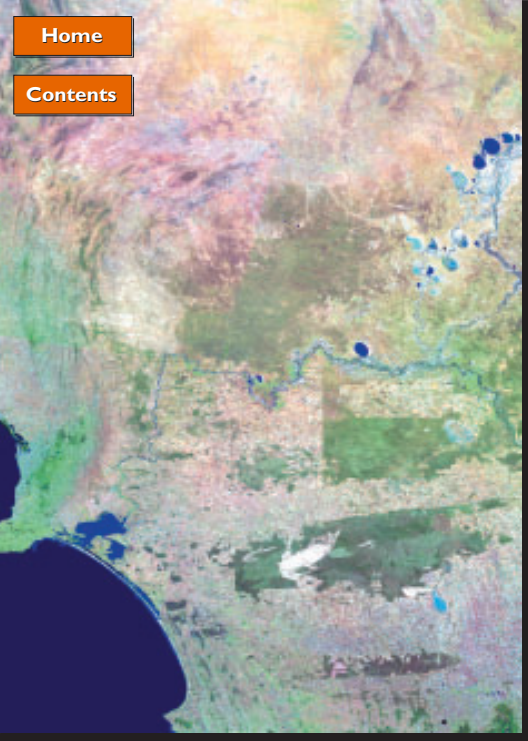

Natural Heritage Trust

Helping Communities Helping Australia

A Commonwealth Government Initiative

AUSTRALIAN NATURAL RESOURCES INFORMATION 2002

National Land & Water Resources Audit

A program of the Natural Heritage Trust

NATIONAL LAND AND WATER RESOURCES AUDIT

Providing Australia-wide assessments

The National Land and Water Resources Audit (the Audit) is facilitating improved decision-making on land, vegetation and water resource management in Australia by:

- **Providing a clear understanding** of the status of, and changes in, the nation's land, vegetation and water resources and implications for their sustainable use.
- **Providing an interpretation of the costs and benefits** (economic, environmental and social) of land and water resource change and any remedial actions.
- **Developing a national information system** of compatible and readily accessible natural resources data.
- **Producing national** land and water (surface and groundwater) **assessments** as integrated components of the Audit.
- **Ensuring integration** with, **and collaboration** between, other relevant initiatives.
- **Providing a framework for monitoring** Australia's land and water resources in an ongoing and structured way.

In partnership with Commonwealth, State and Territory agencies, through its theme activities - Water Availability; Dryland Salinity; Native Vegetation; Rangeland Monitoring; Agricultural Productivity and Sustainability; Australians and Natural Resource Management; Catchments, Rivers and Estuaries Condition; and Information Management – the Audit has prepared:

Assessments of the status of and, where possible, recent changes in Australia's land, vegetation and water resources to assist decision makers achieve ecological sustainability. The assessments set a baseline or benchmark for monitoring of change.

Integrated reports on the economic, environmental and social dimensions of land, and water resource management, including recommendations for management action.

An **Australian Natural Resources Atlas and Data Library** to provide Internet-based access to integrated national, State and regional data and information about key natural resource issues.

Guidelines and protocols for assessing and monitoring the condition and management of Australia's land, vegetation and water resources.

This report presents the key findings for **Australian Natural Resources Information 2002**:

> *Development of a national system of natural resource information to support nationwide assessments of Australia's land, vegetation and water resources.* The *Australian Natural Resources Information 2001 – Operational Manual* describes in detail the technical issues, standards, guidelines and protocols associated with the design and development of the Australian Natural Resources Atlas and Data Library. The operational manual is available on the Internet at http://audit.ea.gov.au/ANRA/docs/op_manual.html.

The information systems and databases were built in partnership with Commonwealth, State and Territory agencies.

AUSTRALIAN NATURAL RESOURCES INFORMATION 2002

National Land & Water Resources Audit
A program of the Natural Heritage Trust

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Disclaimer

We invite all interested people, both within and outside Government, to make use of the Audit's reports, information, its Atlas and products. We encourage you to discuss the Audit's findings with the various partners and contributors that have prepared this information.

The Commonwealth accepts no responsibility for the accuracy or the completeness of any material contained in this report and recommends that users exercise their own skill and care with respect to its use.

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National Land & Water Resources Audit
A program of the Natural Heritage Trust

The Hon. Warren Truss MP
Minister for Agriculture, Fisheries and Forestry
Parliament House
Canberra ACT 2600

The Hon. Dr David Kemp MP
Minister for the Environment and Heritage
Parliament House
Canberra ACT 2600

Dear Ministers

I have pleasure in presenting to you *Australian Natural Resources Information 2002*—a report of the National Land and Water Resources Audit (Audit).

For over one hundred years, politicians, industry and the community have sought better access to integrated and consistent information to support natural resource decision making, to set priorities and invest wisely in natural resource works and activities. Through Audit projects and a successful partnership between State, Territory and Commonwealth agencies, we now have an Australia-wide system of natural resource, agricultural, environmental and social information continuously available to the community.

The Natural Heritage Trust, through the Audit, has delivered significant improvements in the quality, consistency and availability of Australia-wide natural resources information to the community. These include:

- improved community access to data and information about natural resources;
- new natural resources data about land use, soils, salinity, estuaries, river condition, water and native vegetation resources; and
- a landmark agreement between the Audit and ANZLIC – the Spatial Information Council, supported by the Commonwealth and all States and Territories, to significantly streamline access to data required for natural resource assessments.

Improved community access to data and information about natural resources has come about by the establishment of one of the most comprehensive natural resource information systems in the world. This information is available through the Australian Natural Resources Atlas and Data Library where data and information that were previously dispersed and incompatible are now linked and integrated.

This information base must be built upon if the benefits —such as more informed, efficient and cost-effective natural-resource decision making—are to be fully realised.

The Audit provides a model for better doing government business. An Australia-wide partnership to provide natural resources information, assessment and reporting is advocated. This partnership would be coordinated by the Commonwealth working with the States, Territories and industry. Strategic and consistent collection and management of data will deliver efficiencies in data collection at the local scale. Collation and integration of well-managed local data into information products will then deliver efficiencies for natural resource management investments. The benefits of this more coordinated approach are across all sectors—community, industry, local, State and Commonwealth government.

The Audit Advisory Council commends this report to you, together with the supporting information in the Australian Natural Resources Atlas and Data Library. In total, they provide a significant information base for improved natural resource management within Australia.

I am pleased to present this report to the Natural Heritage Ministerial Board.

Yours sincerely

Roy Green

Chair
National Land and Water Resources Audit Advisory Council

January 2002

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INTRODUCTION

Australian Natural Resources Information 2002

Before Federation, a Royal Commission into water conservation in New South Wales in 1887 reported on the adequacy of information about water resources:

> *On entering our duties we found ... that information available regarding our rivers was meagre and fragmentary, and that in some important points public opinion was in danger of being misled by statements and theories which there was ample evidence to refute.*
>
> *... we beg to recommend that the maintenance of river gauge records as extended by us should be made still more complete, and the records kept continuously and in a careful and systematic manner.*

Parliament of the Colony of New South Wales (1887)

One hundred and fourteen years after the Royal Commission, the House of Representatives Standing Committee on Environment and Heritage Inquiry into Catchment Management reported:

> *... from the evidence it has received, it is convinced that there is enough information to formulate policies and strategies. The Committee, however, is aware that the dissemination of reliable information throughout government, industry and local communities can be very poor.*
>
> *... It is also clear that ineffective use of data have limited the success of current catchment management programs.*
>
> *... the Committee concludes that while there is an expanding body of information in this area, it is often inaccessible, patchy, uncoordinated and uncollated.*

Parliament of the Commonwealth of Australia (2001)

The messages about the availability and quality of natural resources information today are fundamentally the same as in 1887. In many cases there is already ample information to inform debate, but:

- data and information are often fragmented and difficult to find;
- some fundamental natural resource data are not being managed systematically; and
- coordinated programs are needed to maintain and fill gaps in time series data.

Australian Natural Resources Information 2002 describes the progress made by the Audit and its State, Territory, Commonwealth and industry partners in addressing these issues.

- Community access to data and information about natural resources has been improved by establishing one of the world's most comprehensive natural resource information systems. Access is through the Australian Natural Resources Atlas and Data Library where results of Audit assessments and integrated views of data and information are presented.
- New Australia-wide natural resources data about land use, soils, salinity, estuaries, water and native vegetation resources have been developed.
- A landmark agreement has been developed between the Audit and ANZLIC – the Spatial Information Council, supported by the Commonwealth and all States and Territories, to significantly streamline access to data required for natural resource assessments and management.

Collecting, collating and standardising information through programs such as the Audit is expensive. Lessons from the past suggest there is a danger that the systems, data and partnerships that have been developed over the past four years will not be maintained. This report provides a plan to help ensure that this investment is not lost.

Summary of recommendations

This report discusses the development of Australia-wide natural resource information and demonstrates the benefits of a coordinated and integrated approach to the development of information products to support natural resource managers. It also highlights areas where we must better manage our investment in information.

Recommendations are summarised below and are described in detail in the report:

1. Building fundamental data (page 36)
2. Providing community access to information (page 49)
3. Maximising value for money (page 54)
4. Reporting progress (page 54)

Building fundamental data

Consistent, Australia-wide natural resource data must be maintained and updated to recognised standards to support multiple uses by governments, industry and the community. Maintenance of the data will support applications including:

- future natural resource assessments;
- programs such as the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality; and
- local, regional and national State of the Environment reporting.

It is recommended that the following Australia-wide databases developed by the Audit continue to be updated and maintained as part of the Australian Spatial Data Infrastructure. They should be maintained by a partnership of governments, industry and community.

- *Surface water and groundwater use, availability and allocation*: five-yearly updates coordinated by Agriculture, Fisheries and Forestry – Australia
- *Surface water management areas*: five-yearly updates coordinated by Geoscience Australia
- *Land use and land management*: 2003 update undertaken by Agriculture, Fisheries and Forestry – Australia
- *Native vegetation*: five-yearly updates coordinated by Environment Australia in partnership with Agriculture, Fisheries and Forestry – Australia
- *Salinity extent and groundwater flow systems*: maintenance and update coordinated by Agriculture Fisheries Forestry – Australia in partnership with the National Dryland Salinity Program
- *Soil properties*: maintenance and update coordinated by CSIRO Division of Land and Water as part of the Australian Collaborative Land Evaluation Program
- *River health*: five-yearly updates coordinated by Environment Australia
- *Estuaries*: five-yearly updates coordinated by Geoscience Australia

Australia-wide, multi-scaled databases should be based on the best available local, regional and national data.

Providing community access to information

Increasing availability and use of natural resource information maximises investment in data and is an essential part of gaining widespread understanding of the extent and significance of natural resource issues. From this understanding, governments, industry and the community can determine priorities for managing natural resources.

To further develop a network of community information services that can support natural resource management and reporting applications, it is recommended that the Australian Natural Resources Atlas and Data Library be maintained as part of the Australian Spatial Data Infrastructure.

Maximising value for money

To assist developing consistent, quality data, it is recommended that all agencies use standard conditions in contracts and agreements when funding collection of natural resource data. Conditions should seek to improve the availability of consistent natural resource data to government, industry and the community.

Reporting progress

It is recommended that progress implementing the natural resource spatial data infrastructure be reviewed annually by ANZLIC – the Spatial Information Council and reported to the Natural Resource Management Ministerial Council.

BUILDING AN INTEGRATED NATURAL RESOURCES INFORMATION SYSTEM

Natural resource management requires sound monitoring, reporting and assessment to track progress and maximise returns on investment. Australia has the opportunity to improve the efficient use of natural resources by allowing decisions about their allocation to be clearly based on the compilation, integration, analysis and interpretation of the best available scientific and technical information.

A broad community of users requires access to natural resources information to make optimal decisions.

Requirements for natural resource information

National, State and Territory governments

Ministers, government agencies, Ministerial councils and their standing committees require data and information about natural resources to:

- underpin assessments of the status and trends in condition of Australia's resources at scales that allow broad priorities to be set and outcomes to be measured against those priorities;
- evaluate regional plans in the context of partnership initiatives (e.g. the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality), to ensure the plans are robust and address priority issues in the region;
- monitor compliance with legislation;
- track progress in initiatives, their impacts and effectiveness in fostering change to meet targets; and
- meet regional, national and international reporting obligations.

Regional

Regional communities and organisations require data and information about natural resources to:

- underpin community participation in preparing, implementing and evaluating natural resource management plans;
- help provide an understanding of the geographic distribution of problems and their implications across the region;
- track improvements in the condition of the environment and progress towards meeting targets and agreed outcomes in regional plans;
- assess the effectiveness of land conservation activities; and
- improve awareness of landscape processes.

Private sector

The private sector requires better information to:

- target investment;
- optimise matching land use and management with available landscape resources; and
- implement environmental management systems.

Scientific community

The scientific community requires improved natural resource information to:

- better understand biophysical processes;
- create improved landscape management tools (e.g. better simulation models to assess the environmental impact of farming systems); and
- develop improved natural resource management systems.

Issues such as ecological sustainability and the social and economic impacts of land degradation pose questions such as:

- Where are current land use practices sustainable?
- What management actions are appropriate across industries and commodities to minimise off-site impacts?
- What are the social and economic effects of land degradation on rural Australia?

To answer these questions we need data about agricultural land use practices, land tenure, land degradation patterns and commodity economics. Investment in natural resource data and information must ensure that data are:

- relevant—providing factual social, economic, and environmental information that meet requirements of users with different perspectives, interests and values;
- accessible—presented in a way that is easy to understand and readily available; and
- consistent and comparable—able to be integrated with other data to analyse trends in the state of natural resources.

Dryland salinity in the Boorowa Shire

We realise salinity as a problem, is here now and it is a problem for the future.

It is affecting our Council infrastructure, our roads, pipelines, water mains, building foundations. It is happening whether you know about it or not.

When the stakes are so high, the costs are potentially so great local councils must have good information on which to base decisions. The [Australian Natural Resources] Atlas is a much-needed addition, a welcome new tool to assist councils in decision making. For Boorowa, the compilation of this information and its accessibility helps shed light as we make difficult choices. We'll certainly be endeavouring to ground-truth this information and feedback our knowledge to the Audit directly and via the likes of Greening Australia. This will also help develop a growing body of knowledge.

Robert Gledhill—Mayor Boorowa Shire
September 2001

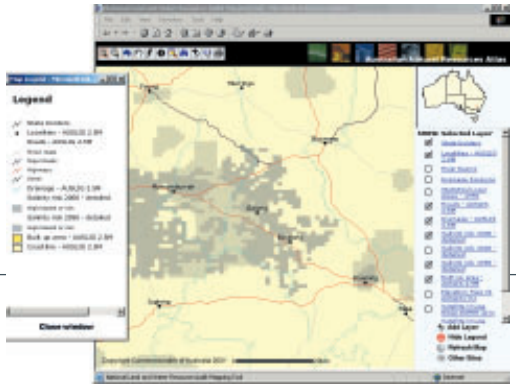


Figure 1. Using the Australian Natural Resources Atlas to map projected salinity risk in 2050 in the region around Boorowa, New South Wales.

Building the information services

Building on past achievements, the Audit has designed information services at scales relevant to decision makers, mainly at national and regional scales. Audit work plans were designed to assess the status and, where possible, trend of Australia's natural resource base and to apply this information to identify management priorities and actions.

The Audit adopted an integrated data cycle and data management approach as outlined by the Australian National Audit Office (ANAO 1998).

Building the system

1998

Reviewing user requirements

Requirements of State, Territory and Commonwealth government users were reviewed to define the scope, quantity and quality of natural resource data needed to meet their needs (Hassall and Associates 1998).

Strategic work plan formulation

Priorities identified were translated into the strategic work plan (NLWRA 1998) and thematic work plans.

1999

Data management arrangements

Protocols were agreed with State, Territory and Commonwealth data custodians to minimise duplication of effort in data collection. A common data management framework was developed for all Audit projects. The framework defined geographic referencing benchmarks, standard coding and terminology. An information management manual identifying guidelines for data collection and data transfer was released. The guidelines ensured that data products from Audit projects could be easily used in Audit assessments and successfully integrated into the Australian Spatial Data Infrastructure.

2000

System design

Data management and reporting systems were designed and developed. A prototype of the Australian Natural Resources Atlas was released in April 2000. Testing of the system by users was used to improve access to information and the design of the service. The primary focus of the Audit's public information management services has been to present national assessments. Data and information in the Australian Natural Resources Atlas were linked where possible to information available over the Internet from State and Territory agencies to assist users find more detailed information.

2001

Analysis and reporting

Integrated results of Audit assessments were made available as they were completed through the Australian Natural Resources Atlas and Data Library. Results were also linked to the most up-to-date data available from State, Territory and Commonwealth agencies. The Australian Natural Resources Atlas and Data Library are continuously being updated.

Maintenance

Arrangements are being established for continued updating and management of fundamental sets of data such as native vegetation, land use and soils. This will help ensure that systems continue to be updated and managed for future natural resource assessments and monitoring of the environment. The *Australian Natural Resources Information Operational Manual* (NLWRA 2001f) details the technical issues, standards, guidelines and protocols associated with the design and development of the system.

Data access agreement

A landmark national agreement to improve access to natural resource data for the community was signed with ANZLIC – the Spatial Information Council. The agreement is supported by data custodians from all governments and streamlines access to and the transfer, sharing and management of, natural resources data.

Figure 2 illustrates the type of information products that are available through the Australian Natural Resources Atlas and Data Library, and the links with other community information services available over the Internet.

Figure 2. A distributed network of natural resource information systems.

The red arrows indicate the many ways of getting access to information products available from the Audit.

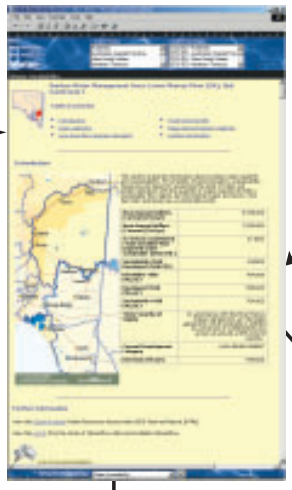
The black arrows indicate the linkages within the Australian Natural Resources Atlas and Data Library and from these services to other natural resources information available over the Internet.

Tell me about an issue in a region

Regional profiles and fact sheets in the Australian Natural Resources Atlas

What reports are available to provide further information?

Assessment and project reports from Audit projects



What information products are available from the Audit for this place?

Navigator—an index to information products available from the Audit

Can I get free access to the data to use in my system?

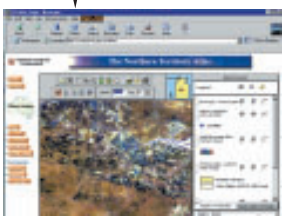
Australian Natural Resources Data Library—access to the data from Audit projects

Make a map of this region

The Australian Natural Resources Atlas Map Maker

What data are available?

The Australian Spatial Data Directory—national directory for map data



What other relevant information is available on the Internet?

Links to other State and Territory atlases

Building an inconsistent infrastructure can be costly to standardise after it is in place

Streamlined access to consistent, Australia-wide natural resource data

Many Australia-wide natural resource databases are incomplete and inconsistent. Data quality and accuracy are often unknown.

The Audit adopted the following principles so that data and information products could be integrated to help answer natural resource management questions, as well as support the ongoing development of the Australian Spatial Data Infrastructure.

To ensure that data from Audit projects are comparable and consistent where required all data were:

- developed and maintained to **meet agreed international or national guidelines or standards** for the management of information as endorsed by ANZLIC – the Spatial Information Council or through national coordination arrangements.

To help users easily find and get access to the data from Audit projects, all data are:

- **documented** in the Australian Spatial Data Directory. The documentation provides enough information for users to determine whether the data are suitable for their purpose.
- **easily accessible** to all sectors of the community in formats, location, cost and under conditions that promote their wide use.

To protect the rights of all contributors to the data, all data are:

- **accompanied by a licence** when transferred clearly setting out the conditions under which the data may be used, the rights and responsibilities of the data provider, and the rights and responsibilities of the data receiver. Licence arrangements ensure map information is accessible, while still protecting copyright, intellectual property, privacy and confidentiality. Rights relate to both individuals and governments.

The following chapters demonstrate the implementation of the Australian Spatial Data Infrastructure principles to efficiently build, analyse and distribute natural resources data.

Australian Spatial Data Infrastructure

ANZLIC – the Spatial Information Council is responsible for coordinating the implementation of the Australian Spatial Data Infrastructure.

The Australian Spatial Data Infrastructure is a national initiative to provide better access to essential spatial data. The Australian Spatial Data Infrastructure has four elements:

Fundamental data

Fundamental data are the Australia-wide data that are required by more than one government agency. All data are checked for format documentation content, standards, accessibility, quality, and have arrangements to ensure that the data are maintained.

Distribution

A distribution network for enquiring, search, discovery, viewing, and retrieval of data over the Internet.

As a first step, the Australian Spatial Data Directory was established in 1998 to provide a service, available over the Internet, to help users to quickly find spatial data of interest to them.

Standards

International standards are applied to data to simplify access and improve data quality and integration. Standards are required for consistent reference systems, data quality, data transfer and documentation.

Institutional framework

The policy and administrative arrangements for building, maintaining, accessing and applying the standards and data for a national data infrastructure.

ANZLIC – the Spatial Information Council

ANZLIC – the Spatial Information Council is the peak council for public sector spatial data management in Australia. To encourage the development of quality, spatially referenced information, ANZLIC – the Spatial Information Council provides:

- national leadership and advocacy in all areas of spatial information, including natural resources information;
- partnerships between the community, industry and governments; and
- promulgation and adoption of standards, policies and guidelines.

By 2005, ANZLIC – the Spatial Information Council aims to:

- establish a comprehensive framework of policies and standards for spatial data and its management;
- encourage availability of accessible fundamental data, compliant with standards for the spatial data infrastructure;
- gain recognition, at all levels of government, industry and the community, of the need for quality, spatially referenced information;
- coordinate development of national standards for data directories and mapping services;
- foster improvements in the quality of summary documentation available through the Australian Spatial Data Directory;
- foster better archiving procedures to avoid loss of fundamental data; and
- identify fundamental data and their custodians.

FINDING DATA FOR USE IN NATURAL RESOURCE ASSESSMENTS

Access to information starts with the knowledge that the information exists.

Australian Spatial Data Directory

The Australian Spatial Data Directory is the national directory of Australia's investment in map data. By making summary documentation about data (metadata) available through the directory, groups ensure that the existence and use of their data is widely promoted and that duplication of effort by users is minimised.

For each set of data, information available in the directory includes:

- a description of the data;
- the location of the data;
- details of data quality, including accuracy and currency;
- how the data were developed (lineage);
- who to contact to obtain access to the data; and
- conditions of access.

By May 2001, nearly 30 000 sets of data were documented in the directory.

Audit findings

For programs such as the Audit, the Australian Spatial Data Directory is an essential tool to ensure we obtain access to the most up-to-date data and do not duplicate the effort of other agencies. However, the Audit found:

- Much of the natural resource data held by Commonwealth and State government agencies was not documented in the Australian Spatial Data Directory. In 1999, the Audit funded agencies to fill some gaps in their documentation of natural resource data and make the documentation available through the directory.
- Important sets of natural resources data funded by the Commonwealth are not documented in the Australian Spatial Data Directory. This includes much data for which the Commonwealth is custodian and that were collated under the Regional Forest Assessment program, the National Forest Inventory, the Agricultural Land Cover Change program, and the Resource Assessment Commission inquiries. Most of the significant terrestrial natural resource data collections of CSIRO divisions are not listed in the Australian Spatial Data Directory. Agencies are currently addressing these gaps.

- Reliability of documentation in the Australian Spatial Data Directory is variable. Many records are out of date, misleading or provide little information to help users determine whether data are suitable for a proposed purpose. A survey (Table 1) undertaken by the Audit of the documentation available for mandatory fields in the Australian Spatial Data Directory, found that for a random sample of 200 Australian Spatial Data Directory entries describing water or vegetation data:
  - 15% of records did not provide information about whether the data were available for use;
  - more than 20% of the records had no information about when the data were created;
  - a third of the records had no information, or very poor information, about how the data were compiled;
  - less than 50% of the records had sufficient information about the quality of the data to allow users to determine whether the data may be useful—for one of the mandatory fields in the directory, 56% of records had no information or were recorded as 'not documented'; and
  - many contact details were out-of-date or misleading.

The survey methodology is outlined in a recent audit of the Australian Spatial Data Directory published by ANZLIC – the Spatial Information Council (ANZLIC 2001).

Table 1. Quality of natural resource documentation in the sample from the Australian Spatial Data Directory.

	Quality of documentation (%)		
Element	*Good*	*Poor*	*No data*
Custodian	100	0	0
Abstract	98	0	2
Format	87	6	7
Access constraint	85	2	13
Ending date	79	0	21
Beginning date	75	0	25
Update frequency	74	1	25
Lineage	66	14	20
Attribute accuracy	50	12	38
Completeness	50	17	33
Positional accuracy	46	25	29
Logical consistency	34	10	56

The Australian Spatial Data Directory provides a public interface to promote and advertise the spatial data holdings of governments and some commercial groups.

The poor quality of much of the information that is publicly promoted suggests that much of the data not documented on the Australian Spatial Data Directory have documentation of even poorer quality.

Effective documentation of data in the Australian Spatial Data Directory is an important and cost-effective way to improve the accessibility and usefulness of natural resources data.

The quality of summary documentation across jurisdictions based on the 200 random water and vegetation records that were reviewed was variable (Figures 3, 4, 5).

The quality and quantity of documentation from Queensland, South Australia, and Western Australia was usually impressive.

Victoria, the Commonwealth and New South Wales need to ensure that better quality documentation is available to promote and advertise their spatial data holdings.

The quality of data summaries in the Australian Spatial Data Directory remains a national issue for effective management of our investment in map data.

ANZLIC – the Spatial Information Council is actively addressing these issues and is developing a strategy and work program to increase the quality and currency of documentation and awareness about the Australian Spatial Data Directory.

Figure 3. Percentage of sampled records by jurisdiction with documentation about the accuracy of attributes in the data*.

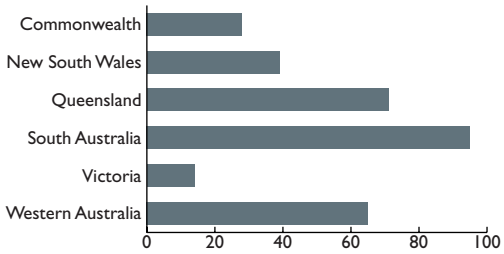


Figure 4. Percentage of sampled records by jurisdiction with documentation about the processes used to compile the data (lineage)*.

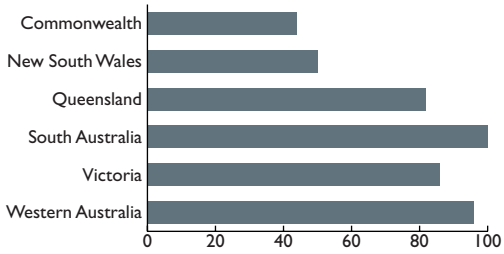
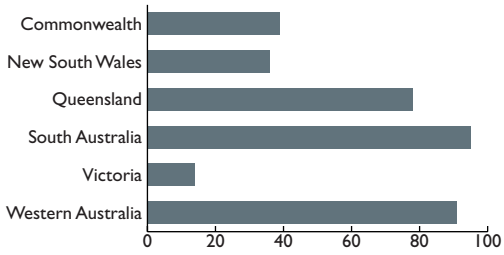


Figure 5. Percentage of sampled records by jurisdiction with documentation about the completeness of the data*.



* Jurisdictions with less than ten records in the sample have not been graphed due to the small sample size.

Finding and using data from Audit projects

Much of the summary documentation initially received by the Audit did not meet standards for inclusion in the Australian Spatial Data Directory. Many individuals and agencies contracted to produce products for the Audit had never before been asked to prepare easy-to-understand summary documentation or metadata (data about the data).

The Audit and its data management consultants worked with data suppliers to edit the summary documentation to ensure that the published summaries provided enough information for users to quickly find data of interest. Support was also provided by distributing documentation guidelines and the *Information Management Manual* (NLWRA 1999) for use in all Audit projects.

Documentation and data are available through the Australian Natural Resources Data Library a node of the Australian Spatial Data Directory (for further information see p. 46).

Where data were not found that could support Australia-wide, natural resource assessments, the Audit worked with government, research and private sector partners to develop new Australia-wide databases.

Three case studies are presented in the next chapter describing some of the issues when building Australia-wide databases.

CONSISTENT AUSTRALIA-WIDE DATA FOR NATURAL RESOURCE MANAGEMENT

Government agencies spend hundreds of millions of dollars each year collecting and maintaining natural resource data.

Despite this investment, data collected by different agencies—particularly in the natural resources area—often use different standards to collect, store, document and provide access to data.

Inconsistent data as illustrated in Figure 6, increases the time and cost to compare areas, solve cross-region problems or analyse trends in the status and condition of natural resources over time. These problems occur at all scales, whether working in a catchment or undertaking a national assessment.

As more information becomes available, organisations and communities want to compare information across regions. Users of natural resource information are demanding:

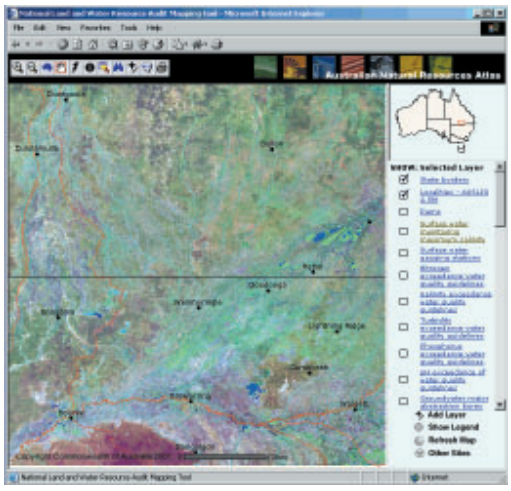
- consistency between related data. For example, the location of stream gauging stations should match the location of streams in the database;
- seamless maps not interrupted by artefacts such as map sheet boundaries or State/ Territory borders; and
- consistent descriptions of similar features so that a feature is defined the same way across Australia.

Data need to be developed so that they are consistent and meet criteria for the Australian Spatial Data Infrastructure ensuring that agencies and the community can achieve maximum value for money through multiple use.

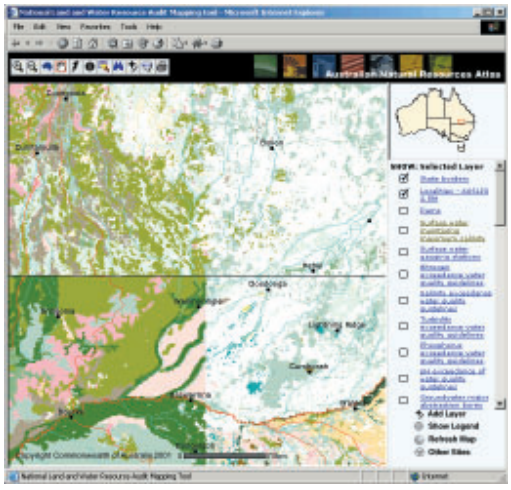
The following case studies—land use, soils and salinity—discuss the development of some of the Australia-wide databases through Audit projects. The *Australian Water Resource Assessment 2000* (NLWRA 2001a) discusses the development of databases concerning water use, quality and availability. The *Australian Native Vegetation Assessment 2001* (NLWRA 2001e) discusses the development of a database about native vegetation and provides an assessment of gaps in the data.

Figure 6. Mapping across borders—the Condamine – Culgoa River Basin.

A seamless satellite mosaic for the year 2000 available in the Australian Natural Resources Atlas showing the south-west of the Condamine – Culgoa River Basin, crossing the New South Wales and Queensland border.



A map from the National Vegetation Information System for the same region illustrates differences that appear when bringing together native vegetation data collected at different times, using different standards, scales and attributes. Artefacts in the data include map-sheet boundaries and State borders. These inconsistencies make it difficult to compare information about the type, extent and change in native vegetation in different parts of the river basin.



CASE STUDY 1. LAND USE IN AUSTRALIA

An understanding of the impact of human settlement and resource development across Australia is a fundamental requirement for the assessment of condition and trend of land and water resources.

Mapping land use pattern provides a basis for characterising Australia's landscape and starting to understand agricultural production and land management practices.

Land use information provides input to:

- planning and implementing different land use practices;
- assessing the suitability of changes in land use with respect to climate, soil, slope and water availability;
- assessing environmental impacts and land at risk from land degradation (e.g. salinity, flood, drought and erosion);
- assessing agricultural productivity and opportunities for diversification; and
- national, State and regional reporting about land use patterns, intensity and diversity.

National classification

As part of the Audit's land use mapping projects, workshops were held with government agencies to develop a classification to consistently map land use for natural resource applications. This classification was trialed in a set of regional mapping projects and then applied in the development of a national map of land use.

Agriculture, Fisheries and Forestry – Australia, coordinated the development of the Australian Land Use Management Classification (ALUMC Version 4, October 2000) in collaboration with Commonwealth, State and Territory agencies. This classification was used for Australia-wide and regional maps of land use. Use of a consistent classification ensures that regions can be compared and that regional information can be aggregated for compiling national summaries.

Australian Land Use Management Classification

- Designed for users who are interested in processes such as land management practices, and/or outputs such as commodities.
- Based on identifying types and levels of intervention in the landscape since European settlement, rather than descriptions of land use based on outputs.
- Allows land use classes on the maps to be aggregated or disaggregated. The classification has a three-tiered hierarchical structure. Primary and secondary classes in the classification relate to land use (the prime use of the land is defined in terms of the management objectives of the land manager). Tertiary classes can include commodity groups, commodities, land management practice, or land cover information.

Regional land use mapping for use at the catchment scale

Regional scale land use maps for Gippsland in Victoria (Figure 7), the Fitzroy river catchment in Queensland, Mt Lofty Ranges in South Australia, and the whole of Western Australia were compiled in partnership with State agencies. These maps cover 35% of Australia, show land use at 1:100 000 scale and are appropriate for use at the catchment scale.

The Fitzroy, Gippsland and Mt Lofty mapping projects were used to develop, test and refine the national land use classification.

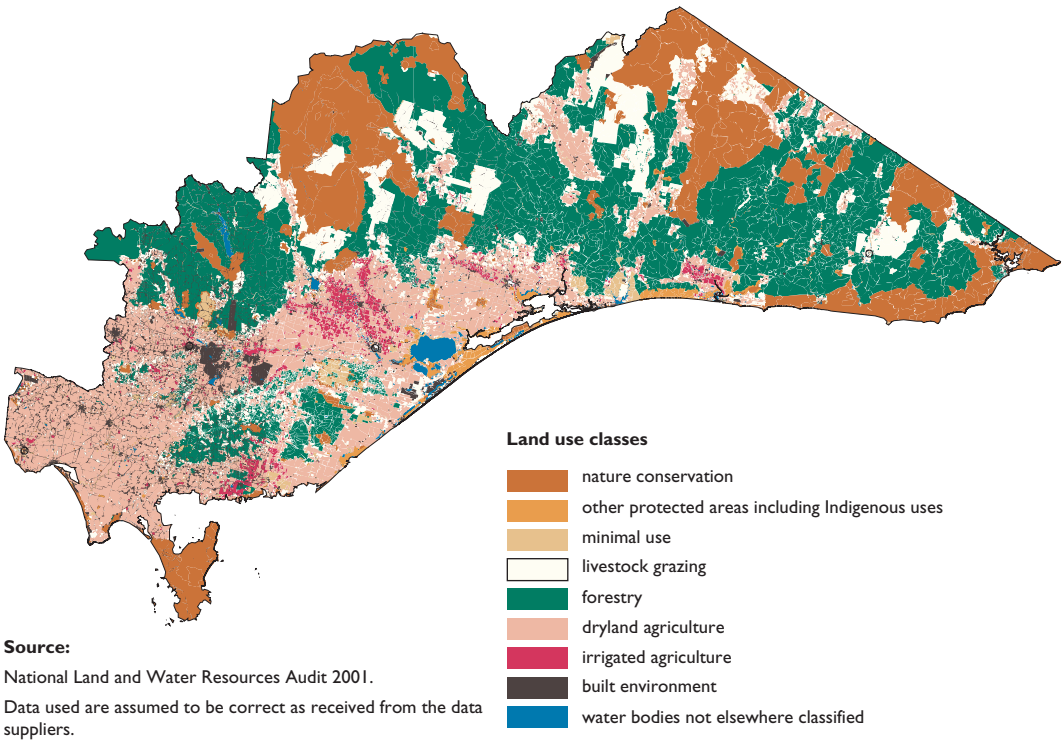
Land use and vegetation were mapped together in Western Australia. The vegetation data were used in *Australian Native Vegetation Assessment 2001* (NLWRA 2001e).

Appropriate use of the data

Regional-scale land use data are limited by:

- limited validation and checking of the maps in the field; and
- resolution of satellite and/or property information where it is too coarse to identify intensive and small acreage uses. Identification of small parcels of land producing a range of commodities or that have more than one crop each year requires collection of detailed map data more frequently.

Figure 7. Land use in the Gippsland region, Victoria.



Source:

National Land and Water Resources Audit 2001.

Data used are assumed to be correct as received from the data suppliers.

Australia-wide land use mapping

The last national land use map was produced by Geoscience Australia more than twenty years ago (Division of National Mapping 1979). To support broad national-scale assessments, a database of agricultural and non-agricultural land use across Australia was developed for the year 1996/1997.

The database contains information about the distribution of land uses, protected areas, broad tenure categories, forest types, agricultural commodities and irrigated areas.

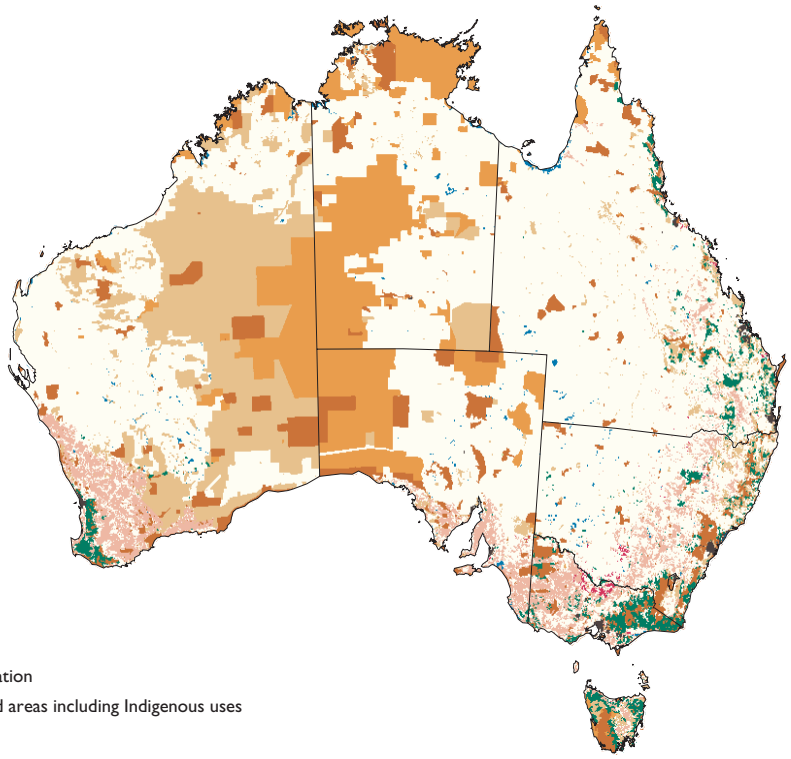
The resultant map (Figure 8) has a resolution of approximately 1.1 km.

Appropriate use of the data

Due to the modelling approach used to map land use nationally, data have some limitations that must be considered before use or updating.

- The small number of control sites collected has limited the validation of the data.
- Satellite imagery used to model land use has a resolution of approximately 1.1 km so that small acreages, including patches of horticulture and mixed land uses, are not identified.
- A primary input to the modelling of land use are agricultural statistics, from the Australian Bureau of Statistics and summarised by statistical local areas. This information does not show the exact location of the land use. Agriculture, Fisheries and Forestry – Australia and the Australian Bureau of Statistics are currently examining the feasibility of linking agricultural statistics to information about the location of farm boundaries.
- The national land use map is a snapshot in time and further mapping is essential for monitoring the use and management of land. Future mapping is likely to be optimised by using more detailed regional information.

Figure 8. Land use in Australia in 1996/1997.



Land use classes

- nature conservation
- other protected areas including Indigenous uses
- minimal use
- livestock grazing
- forestry
- dryland agriculture
- irrigated agriculture
- built environment
- water bodies not elsewhere classified

Source:

National Land and Water Resources Audit 2001.

Data used are assumed to be correct as received from the data suppliers.

Maintaining our investment—next steps

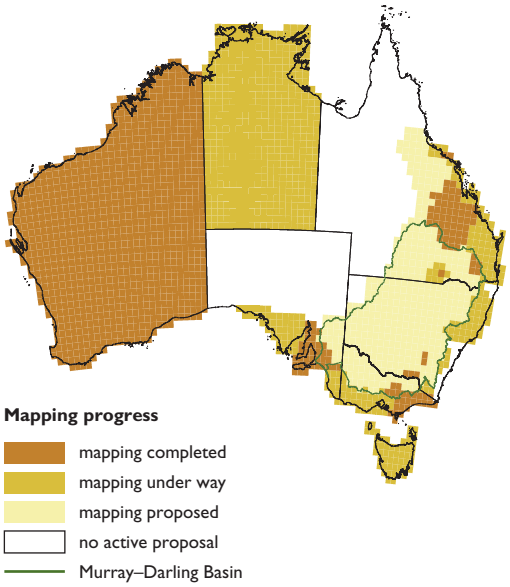
Australia's pattern of land use is continually changing in response to management decisions. The Australian Land Use Management Classification provides an Australia-wide framework for classifying land use and for monitoring change.

The national land use map must be updated for a continued ability to answer questions about the use and management of land in Australia.

Mapping and collation of land use information is based on continuing collaboration and partnerships with all contributing jurisdictions.

Figure 9. Current land use mapping program.

The status of the Agriculture, Fisheries and Forestry – Australia land use mapping program.



Source:

Agriculture, Fisheries and Forestry – Australia.

Data used are assumed to be correct as received from the data suppliers.

Agriculture, Fisheries and Forestry – Australia coordinates the Executive Steering Committee for Australian Land Use Mapping with national, State and Territory government representatives. The committee:

- promotes and coordinates funding and resources required for acquiring and distributing land use data as part of the Australian Spatial Data Infrastructure;
- ensures an effective flow of information on the development of nationally consistent land use data and works with ANZLIC – the Spatial Information Council to ensure that data are assembled, maintained and delivered in a nationally consistent way;
- continues consultation with users of data and across agencies and jurisdictions;
- establishes links with data users to ensure that products continue to be relevant; and
- cooperates with other coordinators of fundamental data to identify and, as far as possible, foster integration of data.

There is no plan to complete another Australia-wide 'snapshot' of land use. It is recommended that the current map be updated every five years using the best available regional-scale data, to support national assessments and reporting as well as be useful at a catchment scale.

Table 2. Compliance of the 1996/97 Land Use of Australia map with standards for the Australian Spatial Data Infrastructure.

Access

✔ *Are the data easily accessible?*

- Land use data are available free of charge over the Internet through the Australian Natural Resources Data Library.
- Data may be mapped through the Australian Natural Resources Atlas Map Maker. Detailed regional summaries of land use for each river basin are available through the Australian Natural Resources Atlas.

✔ *Are the data documented?*

- Summary documentation is available through the Australian Natural Resources Data Library and the Australian Spatial Data Directory.

Supply

✔ *Are licence arrangements in place that ensure that the information are accessible, while protecting copyright, intellectual property, privacy and confidentiality?*

- A licence agreement has been agreed between the Audit and ANZLIC – the Spatial Information Council and is supported by Commonwealth, State and Territory agencies.

Quality

✔ *Do the data meet national guidelines or standards?*

- Data meet the following national guidelines:
  - Spatial data are available in the Geocentric Datum of Australia (GDA94)
  - Attribute data use the Australian Land Use Management Classification Version 4, October 2000. The Executive Steering Committee for Australian Land Use Mapping monitors compliance with the classification.

Maintenance

✔ *Are there national coordination arrangements in place to help ensure that data are being assembled, maintained and delivered in a nationally consistent way without duplication of effort?*

- Agriculture, Fisheries and Forestry – Australia coordinates the Executive Steering Committee for Australian Land Use Mapping with national, State and Territory government representatives.

✔ *Are custodians of the data maintaining the data according to national guidelines or standards?*

- Agriculture, Fisheries and Forestry – Australia maintains the data according to the Australian Land Use Management Classification.

CASE STUDY 2. THE AUSTRALIAN SOIL RESOURCES INFORMATION SYSTEM

Australia's soils are generally not capable of sustained agricultural production without additional physical and/or chemical inputs. Many of Australia's land surfaces are ancient and their soils are strongly weathered and infertile. Wind or water can easily erode them and many are susceptible to leaching of vital nutrients.

In light of issues such as dryland salinity, soil structure decline, inherent soil infertility and the nutrient enrichment of our waterways, many scientists and agriculturalists have concluded that there is a mismatch between the Australian environment and the introduced European-based agricultural systems. To address this mismatch or imbalance, we must first understand the properties of our soil, water and biological resources and how they interact.

The need for better maps of soil information

Until now, Australia did not have a nationally consistent information base on which the relationships between soil, water and biological resources could be adequately quantified or described. This understanding is critical for effective management of resources at a landscape and ecosystem scale, and achievement of sustainable production and environmental protection.

Before the establishment of the Audit, the best Australia-wide coverage of soils information was the 1:2 000 000 scale *Atlas of Australian Soils* by CSIRO in 1968. This information was inadequate to answer important natural resource management questions at a scale relevant to regional planning and development.

In response to this gap, the Audit initiated the development of the Australian Soil Resources Information System. The Australian Soils Resources Information System was designed to be a consistent database for the intensive land use zone. It uses the extensive soil point and survey map data that have been collected and collated by State and Territory agencies since the early 1970s. Much of this information has been collected over the last ten years through national programs such as the National Landcare Program and more recently the Natural Heritage Trust.

What is the Australian Soil Resources Information System?

The Australian Soil Resources Information System contains a set of geographically distributed estimates of soil properties—those most commonly required to characterise, model or predict processes that drive plant productivity, measure resource sustainability or control rate of resource degradation.

Mapped soil properties include:

- amount of organic matter;
- total phosphorus;
- total nitrogen;
- texture;
- depth;
- density of dry soil;
- percentage of clay;
- percentage of silt;
- percentage of sand;
- pH;
- ability to resist pH change;
- water storage capacity;
- permeability of the soil; and
- erodibility.

The Australian Soil Resources Information System also contains attributes that indicate data quality.

A detailed description of each of the attributes is available in the data catalogue in Appendix 1.

How can the Australian Soil Resources Information System be used?

Maps of soil properties were used by the Audit in the preparation of comprehensive assessments of:

- water-borne soil erosion and sediment/ nutrient transport;
- present and projected extent of soil acidification; and
- landscape productivity.

These are reported in the *Australian Agricultural Assessment 2001* (NLWRA 2001d).

Sediment and nutrient delivery

In their natural state, Australian soils are generally shallow, infertile and have a fragile structure. When the soil surface is inadequately protected by vegetation, they are prone to erosion by wind and water.

A major issue in Australian land management is water-borne soil erosion and the resulting degradation of land and water resources. As soil provides the structural support and source of water and nutrients for plants, erosion may result in significant reductions of productivity.

Soil erosion also has off-site effects, including degradation of water quality in streams and water storages by increasing the level of sediments and nutrients.

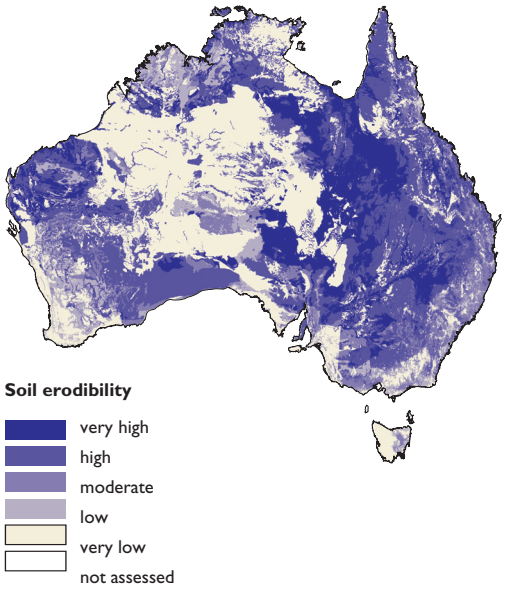
We need to understand the consequences of changes in land use and climate on soil erosion in order to minimise the decline of soil productivity and water quality and optimise the use of resources for soil conservation and management and sustainability of land use. Knowledge about the sources and rates of erosion under past and present conditions is essential.

The Audit assessment of water-borne soil erosion (NLWRA 2001d) used soil erodibility information (Figure 10) derived from the Australian Soil Resources Information System including several primary input attributes and total phosphorus data to model sediment and nutrient delivery from hill-slopes to streams and ultimately estuaries.

Figure 10. Soil erodibility mapped in the Australian Soil Resources Information System.

Soil erodibility is a measure of the resistance of a soil to sheet and rill erosion and is a function of:

- the amount of clay in the soil;
- the amount of organic matter in the soil; and
- how well water drains through the soil.



Source:

National Land and Water Resources Audit 2001.

Data used are assumed to be correct as received from the data suppliers.

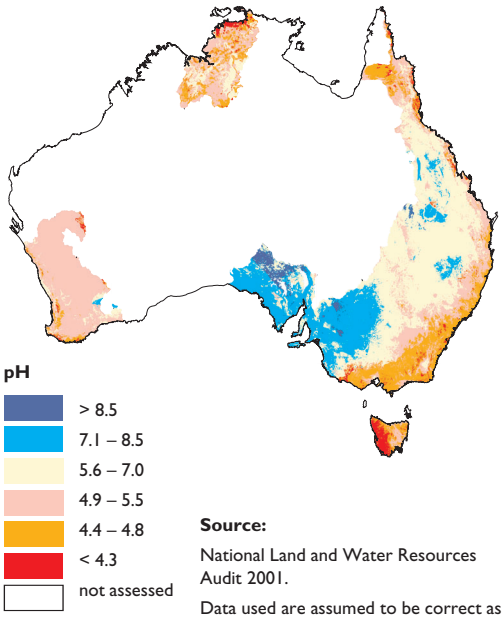
Acidification

Soil acidification insidiously reduces agricultural productivity. In agricultural ecosystems, acidification is caused by actions that break the natural carbon and nitrogen cycles.

The soil acidification process is primarily controlled by soil type, land use and land management. The Audit developed a model that predicts the risk of acidification and allows it to be mapped. The model is based on the Australian Soil Resources Information System attributes including the distribution of acid soils (pH) (Figure 11), capacity for soils to buffer against acidifying practices (organic carbon and percent clay) and plant yield functions (soil pH and other related characteristics).

Figure 11. Soil pH mapped in the Australian Soil Resources Information System.

Soil pH is a measurement of the relative acidity or alkalinity of the soil, providing a guide to the overall chemical balance of the soil. Soil pH is an important factor in plant growth because pH determines the availability of soil nutrients to plants.



Source:

National Land and Water Resources Audit 2001.

Data used are assumed to be correct as received from the data suppliers.

Landscape productivity

Sustainable management of Australia's natural resources requires knowledge and information on the geographic distribution of stores of nature's raw materials—carbon, water and nutrients, the major processes that control these balances and how these balances change in response to land use.

To model the cycles of carbon, nutrients and water in the landscape, information was used that quantitatively and geographically defines terrain, climate, land use and soil stores for water and nutrients. Soil organic carbon and available phosphorus attributes were incorporated into a model that generated estimates of the soil and litter pools of nutrients and water.

Maintaining our investment—next steps

Development of the Australian Soil Resources Information System was possible because most assessors of land resources have been collecting comparable land and soil data to standard attributes and definitions.

Data about soils continue to be collected. If we wish to improve our capacity to answer questions about the soils supporting agricultural landscapes, it is essential that new data are also consistent and comparable Australia-wide.

Maintaining and developing technical standards

In recognition of the need for maintenance of standards, the Australian Collaborative Land Evaluation Program was established in 1992 to coordinate the development, update and review of technical standards for land resource assessment.

Committing to data management

By the mid-1990s the Australian Collaborative Land Evaluation Program in conjunction with Western Australia and Queensland developed the Soil Information Transfer and Evaluation System in response to a growing demand for land resource information across agencies and Australia. The Soil Information Transfer and Evaluation System is a data exchange protocol for soil point data. It provides a standard for exchange of data between all State/Territory or Commonwealth agencies. Without these standards, the Australian Soil Resources Information System would not have been feasible within the time frame.

Technical standards need to be extended and maintained as the demand for comparable, quality assured data continues to grow particularly at the regional scale.

Implementation of data quality standards

Ninety-five percent of the Australian Soil Resources Information System project was spent on 'cleaning up' data. Inadequate data in mandatory or important data fields, and inconsistent adherence to data standards remain a significant issue for Australian land resource databases.

An essential activity for the national coordinators of the Australian Soil Resources Information System is to ensure the implementation of technical standards so that the quality of input data is enhanced.

Data to information—data analysis and reporting tools

The Australian Soil Resources Information System analysis and reporting tools will need to be developed or redeveloped and maintained to improve the ability of soil properties data to be used by people other than technical practitioners within research and government agencies. These tools could take the form of user guidelines or, for more advanced applications, computer-aided decision support systems that use the underlying Australian Soil Resources Information System and other, more extensive data.

Before committing to ongoing development of analysis tools, a comprehensive understanding of user needs, and a commitment to maintain any tools developed is required.

Bridging the gap—adding to the information base

Continuous improvement in development and adoption of technical standards in natural resource assessment should be encouraged. However, it is important that the considerable legacy of soil data is not alienated by the adoption of technical standards that do not maximise the use of this historical data.

Table 3. Compliance of the Australian Soil Resources Information System with standards for the Australian Spatial Data Infrastructure.

Access

✔ *Are the data easily accessible?*

- Access to any nationally compiled primary data is managed through Agriculture, Fisheries, Forestry – Australia. Access is provided on a case-by-case basis with the consent of the primary data custodian(s).
- Derived data are available free of charge over the Internet through the Australian Natural Resources Data Library.
- The data may be mapped through the Australian Natural Resources Atlas Map Maker. Regional summaries of soil properties are available through the Australian Natural Resources Atlas.

✔ *Are the data documented?*

- Summary documentation is available through the Australian Natural Resources Data Library and the Australian Spatial Data Directory.

Supply

✔ *Are licence arrangements in place that ensure that the information are accessible, while protecting copyright, intellectual property, privacy and confidentiality?*

- A licence agreement has been agreed between the Audit and ANZLIC – the Spatial Information Council, supported by Commonwealth, State and Territory agencies.

Quality

✔ *Do the data currently meet national guidelines or standards?*

- Data meet the following national guidelines:
  - Spatial data are available in the Geocentric Datum of Australia (GDA94)
  - Attribute data use standards and guidelines agreed through the Australian Collaborative Land Evaluation Program.

Maintenance

✔ *Are there national coordination arrangements in place to help ensure that data are being assembled, maintained and delivered in a nationally consistent way without duplication of effort?*

- Coordination of the Australian Soil Resources Information System is undertaken jointly by CSIRO Division of Land and Water; and Agriculture, Fisheries and Forestry – Australia, who will work through the Working Group on Land Resource Assessment and Australian Collaborative Land Evaluation Program to facilitate collaboration with States and Territories.

✔ *Are custodians of the data maintaining the data according to national guidelines or standards?*

- Derived data (except lithology data) are maintained by CSIRO Division of Land and Water.
- Lithology data are maintained by Agriculture, Fisheries and Forestry – Australia.

CASE STUDY 3. AUSTRALIAN DRYLAND SALINITY ASSESSMENT 2000

Dryland salinity is most widespread in agricultural areas where it may dramatically reduce farm production. It also affects other land uses, damages infrastructure (e.g. buildings, roads, bridges and sewerage lines), and reduces the diversity of native plants and animals.

Dryland salinity is linked to other degradation issues such as soil erosion, eutrophication of streams and loss of riparian vegetation.

Information about the distribution of salinity hazard is fundamental to effectively set national priorities and targets for the $1.4 billion investment by the Commonwealth, States and Territories in the National Action Plan for Salinity and Water Quality.

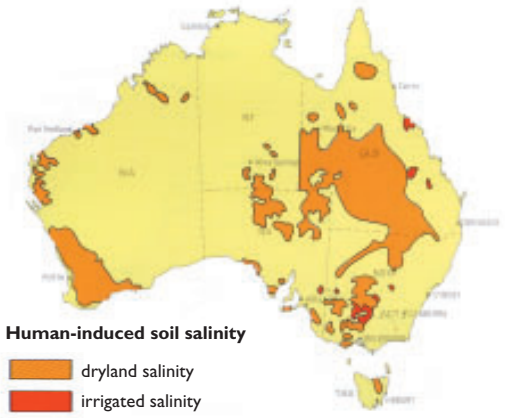
A decade of dramatic improvements in knowledge

Dramatic improvements in our knowledge of the distribution of dryland salinity risks and hazards over the past ten years have allowed investment in salinity and land management to be much better targeted.

1992

The Australian Surveying and Land Information Group published a map of dryland salinity (Figure 12). This was one of the first attempts to compose a national map of salinity, and was based on maps from many sources. Differences in methods used for classifying salinity are clearly seen across the Northern Territory/ Queensland border.

Figure 12. National dryland salinity mapping in 1992.

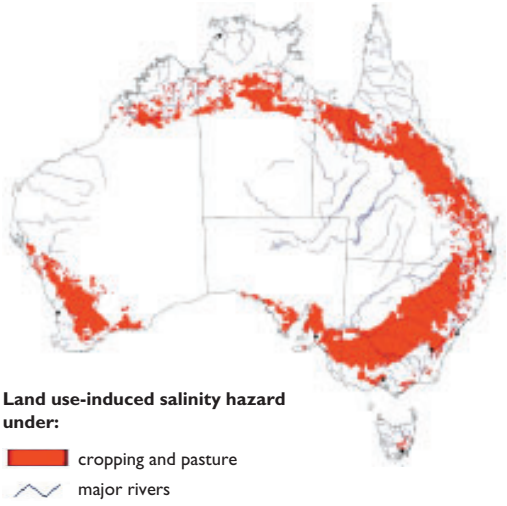


Source:
Australian Surveying and Land Information Group 1992.

2000

A map of land use-induced salinity hazard under cropping and pastures (Figure 13) was prepared by the Bureau of Rural Sciences for the National Action Plan for Salinity and Water Quality. The map was based on modelling possible areas of salinity hazard based on climate, terrain, soil and land use types.

Figure 13. Salinity hazard mapping in 2000.



Source:

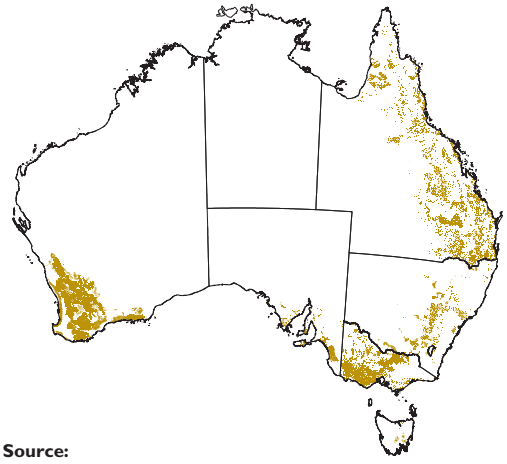
Bureau of Rural Sciences 2000.

2001

The Audit published a national compilation of the best available dryland salinity mapping from State and Territory agencies based on information about trends in groundwater levels (NLWRA 2001b) (Figure 14).

This map is more useful for targeting investment in dryland salinity management than earlier maps as it identifies those areas at higher risk or hazard of dryland salinity and is based on the most up-to-date information and scientific advice from State and Territory agencies. The map is supported by detailed groundwater trend data in many regions.

Figure 14. Areas containing land of high hazard or risk of dryland salinity in 2050, from the Australian Dryland Salinity Assessment 2000.



Source:

National Land and Water Resources Audit 2001.

Data used are assumed to be correct as received from the data suppliers.

Users are now able to use the Australian Natural Resources Atlas to explore the salinity data in detail and compare this to other information in a region of interest.

As reported in the assessment of dryland salinity by the Audit (NLWRA 2001b) there is no consistent approach to monitoring the extent of and trends in dryland salinity. Arrangements are required to update the data in a nationally consistent way. The *Australian Dryland Salinity Assessment 2000* identifies the elements required for better collection, analysis and reporting systems.

Figure 15. Using the Australian Natural Resources Atlas to map dryland salinity risks in 2000 and 2050 around Creighton, Victoria.

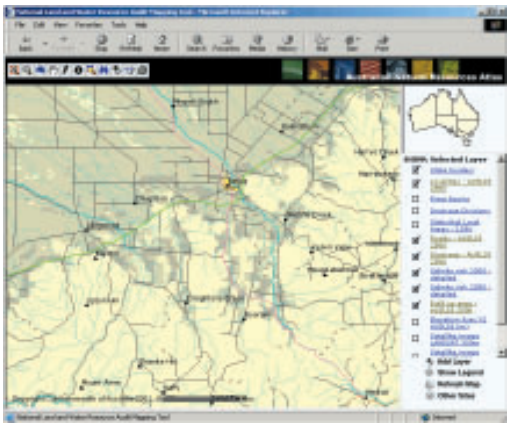


Table 4. Compliance of the Australian Dryland Salinity Assessment 2000 salinity map with standards for the Australian Spatial Data Infrastructure.

Access

✔ *Are the data easily accessible?*

- Maps of salinity hazard and risk are available free of charge over the Internet through the Australian Natural Resources Data Library.
- The data may be viewed through the Australian Natural Resources Atlas.

✔ *Are they documented?*

- Summary documentation is available through the Australian Natural Resources Data Library and the Australian Spatial Data Directory.

Supply

✔ *Are licence arrangements in place that ensure that the information are accessible, while protecting copyright, intellectual property, privacy and confidentiality?*

- Online licencing through the Australian Natural Resources Data Library. Licence agreement has been agreed between the Audit and ANZLIC – the Spatial. Information Council, supported by Commonwealth, State and Territory agencies.

Quality

✘ *Do the data meet national guidelines or standards?*

- Spatial data are available in the Geocentric Datum of Australia (GDA94)
- Standards do not exist for consistently identifying salinity risk and hazard.

Maintenance

✘ *Are there national coordination arrangements in place to help ensure that data are being assembled, maintained and delivered in a nationally consistent way without duplication of effort?*

- National coordination arrangements need to be developed to update the data in a nationally consistent way.

✘ *Are custodians of the data maintaining the data according to national guidelines or standards?*

- National guidelines or standards do not exist.

Building Australia-wide natural resource data—the next steps

The major Australia-wide databases developed by the Audit—land use, soil properties, dryland salinity, native vegetation, water resources, river condition, and estuaries—are fundamental components of a natural resource data infrastructure. These data were used as inputs to many of the Audit assessments including analyses of agricultural productivity, condition of environments, biodiversity and natural resource management.

Data from Audit projects are accessible and documented. They use national guidelines or standards where these exist.

Consistent, Australia-wide natural resource data must be maintained and updated to recognised standards to support applications including:

- future natural resource assessments;
- programs such as the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality;
- local, regional and national State of the Environment reporting; and
- monitoring systems such as the Australian Collaborative Rangeland Information System.

Major Audit data have been assessed against criteria for the development of the Australian Spatial Data Infrastructure (Table 5). All seven sets of data need maintenance programs developed if they are to continue to support these diverse requirements. At a minimum, the Australia-wide views of these data should be updated every five years to align with statutory reporting obligations including the *Australian State of the Environment* report, and the population and housing census.

Table 5. Assessment of major Audit databases against criteria for the development of the Australian Spatial Data Infrastructure.

	Land use	Soil properties	Native vegetation type and extent	Water use, allocation and availability	Dryland salinity risk and hazard	River health	Estuaries
Access							
Are the data easily accessible? Are the data documented?	✔	✔	✔	✔	✔	✔	✔
Supply							
Are licence arrangements in place that ensure that the map information is accessible, while protecting copyright, intellectual property, privacy and confidentiality?	✔	✔	✔	✔	✔	✔	✔
Quality							
Do the data meet national guidelines or standards?	✔	✔	✔	✔	✘	✘	✘
Maintenance							
Are there national coordination arrangements in place to help ensure that data are being assembled, maintained and delivered in a nationally consistent way without duplication of effort?	✔	✔	✔	✔	✘	✘	✘
Are custodians of the data maintaining the data according to national guidelines or standards?	✔	✔	✘	✘	✘	✘	✘
Are regular Australia-wide updates planned?	✘	✘	✘	✘	✘	✘	✘

✔ arrangements are in place

✘ arrangements are yet to be resolved

Recommendations

Building fundamental data

It is recommended that government agencies adopt an integrated and sustainable approach that maintains the existing investment in data and progressively builds a consistent infrastructure of natural resource data.

Major Australia-wide databases developed by the Audit must be maintained and updated if they are to continue to support government, community and industry requirements for natural resource data. It is recommended that within available resources:

Water

- The Natural Heritage Ministerial Board, through the Natural Resource Management Ministerial Council, to develop a program of five-yearly updates of the Australia-wide information system of surface water and groundwater use, allocation, and availability. The information system should be based on the best available regional data, preferably routinely updated by States and Territories as part of their water resource management activities.

  Agriculture, Fisheries and Forestry – Australia is the national coordinator of the Australian Water Resources Assessment database developed by the Audit.

  Geoscience Australia is the national coordinator of the surface water management area boundaries data.

Native vegetation

- The Natural Heritage Ministerial Board, through the Natural Resource Management Ministerial Council, to develop a program of five-yearly updates of Australia-wide information about native vegetation type and extent based on the best available regional data. Integration of native and non-native vegetation data can best be facilitated and coordinated through the Executive Steering Committee on Australian Vegetation Information.

  Environment Australia is the national coordinator of the native vegetation database developed by the Audit.

Land use and management

- The Natural Heritage Ministerial Board, through the Natural Resource Management Ministerial Council, to develop a program of five-yearly updates of the Australia-wide map of land use and land management practices based on the best available regional data. The next update should commence in 2003 and be based on land use in 2001/02.

  Agriculture, Fisheries and Forestry – Australia is the national coordinator of national land use mapping developed by the Audit.

Dryland salinity

- The Natural Heritage Ministerial Board through Agriculture Fisheries Forestry Australia in partnership with the National Dryland Salinity Program and State and Territory agencies to maintain and improve currency, quality and availability of Australia-wide maps of groundwater flow systems and dryland salinity extent. The program should include data collected through detailed regional mapping and assessments being undertaken in the National Action Plan for Salinity and Water Quality.

Soils

- The Natural Heritage Ministerial Board, through the CSIRO Division of Land and Water as coordinator of the national soil information system and in cooperation with Commonwealth, State and Territory agencies through the Australian Collaborative Land Evaluation Program, to ensure the maintenance and improvement of the currency, quality and availability of data in the Australian Soil Resources Information System.

Rivers

- The Natural Heritage Ministerial Board, through the Natural Resource Management Ministerial Council, to develop a program of five-yearly updates of the Australia-wide information system about rivers and their condition. The program would be based on a nationally agreed set of attributes and assessment methods and undertaken in partnership with the Cooperative Research Centre for Freshwater Ecology, and Commonwealth, State and Territory agencies.

  Environment Australia is the national coordinator of the river condition database developed by the Audit.

Estuaries

- The Natural Heritage Ministerial Board, through the Natural Resource Management Ministerial Council, to develop a program of five-yearly updates of the Australia-wide information system about estuaries and their condition.

  Geoscience Australia is the national coordinator of the OzEstuaries database developed by the Audit.

Efficiently building fundamental data

- The Natural Heritage Ministerial Board, through the Natural Resource Management Ministerial Council, to request that ANZLIC – the Spatial Information Council support coordinators of Australia-wide databases by advising on technical standards and guidelines to build a network of information systems. The information systems should link to the most up-to-date natural resource data and avoid duplication of effort within the framework for the Australian Spatial Data Infrastructure.

COMMUNITY ACCESS TO INFORMATION

The Audit has developed information products to meet a broad suite of requirements:

- assessment reports providing national summaries of natural resource issues;
- summaries of the assessment reports outlining key findings;
- compact discs with map data, technical reports and documentation;
- paper maps; and
- online information services—Australian Natural Resources Atlas and Data Library—that provide access to national and regional scale information products and data.

Some of the detailed information products from the Audit are only available through the Internet because of the large amount of data and information involved. As the data are being continually updated, the Internet allows direct access to the most up to date information.

Figure 16. Products available from the Audit include compact discs, reports, brochures and Internet services.

Cutting through the red tape—a landmark national agreement for free access to data

It has long been recognised by all governments and the community that access to natural resource information needs to be improved.

The Intergovernmental Agreement on the Environment signed by all jurisdictions in 1992 (Commonwealth of Australia 1992) agreed to develop mechanisms to make data more accessible. Mechanisms developed included the development of:

- standards for the description and exchange of all geographic information; and
- development of a national directory of geographic data.

In 1999, in order to streamline access to natural resources data, the Audit signed protocols with each State and Territory and key Commonwealth agencies for access to natural resources data, largely at the cost of transfer. These protocols took 18 months to negotiate reflecting the range of data access mechanisms and policies across and within jurisdictions. The delay in negotiating through these inconsistent arrangements is a costly impediment to the efficient business of government and industry.

In 2001, the Audit, and ANZLIC – the Spatial Information Council, supported by data custodians in State, Territory and Commonwealth agencies, signed the single Data Access and Management Agreement. The agreement streamlines access to:

- natural resource data and information products developed by the Audit; and
- data that are required to update natural resource information products and undertake natural resource assessments by Commonwealth, State and Territory natural resource management agencies.

The landmark agreement specifies access, ownership, custodianship, archiving and updating arrangements for the data collected, developed for and used in the assessments undertaken by the Audit.

Data Access and Management Agreement

- A schedule sets out the data that are included under the agreement. The schedule will be expanded as the Audit completes its work program.
- The data are available through the Australian Natural Resources Data Library free of charge except for Internet charges incurred by the users downloading the data.
- Registration and distribution processes are largely automated and require little manual intervention.
- Data are made available using a standard licence agreement that protects the rights of owners and enables value adding by users.
- 'Community access' data licencing provides for use by the public. The agreement provides a royalty-free licence to use, reproduce, make new information products from and print data and combine it with other data held by the user.
- With written permission of the custodians, data under this agreement may be commercialised. The data licencing conditions encourage and enable the development of new information products.

In September 2001, the Commonwealth Government announced the new Spatial Data Access and Pricing policy for access to Commonwealth spatial data (Commonwealth of Australia 2001a). Key aspects of the policy are:

- fundamental spatial data will be provided **free of charge over the Internet** and at no more than the marginal cost of transfer for packaged products and full cost of transfer for customised services;
- there are **no restrictions on commercial value-adding** to the listed fundamental spatial data, although each transaction will be subject to a licence setting out the conditions of the transfer;
- an Internet-based public access system will be developed **within the framework of the Australian Spatial Data Infrastructure**—the Australian Natural Resources Atlas and Data Library provide a model of such a system; and
- the Commonwealth will negotiate a **multilateral agreement with States and Territories** for access to spatial data required for Commonwealth purposes. The Audit agreement with ANZLIC – the Spatial Information Council, supported by the Commonwealth and all States and Territories provides a model for the proposed multi-lateral agreement.

These two developments—the National Land and Water Resources Audit – ANZLIC – the Spatial Information Council agreement; and the new Commonwealth policy—provide a strong foundation for significantly improving accessibility of spatial data in general, and natural resource data in particular.

Australian Natural Resources Atlas—www.environment.gov.au/atlas

Governments and the Australian public are now able to access a comprehensive range of information about Australia's natural resources through the Australian Natural Resources Atlas.

The Australian Natural Resources Atlas provides an Internet-based interface to the data and information prepared by the Audit and its partners. Accessibility has been maximised by investing in user-friendly Internet technology. The Australian Natural Resources Atlas serves several important functions by:

- providing ready access to information about the status and trends in Australia's natural resources;
- linking and integrating data and information by geography and topics—users of the Australian Natural Resources Atlas can navigate through the Audit's data and information by selecting a topic (e.g. surface water quantity) and geography (e.g. river basin);
- providing a dynamic query and mapping facility for the preparation of user-constructed report and map-based products; and
- linking to data and information services available from other sources to ensure that users have easy access to the most up-to-date information.

Figure 17. Home page for the Australian Natural Resources Atlas—www.environment.gov.au/atlas.

Australian Natural Resources Atlas information products

- Regional profiles provide national, State or regional reports integrated with key statistics, maps, text, tables and graphics. Expert explanation from the assessments undertaken by the Audit is provided to assist users interpret the information. These profiles are linked where possible to other detailed information available over the Internet from State and Territory agencies.
- The Map Maker allows users to construct a map for a region of interest, and view a wide range of natural resource, environmental, social and economic information. For example, users can create a map of salinity risk or water quality in a river basin and overlay a map of land use, agricultural productivity or estuarine health.
- A suite of tools has been developed to assist natural resource decision makers. Tools include a broad range of applications such as OzEstuaries which is designed to assist estuary management.

Quickly find the information required

By typing in a location (a town or city) into the Australian Natural Resources Atlas Navigator users can quickly move to relevant national, State or regional profiles, or go straight to the place of interest in the Australian Natural Resources Atlas Map Maker. Over 100 reports—from Australia-wide to regional—are available for each location.

Figures 18 and 19 demonstrate how a catchment manager may use the Australian Natural Resources Atlas to obtain information about the Condamine region and explore some of the new information products now available from Audit assessments.

Figure 18. Using the Atlas Navigator to find information products in the Australian Natural Resources Atlas for the region around Condamine in Queensland.

A summary of information products available for the region around Condamine

Native vegetation type and extent in the Brigalow Belt South bioregion

Agricultural statistics for the Murilla statistical local area

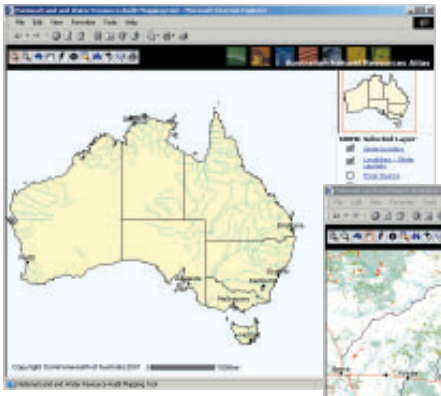
Development of water resources in the Balonne – Condamine surface water management area

Figure 19. Using the Australian Natural Resources Atlas Map Maker to explore the Condamine region in Queensland.

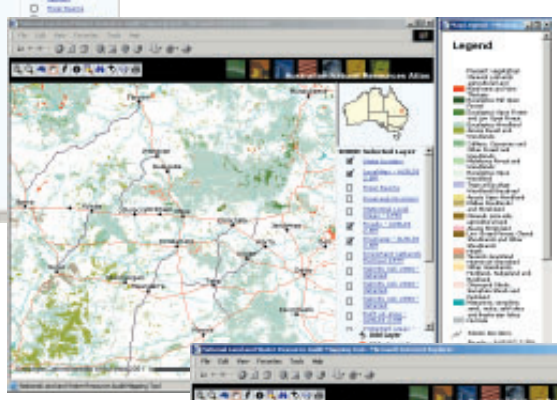
The Map Maker allows natural resource managers to zoom in to a region of interest and add data to the map. Simple queries can be performed on the data to find values of interest.

"Show me information about native vegetation and potential hillslope erosion in the region around Condamine in Queensland."

Begin at map of Australia



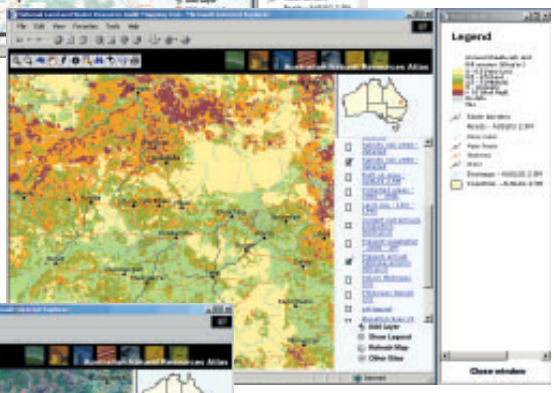
Click on to search for the town of Condamine



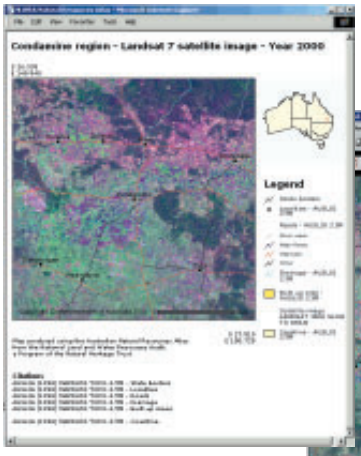
Zoom into the region around the town and click on to add a map of native vegetation

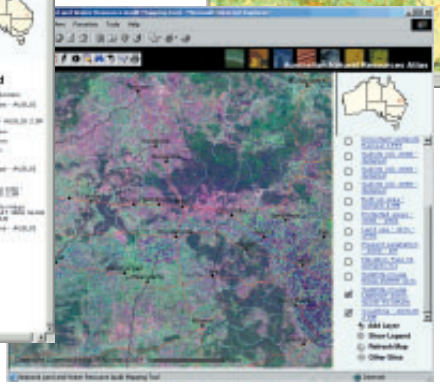
Check the box next to the native vegetation in the table of contents

Select to redraw the map



Format a map and print it out





Change the data on the map by unchecking the for maps you do not want and adding those that you want to explore

View maps of potential hillslope erosion and satellite imagery from the year 2000

You can do similar maps for anywhere else in Australia

Links to more detailed information

Consistent with the development of the Australian Spatial Data Infrastructure and avoiding duplication of data, the Australian Natural Resources Atlas is linked to other data services to help guide users to the most up-to-date and relevant information.

1. *Features on the maps are linked to reports maintained by other groups.*

   For example in the Australian Natural Resources Atlas Map Maker a user can select a wetland on a map and link to a report maintained by another group.

2. *Users are directed to other sites for more detailed information about the region or about the data.*

   Users can follow links from the Australian Natural Resources Atlas Map Maker or Navigator to other more detailed natural resource atlases maintained by State and Territory agencies.

   The data layers used in the Australian Natural Resources Atlas Map Maker are linked to further information available through the Australian Spatial Data Directory.

3. *Integrating maps sourced from many sites over the Internet.*

   International standards and guidelines such as the Web Map Server Interfaces Implementation Specification are being developed that allow data to be sourced from different sites in the Internet and presented to the user.

   The Australian Natural Resources Atlas mapping tool has implemented the Web Map Server Interfaces Implementation Specification. This allows maps from the Australian Natural Resources Atlas to be integrated with other map services available over the Internet.

As well as linking to data and information maintained by other agencies, the Australian Natural Resources Atlas is designed with standard Internet addresses so that other groups can easily link to regional information of interest. These are discussed in detail in the *Australian Natural Resources Information 2001 Operational Manual* (NLWRA 2001f).

Future development of the Australian Natural Resources Atlas

Environment Australia will develop and maintain the Australian Natural Resources Atlas service after the completion of the Audit. Future activities will include:

Enhanced reporting tools to support regional managers

- Many users wish to generate new information products based on regions such as catchment management authority regions, local government areas, postcodes, or user-defined areas that are not currently included in the Australian Natural Resources Atlas. The Australian Natural Resources Atlas Map Maker is being extended to include data analysis and reporting tools to allow generation of reports and statistics for any user-defined area. These tools will be available by June 2002.

  Reporting tools will derive new information products and reports from continuous data such as land use, native vegetation, soil properties, estuaries, and land tenure mapping.

New maps and regional profiles

- The Australian Natural Resources Atlas will become the national node of the Australian Coastal Atlas in early 2002.
- National data for mapping will continue to be added to the Australian Natural Resources Atlas Map Maker. Some summary regional profiles of environmental indicators from *Australian State of the Environment Report 2001* will be available by June 2002.

Involving partners

- Environment Australia will convene regular workshops with data management staff in Commonwealth, State and Territory agencies to review the ongoing development of natural resource Internet atlases.

ANZLIC – the Spatial Information Council is developing a common architecture for a spatial data infrastructure distribution network. When all jurisdictions implement this architecture and publish their maps using the Web Map Server Interfaces Implementation Specification, then a national portal, or entry-point, could be developed to automatically create Australia-wide maps from data held at other sites.

Widespread implementation of the specification is at an early stage in Australia. As of November 2001, only New South Wales and some Commonwealth agencies had implemented online mapping services that are compliant with the specification. It may be some years until all jurisdictions are able to implement these standards in their existing online mapping systems.

Australian Natural Resources Data Library—adl.brs.gov.au

Audit assessments are underpinned by national and regional data, many of which have been brought together for the first time.

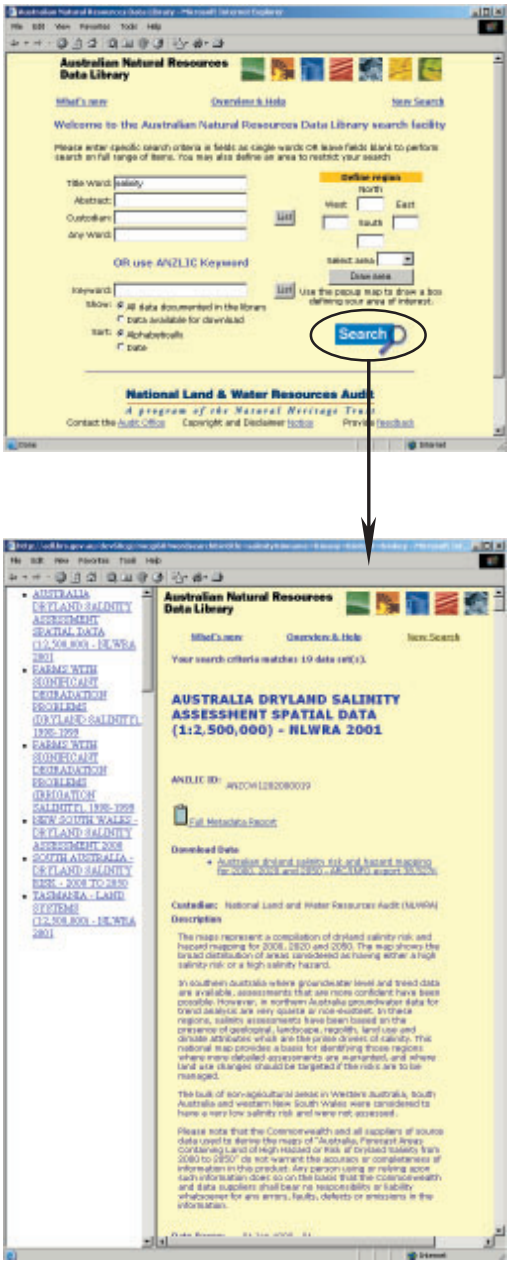
Data custodians are encouraged to make the data from Audit assessments available free of charge over the Internet. Where custodians do not have these facilities, data products are available through the Australian Natural Resources Data Library. The Australian Natural Resources Data Library is a node of the Australian Spatial Data Directory (see page 12).

The Australian Natural Resources Data Library includes a large collection of natural resources data and information collected through Audit projects, integrated with its documentation, data distribution services and tools to manage the data and distribution services. Interfaces to the library provide functionality to securely load, manage and distribute this data. The data in the library are an extension of that portrayed in the Australian Natural Resources Atlas, often providing additional detailed technical information.

The data in the library can be used in geographic information systems and spatial modelling tools.

Figure 20. The Australian Natural Resources Data Library—adl.brs.gov.au

The Australian Natural Resources Data Library allows users to search for data, and after filling in a licence agreement, download the data for use on their own system.



Public access to data

The Australian Natural Resources Data Library provides free and direct access to data from Audit projects, allowing users to:

- find Audit data and information products;
- find out detailed technical information about Audit data and information products; and
- download Audit data for use on their own systems where allowed by owners/ custodians of the data.

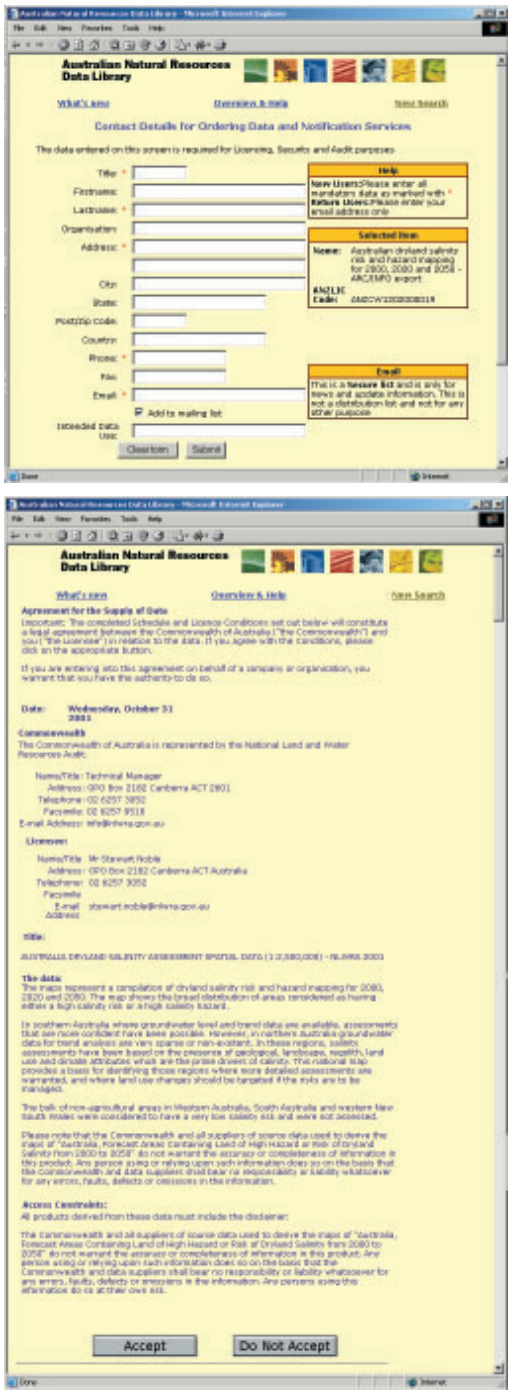
Data available through the Australian Natural Resources Data Library can also be accessed through links from the Australian Spatial Data Directory, or through the Australian Natural Resources Atlas.

The Australian Natural Resources Data Library is underpinned by a single licence agreement, endorsed by ANZLIC – the Spatial Information Council and supported by State, Territory and Commonwealth agencies.

By using the Internet to provide direct access to the map data from Audit projects, the marginal cost of transfer is effectively zero.

After only three months of operation, over 150 sets of data per month were being obtained from the Australian Natural Resources Data Library. The majority of data are packaged so that they can easily be downloaded over Internet connections. For example, the continental soil erodibility data layer is 2.3 MB in size, which is smaller than most of the millions of music and video clips—typically 3 to 20 MB—that are downloaded over telephone lines each day.

Figure 21. Generating a licence to use data from Audit assessments.



Future development of the Australian Natural Resources Data Library

Further development and ongoing management of the Australian Natural Resources Data Library is expected to continue through two stages.

The short-term objective, is to maintain the current system and expand its content and coverage with data from Agriculture, Fisheries and Forestry – Australia and other agencies. The aim is to supplement the Australian Natural Resources Data Library with documentation and data from projects including the National Forest Inventory and the Agricultural Land Cover Change program. This will increase the value of the Australian Natural Resources Data Library to a wider range of users and Australia-wide collaborative programs such as the National Action Plan for Salinity and Water Quality.

Research and development corporations will also be providing data from research projects for the Australian Natural Resources Data Library and contributing information to add to the Australian Natural Resources Atlas (AFFA 2001).

The longer-term, objective of Agriculture, Fisheries and Forestry – Australia is to develop an expanded data warehouse to service its responsibilities for delivery of data and information. This will be undertaken following a comprehensive needs analysis. The enhanced Australian Natural Resources Data Library/data warehouse will link data discovery, data download and web mapping facilities.

Supporting custodians to make their data available

When data are updated, a centralised information service becomes out of date. If data custodians make their data and information available online using nationally agreed protocols, it is more cost-effective and efficient for groups such as the Audit to link directly to that information instead of maintaining and duplicating it centrally.

The agreement between the Audit and ANZLIC – the Spatial Information Council encourages custodians of data to make their data available for download through their node of the Australian Spatial Data Directory. For example, data from Audit projects are also available through data libraries maintained by custodians including Geoscience Australia and Environment Australia.

The Audit in partnership with coordinators of the Australian Spatial Data Directory will identify how the Australian Spatial Data Directory can be enhanced to allow State and Territory custodians to make their data available directly for public access.

Recommendations

Providing community access to information

To further develop a network of community information services that can support natural resource management and reporting applications it is recommended that:

- the Natural Heritage Ministerial Board, through the Natural Resource Management Ministerial Council, evaluate the application of the Australian Natural Resources Atlas and Data Library, and equivalent services at all levels of government, to provide a network of information products used to support regional, national and international reporting obligations such as state of the environment reporting; Montreal Process criteria and indicators for sustainable forest management; and indicators for sustainable agriculture;

- the Natural Heritage Ministerial Board support Environment Australia to maintain, deliver and further develop the Australian Natural Resources Atlas to be compliant with evolving standards for the Australian Spatial Data Infrastructure; and

- the Natural Heritage Ministerial Board support Agriculture, Fisheries and Forestry – Australia to maintain, deliver and further develop the Australian Natural Resources Data Library to be compliant with evolving standards for the Australian Spatial Data Infrastructure.

Monitoring our natural resources requires effective coordination and partnerships

MANAGING OUR INVESTMENT

Australia invests hundreds of millions of dollars each year in data collection and monitoring to inform decision making. Investment is made through Commonwealth, State, Territory and industry activities. For water alone, the Audit has identified monitoring and data collection programs with a total cost more than $185 million each year (Atech 2000).

A more efficient use of this investment in data is essential if we are to better inform and prioritise natural resource decisions.

However, data issues still arise:

- considerable amounts of data are hidden or possibly lost;
- much of the data are not documented and even less data has documentation available to the community; and
- even less data are easily available in a form that allows it to be integrated with other data to support natural resource assessments.

Long-term systematic management of our investment in natural resources data minimises the costs of finding, remediating or re-collecting data, and maximises the opportunities to apply the data to decision making and natural resource management. Resources freed by good data management may then be used to fill critical gaps in our knowledge of our natural resources.

This chapter identifies those actions required to manage the investment in natural resources data and information services developed by the Audit and its partners. Issues discussed and the recommendations identified are designed to complement those in the recently launched *Spatial Information Industry Action Agenda* (Commonwealth of Australia 2001b), and the *Commonwealth Policy on Spatial Data Access and Pricing* (Commonwealth of Australia 2001a).

In particular, the *Spatial Information Industry Action Agenda* addresses private sector involvement in the development of the data infrastructure, and issues of education and training required to improve the capacity to use spatial information systems. The *Commonwealth Policy on Spatial Data Access and Pricing* outlines actions required to build on the success achieved by the Audit to negotiate a single, generic, multilateral agreement with States and Territories through ANZLIC – the Spatial Information Council to enhance access to spatial data.

Building the natural resource spatial data infrastructure

The Audit and its partners have shown that there are substantial benefits in a coordinated approach to providing and managing information across Australia. Yet, lessons from the past suggest that there needs to be a strong and explicit commitment to maintain the systems, data and partnerships that have been developed over the past four years.

Through ANZLIC – the Spatial Information Council, all jurisdictions have agreed on a set of national principles to improve coordination and develop a national spatial data infrastructure (ANZLIC 1999). It is essential that these principles be implemented.

National principles for spatial data management

- Data must be developed and maintained to **meet agreed international or national guidelines or standards** for the management of spatial information as endorsed by ANZLIC – the Spatial Information Council or through national coordination arrangements. *This will ensure the data are comparable and consistent where required.*
- Data must be **documented** in the Australian Spatial Data Directory. Documentation must be current and provide enough information for users to determine whether they are suitable for their purpose. *This will ensure that users can easily find out whether suitable data already exist.*
- Data must be **easily accessible** to all sectors of the community in format, location, cost and under conditions that do not inhibit their use. *This will ensure that users can obtain the data*.
- Data must be **accompanied by a licence** when transferred, clearly setting out the conditions under which they may be used, the rights and responsibilities of the data provider, and the rights and responsibilities of the data receiver. Licence arrangements are required to ensure that the data are accessible, while protecting copyright, intellectual property, privacy and confidentiality. The rights of the individual and governments in relation to confidentiality, privacy, security and intellectual property must be preserved. *This will ensure that the rights of all parties are protected and understood.*
- Before funding data collection, organisations and jurisdictions should actively **identify and exploit** the many existing **opportunities for cooperation and sharing of fundamental spatial data** to avoid duplication and maximise benefits of investment in data collection.

Coordinating the development of Australia-wide data to support natural resource decision making

While the principles for developing an Australia-wide spatial data infrastructure have been agreed by all jurisdictions and may appear simple, they are not always being implemented.

The *Spatial Information Industry Action Agenda* (Commonwealth of Australia 2001b) notes that poor coordination of public data collection between public sector agencies has led to:

- different agencies collecting essentially the same data, either because existing data have not been collected to the required standards or because they are unaware of each other's activities; and
- different agencies using similar technologies to collect different data in the same area, when, with better coordination, a single data collection exercise could collect both sets of data.

The Commonwealth has spent over $20 million for mapping vegetation in past seven years through Commonwealth – State partnership programs including the Regional Forest Agreements, Bushcare, the National Forest Inventory, Save the Bush and the Cape York Peninsula Land Use Study. Despite this significant investment, the Audit assessment of native vegetation (NLWRA 2001e) found that it was difficult to find, standardise and integrate the data to support a national assessment of native vegetation resources. Most of these data are not documented in the Australian Spatial Data Directory, and programs often used different methods to collect the data, define attributes and generate maps.

National coordination

There are many agencies at all levels of government that can supply local, regional or Australia-wide data to help build a national picture.

When undertaking the Audit assessments, the best quality and most accessible Australia-wide data included climate, geology, agricultural statistics, and topography (roads, rivers and elevation) data. These sets of data had been developed through long-term Commonwealth and State/Territory programs, applying agreed standards to develop products that were consistent across Australia.

To date, most Commonwealth funding for data about vegetation, soil, water and land resources has been through short-term projects. The data generated by short-term and regional programs is potentially useful in the construction of Australia-wide data to support natural resource management activities. However with many custodians involved, it is essential to enhance coordination and funding arrangements so that the components of the national picture are compatible.

More effective national coordination is needed to establish strategic data collection priorities, avoid duplication and provide long-term certainty for data collection and management. Strong coordination arrangements are required with leadership and incentives to ensure that efficiencies are achieved.

Consultative and coordinated approaches to data acquisition and determination of priorities will ensure that data enjoy the widest use.

Australia is wasting valuable intellectual and capital resources because of the multitude of uncoordinated data collection and management programs. This situation is not sustainable either from a public policy or investment perspective.

To efficiently build Australia-wide data, national coordination arrangements are needed that:

- Provide leadership in developing standards and procedures for data collection, maintenance and transfer.
- Support the activities of custodians to ensure that data are collected, maintained and delivered in conformance with standards and specifications, with minimum duplication of effort.
- Maintain active consultation across agencies, industry and users of data to identify their priorities and information needs. Regular review of client needs is important to ensure that information services remain relevant.
- Draw together the interests of data custodians and matching these interests to the needs of users.
- Focus on how the activities and lessons from one jurisdiction can be applied in other jurisdictions to minimise 'reinventing the wheel'.
- Expeditiously assess all relevant spatial data collection projects before they commence to minimise duplication and ensuring that data products will be compatible with the spatial data infrastructure.
- Develop and implement programs with custodians and funding agencies (within resource constraints) to update the data to improve monitoring of Australia's natural resources—update programs should reflect the needs of decision makers, and the scales and time frames within which decisions are made.

Government funding of data at all levels of government must encourage consistency, integration and ongoing development of Australia's data infrastructure. Data collections and ongoing monitoring projects, whether large or small, and irrespective of scale, should be managed in accordance with the national data management framework. The Commonwealth can show leadership through better coordinating its own natural resource data collections.

Recommendations

Maximum value for money

To maximise investment in data collection and the provision of information at a range of scales, it is recommended that the Natural Heritage Ministerial Board, through the Natural Resource Management Ministerial Council, ensure that Commonwealth, State and Territory agencies use standard conditions in contracts and agreements when collecting natural resource data. Conditions should seek to improve the availability of consistent natural resource data to government, industry and the community. The conditions should ensure that:

- data are made available to the community within time frames and forms that maximise their use;
- data are collated and made available using nationally agreed standards and guidelines for the Australian Spatial Data Infrastructure as endorsed by ANZLIC – the Spatial Information Council;
- spatial data are fully documented in the Australian Spatial Data Directory;
- data are available through a single licence agreement, such as the agreement developed between the Audit and ANZLIC – the Spatial Information Council and supported by Commonwealth, States and Territories; and
- there are no limitations on the use of natural resource data funded through these projects.

Commonwealth, State and Territory agencies should be encouraged to adopt these conditions for all spatial data.

Progress reports

It is recommended that the Natural Heritage Ministerial Board, through the Natural Resource Management Ministerial Council, requests that ANZLIC – the Spatial Information Council provide yearly reports on the status of the natural resource spatial data infrastructure to the Natural Resource Management Ministerial Council detailing progress on key activities to:

ensure that users can find out whether suitable natural resources data exist by:

- reviewing the Australian Spatial Data Directory and measure trends in the quality and availability of information about natural resource data; and
- recommending actions for consideration by the Natural Resource Management Ministerial Council to improve the quality and availability of information about natural resource data (metadata).

ensure that government, industry and the community can easily obtain natural resources data by:

- reviewing the availability of natural resource data from government to the community and identify important natural resource data that are in a format or location, at a cost, or under licence conditions that inhibit their use; and
- recommending actions for consideration by the Natural Resource Management Ministerial Council to improve the availability of natural resource data.

ensure that natural resource data are comparable and consistent, where required by:

- providing detailed audits on the progress of fundamental Australia-wide sets of natural resource data in meeting guidelines developed for the Australian Spatial Data Infrastructure; and
- recommending actions for consideration by the Natural Resource Management Ministerial Council to improve the development of fundamental Australia-wide sets of natural resource data.

reduce duplication by:

- identifying opportunities for cooperation to avoid duplication and maximise benefits of investment in the collection of natural resource data.

MEETING AUDIT OBJECTIVES

The Audit information management program aimed to meet two of the Audit's six objectives:

Objective 3. Developing a national information system of compatible and readily accessible land and water data.

Objective 6. Providing a framework for monitoring Australia's land and water resources in an ongoing and structured way.

To achieve these objectives the Audit built on existing programs in the natural resources information field. Major achievements include:

Arrangements established with Commonwealth, State and Territory agencies that promote and maximise cooperation and collaboration in all aspects of data and information management.

- In 1999, the Audit signed bilateral data protocols with custodians of data in each State and Territory, and with Commonwealth agencies. The protocols streamlined the process of gaining access to data to undertake Audit assessments.
- In 2001, the Audit and ANZLIC – the Spatial Information Council, supported by the Commonwealth and all States and Territories, signed a landmark agreement to ensure ongoing community access to data from Audit assessments, and for future assessments. This agreement provides a model for future agreements between governments to simplify access to a wider range of data.

Consistent, comparable, Australia-wide data compiled for natural resource assessments.

- Australia-wide sets of data developed through Audit projects include the Australian Soil Resources Information System, the National Vegetation Information System, an Australia-wide map of land use in 1996/97, and a national inventory of estuaries and their condition. These data were used to support the assessments undertaken by the Audit.
- Australia-wide sets of data have also supported the work of other groups. For example in Western Australia the national land use map has supported plague locust control; in New South Wales it has been used in state of the environment reporting. Data compiled in the Audit's assessment of dryland salinity (NLWRA 2001b) have been used in the identification of priorities for the National Action Plan for Salinity and Water Quality. Data from the Audit's assessment of water quantity and quality (NLWRA 2001a) have been used to revise the Western Australian water management framework.
- Data products available to the community are described in the data catalogue in Appendix 1.

A system established for storing, managing and retrieving fundamental data, derived data and information products.

- The Audit has established one of the most comprehensive natural resource information systems available to the community anywhere in the world. However, much data still needs to be collected to support regional, State/ Territory and national outcomes.
- The Australian Natural Resources Data Library, available over the Internet, provides free access to most of the detailed data outputs from Audit assessments.
- The Australian Natural Resources Atlas presents detailed regional information products with statistics, expert opinion and interpretation from Audit assessments.
- The Australian Natural Resources Atlas provides tools to help natural resource managers explore and create maps for any region in Australia, from catchment to national scale.
- To help ensure access to up-to-date data and information, the Australian Natural Resources Atlas presents information products from monitoring systems such as the Australian Collaborative Rangelands Information System (NLWRA 2001c).
- Products developed in partnership with Environment Australia State of the Environment Reporting (landscape health, water quality, estuaries) and Agriculture, Fisheries and Forestry – Australia and the Australian Bureau of Statistics (agricultural statistics) are available through the Australian Natural Resources Atlas.
- Audit information services are linked to the more detailed stores of information available online from existing State and Territory initiatives, and to the Australian Spatial Data Directory to form a national distributed system for data query, display, mapping and access.
- Distributed systems, such as the National Vegetation Information System used in the Audit's assessment of native vegetation (NLWRA 2001e), are also being developed in partnership with States, Territories and the Commonwealth to support the continued update and delivery of fundamental data.

A common information management framework developed for all Audit projects.

- The *Information Management Manual* was released in 1999 (NLWRA 1999) to assist Audit projects collate data and information in a format that could be easily integrated with data from other projects.
- The *Australian Natural Resources Information 2001 Operational Manual* (NLWRA 2001f) released in December 2001 describes in detail the standards, guidelines and protocols used in design, development and implementation of the Australian Natural Resources Atlas and Data Library. The operational manual provides a template for implementing information systems, at international, national and regional levels.

Institutional and related arrangements developed to provide a data system to underpin natural resource assessments after the completion of the Audit.

- Arrangements are in place with Environment Australia and Agriculture, Fisheries and Forestry – Australia, to continue to support the Australian Natural Resources Atlas and Data Library.
- With the Commonwealth Spatial Data Committee, the Audit has identified coordinators to help ensure that major databases from Audit projects continue to be consistently updated and made available to the community.

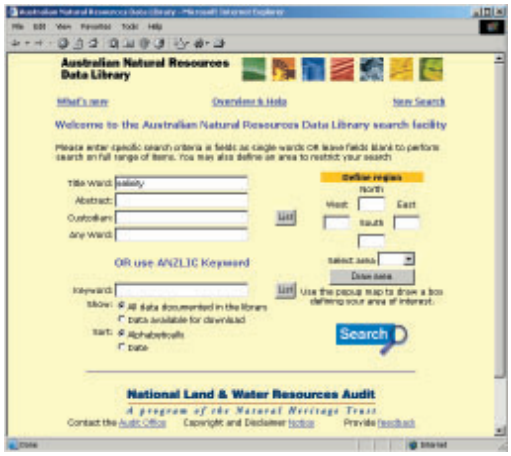
APPENDIX 1. CATALOGUE OF DATA PRODUCTS FROM AUDIT ASSESSMENTS

Digital data products are available for free download over the Internet from the Australian Natural Resources Data Library at adl.brs.gov.au or directly from custodians of the data. The products are designed for analysis and display using geographic information systems.

Documentation for each product is also available through the Australian Spatial Data Directory at www.auslig.gov.au/asdd.

Before the data are downloaded, users accept a set of licence conditions that allow royalty-free, non-exclusive use of the data. The licence conditions do not allow the data to be transferred from the licensee to another person or organisation. Data, or any product or service derived from the data, may be commercialised with permission of the owners of the data.

The following catalogue lists some of the data currently available from Audit projects. New data are continually being added as Audit projects conclude.



AGRICULTURE

A spatially consistent subset of agricultural statistics (AgStats) data 1982/83 to 1996/1997

- Subset of 759 data items from the agricultural census data from 1982/1983 to 1996/1997 published by the Australian Bureau of Statistics.

The statistics have been standardised to version 2.6 of the 1996 statistical local area boundaries from the Australian Bureau of Statistics and take into account areas of agriculture from the national land use map (1996/97).

Proportion of land area under irrigation for 1996

- Map shows the proportion (0 to 1) of 0.05-degree latitude/longitude cells under irrigation.

The assessment was derived from the map of designated and actual irrigation areas in Australia for 1996.

Agricultural industries—regional boundaries

- Data layers show boundaries for the dairy, sugar, cotton, grains, beef and sheep industries in 1999.

Figure A1 AgStats broadacre crop changes from 1983–85 to 1994–97.

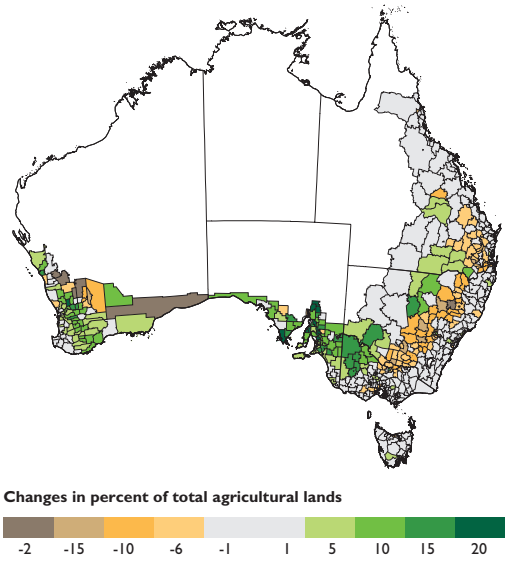
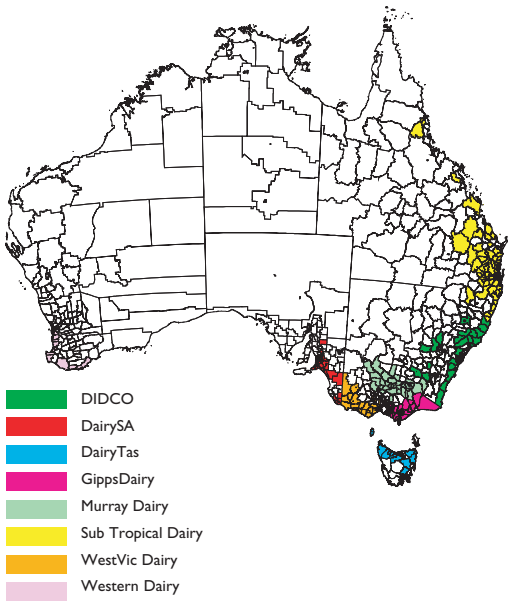


Figure A2 Australian dairy regions.



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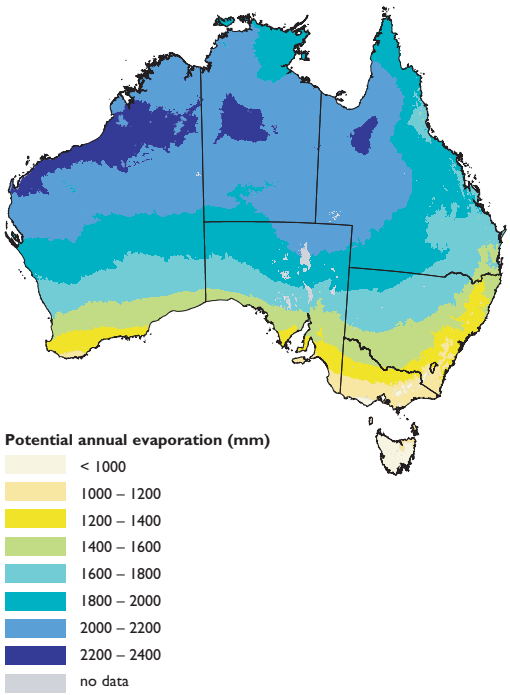
Climate variables used to determine agricultural water balances

- Data layers show mean annual and monthly rainfall, potential evaporation, total evaporation, transpiration from the plant canopy, run-off, maximum and minimum daily surface temperature and solar radiation.

Maps are derived from data from the Bureau of Meteorology, interpolated to a spatial grid of 0.05 degrees of latitude and longitude. Data layers were derived to assess the availability of water for agriculture.

Figure A3 Priestley-Taylor (potential) annual evaporation.

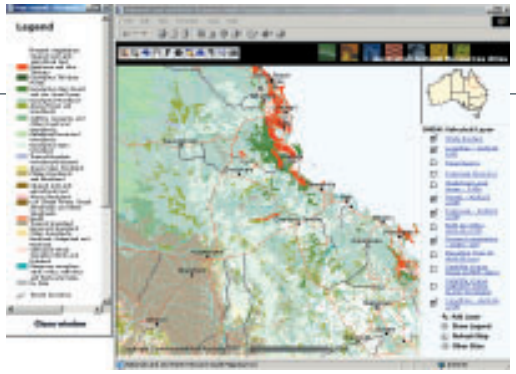


Source: Bureau of Meteorology – Queensland Department of Natural Resources and Mines gridded data on solar irradiance and near-surface temperature.

BIODIVERSITY AND VEGETATION

Native vegetation

The maps were derived from the National Vegetation Information System. For present vegetation the nominal scale is 1:100 000–1:250 000 for the intensive land use zone and 1:250 000–1:1 000 000 for the extensive land use zone. For pre-1750 vegetation, the nominal scale is 1:1 000 000.



Available maps

- Pre-European major vegetation groups and subgroups
- Major native vegetation groups and subgroups
- Extent of native vegetation in Australia
- Cleared major native vegetation groups

Native vegetation information to support regional vegetation management

Figure A4 Pre-European vegetation, Isaac – Comet Downs subregion.

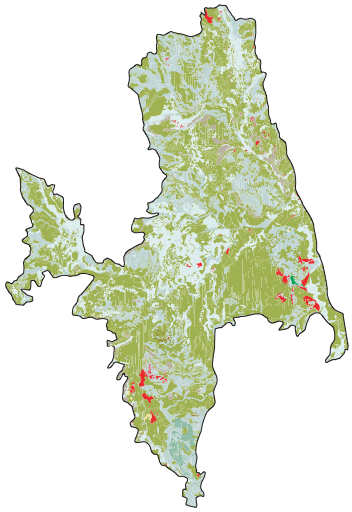


Figure A5 Major vegetation groups, Isaac – Comet Downs subregion.

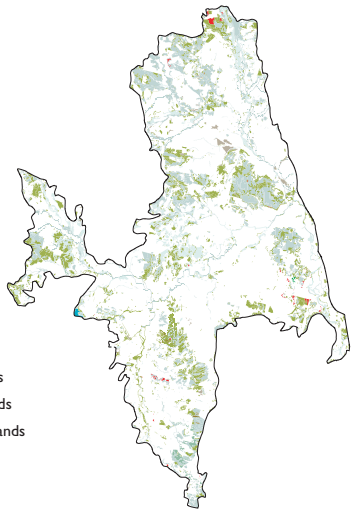
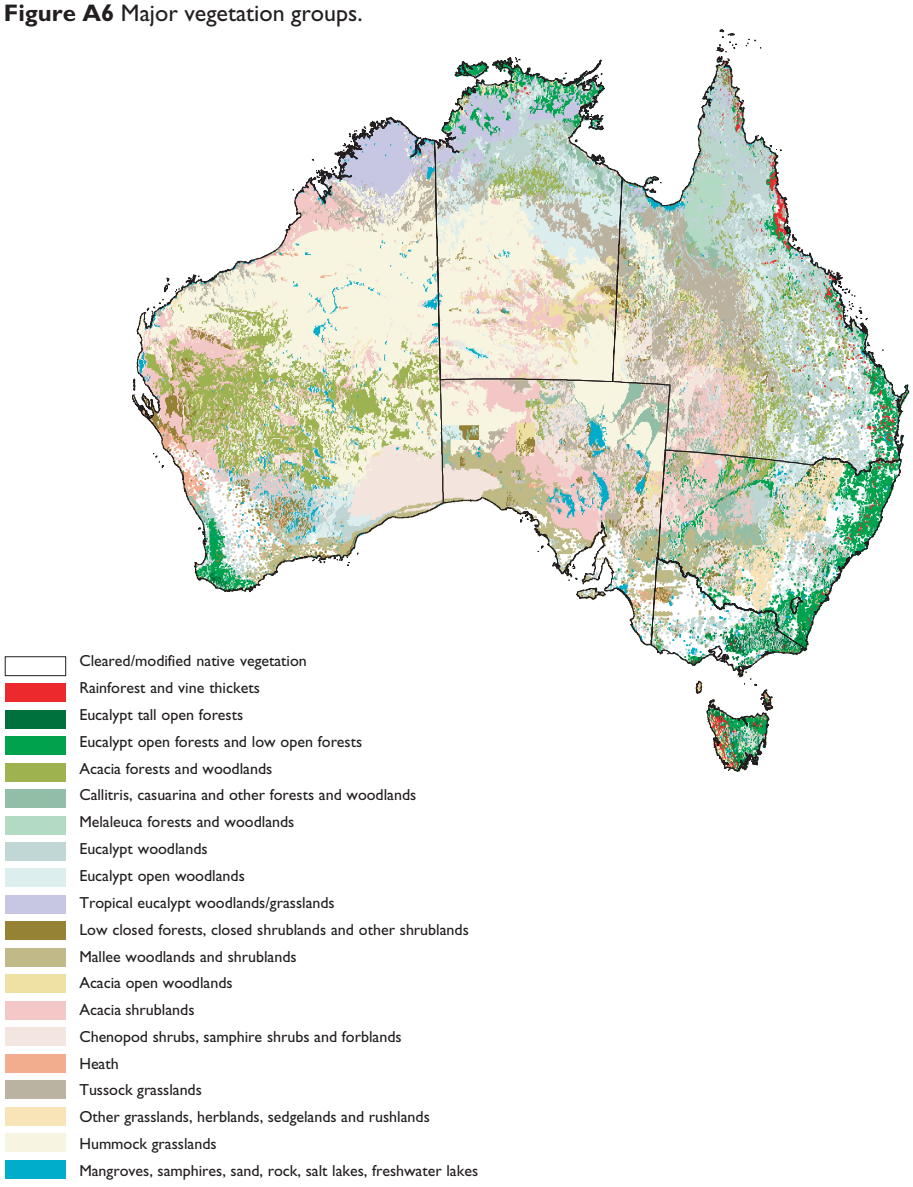


Figure A6 Major vegetation groups.



BIODIVERSITY AND VEGETATION

Landscape health in Australia 2001

An assessment of the relative condition of Australia's bioregions and subregions.

Figure A7 Current extent of native vegetation by subregion (%).

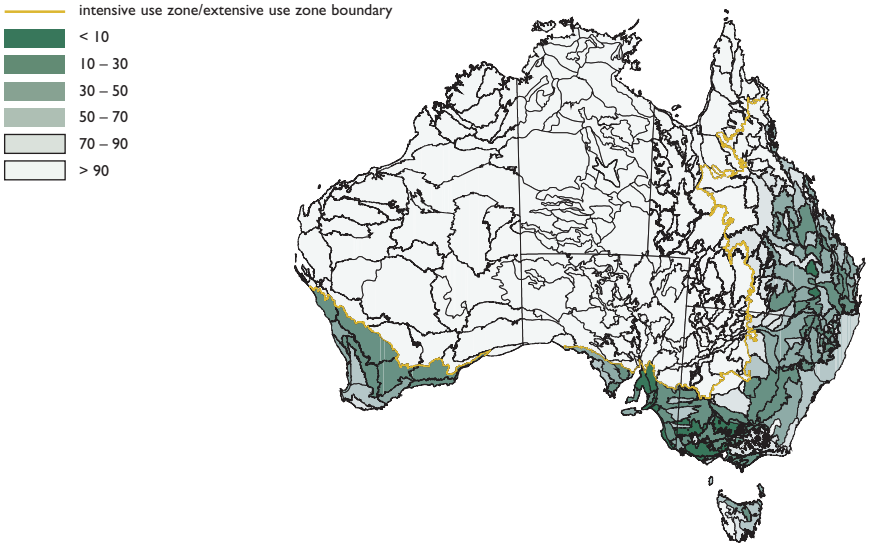
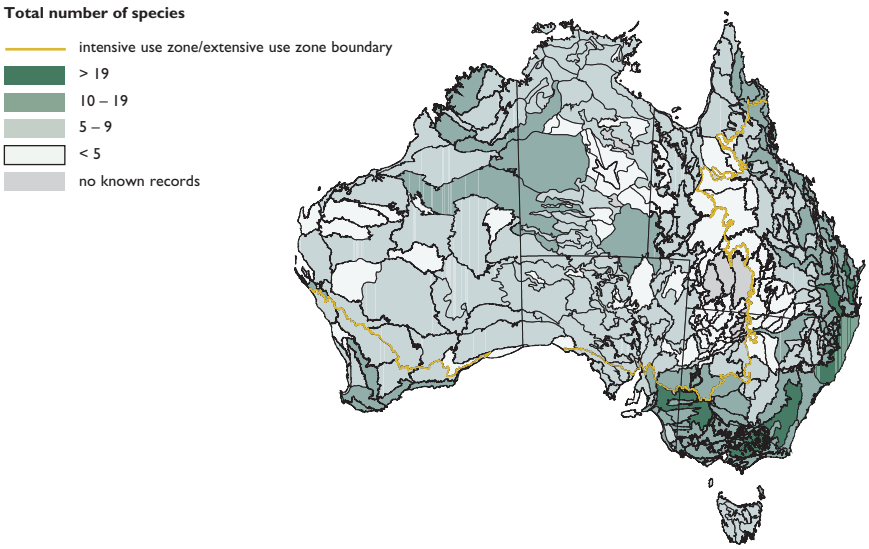


Figure A8 Known and predicted occurrence of threatened vertebrate fauna.



Available maps

Condition

- Percentage of subregion with native vegetation cover
- Degree of connectivity in native vegetation in the intensive use zone. Connectivity classes range from those with little connectivity to those that are totally unmodified by major change in the structure of the vegetation
- Percentage of subregion in conservation reserves
- Percentage of native vegetation outside conservation reserves in the intensive use zone
- Percentage of the subregion in the 'least impact from total grazing pressure' class in the extensive use zone
- Percentage of native vegetation in land tenures associated with conservation
- Percentage of subregion with high dryland salinity risk or hazard in the intensive use zone
- Percentage of native vegetation in the subregion in areas of high dryland salinity risk or hazard in the intensive land use zone
- Degree of changed hydrological conditions (four classes) minor change to major change
- Distribution and density of feral plants by subregion (alligator weed, cabomba, salvinia, hymenachne, para grass, pond apple, buffel grass, gamba grass, mission grass, athel pine, mesquite, prickly acacia, parkinsonia, rubber vine, Chilean needle grass, serrated tussock, bridal creeper, Wards weed, gorse, bitou bush, willows, blackberry, boxthorn, broom, olives, radiata pine, lantana and parthenium weed)
- Distribution and density of feral animals by subregion (rabbits, cats, foxes, goats, pigs, swamp buffalo and cane toads)
- Percentage of subregional ecosystems at risk in the intensive use zone
- Total number of known and predicted occurrences of threatened plants listed nationally in the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
- Total number of known and predicted occurrences of threatened vertebrate fauna listed nationally in the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
- Total number of known and predicted occurrences of marine and pelagic threatened vertebrate fauna listed nationally in the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)

Trend

- Area in hectares per subregion of woody native vegetation cleared each year between 1990 and 1995 in the intensive use zone
- Area in hectares per subregion in Queensland and Tasmania of woody native vegetation cleared each year between 1995 and 1997 in the intensive use zone
- Area in hectares per subregion in Queensland of woody native vegetation cleared each year between 1997 and 1999 in the intensive use zone
- Change in the annual rate of clearing 1995–97 and 1997–99 in the intensive use zone in Queensland
- Percentage of subregion predicted to have high dryland salinity risk or hazard in 2050 in the intensive use zone
- Percentage of native vegetation in the subregion predicted to have high dryland salinity risk or hazard in 2050 in the intensive use zone
- Trend in high dryland salinity risk or hazard in subregion between 2000 and 2050 in the intensive use zone
- Trend in high dryland salinity risk or hazard in native vegetation per subregion between 2000 and 2050 in the intensive use zone

Landscape stress

- Continental landscape stress—relative rating from highest to lowest

Data are available for download from the Environment Australia node of the Australian Spatial Data Directory.

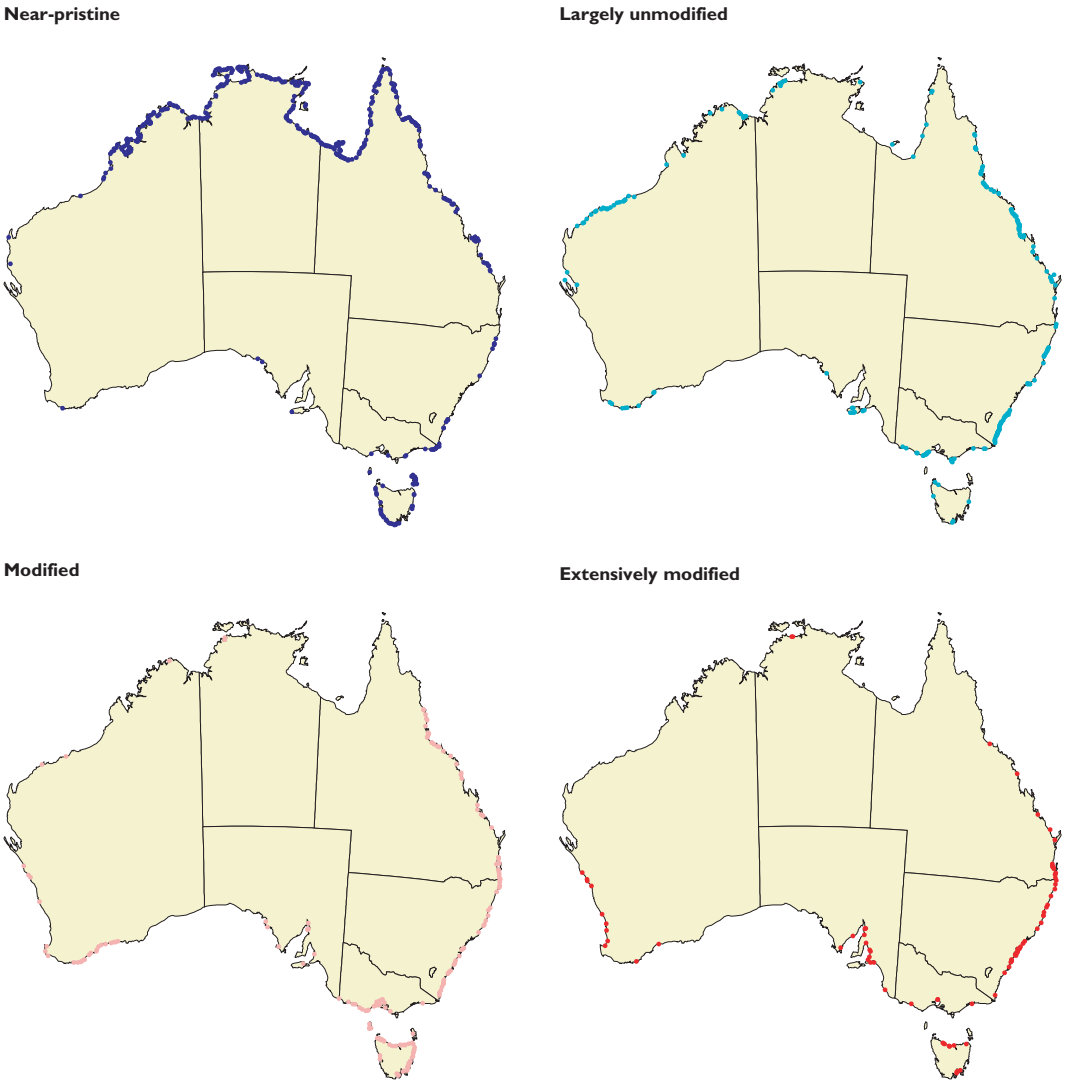
COASTS

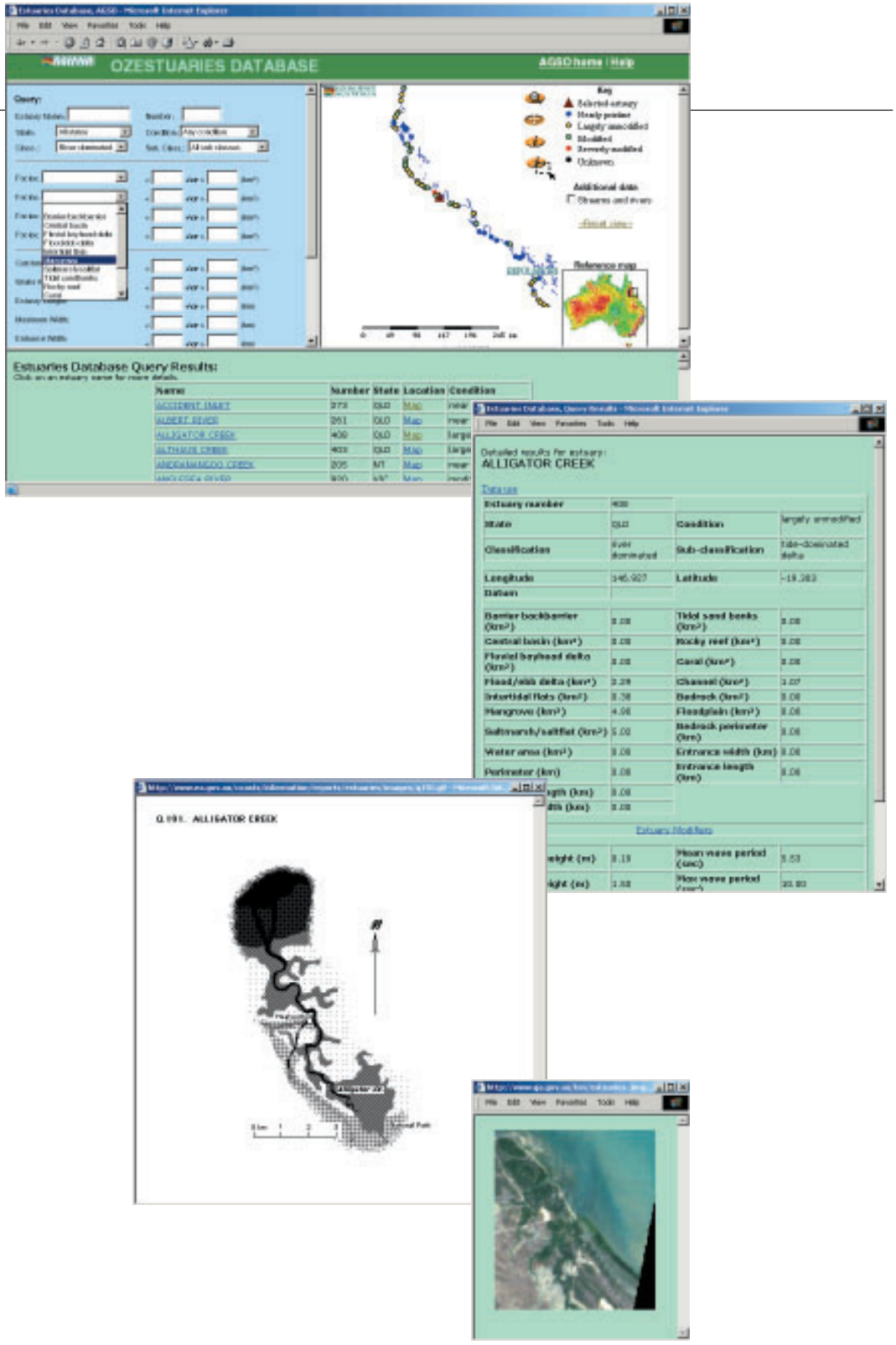
Estuary Condition Assessment 2000

Estuary Condition Assessment 2000 assessed the condition of 974 estuaries and classified each estuary by the key geomorphological processes driving it.

Data are available online from Geoscience Australia at www.ga.gov.au/oracle/ozestuaries/

Figure A9 Condition of Australian estuaries.




OZESTUARIES DATABASE
Estuaries Database Query Results:
ALLIGATOR CREEK
Q 191. ALLIGATOR CREEK

LAND

Australian Dryland Salinity Assessment 2000 to 2050

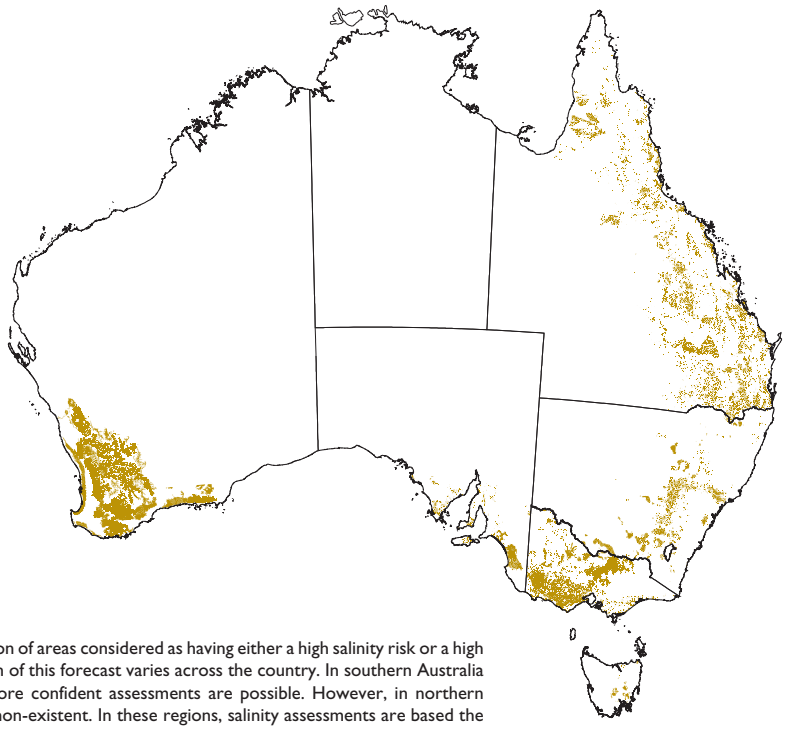
Australia

- Data comprises a compilation of dryland salinity risk and hazard mapping for 2000, 2020 and 2050.
- Maps are at a scale of 1:2 500 000 and show the broad distribution of areas considered as having either a high salinity risk or a high salinity hazard.

Groundwater level and trend data are available in southern Australia and more precise assessments have therefore been possible. In northern Australia groundwater data for time-series analysis are very sparse or non-existent. In these regions, salinity assessments have been based on the presence of geology, landscape, regolith, land use and climate attributes which are the other prime drivers of salinity. The national map provides a basis for identifying those regions where more detailed assessments are warranted and where land use changes should be targeted if the risks are to be managed.

Most non-agricultural areas in Western Australia, South Australia and western New South Wales were considered to have a very low salinity risk and were not assessed.

Figure A10 Forecasted areas containing land of high hazard or risk of dryland salinity in 2050.



This map shows the broad distribution of areas considered as having either a high salinity risk or a high salinity hazard by 2050. The strength of this forecast varies across the country. In southern Australia where better data are available, more confident assessments are possible. However, in northern Australia data are either sparse or non-existent. In these regions, salinity assessments are based the prime drivers of dryland salinity—geology, landscape, soils, land use and climate. This national map allows us to identify regions where we should make more detailed assessments and land use could change to manage risks.

Most non-agricultural areas in Western Australia, South Australia and western New South Wales were considered at very low risk of salinity and were therefore not assessed.

New South Wales

- Data show areas of dryland salinity risk in 2000, 2020 and 2050 in the Murray–Darling Basin within New South Wales and coastal catchments.

Areas of risk are based on groundwater levels and air photo interpretation. The merged data, at a nominal scale of 1:250 000, show actual areas where dryland salinity or watertables < 2 m have been measured. For the map of salinity extent, every delineated area is validated by either air photo data or by one or more groundwater bores. The area at risk is regarded as conservative due to limitations in the spatial coverage of air photo and groundwater bore data.

Coastal catchments are not represented in the prediction for 2050 due to the paucity of groundwater data.

Queensland

Estimates of projected dryland salinity hazard for 2050 were based on integrating attributes that drive salinisation (e.g. geology, landscape features, regolith depth and type, land use and climate). Groundwater data for assessing salinity risk in Queensland are extremely limited. Groundwater trend analysis was possible only in the Condamine-Balonne and Border Rivers catchments of the Murray–Darling Basin. Information has been prepared at a scale of 1:2 500 000.

South Australia

The South Australian maps of dryland salinity risk in 2000, 2025 and 2050 are at 1:250 000 scale.

Current dryland salinity areas were interpreted from aerial photography and existing topographic data. Some additional areas were digitised from topographic base maps.

Areas thought to be at risk from dryland salinity by 2025 and 2050 are based on groundwater trends, topography and professional judgement.

Tasmania

The Tasmanian Department of Agriculture carried out a series of reconnaissance surveys of the State's land systems between 1980 and 1989. The land systems were differentiated initially by examining geomorphic patterns on aerial photographs in conjunction with geologic, topographic and climatic maps. The maps of salinity are based on land systems at 1:250 000 scale containing areas of salinity in 1992, and land systems on agricultural land containing areas of salinity in 2000.

Victoria

The Victorian dryland salinity assessment spatial data comprises:

- Watertable trend into the future using the maximum trend derived from the bore hydrograph analysis (1:250 000)
- Watertable depth as at 1998 (1:250 000)
- Predicted watertable depth in 2020 using the maximum predicted watertable trend (1:250 000)
- Predicted watertable depth in 2050 using the maximum predicted watertable trend (1:250 000)
- Watertable salinity risk into the future using the maximum predicted watertable trend (1:250 000)
- Watertable salinity risk into the future using the minimum predicted watertable trend (1:250 000)

LAND

Australian Dryland Salinity Assessment 2000 to 2050 (continued)

Western Australia

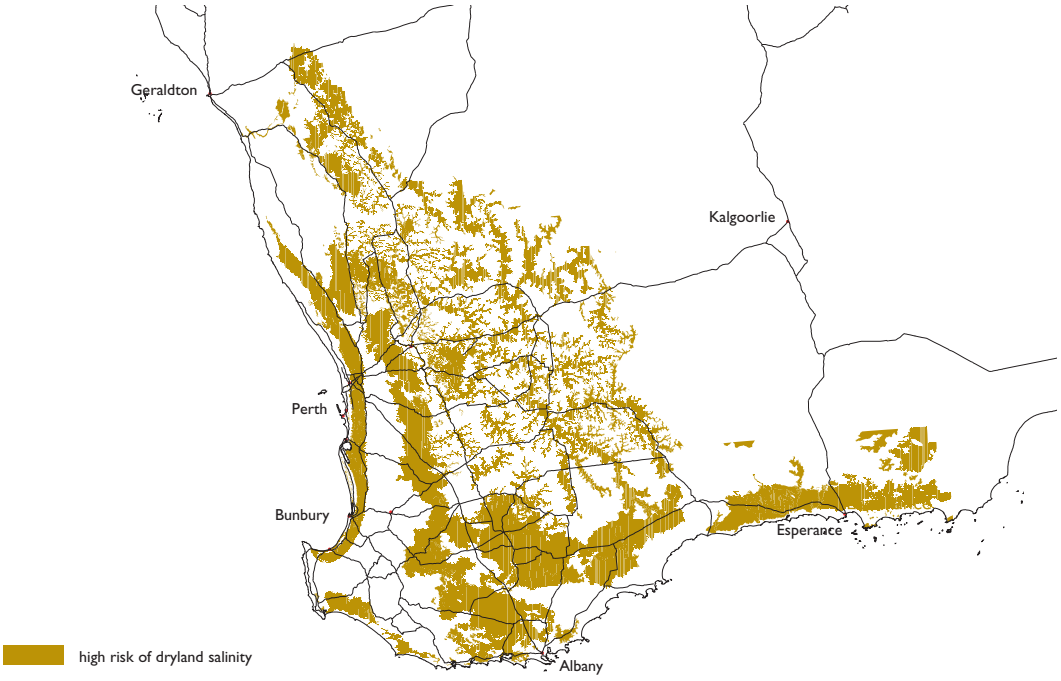
The Western Australian dryland salinity assessment spatial data were derived from detailed soil-landscape mapping at 1:500 000 scale and comprise three maps:

- The risk of shallow watertables across agricultural areas in Western Australia in 2000, 2020 and 2050
- Depth to watertable
- Distribution of groundwater monitoring sites used for the assessment

The risk of shallow watertables was derived from analysis of the groundwater depth and trend over time. As dryland salinity is caused by shallow watertables, the risk of salinity is inferred from the risk of developing shallow watertables. Not all shallow watertables will be saline however. Estimates and projected risk areas are based on analysis of existing groundwater levels and trends at a scale of 1:250 000 based on the mapping of soil systems.

The assessment was restricted to the south-west of Western Australia where dryland salinity or susceptibility is widespread.

Figure A11 Dryland salinity risk in south-west Western Australia 2050.

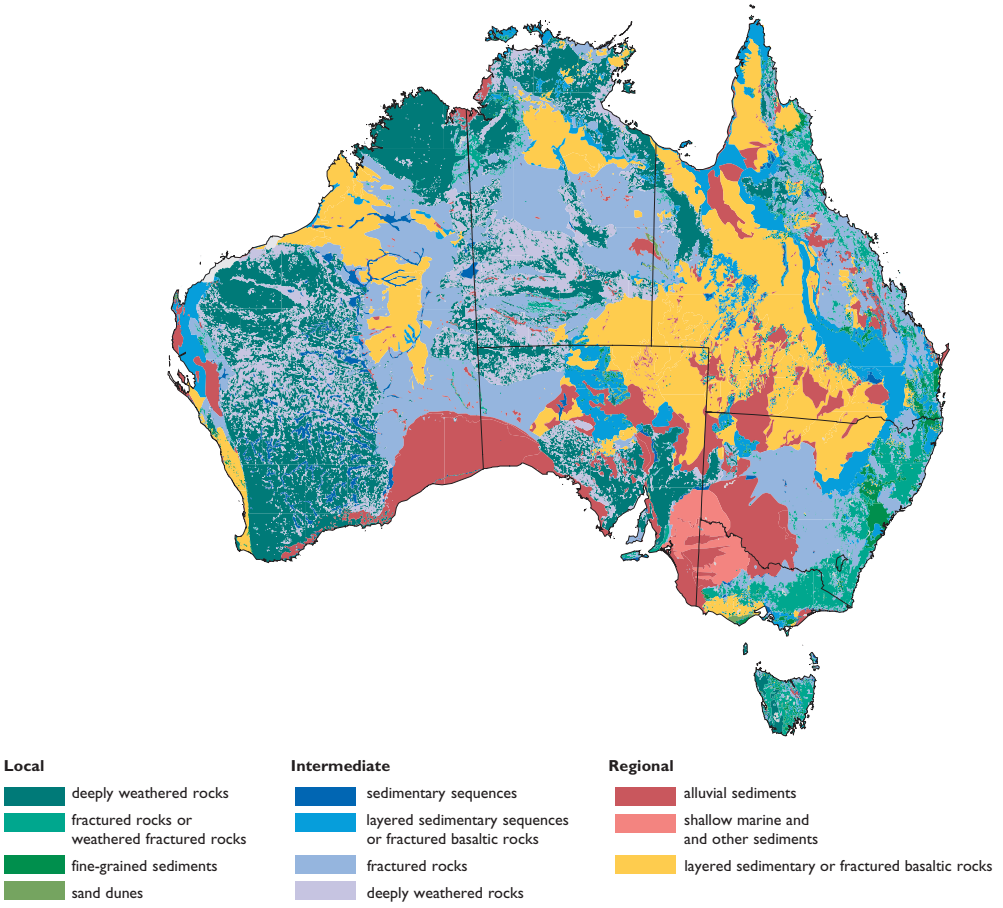


Australian groundwater flow systems (1:5 000 000)

- Data show the distribution of groundwater flow systems at a national scale.

These flow systems were identified using a combination of geology, geomorphology and elevation information at a national scale.

Figure A12 Distribution of groundwater flow systems across Australia.



LAND

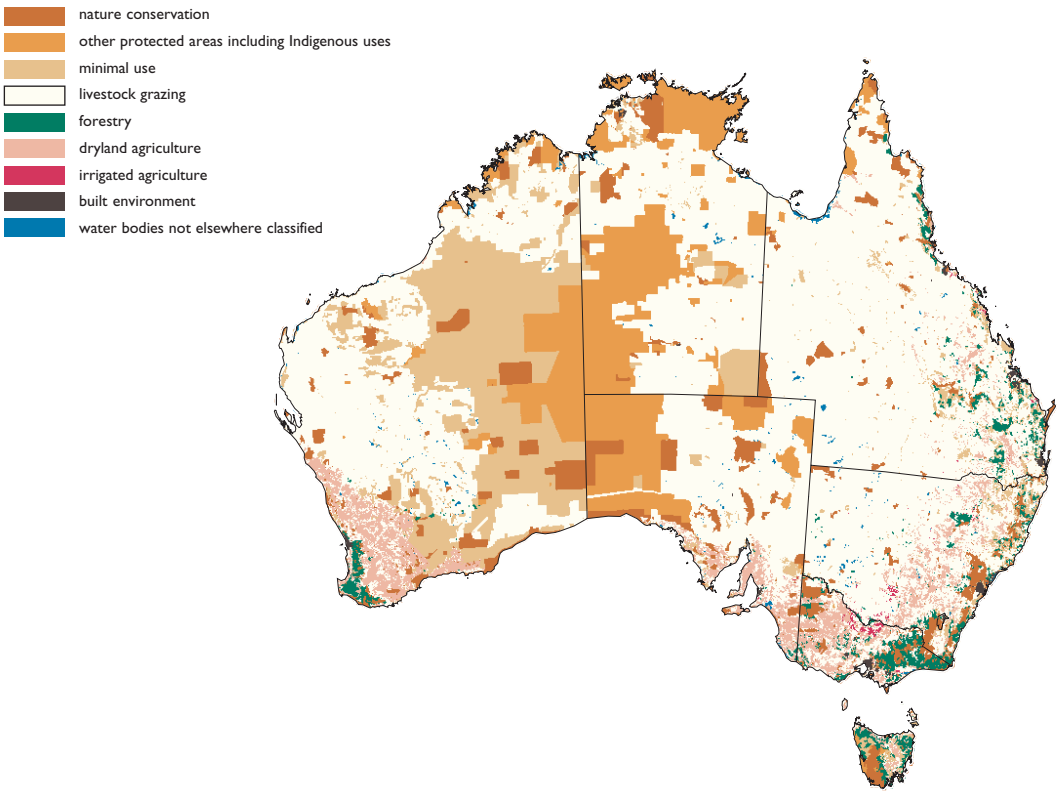
Australia-wide land use (1996/97) (1:1 000 000)

- Land use map shows agricultural and non-agricultural land uses for the year April 1996 to March 1997 at a resolution of 0.01 degrees latitude/longitude.

Information about the distribution of protected areas, forest types, agricultural commodities and irrigated areas is available in the database.

The agricultural commodities and irrigation layers show specific agricultural land uses and were constructed by automated analysis of a one year sequence of normalised difference vegetation index images using control sites to provide known agricultural land uses at known locations.

Figure A13 Land use in Australia.



Fitzroy River catchment land use 1996/97 (1:100 000)

- Map shows 1996/97 land use in the Fitzroy River catchment, Queensland.

The data are attributed using the Australian Land Use Management Classification at 1:100 000 scale. The data were collected using satellite imagery interpretation and extensive fieldwork.

Gippsland land use 1996/97 (1:100 000)

- Land use map for Gippsland Victoria for the year 1996/97.

The map is based on data held at the Victorian Department of Natural Resources and Environment, satellite imagery, Australian Bureau of Statistics agricultural statistics and information collected in the field. The data are attributed using the Australian Land Use Management Classification at 1:100 000 scale.

Mt Lofty land use 1996/97 (1:100 000)

- Land use map for Mt Lofty South Australia for the year 1996/97.

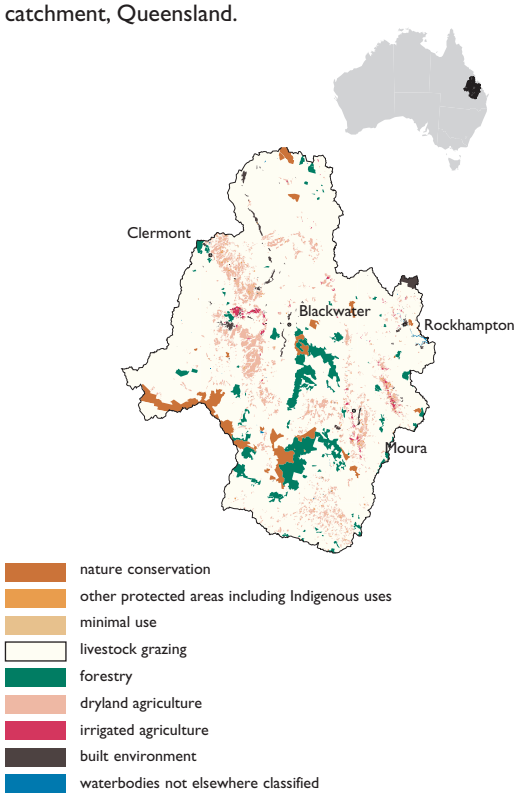
The data are attributed using the Australian Land Use Management Classification at 1:100 000 scale.

Western Australia land use 1999 (1:100 000)

- Map shows land use in Western Australia in 1999.

The data are attributed using the Australian Land Use Management Classification at 1:100 000 scale.

Figure A14 Land use in the Fitzroy river catchment, Queensland.



LAND

Soil properties—Australian Soil Resources Information System (ASRIS)

The maps of soil properties available from the Australian Soil Resources Information System include:

Soil depth

Soil depth defines the zone available for plant roots to grow in and determines the size of the soil water store. Maps are available of solum depth, topsoil depth and subsoil depth.

Solum depth refers to total depth of soil (A and B horizons). It does not include the unconsolidated or partially weathered material which underlie the soil, where soil-forming processes are not obvious.

Topsoils (A horizons) are defined as the surface soil layers in which organic matter accumulates and may include dominantly organic surface layers.

Subsoils (B horizons) contain less organic matter than topsoils and may often have a zone of accumulation of clays, carbonates or iron and aluminium oxides.

Particle size distribution and soil texture

Soil texture is strongly related to many other soil physical properties (e.g. soil structure, bulk density, porosity, permeability) and chemical properties (e.g. cation exchange capacity). Soil texture is often used to estimate other soil properties (particularly soil water properties) if no direct measurements are available. Maps are available of:

- percentage of clay;
- percentage of silt;
- percentage of sand; and
- texture classes.

Bulk density (topsoil and subsoil)

Bulk density is the weight of a dry soil in a unit of volume and gives a measure of soil porosity.

Knowing the bulk density of a soil is important as it can help determine how much air or water can be stored and moved through the soil. Bulk density also indicates how tightly soil particles are packed together.

Soils with low bulk density are generally more suitable for agriculture, since this indicates high pore space (and so greater potential to store water) and roots extend more readily through a soil of low bulk density.

Available water capacity (topsoil and subsoil)

The available water capacity gives an approximation of the water storage capacity of a soil and so is important in assessing suitability for agriculture. Available water capacity is the amount of water in the soil horizon that can be extracted by plants.

Total nitrogen

- Maps are available of the total nitrogen in the topsoil.

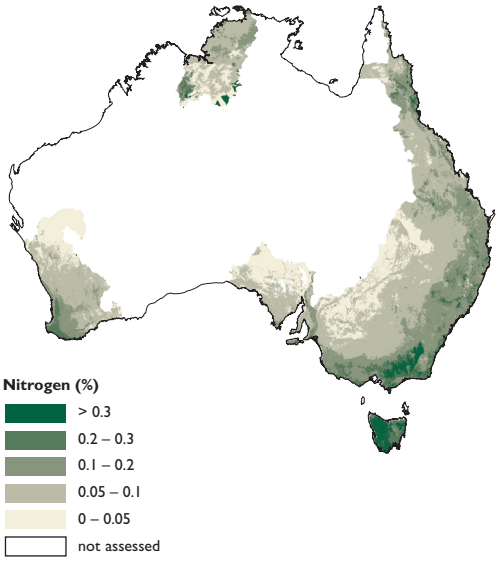
Nitrogen is an element that is part of all living matter. Most soil nitrogen is associated with organic compounds such as proteins or fertiliser inputs.

Total phosphorus and extractable phosphorus (topsoil)

- Maps are available of the total phosphorus and extractable phosphorus in the topsoil.

Phosphorus is an element that is essential for plant growth. The total phosphorus content of most Australian soils is low by world standards and many soils require phosphate fertilisers to maximise production.

Figure A15 Soil nitrogen (%) for river basins containing intensive agriculture (derived from site measurements of carbon/nitrogen ratio).

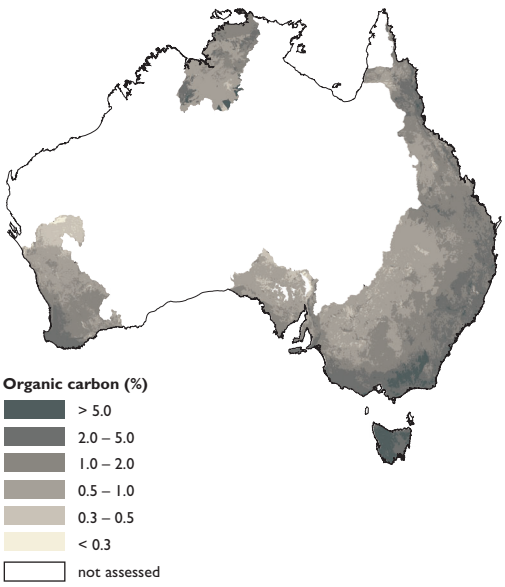


Percentage organic carbon (topsoil and subsoil)

- Maps are available of the amount of organic matter in a soil as a percentage by weight.

Soil organic matter content is an indication of natural soil fertility and is a balance between input of surface litter (fallen leaves and dead organisms) and the rate at which microbes break down organic compounds.

Figure A16 Distribution of organic carbon (%) in the topsoil within the river basins containing intensive agriculture.



LAND

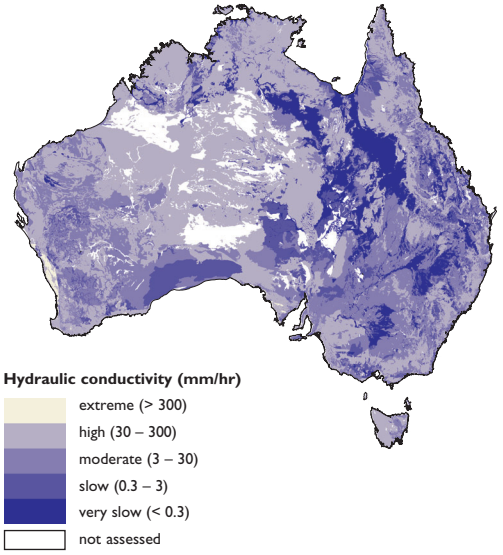
Soil properties—Australian Soil Resources Information System (ASRIS) (continued)

Saturated hydraulic conductivity (topsoil and subsoil)

Saturated hydraulic conductivity is a measure of the permeability of a soil (i.e. how quickly water can move through the soil when it is saturated). Soil permeability, in conjunction with water storage capacity, is fundamental to controlling the soil–water regime, which determines the suitability of land for a range of purposes.

Soils with a slow hydraulic conductivity at or near the soil surface (e.g. < 30 mm/hour) cannot transmit water from heavy showers of rain and this can lead to excessive run-off and potentially to erosion. Run-off also represents a loss of water that could have otherwise been available to plants.

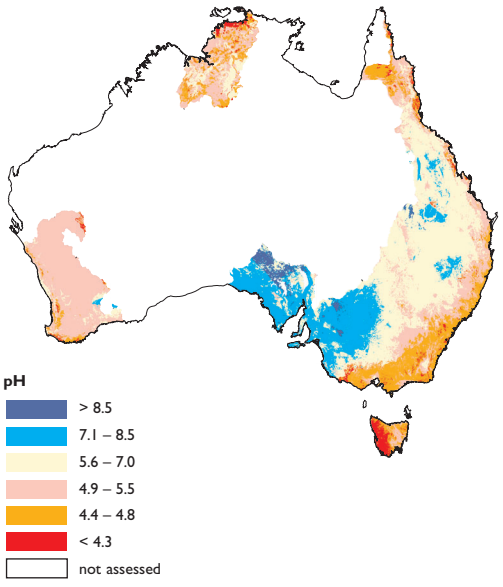
Figure A17 Distribution of saturated hydraulic conductivity (mm/hr) of the subsoils across Australia.



pH

Soil pH is a measurement of the relative acidity or alkalinity of the soil, providing a guide to the overall chemical balance of the soil. Soil pH is an important factor in plant growth because pH determines the availability of soil nutrients to plants.

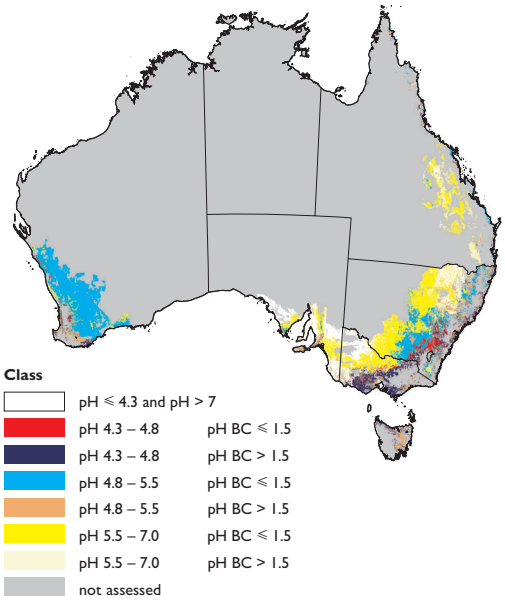
Figure A18 Distribution of pH of the topsoil within the river basins containing intensive agriculture.



pH buffering capacity

Soils have an intrinsic ability to resist pH change, either from a decrease through an input of acid or from an increase through the application of lime. This is known as pH buffering capacity and is determined by a chemical test. Estimates of pH buffering capacity are important for providing advice on levels of lime required to reduce soil acidity.

Figure A19 Distribution of topsoil pH buffering capacity in Australia's agricultural regions.



Erodibility

- Map presents a measure of the resistance of a soil to sheet and rill erosion.

Resistance is a function of:

- amount of clay in the soil;
- amount of organic matter in the soil; and
- how well water drains through.

Except where gullying is extreme, only the topsoil is subject to erosion, so a map of estimated erodibility has been produced only for the topsoil.

Lithology (geology) 1:2 500 000 scale

- Data presents lithology in 23 classes interpreted from geological information in the source data.

The lithology classes were chosen as being of significance for soil formation and relate mainly to chemical composition. Data are presented as a grid with cells 0.0025 degrees of latitude and longitude.

LAND

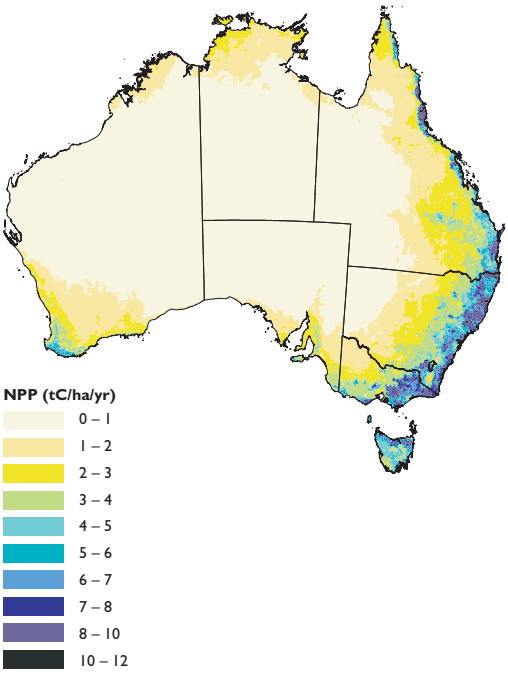
Landscape carbon balance

The following data cover catchments with areas of intensive agriculture.

Mean annual and monthly net primary productivity

Net primary productivity is the net rate at which plants build up carbon from the atmosphere by photosynthesis. It is equal to the difference between carbon gained (positive) by plant photosynthesis and the carbon lost (negative) by plant respiration, per unit land area per year. The carbon gained by the landscape is either lost through litter and soil respiration and disturbance processes (e.g. grazing, harvest and fire) or accumulates in storage. Net primary productivity is the primary driver of the carbon and nutrient cycles and the primary controller of the size of carbon and organic nitrogen stores in the landscape.

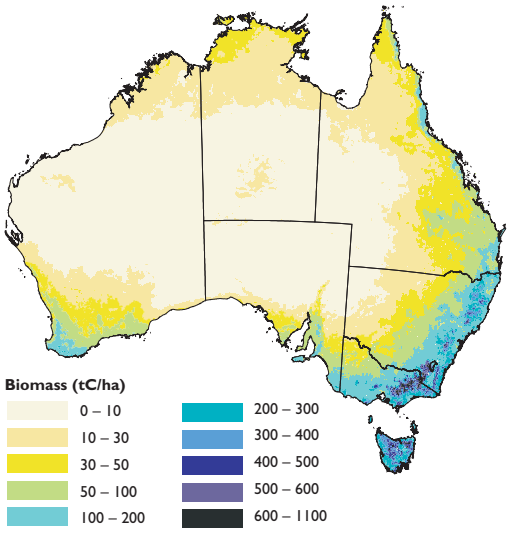
Figure A20 Mean annual net primary productivity with current climate and agricultural inputs.



Mean annual store of carbon in plant biomass

The mean annual store of carbon in plant biomass (kilograms of carbon per hectare) incorporates all above-ground and below-ground carbon in living plants, but not plant litter or soil organic carbon. This is the basic measure of the store of plant biomass on the landscape.

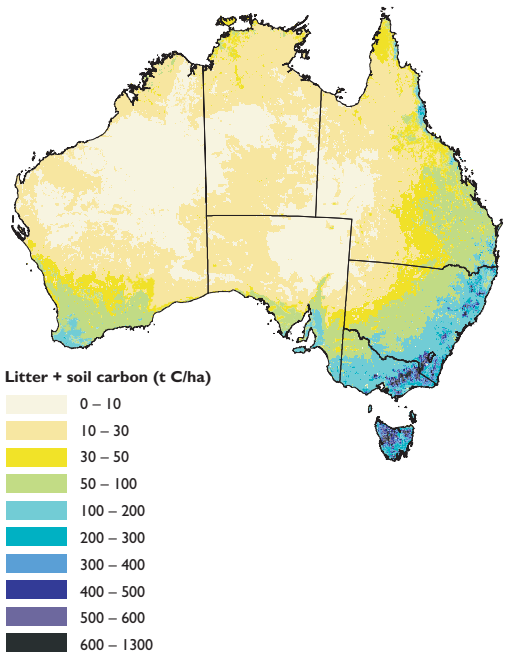
Figure A21 Carbon store in biomass (including leaf, wood and roots, that is all above-ground and below-ground biomass).



Mean annual store of soil organic carbon for the present day and pre-1788 scenario

The mean store of soil organic carbon (kilograms of carbon per hectare), includes all non-living soil storage pools including plant litter. This is the basic measure of the store of soil organic matter in the landscape. Soil carbon stores—similar to those of plant and litter carbon—are strongly controlled by net primary productivity and hence by rainfall and saturation deficits. All these carbon stores are also modulated by temperature because low temperatures slow the decay of plant material and high temperatures promote rapid decay. Most soil carbon occurs in the upper soil layer.

Figure A22 Soil organic carbon.



LAND

Landscape nitrogen and phosphorus balances

Mean annual store of total plant-available soil nitrogen

Total plant-available soil nitrogen consists of the organic nitrogen in litter and soil and the mineral plant-available nitrogen (including both ammonium and nitrate). The pattern of this store strongly resembles the maps of carbon storage and net primary productivity because the nitrogen stores are coupled to carbon stores through well defined nitrogen/carbon ratios in leaves, wood, roots, litter and soil organic matter.

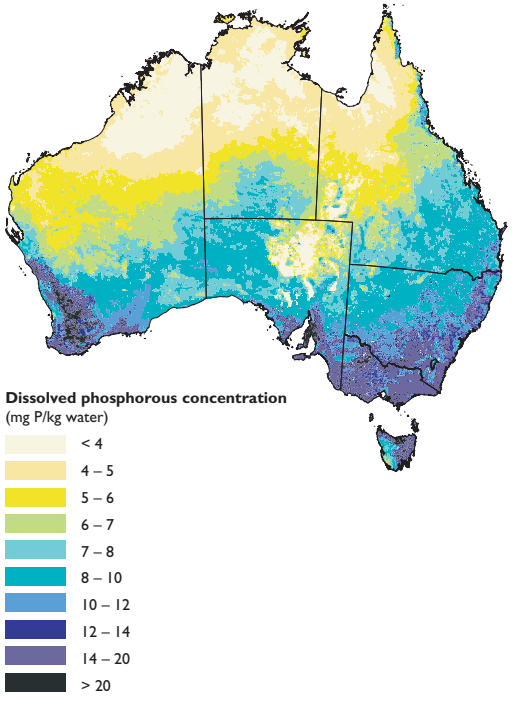
Mean annual concentration of dissolved nitrogen and phosphorus in soil water

Dissolved nutrient concentrations were determined to assess the change on nutrient stores principally because of introducing agriculture into the landscape. Dissolved nutrient concentrations were modelled and calculated assuming that plant available pools of mineral nitrogen and labile phosphorus occur in solution. The dissolved nitrogen concentration is the ratio of mineral nitrogen store to soil water store. Dissolved phosphorus concentration is the ratio of labile phosphorus store to the soil water store.

Mean annual store of total plant-available soil phosphorus

Total plant-available soil phosphorus consists of the organic phosphorus in litter and soil, and the plant-available mineral phosphorus. Plant-available phosphorus stores are less than the total phosphorus store in the landscape, because much of the mineral phosphorus in the soil is tightly chemically bound to the soil matrix and is therefore only weakly available for plant growth or unavailable in time scales less than centuries.

Figure A23 Modelled dissolved concentrations of phosphorus in soil water (kg P/mg H_2O).



Mean annual nitrogen fertilisation

- Map shows mean annual input of nitrogen to the landscape (kilograms of nitrogen per hectare per year).

Before the advent of European-style agriculture, the amount of nitrogen in the landscape was dominated by the input of nitrogen from natural fixation, with a small contribution from atmospheric nitrogen deposition. The counter balancing losses of nitrogen occurred through a mixture of volatilisation, leaching and disturbance. With the advent of European-style agriculture, the nitrogen budget changed substantially: the largest source remains fixation, greatly enhanced in agricultural areas by sown legumes. Losses occur through grazing by stock, leaching and volatilisation.

Mean annual phosphorus fertilisation

- Map shows mean annual input of phosphorus to the landscape (kilograms of phosphorus per hectare per year) from applied fertiliser.

Mean annual nitrogen leaching

- Map shows mean annual leaching of nitrogen (kilograms of nitrogen per hectare per year).

This is the loss of nitrogen from the plant-available mineral pool by transport in dissolved form, mainly through deep drainage of water from the soil store.

Mean annual nitrogen volatilisation

- Map shows mean annual volatilisation of nitrogen (kilograms of nitrogen per hectare per year).

This is the loss of nitrogen from the landscape to the atmosphere in the form of nitrogenous gases, including nitrous oxide and others.

Mean annual phosphorus leaching

- Map shows mean annual leaching of phosphorus (kilograms of phosphorus per hectare per year).

This is the loss of phosphorus from the plant-available mineral pool by transport in dissolved form, mainly through deep drainage of water from the soil store.

Mean annual store of mineral nitrogen

Of the plant-available nitrogen, only a small fraction is in mineral form. The rest is 'in use' in biomass or 'on return' through litter and soil organic matter. Nitrogen storage maps strongly resemble the maps of carbon storage and net primary productivity, because the nitrogen stores are coupled to carbon stores through well-defined (through not constant) nitrogen/carbon ratios in leaves, wood, roots, litter and soil organic matter.

Mean annual store of plant-available mineral phosphorus

- Map shows mean annual input of plant-available mineral phosphorus to the soil (kilogram of phosphorus per hectare per year).

Plant-available mineral phosphorus stores is less than the total phosphorus store in the landscape because much of the mineral phosphorus in the soil is tightly chemically bound to the soil matrix and is therefore only weakly available for plant growth or unavailable in time scales less than centuries.

Mean annual nitrogen fixation

- Map shows mean annual input of nitrogen to the soil (kilograms of nitrogen per hectare per year) through fixation by native, sown crop and pasture legumes.

LAND

Mean annual deep drainage

Mean annual deep drainage is the volume of water draining below the root zone. Significant deep drainage is confined to irrigation areas and wet areas where rainfall exceeds potential evaporation.

Erosion by water

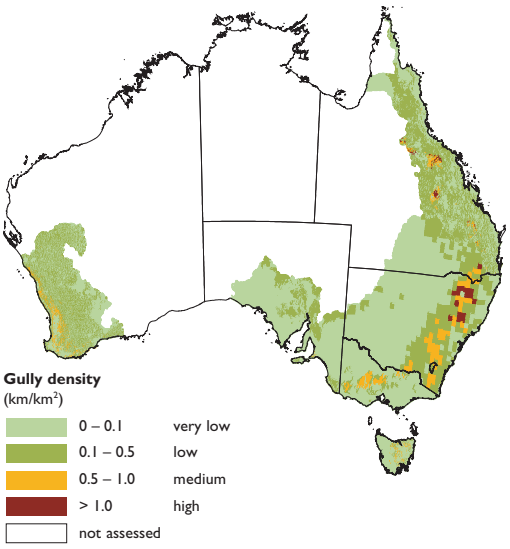
The following data cover catchments with areas of intensive agriculture.

Erosion gully density

- Map shows the density of gullies (km/km^2).

Approximately 325 000 km of gullies across the assessment area have eroded about 4.4 billion tonnes of sediment since European settlement.

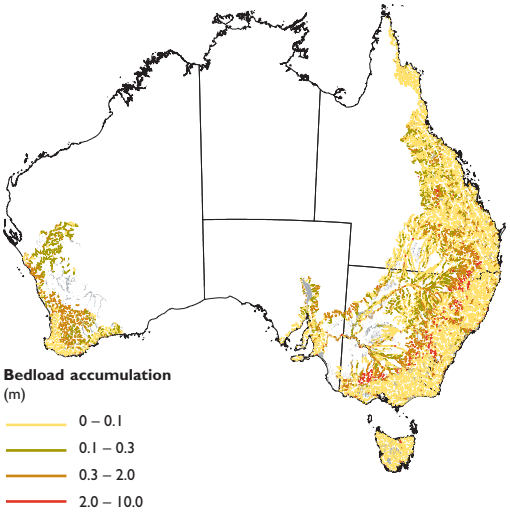
Figure A24 Gully density.



River bed sediment accumulation

- Data provide a measure of sediment accumulation in metres in river basins containing intensive agriculture since European settlement.

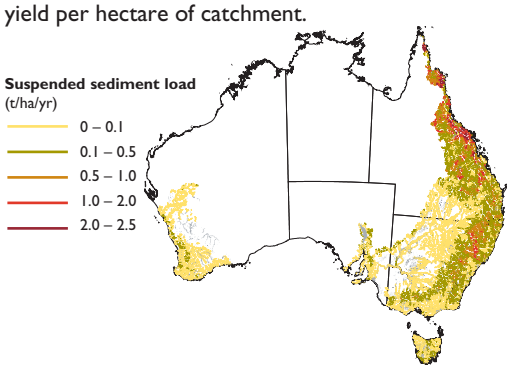
Figure A25 River bed sediment accumulation.



Mean annual suspended sediment yield per hectare of catchment

- Data provide a measure of sediment supplied to streams on an average annual per hectare basis.

Figure A26 Mean annual suspended sediment yield per hectare of catchment.

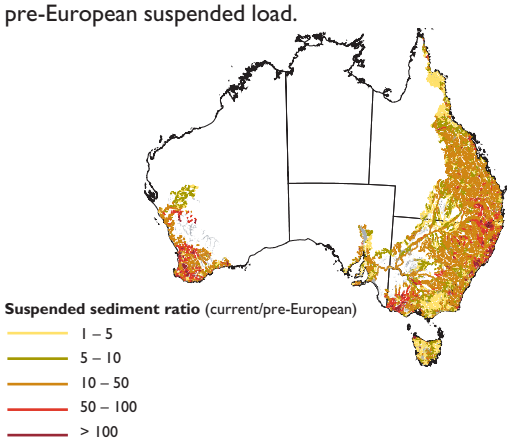


Ratio of current suspended load to pre-European suspended load

- Data provide a measure of the degree of change from modelled pre-European settlement (natural) suspended sediment loads.

River sediment loads are generally 10 to 50 times greater than pre-European loads in intensively used river basins.

Figure A27 Ratio of current suspended load to pre-European suspended load.

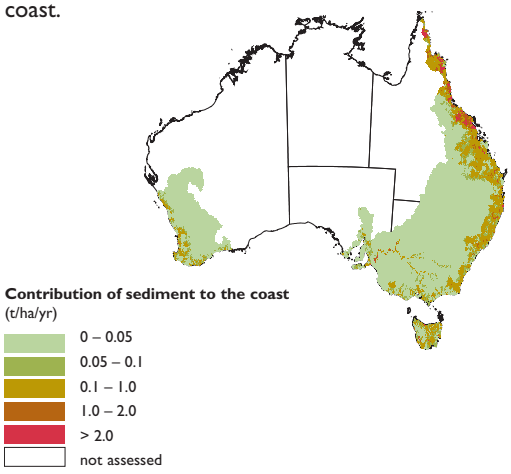


Contribution of sediment to the coast

- Map identifies areas within catchments that have the potential to contribute sediment to the coast.

Ninety percent of the suspended sediment loads reaching estuaries are derived from 20% of catchment areas.

Figure A28 Contribution of sediment to the coast.



LAND

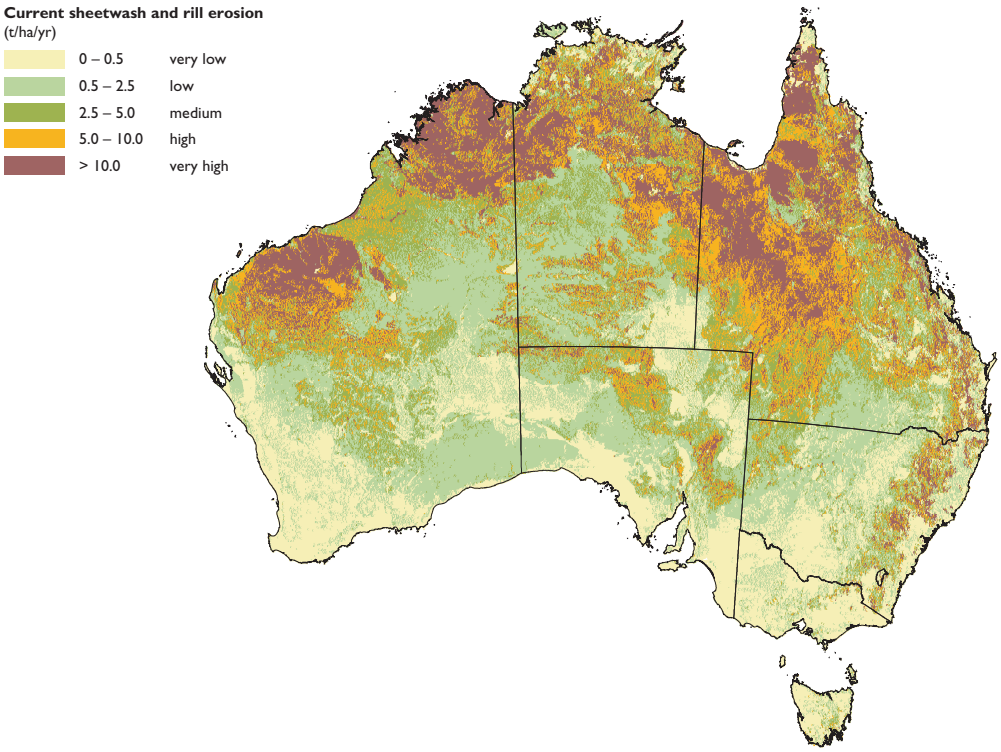
Pre-European and present hillslope erosion

Mean annual sheet-wash and rill erosion rate

- Maps illustrate erosion in tonnes per hectare per year under present and pre-European vegetation cover.

The Revised Universal Soil Loss Equation was used to predict mean annual sheet-wash and rill erosion potential across Australia under current land uses.

Figure A29 Mean annual sheetwash and rill erosion rate.



Ratio of hillslope erosion present to pre-European

- Map shows the ratio of current annual hillslope erosion to pre-European hillslope erosion.

The ratio ranges from 1 (signifying no change since European settlement) to large values indicating large increases in erosion.

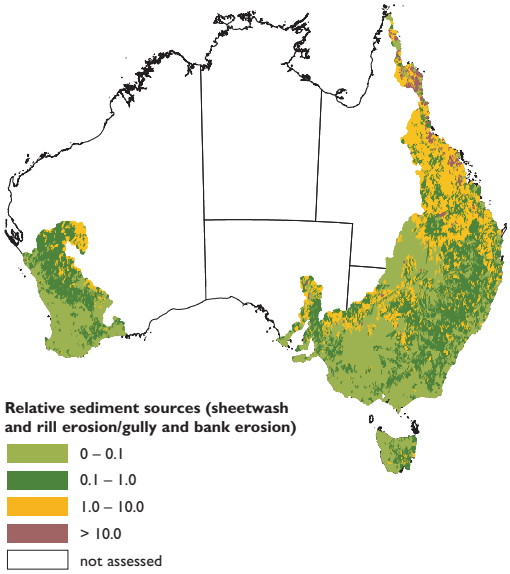
Sediment and nutrient supply to river links

This vector coverage of the streams was generated from a 9-second (approximately 250 m) digital elevation model from the Australian Surveying and Land Information Group. The streams have been attributed with sediment and nutrient source, sink, load and delivery information.

Sediment contributed from areas draining to river links

- Map shows mean annual sediment supplied from the land that drains to each river segment (excluding upstream inputs) for river basins containing intensive agriculture.

Figure A30 Ratio of hillslope to channel (gully and streambank) sediment sources by river link subcatchments.



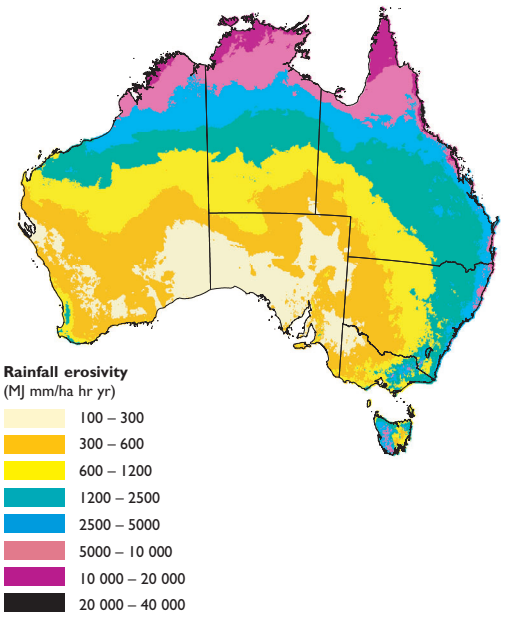
LAND

Factors contributing to sheet wash and rill erosion

Rainfall erosivity (R factor)

Rainfall erosivity refers to the erosive energy of rain, a function of the total amount of rainfall and its intensity in a typical rainfall event. It varies strongly across Australia and is highest in coastal regions of northern Australia.

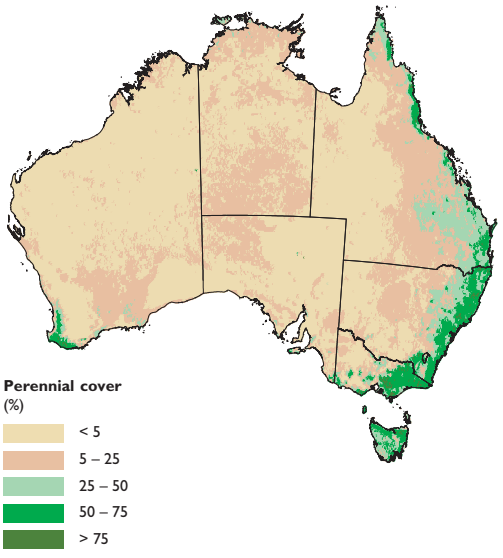
Figure A31 Rainfall erosivity.



Perennial cover (C factor)

Vegetation cover strongly influences erosion potential. As perennial plant cover changes away from the coast, so too does erosion potential.

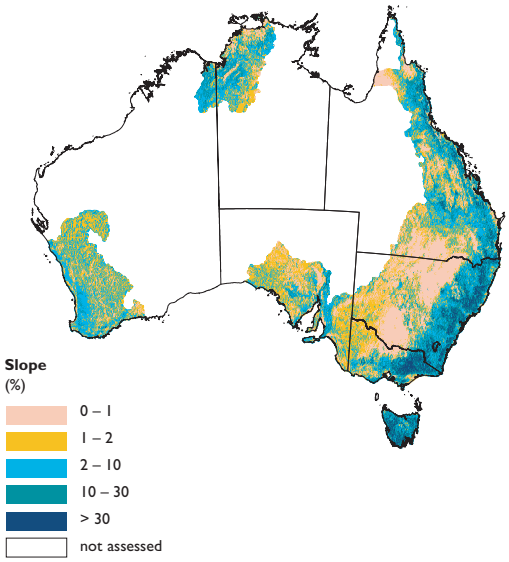
Figure A32 Perennial cover (C factor).



Mean slope (S factor)

- Maps show slope values in percent, averaged over a 1 km radius (basis for the slope factor S in the Revised Universal Soil Loss Equation).

Figure A33 Mean slope (S factor).

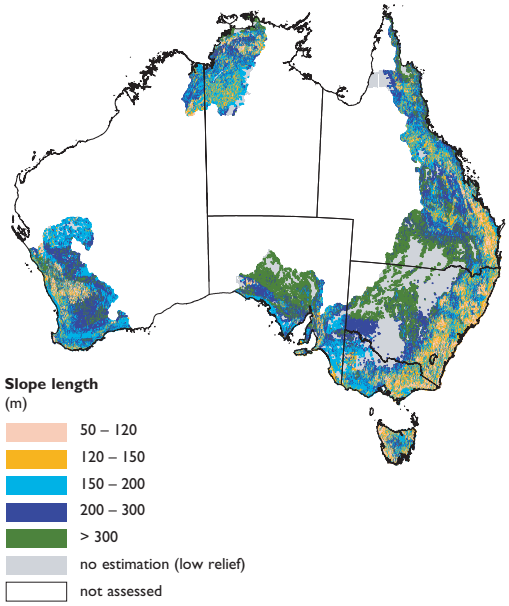


Slope length (L factor)

- Map shows slope length values in metres.

Slope length is the distance from ridge top to valley bottom. The values represent averages over a 1 km radius. The L factor of the Revised Universal Soil Loss Equation is derived from slope length.

Figure A34 Slope length (L factor).



Age and experience

Median age of farmers (1991–1996)

- Data show the median age in years of farmers and farm managers by statistical local areas for the period 1991–1996.

Assessment uses statistics from the Australian Bureau of Statistics population and housing census. The median age of farmers and farm managers increased from 46 to 48 years between 1991 and 1996, whereas over the same period the average age of the metropolitan population increased by only one year.

Education and training

Formal education (1991–1996)

- Data show the proportion of farm managers for the period of 1991 to 1996 with formal education qualifications.

Data are presented by statistical local areas and are from the Australian Bureau of Statistics population and housing census.

Higher qualifications (1991–1996)

- Data show the proportion of farmers for the period of 1991 to 1996 with higher educational qualifications.

Data are presented by statistical local areas and are from the Australian Bureau of Statistics population and housing census.

Basic vocational (1991–1996)

- Data show the proportion of farmers for the period of 1991 to 1996 who stated they have basic vocational training.

Data are presented by statistical local areas and are from the Australian Bureau of Statistics population and housing census.

Skilled vocational (1991–1996)

- Data show the proportion of farmers for the period of 1991 to 1996 with skilled vocational training.

Data are presented by statistical local areas and are from the Australian Bureau of Statistics population and housing census. *Skilled vocational qualifications* is defined as having completed a course lasting two to four years and typically involves on-the-job training for working in a specific vocation, trade or craft that requires a high degree of skill.

Recent training (1996/97 to 1998/99)

- Data show the proportion of farmers who stated they had undertaken recent farm management training.

Data are presented by statistical divisions and are from the Annual Farm Survey conducted by the Australian Bureau of Agricultural and Resource Economics during the period 1996/97 to 1998/99. Continuing education throughout life is linked to farm profitability; one study found that farm incomes tend to be higher as farmer participation in training increases.

Farm family characteristics

Families with dependant children (1996/97)

- Map shows the number of families with dependant children in 1996/97 using statistics from the Australian Bureau of Statistics population and housing census, and presented on a statistical local area basis.

Farm structure

Median Estimated Value of Agricultural Operations (1996/97)

- Data show the estimated value ($ per farm business) of agricultural operations, presented on a statistical local area basis.

This is a measure of the value of the annual production of a farm business, estimated from physical livestock and crop information provided in the agricultural census undertaken by the Australian Bureau of Statistics and three-year weighted average prices derived from the Annual Farm Survey undertaken by Australian Bureau of Agricultural and Resource Economics.

Farm area (1996/97 to 1998/99)

- Map shows three-year average farm size (hectares per farm business).
- Data are presented on a statistical division basis.

Assessment used the Annual Farm Survey conducted by the Australian Bureau of Agricultural and Resource Economics between 1996/97 and 1998/99. Farm area has a marked effect on income from the farming operation, with larger farm businesses generally being more profitable than smaller ones. Small farms tend to be in less remote areas, however, and on average have much higher off-farm incomes.

Remoteness and other community indicators

Degree of accessibility/remoteness (ARIA) (1996)

- Data are presented on a statistical local area basis and show a measure of remoteness from services.

It is calculated for each of 11 338 population centres using a weighted index of each centre's road distance to service centres in four categories (a different calculation method is used for off-shore islands to reflect water barriers). The data are summarised using statistics from the 1996/97 housing and population census conducted by the Australian Bureau of Statistics.

Social capital; degree of socio-economic advantage (1996/97)

- Data are presented on a statistical local area basis and show the degree of rural advantage and disadvantage as measured by the Socio-Economic Index for Areas (SEIFA) index.

The index is derived from census statistics (e.g. income, educational attainment, employment and job skill levels). The index takes all adults into account and covers all areas of rural Australia except centres with a population of 1000 or more. The data are interpreted from the 1996/97 housing and population census conducted by the Australian Bureau of Statistics.

Farm financial characteristics

Off-farm employment income (1996/97, 1997/98 and 1998/99)

- Map, presented on a statistical division basis, shows the three-year average (1996/97, 1997/98 and 1998/99) for off-farm income ($ per farm per year) earned by farm families.

Income from off-farm wages and salaries, other businesses, investments and government assistance payments is included. These data were obtained from the Annual Farm Survey conducted by the Australian Bureau of Agricultural and Resource Economics.

Total farm income (1996/97, 1997/98 and 1998/99)

- Map, presented on a statistical division basis, shows the three-year average (1996/97, 1997/98 and 1998/99) for total farm family income ($ per farm per year).

Income from all sources (both on-farm and off-farm), not only farming returns, is included. These data were obtained from the Annual Farm Survey conducted by the Australian Bureau of Agricultural and Resource Economics.

Annual farm cash income (1996)

- Map shows the median annual farm family cash income ($ per farm per year), presented on a statistical division basis, at the time of the 1996 census.

Farm family income includes income from all sources earned by all members of the family living on-farm, including government social service and exceptional circumstances payments. These data were obtained from the Annual Farm Survey conducted by the Australian Bureau of Agricultural and Resource Economics.

Regionalised profit at full equity (1996/97 and 1998/99)

- Map shows regionalised profit at full equity ($ per farm business per year), presented on a statistical division basis.

This is defined as farm business profit and rent, interest and finance lease payments, less depreciation on leased items. It measures return on all resources used in the farm business. These data were obtained from the Annual Farm Survey conducted by the Australian Bureau of Agricultural and Resource Economics between 1996/97 and 1998/99.

Total household expenditure (1998/99)

- Map shows the median total household expenditure ($ per farm per year) for 1998/99, presented on a statistical division basis.

Median total household expenditure is related to annual family income (on- and off-farm) and reflects the disposable income of farm families. These data were obtained from the Annual Farm Survey conducted by the Australian Bureau of Agricultural and Resource Economics.

Level of farm debt (1996/97 to 1998/99)

- Map shows the median level of farm debt ($ per farm per year) for the period 1996/97 to 1997/99, presented on a statistical division basis.

Farm debt includes all liabilities related to the farm business which appear on balance sheets in financial accounts, including the farm mortgage, other term loans, business overdrafts, fully drawn advances, amounts owed to creditors and hire purchases related to the farm enterprise. These data were obtained from the Annual Farm Survey conducted by the Australian Bureau of Agricultural and Resource Economics.

Farm equity ratio (1996/97 to 1998/99)

- Map shows farm business equity as the value of owned (total) capital less farm business debt as measured at 30 June each year and presented on a statistical division basis.

The farm equity ratio is calculated as farm business equity as a percentage of owned (total) capital. These data were obtained from the Annual Farm Survey conducted by the Australian Bureau of Agricultural and Resource Economics between 1996/97 to 1998/99.

Sustainable practice

Property management plan (1996/97 to 1998/99)

- Map shows the proportion of farmers who stated they have a property management plan in the Annual Farm Survey conducted by the Australian Bureau of Agricultural and Resource Economics between 1996/97 to 1998/99.
- Data are presented on a statistical division basis.

Developing a farm plan or property management plan could indicate that farmers or farm families are adopting an informed and professional approach to the farm business and consider long-term planning.

Proportion of farms undertaking Landcare related work (1998/99)

- Map shows the proportion of farmers who stated they have undertaken Landcare related work in the Annual Farm Survey conducted by the Australian Bureau of Agricultural and Resource Economics in 1998/99.
- Data are presented on a statistical division basis.

Percentages of farms carrying out Landcare-related work might be expected to be related to Landcare membership and reflect farmers' willingness to address land degradation problems.

Cropping management practices (1998/99)

- Map shows the proportion of farmers who reported a range of cropping management practices in the Annual Farm Survey conducted by the Australian Bureau of Agricultural and Resource Economics in 1998/99.
- Data are presented on a statistical division basis.

Data depicted relate only to cropping practices, not to other types of farming and hence are relevant mainly to farmers in the wheat–sheep zone, not pastoral or intensive agriculture areas.

Indicators of rural structural adjustment

Farm establishment area (1996/97)

- Data are presented on a statistical local area basis and show the total area (hectares) of farm establishments reported to the Australian Bureau of Statistics through the agricultural census as a percentage of the total private land (excluding built-up areas).

Change in the number of farm establishments is an outcome of the aggregation or disaggregation of farm establishments and the associated extinction or creation of farms.

Occupation as agriculture (1986, 1996)

Occupation farming (1986, 1991, 1996)

- Data are presented on a statistical local area basis and show the number of persons stating agriculture as their main occupation as a percentage of the total workforce in 1986/87 and 1996/97 using statistics from the housing and population census conducted by Australia Bureau of Statistics.

Farm family income (1986, 1991, 1996)

Average farm family income (1986–96)

Farm family income > $50 000, > $20 000, $20 000 – $50 000

- Data are presented on a statistical local area basis and show the median farm family income 1986, 1991 and 1996 ($ per farm family) using the agricultural census conducted by Australia Bureau of Statistics.

Off-farm income has risen consistently in broad acre agriculture over the past 20 years from $6 000 to $20 000. During 1994/95, farm income comprised only 37% of farm family income on broadacre farms. Off-farm income has not risen nearly as far in the dairy industry.

Estimated value of agricultural operations (1986, 1996)

Estimated value of agricultural operations > $5000 (1986, 1996)

Estimated value of agricultural operations > $30 000 (1986, 1996)

Estimated value of agricultural operations > $300 000 (1986, 1996)

- Data are presented on a statistical local area basis and show the estimated value of agricultural operations ($ per farm business) in 1986, 1991 and 1996 using statistics from the agricultural census conducted by Australia Bureau of Statistics.

Increasing farm scale is seen as important for the maintenance of agricultural competitiveness. One of the most fundamental aspects in the pursuit of improved economies of scale in dryland farming operations is the amalgamation of existing properties to increase the gross value of production from the average farming unit. A temporary rise in average estimated value of agricultural operations during the early 1990s was driven by changed commodity prices.

Farm families (1986, 1991, 1996)

Families in farm establishments (1986, 1996)

- Data are presented on a statistical local area basis and show the number of farm families/establishments in 1986, 1991 and 1996 recorded in the housing and population census conducted by Australia Bureau of Statistics.

The ratio of farm families to farm establishments is calculated in a statistical local area as an indication of the relative frequency of significant off-farm work commitment. This ratio also indicates areas where 'retirement' farming is concentrated along the coastal fringes and in peri-urban areas. Retirement farming is characterised by farmers who have retired from non-farm employment and have taken up farming, often with significant off-farm income through investments

Entry to farming (1986–1991, 1991–1996)

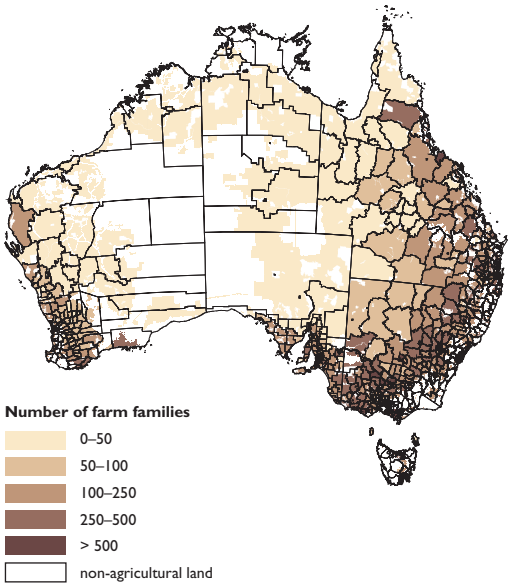
Entry to farming < 35 years old (1986–1991, 1991–1996)

Entry to farming ⩾ 55 years old (1986–1991, 1991–1996)

- Data are presented on a statistical local area basis and show the average annual rate of entry to agriculture during 1986–1991 as recorded in the agricultural census conducted by Australia Bureau of Statistics.

The decision to enter or not enter agriculture has a major impact on the restructuring of agricultural holdings, either initiating investment in farm build up, or alternatively signalling the possibility of land sale and retirement from agriculture for the next generation. Entry to agriculture is also seen as a source of significant new skills and capital to agriculture.

Figure A35 Number of farm families 1996.



Indicators of rural structural adjustment (continued)

Exit from farming (1986–1991, 1991–1996)

- Data are presented on a statistical local area basis and show the average annual rate of exit to agriculture 1986–1991 using statistics from the agricultural census conducted by Australia Bureau of Statistics.

The number of farms in Australian agriculture has declined by 1.3% each year over the past few decades.

Farmer age 1986, 1991, 1996

Farmer age (2001, 2006, 2011, 2016, 2021)—fast and slow projections

- Data are presented on a statistical local area basis and show the farmer age (years) to agriculture 1986, 1991 and 1996 using statistics from the housing and population census conducted by Australia Bureau of Statistics.

The decline in the rate of entry of younger people to farming and the associated deferral of retirement from farming can be expected to lead to an ageing of the farm population. The ageing of the farm population has been evident in official statistics in Australia since 1981. This ageing has implications for both the process of agricultural structural change and the provisions of human services in rural areas. The projection data were derived from trends in the farmer age and are presented as whole of Australia graphs.

Farm numbers (2001, 2006, 2011, 2016, 2021)—fast and slow projections

- Projection data were derived from trends in the farm numbers using the agricultural census conducted by Australia Bureau of Statistics and are presented as whole of Australia graphs.

Social and institutional contact as sources of change

Membership of Landcare (1998/99)

Length of Landcare membership (longest serving member on farm property) (1998/99)

Median length of Landcare membership (1998/99)

Involvement with Landcare influenced farm decisions (1998/99)

- Data provide estimates of involvement with Landcare using statistics from the Annual Farm Survey conducted by the Australian Bureau of Agricultural and Resource Economics in 1998/99.
- Data presented on a statistical division basis.

The community Landcare movement, which began in Victoria in 1986, has been very successful and it is estimated that 37% of broadacre and dairy farms in Australia had a family member who belonged to a Landcare group in 1998/99.

Resource accounts—the economic dimension of natural resource management: returns to the resource base

Gross revenue from agriculture (1996/97)

- Data show gross revenue from agricultural operations ($ per hectare per year) and five-year averages to 1996/97.

Data were modelled on a 1 km by 1 km grid using the national land use map (linked at a commodity level to the Australian Bureau of Statistics 1996/97 agricultural census). Gross revenue is measured as annual value of economic operations exceeding $22 000. Data on gross income, costs and net returns from agriculture in Australia are available from the Australian Bureau of Agricultural and Resource Economics and the Australia Bureau of Statistics.

Farm land values (1992/93 to 1996/97)

- Data are presented as a continuous surface and show broadacre farmland values ($) 1992/93 to 1996/97 as recorded by the Australian Bureau of Agricultural and Resource Economics using the Annual Farm Financial Survey.

The productive value of land is the value that reflects the return to land and water resources from current production activities.

Profit at full equity from agriculture (1996/97, five-year average)

Area contributing to 80% of profit at full equity from agriculture (1996/97)

- Data show profit at full equity ($ per hectare per year) from agricultural operations and five-year average to 1996/97.

Data were modelled on a 1 km by 1 km grid using the national land use map. Economic returns to natural resource base from agriculture can be measured using profit at full equity. This is the return to land, capital and management after the value of labour provided by managers has been deducted. It does not include any debt payments to financial institutions. In 1996/97, the total profit at full equity was approximately $6555 m for the nation. Over the five-year period from 1992/93 to 1996/97, profit at full equity averaged $7530 m each year.

Government support to agriculture (1996–1997, five-year average)

- Data show government support to agriculture ($ per hectare per year) as a measure of average annual cost of agricultural protection in 1996/97.

Data were modelled on an industry and regional basis into the 1 km by 1 km grid using the national land use map. These regional data are indicative only. For the 1996/97 financial year the average annual cost of agricultural protection was $2211 m. A producer subsidy equivalent is the amount of money, which, if given as a cash payment in an unprotected economy, would produce an income effect equivalent to that produced by the protection.

Resource accounts—the economic dimension of natural resource management: returns to the resource base (continued)

Net economic return from agriculture (1996/97, five-year average)

- Data show net economic return ($ per hectare per year) from agricultural operations (1996/97 and five-year average to 1996/97).

Data were modelled on a 1 km by 1 km grid using the national land use map. Profit at full equity minus government support was measured in dollars per hectare over a five-year average.

Costs to agriculture

Relative yield: acidity, salinity, sodicity, aggregate

- Data present relative yield (percentage) surfaces that were derived from the Australian Soil Resources Information System.

The data have been aggregated to align and link with the 1 km by 1 km grid using the national land use map. Relative yield is measured as a percentage and equals the actual yield, as currently recorded, divided by the potential yield that would occur if the soil constraint(s) were not present.

Gross benefit from remediating: acidity, salinity, sodicity, aggregate

- Data present relative yield surfaces that were derived from the Australian Soil Resources Information System.

The data have been aggregated to align and link with 1 km by 1 km grid using the national land use map. Gross benefit ($ per hectare per year) equals profit at full equity attainable without the soil constraint, less the profit at full equity attainable under current conditions. It can be thought of as the dollar value of the yield gap (caused by the soil constraint).

Impact cost of salinity (2000, 2020)

- Data present impact costs ($ per square km per year) that were derived from the *Australian Dryland Salinity Assessment 2000* (NLWRA 2001b) at a varying scales from 1:1 000 000 to 1:250 000.

The data have been aggregated to align and link with the 1 km by 1 km grid using the national land use map. Impact costs result from marginal increases in soil constraints from 2000 to 2020. Impact costs are calculated for salinity as this is the only soil constraint with the required time series data.

Maximum net present value attainable from lime and/or gypsum application

Highest returning soil treatment: lime, lime and gypsum, gypsum

Data present maximum net present value ($ per hectare) attainable from lime and/or gypsum application to manage soil acidity and sodicity. Data were derived from the Australian Soil Resources Information System. These data were aggregated to align and link with the 1 km by 1 km grid using the national land use map (linked to the profit at full equity surfaces). Net present value is equal to the time-discounted benefits minus the time-discounted costs. Net present values show that additional soil treatment by farmers is financially worthwhile for around only four percent of agricultural land.

Costs to non-agricultural infrastructure

Downstream costs: salinity, turbidity, erosion and sedimentation, aggregate (2000)

- Data are presented on a river basin basis and show the downstream costs of salinity, turbidity, erosion and sedimentation (and in aggregate).

Data were derived from the *Australian Agriculture Assessment 2001* (NLWRA 2001d) and *Australian Water Resources Assessment 2000* (NLWRA 2001a). These data were already aggregated to river basins. Downstream or *ex situ* impacts are defined as phenomena that occur away from the original source of the impact. This typically occurs because the problem arises only after a water supply is contaminated (e.g. cost of boiler corrosion in a city factory several hundred kilometres from the place where salt entered the river supplying water to the city). Downstream costs include the impact of salt in water used in urban areas, water turbidity costs and sedimentation costs.

Local impact costs from salinity and rising watertables (2000, 2020, increase 2000 to 2020)

- Data show the distribution of local impact costs of salinity and rising watertables for the year 2000 ($ per square kilometre).

These data were derived from the *Australian Dryland Salinity Assessment 2000* (NLWRA 2001b) at varying scales from 1:1 000 000 to 1:250 000, then aggregated to align with the 1 km by 1 km grid of the national land use map. Local or in situ impacts are defined as those that occur in local association with land degradation processes (e.g. the impacts of rising groundwater on infrastructure are treated as local impacts. Local costs include damage to roads, bridges and houses).

RANGELANDS

Social and economic information

Social and economic information products available for rangelands areas include:

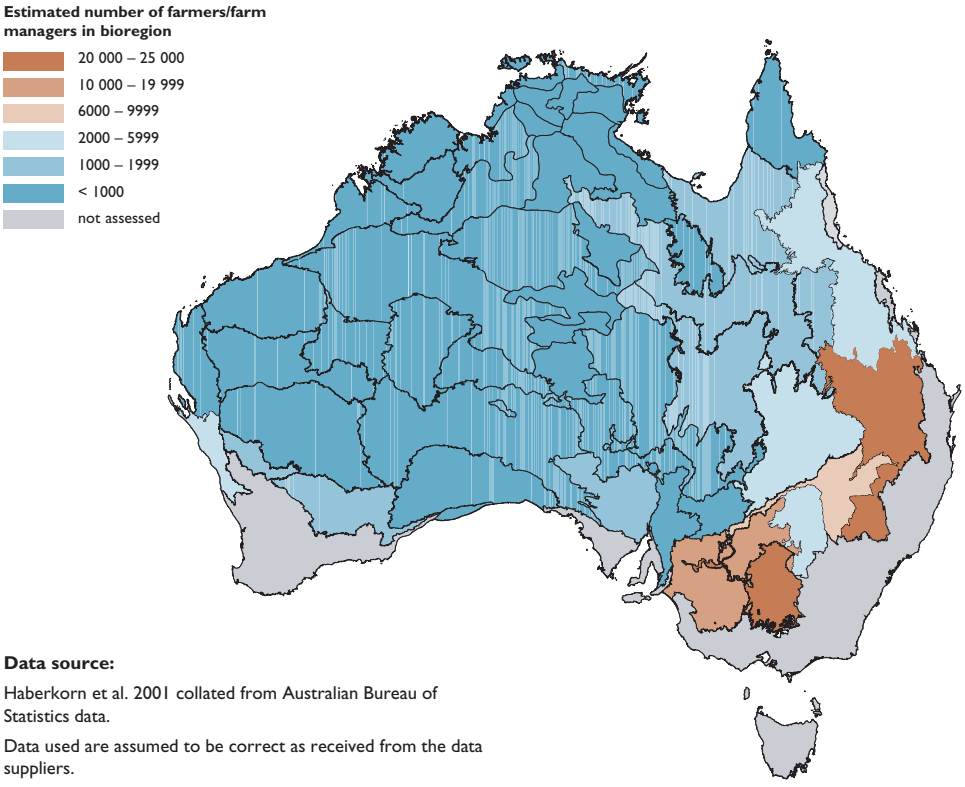
- Median age of farmers and farm managers
- Total farm family income
- The number of farms with property management plans
- Net migration of young Australians
- Population structure to age dependency ratio

All of the data are summarised by Australian biogeographic regions (version 5.1)

Coverage

Rangeland areas of Australia.

Figure A36 Locations of farmers and farm managers in Australia's rangelands (1996).



Data source:

Haberkorn et al. 2001 collated from Australian Bureau of Statistics data.

Data used are assumed to be correct as received from the data suppliers.

Season quality in the rangelands

Data from weather satellites can be used to estimate the response of vegetation to rainfall, using the normalised difference vegetation index. The normalised difference vegetation index provides an estimate of the vegetation greenness. Data are compiled every two weeks throughout the year and give continental coverage across Australia. The spatial resolution of the data is 1 km by 1 km.

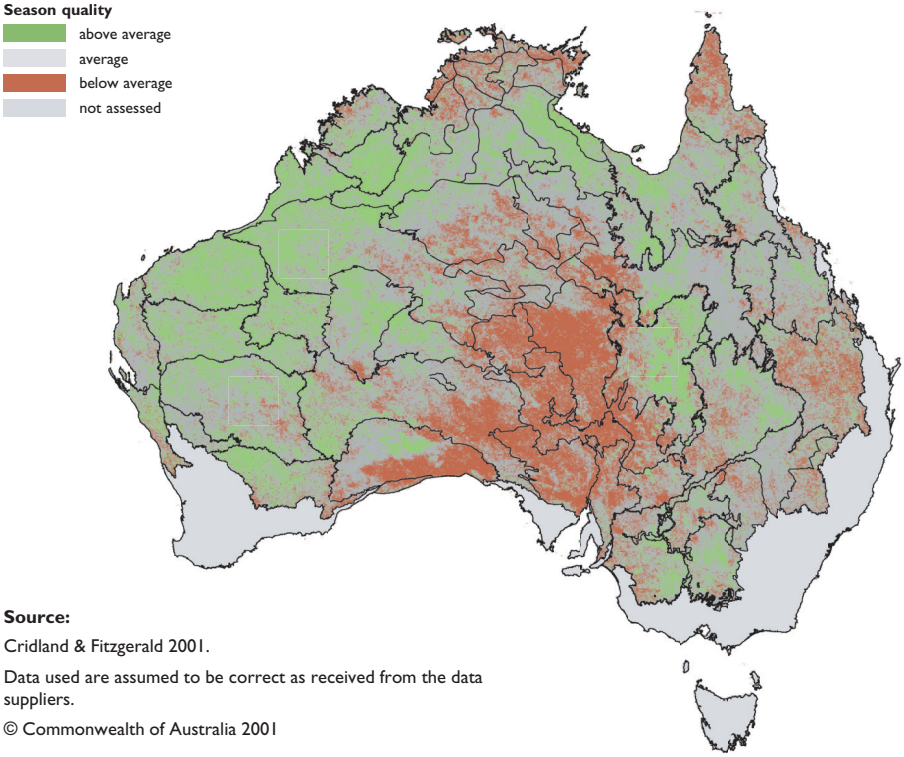
Comparing each area to itself over time gives a good indication of relative changes in herbage. A relative rating of season quality can be mapped by comparing a particular year with all years recorded.

Coverage

Rangeland areas of Australia.

Data are available in image format from the Environment Australia website at www.ea.gov.au/land/monitoring/index.html

Figure A37 Season quality for Australia's rangelands.



Source:

Cridland & Fitzgerald 2001.

Data used are assumed to be correct as received from the data suppliers.

RANGELANDS

Land tenure in the rangelands from 1957 (1:1 000 000)

- Maps of land tenure boundaries across Australia's rangelands for 1955/56, 1965/66, 1975/76, 1985/86, 1995/96 and 1996/99.

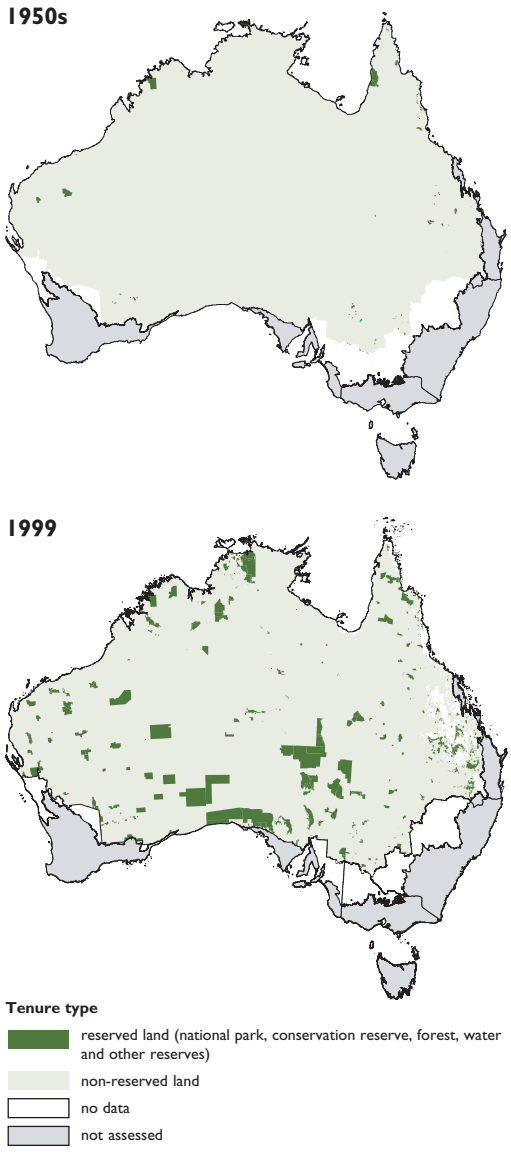
The maps are believed to be the best and in some cases, the only digital historical catalogue of land tenure for Australia's rangelands.

These maps are only intended to illustrate broadscale changes in land tenure across Australia's rangelands. Their application is not intended for accurate cadastre or administrative boundary documentation or analyses.

Coverage

Rangeland areas of Australia.

Figure A38 Nature conservation reserves (1950s to 1999).



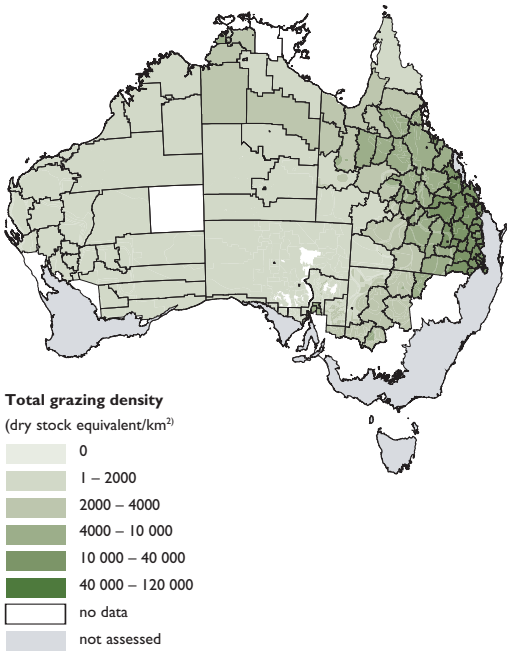
Total grazing pressure from 1957 in the rangelands

A series of maps illustrating the total grazing pressure by statistical local areas for rangeland areas in Australian for each decade since the 1950s. Maps are available of estimates by statistical local area of the density of macropods, goats, rabbits, sheep and cattle.

Coverage

Rangeland areas of Australia.

Figure A39 Total grazing density for Australia's rangelands by statistical local area (1990s).



Total grazing density was calculated using annual data on sheep and cattle and decadal data on macropods and feral animals (goats and rabbits). Each class of animal was converted to dry sheep equivalents in order to allow total grazing density to be calculated.

WATER

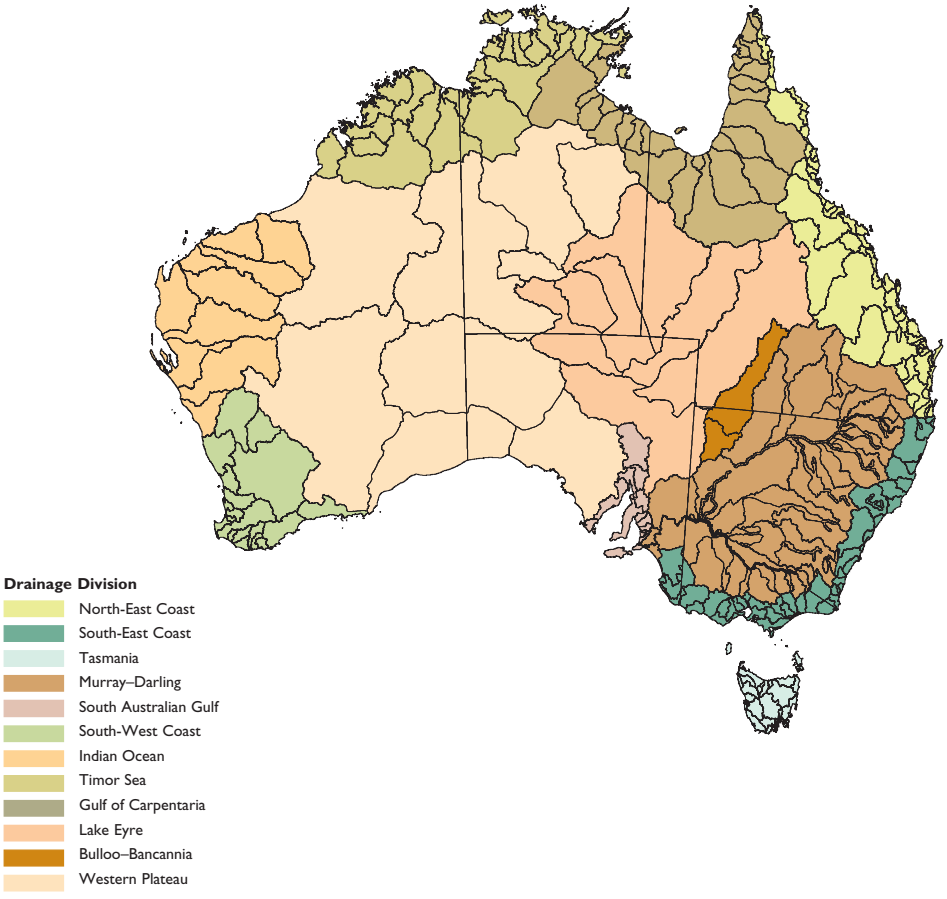
Surface water management area boundaries (1:250 000)

- Data show the boundaries and names of surface water management areas.

Surface water management areas are regions defined by State and Territory water management agencies for use in national water resources reporting.

Many surface water management areas are the same as the river basin boundaries defined by the Australian Water Resources Council. In some States and Territories, however, some surface water management areas are a subset of these river basins.

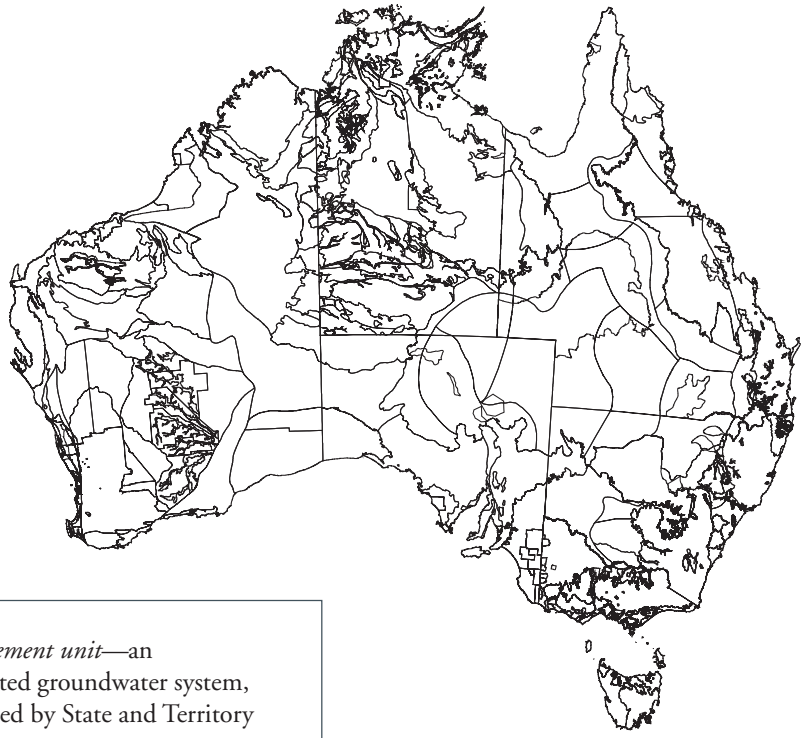
Figure A40 Surface water management areas grouped by drainage divisions.



Groundwater management unit boundaries (1:250 000)

- Data show the boundaries and the name and number of each groundwater management unit, unincorporated area and province.

Figure A41 Australia's groundwater management units.



Groundwater management unit—an hydraulically connected groundwater system, defined and recognised by State and Territory agencies.

Groundwater province—an area having a broad uniformity of hydro-geological and geological conditions identified as either predominantly sedimentary or fractured rock as defined by the Australian Water Resources Council.

Unincorporated area—a groundwater resource defined by a groundwater province and excluding any designated groundwater management units.

A nested set of catchments and subcatchments for Australia

The catchments have been determined from Version 2 of the 9-second continental digital elevation model produced by the Centre for Resource and Environmental Studies at the Australian National University, for the Australian Surveying and Land Information Group.

The grid of subcatchments and catchments are supplied with an associated attribute table defining the subcatchments according to four minimum area thresholds (2.5 km^2, 25 km^2, 50 km^2 and 500 km^2).

Estimated daily and monthly streamflow data from 1901 to 1998 for 286 catchments in Australia

- A database of estimated monthly streamflow from 1901–1998 for 286 catchments in Australia.

The long time series of streamflow data are important for both research and management of Australia's hydrological and ecological systems.

A daily rainfall/run-off model was used to extend the streamflow data. The model estimates streamflow from daily rainfall and areal potential evapotranspiration data. The parameters in the model are first calibrated against the available historical streamflow data. They are then used to estimate monthly streamflow from 1901–1998.

The modelling is carried out on 331 catchments across Australia, most of them located in the more populated and agriculturally important areas in eastern and south-east Australia. These catchments have at least ten years of streamflow data and catchment areas between 50 km^2 and 2000 km^2.

1985 review of Australia's water resources and water use

- Database was used for the assessment of water resources in 1985 and contains information on the extent and magnitude of Australia's water resources and water use.

Australian Water Resources Assessment 2000

- Australian Water Resources Assessment 2000 database contains attributes about the availability, use, allocation, sustainability and management of water.

These attributes are linked to spatial boundaries for 325 surface water management areas and 535 groundwater management units in Australia. Many of these attributes are also aggregated to a national, State and Territory, groundwater province and river basin level.

Major water resources infrastructure

(part of the Australian Water Resources Assessment 2000 database)

- Spatial location of dams and their unique identifiers and names

Surface water gauging stations

(part of the Australian Water Resources Assessment 2000 database)

- Spatial location of surface water gauging stations and their unique identifiers

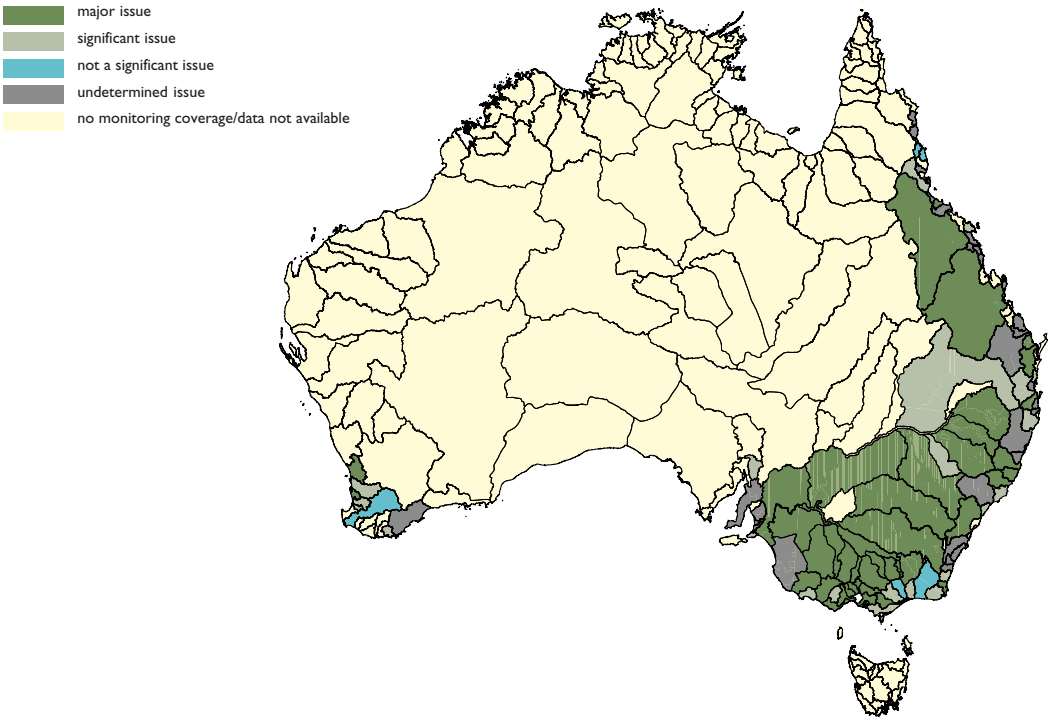
These locations and attributes were entered into a database by each State and Territory to define the location of gauging stations.

Surface water quality

- Summaries of surface water quality at a river basin level of aggregation, based on exceedance of water quality guidelines and trend analyses.

Exceedance and trend analyses are available for monitoring stations. Attributes include total phosphorus, total nitrogen, nutrients, pH, turbidity, salinity (electrical conductivity).

Figure A42 Surface water quality 2000. Exceedance of nutrient guidelines.
Nutrient exceedances are based on total nitrogen and/or total phosphorus values.



Some major or significant water quality issues may not be shown where monitoring coverage at river basin scale is inadequate. Data for Northern Territory and Tasmania did not meet minimum requirements in terms of sampling frequency and length of monitoring record.

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ACKNOWLEDGMENTS

The Audit has worked with government, research and commercial organisations to maximise government investment to develop an integrated system of national information to support natural resources management.

The design, development and implementation of data management protocols, community information systems and long term arrangements for the management of data have been done in partnership with ANZLIC – Spatial Information Council and with government agencies and private sector suppliers, including:

State and Territory

Australian Capital Territory

New South Wales

Northern Territory

Queensland

South Australia

Tasmania

Victoria

Western Australia

Commonwealth

Australian Bureau of Statistics

Australian Greenhouse Office

Agriculture, Fisheries and Forestry – Australia

CSIRO

Environment Australia

Geoscience Australia

Private sector

Sinclair Knight Merz

Beaten Track Group

ESRI Australia

Alexander Tomlinson and Associates

PHOTO ACKNOWLEDGMENTS

Maria Cofinas	page 98
CSIRO	page 30
Department of Agriculture (Western Australia)	page 88
Murray Fagg	page 64
Murray-Darling Basin Commission	pages 60, 66, 102
Stewart Noble	page 62
Drusilla Patkin	page 6
Michael Quinn	pages 10, 18, 24, 50

ABOUT THE NATIONAL LAND AND WATER RESOURCES AUDIT

Who is the Audit responsible to?

The Minister for Agriculture, Fisheries and Forestry has overall responsibility for the Audit as a program of the Natural Heritage Trust. The Audit reports through the Minister for Agriculture, Fisheries and Forestry to the Natural Heritage Board also comprising the Minister for the Environment and Heritage.

How is the Audit managed?

An Advisory Council manages the implementation of the Audit. Dr Roy Green, with a background in research, science policy and management chairs the Advisory Council. Members and observers on the Advisory Council and the organisations they represent are: Drew Clarke (ANZLIC), Warwick Watkins (LWRRDC), Bernard Wonder (AFFA), Stephen Hunter (EA), John Radcliffe (CSIRO), Peter Sutherland (SCARM), Jon Womersley (SCC), Roger Wickes (SCARM) and Colin Creighton (Audit).

What is the role of the Audit Management Unit?

The Audit Management Unit's role has evolved over its five-year life. Phases of activity include:

Phase 1: Strategic planning and work plan formulation—specifying (in partnership with Commonwealth, States and Territories, industry and community) the activities and outputs of the Audit—completed in 1998–99.

Phase 2: Project management—letting contracts, negotiating partnerships and then managing all the component projects and consultancies that will deliver Audit outputs—a major component of Unit activities from 1998–99 onwards.

Phase 3: Reporting—combining outputs from projects in each theme to detail Audit findings and formulate recommendations—an increasingly important task in 2000–2001 and the early part of 2001–02.

Phase 4: Integration and implementation—combining theme outputs in a final report, working towards the implementation of recommendations across government, industry and community and the application of information products as tools to improve natural resources management—the major focus for 2001–2002.

Phase 5: Developing long term arrangements for continuing Audit-type activities—developing and advocating a strategic approach for the continuation of Audit-type activities—complete in 2001–2002.

The Audit Management Unit has been maintained over the Audit's period of operations as an eight-person multi-disciplinary team. This team as at December 2001 comprises Colin Creighton, Warwick McDonald, Stewart Noble, Maria Cofinas, Jim Tait, Rochelle Lawson, Sylvia Graham and Drusilla Patkin.

How are Audit activities undertaken?

As work plans were agreed by clients and approved by the Advisory Council, component projects in these work plans are contracted out. Contracting involves negotiation by the Audit to develop partnerships with key clients or a competitive tender process.

Facts and figures

Total Audit worth, including all partnerships – in excess of	$52 m
Audit allocation from Natural Heritage Trust	$34.19 m
Percentage of funds allocated to contracts	~ 92%
Total number of contracts	130

Natural Heritage Trust

Helping Communities
Helping Australia

A Commonwealth Government Initiative

National Land & Water Resources Audit

A program of the Natural Heritage Trust

www.nlwra.gov.au/atlas