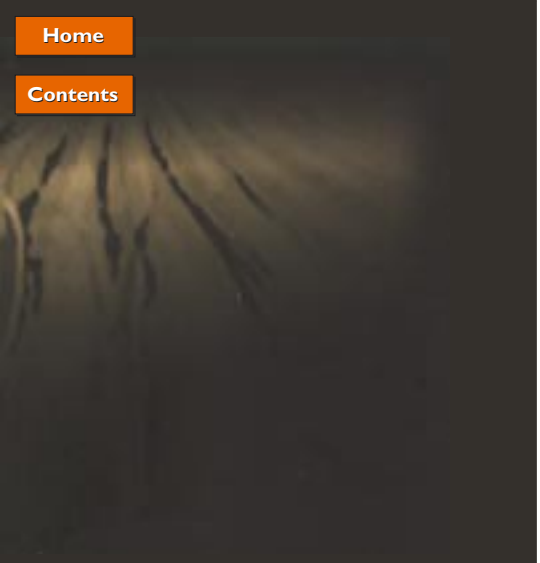

Natural Heritage Trust

Helping Communities Helping Australia

A Commonwealth Government Initiative

AUSTRALIA'S NATURAL RESOURCES

1997 – 2002 and beyond

National Land & Water Resources Audit

A program of the Natural Heritage Trust

AUSTRALIA'S NATURAL RESOURCES: 1997–2002 AND BEYOND

Australia is committed to natural resource management.

In August 1999, Ministers attending the sixteenth meeting of the Agricultural and Resource Management Council of Australia and New Zealand noted the following principles. The Council also noted that these principles might be amended in time to capture economic and regional issues, important changes in attitudes and behaviour, and findings from the monitoring and evaluation of progress.

Principles for natural resource management

1. Ecologically sustainable development is the framework for the management of our natural resources.
2. Natural resource management requires integrated management at the appropriate scale recognising ecosystem processes.
3. Natural resource management requires a partnership between government, communities, industry and individuals, with clear and agreed roles and responsibilities.
4. Relative contributions to the costs of natural resource management are to reflect the private and public costs incurred or benefits derived.
5. A mix of policy and delivery instruments is required for natural resource management outcomes.
6. Policy and programs are to be consistent and aligned within and between all levels of government.
7. Natural resource management actions are to be based on best available science and experience and the principle of continuous improvement. New natural resource management requires a continued investment in science and innovation.
8. Capacity building, leadership and empowerment are fundamental to natural resource management.
9. Natural resource management requires a fundamental change in society's values, thinking and behaviour.
10. Natural resource management objectives are outcome focused and S.M.A.R.T. – simple, measurable, achievable, reasonable and time-bound.
11. Natural resource management recognises the rights and aspirations of indigenous people and their connection to natural resources.

AUSTRALIA'S NATURAL RESOURCES: 1997 – 2002 and beyond

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

Published by:

National Land and Water Resources Audit
On behalf of the Commonwealth of Australia

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We invite all interested people, both within and outside Government, to make use of the Audit's reports, information, its Atlas and products in whatever way meets their needs. We encourage you to discuss the Audit findings with the various partners and contributors that have prepared this information. Partners and contributors are referenced in this report. The Commonwealth accepts no responsibility for the accuracy or completeness of any material contained in this report, and recommends that users exercise their own skill and care with respect to its use.

Publication data: Australia's Natural Resources: 1997–2002 and beyond.

ISBN: 0 642 37139 3

Editing and design: Themeda
Drawings: Marco Wallenius
Printing: Union Offset

June 2002

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

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

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

Dear Ministers,

I have pleasure in presenting to you *Australia's Natural Resources 1997–2002 and beyond*. This report is the final report of the initial National Land and Water Resources Audit. It summarises the principal findings and describes some of the substantial uses already made of the Audit's information. Recognising the government's commitment to continue the Audit, suggestions are made for its future role.

The Audit assessments show that a significant proportion of Australia is in sound condition, with some of it in excellent condition (e.g. approximately 50% of our estuaries are in near-pristine condition—strategic protective management for these areas will be cost effective and ensure these areas continue to deliver the services we need from them—fish production and biodiversity).

The Audit assessments also demonstrate that our country faces a number of serious issues in natural resource management, particularly within the more intensively developed rural areas. The Audit has identified where these issues are occurring and some of the key remediation and management opportunities. It has highlighted the continuous improvements occurring in industries to meet natural resource management responsibilities. There is scope for many further improvements: improvements that maximise productivity, maintain our resource base and minimise off-site impacts.

Continued Audit partnerships between the governments, industries and individuals using Australia's natural resources are essential. We will be able to track changes in condition as we implement programs, provide reports of improvements, and assess the effectiveness of various management actions and incentives. This information will underpin decisions on priorities, policies and programs to meet emerging natural resources challenges.

Providing information to underpin management requires a strategic approach involving:

- content, with gaps identified and filled, to meet the various and changing needs of clients;
- availability of data through libraries, information through atlases and brokering improvements in skills and understanding; and
- application at a variety of scales to meet local, regional and Australia-wide objectives; to undertake scientific assessments; determine trade-offs where necessary; and monitor the outcomes and quality of policy and management decisions.

A continued investment in assessing Australia's natural resources to determine their status and change in condition as a result of use, will be cost-effective and will underpin the success of natural resource management initiatives. The National Land and Water Resources Audit Advisory Council recommends the delivery of this process through the establishment of an independently based organisation that can build on partnerships across all governments, the community and industry; and on maintaining and updating core data sets established during the five years of the Audit. There must also be scope for

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further demand-driven data collections and facilitating of Australia-wide standards for data collection that are underpinned by Australia New Zealand Land Information Council-developed data access and management protocols. The Audit should be overseen by a council responsible to the chairpersons of the Natural Resources Management Ministerial Council.

Audit activities have already had a significant influence on Australia's natural resource management programs and on behalf of the Audit Advisory Council I thank you for your support and the Government's commitment to continue with this strategic approach to collecting and disseminating information on our natural resources.

Yours sincerely

Roy Green

Chair, National Land and Water Resources Audit Advisory Council

SUMMARY

Australia's natural resources: 1997–2002 and beyond

The Natural Heritage Trust of Australia Act—a foundation for sustainable development

Australia is a unique mix of land, water and biodiversity resources. In the 200 years since European settlement, the biological productivity from these resources and the Australian landscapes has been progressively doubled . But there is a growing acceptance worldwide that natural resources are finite and require effective management. This acceptance is so strong that sustainable development has been identified as the central issue of our time. In 1997, the Commonwealth Parliament passed the *Natural Heritage Trust of Australia Act 1997* (Cwlth). Its preamble recognised:

> *… the need for urgent action to redress the current decline and to prevent further decline, in the quality of Australia's natural environment, … to integrate the objectives of environmental protection, sustainable agriculture and natural resource management consistent with the principles of ecologically sustainable development …*

Assessing the status of Australia's natural resources, the health of its ecosystems and the opportunities for improving our use of natural resources is of paramount importance for Australia's development. In recognition of this need, the Commonwealth Government established the National Land and Water Resources Audit under legislation … *to provide the baseline for the purposes of carrying out assessments of the effectiveness of land and water degradation policies and programs,* … [and] … *to improve Commonwealth, State and regional decision-making on natural resource management.* This initiative is sponsored through the Natural Heritage Trust.

Assessing the condition of Australia's natural resources

Over the period 1997–2002, the Audit coordinated and commissioned a range of assessments that encompassed the nation's land, water and biodiversity. All assessments were based on the development and agreement of national data quality standards with ongoing monitoring to establish clear and coherent trends. To facilitate systematic updating and use of the data, the Audit also established web-based sources and repositories for natural resources information—the Australian Natural Resources Atlas and the Australian Natural Resources Data Library.

The Audit has undertaken assessments of surface and groundwater; dryland salinity; native vegetation; rangelands; agriculture, natural resource accounting; river, estuary and catchment health; and terrestrial biodiversity.

Many of Australia's resources are in sound condition, but may require protective management programs to ensure this remains the case. In the small proportion of Australia that contains the greatest concentration of the population and industry there are many opportunities for improved productivity and sustainable development. Resource condition and management opportunities vary as:

- some resources have undergone irreversible degradation and loss (e.g. extinctions of native flora and fauna);
- some issues are amenable and require immediate consideration (e.g. soil acidity and conservation measures);
- some may require more adaptive management (e.g. living with salinity);
- others may represent problems building up for the longer term (e.g. increasing nutrient loads to estuaries); and
- others would benefit from protective management (e.g. managed fire regimes in the rangelands).

Information, the currency for implementing sustainable development

Natural resource management in Australia is increasingly being driven by community commitment, and delegated to regional and local groups and managers. To guide their decision making and make best use of natural resources, it is essential that all managers have ready access to natural resources information based on timely data and sound underpinning science. Managerial decisions also need to be able to be evaluated by monitoring and evaluation of the outcomes, providing a basis for continuous improvement in the use of and investment in the management of our natural resources.

Most importantly, information:

- serves to underpin policy development;
- assists in building an ethos of natural resource responsibility and stewardship across the entire community;
- aids planning and decision making;
- helps to prioritise investment opportunities; and
- guides the development of programs leading to improvements in the effective and sustainable use of our natural resources.

If Australia is to improve the quality of its natural resource management and increase the pace of positive change, it will require a portfolio of natural resource data sets, collation and assessment tools. Information aligned to meet the needs of current and future policy instruments, and able to identify the public and private benefits involved, is essential.

RECOMMENDATION 1

To deliver on the vision for improved natural resource condition, conservation and productive use of its natural resources, Australia through partnerships and contributions across government, industry and the community, should strategically increase its investment in data collection and collation, the provision of information and its application and making it available at cost of transfer, for use by the community and industry.

Translating information into priorities and actions

Providing regular, structured natural resource monitoring programs and consequent assessments will not, of itself, be sufficient to guarantee effective natural resources management. We also need the capacity to turn these assessments into information that will be accessed and valued by stakeholders, and developed as management tools. This requires an ability to recognise the needs of different stakeholders, whether they are operating at property, local, regional or whole-of-government level. A prerequisite is that the community has an awareness of, and facility to find, this information; understands the biological systems underlying the information; appreciates the likely interactions and responses among the environmental variables; and uses the tools as aids in developing their natural resource management objectives and programs. This is required at all scales—from on-farm to regional management and for State or Australia-wide policy development. Part of the Commonwealth response to this demand will be fostering knowledge interchange and support to regional groups within Audit activities 2002–2007.

RECOMMENDATION 2

Based on strategic and integrated information provision, Australia needs to increase its activities in knowledge exchange, investing in a variety of government, industry and community based extension and support services that translate natural resources information into understanding, improved practice and the setting of goals and targets, providing decision support techniques and applying these at regional through to national scales.

Tracking changes in natural resource condition and use

Experience gained in implementing the National Land and Water Resources Audit shows that a continuing monitoring and assessment program should be instituted with a minimum set of components. This program must have the capacity to meet the needs of all resource managers for information required for:

- policy development;
- definition of management practice;
- investment decision making; and
- the monitoring and evaluation of outcomes.

These are the necessary drivers to ensure effective natural resource management at local level, whether within a landscape, catchment or ecosystem framework.

RECOMMENDATION 3

To meet the increasing demand for use, productivity and health information, there should be implemented an integrated and coordinated monitoring and assessment program, building on State and Territory activities, covering:

3.1 **Australia's land resources**, that tracks soil condition, monitors soil, water and nutrient budgets, details land management practice, links practice to soil condition and productivity and is based on the Australian Soil Resources Information System.

3.2 **Australia's surface and groundwater resources**, that tracks water use, monitors water availability and quality, details management practices and is available to underpin an Australia wide agreed policy for sustainable water use.

3.3 **The ecology of Australia's rivers and estuaries** and how they operate, including the current condition of their riparian and aquatic biodiversity, and the impact and sustainability of current and proposed management practices, based on agreed assessment protocols and spatial frameworks, is reported and assessed within a catchment land use context.

3.4 **Australia's native vegetation** and its biodiversity values that tracks change in extent, monitors condition, determines levels of carbon sequestration, details management practice and returns from use and builds on and integrates data from both the National Forest Inventory and the National Vegetation Information System and links to the National Carbon Accounting System and the Australian Collaborative Rangeland Information System.

3.5 **Australia's terrestrial biodiversity**, its condition and management needs using an hierarchical and landscape based bioregional monitoring and assessment program that tracks change in species, populations and regional ecosystems, determines the impact of threatening processes, details management activities and assesses opportunities for improved management.

3.6 **Australia's rangelands** to underpin effective and protective management, including their use, productivity, biodiversity, community, indigenous and economic values, by implementing the Australian Collaborative Rangeland Information System.

Integrating social, economic and biophysical components of natural resource management

Although a large proportion of managerial decisions have been based mainly in rational economic judgements, there is increasing recognition that environmental and social considerations must be objectively evaluated and brought to bear in the process. Australia would benefit from community agreement on how environmental and social resources should be valued. These values can then be added to economic considerations to support sustainable conservation and use of the nation's natural resources.

RECOMMENDATION 4

To facilitate integrated social, economic and environmental planning and management Australia needs to develop and implement an agreed approach to resource accounting, applicable at regional through to Australia wide scales, incorporating market and unpriced values, together with the costs and benefits of resource use.

Assessments, the key to improving programs and policies

Australia needs to undertake long term monitoring and assessment activities on a regular, programmed basis and to a high and consistent standard. The benchmarks and assessments provide a basis for decision making, meeting stewardship obligations and ensuring Australia's continued international credibility as an exporter operating within a sustainability ethic.

RECOMMENDATION 5

To meet demands for information and provide a framework for effective and efficient investment in and returns from our natural resources, Australia should regularly assess and report on their condition and on the outcomes of our natural resources programs, and in the context of these assessments, adjust and implement its natural resource management initiatives.

Meeting changing client demands and providing information on emerging issues

There are many gaps in knowledge on Australia's natural resources and their use. All Audit assessments detail key gaps in knowledge and opportunities to streamline data collection and management.

There are also many natural resource management opportunities and investment strategies that will only become defined with this increasing knowledge.

Any system for providing information for Australia's natural resources needs to apply new knowledge in priority setting to meet client needs.

RECOMMENDATION 6

To meet client information needs and maximise returns from investment in data collection and information analysis, Australia needs to re-assess opportunities to target data collection, improve coverage, relevance and quality, implement any gap-filling and ensure effective information provision, with consequential activities to be implemented in a coordinated manner.

Maximising returns on investment in data collection

Natural resources data sets and information need to be readily and consistently available, managed systematically and be well coordinated. The Audit has identified a variety of activities and organisational initiatives that provide opportunities for improving returns on Australia's investment in natural resources data and information provision. Data management activities need to be based on the Australian Spatial Data Directory and Infrastructure, the use of data library systems, and the compilation of distributed but linked atlases including the Australian Natural Resources Atlas. An effectively run information system is likely to be able to attract client co-investment to support additional data collection and management to meet specific needs.

RECOMMENDATION 7

As part of the development of a more strategic, client responsive and cost effective approach to data collection and information provision, Australia needs to implement through the Natural Resources Management Ministerial Council, recommendations contained within the Audit's Report ***Australian Natural Resources Information 2002.***

The recommendations include building and maintaining fundamental data sets; providing ready access at cost of transfer to data and information through data libraries and atlases; ensuring maximum utility of the investment in data collection activities; ensuring regular reporting within the standard frameworks defined by the Australia New Zealand Land Information Council; and facilitating opportunities for further co-investment and collaborative management in data sets required by client organisations.

Coordinating data collection and the provision of information

A successful and valued natural resource data collection and information system will be both client-driven and strategic. Users expect:

- consistency between related data;
- the ability to produce seamless maps at a range of scales;
- an hierarchical structure that underpins development of data sets so that they can be progressively aggregated to report at regional, State/Territory and national scales;
- effective linking between data sets that allow assessment of the condition of natural resources and of any changes;
- uniform acceptance of descriptors and attributes;
- the ability to meet a demand for new information products; and
- continually improving efficiency of operation.

The Audit has established the foundation for such a natural resource data collection and information system. Continued and strategic coordination Australia wide is imperative to implement the technical standards detailed within the Australian Spatial Data Infrastructure.

RECOMMENDATION 8

To ensure cost effective and client relevant data collection and management, Australia needs to continue coordination and the building of partnerships, as a core part of Audit activities 2002–2007, for the collection, management and assessment of natural resource data and its access through data libraries and atlases operating consistently with the Australia New Zealand Land Information Council standards.

Australia's Natural Resources Information Agency

A critical component in gaining the confidence of contributors to and users of the Audit has been its managerial and geographical independence. This was recognised by the Commonwealth Government when it announced in March 2002 an in-principle commitment to continuing the Audit until 30 June 2007. Key identified principles are:

- *maintaining independence while fostering coordination across agencies;*
- *building a cooperative State, Territory and Commonwealth partnership;*
- *ensuring data collection, processing and storage are primarily demand driven;*
- *a user-pays policy for additional activities;*
- *developing an increased responsiveness to policy information needs that avoids a direct policy role; and*
- *establishing clear and achievable objectives and work plans that are agreed and set by principal users.*

While program-based activities provide valuable outputs and impetus, history suggests that their sustainability is not ensured. Audit-type activities would be best sustained by establishing an independent information agency. Part of this agency's role would be to formally report to government at regular intervals on the status and changes in Australia's natural resources and opportunities for strategic investment to improve or maintain the resource base. Establishing the information agency, its role and responsibilities requires the development of legislation, administrative and accountability arrangements and partnership agreements. These should be progressed over the next term of the Audit (2002–2007).

RECOMMENDATION 9

To ensure the information-based approach to natural resource management that Australia has implemented is effective, Australia needs to establish an information agency with assured life and independence. A legislative base would enable and facilitate processes for the coordinating of natural resource data collection, information provision, mandated assessments of progress, the review and finetuning of major programs and the development of initiatives.

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1. AUSTRALIA'S LAND AND WATER RESOURCES

Australia is a very large continent. It has a total surface area of 7.6 million km² and is surrounded by an ocean territory of 16.1 million km² including its exclusive economic zone and claimable continental shelf. Australia is a very 'old' continent geologically. It is the driest of the world's inhabited continents, with the lowest percentage of rainfall as run-off, the lowest amount of water in rivers and the smallest area of permanent wetlands. More than half of the Australian continent is made up of a peneplain, an extremely large level area constituting most of Western Australia, Northern Territory and western South Australia. This area is poorly and variably supplied with rainfall and has always been sparsely populated.

The original indigenous inhabitants of Australia lived as 'hunter-gatherers' on native plants and animals. Their principal land management tool was the selective use of fire. They were joined from 1788 by the Europeans, settling over time in separate colonies centred on Sydney, Hobart, Perth, Adelaide, Melbourne and Brisbane. These immigrants brought with them their northern hemisphere agricultural practices of cultivating the soil; growing grain, fruit and vegetable crops; and rearing animals. The new arrivals saw the continent as an unallocated resource ripe for development that would be based on previous European experience, albeit at least initially recognising the presence and needs of the indigenous inhabitants.

However, some lessons for improved natural resource management were brought from Europe. Even in the early days of settlement, some important decisions made by surveyors showed an appreciation of natural resource management and the need to avoid private ownership of key natural resources. The littoral environment, some riparian and most estuarine shores and various scenic points, for example, were retained in public ownership.

Australia was soon self-reliant in food production and agricultural exports to Britain and Europe began around 1811. Grain exports using sailing ships were well established by the 1870s. However, interacting factors such as the opportunity to replace native vegetation and animals with introduced crop species and domesticated livestock, and the introduction of exotic plant and animal pests have had a major impact on land use and consequently on the condition of land, water and marine resources. The progressive development of mining, ports and urban areas, particularly following from the gold rush finds of the 1850s, created specific impacts on land resources in localised areas.

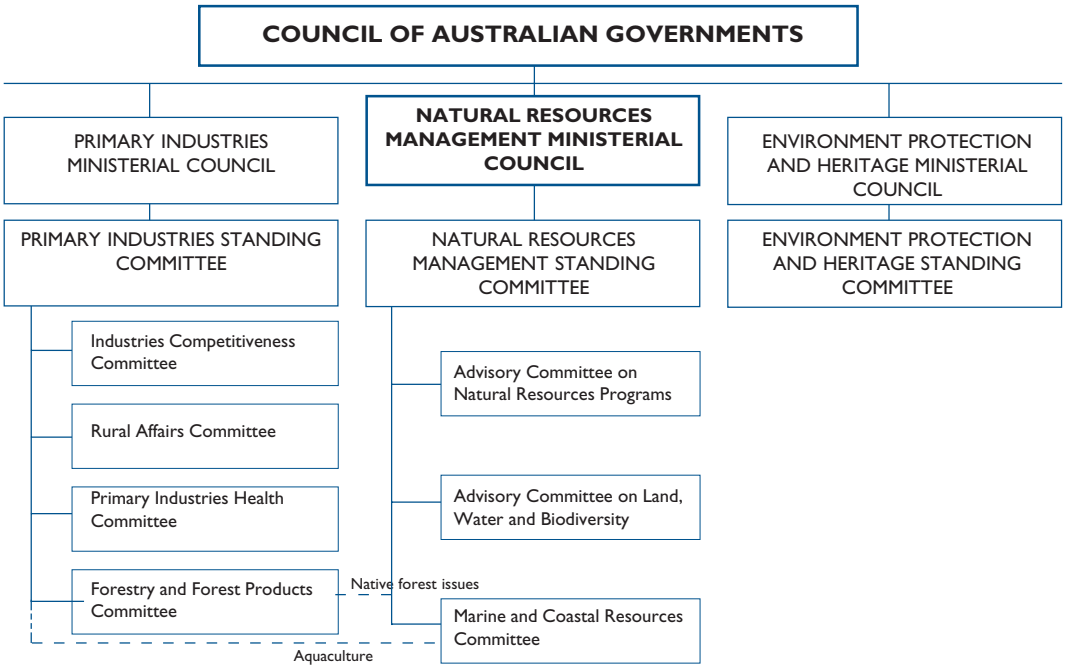
Commonwealth, State and Territory governments

The federation of the Australian colonies in 1901 was a defining event in natural resource management. The *Commonwealth of Australia Constitution Act 1900* (Imp.) provides for the Commonwealth to have powers for *trade and commerce with other countries and among the States* [s 51 (i)] and *external affairs* [s 51 (xxix)], while section 107 inter alia provides for powers previously vested in colonies to continue with the States unless specifically vested in the Parliament of the Commonwealth. Section 107 also precludes the Commonwealth from *abridging the right of a State or its residents therein to the reasonable use of the waters of rivers for conservation or irrigation*. In essence, this left natural resource management responsibilities—excluding Commonwealth waters—with the States, but as the Commonwealth has since ratified various international treaties relating to environment, conservation and heritage, (thirty-nine by 1996 [State of Environment Advisory Council 1996]), there has been an increasing constitutional basis for Commonwealth involvement in land management issues.

With development, increasing interaction occurred between Commonwealth and State governments on the use of natural resources. The Commonwealth assumed responsibility for the Northern Territory from South Australia on 1 January 1911. In 1915, the Commonwealth, New South Wales, Victoria and South Australia had passed Acts of Parliament ratifying the River Murray Waters Agreement, leading to the establishment of the River Murray Commission in 1917. By 1934, the Federal and State Ministers of Agriculture had established Australian Agricultural Council, with a subordinate Standing Committee on Agriculture made up of the heads of Commonwealth and State agencies responsible for agriculture, together with CSIRO and the Commonwealth Department of Health. Later Ministerial Councils and Standing Committees included those for soil conservation, land information, water resources, conservation, forestry, fisheries and environment protection. The Northern Territory achieved self-government in 1978 and the Australian Capital Territory in 1988, with both becoming full members of the Ministerial Councils. Within the last decade there has been an increasing overlap and integration of Ministerial Council activities including:

- initially the formation of the Agricultural and Resource Management Council of Australia and New Zealand and the Australian and New Zealand Environment and Conservation Council;
- their subsequent replacement by the Natural Resources Management Ministerial Council and Standing Committee; and
- Primary Industries Ministerial Council and the Environment Protection and Heritage Ministerial Council with their respective Standing Committees in 2001.

Figure 1. Relationship of Ministerial Councils and their main subordinate bodies to Council of Australian Governments.



Arrangements were set in place to ensure effective cross-linkages between these (Figure 1). These Standing Committee structures and activities reflect a broad recognition of both the importance of partnerships and the effectiveness of undertaking many activities in an Australia-wide context.

Appreciating the limits of natural resources

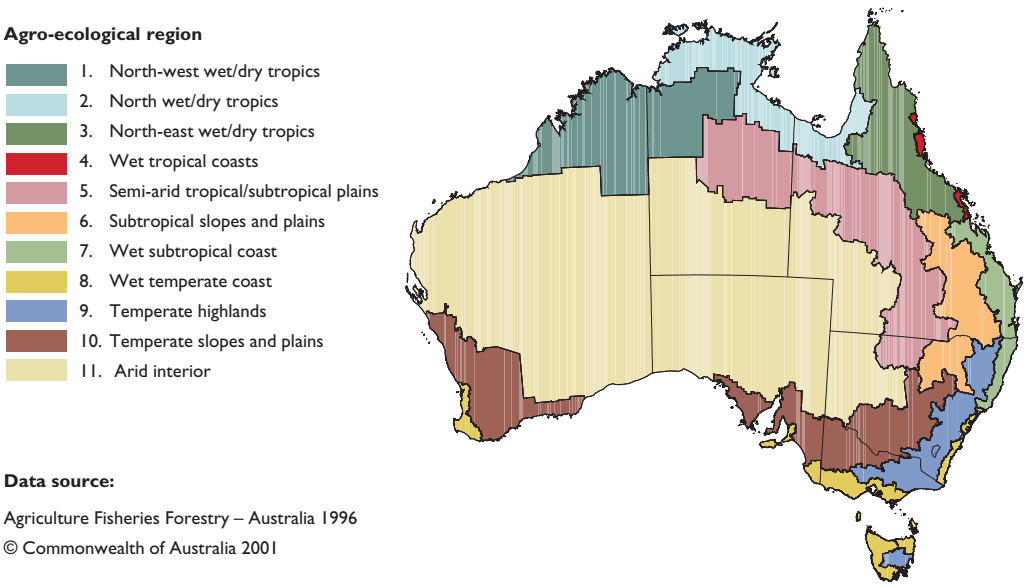
The limits of the world's natural resources have been the subject of debate for hundreds of years. The prospect of resources constraints was given prominence by Malthus (1798). In more recent times, the Club of Rome's report *The Limits to Growth* (Meadows et al. 1972) predicated its study on a belief that the basic behaviour mode of the world system is exponential growth of population and capital, followed by collapse.

Australia has been mapped into agro-ecological zones (Figure 2), but only 25% of the continent has a growing season of more than five months. The area with a growing season of more than nine months—generally recognised as required for long season annual crops and perennial crops—is a mere 9% of the continent. Only 6% of Australian is considered arable. The more highly productive lands, often described as the 'intensive land use zone', are located along the eastern and south-eastern seaboard and in the south-western corner of the continent.

Australia has a mosaic of land use that is continuing to evolve (Figure 3).

- Land continued to be brought under cultivation for agriculture steadily until the 1960s, often encouraged by government incentives, and, even today, a limited amount of continuing land development is taking place through clearing of native vegetation. Considerable development is also taking place on previously established farming land through changing use patterns and intensification.
- The twentieth century also saw a major expansion in land used for extraction of mineral and energy resources.
- Conservation reserves have been progressively increased and now take up a little over 5% of land area.

Figure 2. Australia's agro-ecological zones.



Data source:

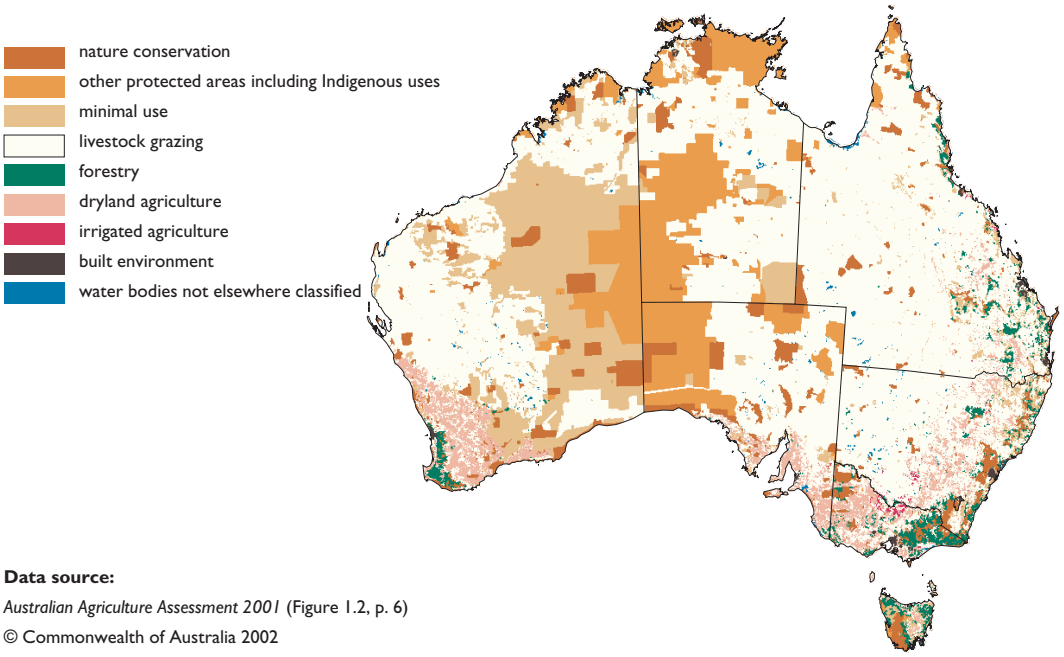
Agriculture Fisheries Forestry – Australia 1996

- Public lands accessible for harvesting of native timber have declined as increased areas have been reserved for nature conservation. The current 4.8% of land in forestry is increasingly based on private plantation and farm forestry production systems.
- Following the passage of the *Aboriginal Land Rights (Northern Territory) Act 1976* (Cwlth), significant areas have been set aside for indigenous use. Aspects of land management were further clarified in the *Native Title Act 1993* (Cwlth). This Act recognises and protects native title, recognises pre-existing rights and interest of Indigenous peoples to land and waters, and establishes ways in which dealings affecting native title may proceed. The legislation was amended in 1998 to provide for alternative State-based regimes.

Australia has a developed, multi-faceted economy. Agriculture continues to be an important contributor to national, State/Territory and regional economies. Including pastoralism, it remains Australia's most extensive form of land use, taking up to 60% of the country's area. With an annual gross value of production at farm gate averaging $25 billion, and exports of $17.6 billion in the period 1989–1999, agriculture represented about 3% of the average annual gross domestic product ($620 billion in that period). Other sectors of the economy, particularly in regional areas, remain highly dependent on the farm sector. Approximately 60% of manufacturing turnover in the Murray–Darling Basin, for example, is derived from food processing industries.

Agricultural exports represent 20% of Australia's total exports. By comparison, crude and processed mineral production, derived from quite small areas (including some off-shore), makes up approximately 35% of exports with a value of approximately $35 billion. The annual gross value of tourism—often related

Figure 3. Australia's broad, dominant land use categories.



Data source:
Australian Agriculture Assessment 2001 (Figure 1.2, p. 6)

to Australia's land and its diversity of natural resources although little of the expenditure relates to natural resource management—is about $25 billion (with approximately 70% generated by domestic households). Tourism represents around 4.5% of Australia's gross domestic product with international visitors representing 11.2% of export earnings in 1997/98.

By the 1980s, Australia began to recognise that new land could no longer be 'developed' over most of the country. Natural resources were seen to be finite and requiring higher levels of protective management to ensure sustainability.

By the end of the decade, government-sponsored working groups were exploring the principles and impact of ecologically sustainable development.

The Australian Science and Technology Council (1990) had observed that Australia lacked:

- a national integrated system for measuring environmental quality;
- a national data set of sufficient calibre to assess and manage environmental quality; and
- appropriate national baseline data to evaluate the effectiveness of environmental protection and reclamation strategies.

The 'Year and Decade of Landcare' was established in 1990. A ground-swell of natural resources awareness developed from it through the creation of informally structured, community-based Landcare groups. Although primarily located in rural and regional Australia, urban awareness also rose. Initially oriented to soil management, the perspective of Landcare groups has progressively broadened to appreciate the interrelationship between natural resources and agricultural practices in the management of an ecosystem. This has been particularly evident in dryland areas with increasing salinity and in irrigation areas with rising water tables.

Increased awareness has also been reflected by the growth of volunteerism in complementary community groups such as Greening Australia and Conservation Volunteers Australia.

The final report of the Ecologically Sustainable Development Agricultural Working Group (1991) noted that a major component for achieving ecologically sustainable development in agriculture *will be the direct monitoring of agricultural systems and practices to assess their long-term sustainability*. Criteria for monitoring included:

- the ability to provide an indication of the relative condition of the resource base, biodiversity, contamination and productivity;
- links between criteria and the processes that help sustain the resource base and agricultural productivity;
- the need for information at several scales ranging from farm to catchment to regional and national; and
- use of simple indicators that target long-term trends and are not subject to wide annual fluctuations.

The system had to be capable of being supported in the long term, noting that a system that was labour intensive and costly may prove difficult to maintain.

The subsequent discussion paper for a Draft National Strategy for Ecologically Sustainable Development prepared by the Ecologically Sustainable Development Steering Committee (1992) considered that achievement of effective land-use decision-making processes would require the

> *… coordinated collection, storage, interpretation and delivery of land and natural resource data and development of methods to enable land-use planners and decision makers to place risk-weighted values on goods and services of a physical, geological,*

> *biological and amenity nature, …* [incorporating] *non-economic and economic considerations into decision-making processes including … the concepts of intra-generational and inter-generational equity.*

Natural resources stewardship sprang to international prominence in 1992, when more than 100 heads of state met in Rio de Janeiro, Brazil for the United Nations Conference on Environment and Development (UNCED). From 1992, Australia signed a number of international conventions pertaining to natural resources, including the United Nations framework *Convention on Climate Change*, the *Convention on Biological Diversity*, and the United Nations *Convention to Combat Desertification* in those countries experiencing serious drought and/or desertification, particularly in Africa.

Australia's State of the Environment Advisory Council (1996) noted that sustainable development was *arguably the central issue of our time*. The Australian State of Environment Committee (2001) report observed *degradation of lands and waters remains of critical concern, especially in the intensive land use zone upon which much of Australia's agricultural production depends*. The then Land and Water Resources R&D Corporation estimate of land and water degradation losses at $1.4 billion per annum was noted by the Australian National Audit Office (1997), which accepted that government was *constrained by the poor baseline information on the current condition of the environment, which makes determining needs and national priorities all the more difficult*.

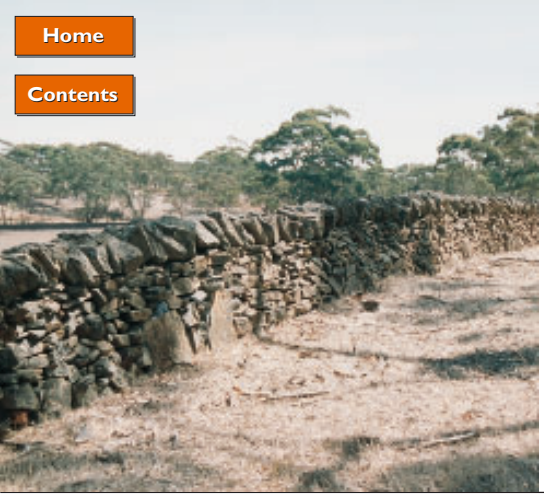
Over the 200 years following the first European settlement, land management has changed from one involving use for subsistence, with only fire as a tool to one where large areas were redeveloped with completely different, commercially-based ecosystems—'farming systems'—that changed water, nutrient and botanical balances dramatically. Natural resource management responsibility moved from the community to the individual, but has since progressively involved a return to a sharing of individual and community responsibility.

An increasing community acceptance of the need for integration of natural resource management has been recognised legislatively. Examples include the introduction of environmental impact review processes throughout Australia, the passage of the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999* (Cwlth), and the gradual development of integrated natural resource management legislation at State and Territory level.

Natural resource management issues are fundamental to the economic and social viability of our rural and regional industries. A continuing decline in the health of our natural resource base will inevitably affect Australia's ability to compete as a quality, low-cost producer of agricultural products in the international market place (ARMCANZ 2000).

Gradually, the use of our land and water resources has taken on more diverse community dimensions. People now value natural resources not only for cropping, grazing, forestry, and fish production but also for aesthetic and intrinsic values, biodiversity and diversity required for future generations, and ecosystem services such as sinks for greenhouse gases and water filtration. The natural resource base supports tourism, recreation, and community lifestyles.

Australia's population in 2001, estimated at about 19.3 million (Australian State of Environment Committee 2001), was ranked as the fiftieth largest country in the world by population. It is also one of the least densely settled with 80% of the population living on just 1% of its land surface along the coastal margins. There has been much debate about the population that can be sustainably supported



(Cocks 1996, Flannery 1994). Water availability has increasingly been hypothesised as the ultimate limit to growth in Australia.

The quality of our natural resources is increasingly recognised as affecting all aspects of the economy and community activity. It is from this broader context of the changing characteristics of our land and water resources that the key drivers of natural resource management are now being considered. If we are to succeed in understanding their inter-relationships, and making the necessary managerial trade-offs that have to be faced, information on our natural resources and the extent to which they are undergoing change is essential.

An audit of Australia's natural resources

In 1997, the Commonwealth Parliament passed the *Natural Heritage Trust of Australia Act 1997* (Cwlth).

The preamble to the Act recognised:

> *… the need for urgent action to redress the current decline and to prevent further decline, in the quality of Australia's natural environment … to conserve Australia's environmental infrastructure, to reverse the decline in Australia's natural environment and to improve the management of Australia's natural resources … to integrate the objectives of environmental protection, sustainable agriculture and natural resource management consistent with the principles of ecologically sustainable development…*

The Commonwealth Government established the National Land and Water Resources Audit (Audit) under the legislation *to improve Commonwealth, State and regional decision making on natural resource management* as an initiative sponsored through the Natural Heritage Trust. Objectives were developed and endorsed by the Natural Heritage Trust Ministerial Board comprising the Minister for Agriculture, Fisheries and Forestry; and the Minister for Environment and Heritage. The National Land and Water Resources Audit Advisory Council was established. It was responsible for advising the Minister for Agriculture, Fisheries and Forestry; and the Ministerial Board on strategic directions, policy priorities, program review and on establishing processes, implementation and performance evaluation of the Audit. The Executive Director of the National Land and Water Resources Audit, with a small support staff, reported directly to the Audit Advisory Council. Full detail of the processes in establishing and managing the Audit is outlined in Appendix 1.

The Audit commissioned a needs analysis to determine, through consultation with key natural resource management agencies and groups, Commonwealth, State/Territory and industry, the key natural resource management issues facing Australia. Assessments of these were undertaken.

The following broad themes were identified:

- surface and groundwater management—availability, allocation, use and efficiency of use;
- dryland salinity;
- vegetation cover, condition and use;
- rangelands monitoring;
- land use change, productivity, diversity and sustainability of agricultural enterprises;
- capacity of, and opportunity for, farmers and other natural resource managers to implement change;
- river, estuary and catchment health; and
- terrestrial biodiversity, which was added as an additional theme for the final year of the Audit.

In identifying these themes as priority areas for examination during the Audit, the Audit Advisory Council noted many other important land and water issues raised including water re-use, wetland health, wind erosion, soil structure change, soil biology, acid sulfate soils, soil water repellence, soil contaminants, fire management regimes, pest plants and animals, floodplains, fisheries, urban and coastal land use change, climate change and carbon budgeting. All of these topics are integral components of, or contribute to, Australia's natural resources and their management. Audit assessments did not encompass Australia's external territories, urban areas, and coastal and Commonwealth waters.

Some of these topics and areas are being addressed elsewhere. They all ultimately need to be addressed.

A major challenge facing the Audit at its inception was to access the data and information required to undertake the theme-based assessments. This resulted in one further priority area:

- information management—a crucial factor as it was the underpinning activity to all the 'theme'-based assessments.

To ensure success in sharing the data (mostly collected locally but required to be collated Australia-wide) the Audit initiated the development of data access and sharing arrangements between Commonwealth, State and Territory agencies. This culminated in the September 2001 signing of a foundation agreement for the provision of government-held spatial data for use in mapping Australia's natural resources between the member agencies of the Australian and New Zealand Land Information Council (ANZLIC—*the Spatial Information Council*) and the National Land and Water Resources Audit. After negotiating standards for data collection to achieve consistent, comparable data sets, the Audit let a number of contracts to collate and analyse data from Commonwealth, States and Territories, research organisations, and industry sources.

All Audit reports provide Australia-wide assessments, summarising data sets and analysis from multiple sources. Data management and information access systems were developed so that they were regionally relevant in information provision and to establish a system for ongoing monitoring and reporting. These are the Australian Natural Resources Atlas (Atlas) and the Australian Natural Resources Data Library.

Information from the Audit is made available on the Atlas <http://environment.gov.au/atlas> (Figure 4) at the finest scale possible within the bounds of the data that were able to be collated.

The Australian Natural Resources Data Library (Figure 5) contains the primary and derived data sets acquired and collated through the Audit process. This library <http://adl.brs.gov.au/ADLsearch/> provides a resource for those wishing to undertake further data analysis and a basis for updating these data sets. Appendix 4 summarises the content of the Australian Natural Resources Atlas and Data Library as at May, 2002.

Figure 4. Australian Natural Resources Atlas—home page.

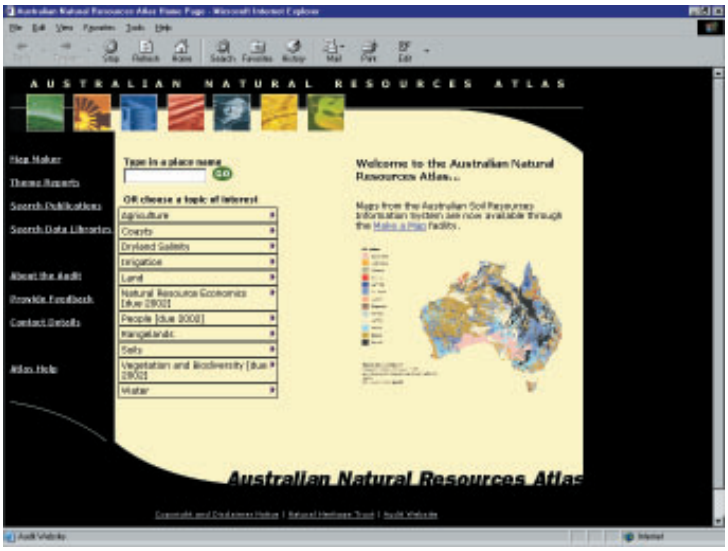
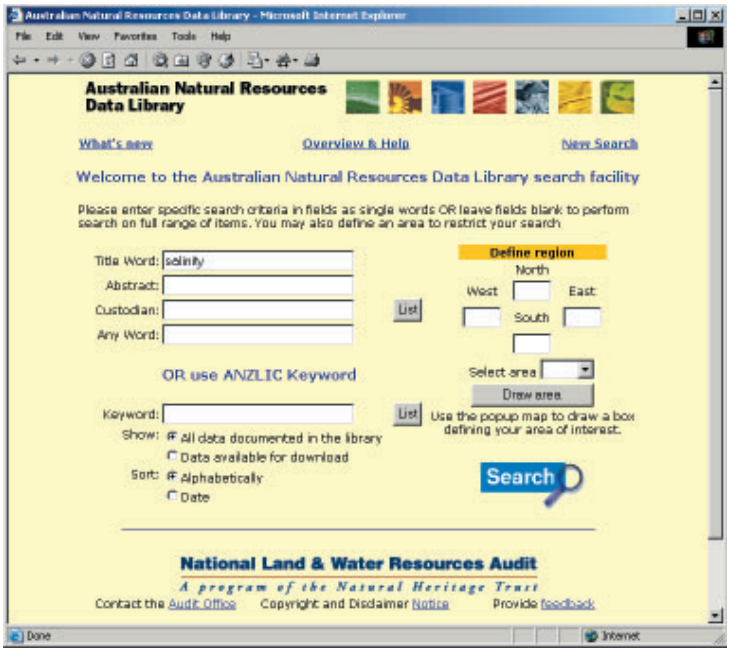


Figure 5. Australian Natural Resources Data Library—home page.



2. AUSTRALIA'S NATURAL RESOURCES TODAY

The complexities of natural resource management

Australia has a diversity of land uses (Figure 3). It must be recognised that most of the land has multiple uses, often co-existing somewhat uncomfortably with each other in terms of natural resource management. Major commodity groups are beef, sheep, grains, dairy, sugar cane, cotton, horticulture and fruit trees and rice (Figure 6).

Australians are familiar with those natural resources that they access in their daily lives:

- farmers work with soil, rainfall and sometimes irrigation-applied water from conservation sources to grow their crops;
- recreational users see the rivers as resources for fishing or waterskiing, the bird species if they are ornithologists, and often the insects if they are campers;
- pastoralists see the rangelands vegetation;
- engineers see the topography and rivers.

However, it can be difficult to appreciate the complexity and range of interactions that occur within an ecosystem and between ecosystems within a catchment or landscape. An awareness of the whole ecosystem, albeit often subliminally, is necessary in natural resource management.

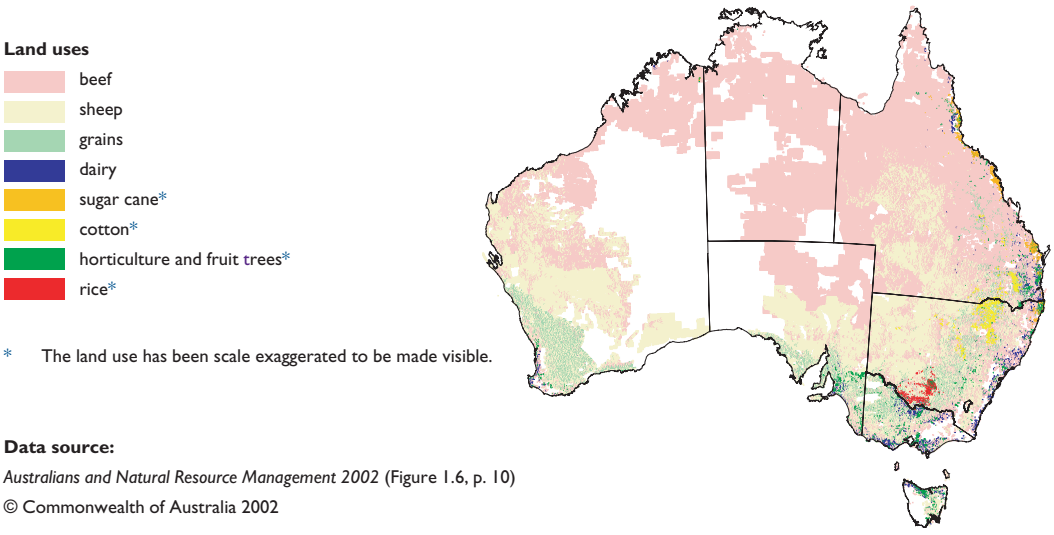
The principal resources that are affected by, and in turn affect, natural resources management decisions, either individually or in an integrated manner, are:

- land;
- water;
- biodiversity;
- air (not within the Audit remit); all together with
- the people making or affected by the decisions.

These represent a natural resources continuum.

The Audit has considered some of the biodiversity components that contribute to the ecosystems in which humans live. The Audit has

Figure 6. Agricultural commodities.



* The land use has been scale exaggerated to be made visible.

Data source:

Australians and Natural Resource Management 2002 (Figure 1.6, p. 10)

facilitated generating the National Vegetation Information System for assessing vegetation. However, consideration has yet to be given in any depth to the role of Australia's fauna, including invertebrates, in the functioning and the services provided by Australia's landscapes.

Natural resource management decision making involves trade-offs. Ultimately, decisions involving land, water and biodiversity and their impact on people are made by managers within an economic, a social and often a political framework as well as in an environmental framework.

- Governments are empowered by the electorate to make management decisions regarding the husbanding and stewardship of natural resources.
- Landholders are responsible for the husbanding and stewardship of the land they occupy.

It is inevitable that optimum decisions from one perspective will generate potentially conflicting responses in another. Natural resource management decision making involves balancing of trade-offs between environmental, economic, social and political options.

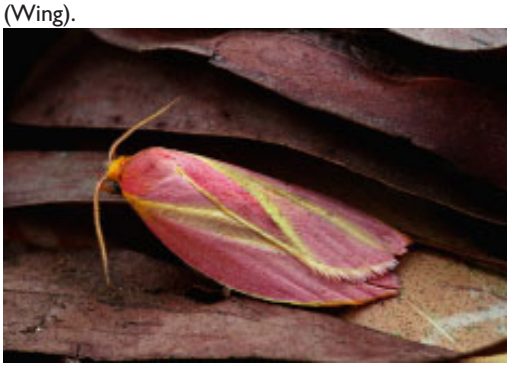
Example of the natural resources continuum

The components of the landscape influence rainfall infiltration and run-off. Run-off is influenced by surface cover (primarily vegetation) and soil structure. Soil structure is influenced by frequency of ground disturbance. Water quality is affected by the extent of run-off and soil structure leading to soil loss, riparian change and water turbidity. Turbidity and entrained nutrients impact on feed sources for river and subsequently estuarine aquatic invertebrates and fish populations. Reduced vegetation through land clearing can bring about opportunities for increased water harvesting and conservation, but can also result in increased infiltration past the plant root zone, potentially leading to rising water tables and dryland salinity. By contrast, increased vegetation cover from newly established forestry enterprises may lead to reduced rainfall run-off and reduced deep percolation, decreasing both surface and undergroundwater conservation, lowering water tables and leading to reduced surface and groundwater resources accessible for irrigation, stock and domestic use. Excess use of surface waters and groundwaters can disrupt the biological ecosystems dependent on them, leading to loss of biodiversity. The result can be the loss of ecosystem services.

Crucial invertebrate contributors to Australian ecosystems

The mallee moths (Figure 7) in the Lepidopteran subfamily *Oecophorinae* are critical to recycling of nutrients in the Australian environment, particularly in the arid areas. Containing an enormous number of species, they are adapted to a diversity of habitats, especially eucalypt forest, woodland, mallee and, in more arid areas, eucalypts growing along watercourses and on rocky outcrops. A high proportion are responsible for breaking down and recycling the nutrients in dead leaves. These leaves are generally tough and leathery, resistant to fungal decay and attacks by most invertebrates except termites, poor in nitrogen, and high in phenolic compounds including tannins.

Figure 7. Mallee moth— *Wingia lambertella* (Wing).



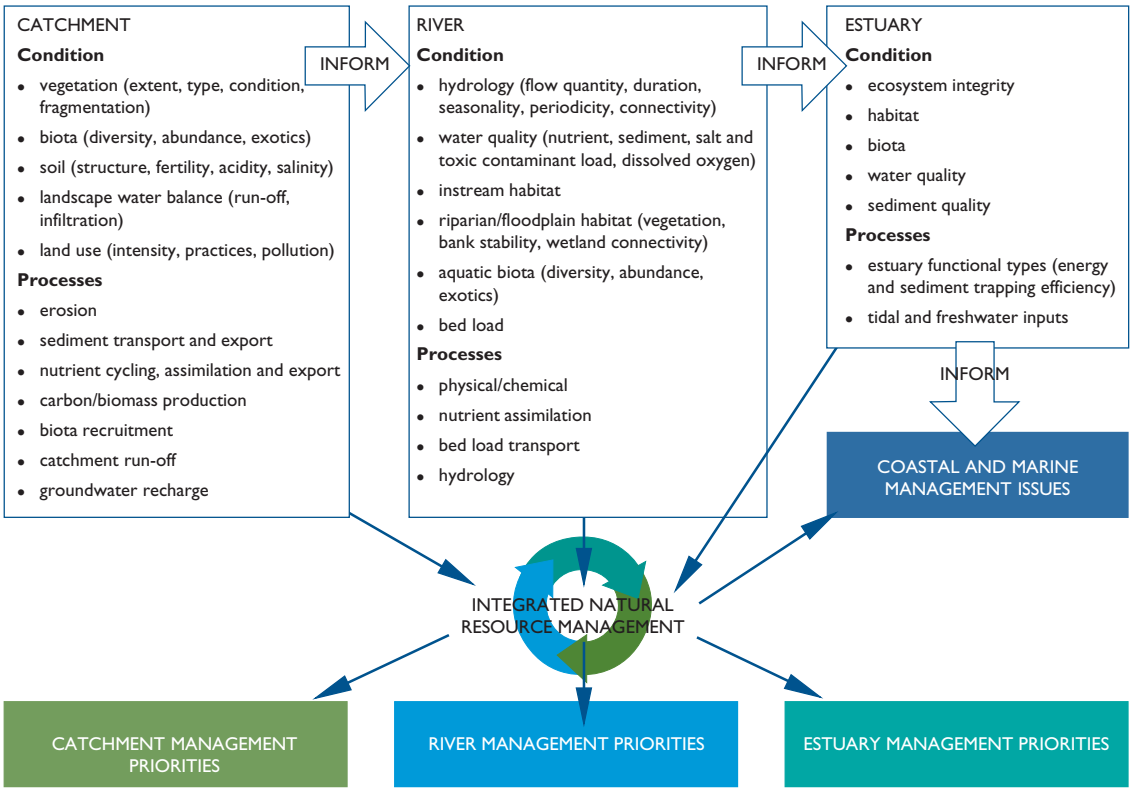
David McClenaghan, CSIRO Entomology

To understand how the components of natural resource management link together, the Audit undertook an integrated set of assessments based on understanding the links between biophysical processes and environmental impacts—in both space and time. Social and economic evaluations complete the integrated natural resources assessment approach. These integrated processes are represented below Figure 8).

Recognising the differing levels of susceptibility, varying response times and resilience in our regional landscapes, surface and groundwater, biota, and land use practice is the key to implementing appropriate management responses.

The Audit assessments have highlighted a wide range of natural resources issues and opportunities and the relative importance of each of these in differing parts of Australia. Some require immediate consideration, others such as nutrient export to waterways, may represent problems building up for the longer term. These issues and opportunities, their consequences and possible solutions, cannot usually be addressed in isolation. In most cases, they are interlinked with other natural resource management issues through feedback loops and interactions. The options for exploring and addressing these issues are developed in Chapter 3.

Figure 8. The Audit-adopted integrated system and process-based assessments.

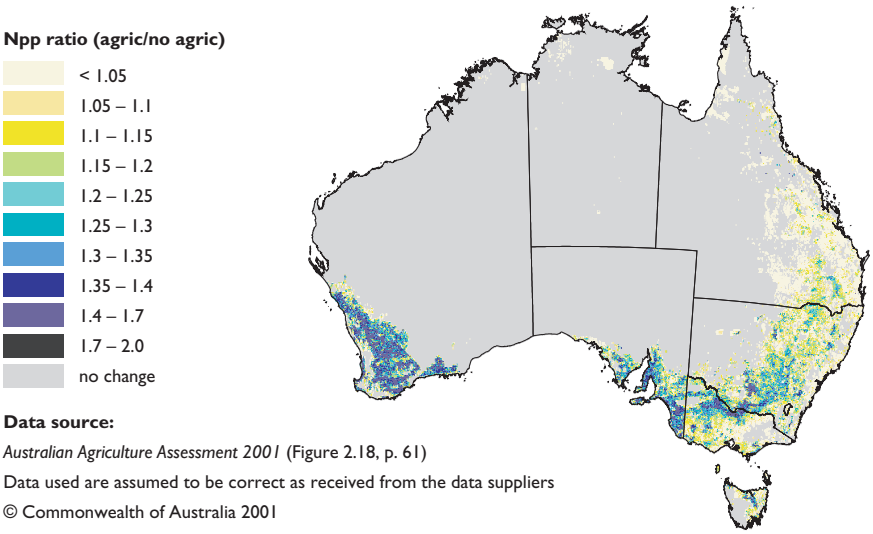


LAND

Australia's agricultural landscapes have doubled in biological productivity since European settlement.

- Agriculture in the higher rainfall, more fertile areas, primarily in the temperate coastal areas has, through addition of nutrients, use of legumes and irrigation, doubled the biological productivity of agricultural landscapes. The importance of further irrigation development, integrated farming systems and nutrient management cannot be underestimated if Australia is to increase its agricultural productivity.

Figure 9. The ratio of biological productivity under current agriculture to the pre-European landscape.



Data source:

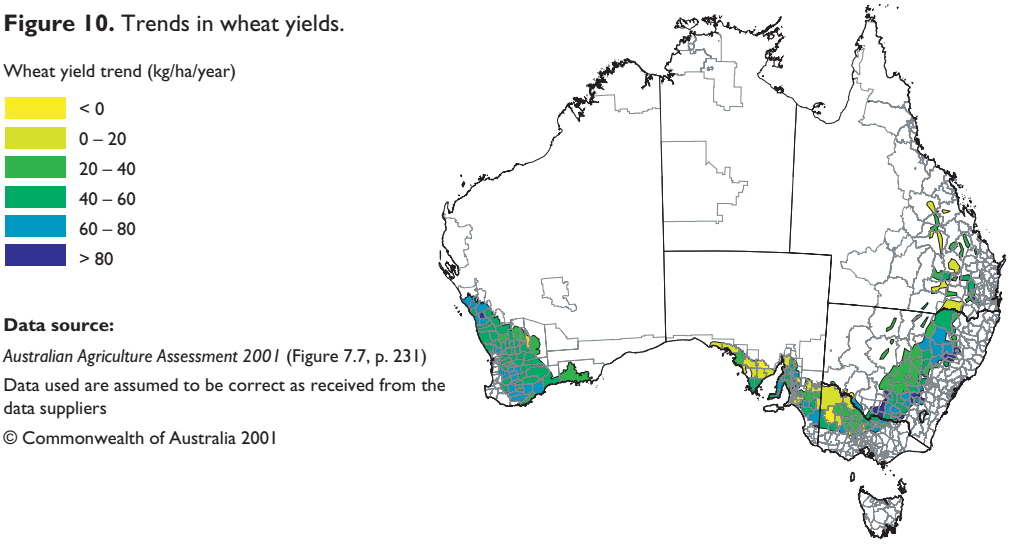
Australian Agriculture Assessment 2001 (Figure 2.18, p. 61)

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

Cropping systems have delivered substantial gains in productivity.

- Between 1982 and 1997, cereal grain yields per hectare have improved in most regions, notably where crops are diversified in regions of more reliable rainfall. Improved nutrient management, especially through the use of nitrogen-based fertilisers, has also contributed significantly.

Figure 10. Trends in wheat yields.



Data source:

Australian Agriculture Assessment 2001 (Figure 7.7, p. 231)

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

Animal husbandry and pasture management systems have also delivered increases in productivity.

- During the last 25 years the number of dairy farms has declined consistently (from around 31 000 in 1974/75 to 14 000 in 1999/2000. The size of the national dairy herd has remained reasonably constant and the volume of milk production has more than doubled since 1980/81. Markets for product have also changed (e.g. a markedly increased proportion of milk produced now goes to manufacturing).

Figure 11. Trends in milk production, cow and farm numbers.

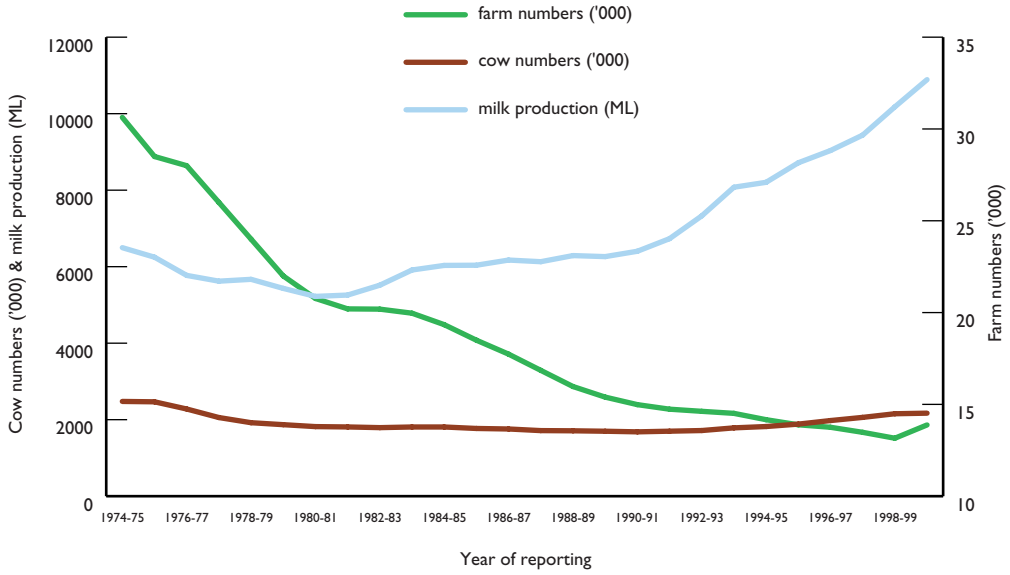
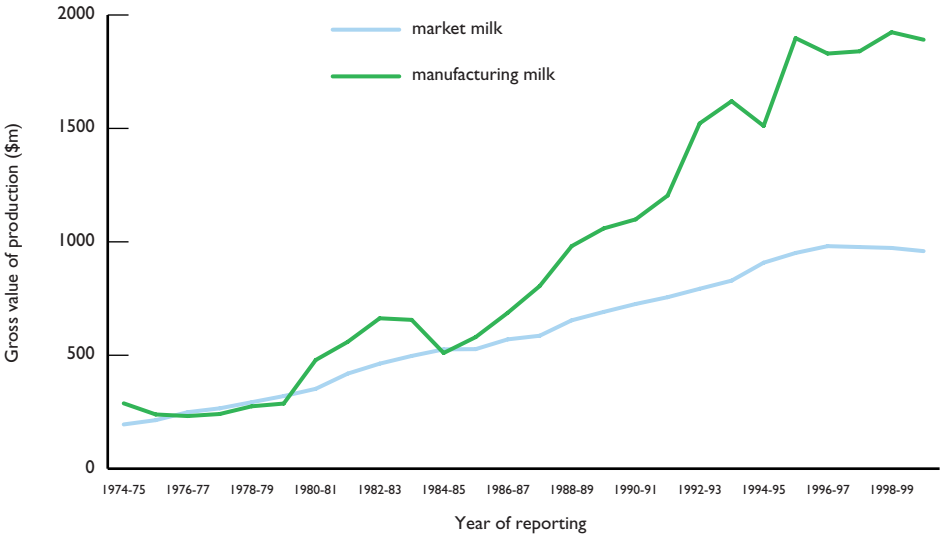


Figure 12. Trends in milk production in Australia (1974–1999).



Agriculture remains a significant component of the Australian economy.

- Australian agriculture has a reputation for technical efficiency by international standards, 70% of the produce is exported and is extremely important to regional economies. A policy challenge will be to ensure it is increasingly based and be seen to be based on producing high quality commodities through the adoption of sustainable production systems that do not degrade the country's natural resource base. A good example is the continuous improvement in cotton industry practices to meet industry best practice standards.

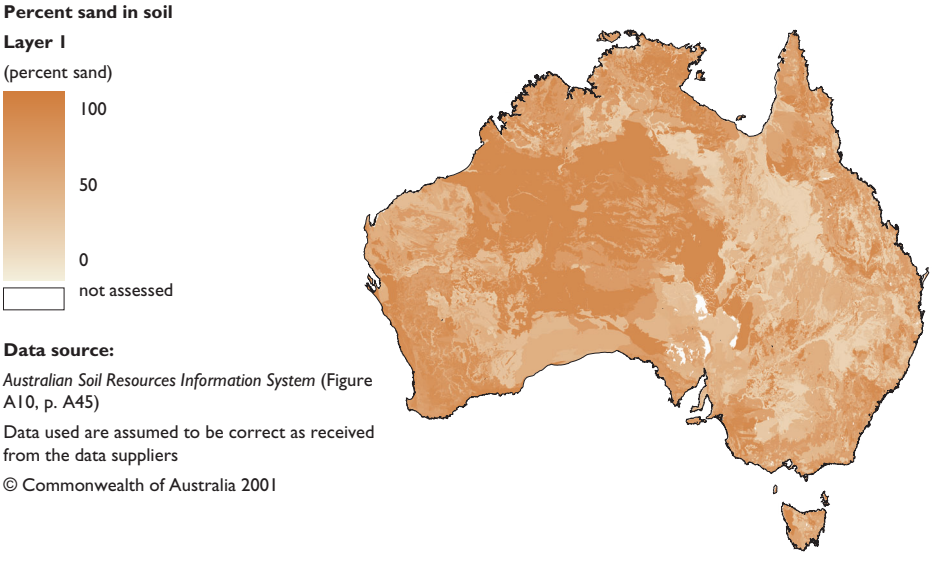
Table 1. Level of adoption (%) of the industry's best management practice manual by regional cotton growers.

Audit stage	Australia total	Northern Region	Central Border Region	Southern Inland Region
Number of growers	1280	112	1006	162
No progress/don't know (%)	17	46	13	19
Progressing (%)	57	37	60	53
Audit ready (%)	12	12	11	16
Audited (%)	11	5	17	12
Best Management Practices Manual (2nd ed) (%)	70	54	79	26

Australia's soils are variable, but we now have much of the spatial information for their management.

- Through the partnerships developed by the Audit, Australia's soil scientists have worked together to develop the Australian Soil Resource Information System. The compilation includes those soil attributes most commonly required to characterise, model or predict land resource processes that drive plant productivity, measure resource sustainability or control the rate of resource degradation.

Figure 13. Australian Soil Resources Information System.



Data source:

Australian Soil Resources Information System (Figure A10, p. A45)

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

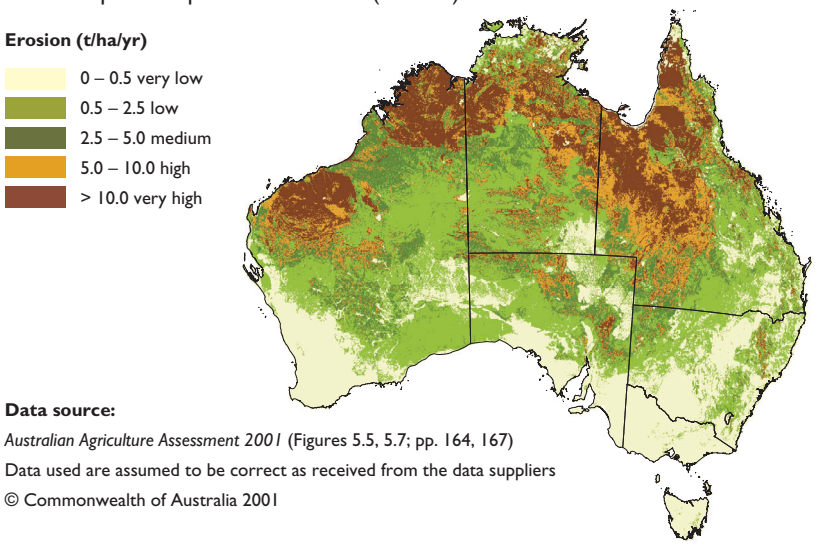
Soil erosion is still occurring.

- The types of erosion (Figure 19) and consequent management strategies vary in relative importance in differing parts of Australia (Figure 18).

Hillslope or sheetwash and rill erosion are dominant in tropical northern Australia.

- Factors contributing to erosion rates include rainfall erosivity, vegetation cover, slope length and gradient and soil erodibility. Grazing is the main land use contributing to hillslope erosion and the key localities for improved management have been determined through the Audit's analysis. The greatest scope for reducing soil loss is through improved pasture and stock management aimed at maintaining adequate ground cover at all times, (including drought planning, off-stream watering, cell grazing and management of pasture species). These issues are of greatest importance in the northern Queensland grazing lands where the greatest increases in river, suspended sediment loads have occurred and where sediment delivery to the coast is more likely.

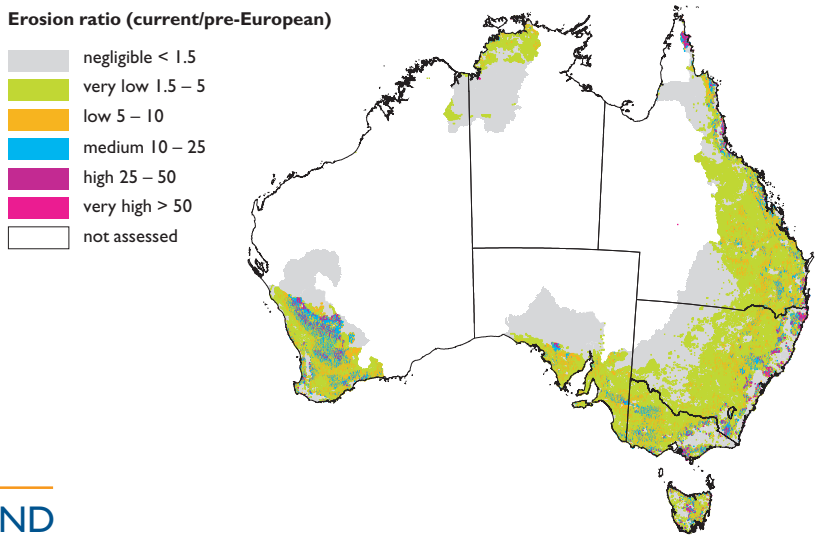
Figure 14. Current mean annual sheetwash and rill erosion rate (T/ha/year) (top) and present rate: modelled pre-European erosion ratio (bottom).

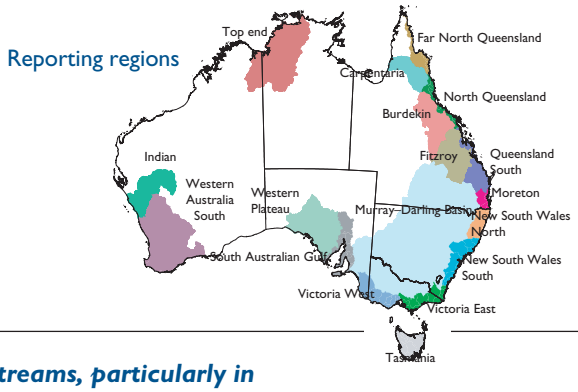


Data source:

Australian Agriculture Assessment 2001 (Figures 5.5, 5.7; pp. 164, 167)

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





Gully erosion is a significant source of sediment delivered to streams, particularly in southern Australia.

- Remedial works should focus on those gullies that continue to erode and either threaten structures or yield considerable amounts of sediment. Areas to target across Australia—under programs such as Landcare—are those with high levels of gully erosion (e.g. parts of the Burdekin and Fitzroy, much of the highlands and slopes of the Murray–Darling Basin and parts of the New South Wales north and south coasts). Low to moderate but extensive gully erosion occurs in south-west Western Australia. This is a significant erosion process for the region considering the estimated low natural rates of erosion.

Figure 15. Area of moderate and high gully density in river basin regions.

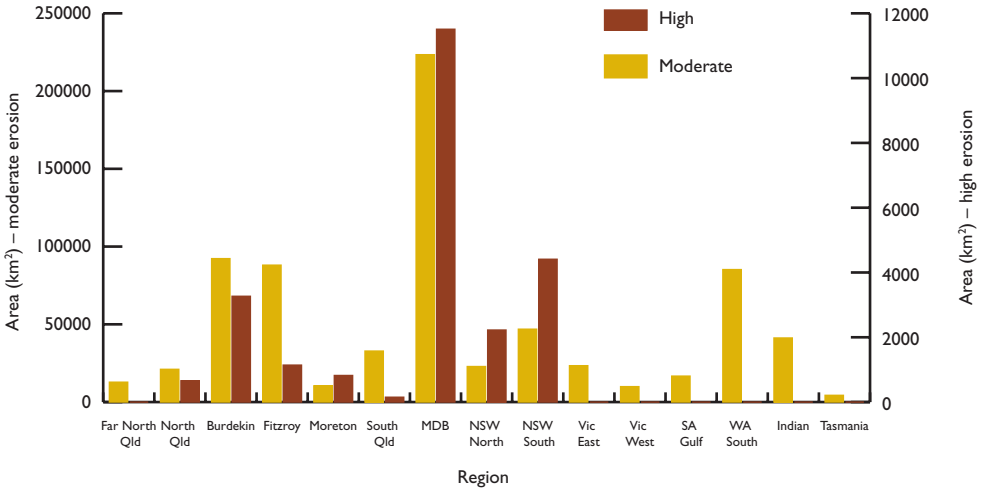
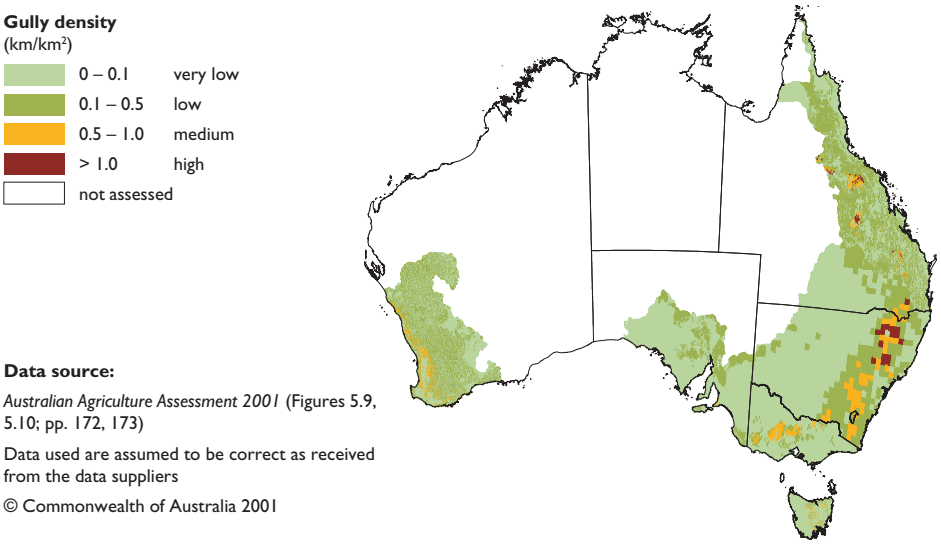


Figure 16. Area of moderate and high gully density in river basins containing intensive agriculture.



Data source:

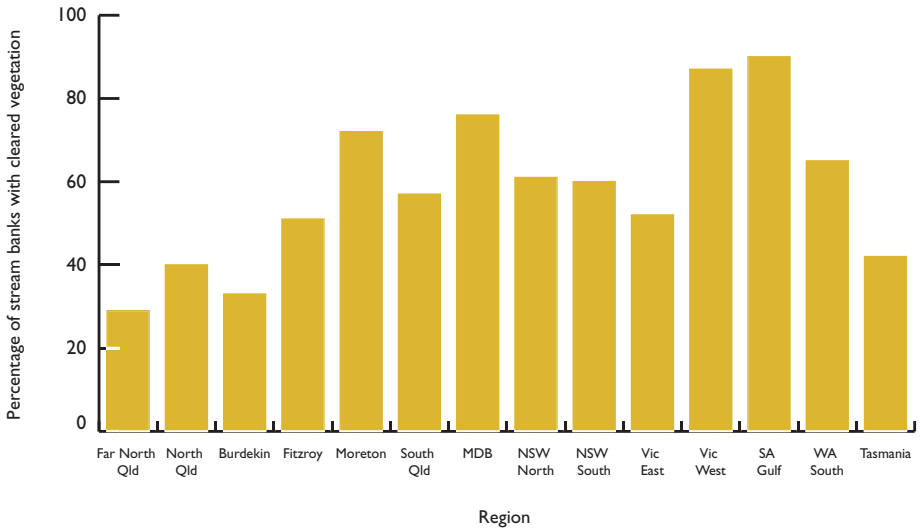
Australian Agriculture Assessment 2001 (Figures 5.9, 5.10; pp. 172, 173)

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

Riverbank erosion is widespread in agricultural landscapes.

- Sixty-five percent or about 120 000 km of the river length assessed is cleared of riparian vegetation. At a conservative cost of $10 000 per kilometre for fencing and replanting, rehabilitation would cost about $1.2 billion. This high cost of repair demonstrates the imperative for encouraging conservation in those areas where riparian vegetation is relatively intact (e.g. by encouraging best practice) and, if necessary, backed up by planning controls. For that component of funds under Rivercare allocated to repair rather than protection, this analysis provides estimates of the relative proportions that might need to be invested in each region.

Figure 17. Estimated proportion of native vegetation removed along stream banks in river basins.



Data source:

Australian Agriculture Assessment 2001 (Figure 5.11, p. 175)

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

The source of sediment delivered to streams varies across Australia.

- Allocations for soil erosion control works under the National Action Plan need to be responsive to the varied sources of stream sediments. They will vary in relative proportions for differing regions:
  - in far North and North Queensland, much of the available resources would be most effectively allocated to minimise hillslope erosion;
  - in Tasmania the majority of works to minimise sediment delivery to streams would be most effectively directed to riparian area re-vegetation.

Figure 18. Reporting regions for erosion and sediment transport assessment.

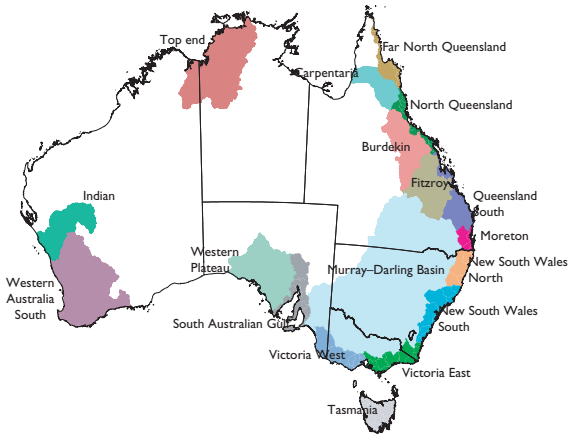
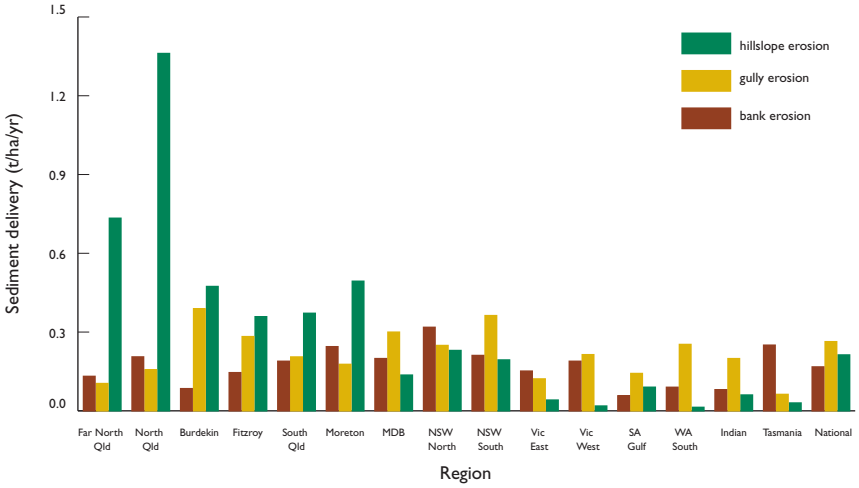


Figure 19. Estimated amounts of sediment supplied to streams by each erosion process.



Data source:

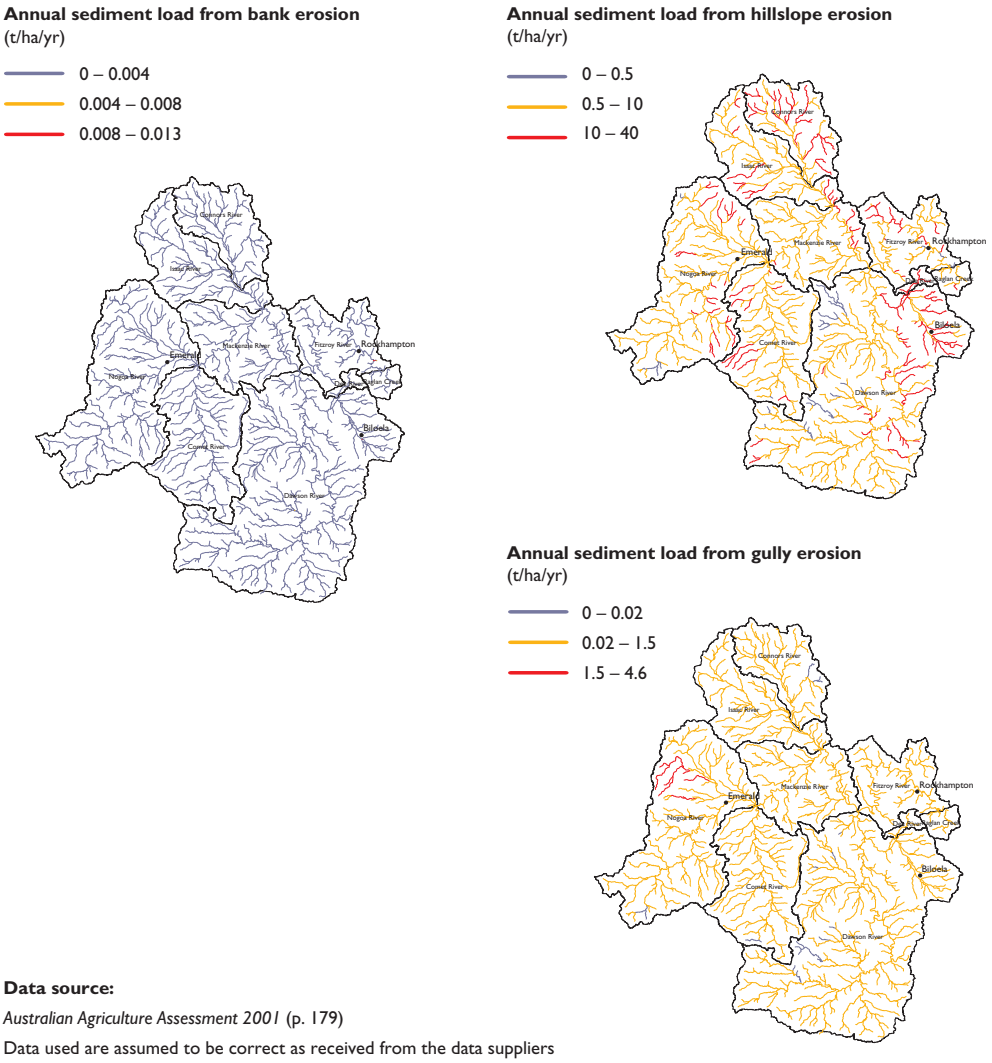
Australian Agriculture Assessment 2001 (Figure 5.12, p. 176)

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

Soil erosion varies in locality and type within any basin.

- On average across agricultural Australia 90% of the erosion comes from 20% of the area. The mix of soil erosion types also varies within each basin. The Audit assessments need to be used at a basin scale as well as within the broader regional context to determine priorities for works and activities and to set targets (e.g. the relative importance in all subcatchments of bank, hillslope and gully erosion can be determined using information from Figure 20).

Figure 20. Sediment sources in the Fitzroy basin, Queensland. Bank erosion loss is relatively low, there is moderate loss from gully erosion, but there are some areas of high sediment load from hillslope erosion, particularly near the coast.



Data source:

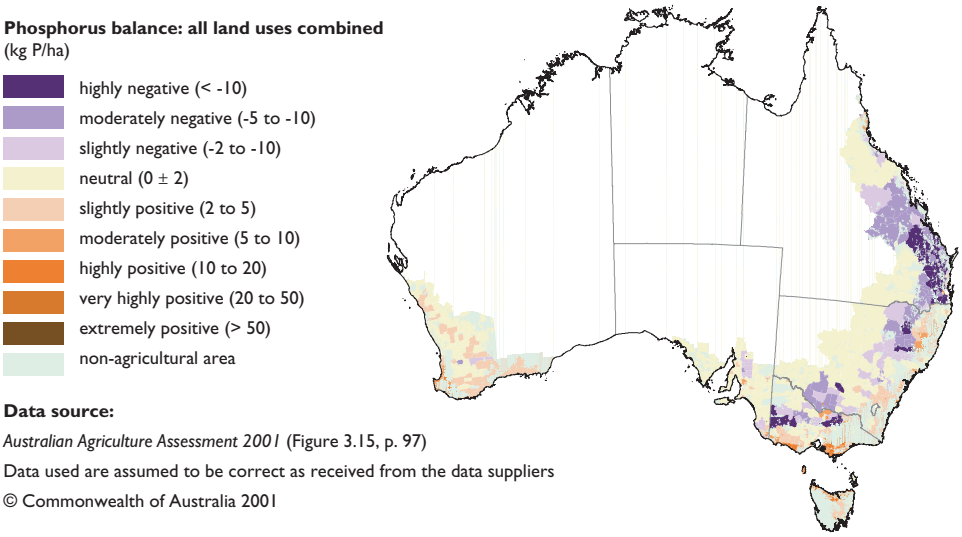
Australian Agriculture Assessment 2001 (p. 179)

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

Nutrients are being lost as a result of some agricultural practices.

- Nearly 19 000 tons of phosphorus and 141 000 tons of nitrogen are travelling down Australia's rivers to the estuaries and, in some cases, to near-shore marine environments each year. Yet, much of the land is in negative nutrient balance, with inputs less than exports (Figure 21).
- Significant excesses or positive balances in some areas, suggest potential over-investment in phosphatic fertilisers.

Figure 21. Farm-gate phosphorus balance (kg P/ha) with all land use combined (averaged 1992–96) over the intensive land use zone.

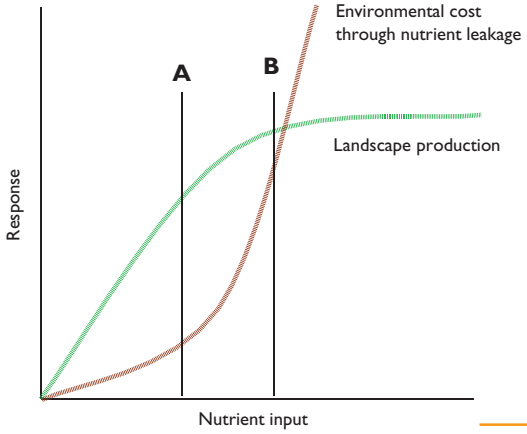


Data source:
Australian Agriculture Assessment 2001 (Figure 3.15, p. 97)
Data used are assumed to be correct as received from the data suppliers

Partnerships with agribusiness provide the key to better nutrient management on-farm.

- The analysis across all key nutrients was based on on-farm soil testing linked to an understanding of soil properties and production rates. This analysis has demonstrated that Australian agriculture needs to closely examine and finetune fertiliser use and become more skilled in managing legume regimes to achieve optimum plant productivity. These could both reduce input costs and minimise negative impacts to rivers and estuaries (Figure 22).

Figure 22. Conceptual responses of landscape production and environmental cost to nutrient inputs.

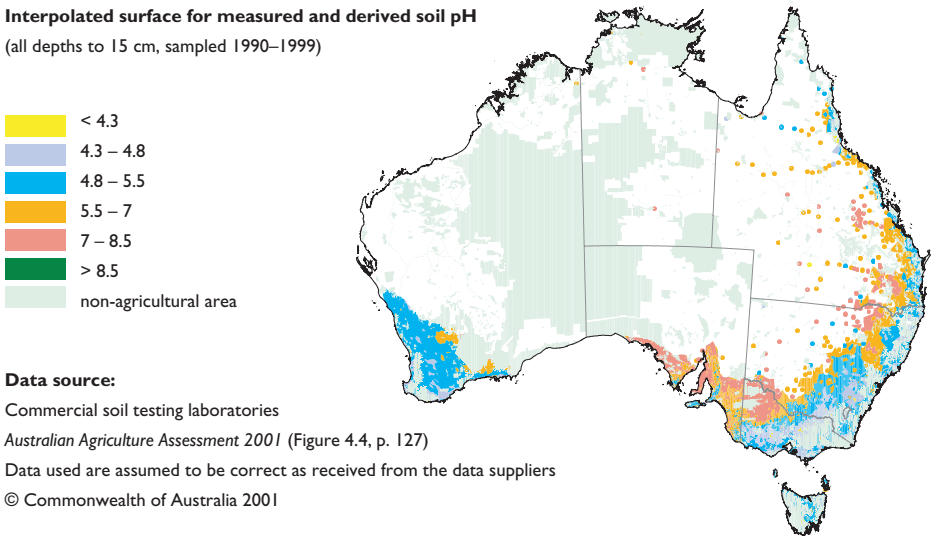


Data source:
Australian Agriculture Assessment 2001 (Figure 2.31, p. 75)
Data used are assumed to be correct as received from the data suppliers

Attention to soil management practices to minimise soil acidity needs to be coupled with nutrient management.

- In the more intensive agricultural areas, the use of nitrogen-fixing legumes and nitrogenous fertilisers have become common. This has improved soil fertility and plant productivity. Excess soil nitrogen can lead to soil acidification. This looms as a significant soil degradation issue, already affecting up to 25 million hectares, with more to come. By working with agribusiness and its on-farm soil testing activities we will be able to track progress in addressing this issue.

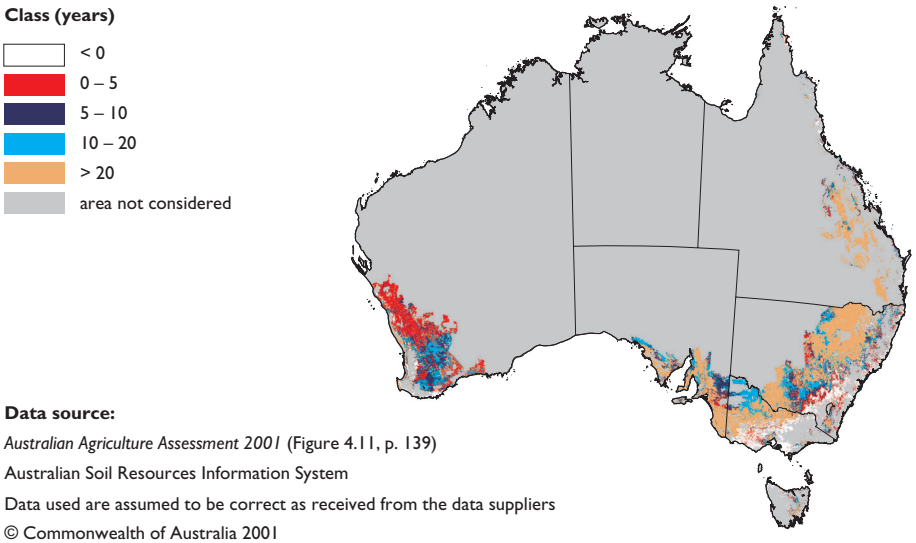
Figure 23. Topsoil pH showing the interpolated surface for measured and derived soil pH (measured in 0.1M $CaC1_2$) based on the collation of soil data obtained from agribusiness records of on-farm soil testing.



Australia can now set targets for action on soil acidity.

- Information on soil properties detailed in the Australian Soil Resources Information System and land use mapping were used to identify the levels of lime required across agricultural Australia to mitigate against the acidifying effects of current farming systems. These targets will assist agribusiness and farmers in their soil management activities (e.g. approximately 12 and 66 million tonnes of lime are required to adjust existing acidic soils to a typical agricultural production pH of 4.8 and 5.5 respectively). Maintaining soil pH values at 4.8 and 5.5 requires ranges of 0.6 – 3.1 million tonnes and 2.4 – 12.3 million tonnes of lime each year respectively. These estimates for lime application are based on the data for estimated years to reach soil pH* 4.8 at minimum rates of acidification (Figure 24) and a companion data set estimating maximum rates of acidification.

Figure 24. Modelled estimated years for Australia's agricultural soils (pH > 4.8) to reach pH 4.8 at minimum rates of acidity development, and in the absence of lime applications.



Data source:

Australian Agriculture Assessment 2001 (Figure 4.11, p. 139)

Australian Soil Resources Information System

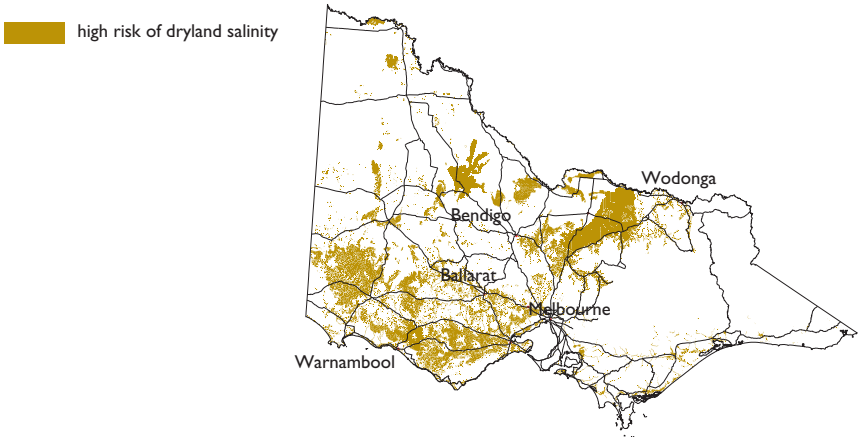
Data used are assumed to be correct as received from the data suppliers

* Soil pH measured in 0.1M $CaCl_2$

Salinity will continue to degrade rural and urban landscapes.

- Changes in water balances following tree clearing and loss of perennial grasses, loss of vigour in the remaining and substitute vegetation, and changes in rainfall patterns have all served to increase the amount of water entering watertables. This has raised groundwater levels and brought salt into the plant root zone. Modelling and mapping has determined the location and extent, at approximately 5.7 million hectares of Australia currently at risk of dryland salinity. Predictive modelling suggests that in fifty years time the at-risk area could increase to 17 million hectares. The condition of habitats is declining as a result of increasing pressures of salinity and changes in hydrological regimes. The risk in Victoria is shown below as an example. With this information natural resource managers can target their works, activities and protective measures as part of the National Action Plan for Salinity and Water Quality.

Figure 25. There is a considerable risk of increased salinity in parts of Australia over the next 50 years, as shown in the shaded areas forecast for Victoria.



Data source:

Australian Dryland Salinity Assessment 2000 (Figure 6, p. 23)

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

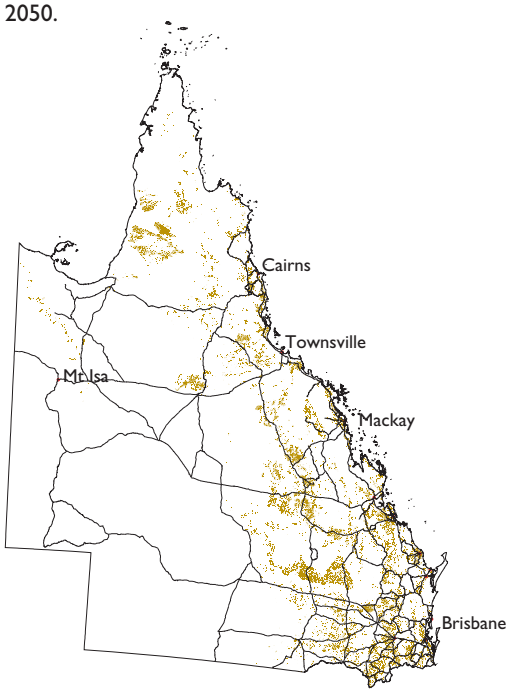
Northern Australia presents opportunities to avoid the dryland salinity problems of temperate Australia.

- Hazard assessment has confirmed that large areas of the tropics and subtropics, particularly in Queensland, have a significant potential salinity problem if changes in water balance occur through clearing. Vegetation management policies to retain native vegetation could ensure that salinity does not develop and are a cost-effective way to minimise the onset of salinity. Queensland agencies are building on this assessment at a finer scale to determine the most appropriate management responses and key areas for protective management of water balance.

Figure 26. Dryland salinity hazard in Queensland 2050.

high risk of dryland salinity

Estimates of projected dryland salinity hazard in 2050 were based on a map overlay analysis using attributes that drive salinisation such as 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 Condamine–Balonne and Border Rivers catchments of the Murray–Darling Basin. The estimate of area affected (48 000 ha) by dryland salinity was based on field observation in the early 1990s, and workshop-based consultations. Information has been prepared at a scale of 1:2 500 000.



Data source:

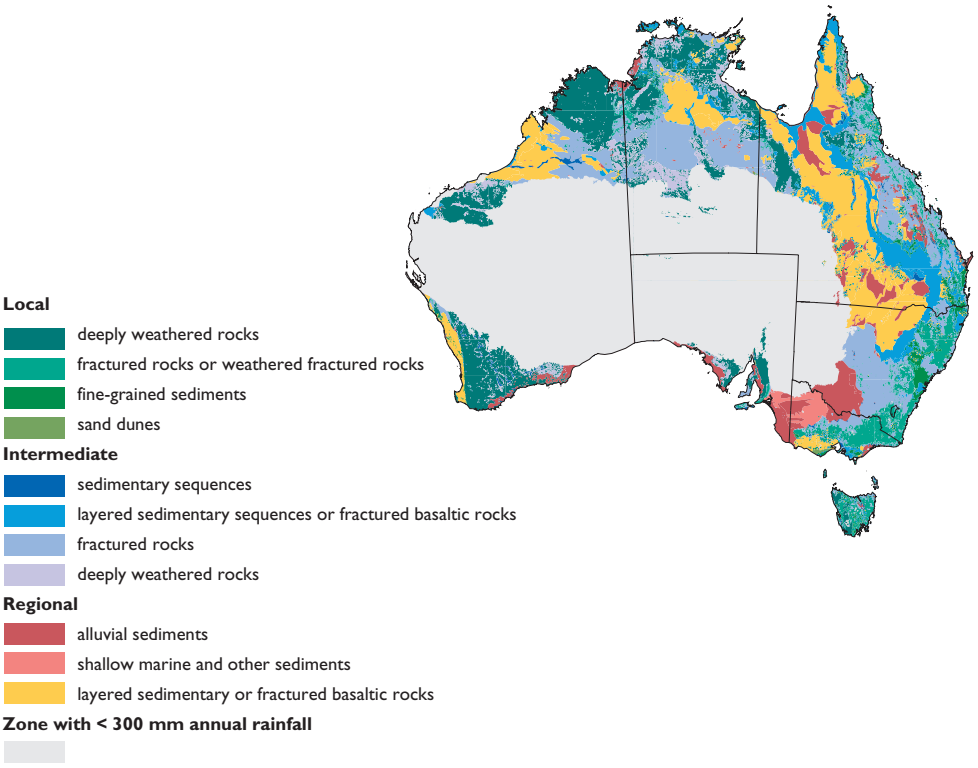
Australian Dryland Salinity Assessment 2000 (Figure 7, p. 28)

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

The mapping of groundwater flow systems provides a basis for defining effective management options and tracking progress.

- The responsiveness of groundwater systems to change will dictate what can be effectively achieved within reasonable time frames through groundwater recharge and discharge management which involves minimising the amount of rainfall that drains past the root zone of the vegetation into the groundwater (thereby recharging groundwater levels) while learning to manage any areas where groundwater is being discharged from the soil surface. Options for recharge management, engineering watertable management and use of saline resources have been defined for each of Australia's 12 groundwater flow systems and provide a basis for more intensive local scale mapping. This understanding of hydrogeology, salt and water balance provides a basis for monitoring the activities funded under the National Action Plan for Salinity and Water Quality.

Figure 27. Distribution of groundwater flow systems across Australia.



Data source:

Australian Dryland Salinity Assessment 2000 (Figure 17, p. 49)

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

Increasing salinity presents a risk to public infrastructure.

- By understanding the current extent of salinity and its likely extent in 2050, we can implement strategic approaches to minimise the impact on infrastructure. Estimates suggest up to 67 400 km of road, 5 100 km of railway, 41 300 km of streams, two million hectares of native vegetation and the infrastructure of 200 towns could be at risk over the next 50 years. Public costs from the effects on railways, roads and towns could approach $500 million annually over the next 20 years. Planning and implementing works in priority areas will reduce the risk of incurring these costs.

Table 2. Summary of Australian assets at risk from shallow water tables or high salinity hazard.

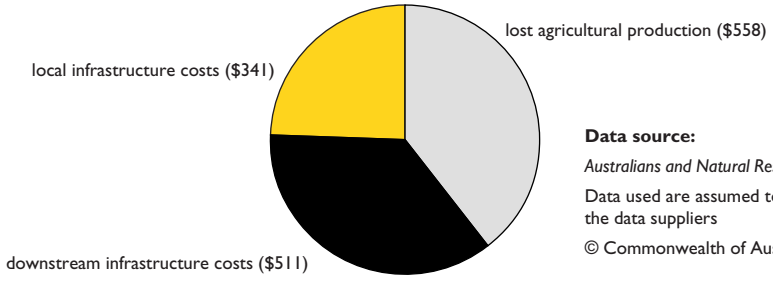
Asset	2000	2050
Agricultural land (ha)*, 1	4 650 000	13 660 000
Remnant and planted perennial vegetation (ha)*, 2, 5	631 000	2 020 000
Lengths of streams & lake perimeters (km)*, 2	11 800	41 300
Railway (km)2	1 600	5 100
Roads (km)2	19 900	67 400
Towns (number)3	68	219
Important wetlands (number)*, 1, 4	80	130

* uncosted effects
1 data from all States, Queensland only for 2050
2 data from Western Australia, South Australia, Victoria and New South Wales (Queensland only for 2050)
3 data from Western Australia, South Australia, Victoria and New South Wales
4 including Ramsar wetlands
5 much of the remnant and perennial vegetation reported for each State occurs on agricultural lands

Salinity management activities will deliver benefits both on and off farm.

- The Audit's assessment of current salinity extent and future salinity hazard coupled with its assessment of the value of infrastructure at risk and the current and future cost to production on-farm provides a basis for determining the relative levels of benefit that are likely to be achieved through investment under the National Action Plan for Salinity and Water Quality.

Figure 28. Present values of increases in dryland salinity induced costs from 2000 to 2020, determined at a 5% discount rate.

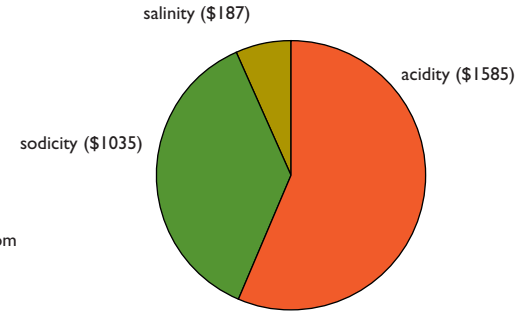


Data source:
Australians and Natural Resource Management 2002
Data used are assumed to be correct as received from the data suppliers

Soil acidity is Australia's major on-farm soil management and productivity issue.

- Dryland salinity is a significant source of degradation in many areas. However, from an Australia-wide perspective, the economic impact of soil acidity on-farm is five to six times greater than that of dryland salinity. Based on yield gap calculations, a gross benefit of $1.5 billion, equivalent to 24% of profit at full equity, could be secured by addressing acidity. By comparison, salinity results in losses of $200 million on-farm (3% profit at full equity), and is not always treatable. Sodicity, an inherent soil characteristic, was also included in the Audit assessments to demonstrate the relative biophysical limitations to agricultural productivity.

Figure 29. Estimated national gross benefits (additional agricultural profit) attainable from treatment of soil acidity, soil salinity and soil sodicity ($m).



Data source:

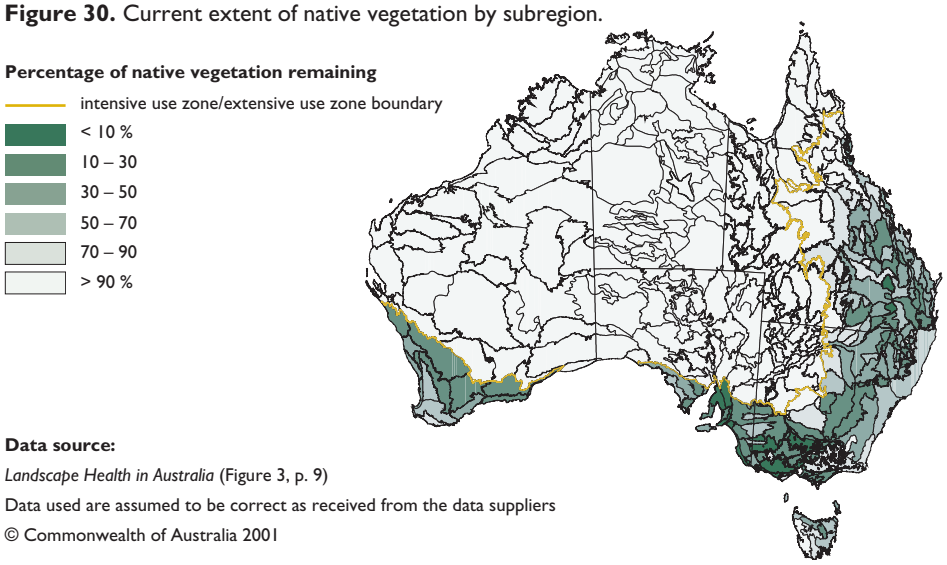
Australians and Natural Resource Management 2002

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

Australia's rangelands provide opportunities for protective management.

- Relatively little clearing has occurred in Australia's rangelands—constituting approximately 75% of the country's land area. Protective management to maintain biodiversity values is likely to be cost-effective in these comparatively intact areas of native vegetation.

Figure 30. Current extent of native vegetation by subregion.



Data source:

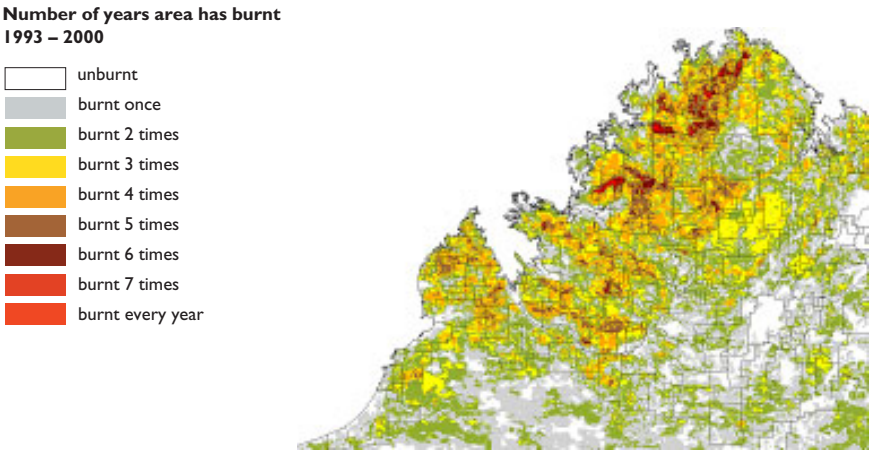
Landscape Health in Australia (Figure 3, p. 9)

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

Fire is a tool and an imperative for improved management of Australia's rangelands.

- Determining and then applying appropriate fire regimes within a multi-objective context to Australia's rangelands is a major challenge.

Figure 31. Remotely sensed image showing fire frequency in the Kimberley.



Data source:

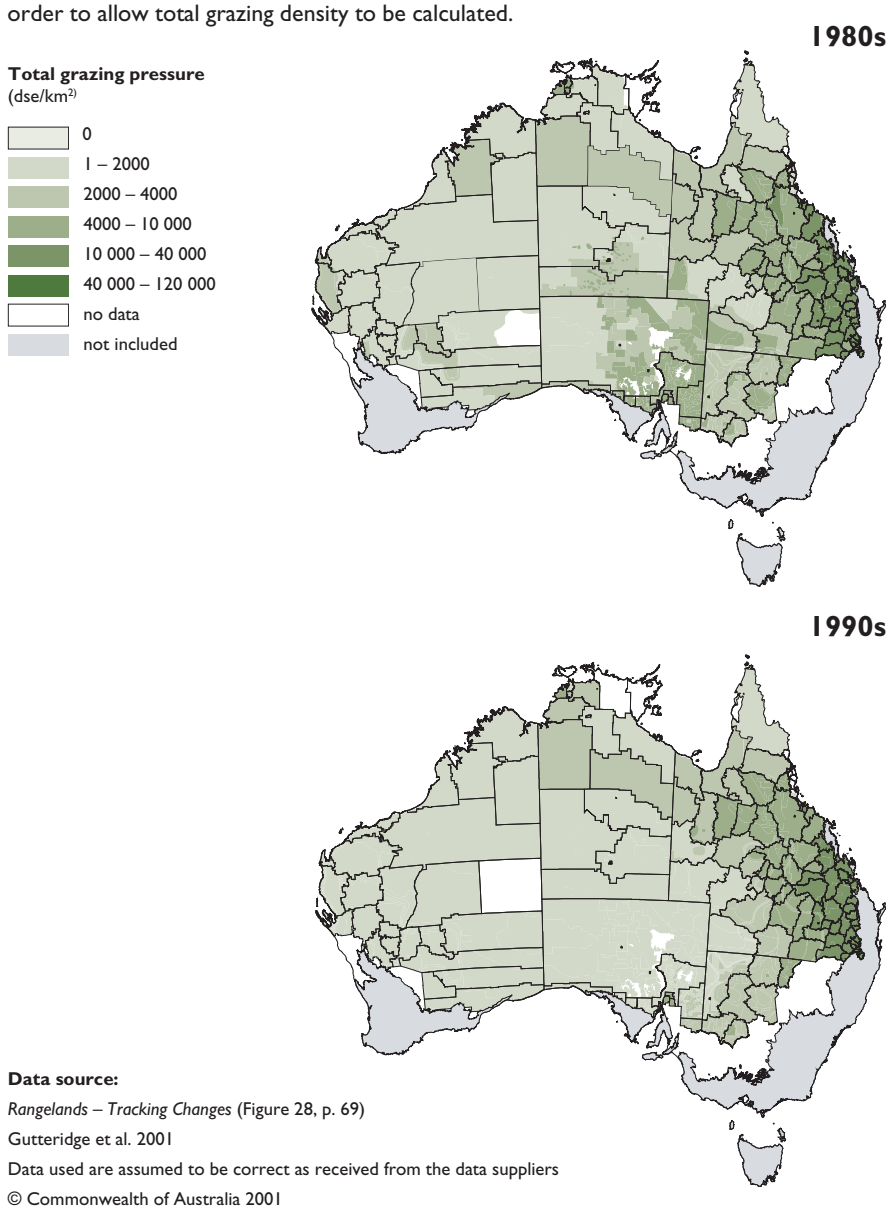
Rangelands – Tracking Changes (Figure 36, p. 82)

Western Australian Department of Land Administration

Understanding total grazing density is part of the information needed for managing Australia's rangelands.

- Total grazing density is relatively low and variable across Australia's rangelands. Land condition is improving particularly with reductions in rabbit populations following the spread of calicivirus.

Figure 32. Grazing density (sheep + cattle + kangaroos + goats + rabbits) in the rangelands. 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.



Data source:

Rangelands – Tracking Changes (Figure 28, p. 69)

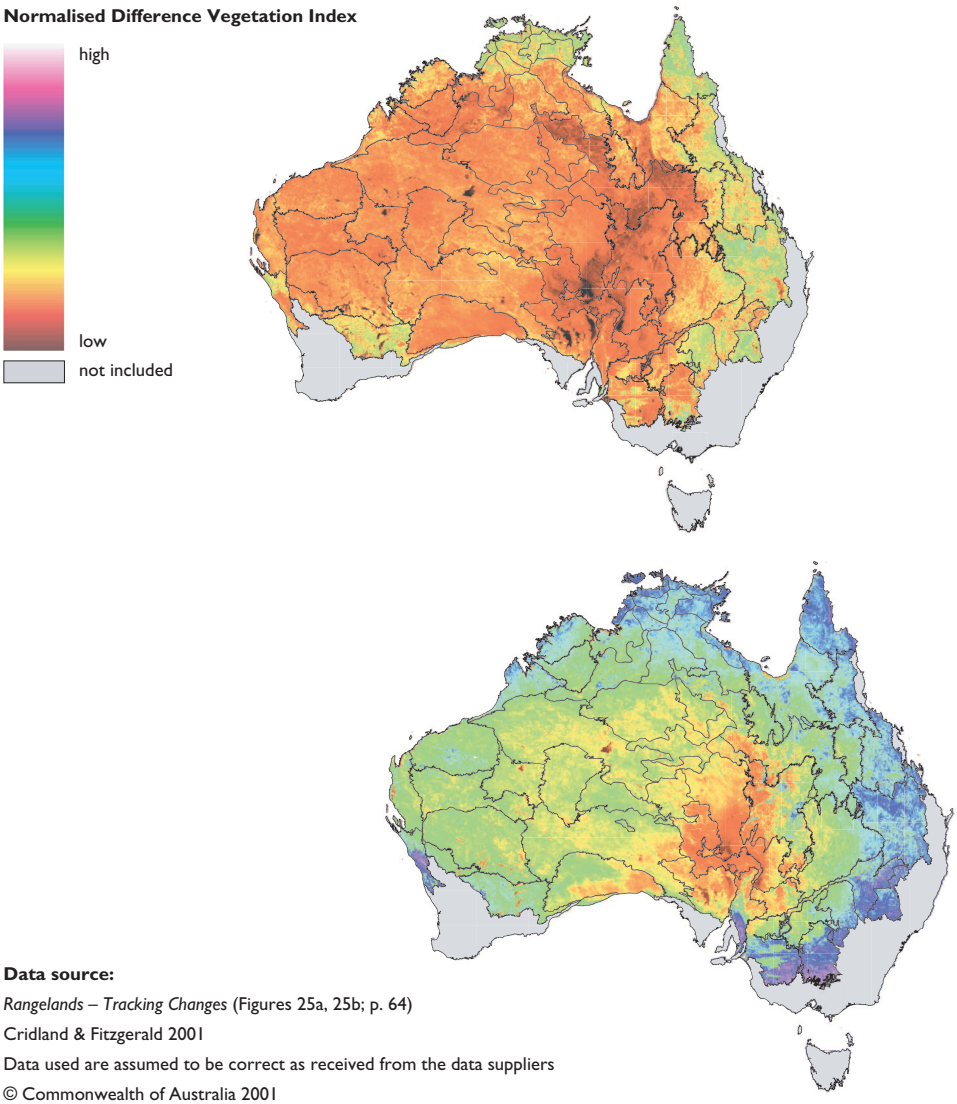
Gutteridge et al. 2001

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

Predictive and protective management is essential for Australia's rangelands.

- Because of the vast areas and low value per hectare, degradation is potentially much more difficult to reverse in Australia's rangelands. Management should be strongly oriented to minimise any degradation impacts. Working within an understanding of climate variability is a particularly important aspect of decision making (e.g. a wide variation in the feed quantity and vigour can be available in two overlapping twelve-month periods across Australia's rangelands as estimated by the normalised difference vegetation index [Figure 33]).

Figure 33. Minimum greenness (June 1999 to July 2000; top) and maximum greenness (January 2000 to December 2000; bottom) as estimated by the Normalised Difference Vegetation Index.



Data source:

Rangelands – Tracking Changes (Figures 25a, 25b; p. 64)

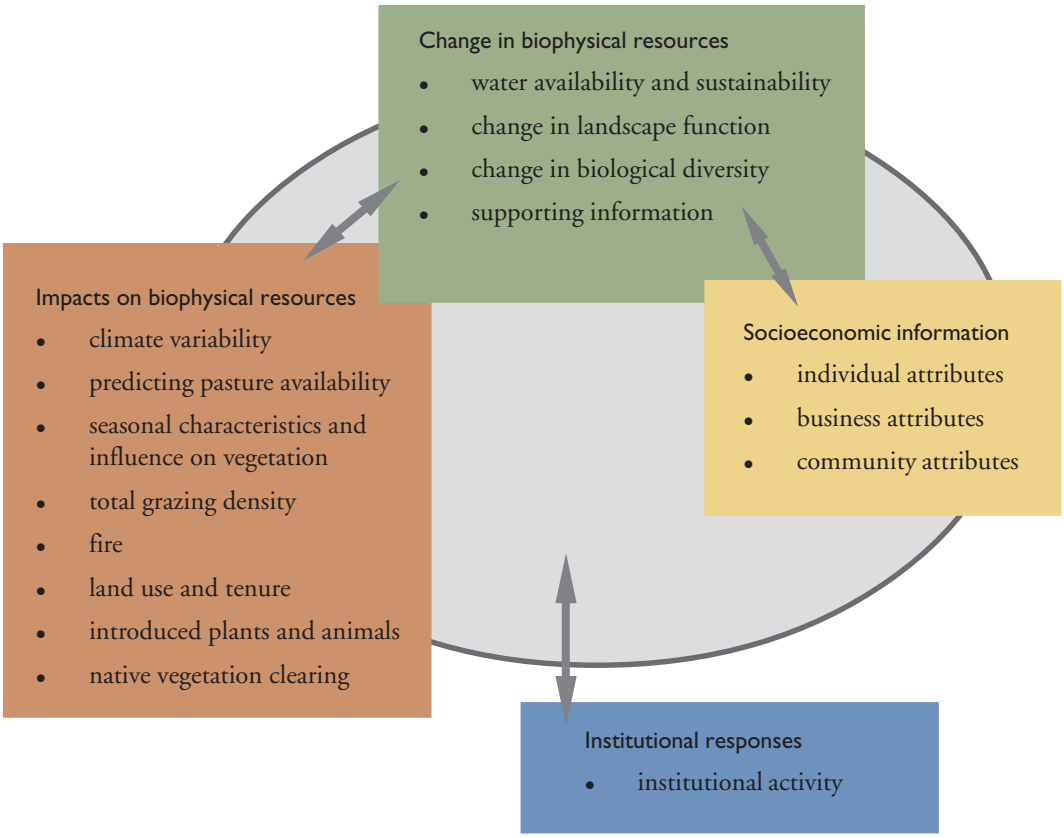
Cridland & Fitzgerald 2001

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

Management of Australia's rangelands can be improved through coordinated approaches.

- Current monitoring is largely oriented to the 'pastoral estate' and prior to Audit activities was uncoordinated between the States and Northern Territory. Improved information capabilities based on Australia-wide coordinated and standardised data sets with broader environmental parameters would be of advantage to management decision making, particularly from a multiple-use perspective.

Figure 34. Components of a comprehensive rangeland monitoring system and associated information products.



WATER

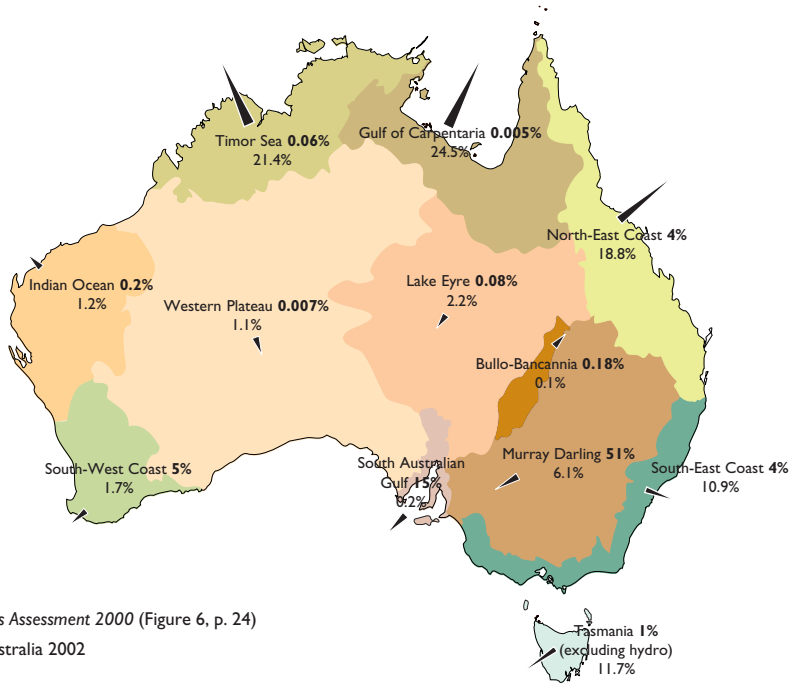
Only 12% of Australia's rainfall runs off to collect in its rivers.

- Of the water collected in Australian rivers, nearly half runs off into the Timor Sea and Gulf of Carpentaria from the adjacent drainage divisions.

There is a net utilisation of about 20% of the potentially divertible water resources in Australia.

- The mean figure for water use (20%) masks the great variation in the distribution of use. Some areas of the country such as the northern coastline have little use of divertible water resources. Other areas have significant use, notably the Murray–Darling Basin where provision of adequate water for the environment has become an important policy issue.

Figure 35. Percent of total Australian run-off from each drainage division. Bold percentages after each division caption represent proportion from division diverted for use.



Data source:

Australian Water Resources Assessment 2000 (Figure 6, p. 24)

Australia's mean annual water use in 1996/97 was about 19 000 GL of surface water and 5000 GL of groundwater.

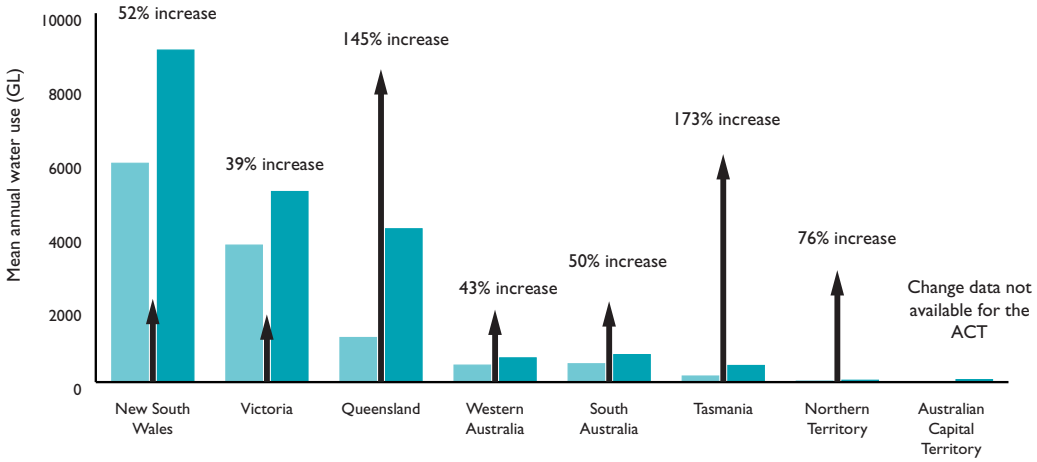
- The area irrigated since the 1980s increased by approximately a 26%. This increase underlies much of Australia's increased agricultural production.

Table 3. Total area ('000 ha) of commodity groups in Australia that were irrigated in 1983/84 and 1996/97.

Commodity group	1983/84	1996/97	Increase ('000 ha)	Increase (%)
Pastures	871	935	64	7.3
Cereals	315	337	22	6.9
Vegetables	76	87	11	14.5
Fruit	97	151	54	55.7
Other crops*	260	544	284	109.2
Total	1625	2056	431	26.5

* 'Other crops' are made up mainly of cotton, sugar cane and soybean

Figure 36. Change in mean annual surface water use (GL) between 1983/84 and 1996/97 largely attributable to increase in irrigation.



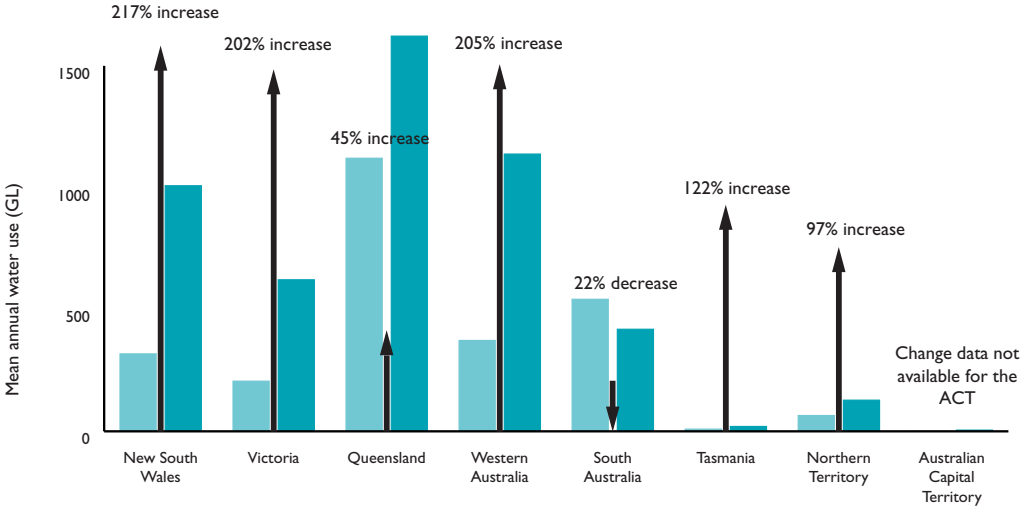
Data source:

Australian Water Resources Assessment 2000 (Figure 26, p. 61)

Groundwater use markedly increased in the period 1983/84 to 1996/97.

- The increasing use of groundwater in most States and Territories (88% overall since 19983/84), indicates the need for increasing knowledge and management of our groundwater resources.

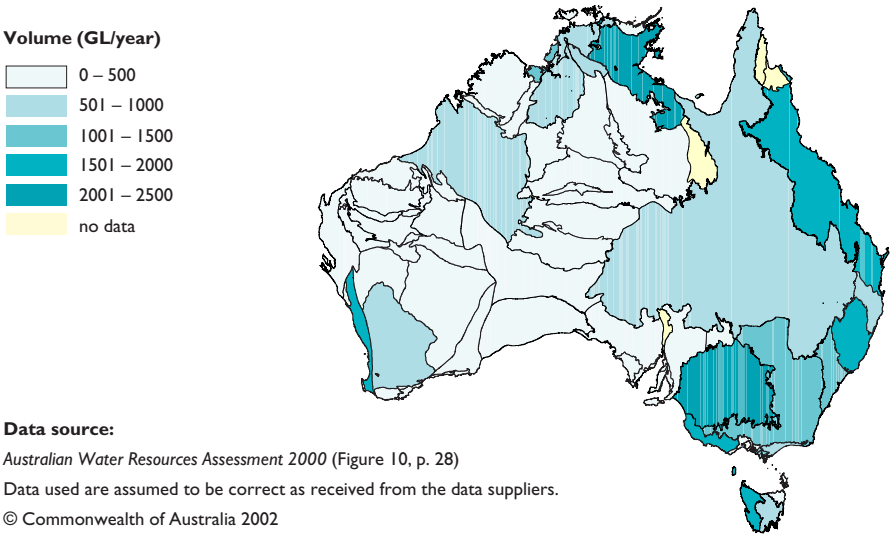
Figure 37. Change in mean annual groundwater use (GL) between 1983/84 and 1996/97.



Groundwater management areas are now defined.

- For the first time groundwater management areas have been defined for Australia and information collated on each of these 535 areas. There is considerable variation in the developed yield taken from the various provinces.

Figure 38. Sustainable yield of groundwater provinces.



Data source:

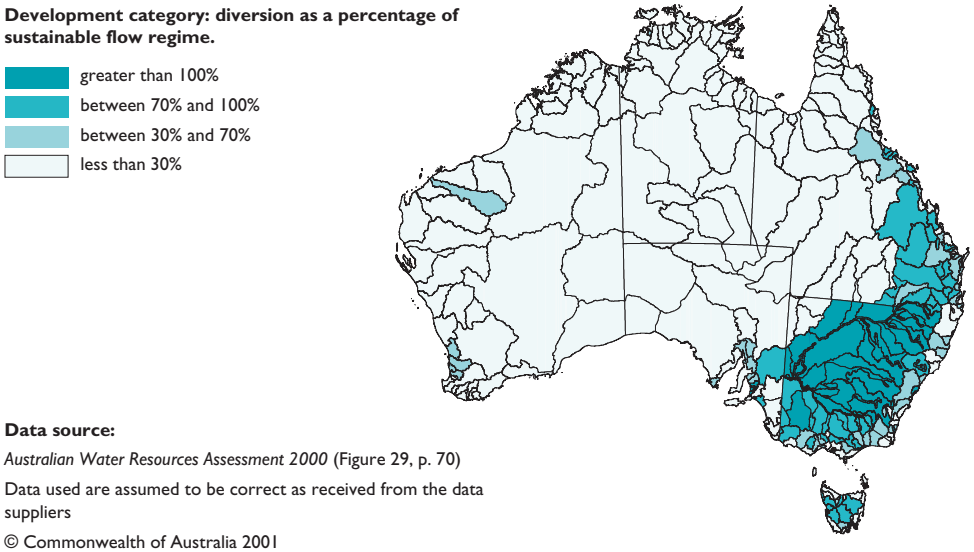
Australian Water Resources Assessment 2000 (Figure 10, p. 28)

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

Ensuring sustainable use of surface water is a priority.

- Many of Australia's surface water resources have limited opportunities for further development. Eighty-four (26%) of Australia's 325 surface water management areas, drawn from the 246 recognised river basins, are either close to or overused compared with their sustainable flow regimes.

Figure 39. Levels of surface water commitment for Australia's surface water management areas.



Data source:

Australian Water Resources Assessment 2000 (Figure 29, p. 70)

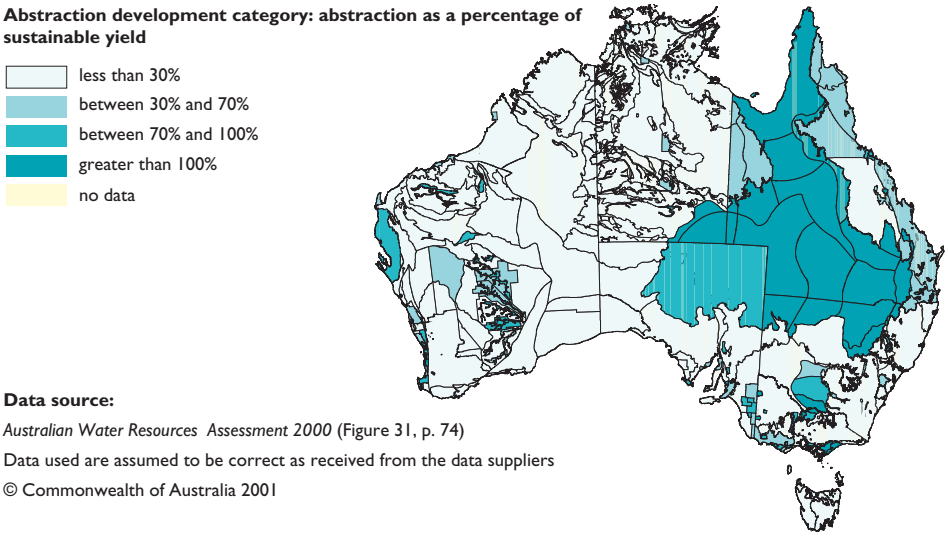
Data used are assumed to be correct as received from the data suppliers

Competition for groundwater resources for stock and domestic purposes, Penong, South Australia

Many groundwater resources require increased management to achieve sustainability.

- The water from 168 of Australia's 538 groundwater management units is either totally allocated or is already over-allocated. Not all allocated water entitlements are used, but 161 (30%) of Australia's 538 groundwater management units are close to or overused compared with their sustainable yield. There is scope for further development and finetuning of groundwater management policies to more effectively underpin sustainable resource management. Mapped at province scale (Figure 40), the abstraction development category demonstrates the key areas of groundwater use and the relative levels of management needs.

Figure 40. Groundwater development status—in some provinces, abstraction exceeds recruitment to the resource, notably in the Great Artesian basin.



Data source:

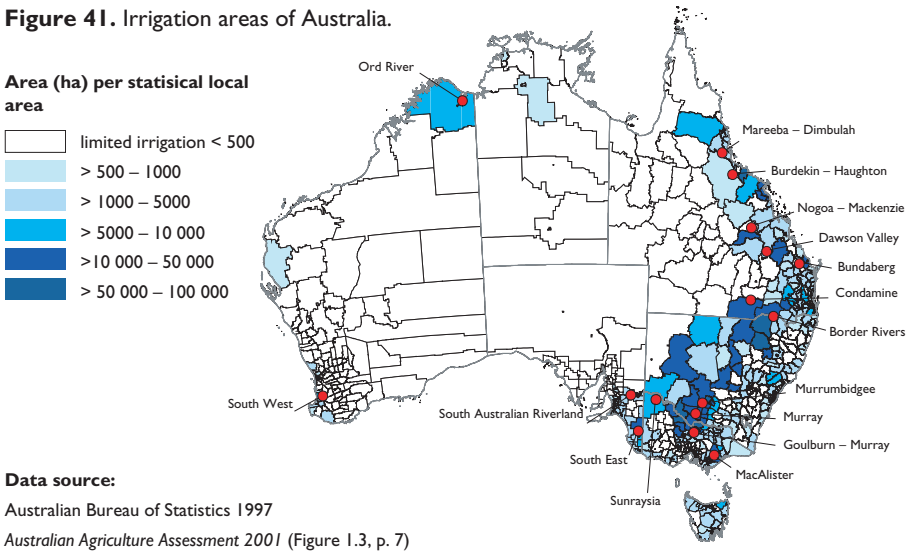
Australian Water Resources Assessment 2000 (Figure 31, p. 74)

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

Irrigation is a major contributor to Australian agriculture.

- Half of the profit in 1996/97 from Australian agriculture when measured as profit at full equity was generated from irrigated production systems. These occupy less than 0.5% of Australia's land area. Continued emphasis on improved irrigation practices will ensure increasing productivity and better land and water management.

Figure 41. Irrigation areas of Australia.



Data source:

Australian Bureau of Statistics 1997

Australian Agriculture Assessment 2001 (Figure 1.3, p. 7)

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

There is a wide range in economic return from irrigation.

- Different irrigation enterprises and the intensity of use of water in those enterprises leads to a wide range in the economic benefits achieved from irrigation. There is scope for further rationalisation of water use and increases in returns as water use moves to higher value products.

Table 4. Annual returns to water and intensity of water use (PFE 1996/97)*.

Land use	Water returns $/ML	Total water use GL	Per cent of total water use %	Water use ML/ha
Vegetables	1 295	392	2.6	3
Fruit	1 276	665	4.4	7
Tobacco	985	13	0.1	4
Grapes	600	781	5.2	8
Tree nuts	507	140	0.9	6
Cotton	452	2 314	15.5	7
Coarse grains	116	518	3.5	3
Dairy	94	5 902	39.5	7
Peanuts	90	25	0.2	3
Hay	54	20	0.1	4
Rice	31	1 696	11.3	11
Legumes	24	33	0.2	3
Sheep	23	13	0.1	4
Sugar cane	21	1 195	8.0	7
Beef	14	1 080	7.2	4
Oilseeds	10	85	0.6	3
Cereals	-9	87	0.6	3
All irrigated land uses	**193**	**14 959**	**100.0**	**7**

* Derived from estimates of mean water use per land use type in each region

Increasing the area under irrigation provides a development opportunity for northern Australia

- 241 surface water units and 265 groundwater units have minimal or no development. Many of these are in arid environments where development potential is minimal to nil. The greatest unallocated water resources are in northern Australia. Northern Territory government resource planners estimate that the area of irrigated agriculture could sustainably expand 30 to 40 times. Based on an annual water consumption of 10 Ml/ha/year the area for potential irrigation in the Top End was projected to be 27 500 ha (groundwater) and 85 600 ha (surface water). This assessment required no on-stream dams to be constructed, ensured adequate water allocations for environmental flows (80% of streamflow or recharge) and required land clearances in river basins of <4% (Table 5). Knowledge of tropical systems, water use technology, irrigated production systems and potential commodity markets from these tropical environments is still developing. Much of the rest of Australia, particularly the southern settled areas and the arid zone, has very limited potential for further development.

Table 5. Projected area with potential for irrigation development in the Top End region of northern Australia.

River basin	Basin area (km^2)	Potential irrigable area* (ha)	Total basin clearing (irrigation, fallow, dams) (ha)	(% of basin)
Ord River	55 380			
Groundwater		nil	nil	nil
Surface water		56 000	181 000	3.3
Victoria River	77 230			
Groundwater		nil	nil	
Surface water		10 400	34 300	0.5
Moyle River	7 020			
Groundwater		5 000	15 000	2.2
Surface water		nil	nil	nil
Adelaide River	7 430			
Groundwater		nil	nil	nil
Surface water		4 000	13 200	1.8
Mary River	8 060			
Groundwater		2 500	7 500	1.0
Surface water		nil	nil	nil
Blyth River	9 080			
Groundwater		2 500	7 500	0.9
Surface water		nil	nil	nil
Roper River	79 130			
Groundwater		3 000	9 000	0.1
Surface water		14 400	47 500	0.6
Daly River	52 940			
Groundwater		14 500	43 500	0.8
Surface water		40 000	132 000	2.5
McArthur River	19 200			
Groundwater		nil	nil	nil
Surface water		16 800	55 400	2.9

Data source: Northern Territory Department of Lands, Planning and Environment

* Estimated at 10 Ml/ha/yr

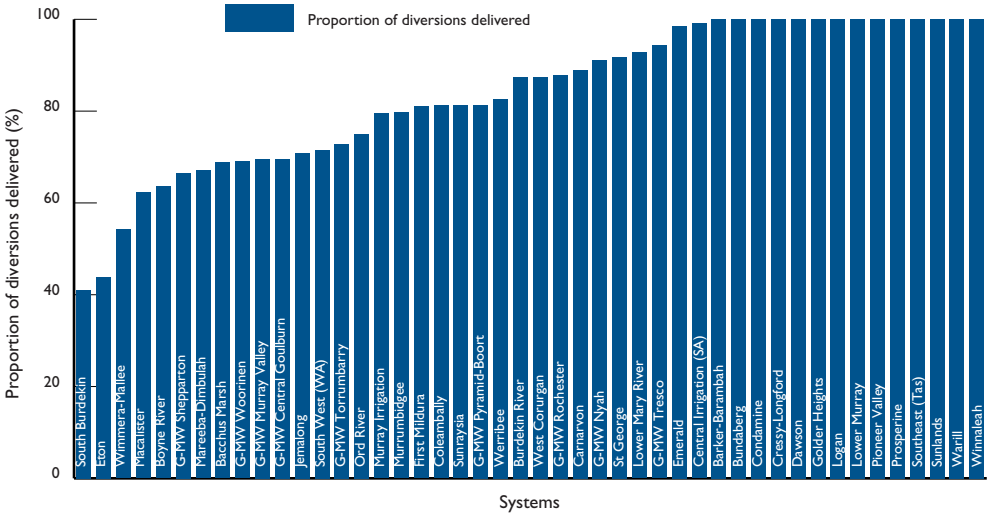
Multi-objective assessment methods are becoming available to evaluate the potential for irrigation developments.

- The Audit sponsored the formulation of *Large scale resource developments – an integrated assessment process* (NLWRA 1999) to define methods that improve evaluation of water resource development proposals. This method has been adapted and modified to meet State and Territory needs and used to assess several projects in Queensland and Tasmania.

Water distribution efficiency can be improved and provides a development opportunity.

- There are great variations in the delivery systems used to supply irrigation water. On average, only 77% of water reaches users' properties. Supply efficiency can be as low as 45% in some irrigation areas. There is technology to address these issues and it provides a major opportunity for improving water resource management in southern Australia.

Figure 42. Water distribution efficiency for irrigation supply systems in Australia.



Data source:

ANCID 2000, *1998/99 Australian irrigation water provider - benchmarking report*, an Australian National Committee in Irrigation and Drainage report supported by Land & Water Australia and Agriculture, Fisheries and Forestry – Australia

Efficiency of water use is quite variable.

- Both market and technological options are available for maximising the efficiency of water use, and some growers have readily adopted best practice options. A recent example is the introduction of partial root zone drying in the irrigated horticultural and viticultural industries. There remains a great variation in the economic and physical efficiency with which water is applied within individual agricultural commodity production systems, and a further variability in production outputs achieved. Industry codes of practice such as that developed for the dairy industry are addressing these issues and will provide a sound basis for continuous improvement.

Table 6. Irrigation statistics for dairy industry regions.

Region	% of farms irrigating (%)	Average area irrigated (ha)	% of irrigating farms using flood irrigation (%)	% of irrigating farms using spray irrigation (%)	Average irrigation water application rate (ML/ha)	Average irrigation water usage rate (ML/cow)
West Victoria dairy	25	34	16	89	4.5	0.9
Gippsland dairy	29	60	58	53	4.1	1.3
Murray dairy	92	98	96	10	6.0	2.6
Dairy Industry Development Company (NSW)	57	49	5	98	4.5	1.4
Subtropical dairy	62	29	2	100	4.5	0.9
Dairy Tasmania	62	45	2	99	2.7	0.5
Dairy Western Australia	42	41	92	13	9.5	2.1
Dairy South Australia	71	46	27	86	5.4	1.3
Australian average	**57**	**64**	**49**	**56**	**5.3**	**1.9**

Data source:

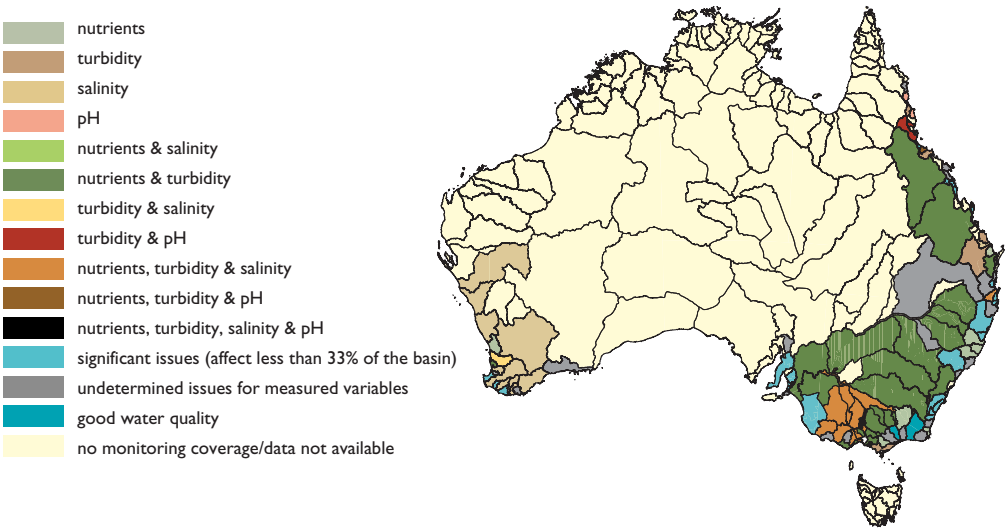
Australian Agriculture Assessment 2001

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

Water quality assessment has defined the priority catchments for the National Action Plan for Salinity and Water Quality.

- Approximately one-quarter of Australia's 246 basins can be adequately assessed for the key variables of turbidity, nutrients and salinity.
- Water quality was found to exceed acceptable standards for nutrients in 43 basins.
- Water was excessively turbid in parts of 41 basins.
- Water quality exceeded salinity standards in 24 basins.

Figure 43. Water quality issues—major quality issues affecting more than 33% of a drainage basin.



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

Data source:

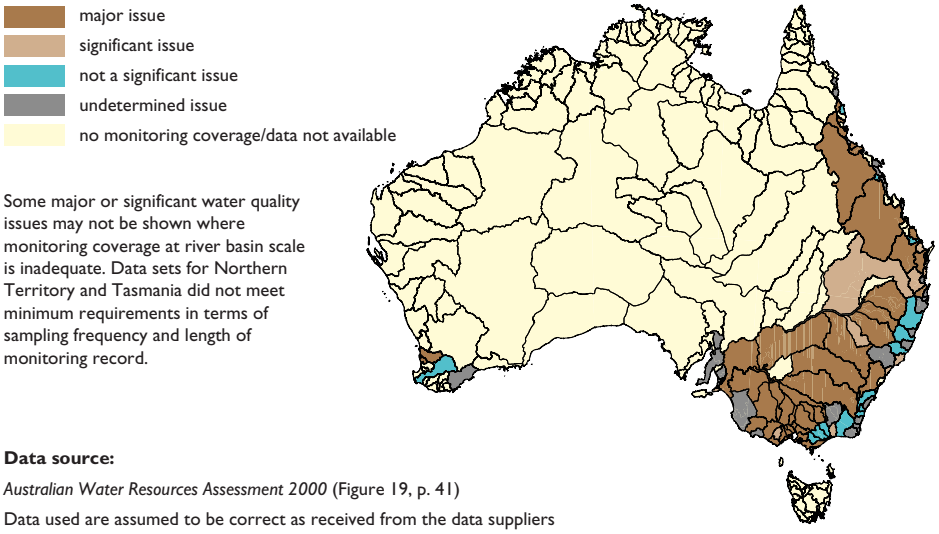
Australian Water Resources Assessment 2000 (Figure 11, p. 31)

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

Soil erosion and in-stream turbidity are clearly major issues for eastern Australia.

- Turbidity deriving from soil loss has a particularly strong impact on water quality in much of eastern Australia. The Audit's assessment of water-borne erosion provides the key for targeting works and activities to address this issue.

Figure 44. Soil loss, leading to turbidity, remains a major issue in much of eastern Australia.



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

Data source:

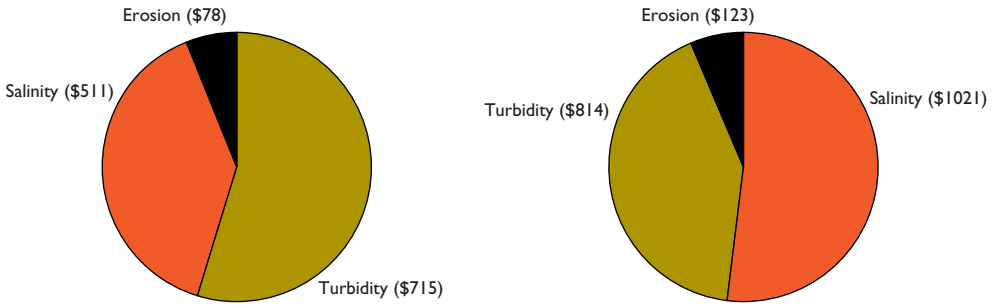
Australian Water Resources Assessment 2000 (Figure 19, p. 41)

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

Turbidity is equally important as salinity in downstream costs.

- Soil management to minimise erosion and hence turbidity has immediate benefits and is likely to provide a more rapid return on investment than activities to minimise dryland salinity.

Figure 45. Present values of downstream costs associated with increases in water quality parameters over the period 2000 to 2020. Estimates of costs are given for making incremental improvements of 5% (left) and 10% (right) in water quality.

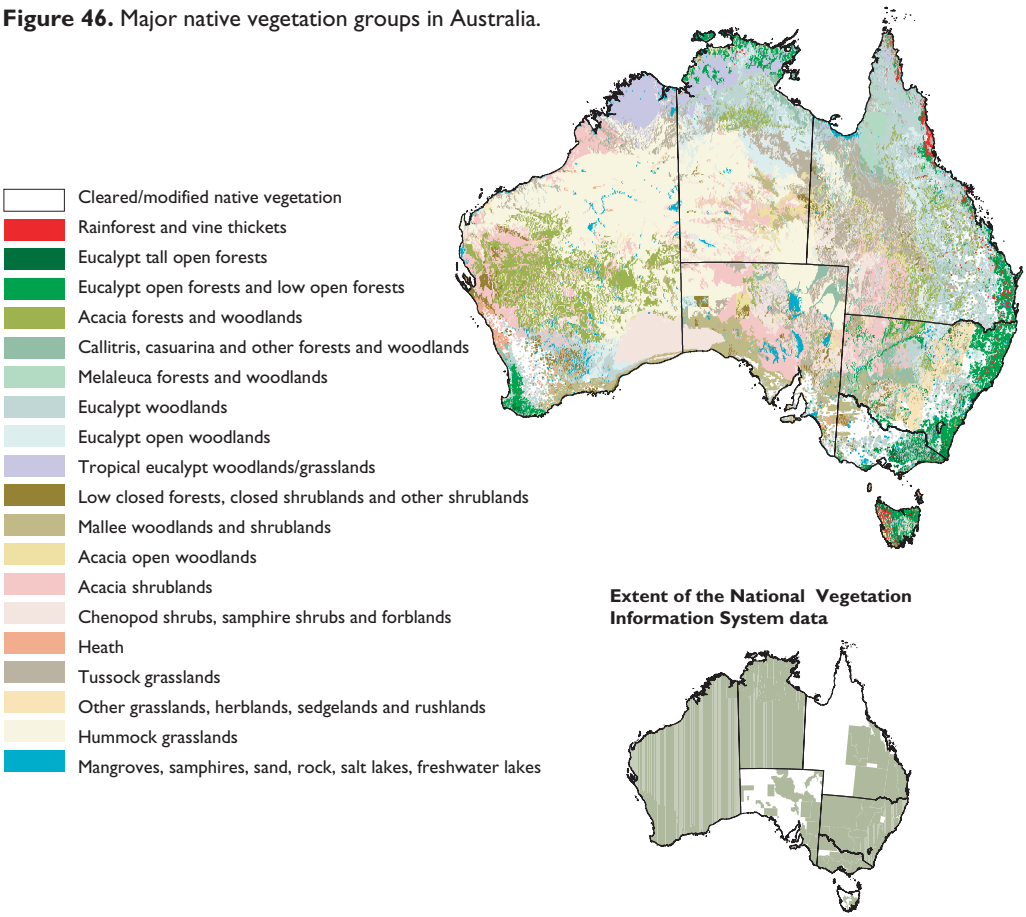


BIODIVERSITY
VEGETATION

Australia now has a standardised approach to collating native vegetation information.

- Through an Australia-wide partnership a hierarchical classification of Australia's native vegetation has been implemented. This can be summarised by presenting native vegetation in major vegetation groups.

Figure 46. Major native vegetation groups in Australia.



This summary map provides information on Australia's native vegetation collated within the National Vegetation Information System at July 2001 and with additional mapped information where not available from the National Vegetation Information System. The National Vegetation Information System will be updated continuously as vegetation mapping data becomes available from States and Territories.

Data source:

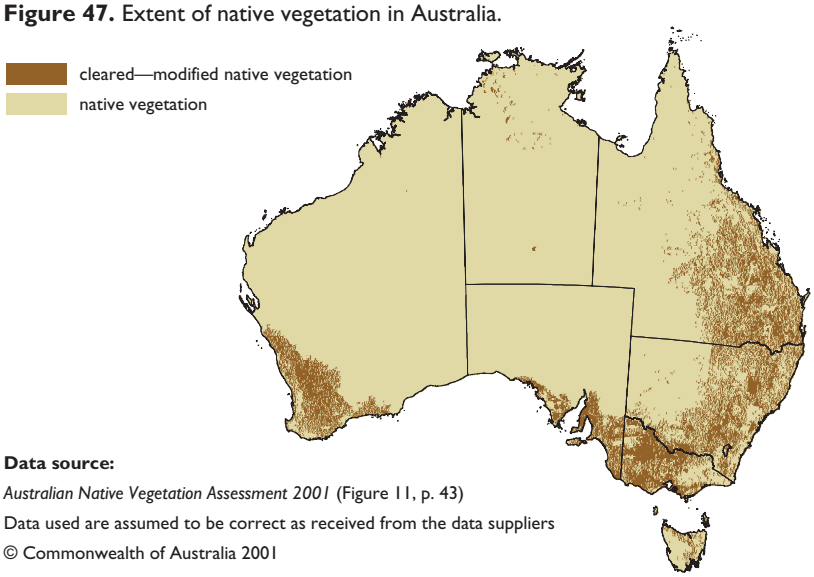
Australian Native Vegetation Assessment 2001 (Figure 8, p. 39)

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

There have been significant changes to the extent of native vegetation.

- About 33% of Australia's native vegetation in the intensively used areas, primarily agricultural and urban land uses, have been cleared or modified.

Figure 47. Extent of native vegetation in Australia.



Data source:
Australian Native Vegetation Assessment 2001 (Figure 11, p. 43)
Data used are assumed to be correct as received from the data suppliers

The level of clearing of native vegetation in each State and Territory varies substantially.

- Re-vegetation programs and protective management programs can be targeted according to the level of clearing of vegetation in each State and Territory. At the State scale, for example, Northern Territory, with the most intact native vegetation might be a priority for protective management activities whereas Victoria, with the least native vegetation intact, might be a priority for targeted re-vegetation programs under Bushcare.

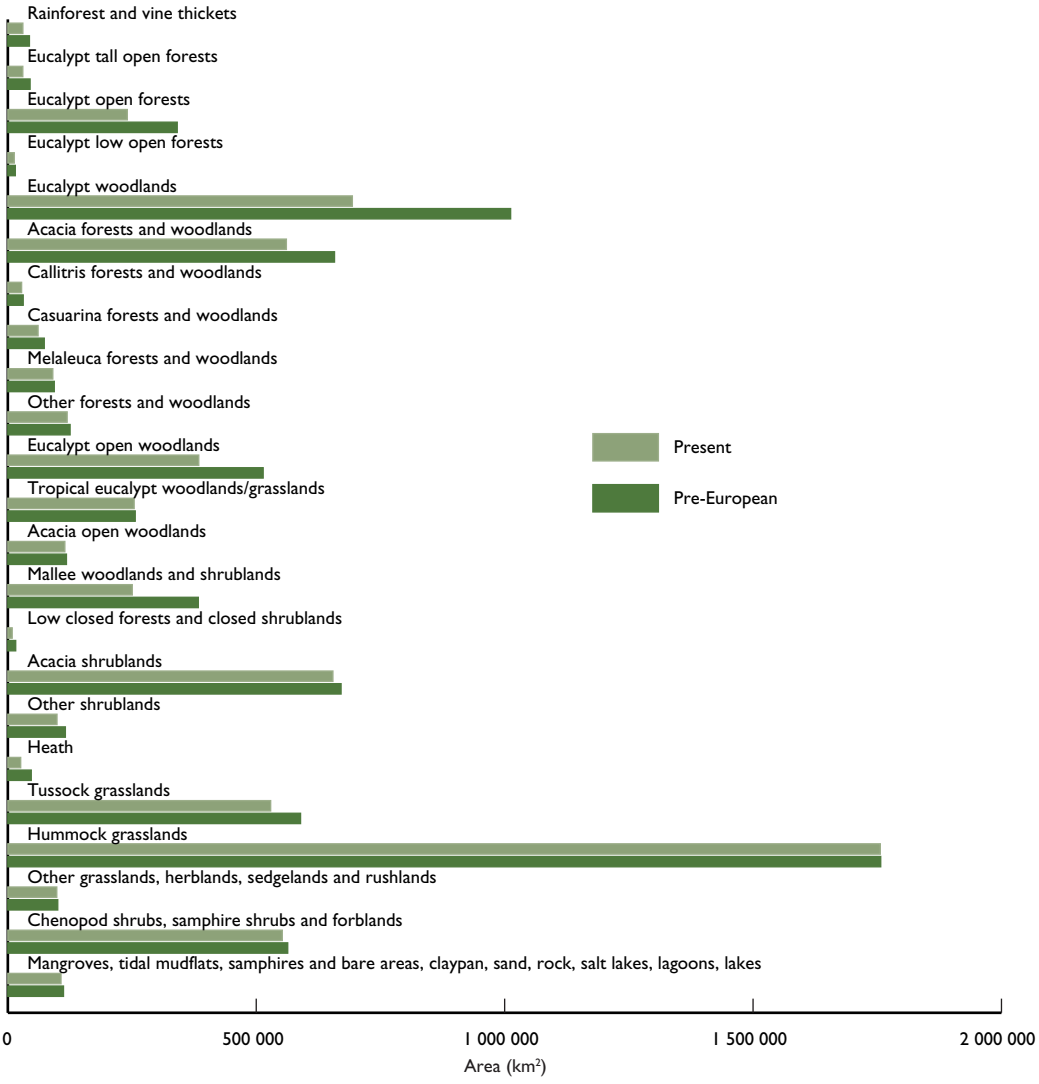
Table 7. Native vegetation remaining in the intensively used (as defined by Graetz et al. 1995) areas of Australia.

	Area native vegetation remaining (km²)	**Percent remaining** (%)
Victoria	84 541	37
Western Australia	234 423	56
South Australia	174 966	64
New South Wales	470 604	67
Australian Capital Territory	1 620	69
Queensland	772 452	72
Tasmania	42 520	80
Northern Territory	186 629	98
Australia (intensive land use zone)	**1 967 754**	**68**

The vegetation types most impacted by clearing can now be defined.

- Mapping in major vegetation groups provides context for finer-scale vegetation management and conservation activities.

Figure 48. Area (km^2) of pre-European and present major vegetation groups in Australia.



Data source:

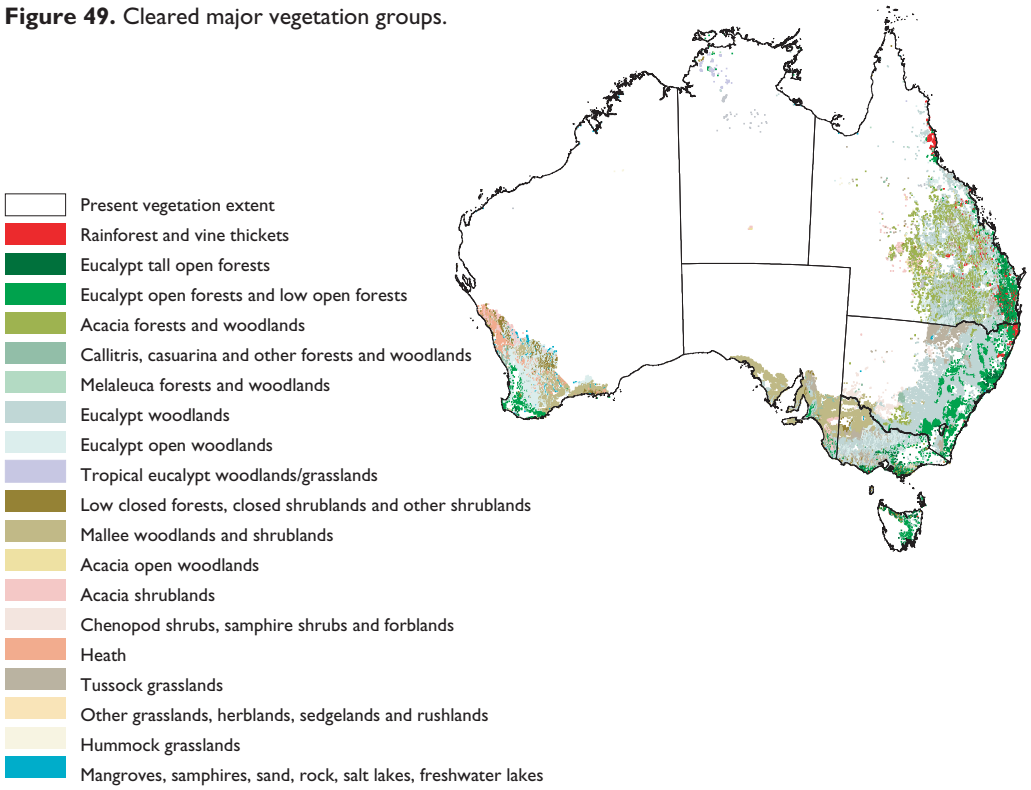
Australian Native Vegetation Assessment 2001 (Figure 15, p. 50)

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

Clearing and fire are key threatening processes for Australia's native vegetation.

- Clearing of native vegetation remains the single most significant threat to terrestrial biodiversity. Land clearing has decreased in most States and Territories. Likewise, determining and then applying appropriate fire regimes is a major challenge for Australia's biodiversity managers. Comparative estimates of the population density of woodland birds, for example, indicate that between 1000 and 2000 birds permanently lose their habitat for every 100 ha of woodland cleared (Glanzig & Kennedy 2000).

Figure 49. Cleared major vegetation groups.



Data source:

Australian Native Vegetation Assessment 2001 (Figure 19, p. 55)

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

This summary map provides information on Australia's native vegetation collated within the National Vegetation Information System at July 2001 and with additional mapped information where not available from the National Vegetation Information System. The National Vegetation Information System will be updated continuously as vegetation mapping data becomes available from States and Territories.

The current protection status of the major vegetation groups varies substantially.

- With the development through the Audit of Australia-wide consistent mapping and classification of native vegetation, managers can now assess the conservation status of major plant communities and plan further reservations accordingly.

Table 8. Area (km^2) of major vegetation groups in protected areas.

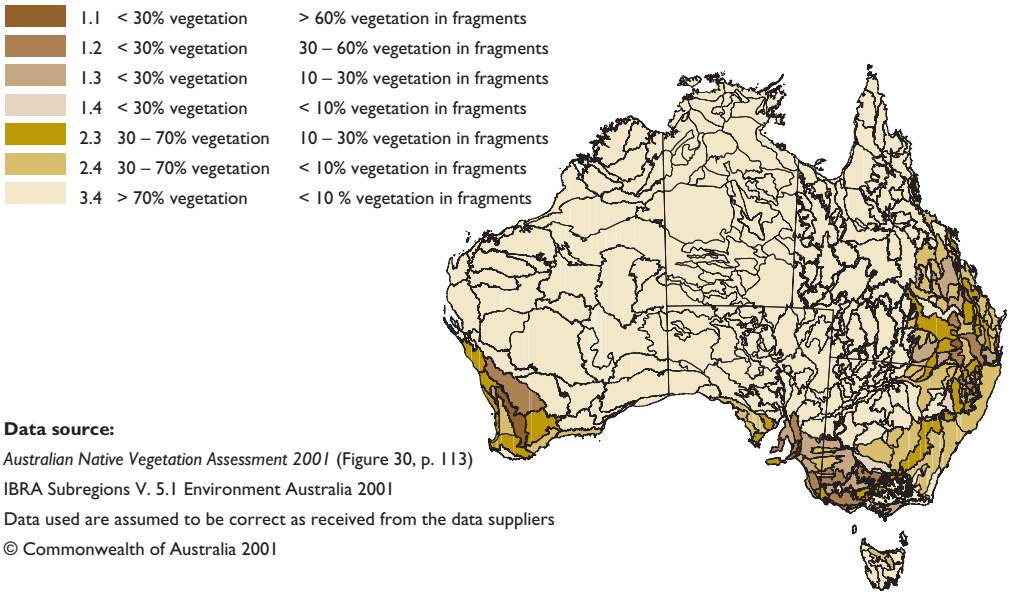
Major vegetation group	Western Australia	Northern Territory	South Australia	Queensland	New South Wales	Australian Capital Territory	Victoria	Tasmania	Australia
Rainforest and vine thickets	–	265	–	5 058	1 545	–	134	4 241	11 244
Eucalypt tall open forests	554	–	–	48	1 286	4	4 550	1 569	8 011
Eucalypt open forests	1 705	6 806	87	4 016	21 580	858	2 844	3 657	41 552
Eucalypt low open forests	106	70	17	104	509	42	77	31	957
Eucalypt woodlands	9 543	4 280	1 311	15 437	10 478	179	7 887	1 420	50 534
Acacia forests and woodlands	8 065	10	659	3 326	539	–	97	6	12 701
Callitris forests and woodlands	–	–	220	67	1 157	4	279	–	1 728
Casuarina forests and woodlands	163	–	7 363	223	647	2	42	16	8 457
Melaleuca forests and woodlands	348	1 695	1	5 744	1	–	24	–	7 812
Other forests and woodlands	751	127	10 731	2 197	2	–	1 290	252	15 350
Eucalypt open woodlands	4 236	8 190	7 050	6 990	2 166	48	333	33	29 047
Tropical eucalypt woodlands/grasslands	10 073	17 072	–	1 757	–	–	–	–	28 903
Acacia open woodlands	75	24	8 953	1 899	8	–	–	–	10 959
Mallee woodlands and shrublands	14 763	1 318	47 809	–	2 919	–	8 675	–	75 484
Low closed forests and closed shrublands	276	–	2	115	31	–	403	1 388	2 214
Acacia shrublands	12 427	1 305	2 748	2 073	1 664	–	5	3	20 225
Other shrublands	4 291	1	9 374	1 863	23	7	2 390	329	18 278
Heath	5 294	–	2 011	140	730	9	1 405	765	10 354
Tussock grasslands	2 314	701	6 166	5 033	1 994	40	165	144	16 556
Hummock grasslands	54 689	5 870	54 404	10 441	–	–	–	–	125 403
Other grasslands, herblands, sedgelands and rushlands	873	1 913	261	405	204	–	395	6 385	10 437
Chenopod shrubs, samphire shrub and forblands	21 363	441	32 696	2 003	740	–	704	5	57 952
Mangroves, tidal mudflats, samphires and bare areas, claypans, sand, rock, salt lakes, lagoons, lakes	3 127	265	22 900	633	300	10	272	733	28 240

– Indicates that this major vegetation group does not exist in a particular jurisdiction or that the scale and type of mapping compiled has not captured this major vegetation group

Analysis of fragmentation of native vegetation at the subregional scale provides an information base for setting priorities for re-vegetation and protection through reservation of remnants.

- Of Australia's 354 subregions, 42 have less than 30% of native vegetation remaining, with 22 of these having the remaining vegetation highly fragmented. These subregions occur in south-western Western Australia, south-eastern South Australia, central and western Victoria, the New England Tablelands in New South Wales and southern and central eastern Queensland. These subregions are likely to be priority areas for strategic re-vegetation, re-establishing linkages and wildlife corridors across the landscape. Protective management of the native vegetation remnants in these subregions is also an imperative and provides a cost-effective way to retain native vegetation in these landscapes.

Figure 50. Fragmentation classes in subregions.

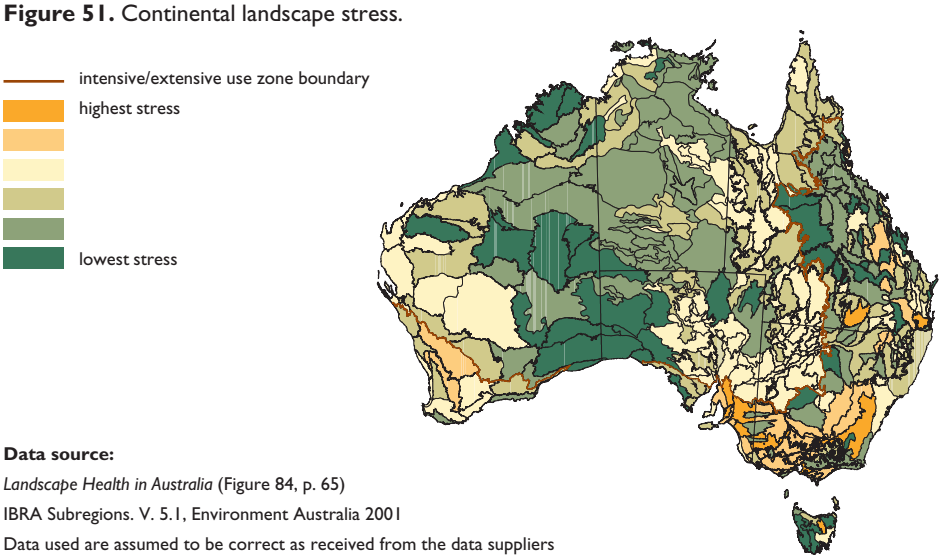


Data source:
Australian Native Vegetation Assessment 2001 (Figure 30, p. 113)
IBRA Subregions V. 5.1 Environment Australia 2001
Data used are assumed to be correct as received from the data suppliers

Nearly half of Australia's subregions are in excellent environmental health, presenting opportunities for protective management.

- Australia's 354 subregions were assigned to one of a six-tiered classification of the extent of 'landscape stress'. This assessment took account of the extent and fragmentation of native vegetation; threatened ecosystems and species; and frequency of salinity, weeds and feral animals. One hundred and fifty-two regions are in relatively good condition. Protective management activities across all tenures in these subregions are likely to be most cost-effective and will ensure these subregions remain in good condition. Approximately 10% of Australia's subregions have been identified as stressed, with 17 subregions appearing in the highest stress category and a further 20 in the second tier, together representing 10% of the nation's subregions. These subregions would require substantial investment to regain key conservation values.

Figure 51. Continental landscape stress.

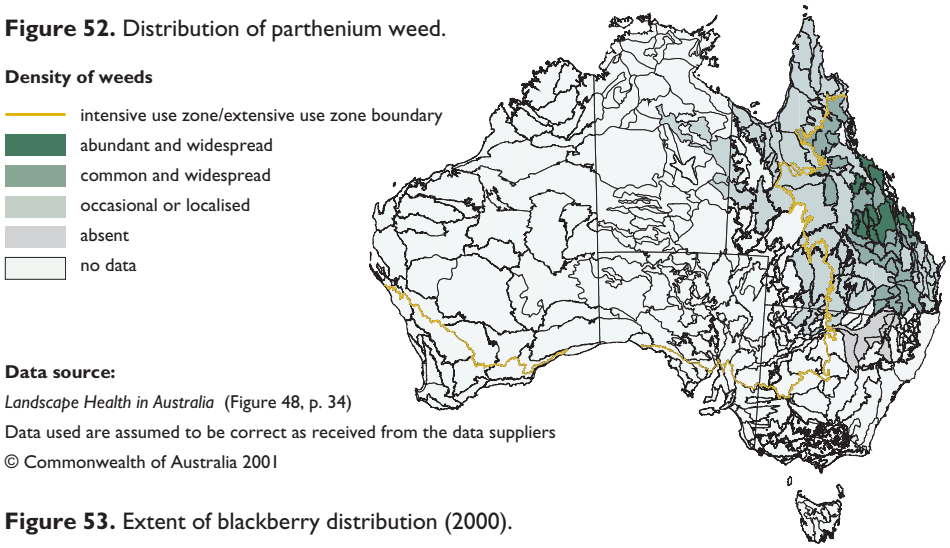


Data source:
Landscape Health in Australia (Figure 84, p. 65)
IBRA Subregions. V. 5.1, Environment Australia 2001
Data used are assumed to be correct as received from the data suppliers

Australia is increasingly focusing on strategic weed management

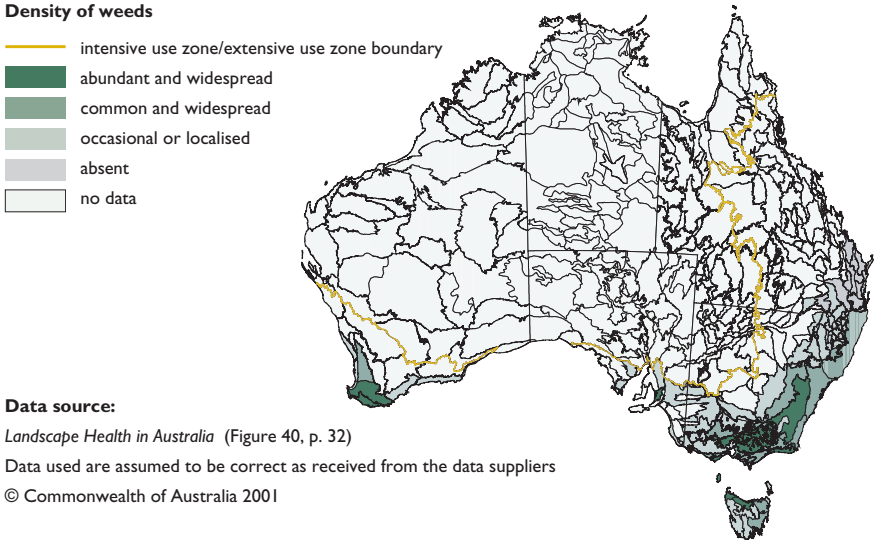
- Australia has defined 20 weeds as 'weeds of national significance'. A number, including lantana and parthenium weed have the potential to colonise suitable habitats across much of Australia and are expanding aggressively. In 1955, for example, parthenium, a native of the Caribbean, was first identified in northern Queensland. Between 1955 and 1979 it spread through 170 000 km^2 of north-eastern Queensland, with lighter infestations gradually extending southwards. Parthenium reached the New South Wales border in 1979 and Victoria by 1989. Local infestations have been found in the Roper River area of the Northern Territory and the Kimberleys. Other long-established weeds such as blackberries have probably reached the limits of their ecological adaptation and have had considerable impact on natural and agricultural ecosystems. They are still proving difficult to manage, despite the introduction of biological control measures.

Figure 52. Distribution of parthenium weed.



Data source:
Landscape Health in Australia (Figure 48, p. 34)
Data used are assumed to be correct as received from the data suppliers

Figure 53. Extent of blackberry distribution (2000).



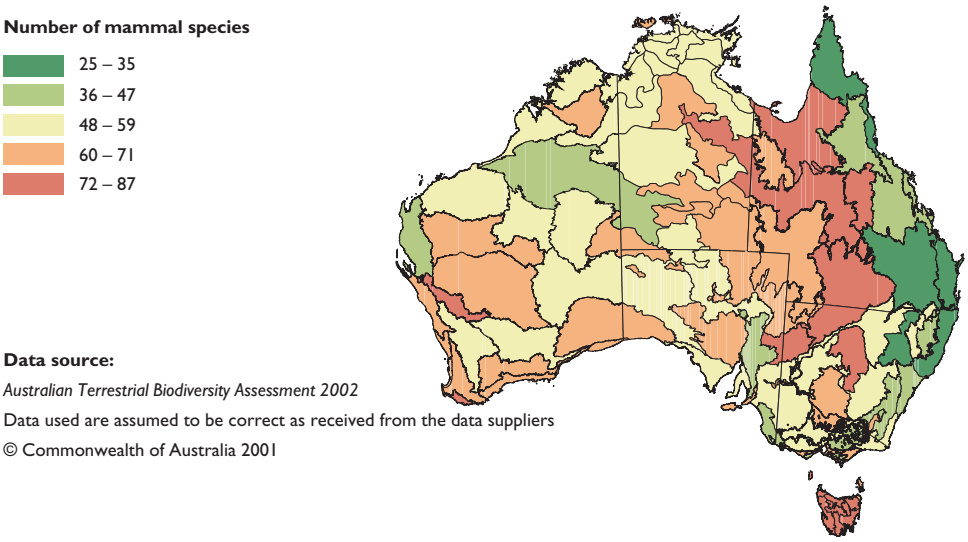
Data source:
Landscape Health in Australia (Figure 40, p. 32)
Data used are assumed to be correct as received from the data suppliers

BIODIVERSITY MAMMALS

Australia has a unique fauna.

- The 305 indigenous species of mammals include 258 (85%) that are endemic to Australia. The remainder, mostly bats, are shared with New Guinea and nearby islands.

Figure 54. Species richness (number of species) of the pre-European mammal fauna in each bioregion.

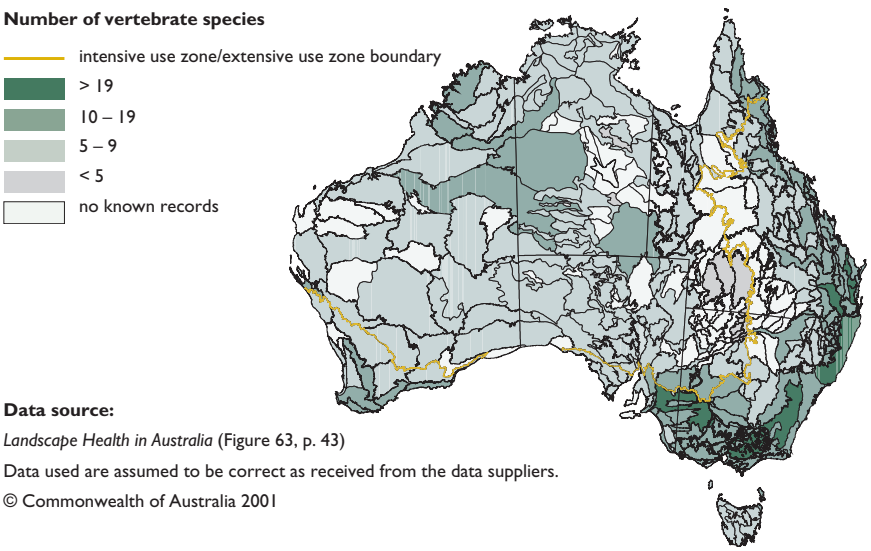


Data source:
Australian Terrestrial Biodiversity Assessment 2002
Data used are assumed to be correct as received from the data suppliers

Twenty-six exotic species of mammals have been introduced to Australia.

- Competitive pressures from introduced species have contributed to declines in populations and losses by extinction of Australian mammals.

Figure 55. Known and predicted occurrences of threatened vertebrate fauna.



Data source:
Landscape Health in Australia (Figure 63, p. 43)
Data used are assumed to be correct as received from the data suppliers.

Australia's vertebrate pests have vastly expanded in range since their introduction.

- Despite some success at control measures, feral goats, which have a serious impact on plant biodiversity, remain in high density in some areas. Feral cats, threatening many small native mammals, have become ubiquitous over most of the country. Policy measures that encourage continued effort to reduce vertebrate pest numbers can be targeted based on the now documented ranges of each particular feral animal. Such measures would be part of protective management activities across all tenures to retain Australia's biodiversity.

Figure 56. Goats have become a major feral pest in southern and western Australia.

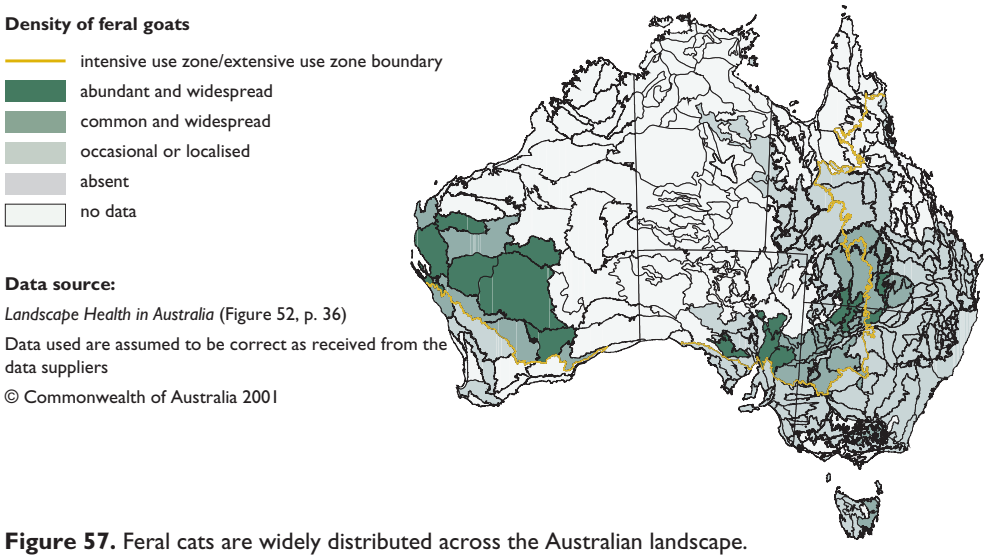
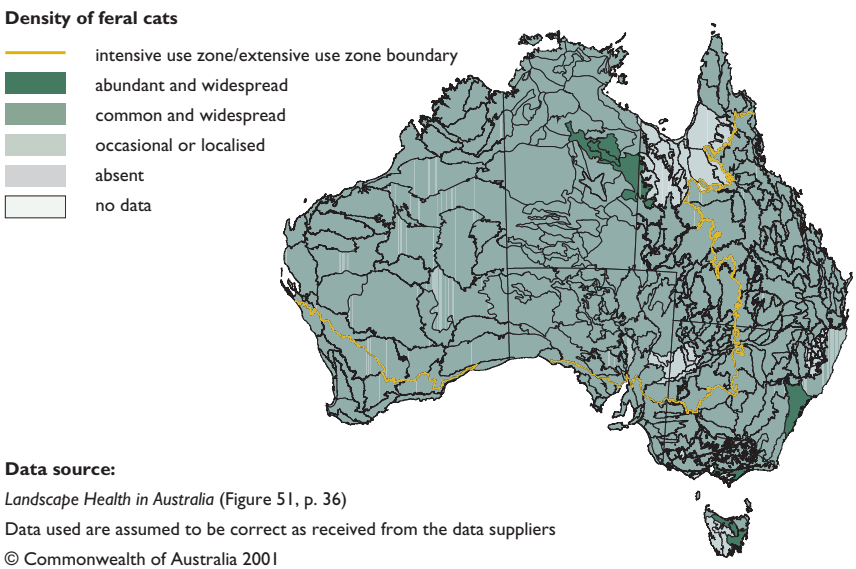


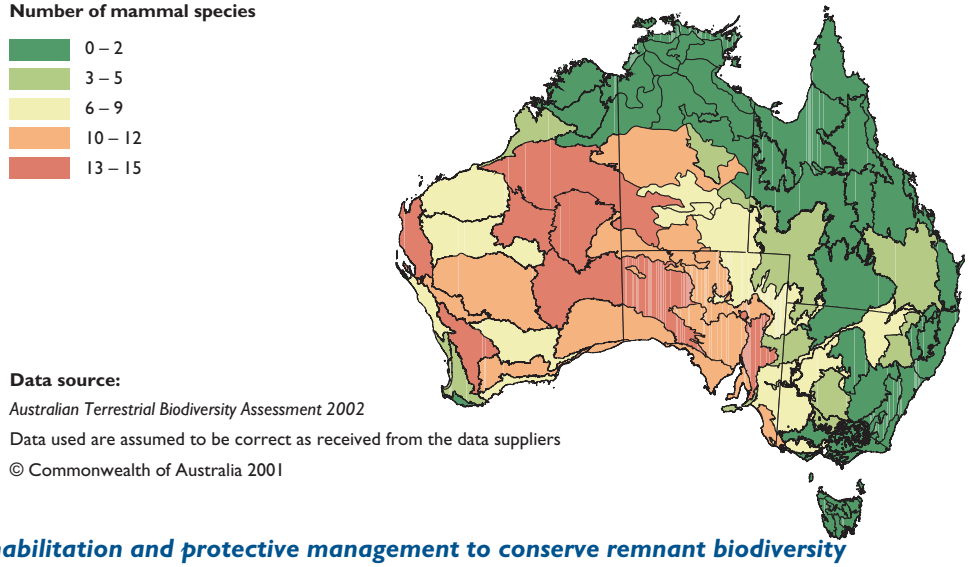
Figure 57. Feral cats are widely distributed across the Australian landscape.



Australia's mammal populations require strategic and targeted approaches.

- Some mammal species have contracted to less than 10% of the regions they originally occupied (Figure 58) principally in the desert and cereal crop regions.

Figure 58. Number of mammal species, of the original fauna in each region, whose range has contracted from >90% of the regions original occupied, showing a measure of environmental change.

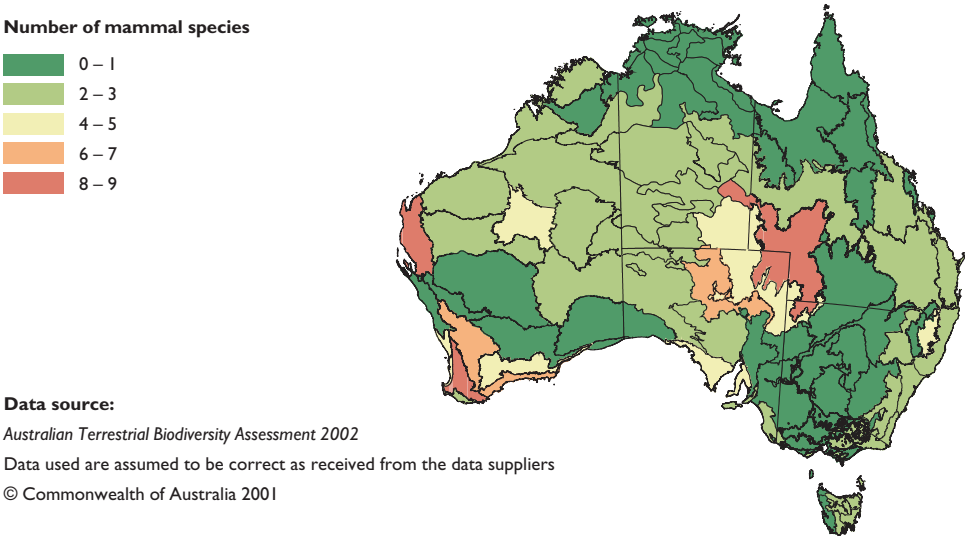


Data source:
Australian Terrestrial Biodiversity Assessment 2002
Data used are assumed to be correct as received from the data suppliers

Rehabilitation and protective management to conserve remnant biodiversity

- Rehabilitation and protective management are essential in those bioregions that now contain populations of mammal species which were once widespread. The Avon wheatbelt in the south west of Western Australia and channel country of the Lake Eyre Basin are examples of bioregional refuges for mammals.

Figure 59. Number of mammal species that have undergone Australia-wide range reduction > 50%.



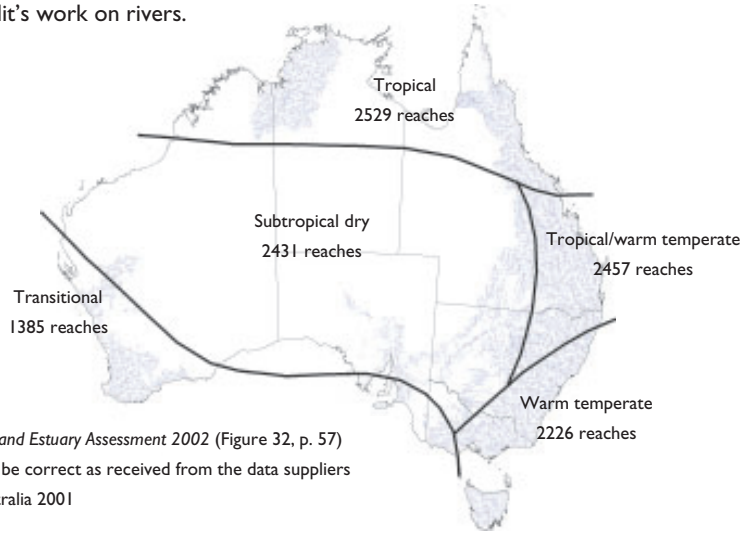
Data source:
Australian Terrestrial Biodiversity Assessment 2002
Data used are assumed to be correct as received from the data suppliers

BIODIVERSITY
RIVERS & ESTUARIES

River reaches provide a spatial framework for river management and monitoring.

- A river reach is a section of river with relatively uniform physical characteristics. Fourteen thousand, six hundred and six reaches have been defined for Australia's more intensively used catchments. With further finetuning to meet State and Territory needs, these reaches will provide a rigorous and consistent reporting framework for tracking progress in river management.

Figure 60. Climate zones in Australia relevant to river condition—also showing those reaches assessed for the Audit's work on rivers.



Data source:

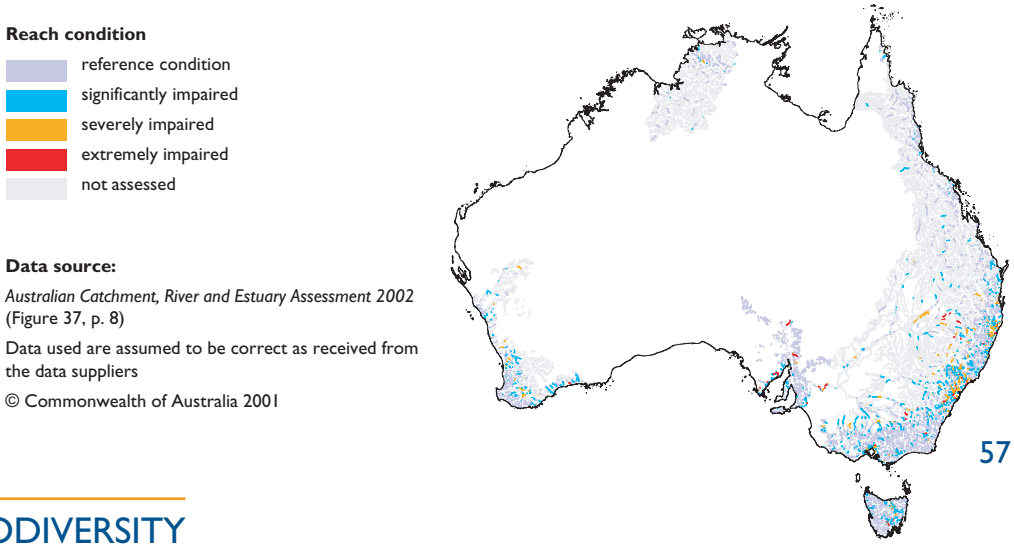
Australian Catchment, River and Estuary Assessment 2002 (Figure 32, p. 57)

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

Aquatic biota, as represented by macro-invertebrate indicator species provide a partial measure of river condition.

- The collated National River Health Program – Australian River Assessment Scheme (AusRivAS) data sets suggest that, based on macro-invertebrates as indicators, little change from apparently natural conditions has occurred in 67% of river reach length. Within the remaining 33% of river length with impaired aquatic biota, almost 25% has lost between one fifth and one half of the macro-invertebrate groups used as indicators of river biodiversity.

Figure 61. Condition of river reaches based on the aquatic biota (macro-invertebrate) index.



Data source:

Australian Catchment, River and Estuary Assessment 2002 (Figure 37, p. 8)

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

An assessment of environmental modification provides the key to management opportunities for Australia's rivers.

- Over 85% of river length was classified as having undergone some environmental modification, including catchment disturbance, reduced riparian vegetation, hydrological disturbance and increases in the load of suspended sediments and nutrients. New South Wales, South Australia and Western Australia have the greatest percentage of modified river length (97%, 96% and 93% respectively) and the Northern Territory has the smallest amount (34%).

Table 9. River environment index results for each State and Territory.

	Total length of reach (km) in each category and percentage of total in parentheses								Percent of total length with data
	Largely unmodified		Moderately modified		Substantially modified		Extensively modified		
Queensland	8 743	(13)	48 214	(71)	10 599	(16)	0	(0)	93
New South Wales	1 619	(3)	39 232	(68)	17 089	(29)	18	(0)	97
Australian Capital Territory	43	(16)	191	(71)	36	(13)	0	(0)	100
Victoria	3 085	(20)	9 042	(60)	3 099	(20)	0	(0)	97
Tasmania	2 028	(37)	3 250	(59)	194	(4)	0	(0)	98
South Australia	299	(4)	4 666	(61)	2 635	(35)	0	(0)	79
Western Australia	1 487	(7)	15 927	(78)	2 929	(14)	12	(1)	80
Northern Territory	9 165	(66)	4 630	(34)	0	(0)	0	(0)	67
Total	**26 468**	**(14)**	**125 152**	**(66)**	**36 581**	**(19)**	**31**	**(1)**	**90**

Data source:

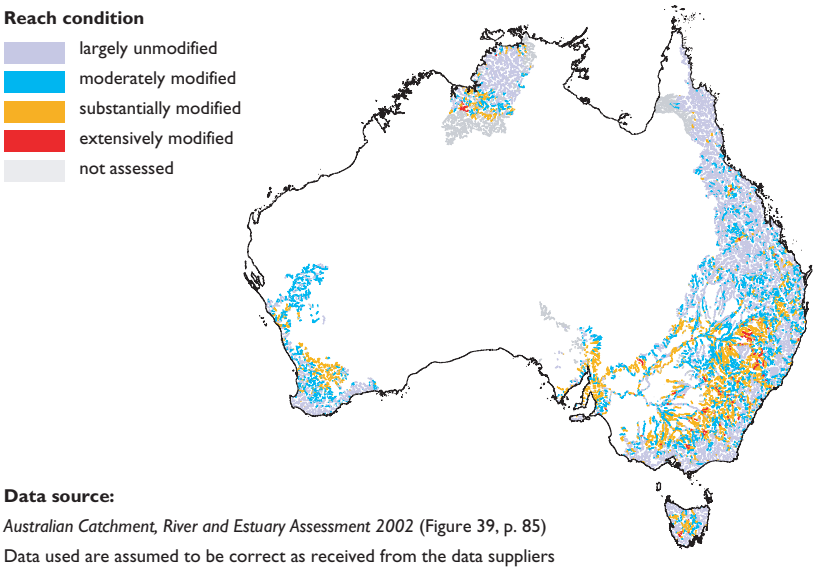
Australian Catchment, River and Estuary Assessment 2002

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

Riparian and in-stream habitats are key management factors for the health of Australia's rivers.

- Protection of existing riparian habitat and its re-establishment in most catchments together with improved catchment management to minimise sediment and nutrient inputs is essential. Largely unmodified rivers occur especially in far north Queensland, eastern Victoria and Tasmania. These require protective management to ensure their condition is maintained. Rivers with the most modified condition are in parts of the Murray–Darling Basin, the Western Australian wheatbelt, western Victoria and the South Australian cropping areas. Riparian areas of many of these rivers are dominated by weeds.

Figure 62. Condition of river reaches.



Data source:

Australian Catchment, River and Estuary Assessment 2002 (Figure 39, p. 85)

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

Native fish populations are a key indicator of river health for which we need more information.

- Issues for management include barriers to fish movement, poor water quality, reduction in habitat and competition from exotic species. These impact on fish populations and need to be analysed for each of our major river basins. Some species of freshwater crayfish are also considered to be at risk, primarily from loss of habitat.

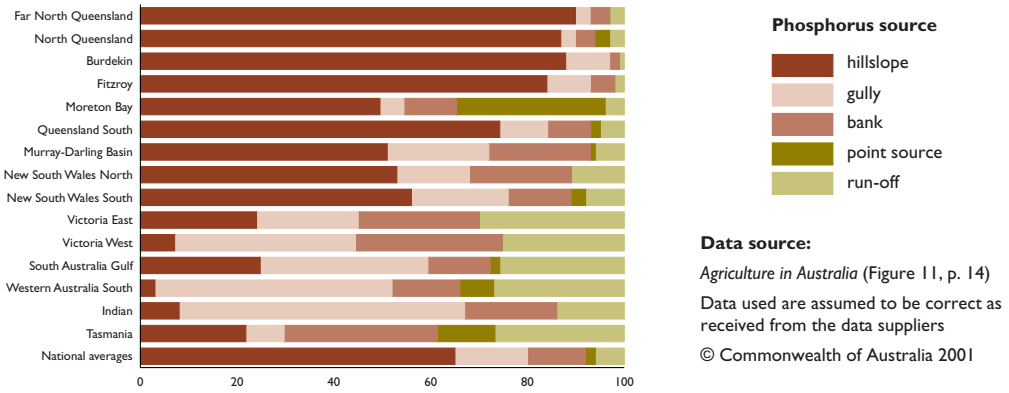
Reductions in Australia's waterbird populations reflect the decline in wetland condition.

- Fifty percent of Australia's inland waterbirds are listed as vulnerable or threatened, mainly from loss of wetland and riparian habitat. Further assessment is required to provide input to management.

Management needs and opportunities for investment vary.

- Most river reaches in Queensland and northern coastal New South Wales, western Victoria and south-west Western Australia have largely unmodified riparian habitat. The condition of these rivers is affected by very high instream nutrient and suspended sediment loads. Sediment and nutrient sources vary in relative proportions, providing an indication of where management activities are likely to deliver the highest return (Figures 63, 64). The total loads vary for these regions (Figure 19).

Figure 63. Proportion of phosphorus (%) from different types of erosion in the assessed regions.

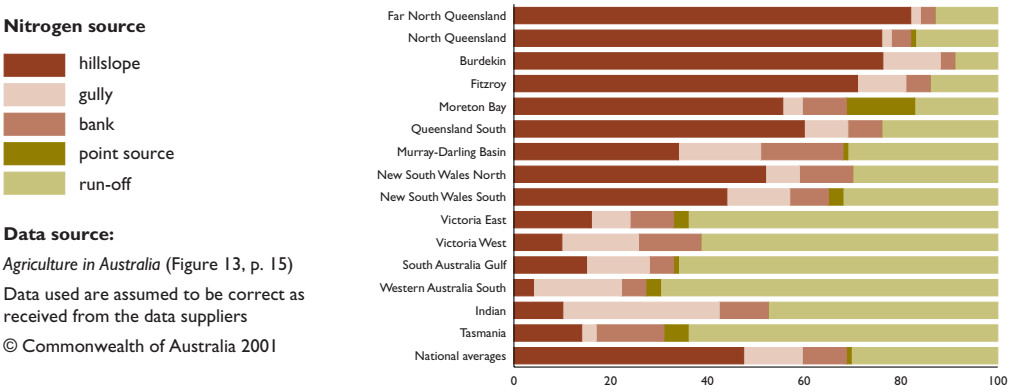


Data source:

Agriculture in Australia (Figure 11, p. 14)

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

Figure 64. Proportion of nitrogen (%) from different types of erosion in the assessed regions.



Data source:

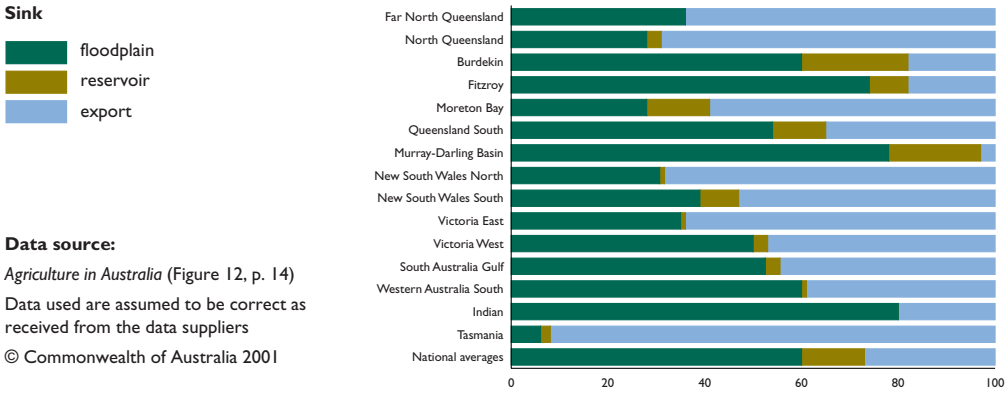
Agriculture in Australia (Figure 13, p. 15)

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

The fate of nitrogen and phosphorus entering rivers also varies.

- With an understanding of the location of nutrient change (deposition or loss), managers can start to understand key differences in processes and management opportunities. In far north Queensland, for example, less than 40% of phosphorus and nitrogen ends up on floodplains, with the remainder transported down river to estuary. In the Burdekin and Fitzroy, further south, more than 60% of the phosphorus is captured by floodplains. The total loads vary for these regions (Figure 19).

Figure 65. Proportion of phosphorus (%) to different locations of deposition and export to the coast in the assessed regions.

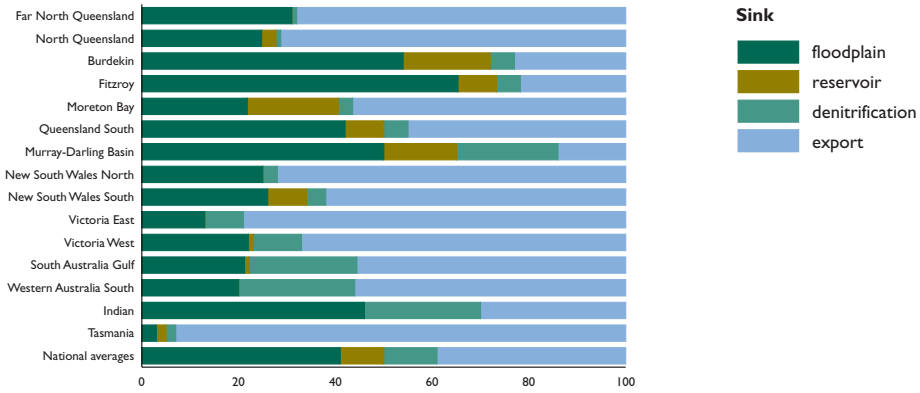


Data source:

Agriculture in Australia (Figure 12, p. 14)

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

Figure 66. Proportion of nitrogen (%) to different locations of deposition and export to the coast in the assessed regions.



Data source:

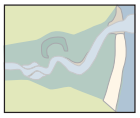
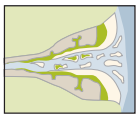
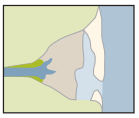
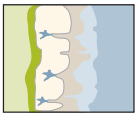
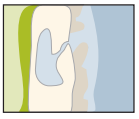
Agriculture in Australia (Figure 14, p. 15)

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

An understanding of estuary type allows managers to identify the key sinks for sediments and nutrients.

- The dominant processes that drive estuary behaviour determine the susceptibility of estuaries and their adjacent near-shore areas to various catchment pressures such as changes in turbidity, circulation and sediment trapping/nutrient enrichment. Sedimentation caused by catchment erosion, for example, is particularly significant for wave-dominant estuary systems because this type of estuary has a high tendency to trap sediment in the lake environments that characterise them. In comparison, tide-dominant estuaries efficiently transport sediments to the near-shore marine zone with consequential marine environmental impacts.

Figure 67. Estuary types and their typical characteristics.

Type of coastal environment	Sediment trapping efficiency	Turbidity	Circulation	Risk of sedimentation
 Tide-dominated delta	low	naturally high	well mixed	low
 Wave-dominated delta	low	naturally low	salt wedge/ partially mixed	low
 Tide-dominated estuary	moderate	naturally high	well mixed	moderate
 Wave-dominated estuary	high	naturally low	salt wedge/ partially mixed	high
 Tidal flats	low	naturally high	well mixed	low
 Strandplains	low	naturally low	negative/salt wedge/partially mixed	low

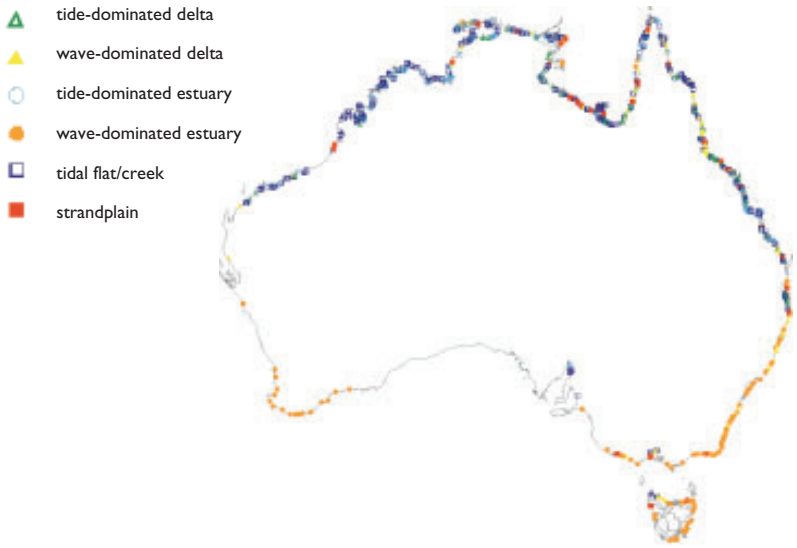
Data source:

Australian Catchment, River and Estuary Assessment 2002 (Figure 55, p. 129)

For the 1000 estuaries assessed, key processes and therefore management opportunities and constraints vary.

- In much of southern Australia, wave-dominated systems are common, with most of the catchment-derived sediment and enrichments staying within the estuaries. For much of tropical Australia, tide-dominated systems are common, with the estuary acting more as a conduit than a sink. In these systems much of the catchment-derived sediments and enrichments are exported to the near-shore zone, such as to the Great Barrier Reef lagoon.

Figure 68. Distribution of Australia's estuaries by process type.



Data source:

Australian Catchment, River and Estuary Assessment 2002 (Figure 47, p. 120)

Data assumed to be correct as received from the data suppliers

Half of Australia's 1000 estuaries are in near-pristine condition.

- Of the remaining 50% of Australia's estuaries that are not in near-pristine condition, a further 22% are largely unmodified, 19% are considered modified and 9% are regarded as extensively modified.

Figure 69. Location of the near-pristine, the largely unmodified, the modified, and the extensively modified Australian estuaries.

Data source:

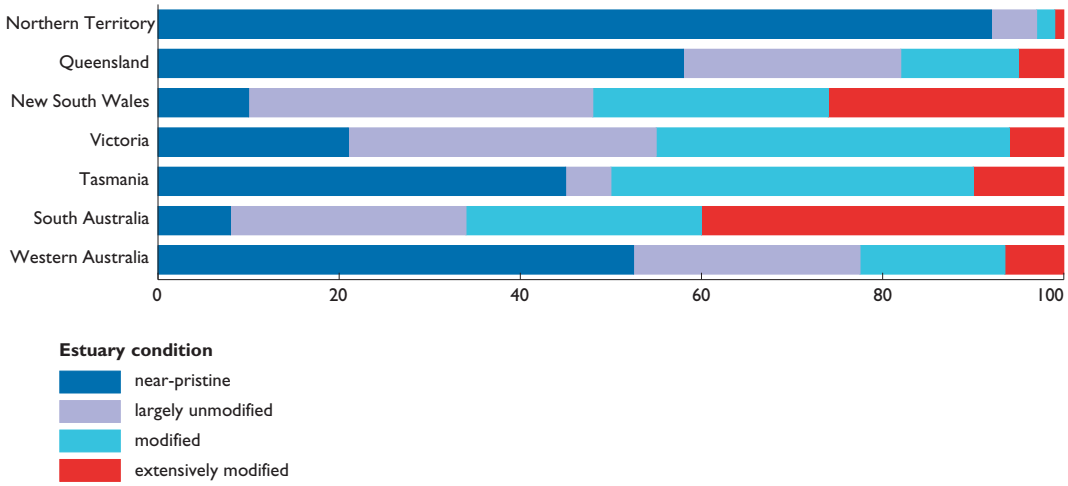
Australian Catchment, River and Estuary Assessment 2002 (Figure 56, p. 133)

Data assumed to be correct as received from the data suppliers

Estuaries have value as productive ecosystems and a key role in biodiversity and fisheries.

- Many fish species are estuary-dependent in larval or juvenile phases. Protective management arrangements for Australia's pristine estuaries will deliver multiple benefits. They will also be more effective in the long term obviating the necessity to undertake rehabilitation that may be expensive or even not possible. These pristine estuaries are spread around the States and provide the keystone for an effective estuarine and marine management program.

Figure 70. Condition of Australian estuaries by State and Territory (%).



Data source:

Australian Catchment, River and Estuary Assessment 2002 (Figure 63, p. 144)

Data assumed to be correct as received from the data suppliers

PEOPLE INCORPORATING ECONOMIC & SOCIAL CONSIDERATIONS

Profit at full equity is variable across the agricultural commodities.

- Over the five years to 1996/97, total profit at full equity from agriculture averaged $7.5 billion, with the commodity groups of dairy, cereals and cotton accounting for over 50% of the profit. The comparatively depressed state of the sheep industry over this period is readily apparent.

Table 10. Profit at full equity by dominant land use type.

Land use*	Five-year mean ($m)	1996/97 ($m)
Dairy	1 649	1 590
Cereals	1 305	1 836
Cotton	1 089	1 213
Fruit	951	889
Coarse grains	649	560
Vegetables	593	508
Beef	578	-718
Grapes	482	468
Sugar cane	264	167
Tree nuts	68	71
Oilseeds	63	93
Rice	48	52
Legumes	19	85
Peanuts	17	23
Tobacco	15	13
Hay	9	11
Sheep	-270	-306
Total	**7 530**	**6 555**

Data source:

Australians and Natural Resource Management 2002

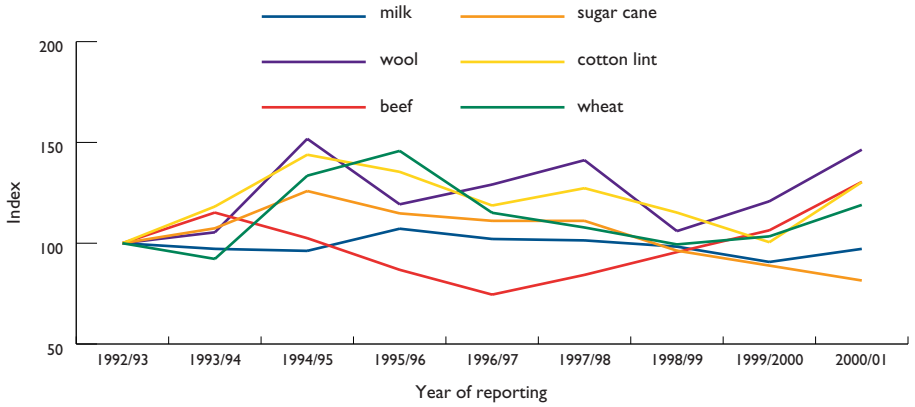
Data used are assumed to be correct as received from the data suppliers

* Figures are Australia wide including extensive and intensive agriculture. They have not been segmented industry sectors, such as intensive beef or feedlots. Profit from production from mixed farming enterprises (e.g. a wheat–sheep farm) are proportionately reported within each 'land use' class.

Profit at full equity is an indicator worthy of continued analysis.

- Since 1996/97 wool, sheep meat and beef prices and profits have recovered significantly. Undertaking regular re-analysis of profit at full equity, building on agricultural census results, will assist policy makers in understanding the comparative shifts and positions of all commodity sectors.

Figure 71. Price movements for major agricultural commodities from 1992/93 to 2000/01 with 1992/93 used as the base year.



Data source:

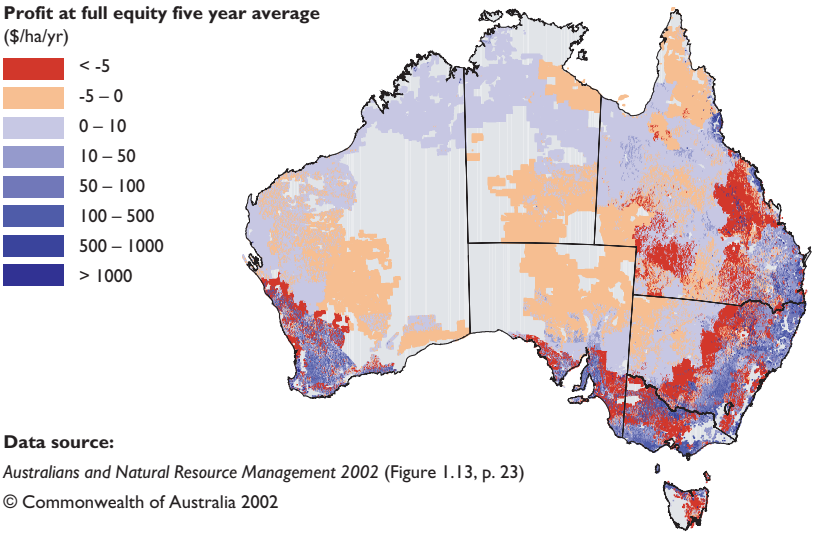
Australians and Natural Resource Management 2002 (Figure 1.15, p. 25)

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

Managing lands for maximum Australian agricultural productivity can be concentrated in key areas.

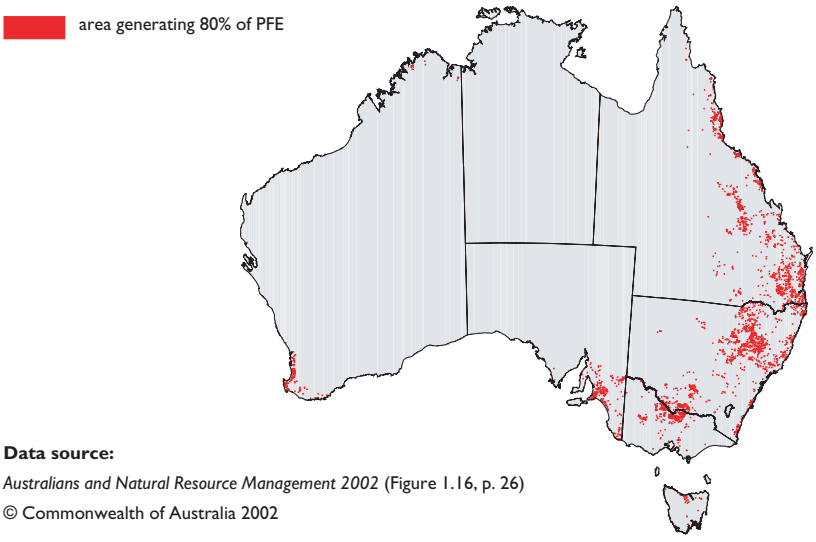
- Of 454 million hectares used for agriculture and pastoralism, 6% is used for cultivation and intensive farming. A very small proportion of the Australian total agricultural landscape produces most of the net return to land, water, capital and management. Eighty percent of profit at full equity comes from about 4 million hectares, or less than 1% of the area used for agriculture and pastoralism in total.

Figure 72. Profit at full equity—five-year average (1992–1996).



Data source:
Australians and Natural Resource Management 2002 (Figure 1.13, p. 23)

Figure 73. Areas in Australia accounting for 80% of profit at full equity, 1996/97.



Data source:
Australians and Natural Resource Management 2002 (Figure 1.16, p. 26)

Productivity can also be analysed in a catchment context, providing insights to catchment management opportunities and needs.

- Fourteen river basins out of a total of 246 account for 50% of the total profits from agriculture in Australia. Many of these basins include irrigation areas. Irrigation areas, because of their small size, capital intensiveness and close attention to management, provide a unique opportunity to improve natural resource management practices.

Table 11. Contribution of river basins to total profit at full equity.

Basin	Total profit at full equity ($'000)	Cumulative contribution to total for all agriculture (%)
Condamine–Culgoa Rivers	424 572	5.6
Murrumbidgee River	418 392	5.6
Namoi River	380 857	5.1
Avon River	303 668	4.0
Lower Murray River	302 864	4.0
Mallee	283 720	3.8
Border Rivers	266 110	3.5
Gwydir River	225 494	3.0
Broken River	197 455	2.6
Fitzroy River (Qld)	196 296	2.6
Goulburn River	193 330	2.6
Brisbane River	191 824	2.5
Broughton River	168 094	2.3
Macquarie–Bogan Rivers	159 375	2.1
Subtotal	3 712 051	49.3
Rest of Australia	3 817 938	50.7
Total	**7 529 989**	**100.0**

Data source:

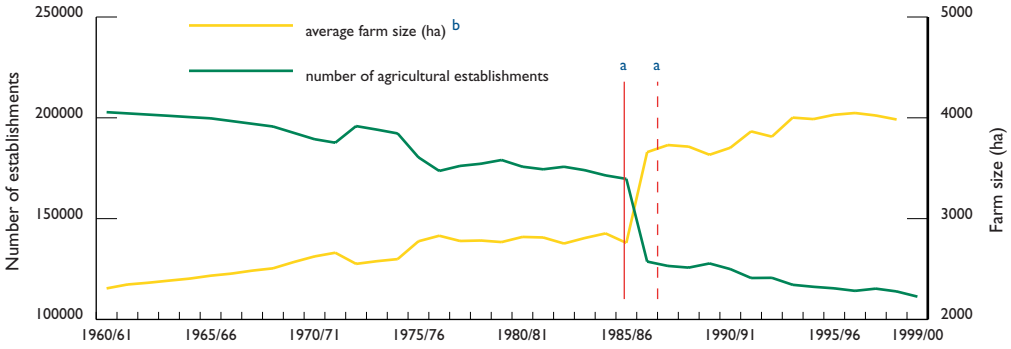
Australians and Natural Resource Management 2002 (Table 1.7, p. 25)

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

Australian agriculture is continuously changing in a social context.

- The number of agricultural establishments or farming businesses has declined, but the average size of farms has markedly increased. These indicate a robust and market responsive agricultural sector. These trends in Australia are similar to many other developed economies.

Figure 74. Change in farm number and area (1960–2000).



Data source: ABARE (2000)

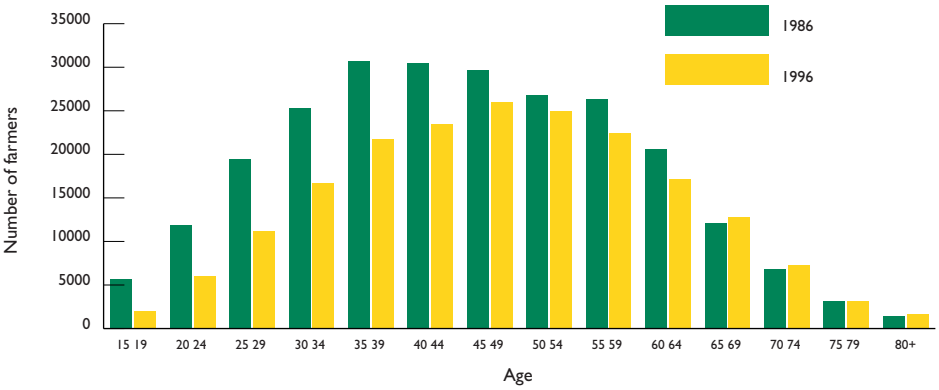
a Alteration due to change in definitions by ABS

b Derived by dividing total area of farms by the number of agricultural establishments

Demographics of Australian farmers is changing.

- Over the past decade, there has been an underlying trend of fewer young people entering agriculture, with a concomitant increase in the average age of farmers including the managers responsible for the natural resource management of the 60% of Australian land that is principally in agricultural or pastoral use (Figure 3). The low recruitment of younger persons may reflect adjustment decisions to move out of agriculture—an adjustment process that has been going on for many years, and is a logical response to changing technologies and markets in agriculture.

Figure 75. Number of persons with farming as their main occupation by age group 1986 and 1996.

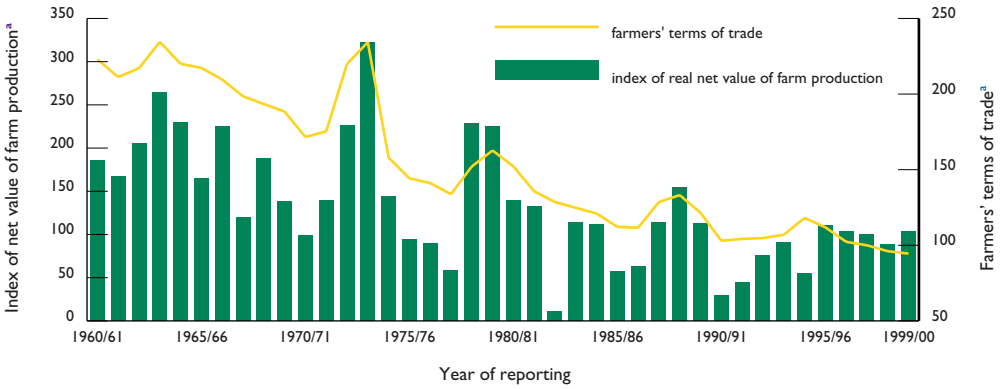


Data source: ABS Australian Population and Housing Census

Australian agriculture reflects worldwide trends in terms of trade.

- Farmers' terms of trade and the net value of agricultural production have both shown strong downward trends. Farmers have responded to these changing conditions by adopting more efficient technologies.

Figure 76. Farmers' terms of trade and the real net value of agricultural production.



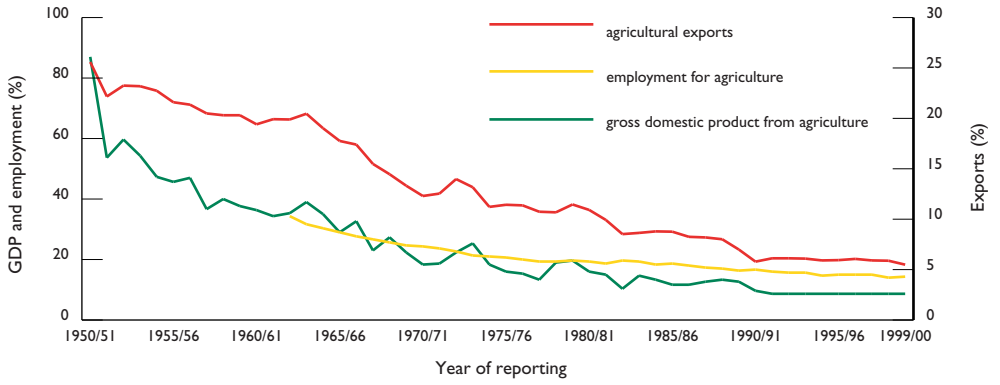
Data source: ABARE (2000)

a Indices with base or reference year 1997/98 = 100. Farmers' terms of trade is the ratio of the index of prices received by farmers to the index of prices paid by farmers.

Structural changes in agriculture are an inevitable consequence of economic maturity.

- Structural change occurs as any economy moves away from a heavy reliance on the primary industry sector. In Australia's case, economic dependence on agriculture has declined markedly over the past thirty years.

Figure 77. Contribution of agriculture to economic growth (GDP), employment and exports.



Data source: ABARE (2000)

Australian farm families are broadly similar to the Australian community in income distribution.

- The similarity between the income of farm families and non-farm families, including other rural families is striking. This is probably indicative of the economic maturity and continuously improving productivity of the Australian agricultural sector, mirroring the broader Australian community in characteristics.

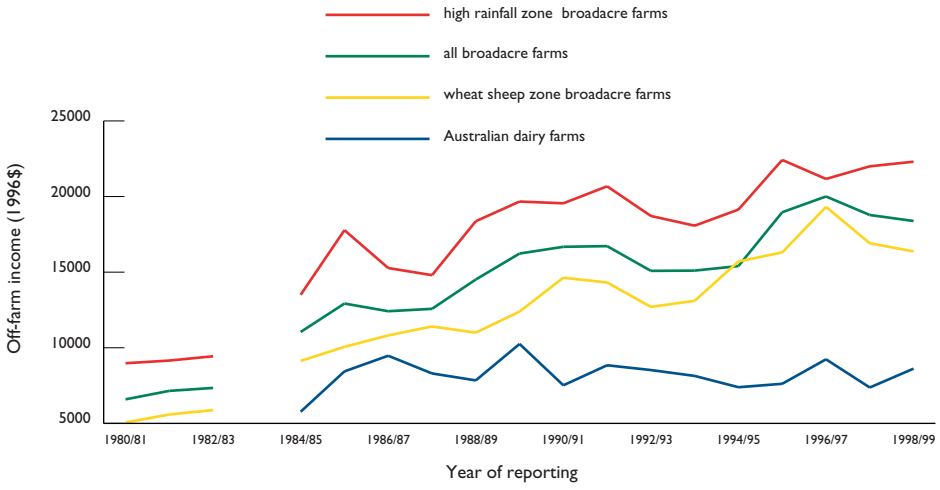
Figure 78. Australian farm family income distribution and Australian family income distribution in 1996.

Data source: Australian Bureau of Statistics Population and Housing Census (1997)

Off-farm income has been a key response to changing economic circumstances.

- The increasing reliance of farm families on dual incomes replicates trends across the developed world. As in many other countries, the shift towards the two-income family is the middle-class norm that has taken place in the past generation. This is reinforced by an increasing trend in many developed economies towards part-time farming.

Figure 79. Annual off-farm income earned on Australian broadacre and Australian dairy farms 1980 to 1998.



Data source: Australian Bureau of Agricultural and Resource Economics Farm Surveys.

The challenge facing natural resource managers, including farmers, is to develop farming systems that are both increasingly productive and sustainable.

- Farmers' adoption of new technologies and practices is part of the move towards increasing production efficiency and improved natural resource management. Australian farmers have a long tradition of innovation and adoption of new farming practices. In evaluating options for moving towards greater sustainability, landholders generally will adopt practices that provide economic advantage (that may depend on prevailing commodity prices), but will also seek to reduce the risk of adopting a new practice by adopting those which are observable, trialable and less complex than alternative options.
- Duty of care, continuous improvement in practice, property rights and stewardship incentives are essential to deliver improved natural resource management. Partnerships across community, industry and government enable management. Information and assessments underpin management.

APPLYING AUDIT FINDINGS & METHODS

As Audit products have been completed, they have been progressively made available and tested.

Uses of Audit products

- As part of the *Australian Water Resources Assessment 2000* activities, the Western Australian Water and Rivers Commission revised its surface water and groundwater data systems, improving them at the same time as collating data. The Audit's Australia-wide report has since been complemented by the State-wide report published by the Western Australian Water and Rivers Commission. Western Australia continues to build on the Audit activities by developing water resource information and monitoring systems to link with water resource data.
- The Australian groundwater flow system classification was developed as part of the Audit's *Australian Dryland Salinity Assessment 2000* activities to provide a technical framework for a hydro-geological assessment and the identification of salinity management options. This technical framework has now been refined at regional scales and adopted by the Murray-Darling Basin Commission; Department of Primary Industries, Water and Environment, Tasmania; Department of Water Land and Biodiversity Conservation, South Australia; Department of Natural Resources and Mines, Queensland; and catchment management groups across Victoria, New South Wales and Queensland.
- The groundwater flow systems classification has also been used as a basis for defining monitoring and evaluation guidelines for the Natural Heritage Trust extension and National Action Plan for Salinity and Water Quality.
- The South Australia Department of Environment and Heritage has already adopted the National Vegetation Information System database and mapping framework developed in the *Australian Native Vegetation Assessment 2001* as part of its core operational and data management activities. Other States and Territories are reviewing their data management systems with an Australia-wide commitment to migrate to the National Vegetation Information System.
- Rangelands Australia, based at the University of Queensland in Gatton, is using the rangelands theme report *Rangelands – Tracking Changes* as a basic input to short courses offered in 2002. Like many other universities, it recognises the Australian Natural Resources Atlas as a valuable information resource for the graduate and postgraduate courses. (JA Taylor, Rangelands Australia, pers. comm. 2001).
- The Audit's work on sediment and nutrient loads and transport down rivers, described in *Australian Agriculture Assessment 2001*, was the main river by river modelled input used to calculate water quality targets for Great Barrier Reef catchments. These Audit data, together with a number of data sets collected in the field, were used by scientists from the Great Barrier Reef Marine Park Authority and Australian Institute of Marine Science to determine the targets. Work continues to refine targets. Community groups such as the

Fitzroy Basin Association and the Mackay–Whitsunday Water Quality Group are using the Audit data to help identify key sites and subcatchments for erosion control activities.

- The Murray-Darling Basin Commission used the results of the Assessment of River Condition from *Australian Catchment, River and Estuary Assessment 2002* as the primary source of data, methods and information for its publication *Snapshot of Murray–Darling Basin River Condition*.
- As a result of the Audit, the Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management and lead State agencies have formed a consortium for Australia-wide estuary monitoring and management, building an Australia-wide approach to estuary management. An estuary management handbook is being developed with support from the Fisheries Research and Development Corporation.
- The foundation agreement between the Audit and Australia New Zealand Land Information Council, for the provision of government-held spatial data for use in mapping Australia's natural resources, has now been adopted by the Australia New Zealand Land Information Council as a model agreement between Commonwealth, State and Territory agencies for the sharing of natural resource spatial data including those from the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality.
- The Audit's work across Commonwealth agencies highlighted the need for an improved policy and approach to access and use of Commonwealth spatial data. The Commonwealth Government through Cabinet has endorsed proposals for revised policy and the formation of the Commonwealth Office of Spatial Data Management—building on the Audit experiences and extending the concept to spatial data management across all disciplines as well as natural resources.
- The Western Australia Land Information System (WALIS) has adopted and adapted the MapMaker software developed for the Australian Natural Resources Atlas to replace and upgrade their community information delivery systems. The Department of Natural Resources and Mines, Queensland is doing likewise.
- A comprehensive review of Audit findings is providing input to the policy and program development of the Natural Resource Management Ministerial Council's Land, Water and Biodiversity Advisory Committee.

3. AUSTRALIA'S NATURAL RESOURCES: looking ahead

Natural resource management in Australia is changing. Responsibility for innovative approaches to local problems is increasingly being delegated to regional and local groups and managers. People are being encouraged and in some States are already empowered to participate in the design and implementation of innovative solutions based on local knowledge and experience within their own catchments. An all-encompassing, community-driven approach involving encouragement, partnerships and local commitment is being given greater emphasis than an externally driven regulatory approach.

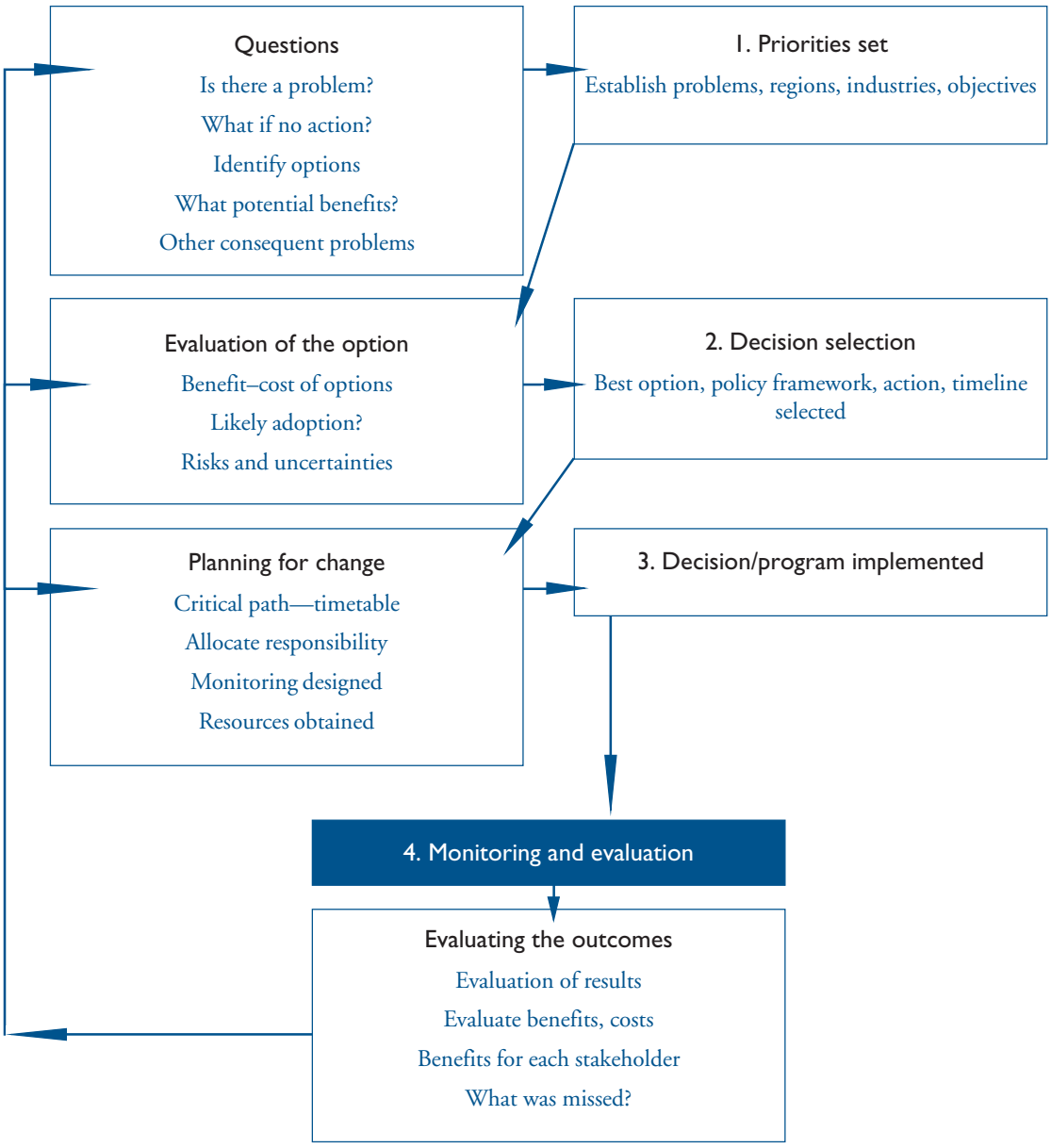
The future management of Australia's natural resources depends on adopting a common understanding of and approach to the task.

Key ingredients for natural resource management in Australia

- **Multi-faceted approaches** across disciplines and issues.
- **Planning** based on regions of common or linked management interests.
- **Spatial assessment and management frameworks** that consider available data; scale of management responses; and the 'total' system for example catchments, bioregions, groundwater flow system, landscape/land system units.
- **Partnerships** that are wide ranging across industries, government, science and community groups.
- **Commitment**, facilitation and resources provided by local, State and Commonwealth governments.
- **Shared vision** for a region that recognises trade-offs between competing social, economic and environmental demands.
- **Solutions focus** providing pragmatic and solution-orientated activities that make best use of often incomplete data and scientific understanding.
- **Cost-effective delivery** emphasis on key components where improvement can be achieved, based on an analysis of costs, benefits and likely return on investment of various opportunities.
- **Opportunistic management** identifying key management opportunities, promoting common property resource stewardship and protective management of ecosystems in natural condition.

These ingredients apply equally to information provision. Information based on ready access to data, sound underpinning science, and subsequent monitoring and evaluation of programs and their outcomes, are all crucial to the success of any natural resource management program. As an aid to reaching soundly based decisions, the Audit has summarised the key processes of natural resource decision making and project implementation in a model (Figure 80).

Figure 80. Phases in natural resource management decision making.



Access to information

Information, partnerships, property rights and incentives are four key components identified for natural resource management (John Anderson, Deputy Prime Minister, ABARE Outlook Conference, 7 March 2002).

Investment in information is essential as it provides the context for:

- **policy development**, particularly at State and Australia-wide scales (e.g. the development of the Council of Australian Governments water allocation and management arrangements);
- **understanding** to build an ethos of sustainable natural resource management behaviour and stewardship across all sectors of the Australian community;
- **planning**—especially regional planning—as a way to engage community, industries and government in natural resource management partnerships;
- **decision making** that is evidence-based and uses information collated from data sets at scales from local and specific through to regional and national (e.g. assessment under the *Environmental Protection and Biodiversity Conservation Act 1999* [Cwlth]);
- **establishing priorities** and setting targets (e.g. the Great Barrier Reef Marine Park Authority Catchment Water Quality target);
- **program implementation** to monitor progress and finetune delivery of major programs (e.g. the National Action Plan for Salinity and Water Quality and the Natural Heritage Trust); and
- **making improvements** in management and practice to develop and implement, through industry, community and agency partnerships, activities such as sustainable and productive farming systems, ecologically appropriate fire regimes and pollution-minimising waste treatment systems.

The information must be based on rigorously collected data. Sound data allows changes in resource condition to be tracked and policy and management initiatives to be evaluated, an essential basis for continuous improvement and to show with certainty the extent of any benefits from investment in natural resource management programs.

We need a portfolio of natural resources data sets, collation and assessment tools and information packages aligned with policy instruments and refined within the context of public and private benefits. Australia has made progress through the Audit. This work has revealed shortcomings in the structure and breadth of natural resources data. Carefully planned and coordinated enhancement of the Australia-wide effort in data gathering and information provision, will yield environmental and economic benefits well beyond the level of investment.

RECOMMENDATION 1

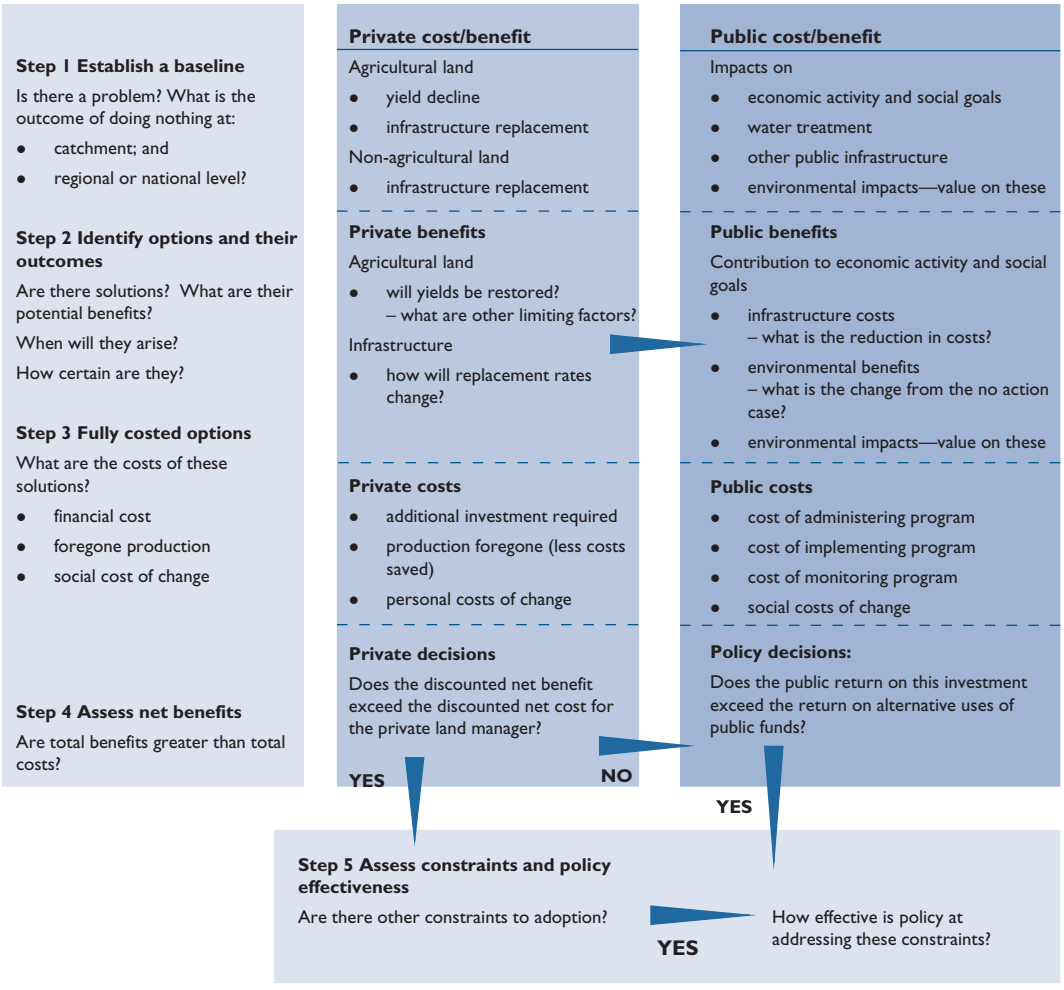
To deliver on the vision for improved natural resource condition, conservation and productive use of its natural resources, Australia through partnerships and contributions across government, industry and the community, should strategically increase its investment in data collection and collation, the provision of information and its application and making it available at cost of transfer, for use by the community and industry.

Adoption of improved management practices can be encouraged with the use of incentives. Market forces are increasingly providing some of these incentives. They may be driven locally by consumer expectations in retail trade, or internationally in negotiating forums such as the World Trade Organisation.

Policies are now being implemented using market-based mechanisms. Natural resources property rights and their tradability in markets serve as further incentives to improve economic and resource use efficiency.

In considering policy change, government evaluates the respective extents of private and public costs and benefits (Figure 81). Although this differentiation is commonly addressed in public policy making, it is less readily recognised by private landholders. Landholders' decisions sometimes have public benefits, may also have public disbenefits.

Figure 81. Framework for options assessment by natural resource management policy makers.



Changes in natural resource condition develop slowly but progressively with time. Amelioration and/or reversal can also involve considerable lengths of time from adoption to implementation to completion to achieving desired outcomes. It is imperative to recognise the need for policy direction as quickly as possible, a requirement that can be most effectively met with good data access and information services.

Policy options should consider incentives and disincentives that may be available to encourage private decision makers and managers to maximise any public benefits.

With a limit to our natural resources and competing demands for their use, policy developers and natural resources managers will always need to balance the merits of proportionate investment in alternative options. The quality of these trade-offs will be maximised by having access to sound information underpinned by standardised data sets upon which comparative judgements can be made. Most will require a consideration of private and public benefits resulting in a private–public partnership approach to natural resource management based on a shared knowledge and understanding of natural resource processes, economic opportunities, and nature conservation needs. The Australian Natural Resources Atlas and Data Library coupled with similar systems available in some States, Territories and regions are tools for making information available and facilitating the prerequisite comparative analysis. There is a need for greater awareness of their initial potential and the increasing benefits from their continuing development to add strength, better integration and more effective collaboration to natural resource decision making. Part of the Commonwealth response to this demand will be fostering knowledge interchange and support to regional groups within Audit activities 2002–2007.

Much remains to be done to build evidence-based, decision-making processes into our natural resource decisions at all tiers of government. Nevertheless the foundations are in place and provide the basis for the following sections detailing natural resource management opportunities and imperatives for Australia.

RECOMMENDATION 2

Based on strategic and integrated information provision, Australia needs to increase its activities in knowledge exchange, investing in a variety of government, industry and community based extension and support services that translate natural resources information into understanding, improved practice and the setting of goals and targets, providing decision support techniques and applying these at regional through to national scales.

Opportunities for improved management

Use of Australia's natural resources continue to change as management systems, market opportunities and conservation demands evolve. These factors affect both on-farm and off-farm resource use options and the condition of the natural resource base. Despite the adaptability of Australian agriculture and increases in productivity, the Audit has highlighted a range of deteriorating components of land quality, including:

- salinity (affecting 1% of agricultural land in Australia);
- water borne soil erosion (with hillslope, gully and river bank erosion varying in relative proportions and importance across Australia);
- widespread soil and nutrient redistribution and loss; and
- increasing soil acidity (threatening productivity on 25% of agricultural land).

As a consequence, there is diminished health of streams, estuaries and adjacent inshore waters.

Although not addressed by the Audit in its first phase of assessments, further but uncosted impacts occur on fisheries, general ecology, biodiversity and recreational amenity.

Improvements in farming systems and a more integrated landscape or catchment-scale approach to natural resource management are delivering improvement in the condition of our natural resources. Continued improvements will largely depend on further improvements in land management practices. In some cases, changes in land use may have to occur, particularly where the current uses are unsustainable. If we are to foster improved practices we need better linking between environmental management systems, property planning, soil use and nutrient practices and catchment management programs. These links encompass key issues such as riparian land management and most importantly, incentives to foster the changes through a more integrated approach to land-management decision making.

Activities on-farm can be broadly classified as:

- economic—those delivering a strict economic, market-driven return;
- duty of care—the responsibilities of any landholder to manage resources sustainably; and
- stewardship—works undertaken for broader benefit of the public and future generations.

Recognising the well-documented trend of declining condition in our public resources including landscapes, rivers and estuaries, a more integrated approach across these broad activities is essential and needs to be fostered through a range of policy mechanisms.

Changes towards more sustainable practices, tracking progress in the adoption of practice and resource condition, and effective outcome monitoring through consistent data gathering are essential. This will allow both public and private land managers to initiate new programs, measure the changes, and evaluate the outcomes—as part of a process of continuous improvement.

To meet the increasing demand for use, productivity and health information, an integrated and coordinated monitoring and assessment program needs to be implemented that builds on existing activities—particularly those within the State and Territory agencies.

Land resources

Access to land for productive purposes is the linchpin of the nation's agriculture and forestry. In the first two hundred years following European settlement, new agricultural land was being 'opened up'. In more recent years, the limits to the intensive land use zone have largely become determined, and land managers have moved to make more intensive use of land (e.g. by the adoption of continuous cropping systems, new agricultural chemicals and new genetic materials). As a greater cognisance has developed of the limitations in our land resources, programs such as the National Soil Fertility Program, the National Soil Conservation Program and more recently the Landcare initiative have been introduced.

Opportunities with potential for improving land resource management

Data from the Audit have highlighted opportunities for improving the management of our land resources. These include:

- Encouraging a more integrated approach by individual landholders, and community groups and authorities at the regional/catchment level to the complexities of sustainable land management, including salinity management; increasing soil acidity; the impact of climate variability on sustainable use of land resources; the role of diagnostic services in soil nutrient management; and the appropriate targeting of differing forms of erosion management based on access to sound monitoring.

EXAMPLES OF INTEGRATED LAND RESOURCE DECISIONS

Identifying groundwater flow systems/hydrology of individual basins to determine possible management strategies and their likelihood of success.

Using market mechanisms to encourage improved water balance in key recharge areas, possibly involving transfer of financial resources to salinity-affected owners to encourage adaptation or remediation

Evaluating the benefits from investment in treating soil acidity as compared with dryland salinity and soil sodicity, the latter being an inherent constraint in much of agricultural Australia (Figure 29).

Encouraging uptake of soil diagnostic tests that link soil physical, chemical and biological condition to productivity; and minimise nutrient, sediment and soil pests and disease export to rivers and estuaries. These tests will contribute to profitability, with partnerships being developed between government, the fertiliser industry and its clients to regionally and routinely present the results of soil testing

More effectively controlling soil erosion by targeting the variability and specifics of sheet, rill, gully and riparian erosion, noting that the Audit has assessed that approximately 90% of erosion sources are in only 20% of catchment areas.

Reinstating selected wetlands and riparian lands to re-establish trapping mechanisms that capture sediment and nutrient exports from agricultural lands.

- Providing better access to information on the relationships between farming practices and natural resources condition and responses, and on opportunities for changing production techniques to more effectively manage land.

ACTIVITIES TO IMPROVE LAND MANAGEMENT AND PRODUCTIVITY

Introducing local training programs commissioned at the landscape scale and co-sponsored by government and industry, so that resource managers can learn to access information on the impact of management decisions on resources, particularly the less obvious off-site impacts. This would lead to greater confidence in addressing natural resource issues.

Development of new enterprise combinations using revenue streams that allow land management to be undertaken responsibly and profitably. Viability of a cereal/sheep enterprise, for example, might be strengthened by the strategic establishment of forestry and native vegetation. This would lead to improved revenue streams by restoring productivity of salt-affected land, through use of more salt-tolerant crop and pasture species, and from the sale of timber. It has been hypothesised that further revenue streams may develop if natural resource markets are implemented. These possibilities include sale of carbon credits from timber growth, marketing of tourism and amenity value, sale of salinity credits, sale of catchment water filtration services to an urban water authority and sale of biodiversity credits to a natural resource management authority.

Increased regional climate data sets and locally adoptable climate applications to allow land managers to assess inter-seasonal climate risks and make adjustments to meeting both economic and environmental sustainability objectives. Relevant techniques include crash grazing/pasture spelling based on feed availability and seasonal climate change, and use of predictive tools such as 'Aussie GRASS' so that destocking occurs well before major drought onset.

Concentrate farming on the areas of high productivity using modern evaluation and management techniques. Land managers to be encouraged to withdraw from areas of low productivity and high natural resource hazard. Tools include 'precision agriculture' and vertical industry expansion programs (e.g. the cane industry's encouragement of higher production through improved production on current lands rather than developing new lands).

Develop strategic packages for industry to encourage their assumption of responsibility in planning and development of natural resource strategies that foster farm practice improvements with outcomes evaluated by regular data collection and monitoring. The Dairy Industry's 'Sustaining our Natural Resources – Dairying for Tomorrow' that includes eight regional action plans (Dairy Research and Development Corporation 2001) is a good example.

Encourage quality assurance and/or best management practice programs that take account of environmental standards or of formalised environmental management systems. Industries will thus be able to demonstrate to international markets that products are derived from ecologically sustainable systems, responding to an increasing requirement for some form of environmental credentials to assure market access.

- Building into new public programs a series of incentives that will promote the adoption of improved natural resource management practices while linking with the achievement of public benefits.

ACTIVITIES THAT ENSURE RESOURCE MANAGEMENT BENEFITS

Reducing risks to public infrastructure by identifying likely public benefits from public co-investments towards the management of privately owned land.

Require evidence-based proposals from regional and community groups, with eligibility for government-sponsored programs being predicated on evidence that sources of known regional data have been accessed in the development of the program proposal, that provision for natural resource monitoring and evaluation of the outputs have been included, and that the data obtained in this way is to be made available for inclusion in the Australian Natural Resources Data Library.

Eligibility for personal participation in government-sponsored programs in agriculture to be underpinned by evidence that applicants have accessed appropriate natural resources information sources to ensure their planning will achieve profit within a framework of environmental responsibility.

Providing land information

To achieve effective management of the productivity and ensure responsible stewardship of our land resources, regular updating of the Australian Soil Resources Information System and the correlation of soil properties to a series of key information sets and assessment activities will provide the basis for strategic investment in land management—to maximise their productivity, minimise off site impact and maintain soil condition. Key information sets and assessment activities to be correlated with the Australian Soil Resources Information System and provide the information basis for improved soil management include:

- nutrient budgets—providing a basis to finetune fertiliser applications for maximum productivity and minimising fertiliser losses off farm;
- water balance—providing a basis to maximise soil moisture use and productivity and minimise water surplus to recharge so that dryland salinity and waterlogging can be improved;
- pH levels—providing a basis for adding ameliorants and modifying practices to minimise the likelihood of soil acidity;
- soil erosion budgets, tracking losses from water-borne and wind erosion, correlating trends with improvements in on-farm and urban practice and also providing input to the assessment of the condition of rivers and estuaries;
- soil management practices—tracking industry by industry changes and encouraging improvements in practice to maintain soil health, maximise productivity and minimise exports off site;
- development opportunities and constraints—providing input to land-use planning;
- program performance—incorporating the outputs of various natural resources programs and activities including Landcare; and
- soil carbon budgets for soil health, productivity and as an input to the National Carbon Accounting System.

RECOMMENDATION 3.1

To meet the increasing demand for information on Australia's land resources, their use, productivity and health, Australia should implement an integrated land monitoring program that tracks soil condition, monitors soil, water and nutrient budgets, details land management practice, links practice to soil condition and productivity and is based on the Australian Soil Resources Information System.

Water resources

Water is a scarce and valuable resource in Australia. The Audit has collated and reporting on the availability and environmental status of surface water and groundwater resources, rivers, and estuaries. It has highlighted limitations on how water is managed and Australia's dependence on irrigation for half the profit at full equity from the nation's agriculture.

Management of Australia's water resources is increasingly attracting a more integrated, Australia-wide, community-oriented approach to meet multiple objectives. Issues being addressed include:

- mechanisms to better secure trade-offs between economic, social and environmental needs for this finite resource;
- improved definition of water management objectives (e.g. in the Murray–Darling Basin where goals are now to meet production outcomes water quality obligations and an environmental requirements);
- introduction of property rights, clearly defined in terms of who owns the water, and where and what are the management obligations of landholders to manage their irrigation water use, with any approved delivery to waterways being of a specified minimum quality;
- integrated catchment assessments, based on an understanding of hydrology and how it changes with factors such as land use, tributary watercourse development and farm dam construction;
- water trading mechanisms, including incorporating non priced benefits of water uses;
- cross-compliance mechanisms, linking land management and improvements in current practices such as tailwater recycling to ensure water use efficiency and water quality outcomes; and
- management of flood and drought—both being natural phenomena integral to the health of natural ecosystems and landscape renewal, but often mitigated or controlled by infrastructure to minimise impact on productive land uses

Opportunities with potential for improving water resource management

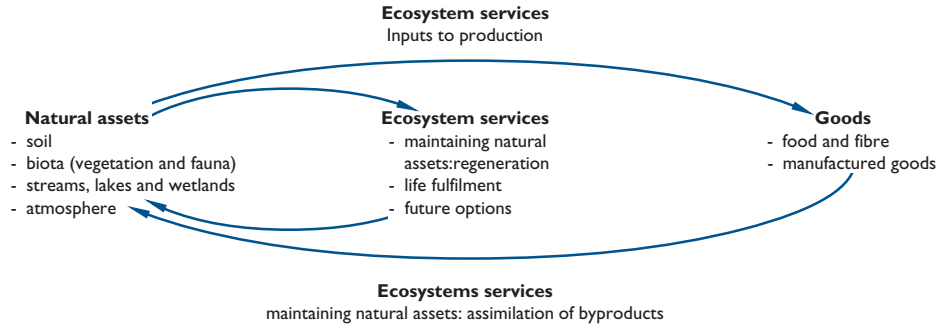
Some of the following potential opportunities are already being considered.

- Developing a more integrated understanding of water resources, including an understanding of the ecosystem components and how they contribute to the quality and quantity of Australia's water resources. Ensuring responses though water resource management are themselves integrated to generate the best economic, environmental and social outcomes while still meeting sustainability objectives.

UNDERSTANDING INTEGRATED WATER RESOURCES

Identifying and facilitating the contribution of 'ecosystem services'. Ecosystems services involve transforming a set of natural assets—soil, plants and animals, air and water—into things that we value including provision of clean and pure water; sustained supply of plant nutrients; maintenance of a liveable climate; and clean, breathable atmosphere. Environmental standards required for the regional planning and management of riparian lands, rivers and estuaries will be better defined by incorporating a consideration of ecosystem services.

Figure 82. Ecosystems services conceptual framework: a conceptual framework developed to illustrate the role of ecosystem services in maintaining assets and in supporting the production of goods of value to the Goulburn–Broken catchment in Victoria



Source: Australian State of Environment Committee 2001

Establishing and adopting Australia-wide, agreed definitions and methods for determining sustainable flow regimes for surface waters and sustainable yield for groundwater resources.

Establishing and maintaining sustainable flow regimes for all developed rivers. The Australian natural environment has significant inter-seasonal variation in surface water flows. These processes will involve limiting the surface water that is potentially divertible from a catchment after taking account of environmental values and making provision for environmental water needs.

Establishing sustainable yield regimes for all highly used aquifers. The Australian natural environment has significant inter-annual variation in recharge. In most cases, groundwater resources require long time frames for replenishment. Establishing sustainable regimes would include providing for maintenance of groundwater quality, pressure and environmental values, and for environmental water needs (e.g. mound springs and other groundwater dependent ecosystems) and ensuring integration with surface water management through conjunctive use strategies.

Fostering an understanding of the links between land and water resource management (e.g. generating remediation works in the riparian zone to improve water conservation and quality).

Progressively establishing inter-jurisdictional agreements for all catchments and underground water resources spanning State and Territory borders based on agreed Australia-wide standards for water resource management. Current examples include the Border Rivers agreement between New South Wales and Queensland, and the Border Groundwaters Agreement between Victoria and South Australia.

MULTI-OBJECTIVE NATURE OF WATER RESOURCE MANAGEMENT

Figure 83. Surface water (left) and groundwater (right) basins spanning the South Australian border to adjacent States or the Northern Territory

State Water Plan 2000, South Australia

The multi-objective nature of water resource management can be well demonstrated in the Murray–Darling Basin where current objectives provide for water resource outcomes over and above the minimum entitlement flow of 1850 GL at the South Australian border. These objectives have their basis in the Murray–Darling Basin Agreement:

- A cap on diversions to underpin water resource security and address over-allocation;
- Water for meeting quality standards or 'dilution flows' (e.g. maintaining water salinity levels at Morgan below 800 EC units 95% of the time);
- Water for needs of landscape biodiversity or 'environmental flows' (e.g. in maintaining the viability of the Barmah–Millewa Forest); and
- Water to maintain estuarine water condition (e.g. in the Coorong by ensuring adequate flushing flows through the Murray mouth).

Figure 84. The Murray mouth nearly closed, 28 November 2001.

Photography supplied by MAPLAND
Environmental and Geographic Information
Department of Environment and Heritage

- Developing strategies with incentives and targets that encourage greater water use efficiency from existing installations and new developments.
- Considering water resource developments from a natural resource management perspective as well as from an economic efficiency perspective.

ACHIEVING WATER USE EFFICIENCY

Ensuring access to and use of sound, current water resources data. While meeting community expectations of improved conservation standards, these will underpin:

- policy development and implementation in strategic water resource planning (currently at various stages of development);
- bringing farm dams within a management framework (there is considerable divergence of approach between States and Territories);
- encouragement of greater water use efficiency; and
- more successful economic development.

- **Adopting water use efficiencies measures as well as alternative supply sources** to bring water allocations within sustainable flow regimes. This needs to recognise any likely environmental consequences. Strategies can include increasing the efficiency of water storages (e.g. by further developing the use of aquifer recharge techniques, such as outback areas with high evapotranspiration).

LOOKING BEYOND ECONOMIC EFFICIENCY

Facilitating the better operation of market mechanisms that allow irrigation water to move to uses with the highest economic value—recognising that its ecological footprint can be more readily managed than that of extensive agriculture.

Considering rights of access to water resources—whether for economic or non-market uses such as recreation or aesthetic enjoyment—within a multiple-use framework and keeping in mind an appreciation of the impact of each use on other uses and on the landscape.

Broadening future National Competition Council assessments of Council of Australian Governments Water Reform to take account of the achievement of physical as well as economic efficiency improvements in water management.

Figure 85. The rehabilitation and pipelining of Great Artesian Basin bores, some over 100 years old, can be used as an aid to biodiversity management as well as reducing water waste.

CSIRO Land & Water, Willem van Aken

- Improving decisions on water resource capital development within a framework of surface water and groundwater sustainability that considers the hydrology of the entire catchment, alternative water sources, and an evaluation of all alternative economic and social users and uses. Adoption of procedures described in *Large scale resource development—an integrated assessment process* (NLWRA 1999) would support such an approach.

Water resources information

From the outputs of the Audit, Australia can establish a baseline on how its water resources are used, identify ways in which water resources can be more effectively and efficiently managed, and with continued assessments, measure the progress achieved.

Development opportunities can also be evaluated from this base—opportunities involving both new schemes that foster profitable and sustainable production, and improvements to existing schemes to deliver water use efficiencies and therefore more water for both productive and environmental uses.

To respond to these opportunities, information sets and assessment activities are required at scales relevant to local water resource and catchment managers including:

- detailed water use and assessed water use efficiency opportunities;
- collated water quantity information with assessed development opportunities and environmental requirements;
- monitored changes in water quality and assessed opportunities for changes in catchment land use and practice to improve water quality; and
- tracked progress in major programs.

RECOMMENDATION 3.2

To meet the increasing demand for information on Australia's surface and groundwater resources, their use, productivity and health, Australia should implement an integrated water resource monitoring program, that tracks water use, monitors water availability and quality, details management practices and is available to underpin an Australia-wide agreed policy for sustainable water use.

Biodiversity and key ecological resources

The community is becoming increasingly aware of the uniqueness of Australia's flora and fauna. Native vegetation conservation has had progressively increasing attention over the past two decades. The Audit has brought rigour to the information sets and assessments by initiating a consistent framework for compiling data on Australia's flora—the National Vegetation Information System.

To date, public attention has primarily been drawn to the more conspicuous components of the environment such as rainforests and wet sclerophyll forests. Only now are we beginning the first steps to understand how all the biological components of the environmental jigsaw fit together with Australia's land and water resources:

- landscape management is being developed as a concept;
- community understanding is increasing; and
- the biological role and functions of ecosystems are more evident and understood in pristine natural environments and these have received much of the ecologists' attention.

The processes of change in landscapes modified for human use are less well understood. Australia's rivers and estuaries are a good example. They are key multi-use resources requiring management in a multi-objective framework. They provide high value community assets such as drinking water and estuarine/marine fisheries, are the basis for a range of commercial and non-commercial activities, and are vital components of our biodiversity, natural habitats and ecosystem services.

Although farming seeks to generate a monoculture in field or horticultural crop production, it nevertheless occurs within an adapting ecosystem that also contains competing plants (weeds); beneficial and pathogenic organisms in the soil environment; and beneficial and harmful animals, birds and insects in the above-ground environment. Managers increasingly need to know how this ecosystem works, they can influence it and its 'services' can be maximised.

The increasing use of integrated pest management in agriculture, and the use of biological remediation of polluted sites through 'land farming' are examples of the recognition of the potential of 'ecosystem services'.

Opportunities for improving biodiversity conservation and management

- **Strategic and protective management.** We need to recognise that:
  - ecosystems have a natural resilience to disturbance; and that
  - there are complementary policy approaches that encompass both biodiversity protection and the remediation of biodiversity and ecosystem loss.

- Protection is likely to be more economical than remediation. It means considering and minimising potential changes or threatening processes that may have scope for prevention; remediation involves identifying the changes that have occurred, their drivers, and potential for reversal or adaptation.

STRATEGIC AND PROTECTIVE MANAGEMENT OPPORTUNITIES

Protecting key productive and biodiverse resources (e.g. developing a protective program for Australia's near-pristine estuaries—over half of the 1000 assessed by the Audit).

Implementing protective measures for minimally disturbed broadscale ecosystems across key areas of Australia's rangeland to reduce disturbance from roads, weeds, feral animals and changed fire regimes, working in partnership with Indigenous communities.

Minimising the extent of habitat modification and loss by ensuring that key landscape function elements such as riparian lands are maintained.

Modifying land-use practices by encouraging grazing enterprise managers to manage grazing impacts and, where necessary, repair riparian zones of rivers and estuaries.

Maintaining vigilance against exotic introductions of animals (e.g. foxes, feral cats), plants (e.g. prickly acacia [*Mimosa pigra*]), pathogens (e.g. *Phytopthora cinnamomi*) and toxicants (e.g. endosulfan).

Limiting changes to the physical environment (e.g. limiting water flow modifications to minimise deleterious changes in river hydrology and ecosystems).

Minimising lost of habitat continuity, including migration paths (e.g. by ensuring continuity of fish passages up rivers).

- **Providing an information basis for better management.** A range of opportunities are available to contribute to better management of the nation's biological resources, including development of multi-dimensional ecologic models to understand ecosystem processes, encouraging partnership investment and ensuring adoption of appropriate development standards.

CONTRIBUTORS TO BETTER MANAGEMENT

Ecological models can help understand how ecosystem processes interact and the extent of resilience and flexibility they can accommodate. Components would include droughts, floods, fires, soil erodibility and fertility, topography, and water balance.

Investment—encouraged through private–public partnerships that recognise the public good role for stewardship of rare and threatened biodiversity that landholders may have in their management programs.

Establishment of standards with objectives that ensure desired biodiversity outcomes from the design of new infrastructure developments such as roads, railways and dams.

Minimisation of key point source discharges by identifying and reducing impact from facilities such as sewage treatment plants to reduce the extent of hazard and risk to riparian, riverine and estuarine ecosystems.

Biodiversity information—rivers and estuaries

Rivers and estuaries are key ecological resources. Their improved and cost-effective management requires information and assessment activities that:

- are consistent and comparable Australia-wide and based on agreed methods and spatial reporting frameworks (e.g. river reaches);
- include both physical and ecological measures that recognise the diversity of physical processes and ecological assemblages across Australia (e.g. estuaries and their wetlands are our most ecologically productive and biodiverse natural resources);
- link river and estuary condition to catchment land use and management and thereby identify opportunities for improvement in our natural resource management activities; and
- incorporate the outputs of various natural resources programs and activities such as Rivercare and Coastcare.

RECOMMENDATION 3.3

To provide sought-after information and understanding on how the ecology of our rivers and estuaries operates, including the current condition of their riparian and aquatic biodiversity, and the impact and sustainability of current and proposed management practices, Australia should implement an integrated river and estuary monitoring program that is based on agreed assessment protocols and spatial frameworks, and is reported and assessed within a catchment land use context.

Biodiversity information—native vegetation

Improved and cost-effective management of our native vegetation requires information and assessment activities that:

- are consistent and comparable Australia-wide—they should be based on agreed methods, standards and reporting frameworks as established under the National Vegetation Information System;
- provide information on current type, extent and condition, and changes in type, extent and condition;
- link with use and management activities (e.g. forestry) and identify opportunities for improving returns from investment in their management and use;
- detail regional ecosystems so that assessment and planning such as required in regional vegetation management plans are facilitated;
- build a basis for improved biodiversity management, including defining and minimising the impact of threatening processes (e.g. changes in fire regimes and the spread of weeds);
- facilitate assessment of key ecosystem services and changes in these (e.g. carbon sequestration); and
- incorporate vegetation information outputs of all natural resources programs and activities, particularly Bushcare.

RECOMMENDATION 3.4

To provide underpinning information required for the management of Australia's native vegetation, its use, productivity and biodiversity values, Australia should implement an integrated native vegetation monitoring program that tracks change in extent, monitors condition, determines levels of carbon sequestration, details management practice and returns from use and builds on and integrates data from both the National Forest Inventory and the National Vegetation Information System and links to the National Carbon Accounting System and the Australian Collaborative Rangeland Information System.

Biodiversity information—terrestrial landscapes

Adoption of landscape units should be encouraged as an appropriate framework for assessing the status of terrestrial biota and, in particular, recognising that landscape units may be more appropriate than catchments as a framework for management programs across the large arid regions of Australia.

Information and assessment activities on which to base cost-effective and efficient protection and management of terrestrial biodiversity include:

- native vegetation type, extent and condition, provided through the National Vegetation Information System;
- threatening processes (e.g. changes in fire regimes, feral animals and weeds) that are best collated at subregional scales;
- specific flora and fauna attributes (e.g. fragmentation of populations and endemism);
- distribution of threatened ecological communities and wetlands under the *Environmental Protection and Biodiversity Conservation Act 1999* (Cwlth); and
- outcomes of protective management activities (e.g. the National Reserves System and various off-park management and stewardship initiatives).

RECOMMENDATION 3.5

To provide information on Australia's terrestrial biodiversity, its condition and management needs, Australia should implement an hierarchical and landscape based bioregional monitoring and assessment program that tracks change in species, populations and regional ecosystems, determines the impact of threatening processes, details management activities and assesses opportunities for improved management.

Biodiversity information—rangelands

The rangelands make up 75% of Australia's surface area. They include ecosystems that encompass major subsets of Australia's biological diversity and are a significant natural resource that provides economic, ecological and cultural values. The demand for their use is increasing. Most of their use is built on their biodiversity, with increasing opportunities to develop complementary economic enterprises based on a multiple-use philosophy.

Expanded transport infrastructure—road and rail and air— is making travel through the rangelands easier. Population pressure on the environment for a range of non-pastoral uses including mining, tourism and defence is increasing. Interestingly, unlike many of the agricultural areas of Australia, the Audit found that the mean age of the rangelands population is decreasing. Tenure arrangements are undergoing change. Indigenous rights and aspirations are having an increasing influence on rangeland use and management.

Australia's rangelands present a management challenge. Since the costs of remedial works usually far outstrip the economic value of the land resource, management needs to be proactive, operating within a conservation framework. It needs to be based on monitoring of condition and trend that predicts variability (e.g. drought) and ensure intervention to minimise the likelihood of any impacts well before the impacts have the opportunity to occur.

The Audit has developed the Australian Collaborative Rangeland Information System. This system:

- includes attributes and assessment activities covering change in biophysical resources, impacts on biophysical resources, socioeconomic information and institutional responses;
- is designed to be linked to and use the outputs of other monitoring activities including water, native vegetation and soil condition; and
- includes regular five-yearly assessments and reporting, to track progress in management and provide a basis for further investment and improvement in management activities.

The system is designed to link to existing State and Northern Territory monitoring programs, but also has provision to broaden their monitoring activities to meet already-negotiated and agreed standards. There is further scope to build a link with the Northern Territory Desert Knowledge initiative. Because of the size and complexity of the rangelands, a particularly important aspect will be to ensure clearly established lines of responsibility for monitoring, audit and policy coordination at Commonwealth, States and Territory whole of government level. There may be opportunities to better integrate policy responsibilities for the rangelands as government structures evolve.

RECOMMENDATION 3.6

To underpin effective and protective management of Australia's rangelands, including their use, productivity, biodiversity, community, indigenous and economic values, Australia should implement the Australian Collaborative Rangeland Information System.

Linking ecological, economic and social aspirations

Natural resource management is but one of the major policy issues being developed by government—issues which are increasingly finalised at the Council of Australian Governments. Natural resource management policies have to be considered within the wider agenda of government, in the context of the economic and social aspirations of the Australian community, its future population, living standards, and its place on the world stage.

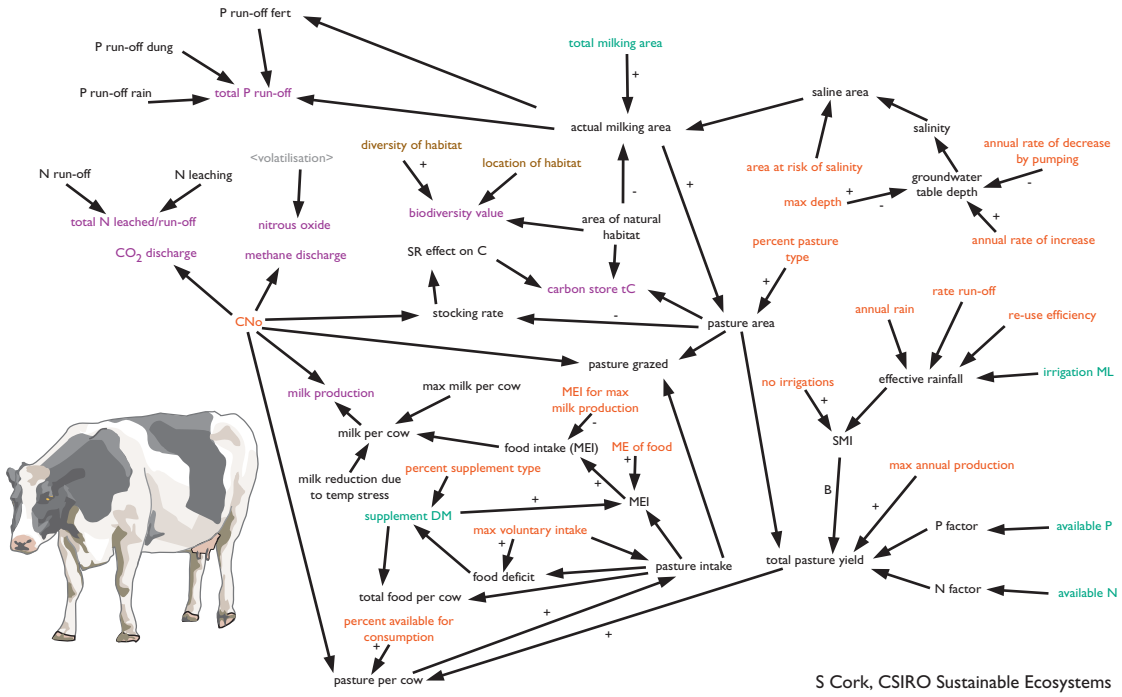
All land managers operate in complex communities and respond to a plethora of cultural, legal, market and institutional agenda:

- Sixty percent of the Australian continent is used for cropping and grazing. Agricultural managers have a crucial 'front line' influence on biophysical processes and resource condition. Their choice of practices can either induce or minimise much of our natural resource degradation.
- Other resource users, including the mining and the tourism industries are also directly dependent on the nation's land, water and biodiversity.

Natural resource management is just one of these managers' many priorities. Their decisions can have both private and public benefits and costs.

Decision making faced by managers in agricultural industries are complex (Figure 86).

Figure 86. The complexities of interactions and decision making faced by the commercial dairy farmer.



S Cork, CSIRO Sustainable Ecosystems

The Audit found that in 1996/97, approximately 80% of the agricultural profits at full equity were derived from less than 1% of Australia's land. Half of all profits derive from irrigated agriculture. About 10% of farm establishments produce 40–50% of the gross agricultural income.

Quite clearly the ecological and economic footprints differ dramatically between regions and between industries, and may well be subjected to different interpretations by the community.

Changes in practice takes time to implement and outcomes of change in practice have even longer time frames. Audit assessments have demonstrated that the sustainable resource management practices most likely to be adopted are those that:

- provide economic benefits and have other advantages;
- are also low risk and simple to manage; and
- have been successfully trialed.

Some natural resource management practices do not readily demonstrate these characteristics.

Significant and continual change is occurring in land-use patterns in rural and regional Australia. This might lead to some regions remaining predominantly agricultural in character and with investments accordingly in sustainable agriculture while others move towards amenity landscapes with less emphasis on agriculture. In some areas nature conservation uses can be expected to increase. Some properties are now being managed by landholders seeking to meet the triple objectives of economic production, lifestyle choice and conservation achievement.

Some questions remain.

- Can such an approach be encouraged more widely?
- How will this happen?
- Should government play a role?
- What are the public benefits of facilitating or influencing the direction of additional change?
- Should the general taxpayer contribute to these public benefits, and if so, on what basis?
- How can public expectations be met at least cost?
- Are sound economic analyses available?
- What are the trade-offs involved?

These are among the questions that usually need answering as part of a strategic approach to managing change while fostering improvements in land-use practice. Answering these questions will need access to natural resources information.

Integrating economic and biophysical information

Natural resource management requires an appreciation of the costs and benefits of resource use and the likely outcomes of management intervention and investment. Setting priorities, and clarifying the opportunities for improved management and the roles of government and land users is essential to determining investment strategies and trade-offs at scales from regional through to Australia wide. Resource accounting involving economic, social and environmental attributes requires:

- an understanding of social conditions and changes to the fabric of our communities;
- detailed information of the economic returns from use of land and water, and the non-market value of ecological assets;

- estimates of the partitioning into public and private costs, and benefits accompanying resource use patterns;
- assessment of the costs and benefits of various management options; and
- decision-support tools that facilitate trade-offs between social, economic and environmental outcomes.

Many of the information sets on which to base resource accounting are available through existing data collection activities such as those of the Australian Bureau of Statistics. The key challenges are to spatially integrate these data sets with information on natural resource condition collated through monitoring and assessment activities (see Recommendations 1–3) and to test the opportunities and effectiveness of various investment options. Assessment at regional scales is essential and provides key inputs for formulating and finetuning regional plans.

RECOMMENDATION 4

To facilitate integrated social, economic and environmental planning and management Australia needs to develop and implement an agreed approach to resource accounting, applicable at regional through to Australia wide scales, incorporating market and unpriced values, together with the costs and benefits of resource use.

Measure to manage

There is much still to be done in delivering knowledge to decision makers at the scales relevant to their decisions. Within the broader, Australia-wide landscape context, we need to seek both wise and sustainable development, and continual improvement in land-use practices.

Australia spends billions of dollars meeting demands for natural resource research, management, advice, data collection and monitoring. These investments range from:

- major Australia-wide programs (e.g. the Commonwealth Government's National Action Plan for Salinity and Water Quality and State of Environment reporting); to
- commodity-based activity such as through research and development corporations);
- coordinated research initiatives (e.g. undertaken by cooperative research centres);
- mega-regional joint initiatives (e.g. the Murray-Darling Basin Commission);
- various State/Territory research, management, regulatory, extension and monitoring initiatives;
- regional and local Landcare projects where groups of landholders pursue integrated approaches to a particular problems; and to
- initiatives by individual landholders (e.g. adopting changed cultivation practices, revegetation or control of introduced pests).

Regular assessments

For Australia to maximise its investment in natural resource management and returns from the use of our natural resources, we need rigorous, regular and legislatively based processes that:

- assess and report on the condition and trends of our natural resources;
- determine priorities and opportunities for improved use and returns from our natural resources;
- incorporate improved knowledge and understanding resulting from research activities;
- track the progress of natural resource management programs and evaluate their effectiveness in both improving natural resource condition and delivering increased productivity; and
- apply the findings to finetune policies, investments and practices.

RECOMMENDATION 5

To meet demands for information and provide a framework for effective and efficient investment in and returns from our natural resources, Australia should regularly assess and report on their condition and on the outcomes of our natural resources programs, and in the context of these assessments, adjust and implement its natural resource management initiatives.

Coordinating and harmonising assessment methods and data collection

Evaluation of the worth of Australia-wide investment in natural resource management requires a nationally consistent framework for monitoring and evaluation that:

- is useful for all partners in natural resource management—Commonwealth, States and Territories, regions, communities and industries;
- is simple, cost-effective, affordable and practical;
- recognises that natural resource management interventions encompass a range of time scales, that significant changes in the resource condition may not be evident for many years, and that ongoing tracking of management actions will be important elements in reporting progress;
- supports meaningful interpretation of data over time by establishing standard Australia-wide indicators; protocols for their sampling, measurement and interpretation, and data quality and management requirements; and
- specifies consistent and documented assumptions on which monitoring and evaluation activities are undertaken.

The Commonwealth Government has announced the continuation of the National Land and Water Resources Audit and, accordingly, a coordinating and value-adding approach should provide the basis for the Audit's future operations.

The most cost-effective approach will be to ensure continuity through building on the recently completed Audit assessments of water, soils, rivers, estuaries, native vegetation, land use and biodiversity. These assessments already cover the key ecosystem drivers of climate, landscape and topography, land use intensity, erosion rate,

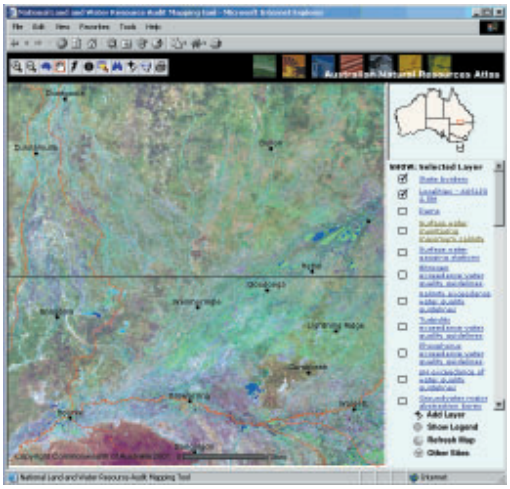
sediment and nutrient loading, native vegetation cover, soil degradation, water quality, water resource use, altered flow hydrology, and exotic biota. Building on these compilations will provide opportunities for filling information gaps required by decision makers and updating data sets as conditions change.

Each of the Audit reports has identified significant gaps in both the data available on the trend, condition and use of Australia's natural resources and in the methods of analysis and collation to provide management-orientated information. Examples of gaps in data sets and information analysis are:

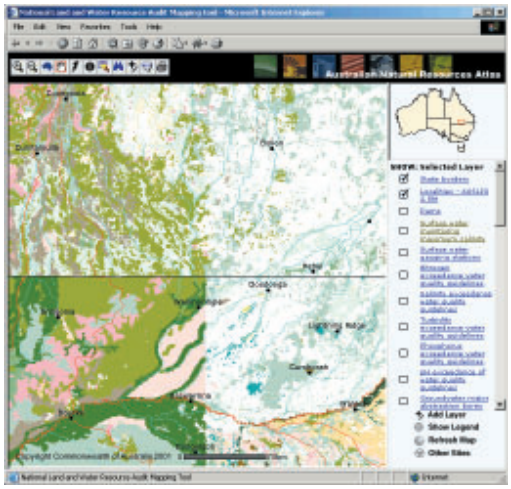
- descriptions of land-use practice across all industries, to compare and contrast with industry best practice;
- water use data to determine opportunities for improvements in water use efficiency;
- water quality data sets linked to flow regimes to calculate load information;
- river and estuary biological resource data such as riparian vegetation and fish populations and community structure to determine river and estuary condition and opportunities for improved management;
- coverage, scale and detail of the extent and type for Australia's native vegetation to support regional, vegetation management planning, overcoming current inconsistencies and boundary discontinuities (Figure 87) evident in the Audit's recent vegetation assessment;
- fire regimes and their change and impact on Australia's landscapes to determine impacts on biodiversity;
- changes in distribution and abundance of Australia's fauna to determine biodiversity condition;
- economic analysis of the costs of land degradation, and impacts on agricultural productivity, common property resources (e.g. fisheries and ecosystem services) to determine investment priorities.

Figure 87. Satellite image (A) and map (B) of vegetation showing State and map sheet boundary discontinuities.

A



B



Data collection and information analysis will always be limited in funding. Both tactical and strategic responses are required to meet client needs. Well-planned, Australia-wide approaches to data provision will establish priorities based on:

- the needs of policy makers—gaps need to be filled so that information is available to evaluate policy options for emerging issues;
- provision and enhancement of data sets in a structured and rigorous manner so that time based data sets are available and trends in key natural resource attributes can then be determined; and
- the impact and outcomes of major planning and management initiatives, filling gaps in information and providing a basis to evaluate and finetune policies and programs.

We already have many investments in monitoring including:

- $185 million spent by a disparate range of agencies on water monitoring;
- over $20 million for mapping vegetation over the past seven years through Commonwealth–State partnership programs; and
- $24 million spent annually on rangelands assessment by States and Territory pastoral lands management agencies.

The full Australia-wide benefit of these endeavours is not being achieved because of inadequate integration. Despite the best efforts of the Audit to harmonise data standards, there are clearly discernible differences in some of their assessments. These are attributable to variations in definitions, data collection protocols and information management strategies adopted over the years by the different State, Territory and Commonwealth governments and research agencies. In many cases, while data are collected, the links between data sets to determine resource condition and the analysis to provide information to assist decision makers are often lacking.

Preparing to construct the Audit's *Australian Native Vegetation Assessment 2001* resulted in contributing agencies agreeing for the first time on a technical framework and guidelines allowing for the collection, compilation and monitoring of Australia's native vegetation data. Through the partnership between the Audit and Commonwealth, State and Territory agencies, there is now an Australia-wide regional assessment of the type, extent and change in Australia's native vegetation cover between 1788 and the current day through the National Vegetation Information System. However, Australia still has much to improve in the collection, collation, analysis and then application of the data sets it already collects.

It might be argued that a prior commitment to their existing processes by the various agencies may mitigate against achieving truly integrated data sets. However, there is positive encouragement from the experience of the Australian Collaborative Land Evaluation Program, initiated in 1992 through a Commonwealth, State and Territory commitment under the aegis of the Agricultural and Resource Management Council of Australia and New Zealand. In the ensuing years, the participating agencies have seen the benefits of moving towards and accepting a standardised data collection system for Australia's soils. The contribution of the Audit, building on this activity, has been to add value to the comparable data sets by analysing them and establishing additional information useful to decision makers. The outcome is a nationally conformable database from the point and survey map data that have been collected by the State

and Territory agencies and CSIRO since the 1970s, brought together in the Australian Soil Resources Information System (NLWRA 2001e). Based on this information, other analyses can then proceed and deliver major advances in understanding natural resource condition, thereby establishing priorities for works and activities.

Coordination of data gap filling activities in partnerships across government, community and industry is essential and needs to be undertaken as part of an Australia-wide response to improving our natural resources information. Coordination will meet wide ranging and varied client needs by:

- maximising the returns from investment in data collection;
- brokering combined approaches; and
- ensuring policy and program relevance.

The National Land and Water Resources Audit is far from a complete assessment of natural resource issues for Australia, both in terms of issues and current coverage. Some of the issues that have been identified by Commonwealth, State and Territory agencies and are yet to be assessed include:

- feral animals and weeds—extent and impact on biodiversity and production, with estimates that together they cost the nation about $3 billion annually in lost productivity;
- floodplains and wetlands—their values for fisheries, nature conservation value and multiple use;
- chemicals—in the environment and our management systems for their use;
- fisheries—freshwater, estuarine and marine, especially maintaining habitat and viable populations;
- urban environments—stormwater, sewage and waste management systems; and
- other soil issues impacting on productivity on and off farm (e.g.. acid sulphate soils, structural decline, wind erosion).

RECOMMENDATION 6

To meet client information needs and maximise returns from investment in data collection and information analysis, Australia needs to re-assess opportunities to target data collection, improve coverage, relevance and quality, implement any gap-filling and ensure effective information provision, with consequential activities to be implemented in a coordinated manner.

Australia-wide standards and access

The Audit's Report *Australian Natural Resources Information 2002* notes that natural resource data and information are:

- often fragmented and difficult to find;
- not managed systematically; and
- lacking in coordination.

There is considerable scope to enhance the value of our data collection activities. The report recommends a series of activities and organisational initiatives to improve returns from investment. These recommendations are in the context of the progress made during the Audit in the provision of and access to data and information through the application of standardised approaches. These are based on the Australian Spatial Data Directory and Infrastructure, the development of data library systems and the compilation of distributed and linked atlases including the Australian Natural Resources Atlas at <www.environment.gov.au/atlas>.

Recommendations are detailed in Appendix 2 and cover:

- building and maintaining fundamental data sets;
- providing continued access to data and information through data libraries and atlases;
- maximising returns on investment in data collection activities; and
- reporting progress and assessing priorities for further investment in partnership and under the standard frameworks provided by the Australia New Zealand Land Information Council.

RECOMMENDATION 7

As part of the development of a more strategic, client responsive and cost effective approach to data collection and information provision, Australia needs to implement through the Natural Resources Management Ministerial Council, recommendations contained within the Audit's Report ***Australian Natural Resources Information 2002.***

The recommendations include building and maintaining fundamental data sets; providing ready access at cost of transfer to data and information through data libraries and atlases; ensuring maximum utility of the investment in data collection activities; ensuring regular reporting within the standard frameworks defined by the Australia New Zealand Land Information Council; and facilitating opportunities for further co-investment and collaborative management in data sets required by client organisations.

Coordinating Australia-wide activities in natural resources information

As part of natural resource management, Australia invests considerable resources in data collection and information provision. Within the natural resources area, there has been an increase in the range and type of organisations collecting data and providing information—including government departments, government statutory authorities (e.g. the Murray-Darling Basin Commission and the Great Barrier Reef Marine Park Authority), community groups, industry, research and development corporations, CSIRO, cooperative research centres and universities. Convergence of data sources should be encouraged.

The value of time series data sets has been well demonstrated in fields such as hydrology and climate change to support natural resource management. The coordination task is complex and requires facilitated partnerships. Partnerships between government, industry and communities are essential and require long term commitment.

There is an increasing diversity of applications for data and information products. Uses range from individuals and local groups, to regional planners through to those responsible for State and Territory and Australia-wide reporting (e.g. State of Environment reporting and international reporting obligations such as the Montreal Protocol). Users of natural resource information are demanding:

- consistency between related data, often with spatial definition of attributes;
- seamless maps not interrupted by artefacts such as map sheet boundaries or State and Territory borders;
- a hierarchy and standardised approach to data sets so that fine-scale local information is progressively aggregated to report at regional, State and Territory, and national scales;
- distributed but comparable data collection, access and presentation systems including linked data libraries and atlases;
- equivalent description and attributes so that a feature is defined in the same way across Australia;
- explicit links between data sets detailing condition and trend of natural resources;
- outcomes from investment in works to be monitored and reported, such as programs of the Natural Heritage Trust;
- improved returns on investment in data collection by making data sets readily available and used for a range for applications; and
- increased assessment and readily available information products that combine a number of data sets and are then comparable with other information products.

Many of the issues such as standardisation and access, are generic to data activities, not just to natural resources data. The Australia New Zealand Land Information Council has been responding to these generic issues by fostering implementation of the Australian Spatial Data Infrastructure. The Audit has been a test case for improving natural resources data management and information provision and the catalyst for the formation of the Commonwealth Office of Spatial Data Management.

Continuing activities in coordinating natural resources data as a subset of more generic data management standards and coordination are imperative and will ensure Australia develops a much more cost-effective and client-relevant set of natural resources data collection, management and information provision activities.

To ensure cost-effective and client-relevant data collection and management, Australia needs to continue coordination and the building of partnerships, as a core part of Audit activities 2002–2007, for the collection, management and assessment of natural resource data and its access through data libraries and atlases operating consistently with Australia New Zealand Land Information Council standards.

RECOMMENDATION 8

As part of the development of a more strategic, client responsive and cost effective approach to natural resources data collection and information provision, Australia can build on the lessons learnt from the Audit. To ensure cost effective and client relevant data collection and management activities Australia needs to continue coordination and the building of partnerships for the collection, management and assessment of natural resource data and its access through data libraries and atlases operating consistent with the Australia New Zealand Land Information Council standards.

Independence and client relevance of the Audit

A critical component of the current Audit has been its independence from specific agencies of government while retaining a direct accountability to the Natural Heritage Ministerial Board through the Audit's Advisory Council and a communicative relationship to inter-governmental standing committees. This has helped engender an inclusiveness among participants that would otherwise have been difficult to achieve.

In announcing in March 2002 that the Government would continue a commitment in principle to the continuation of the Audit until 30 June 2007, the Natural Heritage Board agreed to the following key principles in the development of future Audit arrangements:

- maintaining independence while fostering coordination across agencies;
- building a cooperative State, Territory and Commonwealth partnership;
- data collection, processing and storage should be primarily demand driven;
- users should pay for additional activities;
- increased responsiveness to policy information needs that avoid a direct policy role; and
- clear and achievable objectives and work plans that are agreed and set by principal users.

A continuing and independent Audit could also assume responsibility for coordinating monitoring for major, Australia-wide, cross-jurisdiction programs such as those sponsored by the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality. Accountability could be improved by using facilities such as the Australian Natural Resources Data Library. Advantages for adopting this coordinated approach include transparent independence and elimination of duplication as part of the Commonwealth leadership role in coordination.

There is opportunity to integrate other data sets not yet covered by the Audit (e.g. the National Forest Inventory). Another potentially developing area is that of sequestered carbon, being developed by the Australian Greenhouse Office, with which the Audit has had valuable interaction. The Audit made considerable input by providing data for interpretation and

incorporation into the State of the Environment 2001 report.

A potentially topical development could be for a continuing Audit to assume responsibility for facilitating marine data storage and information display through the Australian Natural Resources Atlas and Data Library from the natural resources assessments being undertaken by the other agencies such as the National Oceans Office. The draft Data and Information Strategy of that office has proposed developing a marine data and information guide that provides minimum specifications for delivery of National Oceans Office project data and information based on the *National Land and Water Resources Audit Information Management Manual*. There is a direct natural resource continuum in managing the land and the oceans. The current Audit has recognised that by taking its study as far as estuaries.

The Audit has tackled issues that were perceived to be most pressing and their key drivers as determined from the 1996 needs analysis. It has shown that there is scope for strategic investments to be undertaken through partnerships developed with other parties, including:

- other government agencies on behalf of the Commonwealth and States/Territories;
- research and development corporations on behalf of specific industries; and
- directly with the private sector.

These investments would pursue opportunities to fill critical gaps in existing information and develop additional data products through a series of new initiatives. As part of the strategic planning for the recently announced next phase of the Audit, it will be timely to revisit with stakeholders their future needs for natural resources data and information.

The Audit as an information agency

To deliver on Australia's approach to natural resource management, information will be required to:

- foster policy development;
- facilitate decision making;
- determine investment priorities and maximise returns; and
- achieve better management and practice.

The Australian National Audit Office (ANAO 2000), noting that the Natural Resources Management Ministerial Council is to have oversight responsibility for the National Action Plan for Salinity and Water Quality, considered that:

> *A joint Commonwealth–State/Territory body that builds on the results on the NLWRA could provide joint monitoring and reporting mechanisms to strengthen performance measurement and accountability for both spheres of government. In particular, this cooperative approach could lead to the enhancement of data that could contribute to improved performance targets and baseline data on environmental condition for the purposes of policy development and program management.*

Similarly, the House of Representatives Standing Committee on Environment and Heritage (2000) recommended:

> *... that the National Land and Water Resources Audit be formally established as an on-going, independent statutory Commonwealth authority … with the power to collect relevant data and maintain an ongoing audit of the state of Australia's catchment systems; and purpose of educating the community of the need for, and effective measures to attain, the ecologically sustainable use of Australia's catchment systems.*

The commitment by the Government to continue the Audit reflects a need for the continuing operation to:

- be responsive to and informing the policy needs of government, community and industry while maintaining independence in maintaining standards for quality control of data and information;
- be linked to and within the formal Australia-wide institutional structures for natural resource management;
- encompass and facilitate partnerships across government, community and industry;
- coordinate Australia-wide issues of natural resource data collection, collation, standards and access;
- coordinate Australia-wide issues of analysis, assessment, information provision, knowledge brokering and reporting on the condition and trends of natural resources;
- coordinate the monitoring and reporting of progress in major programs and incorporating findings within overall assessments of trend and condition; and
- regularly provide progress statements on the status and trends of natural resources, incorporating program review; and identifying opportunities for new initiatives, finetuning of investment and review priorities.

This approach is similar to the role and functions of the United States Natural Resources Conservation Service. Its core activities are to coordinate natural resources data collection and information provision as the basis for the review under legislation and the finetuning of United States natural resource programs every five years.

During the period to June 2007, the Audit will continue to develop as a cost-effective data resource with assessments providing information on the progress in Australia's natural resources management. However, while program-based activities provide valuable outputs and impetus, history suggests that they are not sustainable in the long term. Audit-type activities would be best sustained by establishing an independent information agency. Part of this agency's role would be to formally report to government at regular intervals on the status and changes in Australia's natural resources and opportunities for strategic investment to improve or maintain the resource base. Establishing the information agency, its role and responsibilities requires the development of legislation, administrative and accountability arrangements and partnership agreements. These should be progressed over the next term of the Audit (2002–2007).

RECOMMENDATION 9

To ensure the information-based approach to natural resource management that Australia has implemented is effective, Australia needs to establish an information agency with assured life and independence. A legislative base would enable and facilitate processes for the coordinating of natural resource data collection, information provision, mandated assessments of progress, the review and fine tuning of major programs and the development of initiatives.

APPENDIX 1. THE NATIONAL LAND AND WATER RESOURCES AUDIT—AN ACCOUNTABILITY

Origins of the National Land and Water Resources Audit

The *Natural Heritage Trust Act* (Part 3, s 11) provided for the National Land and Water Resources Audit, to have primary objectives

> *(a) to estimate the direct and indirect causes and effects of land and water degradation on the quality of the Australian environment and to estimate the effects of land and water degradation on Australia's economy;*
>
> *(b) to provide the baseline for the purposes of carrying out assessments of the effectiveness of land and water degradation policies and programs*

Following its creation, the following more detailed objectives were endorsed by the Natural Heritage Board comprising the Minister for Agriculture, Fisheries and Forestry and the Minister for Environment and Heritage.

To achieve these objectives, the Audit was required to provide a series of outputs to meet user needs.

AUDIT OBJECTIVES

1. 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.
2. Providing an interpretation of the costs and benefits—economic, environmental, and social—of land and water resource change and any remedial actions.
3. Developing a national information system of compatible and readily accessible resource data.
4. Producing national land, vegetation and water—surface and groundwater—assessments as integrated components of the Audit.
5. Ensuring integration with, and collaboration between, other relevant initiatives.
6. Providing a framework for monitoring Australia's land and water resources in an ongoing and structured way.

AUDIT OUTPUTS

1. *Scientific assessments* on the status of, and where possible recent changes in the nation's land, vegetation and water resources to assist decision makers in their efforts to achieve ecological sustainability. The assessments are also to serve as a baseline or benchmark for future trend analysis.
2. *Reports* on economic, environmental and social dimensions of land and water resource change, including land cover and remedial actions.
3. *Integrated, nationally compatible data sets* to support the Audit process and which are suitable for ongoing development and maintenance as a readily accessible national information system.
4. *National water resources assessment* to show the extent of the surface and groundwater resources, quality, supply capacity and use. The assessment is to consider all water uses, including environmental requirements.
5. *Defined and agreed reporting links* between the Audit and the State of the Environment reporting process, the Indicators of Sustainable Agriculture and other relevant activities at State and Commonwealth level.
6. *Framework* for the long-term monitoring and assessment of the health and management of Australia's land and water resources that meets the needs of all major stakeholders.

Establishing the Audit

To implement the Audit, an advisory council was established with:

- an independent chair;
- one member from the Department of Primary Industries and Energy (now Agriculture, Fisheries and Forestry – Australia);
- one member from Environment Australia;
- two members from Sustainable Land and Water Resources Management Committee representing the Agricultural and Resource Management Council of Australia and New Zealand;
- one member from CSIRO;
- one member from the Land and Water Resources Research and Development Corporation; and

Audit Advisory Council

Chair ..... Roy Green

Agriculture, Fisheries and Forestry Australia ..... Geoff Gorrie (October 1997 to October 2001)
..... Bernard Wonder (from October 2001)

Environment Australia ..... Stephen Hunter

Sustainable Land and Water Resources Management Committee ..... Peter Sutherland
..... Kevin Goss (October 1997 to July 1998)
..... Michael Lee (July 1998 to March 2000)
..... Roger Wickes (from July 2000)

CSIRO ..... John Radcliffe

Land & Water Resources R&D Corporation ..... Alex Campbell (October 1997 to June 2001)
..... Warwick Watkins (from June 2001)

Standing Committee on Conservation ..... Jon Womersley

Standing Committee on Environment Protection ..... Bryan Jenkins (October 1997 to July 2001)

Audit Management Unit

The Audit Management Unit comprised seven or eight staff at any time over the period of activities. Following is a list of staff at the Audit in its final year:

Executive Director ..... Colin Creighton

Technical Director ..... Warwick McDonald

Technical Manager, Ecology ..... Jim Tait

Technical Manager, Data ..... Stewart Noble (resigned December 2001)

Business Manager ..... Sylvia Graham

Information Specialist ..... Maria Cofinas

Project Manager ..... Rochelle Lawson

Publicist ..... Drusilla Patkin

Staff who contributed to earlier phases of the Audit included:

Ian Cresswell, Janice Oliver, Kate Ord, Andrea Schuele, Robert Scott, Paul Shelley, Heping Zuo

AUDIT TERMS OF REFERENCE

1. 'The Advisory Council is established to advise the Minister for Primary Industries and Energy and the Natural Heritage Trust Board on implementing the NLWRA consistent with objectives and outcomes agreed by the Minister and the NHT Board.
   - Developing and detailing the Audit's strategic direction within a strategic plan for the Minister's approval.
   - Preparing within the context of the strategic plan, annual operating plans for the Minister's approval.
   - Developing policy, priorities and operational procedures for the implementation of the Audit.
   - Recommending arrangements for national implementation after the four years of the Audit development program of an integrated resource accounting system capable of estimating the spatial extent of land and water resource condition and management, and trends on a regular basis.
2. In supervising the implementation of the Audit, the Advisory Council will:
   - manage the financial resources allocated from the NHT;
   - facilitate integration of the Audit with industry, State and Commonwealth initiatives;
   - set, monitor and direct strategic outcomes for the Audit Management Unit and participating working groups;
   - regularly review performance of implementing the Audit.
3. As part of the development of the Audit as a nationally integrated ongoing resource accounting system, the Advisory Council will:
   - ensure effective communication and interaction with all key stakeholders in the development and implementation of the Audit;
   - establish regular reporting arrangements with peak groups particularly ARMCANZ (through SCARM/SLWRMC) and ANZECC (through SCC/SCEP) and
   - report regularly to the Minister and the NHT Board, evaluating progress and performance of implementing the NLWRA.'

- one member each from the Australian and New Zealand Environment and Conservation Council's Standing Committees on Conservation and Environment Protection.

The Audit Advisory Council was responsible for advising the Minister for Primary Industries and Energy and thence the Natural Heritage Ministerial Board on strategic directions, policy priorities, program review and on establishing processes and performance evaluation of the Audit activities. An executive director of the National Land and Water Resources Audit, together with a small support staff made up the Audit Management Unit. This group reported directly to the Audit Advisory Council. In an agreement between the Commonwealth and the Land and Water Resources Research and Development Corporation (now operating as Land and Water Australia), provision was made administratively for the Audit Management Unit to operate as a special program attached to Land and Water Resources Research and Development Corporation.

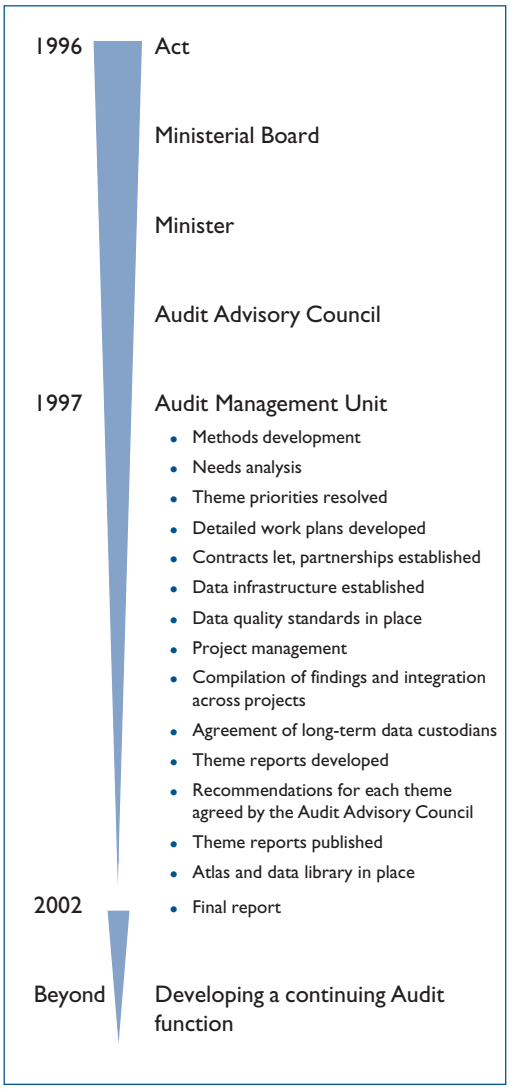
The outputs for which the Audit Advisory Council was accountable included a strategic plan and annual operating plans subject to Ministerial overview, annual reports meeting Natural Heritage Trust standards for submission to the Ministers and a final report—this document—which reviews Audit activities, summarises Audit findings and proposes arrangements for continuation of Audit-type activities.

The Audit Advisory Council had detailed terms of reference (see box above).

Audit Operations—making it happen

The flow diagram outlines the conduct of the Audit. A detailed description of how the Audit was developed and conducted, the outputs of the Audit, experience gained and the benefits already achieved through adoption of Audit outputs is given below.

Figure A1 Implementing the National Land and Water Resources Audit.



The primary components of the Audit's operations were:

- establishment of the priority areas to be assessed;
- identification of suitable methods and data sources for compiling assessments;
- negotiation of partnerships and letting of contracts;
- management of all projects to meet objectives and outputs specified in work plans;
- assembly and processing of data;
- determination of data sets to be maintained through data custodians;
- design of the Atlas to detail and document Audit findings at local/regional scales; and
- integration of the data into outputs from an Australia-wide perspective that could be interpreted and published as summary statements on the principal components of Australia's natural resources and their current status.

The whole process had to be underpinned by an ethos of good data management that led to making available the information sought by clients, all achieved with effective two-way communication.

A most important issue was to achieve 'engagement' and 'ownership' among the likely stakeholders, and to do so at an early stage to achieve the best possible outcomes. Initial awareness visits were made to Ministers' offices and those of senior State/Territory officials.

Phase 1. Scoping the program

The Audit commissioned a needs analysis from Hassall and Associates, assisted by the Audit's Executive Director. The aim was to determine, through consultation, the questions that needed to be answered. It encompassed:

- the resource allocation, decision-support needs of the main natural resource management agencies—Commonwealth, State and Industry—for the key natural resource management issues of Australia's ecological regions, States/Territories and natural resource-based industries; and
- a recommendation of those key natural resource management themes that must be included in the Audit.

AUDIT THEMES

- Surface and groundwater management—availability, allocation, use and efficiency of use
- Dryland salinity
- Vegetation cover, condition and use
- Rangelands monitoring
- Land use change, productivity, diversity and sustainability of agricultural enterprises
- Capacity of, and opportunities for farmers and other natural resource managers to implement change
- River, estuary, catchment and landscape health
- Biodiversity

At the same time, the process provided an opportunity to market the Audit initiative to Commonwealth, States and Territories, and industry groups, and to explore the potential for synergy between the Audit and other initiatives. A series of workshops was held in all States, the Territories and in the Commonwealth, with attendees from government agencies, local government, farmers federations, the Landcare movement, conservation groups and Aboriginal land councils. Based on outcome priorities established for each State and Territory, the Audit Advisory Council framed a strategic plan and work program around the identified major sets of resource issues or 'themes', which were managed as subprograms of the Audit.

To underpin each of the themes, to meet Audit Objective 6 of establishing a framework for monitoring Australia's land and water resources in an ongoing and structured way, and to communicate findings, the Audit established a subprogram for data management and information provision. Key activities and outputs from this subprogram included:

- using consistent and rigorous data to answer key natural resource management questions in a manner that integrates biophysical, economic and social information;
- compiling additional data to clarify particular natural resource management problems, their extent, economic cost and required remedial actions;
- establishing protocols, coordination and standards for data collecting, sharing and access;
- brokering Australia-wide monitoring systems with rigorous benchmarks that facilitated estimates of rates of change;
- assembling key data sets useable as input for evaluating current policies and developing new policy proposals at all tiers of government;
- providing a data framework suitable for linking in with key Australia-wide natural resources agendas such as species-level biodiversity, State of Environment reporting; and
- establishing commitment to a rigorous approach to natural resource management

decision making through demonstrating the entire Audit process on key regional problem areas in collaboration with States and Territories.

A communication strategy was developed and implemented as a further subprogram to attract involvement of natural resource managers from across Australia. The strategy was based on:

- broad consultation to ensure the Audit remained relevant to client needs;
- identification and application of effective communication mechanisms;
- provision of opportunities for feedback and dialogue between natural resource managers and the Audit;
- networking across communication and information professionals in the natural resource industries to facilitate cooperation and information sharing; and
- development of interactive components of the Audit's website and Atlas.

The Audit's *Strategic Plan* was endorsed by the Natural Heritage Trust Ministerial Board and published in June 1998.

Phase 2. Scoping the methods, applying regionally and building the work plans

Initiating an Australia-wide program that brings together multi-disciplinary and multi-partner science and seeks to develop comparable information across Australia from variable quality and coverage data sets as well as applying untested methods for assessment required a multi-faceted and well-planned approach. The Audit chose a three-part and interlinked process:

- scoping of methods for data compilation and assessment;
- applying at regional scale selected methods to test compilation and assessment methods; and
- integrating lessons learnt from these two processes, developing detailed work plans for each of the themes and for the underlying activities of data management.

Following a series of workshops involving many of Australia's best natural resources scientists, 24 'methods development' papers were commissioned.

BENEFITS FROM THE METHODS PAPERS

The methods papers helped scope the possibilities for the Audit, defined how assessment could be undertaken, and helped to define those issues which were readily able to be assessed, and those which were likely to be more difficult. Notably highlighted were the social issues, where originally there was no clear consensus on the attributes to be assessed or how to approach an assessment. Most papers showed that additional methods development would be required before assessments were commenced, albeit more in some fields than others. At the same time, the papers gave a measure of the costs, time and skills necessary to undertake the assessments. In preparing the papers, the researchers also helped generate a perspective of what the Audit could be—a perspective drawn from the natural resource science community that could also be reviewed with staff of Commonwealth, and State and Territory agencies when developing the work program. Not all of the papers produced methods which were adopted. Most made a useful contribution. Several were crucial to the ultimate choice of approach.

Outputs of the methods papers are available at <www.nlwra.gov.au/minimal/30_themes_and_projects/50_scoping_projects/04_methods_papers/methods_papers.html>.

Each paper was prepared to a set format so that issues such as data quality, data coverage, compilation, assessment methods and information presentation were consistently covered. Most papers involved small teams of researchers, building on the findings of the methods workshops.

Complementing the scoping of methods, a group of projects at regional scales were selected across the themes for application within Australia's States and Territories. The 'Regional Applications' project proposals were developed by Audit staff with key contacts in the States and Territories. Invitations to suggest projects were also circulated to all members of the Sustainable Land and Water Resources Management Committee of Standing Committee on Agriculture and Resource Management; Standing Committee on Conservation and Standing Committee on Environment Protection, these being the principal Commonwealth/States/Territories forums for discussing land and water management policies and issues. Seven projects were undertaken. The experience and outputs from these projects were incorporated into the design of Audit work plans and subsequently into the theme reports and the communications program.

The work program

Work planning for each of the subprogram themes and for data management completed the scoping and planning of Audit assessment activities. Leaders were appointed for all themes, usually under contract. Each leader was supported by a group of contact officers from key client groups including Commonwealth agencies, each State and Territory and CSIRO. The groups, in association with Audit staff, prepared work plans for each theme.

All work plans followed a similar format and included:

- analysis of the key questions being asked by decision makers as articulated in the Audit *Strategic Plan*;
- based on this analysis, development of a set of projects to provide information that answered key aspects of these questions;
- detailed specification of each component project, including data required, methods for collation, interpretation and presentation of findings, budget, phases and likely contracting arrangements;
- methods for integration of all projects towards producing the theme report; and

BENEFITS FROM REGIONAL APPLICATIONS

The Regional Applications Projects:

- tested and enhanced various Audit methods;
- provided Audit projects operating at a regional level, and in some instances finer scale than subsequent Australia wide projects;
- demonstrated the Audit's applicability to solving problems and assessing development opportunities;
- engendered widespread support for the Audit program and its concepts within agencies, including recognition for data sharing, model building and the integration of economic, social and environmental data; and
- acted as a 'springboard' for Australia-wide Audit activities.

- project management details including likely contract conditions, milestones, specified outputs and Gantt charts showing project and data independencies.

BENEFITS OF WORK PLANNING

The work planning involving full documentation of all component projects, the negotiation of partnerships and contributors, reaching agreement of working group members and then the approval of the Audit Advisory Council of the proposed budget allocations and outcomes generally took a year to complete for each theme. This was done in a staged process so that the final work plan was approved by the Audit Advisory Council some two years after the initiation of the Audit program. The time taken in planning proved to be well justified providing:

- detailed specifications for the next and very important phase of project management;
- basis for negotiated agreement amongst all stakeholders of methods, activities and presentation of outputs; and
- context for negotiating partnerships.

SCIENTIST AND AGENCY PARTICIPATION

Scientists, through contributing to the methods papers, the needs analysis and the work planning and thereby becoming aware of the possibility of contracting to undertake parts of the work program, engendered an immediate interest in the Audit. This ensured a grounding for the Audit in 'good science'.

The States and Territories held many of the data sets which the Audit would be seeking to access. The Audit staff found that once the themes had been identified, assembling agency and research staff from similar fields of expertise to develop theme planning in an inclusive manner had the advantage of broadening 'ownership', bringing to light a range of technologies useful for assessment, and providing a forum in which data standards might be progressively improved.

From the participants' viewpoint, it also opened up an Australia-wide perspective of the field in which they were operating, and led to stronger professional cohesiveness. This was particularly so, for example, among the rangelands group and the native vegetation mapping, estuary and river assessment groups across the States and Territories, whose members deal with quite disparate ecosystems spread across large areas of the country. Indeed the lack of Australia-wide approaches and shared understanding was one of the more surprising institutional gaps. The vegetation mappers, for example, had never previously had an Australia-wide forum within which to develop comparable and consistent approaches. Subsequently, these groups proved invaluable in helping to integrate the data sets and interpret them during the theme workshops which were a prelude to drafting the theme reports.

Phase 3. Letting and project managing contracts

A total of 150 contracts were progressively let on a basis of merit by the Audit Advisory Council in implementing the endorsed work plans. Contracts were let to a wide range of government and private sector contributors (see *Acknowledgments* section).

Contracts were broadly classified in three categories:

- open tender competitive contracts—where it was recognised that many groups within and outside government were capable of delivering the outputs;
- partnership contracts—where substantial cash and/or in kind contributions had been negotiated and increased the worth and improved the outputs of the project; and
- sole provider contracts—where it was recognised that due to specified and documented reasons there was only one provider of the outputs required.

The contracts required specified data management standards, the standards and form of data presentation, the milestones for continuous appraisal of contract performance and the outputs required at the end of the project. To assist project scheduling Gantt charts covering the project duration and any phases of project activity and milestones were negotiated and agreed to with contractors at time of letting contracts.

Project management was a major body of work for all eight members of the Audit Management Unit. Activities were based on a project management system and formal training and included:

- attention to full contract specification, translating work plans into discrete activities and outputs;
- frequent and detailed communication with contractors, initially ensuring there was mutual understanding of the scope of each contract and the Audit's requirements; and then consolidated with
- continuous review of progress towards specified milestones; and
- review of draft final outputs with often several reiterations before projects were signed off as complete.

The Audit Management Unit also defined and reviewed the data dependencies between projects as they proceeded and therefore the interdependencies across all Audit themes, with outputs of some themes becoming data for other theme activities.

Individual Audit Advisory Council members assume roles of 'champions' for specific themes, and for data and information management. During the project management phase, champions had a watching brief over progress, becoming involved as appropriate to ensure specified outputs were achieved. This approach has merit for continuation in the future of the Audit.

EFFECTIVE PROJECT MANAGEMENT ESSENTIAL

Well-structured and defined project management processes were essential to the successful delivery of Audit outcomes. These encompassed recognition of adequate formal training, clear definition of objectives and outputs, attention to specific details in the preparation of contracts and their implementation, selection and use of appropriate computer-aided project management systems, and encouraging adherence to performance timelines.

Welcoming co-investment

Wherever possible, the contracts were approached on a collaborative basis, encouraging co-investment in the work by the contracting groups. This inclusive approach ensured greater return on the Audit investment and client focus, with many of the Audit's partners also being organisations that would use Audit findings in their work for improved natural resource management in Australia.

THE GAINS FROM CO-INVESTMENT

The contribution through co-investment by research organisations such as CSIRO and cooperative research centres and industry bodies, particularly research and development corporations, increased the level of data capture for the Audit, while also helping those bodies achieve their own additional outcomes which the Audit infrastructure could help facilitate. The co-investment in the Audit from other organisations exceeded $18 million, and when in-kind support was taken into account, effectively doubled what the Audit was able to undertake. Particularly supportive relationships developed between the Audit and the dairy, horticulture, fishing and grain industries, and also with a number of research organisations including CSIRO and many of the 'public good' cooperative research centres. The fertiliser industry for the first time generously provided access to many years of historical soil test and diagnostic data which were able to be geo-referenced to the nearest towns.

It could be anticipated that there might be added commitment from the agricultural industries towards supporting future audit-type activities, as environmental issues are becoming increasingly important in international trade. Industry organisations are assuming greater responsibility for environmental standards within their industries. This involves moving towards establishing their own best management practices programs, and encouraging individual growers to adopt environmental management systems, or ISO 14000-type accreditation. Buyers in some markets are demanding these standards.

Phase 4. Developing and implementing a data management and information presentation system

There were two key components to developing the data management and information management system.

1. Securing the data sets in appropriate form, quality and content

Contracts ensured data collected and collated was in forms that provided the content for the system. This was a large part of the Audit's project management activities and involved adoption of three key principles in all projects:

- to ensure that data from Audit projects were 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 the Australia New Zealand Land Information Council or through national coordination arrangements;
- to help users easily find and get access to the data from Audit projects, all data were to be documented in the Australian Spatial Data Directory (the documentation provides enough information for users to determine whether the data are suitable for their purpose) and easily accessible to all sectors of the community in formats location, cost and under conditions that promote their wide use; and
- to protect the rights of all contributors to the data, all data were to be 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 are required to ensure that the map information is

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 are preserved.

2. Building the information services

Once the projects to collect, collate and interpret data sets had been initiated, work began in parallel with the main group of project management activities across the Audit themes to build the information and data access system.

- **Access was secured and data management protocols agreed**—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 was released that identified guidelines for data collection and data transfer. 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.
- **Information display and data storage systems designed**—the Australian Natural Resources Atlas and Australian Natural Resources Data Library were designed and developed. A prototype of the Australian Natural Resources Atlas was released in April 2000. User testing of the system was used to ensure effective location of and access to information within the design of the service. This included trialing appropriate internet page designs, mounting of large data bases such as the Australian Soil Research Information System and providing background information such as topography, infrastructure locations and catchment boundaries. The primary focus of the Audit's public information management services has been to present national assessments. To assist users find information that is more detailed, data and information in the Australian Natural Resources Atlas were linked where possible to information available over the internet from State and Territory agencies.
- **Data sets and information products were added and updated, outputs from theme projects and related data activities were compiled.** Integrated results of Audit assessments were made available as they were completed through the Australian Natural Resources Atlas and Data Library. These results were linked to the most up-to-date data available from State, Territory and Commonwealth agencies. These services are being continuously updated and arrangements are being established for the continued update and management of fundamental sets of data such as vegetation, land use and soils. This will help ensure that all systems continue to be updated and managed for future natural resource assessments and ongoing monitoring of the environment. A technical manual, the *Australian National Resources Information Operational Manual* (NLWRA 2001f), describes in detail the technical issues, standards, guidelines and protocols associated with the design and development of the system.

Developing and maintaining the data management framework

In summary, to identify the potential content of a data framework, gaps in coverage, project specifications for its management and data access specifications, the Audit let a series of contracts, asking Australian Survey and Land Information Group (now the National Mapping Division of Geoscience Australia) to coordinate project outputs to ensure standardised products. An agreement between the Audit and the Australia New Zealand Land Information Council specified documentation, access, ownership, custodianship, archiving and updating arrangements for the data collected, and was developed for and used with the outputs from the Audit's assessments. Agreements with data custodians in Commonwealth, State and Territory agencies were developed to secure access to data. A tripartite agreement was established between the Audit, the Bureau of Resource Sciences in Agriculture, Fisheries and Forestry – Australia; and Environment Australia through a shared understanding of the role and objectives of the Audit, to provide data management and processing services. Environment Australia has assumed

ACHIEVING EFFECTIVE INFORMATION TECHNOLOGY OUTCOMES

The second group of participants after the scientists to become involved with the Audit were those involved in managing information technology and databases within the State and Territory agencies and the research organisations. The Audit was obliged to win commitment at a high level to facilitate development of data management processes. As far as possible, existing protocols such as Australian Spatial Data Directory and Australian Spatial Data Infrastructure were adopted for good data management.

Ultimately, resolution of policy issues at the level of the Commonwealth Spatial Data Committee and subsequently the Australian and New Zealand Land Information Council ensured acceptance of the Audit's approach and meeting the standards for Australian Spatial Data Infrastructure.

Nevertheless, some difficulties did arise. Core data standards and specifications had to be unified between data suppliers. Very large historical data sets proved difficult to manage within the standards agreed. There were limits of expertise available to some contributors to facilitate resolution of problems. In some cases, former staff had to be brought back to resolve or clarify these issues. Audit staff had to spend considerable effort checking some data sets. Definition of data confidence limits was important, and this also had to be included on the subsequent outputs. A developed data input plan proved essential. At an early stage, a decision was taken to resist the temptation to pick up 'extra' data as they came to light, but rather to concentrate on securing a consistent supply of data with the quality that the Audit was seeking, and to ensure that the process was managed well.

In developing systems, off-the-shelf software was adopted as far as possible. This was to ensure that upgrades would be provided by commercial providers and that systems would stay current. Strategic partnerships were developed with providers so that any additionally required functionality they were to deliver became part of their software systems.

Contractors and contributors of data sets and projects needed the capacity and commitment to manage tightly and to deliver on time. An accountability system was set in place, with a summary report on all projects being provided to all meetings of the Audit Advisory Council. Some organisations, both public and private, found it difficult to meet contract schedules. Nevertheless, without the support of State, Territory and Commonwealth agencies, CSIRO, a number of cooperative research centres, universities and private consultancies, the achievements of the Audit would not have been possible.

responsibility for the ongoing management of the Australian Natural Resources Atlas, and the Bureau of Rural Science of Agriculture, Fisheries and Forestry – Australia has assumed the role of managing and maintaining the Australian Natural Resources Data Library.

Phase 5. Presenting and communicating findings

Individual Audit Advisory members assume roles of 'champions' for specific themes, for data and information management and for communications. During the project management phase, 'champions' had a watching brief over progress, becoming involved as appropriate to ensure specified outputs were achieved and subsequently chaired workshops at which the project contributors worked together to develop an integrated interpretation of theme data.

A communications strategy encompassing electronic communication through email and the use of brochures and *Fast Fact* leaflets was established at an early stage to ensure stakeholders were kept informed and had ownership of the Audit processes as they developed. Regional presentations on the Audit were made as the opportunity arose. The major communications endeavour was to develop effective web access to the Audit and its data sets, and hence to develop a series of reports and tools which could be used in future decision making by stakeholders. This necessitated a close relationship being developed between the Audit's communications and data handling programs.

Communicating Audit outputs

Communicating the outputs of the Audit has been difficult and challenging, with a wide range of techniques used to maximise dissemination of the findings and foster the use of Audit information in improving natural resource management. A key strength of the Audit approach has been the very deliberate development of 'storyboards' on the Australian Natural Resources Atlas – planned and implemented as much as possible within the context of the information needs of the Audit's clients.

All of the various techniques used had their advantages. *Fast Facts* allowed for the rapid dissemination of consistent messages. The Australian Natural Resources Atlas has built an increasing clientele as users became aware of its functions and information sets. Verbal presentations and interactive sessions with regional, community and policy groups have led to increased engagement in the Audit and recognition of the role of information as input to decision making. These presentations have also increased the understanding by the community of the ethos of natural resource management. Articles in the media have led to others outside our network of contacts to become aware of the Audit. 'Info@audit' as an email newsletter has been a cheap and rapid means of keeping many interested persons up to date. Parliamentary briefings, particularly those in Canberra have been well attended. Launches of reports have stimulated further media interest. Conferences have provided forums for discussion, particularly the policy implications of Audit findings. Project reports were deliberately at a technical level and only disseminated via the Australian Natural Resources Atlas. Theme reports were designed to integrate across projects and presented as high quality publications. Dissemination of these reports and accompanying summaries has been a massive task. All reports have evoked positive responses in terms of the quality, content and relevance.

All these activities come at a cost, with expenditure on communication activity well in excess of the actual communication budget and staff time well in excess of the time allocated to

the Audit's Publicist. All staff contributed. Particularly, time in excess of that allocated was required from the Audit's Business Manager in supporting various communication activities and mail outs and the Executive Director and Technical Director, as key participants in forums and writing of articles, summaries and conference papers and PowerPoint presentations. In the last two years the Executive Director averaged at least two presentations each week, with substantial travel required across Australia to meet client demands for briefing on the Audit findings.

LESSONS FOR AUDIT 2

Distinguishing between promotion and communication.

Across the Audit and its partners there has been a general tendency to promote Audit outputs to the wider community (through media releases and launches), and to facilitate adoption of key findings at senior government levels. There has been substantially less effort communicating the value of Audit information to regional natural resource managers.

Addressed by demonstrating real benefits of Audit outputs to key stakeholders

Facilitating uptake of Audit outputs into natural resource management decision making means demonstrating the benefit of using Audit information to key stakeholders. This requires linking Audit activities with 'hands-on' regional activities and remains a key challenge.

Addressed by improving accessibility of Audit products to a wider range of stakeholders

Audit 1 focused on getting the technical information right. Audit 2 provides an opportunity to value add to this information through improving Atlas accessibility and increasing interaction with key stakeholders.

Balancing partner needs

Balancing the needs of various Audit partners provided opportunities for cross promotion, but also created conflict between partners wanting to promote their role in Audit activities ahead of the findings.

Ways to address communication issues

Redefining the Audit target audience.

Developing a communication plan that focuses on adoption and promotion. This requires setting clear targets and outputs within each year's operational plan, then working in a more structured, coordinated and planned manner to deliver these outputs.

Tailoring communication products to meet target audience needs including:

- ensuring all the messages to be communicated are always well thought through using a decision-support framework similar to that employed in the Atlas storyboards;
- increasing attention in costing all communication activities, their inclusion within all programs and with these program budgets complemented by a core well-resourced communication program; and
- employing an in-house science writer who is well aware of Audit findings, contributing to finalising all Audit reports and capable of preparing multiple articles, press releases and other outputs in very short time frames—responsive and proactive to opportunities that arise.

Increasing ownership of Audit activities across all stakeholders:

- involving Audit Advisory Council members more in both the preparation and the delivery of presentations.

Independent evaluation of progress of the Audit

To provide an independent monitoring and evaluation of progress of the National Land and Water Resources Audit, Agtrans Research was contracted by Agriculture, Fisheries and Forestry Australia. The *Executive Summary of Progress Report No 6*, dated 10 October 2001, is given in Appendix 3.

The published outputs

The initial outputs from the Audit were a series of assessment reports covering each of the themes, providing descriptions of the Audit's approach to assembling natural resource data sets, the quality standards set, and providing in comprehensive yet easily understood detail, the results obtained together with discussions of future options. Summaries of the individual reports follow.

Water

The *Australian Water Resources Assessment 2000* provides details of water allocation and use within 335 surface water management areas. Hydrogeological characteristics estimated included annual inflows, run-off from rainfall, and outflows. Water quality measures considered were salinity, turbidity, the levels of the nutrients nitrogen and phosphorus, acidity (pH), and faecal coliforms. Using a framework of 538 groundwater areas, estimates were obtained of the possible groundwater extraction from current infrastructure and present levels of use. Aquifer characteristics recorded included depth, thickness, salinity and where available, results from monthly hydrograph readings.

The Audit also commissioned the development of an assessment technology which can be used to review proposals for new resource developments such as reservoirs and dams. Titled, *Large scale resource developments—an integrated assessment process*, it is available on the web (NLWRA 1999).

Salinity

The *Australian Dryland Salinity Assessment 2000* presents the outcomes of regional-scale dryland salinity or hazard assessments undertaken by State agencies, using information on groundwater levels and trends, the known incidence of salinity, soil characteristics and topography. These data were used to assesses the current extent of salinity and the anticipated extent in the year 2050 if no action were taken. A model of how salinity develops, based on a range of groundwater flow systems, is described. The likely impact of salinity on agriculture and on public infrastructure in regional areas is outlined. Management options are explored and some case studies considered.

THE VALUE OF THE INDEPENDENT EVALUATION TO PROGRESS OF THE AUDIT

The independent monitoring and evaluation of progress proved to be a helpful adjunct to the conduct of the Audit. Although there were from time to time differences of interpretation, the involvement of independent reviewers charged to take a dispassionate view of Audit activities was especially valuable in participating in the initial theme workshops which examined the data sets obtained, helping to identify the limitations of the data sets and the extent and quality of conclusions which could be drawn, and contributing to how the final reports from each theme might be developed. Similarly, the reviewers offered a number of valuable and constructive suggestions towards the preparation of the Audit's final report.

Native vegetation

Australian Native Vegetation Assessment 2001 defines the structural and floristic characteristics of native vegetation using an agreed National Vegetation Information System facilitated by the Audit. Using data from States/ Territory lead agencies, pre-European and present-day native vegetation maps were assembled covering two-thirds of Australia using 23 major vegetation groups for reporting. These groups encompass the broad structural and floristic groupings of Australia's native vegetation. The information has been used to generate a rapid assessment of the relative condition of native vegetation in Australia's bioregions and subregions. A synthesis of 'landscape stress' was undertaken, reported in *Landscape Health in Australia* (NLWRA 2001g).

Rangelands

Rangelands—Tracking Changes—an Australian Collaborative Rangelands Information System summarises currently available information on Australia's rangelands at national and regional scales. Trends are identified in ecosystem function, land tenure and use, stocking rates, native and feral animals, and climate variability, and their impact on rangelands biodiversity. Economic, social and institutional factors affecting rangelands communities were also considered. The report defines elements of a comprehensive monitoring and reporting program (the Australian Collaborative Rangelands Information System) that provides for the introduction of regular Australia-wide assessment encompassing the impact of climate variability, pasture availability, seasonal variation, grazing density, fire, land use and tenure, introduced plants and animals and native vegetation clearing on rangelands biophysical resources.

Agriculture

The *Australian Agriculture Assessment 2001* includes a description of the Australian agricultural environment, with details of agricultural production, soils, climate, carbon, landscape nutrients, and where possible, river nutrients in terms of budgets, together with erosion and sediment transport for Australia's river basins. A description is given of soil acidification, with forecasts of its likely future extent and impact on agriculture. The first comprehensive assessment of water-borne soil erosion and sediment transport is provided for Australia's agricultural catchments and rivers.

The range of Australian soils is described in the Australian Soil Resources Information System.

Australians and natural resource management

The *Australians and Natural Resource Management 2002* report presents the social and economic dimensions of natural resource management based on natural resource accounting and a social profile of rural Australia. To demonstrate the value of natural resource accounts, the report includes an assessment of the economic consequences (in profit terms) on- and off-farm (e.g. soil acidity on farm and (e.g. dryland salinity and river turbidity). Some insight into current and future opportunities for structural adjustment in agriculture is provided. An assessment of the willingness of the Australian community to support natural resource management initiatives suggests that the community is willing to pay $4 billion over 20 years, in addition to existing investments, to achieve enhanced natural resource outcomes—in the form of species protection, bushland restored and river and estuary rehabilitated to a condition that supports fishing and swimming.

Catchments, rivers and estuaries

Australian Catchment, River and Estuary Assessment 2002 presents an assessment of catchment biophysical condition using an indicator approach assessing land, water and biota attributes at a river basin and subcatchment scale. The river assessment reports biological and environmental condition indices and subindices for river-reach reporting units. The estuary assessment classifies Australia's nearly 1000 estuaries in terms of their dominant physical process drivers and defines their condition in terms of level of modification from the pristine state using a 'pressure, state, response' assessment framework and indicators. Catchment, river and estuary management challenges including opportunities for protective initiatives and priority remedial works are identified by reference to identified drivers of change and observed patterns of condition. Summary integrated findings from the catchment, river and estuary assessments and other Audit assessments are presented for each of Australia's drainage divisions, highlighting the catchment based nature of river and estuary condition and the need for region-specific integrated natural resource management approaches.

Biodiversity

The *Australian Terrestrial Biodiversity Assessment 2002* provides a synthesis of terrestrial biodiversity characteristics, values, potential threats and conservation and management options collated for Australia's 354 biogeographic subregions. Biodiversity data collated include species richness and endemism for Acacias, Eucalypts, birds and mammals, and numbers of threatened species and ecosystems. Processes which threaten the condition and trend of ecosystems, species, riparian zones and nationally important wetlands are also identified. Information on dynamic aspects of biodiversity is provided through change in distribution and reporting rates for bird and mammal species, encompassing groups, guilds, exotic species and translocated species. Management challenges are defined with collated information on threatened species and ecosystem recovery needs, priority bioregions and subregions for consolidation of the National Reserve System, key data gaps and existing natural resource management measures serving biodiversity conservation, within each subregion. Fourteen biodiversity conservation option case studies stratified across major agro-ecological regions provide detail of the specific resource and operational needs for delivering biodiversity conservation outcomes and give an indication of Australia-wide challenges for subregions with similar management contexts.

Information

Australian Natural Resources Information 2002 recommends an Australia-wide natural resources information system based on building fundamental data, providing access to information, maximising value for money, and annual reporting as part of the Australian Spatial Data Infrastructure. Database maintenance concepts for surface and groundwater, land use, native vegetation, salinity, soils, river health and estuaries are given.

Underpinning projects

Details of the 150 projects commissioned as inputs to the various themes are available on the Audit's archive website <www.nlwra.gov.au>.

The Australian Natural Resources Atlas and Australian Natural Resources Data Library

The integrated outputs from the Audit have been placed on a single Audit website <www.environment.gov.au/atlas>, a contractually managed site operated on behalf of the Audit by Environment Australia, and forms the **Australian Natural Resources Atlas,** operating through <http://audit.ea.gov.au/ANRA/atlas_home.cfm> which also provides access to the Theme reports outlined above.

The **Australian Natural Resources Data Library** was established to contain the collected primary and derived data acquired through the Audit processes. It has been lodged in a Bureau of Rural Sciences–managed website <http://adl.brs.gov.au/ADLsearch/>, from where the data may be accessed by scientists and other potential users.

Details of the Atlas and Data Library are provided in Appendix 4.

Free community access to the available data

The progressive availability of the Audit's output has led to development of a Commonwealth Spatial Data Policy providing for community access to Atlas data at the cost of downloading the information from the internet. A foundation agreement was established (Data Access and Management Agreement 2001) under which the Commonwealth, States and Territories as members of Australia New Zealand Land Information Council, provide community access to data sets under a single license agreement. Commercial use of the information can be arranged subject to licensing conditions.

Adoption of Audit principles in Australia

As described at the conclusion of Chapter 2, there has been considerable adoption of products from the Audit as projects have drawn to a conclusion and outputs been published.

Adoption of Audit principles overseas

Implementing the Audit was an entirely new initiative for Australia, which had no previous background infrastructure for its conduct. It has been recognised overseas that the Australian government, through the National Land and Water Resources Audit, has developed an innovative new approach to objectively assembling a library of benchmark data capable of easy access and suitable for assessing the nation's natural resources and potentially tracking them in the future. As a consequence, the Audit has been requested to make major contributions to the infrastructure planning for and hence has been assisting in the creation of the Millenium Ecosystem Assessment <www.ma.secretariat.org>. This is described as:

> *… an international assessment of the impact of changes to ecosystems on the goods and services they provide, and will provide a foundation for wise policy making.*

The Millenium Ecosystem Assessment was launched by United Nations Secretary-General, Kofi Annan, on World Environment Day, 5 June 2001.

ACHIEVING AWARENESS AND ACCESS

It was recognised that there would need to be ready access to the outputs from the Audit for a range of stakeholders. These included technical users, policy staff, the local and regional community, and ultimately the public at large. The cooperation between the Commonwealth, States and Territories, spearheaded through the Australia New Zealand Land Information Council has been crucial in the development of the Audit. This cooperation ultimately resulted in an agreement that data obtained by the Audit could be accessed under licence. Cost for community use would exclude intellectual property charges and be the cost of electronic transfer only. A mechanism to allow negotiation for the data for commercial purposes was also set up.

Suitable access has helped achieve awareness in the media for emerging issues. This was notably evidenced in the extent of national debate on the issue of dryland salinity which received extensive feature–level cover in the press, radio and television following the release of the Audit's Australian Dryland Salinity Assessment 2000.

The inclusion of case studies, enabling readers to appreciate how environmental interactions are occurring in a real situation, has proved helpful in broadening the appreciation of opportunities and threats which can be derived from the data.

Nevertheless, as awareness of the Audit's products grows, there could be a risk that the limitations of Audit data may not always be appreciated, resulting in un-met expectations. At the current time, it is rarely possible to secure property-sized information from the Audit's Atlas and Data Library.

One of the major groups perceived to be potential users of Audit's data library and products has been the staff and senior managers of agencies responsible for development of and implementation of natural resource management policies. Perhaps not surprisingly, they evinced commitment, but no especial commitment to the Audit's activities until outputs began to derive from the Audit's activities. This undoubtedly reflected a healthy and critical scepticism until there were products to evaluate.

MEETING AUDIT OBJECTIVES

The extent to which the Audit has met the objectives set for it is summarised below. More detailed aspects are described in the individual theme reports which underpin the Audits principal outputs—the Australian Natural Resources Atlas and the Australian Natural Resources Data Library.

Objective 1. 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.

The Audit has collated and presented information on Australia's land use including agricultural and rangeland productivity, nutrient status, and potential continuing degradation in terms of salinity, acidity and erosion loss, has generated maps of pre European settlement and current day native vegetation resources, and assessed the availability, quality and use of surface and groundwater resources. The information is readily available in integrated form on the Australian Natural Resources Atlas, and the collected data is available on the Australian Natural Resources Data Library.

Objective 2. Providing some interpretation of the costs and benefits—economic, environmental, and social—of land and water resource change and any remedial actions

The Audit has evaluated the economic impact and aspects of the social impact of natural resource changes on rural and regional communities in the intensively managed land use zones and in the rangelands. These changes include effects of land degradation on agricultural productivity and economic returns and on public infrastructure.

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

The Audit established bilateral protocols with custodians of data in each State/Territory to streamline data access for Audit assessments. An agreement with the Australia New Zealand Land Information Council ensures ongoing community access to Audit data. Australia-wide data sets established after agreements with data custodians include the Australian Soil Resources Information System, the National Vegetation Information System, a national inventory of estuaries and their condition, and assessments of the sustainability of Australia's surface and groundwaters. The Audit also gained agreement on parameters for establishing a rangeland monitoring system.

Objective 4. Producing national land, vegetation and water—surface and groundwater—assessments as integrated components of the Audit.

Fundamental data sets have been developed which have been integrated for an evaluation of Australia's water resources, and have been accessed by the National Competition Council in overseeing the National Water Reform Agenda. Water and native vegetation data sets have been used as integral components of river and catchment health and as inputs to the Audit's assessment of biodiversity. Catchment and river health have been linked with carbon, water and nutrient budgets, evaluated from a perspective of nutrient and sediment transport. Vegetation data sets have contributed to rangelands assessment. An Australia-wide land-use map has been produced.

Objective 5. Ensuring integration with, and collaboration between, other relevant initiatives.

The Audit has worked in partnership with Australia's leading research, industry and resource management agencies to develop an agreed harmonised approach to standards and quality underpinning data collection, and to deliver valuable new outputs that define the status of Australia's natural resources. These outputs have, where possible, drawn on data from earlier initiatives such as Landcare and Natural Heritage Trust projects. Audit products have provided a basis for the further development of new initiatives and their priorities such as the National Action Plan for Salinity and Water Quality.

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

The agreements with Commonwealth State and Territory agencies promote and maximise cooperation and collaboration in all aspects of data and information management. Common frameworks developed for all Audit projects have resulted. These provide a basis for consistent, comparable Australia-wide data sets to continue to be collected and to be integrated with past collections to generate readily interpretable trends in natural resource management. A system has been set in place for storing, managing and retrieving fundamental data, derived data and information products. Institutional arrangements have been developed to provide a data system to underpin natural resource assessment after completion of the Audit through Environment Australia continuing to support the Australian Natural Resources Atlas and Agriculture, Fisheries and Forestry – Australia managing the Australian Natural Resources Data Library.

The independent monitoring and evaluation report No 6 (Agtrans Research) noted *The Audit has produced a set of products and outputs to date that are impressive in their coverage and depth. Overall, we consider the investment in the Audit to be sound and it provided good value for money* (see Appendix 3).

The completion of the Audit, issuing of reports on the status of Australia's principal natural resources, and the establishment of the Data Library and the Australian Natural Resources Atlas means for the first time that there is a comprehensive benchmark against which the outcomes of future natural resource management initiatives can be evaluated.

APPENDIX 2. AUSTRALIAN NATURAL RESOURCES INFORMATION 2002

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 the 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 the 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 the government, industry and the community can easily obtain natural resource 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 cost, or under licence conditions that inhibit their use; and
- recommending actions for consideration by the Natural Resource Management Ministerial Council in improve the availability of natural resource data.

ensure that natural resource data are comparable and consistent, when 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 collection of natural resource data.

APPENDIX 3. MONITORING AND EVALUATION OF THE NATIONAL LAND AND WATER RESOURCES AUDIT: PROGRESS REPORT 6

Agtrans Research, 10 October 2001

Executive summary

This aim of this report is to provide an evaluation of the Audit's performance, products and processes up until the end of September 2001. The timing of this report has been determined so that is can provide input before the final Audit report is written and finalised.

Achievements

The Audit has produced a set of products and outputs to date that are impressive in their coverage and depth. Overall, we consider the investment in the Audit to be sound and it provided good value for money. The foundation provided by the Audit including the development of ongoing standards and protocols, the establishment of baselines, and a framework for ongoing monitoring at a national level of natural resource management information are expected to be the most valuable outputs.

The Atlas and the Data Library are high profile products of the Audit and will be valuable for a range of natural resource management managers. These resources, together with the enhanced comparability of data sets, and the development of a range of new natural resource management information products targeted at decision-making needs, all represent a significant improvement in information availability and accessibility.

Objectives and role

All of the six objectives of the Audit have been at least partially met, with delivery of the second objective relating to interpretation of costs and benefits, being the weakest. However, for what the Audit tried to achieve, it was under-resourced and its objectives were over-ambitious for the time period, the complexity of the tasks, and the budget. The Audit could have been even more effective if it had been more focused on a specific role.

Information provided

The Audit has been successful in drawing on a wide range of existing data and has reworked it into comparable national data sets and products. This has been an outstanding achievement in itself given the difficulties faced. However, information about cause and effect, trends over time, and the 'condition' of some natural resources has proved difficult to provide, largely due to existing data inadequacies and different perceptions regarding condition. Also, information on management practices, important in understanding causal effects and impacts and leading to appropriate remedial activities was scarce. This was understandably not a principal focus of the Audit but where information was assembled, (e.g. the dairy industry) its value is already being demonstrated.

Availability, accessibility and relevance of the data provided were generally good, but less confidence is held in the capacity for integration, repeatability and accuracy of the information due mainly to its different sources and methods of collection/estimation.

Integration of data across themes was generally weaker than integration within themes. This is particularly so with regard to future monitoring systems that might evolve and become established from the existing theme initiatives. The future framework for monitoring needs to be integrated to ensure that it is useful for natural resource decision making.

Outcomes

There are difficulties in relating changes in policy and investment programs to improved information and also in attributing changes in the state of natural resources to policy and investment changes. The long lead times to measurable improvements is one reason. However, whatever the final outcome, it is clear that Audit information is already being used by a range of natural resource management decision makers and examples of this use are provided in this report. It can be expected that such decisions in program planning and policies will result in improved natural resource management.

Management

The Management of the Audit via the Audit Management Unit has been outstanding, given the starting point, the very broad brief, the resources and the constraints faced due to the investment in existing data collection processes and the range of jurisdictions involved. The Audit Management Unit is held in high esteem by all those involved in the Audit and project management by the unit has been accountable and of a high standard.

On the other hand, the Audit would have benefited from a better designed program plan and an integration model that recognised the critical pathways needed to provide the integrated outputs and outcomes. Greater emphases could have been placed on the early consultative processes with regard to each theme. Permanent steering committees should have been established for each theme and representatives should have been drawn from a wider cross section of natural resource management interests and with a strong representation from users. An independent mid-term review of each theme in order to refocus the highest priority theme outputs would have improved outputs and built ownership.

Consultation and communication with interested users outside of the Commonwealth, State and Territory agencies varied with those engaged in projects or peak bodies subject to regular communication. More general consultation with decision makers, industry and community groups would have been beneficial in building support and knowledge.

The Audit has made a start regarding team building and leadership in a nation-wide approach to natural resource data and monitoring. However, significant improvement in processes, institutional arrangements, and change in cultures is required.

Jurisdictional factors inhibit the efficiency and continuity of a comparable national data assembly program for natural resources. This particularly applies to coordination of effort between departments and agencies within both Commonwealth and State/Territory governments.

Communication and training

Strong communication and extension of the Audit's products will be required to obtain the most value for the Audit investment. This communication should detail the products available, where they can be found, their limitations and how they can best be used. Some form of training for using the Atlas and Data Library will also be required to maximise use and effectiveness of the Audit products.

The Audit final report

Suggestions for material that might be contained in the final report from the Audit have been made. The most important include:

(i) what has been delivered set in the context of varying expectations;

(ii) the important products and outputs produced;

(iii) integration and demonstration of linkages between themes;

(iv) needs, uses and benefits of information in decision making;

(v) index/signposts as to where information resides and how it can be accessed;

(vi) lessons learnt;

(vii) plans for maintaining the data within an ongoing framework; and

(viii) policy issues regarding natural resource management information.

The future

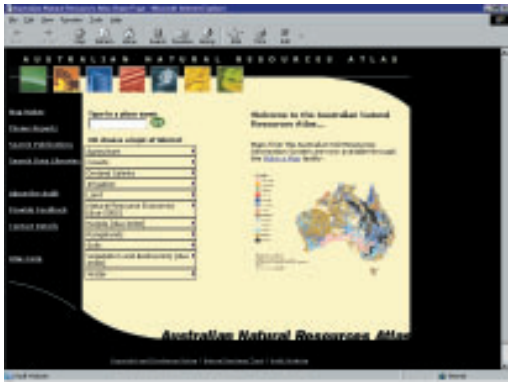
To take advantage of many of the outputs of the Audit, it is essential that some manner of nationwide comparable data collection and monitoring continue. Future initiatives should be accompanied by a higher level of consultation and involvement with target groups particularly those who are involved in natural resource management decision making.

An improved balance will be required in the future between regional and national level data assembly. It would be appropriate for any future Audit to focus on priority areas and be comfortable with investing greater effort in some areas compared with others.

It would be worthwhile examining the theme structure used in Audit 1 with the objective of providing a higher level of integration in future Audit products.

APPENDIX 4. AUSTRALIAN NATURAL RESOURCES ATLAS AND DATA LIBRARY (May 2002)

Australian Natural Resources Atlas



Agriculture

- Agriculture – an overview
- Agriculture – context for sustainable natural resource management
- Agriculture – changing face of agriculture
- Agriculture – statistics
- Industry – beef
- Industry – cotton
- Industry – dairy
- Industry – grains
- Industry – horticulture
- Industry – sheep/wool
- Industry – sugar
- Irrigation – an introduction
- Irrigation – extent
- Irrigation – production
- Irrigation – water consumption
- Irrigation – infrastructure and distribution

Coasts

- Estuary Assessment 2000
- Tools and information to support estuary management
- Understanding estuary condition
- Understanding estuary processes

Land

- Land use – an overview of land use in 1996/97
- Land use – change, intensity and diversity
- Dryland salinity – in context
- Dryland salinity – risk and hazard 2000–2050
- Dryland salinity – groundwater flow systems
- Dryland salinity – impacts and costs
- Dryland salinity – management
- Dryland salinity – monitoring and evaluation
- Dryland salinity – case studies
- Landscape – carbon, nutrients, water and productivity
- Nutrients – farm gate nutrient balance
- Soils – an overview
- Soils – Australian Soil Resources Information System
- Soils – erosion and sediment transport
- Soils – acidification
- Monitoring – land condition

People

- Australians and Natural Resource Management 2001 – an overview
- Individuals and farm management
- Adjustment – agriculture structure—an overview
- Adjustment – Australian agricultural sector in 1986

- Adjustment – Strategies and outcomes 1986–1996
- Adjustment – future structure of agriculture and catchment communities
- Economics – in natural resource management – an overview
- Economics – natural resource accounting framework
- Economics – returns to the agricultural resource base
- Economics – costs to agriculture from resource degradation
- Economics – costs of resource use off-farm and downstream
- Economics – valuing non-markets assets

Rangelands

- Rangelands – an introduction
- Monitoring
- Biophysical resources
- Impacts on biophysical resources
- People in rangelands
- Institutional response
- Project documentation

Vegetation and biodiversity

- Landscape health
- Natural resource management and native vegetation
- The National Vegetation Information System framework
- Native vegetation types and extent in Australia
- Effects of clearing on native vegetation in Australia
- Native vegetation management in Australia

Water

- Water resources – an overview
- Water resources – availability
- Water resources – allocation and use
- Water resources – management and development
- Water resources – water quality
- Rivers – nutrient loads and transport
- Rivers – assessment of river condition

Australian Natural Resources Data Library

Agriculture

- Agricultural industries—regional boundaries
- Spatially consistent subsets of agricultural statistics from 1982/83 to 1996/97

Biodiversity and Vegetation

- Pre-European major vegetation groups and subgroups
- Major native vegetation groups and subgroups
- Cleared major native vegetation groups
- Landscape health in Australia 2001 (held by Environment Australia)

Coasts

- Estuary condition assessment 2000 (held by Geoscience Australia)

Land

- Australian Dryland Salinity Assessment 2000
- Australian groundwater flow systems
- Australia-wide land use (1:1 000 000)
- Soil erosion and sediment transport
- Landscape carbon balance
- Landscape nitrogen and phosphorus balances
- Fertiliser use
- Soil properties—the Australian Soil Resources Information System:
  - Organic carbon in the soil
  - Total phosphorus or nitrogen
  - Soil texture, depth and density
  - % of clay, silt or sand
  - pH and ability to resist pH change
  - Water storage capacity
  - Permeability of the soil

Rangelands

- Land tenure in the rangelands from 1957
- Season quality in the rangelands
- Total grazing pressure from 1957 in the rangelands

Social and economic dimensions of natural resources

- Age and experience
- Education and training
- Farm financial characteristics
- Farm family characteristics
- Farm structure
- Sustainable practice
- Social and institutional contact as sources of change
- Remoteness and other community indicators
- Indicators of rural adjustment
- Agricultural profit at full equity
- Costs to agriculture
- Input costs to non-agricultural infrastructure

Water resources

- Australian Water Resource Assessment 2000
- Surface water quality (held by Environment Australia)
- Surface Water Management Area boundaries (held by Geoscience Australia)
- Groundwater Management Unit boundaries (held by Geoscience Australia)
- A nested set of catchments and subcatchments for Australia
- Estimated daily and monthly streamflow data from 1901 to 1998 for 286 catchments
- 1985 review of Australia's water resources and water use
- River nutrients, loads and transport
- Assessment of river condition (held by Environment Australia)

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ACKNOWLEDGMENTS

The Audit Advisory Council acknowledges those who have challenged, shaped, executed and participated in the Audit assessments. In particular, this includes the project teams—this work could not have been completed without their dedication and commitment. As a result understanding of Australia's natural resource issues and access to data and information has been extended well beyond our expectations.

Partnerships have been a key feature of the Audit activities. The in-kind and cash contributions of Commonwealth, State and Territory governments, agricultural industries and research agencies in Audit activities were critical to the success of the Audit Program. The quality, depth and breadth of the Audit Program outcomes measure the value of these partnerships. The Audit Advisory Council wishes to acknowledge their indebtedness to the generosity of all these partners.

The Audit Advisory Council particularly expresses its appreciation to Dr John Radcliffe, Colin Creighton and Warwick McDonald who prepared *Australia's Natural Resources: 1997 – 2000 and beyond*, the report that synthesises the outcomes of the Audit and a way forward to the future.

PHOTO ACKNOWLEDGMENTS

Baden Williams ..... pages 5, 7

CSIRO Land and Water ..... page 38

Murray-Darling Basin Commission ..... page 2

PUBLISHED AUDIT OUTPUTS

Australian Water Resources Assessment 2000

- Status of Australia's water resources, surface and groundwater, including use, environmental flows, development opportunities

Australian Dryland Salinity Assessment 2000

- Assessment of the extent of, and management options for, dryland salinity

Australian Native Vegetation Assessment 2001

- Detailing the condition of Australia's sub-bioregions and the extent and type of Australia's native vegetation respectively

Rangelands – Tracking Changes

- Collating information on Australia's rangelands and recommending the implementation of the Australian Collaborative Rangeland Information System

Australian Agriculture Assessment 2001

- Resource challenges facing agriculture and practice issues on-farm (acidification, nutrient management, soil erosion) and off-farm (sediment, nutrients transported through waterways to estuaries

Australians and Natural Resource Management 2002

- Social and economic dimensions of natural resource management based on natural resource accounting and a social profile of rural Australia.

Australian Catchment, River and Estuary Assessment 2002

- Assessment of the ecological impact of the changes to hydrology, habitat, sediment and nutrient regimes within rivers and estuaries. These assessments are part of the report.

Australian Terrestrial Biodiversity Assessment 2002

- Assessing the condition of Australia's terrestrial biodiversity

Australian Natural Resources Information 2002

- Setting the directions for data management and information provision

Australian Natural Resources Atlas <www.environment.gov.au/atlas>

- Providing information to aid decision making across all aspects of natural resource management. It covers the broad topic of water, land agriculture, people and ecosystems. The Atlas presents information nationally, by State/Territory and regionally, and also by information topic. Users of the Atlas can prepare a map—using the 'make a map' facility—or search hundreds of reports in a matter of seconds. The Atlas provides access to the Theme reports which have also been published in 'hard copy'.

Australian Natural Resources Data Library <http://adl.brs.gov.au/ADLsearch/>

- Providing a data documentation search and data download facility and supports the Atlas with links to Commonwealth, State and Territory data management systems. The Data Library primarily contains Australia-wide biophysical, social and economic data prepared through the Audit. Data are provided under licence and where possible, links to other Commonwealth, State and Territory data management services.

www.environment.gov.au/atlas

Natural Heritage Trust

Helping Communities Helping Australia

A Commonwealth Government Initiative

National Land & Water Resources Audit

A program of the Natural Heritage Trust

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