASRIS-WA	–
	ACC	Half-way through 3-year program	Representative areas	Three areas within the Avon Basin	2007–09	–	–
Soil carbon change	DAFWA	To commence 2008	Representative catchments	Agricultural zone of WA	To commence 2008	ASRIS-WA	–

– = data not available; ACC = Avon Catchment Council; ASRIS-WA = Australian Soil Information System, Western Australia; DAFWA = Department of Agriculture and Food, Western Australia



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## About the 'Status of Natural Resource Information' series

This series of booklets outlines the status of data and information relating to indicators agreed under the National Natural Resource Management Monitoring and Evaluation Framework (2002). Each booklet describes the status of coordination, indicators, information management systems, and data and information products for a particular theme area.

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- Inland aquatic (wetlands)
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- Land use
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